

Design, Deployment, Automation, and Testing Strategies for 6G Mobile Core Network



D. Satish Kumar, G. Prabhakar, and R. Anand



Handbook of Research on Design, Deployment, Automation, and Testing Strategies for 6G Mobile Core Network

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Fifth-generation communications standardization has concluded, and global deployment has commenced. To maintain wireless networks' significant competitive advantage, industrial and academic collaboration has started to design the next generation of wireless communications networks called sixth generation (6G) to establish the foundation for the segmentation of communication demands in the 2030s. This study highlights the most encouraging fields of inquiry from the recent literature in familiar angles for the 6G project to support this vision. Its major contribution is to investigate the crucial difficulties and significant prospective features of 6G communications, such as (1) vision and key features, (2) research activities, (3) architecture of 6G, and (4) challenges and potential solutions. These critical research topics were thoroughly studied in terms of the motivation with their many sub-domains in order to get a precise, specific, and brief conclusion. As a result, this study will greatly contribute to the opening of new boundaries for future research initiatives.

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Sixth generation (6G) wireless communications have commenced in research after the deployment of fifth generation (5G). It's anticipated that 6G networks can take abundant heterogeneous devices and infrastructures with greater efficiency and safety over various resources, storage, computing. Conversely, this objective is hindered by a number of trust-related issues that are frequently ignored in network plans. Blockchain is a distributed ledger technology that has arisen in the recent decade with fundamental traits (e.g., transparency, traceability, immutability, decentralization, anonymity). Blockchain can inaugurate cooperative trust among distinct network entities and simplify various intrinsic features like privacy protection, tracing, trusted data interaction, verified certification for trusted users, monitoring functionalities for wireless networks, thus awarding a new paradigm towards 6G. This chapter provides the role of blockchain in wireless communication technologies.

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Due to increasing demand and faster access, the 6G technology is under invention, and as expected, it will come into functioning in 2030. This new paradigm of network communication brings more changes to the digital era with the aid of artificial intelligence. The architecture of 6G is compared with 5G technology and an analysis of 6G technologies in various applications domains is done. Various technologies integrated along with 6G including IoT, blockchain, big data, artificial intelligence, machine learning, robotics, quantum communications are analyzed. This chapter describes the requirements for new generation networks 6G technology as well as key performance indicators required for 6G networks. The research challenges are explored under different attributes for future contribution of new technology towards the wireless evolution.

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The arrival of the 6th generation (6G) technology will revolutionize the digital transformation of society. It offers speeds of several gigabits per second, with small latencies less than 5ms, ultra-reliable transmission medium, while it is able to handle a huge quantity of nodes simultaneously connected to the network. 6G will be accepted for commercial launch within 10 years. 6G will be industrialized in retort to progress the dispersed radio access network (RAN) and longing to use terahertz band to increase the number of users. On proposing an adaptive hybrid transmission (AHT) arrangement about 6G with mobile internet protocol television network (MIPTVN), the proposed algorithm uses a hybrid mechanism. The AHT mechanism is the combination of the multichannel multicast and unicast process which increases the service over service probability of blocking the service and reduces the overall bandwidth consumption of MIPTVN on demand over 6G.

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The framework should work under both function cooperation and function convergence models, support cloud-network-terminal cooperation and convergence, and bring the basic radio capabilities of cooperative sensing, cooperative machine learning, and deterministic transmission with higher reliability and data rate. Integration of sensing and communication (ISAC) offers two advantages over dedicated sensing and communication functionalities: 1) gain in integration to more effectively use crowded resources and 2) gain in coordination to balance dual-functional performance. ISAC has lately been proposed for a variety of new applications such as automotive networks, environmental monitoring, remote sensing, IoT, smart cities, and indoor services such as human activity and gesture detection, all of which benefit from these two benefits. More crucially, ISAC has lately been highlighted as a key enabler for B5G/6G and next-generation Wi-Fi systems. The goal of this study is to figure out how sensing and communication can work together to give 6G new capabilities and services.

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Through specific technical approaches, 6G will provide people with high quality of service (QoS) and high quality of experience (QoE), so as to make human life better. The author predicts the huge potential and development trend of 6G wireless communication technology combined with the healthcare field. 6G is a promising communication technology, and it is expected to revolutionize many sectors, including healthcare. Currently, time and space are the primary barriers to healthcare, and 6G has the potential to break these barriers down. The authors first introduce the background and related obstacles of the current healthcare development field and then prove the huge potential of 6G in its development field. Further, they reveal how 6G technology can be utilized for remote surgery, epidemics, and pandemics. Finally, there are related challenges. Similarly, the cell free communication in AR/VR helps in 360 video scenes.

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The diversified opportunities and challenges in various sectors necessitate development of sixth-generation (6G) wireless systems with extremely high data rate, massive connectivity, minimal latency, good coverage, high reliability, optimal resource allocation, good spectral and energy efficiency. Multiple access is a key technique in the wireless technological evolution that provides access to multiple users with the available resources. Even though 5G system promises data rate in Gbps and latency below 1 ms with a wide bandwidth ranges from 30 GHz to 300 GHz, its range of coverage was limited. Hence, the infrastructure needs to be rebuilt to overcome the limitation. NOMA is the key enabler for bringing down the interference effects and sharing the spectrum among multiple users in an efficient way. Cooperative communication is another promising technology that can improve coverage and capacity of the wireless system. Cell free communication with cooperative NOMA architecture is proposed in this chapter to meet 6G requirements at THz band.

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5G is being marketed the world over currently with research institutions initiated to go ahead of 5G and 6G evolving as green networks with excellent energy efficiency provide the quality of services. As communication growing day by day with the 5th generation communications deployed worldwide, 6th generation (6G) communications have become more attractive towards both industry and academia. The main objective of the research is to increase the speed of sensing and communicating. In the future, vehicular communication or VANET, smart cities, healthcare, gaming, public safety and security, transport and industrial needs, and robotics will play vital roles in the integration of sensing and communication. While comparing with 5G, 6G will have more advantages such as higher transmission rate, wider frequency band, larger capacity for connection, lesser delay, more coverage, and added robust anti-interference capacity, fulfilling different specification of networks.

Section 3

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In recent years, the machine learning approach has been a major surge of research interest in intelligence, data-driven advanced dynamic approaches, and automation of low-powered gadgets. The goal for 6G is a massively linked complex network capable of reacting quickly to user service requests by real-time learning of network status as given by the network edge, user-side, and air interface. Most machine learning application 6G vehicular networks are intended to generate a rapidly evolving and intelligent system that allows networks to adapt to various application requirements and service types. In the autonomous driving age of 6G, ML is used to design a route, and 6G's improvements in response time, roaming range, network energy efficiency, and connectivity provide a better experience for users. Scholars are afraid about this problem due of privacy concerns. Overall, the chapter includes the basic and advanced levels of machine learning including the unsupervised, supervised, and reinforced learning and the challenges of ML for 6G.

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Modern networks may not even be equipped to fully satisfy rapidly increasing traffic needs due to the fast growth of intelligent endpoints and systems and various programs with diverse needs. As a result, a study on 6G technology has already been undertaken by businesses and academics. AI (artificial intelligence) has subsequently been used as a paradigm shift to optimise high-intelligence 6G technology. To realize information exploration intelligent resource planning, automatic network adaptation, and astute service configuration management, the authors proposed an AI-enabled smart architectural design for 6th generations systems; here, it is categorized into four tiers: data mining, intelligent sensing layer, smart application layer, and intelligent control layer. The author also discussed modern technology in the mobile generation, uses, security, opportunities, and challenges.

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The terahertz band is the next frontier in wireless communications for its ability to unlock significantly wider segments of unused bandwidth. It offers the enhanced transmission bandwidth when compared to mmwave band in 5G networks. Terahertz communication reduces the problem of mmWave bands where the propagation loss is more due to molecule absorption of electromagnetic waves. The development of Reconfigurable MIMO techniques, subwavelength guiding structures, nanoantennas, superlenses, hyperlenses and light concentrators, communication distance can be increased in THz systems. 6G wireless networks will consist of a multitude of small radio cells with shorter communication distances. Base stations of radio cells in the 6G network need to be connected with high-speed wireless, enhanced data rate, minimum energy consumption, and low electromagnetic emission links. These broad band links can be implemented by terahertz waves in 6G networks. Terahertz bands are inevitably going to be the next in line. THz communication will contribute to enabling interesting and needed applications.

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The internet of things (IoT) has cleared the door for sophisticated functionalities to be introduced into the healthcare business. IoT systems handle a significant amount of data and require 6G network connectivity, power, and storage to convert it into useful information. The internet of medical things refers to the use of IoT-based internet-enabled medical devices in the healthcare business (IoMT). The lack of security standardization and energy-consuming cryptographic algorithms in man-in-the-middle attacks, session hijacking, and wireless encryption breaking are all possible security problems with IoMT. On the other hand, because of its decentralised nature, blockchain may be used to address IoT problems. The widespread adoption of decentralised blockchain technology in IoT has significantly reduced the danger of sensitive healthcare data being exposed. The authors combine blockchain technology with IoMT (B-IoMT) in this chapter to enable secure data transfer over a 6G network connection. The blockchain's security characteristics aid in achieving tamper-proof data transfer in IoMT.

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From 2030 onward, 6G is a potential communication technology that will dominate the whole health sector. Finland was the first to start a 6G experiment in 2018. Second, in 2019, the US, South Korea, and China launched the 6G initiative. Japan has just announced a 6G research initiative for 2020. In addition, 6G has spawned a slew of new algorithms. It is now critical to begin the 6G project in order to avoid falling behind other countries. On the other hand, 5G communication technology has yet to be fully deployed globally, and B5G has yet to be created. 5G and B5G will have a number of disadvantages when it comes to revolutionizing current lifestyles, society, and industry. For example, due to the reduced data rate, holographic communication is not possible. As a result, now is the best moment to think about the future of 6G communication technology. It is also important to consider future healthcare in order to ensure the well-being of society's citizens. It will rule not just the health industry, but also a variety of other industries.

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6G is a sixth-generation telecommunications standard that is presently being developed for wireless communications technologies that support cellular data networks. The ongoing deployment of 5G technology has urged researchers to explore what occurs next. From 2030 onward, 6G is a prospective communication technology that will enable wireless healthcare to become a reality. The current trend in the smart healthcare system has obstacles like risk of failure, security, and privacy. Healthcare will be absolutely AI-driven and reliant on 6G connectivity technologies, transforming our lifestyle perceptions. In order to have access, creative solutions must be introduced to improve our way of life including intelligent wearable devices, hospital-to-home services, intelligent internet of medical thing, quality of life (QoL), and new business strategy. The proposed intelligent healthcare system is classified into three major modules: hospital atmosphere, remote medical care, and disaster retaliation.

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Every healthcare division should be provided with sophisticated technology to offer patients appropriate diagnostics, therapies, and a variety of health services either inside hospitals or remotely. A quick responding division is also necessary to deal with the influx of patients and inquiries throughout disasters. This would control not just the healthcare field, but also a variety of other industries. Many industries, notably healthcare, are likely to be transformed by 6G. Healthcare and hospitals will be entirely AI-driven and reliant on 6G connectivity technologies, altering our perspective of life. Nowadays, time and area seem to be the most crucial hurdles to medical systems, which 6G would be capable of overcoming. Under the human-centric perspective of 6th-generation wireless technology, this chapter examines healthcare communication and networking issues and potential strategies for early warning and quick action in crisis scenarios. This chapter also discusses the problems encountered during the deployment of 6G, as well as applicability and future research directions.

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The vision towards future sustainability in healthcare has become an alarming factor owing to its imperfect system in place based on growth and aging. In order to follow and control every citizen in the health process of their lives, wireless health monitoring must be achieved. The aim of next gen is not just to make wireless healthcare a true technology, but will also enable bio-nano-internet, things allowing the human healthcare to form a controlled network. Less sophisticated wearable and/or implantable equipment would be an integral part of our day-to-day life, which can recognize the lifestyle and health data from all the possible means of interaction. The authors present a vision for a complete model that should meet the expanding healthcare hassles and a conceptual model that can solve these growing expectations in full. In conclusion, the latest developments in the healthcare domain are discussed, and the authors suggest upcoming avenues in this domain on par with the technological growth.

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The next generation 6G era is considered to be highly coupled with intelligent network management and orchestration, while 5G is completely renowned for micro-service architecture-based network cloudification. 6G has been revolutionized for satisfying the mandatory services and carry forwarding the potentialities of 5G to superior and intelligent level. 6G network structure is determined to be dynamic, densely deployed

and extremely heterogeneous, and when integrated with a high degree of Quality of Service (QoS) completely transforms the complex architecture into a seamless operating process of classical networks. The immense role of Artificial Intelligence (AI) and Machine Learning (ML) is required for improving the paradigm of 6G for learning information from uncertain and dynamic environments. This integration of AI and 6G resembles a double-edged sword since the application of AI may positively influences the privacy or security of 6G on one side, and negatively introduces the possibility of security infringement into 6G on the other side. In specific, the self-sustaining networks in 6G are obtained by guaranteed application of intelligent security attack mitigation schemes and proactive threat discovery approaches that facilitate end-to-end future network automation. In this Chapter, a comprehensive review of AI and ML-based security enforcement techniques are contributed for improving reliability during robust data dissemination in 6G communications. It presents consolidated and solidified role of AI and ML towards the enforcement of security in 6G networks. In addition, it also demonstrates the challenges and solutions that are handled by the inclusion of AI and ML-based attack mitigation approaches concerning energy and security-based ultra-massive access.

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In WSNs, attention is given to evaluating the first generation (1G) networks to 6G networks. AI techniques were applied to achieve network intelligence, closed-loop optimization, and intelligent wireless communication for 6G networks. DRL was adopted to preserve reliable wireless connectivity for UAV-enabled networks by learning the environmental dynamics. Hence, it is promising to adopt AI to 6G networks to optimize the network architecture and improve network performance. 6G networks utilize different spectrum bands to support high data rates. In 6G networks, the massive amounts of collected data and complex network architectures pose challenges for AI-enabled learning and training processes. Limited computing resources may be insufficient to process massive high dimensional data to meet the training accuracy rate, robustness, scalability, and flexibility of learning frameworks, which are crucial aspects for providing high-quality services in real-world dynamic networks. Thus, designing robust, scalable, and flexible learning frameworks for 6G networks is still an open issue.

Chapter 19

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Smart healthcare systems have been widely applied in the fields of intelligent healthcare, self-monitoring, diagnosis, and emergency. In recent years, there have been growing concerns regarding the privacy of the data collected from the users of the smart healthcare systems. This chapter proposes a light-weight

federated learning framework based on multi-key homomorphic encryption for deploying predictive models trained on patient data distributed across multiple healthcare institutions without exchanging them. Two predictive models based on the proposed framework are deployed for in-house mortality prediction from patient data and COVID-19 detection from chest x-ray images. Performance evaluation of these models with standard datasets and comparative analyses show that the proposed models are superior to state-of-the-art approaches. The proposed framework and the models are potential solutions to improve the quality of healthcare across multiple healthcare institutions, protecting the sensitive patient data and ensuring personalization of healthcare.

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This chapter presents a simple, metamaterial-loaded planar ring antenna for WLAN/WiMAX applications. The proposed antenna is equipped with two neutralization lines to improve performance in the desired operating bands. The use of neutralization lines as conducting strip allows the antenna to function at the upper resonance-3.5GHz and the incorporation of complementary split ring resonator at the rear of the substrate benefits in the antenna's compact size. Due to the incorporation of a quarter wave transformer with a semicircular ring construction, the ring antenna produces better dual-band response. The upper resonance 3.5GHz is obtained due to the combination of tuned semicircular ring and circular ring along with the conducting strip in the structure. The fabricated antenna is printed on FR4 substrate with dimensions 10×10×1.6 mm³. The simulated results are verified by experimenting the fabricated antenna. It offered 14.6% bandwidth in the lower resonance 2.4 GHz and 8.5% bandwidth at upper resonant frequency 3.5GHz with radiation characteristics suitable for the WLAN/WiMAX applications.

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Preface

This book presents a vision for the coming years, one that the editors of this book, active employees of leading educational institutions with more than decades of experience in wireless communication, and the collective chapter authors see ahead in terms of emerging sixth generation (6G) wireless technology trends and best practices. Each section delves into the challenges and technical opportunities that will arise as a result of developing and deploying 6G networks for emerging applications and services. The book also examines the fundamentals of physical layer, terahertz communication, artificial intelligence, 3D networking, and advanced research in wireless communication in the future.

The book editors have known each other for many years and have worked together in various capacities: research activation and university work. They have organised this book especially for researchers, students, and network engineers and designers, and leaders of emerging companies, decision-makers in standards, consumers, and product developers. Our goal is to provoke a discussion about the impact of 6G mobile core communication technology trends in the coming years. This is critical for comprehending a change, anticipating a change, even controlling a change, and, ultimately, making it work globally. The sixth generation (6G) of cellular wireless is a successor to the 5G, 4G, 3G, and 2G standards. It is understood that 6G systems may upgrade existing communication networks and are expected to provide comprehensive and secure IP-based solutions that facilitate existing and emerging services such as voice, data, streamed multimedia, sensory, e-health, and social networking. The 6G mobile core networks are expected to provide simultaneous wireless connectivity that is 1000 times (thousands) higher than 5G (fifth generation). Moreover, ultra-long-range wireless communication with less than 1 ms of latency is also expected in 6G mobile core networks. Video-type traffic is likely to be dominant among various data traffic systems in 6G mobile core networks. The most important technologies that will be the driving force for 6G (sixth generation) are the THz band, AI, unmanned aerial vehicles (UAV), IRS, optical wireless communication (OWC), wireless power transfer, and 3D networking.

Wireless communication is the fastest growing and most vibrant technological area in the communication field. Wireless communication is a method of transmitting information from one point to another without using any connection like cables, wires, or any physical medium. Modern wireless communication such as radio waves has been around us for more than 100 years. There are many advantages to wireless communication, like cost, mobility, ease of installation, and reliability. The most common disadvantages of wireless communication are interference, security, and health. In the last three decades, the explosive growth of mobile and wireless communications from 2G to 3G, 3G to 4G, 4G to 5G, and 5G to 6G has radically changed the lives of people. Wireless services have migrated from the conventional voice-centric services in 3G to data-centric services in 4G, 5G, and 6G. 5G networks are also aimed at Internet of Things (IoT) related applications and future automobiles, but 6G networks use artificial intelligence.

Professionals working in computer networks, wireless communication, mobile communication, and future wireless networks will find this book useful when working to develop practical knowledge of 6G. This book is for practitioners, teachers, students, and researchers who are interested in the understanding, design, deployment, automation, and testing of 6G mobile core networks. Moreover, this book is a collective effort of the contributors to highlight and promote the value of 6G mobile core networks.

ORGANIZATION OF THE BOOK

This book is organised into five major parts, covering the following topics: Future networks 2030: Architecture and Requirements (Section 1), Research Challenges and Directions of 6G Mobile Core Networks (Section 2), Technologies in Design and Deployment of 6G Mobile Core Networks (Section 3), Applications of 6G Mobile Core Networks in Smart Healthcare (Section 4), Performance and Challenges in 6G Mobile Core Networks (Section 5).

Section 1: Future Networks 2030 – Architecture and Requirements

The first section of the book (Chapters 1-4) introduces readers to future technologies in wireless communication. It deals with 6G mobile core network architecture and requirements.

In Chapter 1, S. Senthil Kumar introduces the reader to the closure of 5G networks and the evaluation of 6G mobile core networks. They describe in detail the closure of 5G. Fifth-generation communication normalisation has closed, and worldwide organisation has started. To hold remote organizations' major upper hand, a synergistic exertion among industry and the scholarly world has started to make the 6th era (6G) remote interchange organizations, which will give the preparation to fragmenting correspondence requests during the 2030s. The authors have discussed the new technologies in wireless networks; these were completely examined as far as inspiration and its different sub-spaces to show up at an exact, point-by-point, and brief end. Therefore, this examination will all add up to the kickoff of new exploration wildernesses later on.

In Chapter 2, Ms. S. Madumidha and Dr. P. Sivaranjani provide readers with an overview of the history of block chain based wireless communications—a new paradigm in 6G mobile core networks. In the first section of the chapter, a brief overview of the essentials of block chain is discussed, followed by a complete investigation of the most recent efforts towards block chain in wireless infrastructures from several facets. In the second section, an incorporated framework of the block chain radio access network is proposed as a trustworthy and secure paradigm for 6G networking with enhanced security and efficiency by exploiting block chain technologies. The final section goes into detail about various consensus mechanisms, cross-network sharing, data tracking and auditing, smart contracts, mathematical modeling, and intelligent system networking in a block chain radio access network. They have spotted the vital trust-related issues in Wi-Fi networks that obstruct the growth of modern-day 5G to protected 6G networks. They then discussed the merged B-RAN framework for a reliable and secure 6G prototype using block chain.

In Chapter 3, Dr. M. Dhurgadevi and Dr. K. Gunasekar provide readers with different technologies of 6G mobile core networks and their analysis. In this work, an analysis of 6G technologies in various application domains such as healthcare, satellite, autonomous systems, industrial applications, and vehicular IoT is done. They discussed various technologies integrated along with 6G, including IoT, block

chain, big data analytics, artificial intelligence, machine learning, quantum communications, space-air-ground underwater communications, Terahertz communications, massive ultra-reliable and low-latency communications, wireless optical technology, and edge intelligence are analyzed. They explored various applications of 6G technology along with their communication requirements and possible technologies. Various research gaps are also presented.

In Chapter 4, Mr. Augustine C. and Dr. Jose Anand provide readers with 6G-based Mobile IPTV using Adaptive Hybrid Transmission. They discussed how 6G will be industrialized in response to the dispersed Radio Access Network (RAN) and the longing to use the terahertz band to increase the number of users. It will have reduced latency with improved spectrum sharing efficiency when compared to 5G. Proposing an Adaptive Hybrid Transmission (AHT) arrangement over 6G with Mobile Internet Protocol Television Network (MIPTVN), the proposed algorithm uses a novel hybrid mechanism. The AHT mechanism is the combination of the multichannel multicast and unicast processes that increases the service availability probability of blocking the service and reduces the overall bandwidth consumption of MIPTVN on demand over 6G. Also, the proposed adaptive scheme with resource distribution is to obtain the least obstructive prospect. To assess the concert, they compared the projected method with the unicast and multicast processes in 6G technology.

Section 2: Research Challenges and Directions of 6G Mobile Core Network

The second section of the book (Chapters 5-8) introduces readers to Research challenges and directions of 6G Mobile core network.

In Chapter 5, Ms. R. Aswatha and Dr. V. Seethalakshmi introduce the reader to 6G with the integration of sensing and communication. Their goal is to figure out how sensing and communication can work together to give 6G new capabilities and services. The integration of sensing, communication, and computing is an E2E information processing framework, where information delivery will be performed along with information acquisition and information computing. It can be divided into three categories: function cooperation, function fusion, and function reconfiguration. In traditional information service architecture, the terminal is responsible for sensing. The network is responsible for communication, and the cloud is responsible for computing.

In Chapter 6, Dr. Zhang Yiming and Dr. Zhu Yunfeng provide readers with an overview of the application of 6G enabling technologies and challenges. In this chapter, the author's emphasis is on the challenges in various applications of 6G technology in different fields like education, assistive technology, remote medicine, smart cities, and cell-less communication. Despite the fact that the emergence of 6G will be 5 years later, the authors make a reasonable prediction and consideration on the application of 6G based on the network's development history. There is no doubt that the emergence of 6G will improve technologies such as augmented reality, virtual reality, and holographic communication, which can well serve the fields of education and assistive technology. Through specific technical approaches, 6G will provide people with a high quality of service (QoS) and a high quality of experience (QoE), so as to make human life really better. There is also a huge potential and a development trend for 6G wireless communication technology combined with the healthcare field. 6G is a promising communication technology, and it is expected to revolutionize many sectors, including healthcare.

In Chapter 7, Mr. Ganapathy Ram B and Dr. Naveena A Priyadarshini introduce the reader to Cell Free Cooperative Non-Orthogonal Multiple Access for 6G Wireless Systems. They discussed the non-orthogonal multiple access that has recently been proposed as a promising technology to achieve

much superior spectral efficiency compared to the conventional orthogonal multiple access techniques employed in present communication systems. The proposed NOMA system model can be applied to wireless networks to strike a balance between user fairness and user data rates. Expanding the proposed cooperative NOMA system to function in a MIMO scenario while maintaining a practical level of user fairness is a promising future direction for the authors.

In Chapter 8, Prof. Sentamilselvan K and Dr. Kamalam G K introduce the reader to Cell Free Cooperative Non-Orthogonal Multiple Access for 6G Wireless Systems. In this chapter, the authors compared 5G with 6G. While compared with 5G, 6G will have more advantages such as higher transmission rate, wider frequency band, larger capacity for connection, less delay, more coverage and added robust anti-interference capacity to fulfill different specifications of the network. At the same time, IOT, blockchain, Machine Learning (ML), and AI (Artificial Intelligence) play an important role in addressing the problems caused by wireless communication systems. This chapter mainly focuses on the integration of sensing and communication capabilities of the devices with effective technologies. 6G is an intelligent wireless system that provides effective communication, high accuracy, and high resolution sensing services.

Section 3: Technologies in Design and Deployment of 6G Mobile Core Networks

The third section of the book (Chapters 9-12) introduces readers to Technologies in Design and Deployment of 6G Mobile Core Networks

In Chapter 9, Prof. Sunil Prabhatbhai, Lavadiya and Prof. Vishal Sorathiya introduce the reader to machine learning in 6G mobile core networks. The most machine learning application, the 6G vehicular network, is intended to generate a rapidly evolving and intelligent system that allows networks to adapt to various application requirements and service types, such as massive machine-type communications (mMTC), ultrareliable and low-latency communications (uRLLCs), and enhanced mobile broadband (eMBB). Conversely, increased network performance may see a greater role for ML algorithms in a variety of functions and service needs. 6G will offer numerous advantages to our lives, with ML being the most crucial. And although these conveniences rely on large heterogeneous networks and heavy data exchange, they also come with their own unique risks. Scholars are afraid of this problem due to privacy concerns. The overall book chapter includes the basic and advanced levels of machine learning. This includes unsupervised, supervised, and reinforced learning and the challenges of ML for the 6G.

In Chapter 10, Dr. Reshma V.K. and Mr. DaisonStallon S provide readers with an overview of Artificial Intelligence in 6G mobile core networks. Artificial intelligence (AI) has subsequently been used as a paradigm shift to optimize high-intelligence 6G technology. To realize information exploration, intelligent resource planning, automatic network adaptation, and astute service configuration management, the authors proposed an AI-enabled smart architectural design for 6th generation systems; here, it is categorized into 4 tiers: data mining, intelligent sensing layer, smart application layer, and intelligent control layer. The author also discussed modern technology in the mobile generation, its uses, security, opportunities, and challenges.

In Chapter 11, Ms. Senbagavalli G and Dr. Kavitha T introduce the reader to Terahertz communication with 6G mobile core networks. The terahertz band (0.3 THz to 10 THz) is the next frontier in wireless communications due to its ability to unlock significantly wider segments of unused bandwidth. The THz spectrum offers enhanced transmission bandwidth when compared to the mm wave band in 5G networks. Future 6th generation (6G) wireless networks will consist of a multitude of small radio cells

with shorter communication distances. Base stations of radio cells in the 6G network need to be connected with high-speed wireless, enhanced data rate, minimum energy consumption, and low electromagnetic emission links. These broad band links can be implemented by terahertz waves in 6G networks, which is a replacement for optics, copper, and mm waves. Terahertz bands are inevitably going to be the next in line. THz communication will contribute to enabling interesting and needed applications such as immersive virtual reality, ultrabroadband connectivity for rural areas, or even a Terabit backhaul in the sky, close-in communications, also known as whisper radio applications, position localization studies, and gigabyte Wi-Fi support of internet of things (IoT) applications. By leveraging the very small size of THz transceivers and antennas, THz communication opens the door to transformative applications that include new nano-bio-sensing wearable and implantable devices that interact with our bodies at the actual biological scale, and others that we just do not know about yet. This chapter is devoted to investigating THz communication, which is one of the key 6G enabling technologies.

In Chapter 12, Dr. Murugan K and Mr. Somasundaram R introduce the reader to the Blockchain Internet of Medical Things (B-IoMT) in 6G mobile core networks. The widespread adoption of decentralised blockchain technology in the IoT has significantly reduced the danger of sensitive healthcare data being exposed. They combine blockchain technology with IoMT (B-IoMT) in this chapter to enable secure data transfer over a 6G network connection. The blockchain's security characteristics aid in achieving tamper-proof data transfer in IoMT. Blockchain, on the other hand, may be used to address IoT issues due to its decentralized nature.

Section 4: Applications of 6G Mobile Core Networks in Smart Healthcare

The fourth section of the book (Chapters 13–16) introduces readers to applications of 6G Mobile Core Networks in Smart Healthcare.

In Chapter 13, Dr. K. Kousalya and Dr. R.S. Mohana introduce the reader to an Overall Perspective of 6G With Smart Healthcare and Haptic Communication. They introduce 6G, which will be proven to be a game-changing technology in the healthcare industry. As a consequence, in light of the future of 6G communication technologies, envisioning a healthcare system is proposed. To enhance our lifestyle, new techniques such as Quality of Life (QoL), Intelligent Wearable Devices (IWD), Intelligent Internet of Medical Things (IIoMT), Hospital-to-Home (H2H) services, and new business models must be developed, which is discussed in this viewpoint.

In Chapter 14, Dr. A.R. Kavitha and Ms. Adlene Ebenezer P give the reader an overview of the smart health care system in 6G mobile core networks. The emergence of smart healthcare systems is widespread these days, and wireless communication is the foundation of such systems. The current trend in the smart healthcare system has obstacles like risk of failure, security, and privacy. Healthcare will be absolutely AI-driven and reliant on 6G connectivity technologies, transforming our lifestyle perceptions. Under the human-centric vision of 6G wireless technology, healthcare communication issues and realistic solutions for early apprehension and swift response in catastrophe circumstances will be addressed. Pandemics leave cities desolate due to a lack of human resources as a result of death, disease, and a refusal to work due to health hazards. In order to have access, creative solutions must be introduced to improve our way of life, which is addressed in this context, including Intelligent Wearable Devices (IWD), Hospital-to-Home (H2H) services, the Intelligent Internet of Medical Things (IIoMT), Quality of Life (QoL), and new business strategy. The proposed intelligent health care system is classified into three major modules: hospital atmosphere, remote medical care, and disaster retaliation.

In Chapter 15, Mr. Arunkumar S and Mrs. Sivakami K introduce the reader to 6G, a powerful and promising communication system that is expected to overtake the whole health sector by 2030. This would control not just the healthcare industry, but also a variety of other industries. Many industries, notably healthcare, are likely to be transformed by 6G. Healthcare and hospitals will be entirely AI-driven and reliant on 6G connectivity technologies, altering our perspective on life. Nowadays, time and area seem to be the most crucial hurdles to the medical system, which 6G would be capable of overcoming. Furthermore, 6G would be demonstrated as a game-changing breakthrough in the medical industry. From the human-centric perspective of 6th-generation wireless technology, this chapter examines healthcare communication and networking issues and potential strategies for early warning and quick action in crisis scenarios. This chapter also discusses the problems encountered during the deployment of 6G, as well as applicability and future research direction suggestions.

In Chapter 16, Mrs. Priya A K and Mr. Saravanakumar R provide readers with an overview of Smart Healthcare Technology, its challenges, and future perspective. The next generation telecommunication trend setter would be the 6G network system, wherein academia and business are currently focusing on it. The vision towards future sustainability in health care has become an alarming factor owing to the imperfect system in place based on growth and aging. Wireless health monitoring must be achieved through a frugally viable method in order to follow and control every citizen in the health process of their lives. The aim of next gen is not just to make wireless healthcare a true technology, but to also enable Bio-Nano-Internet, things that allow human health care to form a controlled network. In this chapter, they present a vision for a complete model that should meet the expanding healthcare hassles and a conceptual model that can solve these growing expectations in full. In conclusion, the latest developments in the health care domain are discussed and suggest upcoming avenues in this domain on par with technological growth.

Section 5: Performance and Challenges in 6G Mobile Core Networks

The fifth section of the book (Chapters 17-20) introduces readers about Performance and Challenges in 6G Mobile Core Networks.

In Chapter 17, Dr. Deva Priya M. and Dr. Christy Jeba Malar A introduce the reader to artificial intelligence and 6G mobile core networks. This integration of AI and 6G resembles a double-edged sword, since the application of AI may positively influence the privacy or security of 6G on one hand, and negatively introduce the possibility of security infringement into 6G on the other hand. In particular, the self-sustaining networks in 6G are achieved by the guaranteed application of intelligent security attack mitigation schemes and proactive threat discovery approaches that facilitate end-to-end future network automation. A comprehensive review of AI and ML-based security enforcement techniques has contributed to improving reliability during robust data dissemination in 6G communications in this chapter. This chapter presents the consolidated and solidified role of AI and ML towards the enforcement of security in 6G networks. In addition, it also demonstrates the challenges and solutions that are handled by the inclusion of AI and ML-based attack mitigation approaches with respect to energy and security-based ultra-massive access.

In Chapter 18, Dr. Vanitha G and Dr. Beulah David provide readers with an overview of 6G mobile core networks with WSN (wireless sensor networks). They also used artificial intelligence techniques to address the problems of WSN and 6G mobile core networks. Various attention in WSN evaluates first generation (1G) networks to 6G networks. For 6G networks, AI-based networks are used. techniques

Preface

were applied to achieve network intelligence, closed-loop optimization, and intelligent wireless communication. By learning the environmental dynamics, DRL was adopted to preserve reliable wireless connectivity for UAV-enabled networks. Hence, it is promising to adopt AI in 6G networks to optimize the network architecture and improve network performance.

In Chapter 19, Dr. R. Velumani and Dr. S. Hariharasitaraman introduce the reader to the Federated Learning Based Light-Weight Privacy Preserving Framework for Smart Healthcare Systems in 6G mobile core networks. This chapter proposes a light-weight federated learning framework based on multi-key for deploying predictive models trained on patient data distributed across multiple healthcare institutions without exchanging them. Two predictive models based on the proposed framework are deployed for in-house mortality prediction from patient data and COVID-19 detection from chest X-ray images. Performance evaluation of these models with standard datasets with objective metrics such as accuracy, specificity, sensitivity, precision, Fi-score, operating characteristics, etc., and comparative analyses show that the proposed models are superior to state-of-the-art approaches. The proposed framework and the models are potential solutions to improve the quality of healthcare across multiple healthcare institutions while protecting sensitive patient data and ensuring personalization of healthcare.

In Chapter 20, Dr. U. Surendar and Dr. S. Senthilkumar provide readers with an overview of the Planar Meteor material-inspired Circular Ring Antenna with Neutralization Lines for Dual-band Application. This chapter presents a simple, metamaterial-loaded planar ring radiator for WLAN-WiMAX applications. The proposed radiator is equipped with two neutralization lines to improve performance in the desired operating bands. The use of neutralization lines as a conducting strip allows the antenna to function at the upper resonance of 3.5GHz, and the incorporation of a complementary split ring resonator (CSRR) at the rear of the substrate benefits the antenna's compact size.

All these parts will lead to the emergence of what 6G will bring to us as the basis for a virtual society, a society in which everybody and everything will be virtually connected and linked to 6G mobile core networks. Moreover, almost everyone and everything will be accessible from everywhere via the Internet, using all sorts of devices.

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Section 1

Future Networks 2030: Architecture and Requirements

Chapter 1

Evaluation of Sixth Generation 6G Wireless Networks: The Vision of Future Wireless Communication

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ABSTRACT

Fifth-generation communications standardization has concluded, and global deployment has commenced. To maintain wireless networks' significant competitive advantage, industrial and academic collaboration has started to design the next generation of wireless communications networks called sixth generation (6G) to establish the foundation for the segmentation of communication demands in the 2030s. This study highlights the most encouraging fields of inquiry from the recent literature in familiar angles for the 6G project to support this vision. Its major contribution is to investigate the crucial difficulties and significant prospective features of 6G communications, such as (1) vision and key features, (2) research activities, (3) architecture of 6G, and (4) challenges and potential solutions. These critical research topics were thoroughly studied in terms of the motivation with their many sub-domains in order to get a precise, specific, and brief conclusion. As a result, this study will greatly contribute to the opening of new boundaries for future research initiatives.

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INTRODUCTION

Remote correspondence networks are the Eureka analogues of our day, regardless incredible mechanical advancements throughout the most recent couple of many years and balanced innovations for the Internet of Things. There are five (5) generations of portable remote cell correspondences frameworks in activity today, with 5G remote correspondence having all the earmarks of being the latest. Since 1980, another remote cell correspondence age has arisen around like clockwork, with the original simple FM versatile organizations in 1981, the 2nd era in 1992, the 3rd era (3G) in 2001, and the 4th era (4G) (regularly alluded to as long-haul progressions [LTE]) in 2011 (Alsharif and Nordin, (2017), Albreem et al. (2020). Figure.1 portrays an undeniable level outline of quickly developing remote innovation. As a general rule, remote innovation has progressed fundamentally somewhat recently, bringing about a blast in information hungry advances like sight and sound, online computer games, and superior quality (HD) real time recordings. The versatile business is blasting. Broadband innovation would go about as an impetus for empowering and spreading various state of the art client characterized administrations, for example, web-based shopping and online instalments through cell phones, the production of brilliant homes and savvy urban areas, and portable gaming as reported by Alsharif and Nordin (2017), Mohammed et al. (2019).

5G broadcast communications has been normalized, and the innovation is as of now being used all throughout the planet. The world inclusion guide of 5G business organizations (5G field testing/5G preliminaries/5G examination) is portrayed in Figure 2. With 86,000 5G ground stations, South Korea has been the main country as far as enormous scope 5G rollout for about 85 urban areas since April 2019 (*MobileWorld Live*, n.d.). Besides, 85% of the 5G ground stations were presented in six areas, including Korea, Incheon, and Dongguan, using a 3.5 GHz (sub-6) territory in a scattered system with data rate speeds going from 194 to 440 Mbit/s. (*Samsung “5G Launches in Korea”*., n.d.). In excess of 65% of the total populace is anticipated to approach 5G ultrafast 5G Internet associations before the finish of 2025 (*Ericsson Report “This Is 5G”*., n.d.). 5G organizations will offer an assortment of administrations, including upgraded portable broadband (eMBB), super dependable and low-inertness correspondences (uRLLC), and monstrous machine-type interchanges (mMTC); see Albreem et al. (2019), Parikh and Basu (2020), Mallat et al. (2020) for additional subtleties on the vision, necessities, and center components of 5G remote cell versatile correspondence organizations.

Besides, in a given cubic meter, the volume of remote information traffic and the recurrence of connected things is relied upon to duplicate by a factor of 100. Information hungry applications like streaming holographic movies, then again, require a range data transfer capacity that is presently inaccessible in the mm-wave range. The present circumstance makes huge difficulties as far as provincial phantom proficiency and the recurrence range groups needed for network. Along these lines, a more critical radio repeat range information move limit, which should be found in the sub-terahertz (THz) and terahertz (THz) districts, is required. Besides, the current improvement of various compact applications, particularly those maintained by Artificial Intelligence (AI) development, has goaded warmed conversation concerning remote exchanges' future progression (Alsharif et al. (2020). These barricades have incited industry and the scholarly world to begin pondering the up and coming age of remote correspondence frameworks (6G), determined to fulfill future correspondence needs during the 2030s while additionally guaranteeing remote correspondence frameworks' drawn out reasonability and intensity as reported by

Evaluation of Sixth Generation 6G Wireless Networks

Letaief (2019). 6G correspondence frameworks are relied upon to give an enormous inclusion that permits supporters of speak with each other wherever at a high information rate speed because of the capricious innovations that will be embraced by 6G correspondence frameworks, for example, amazingly huge data transmission (THz waves) and high AI that incorporates the functional and natural perspectives just as the administrations. Figure 2 portrays the sequence for 6G correspondence.

Figure 1. Tremendous communication advancements for various generations (1G–6G).

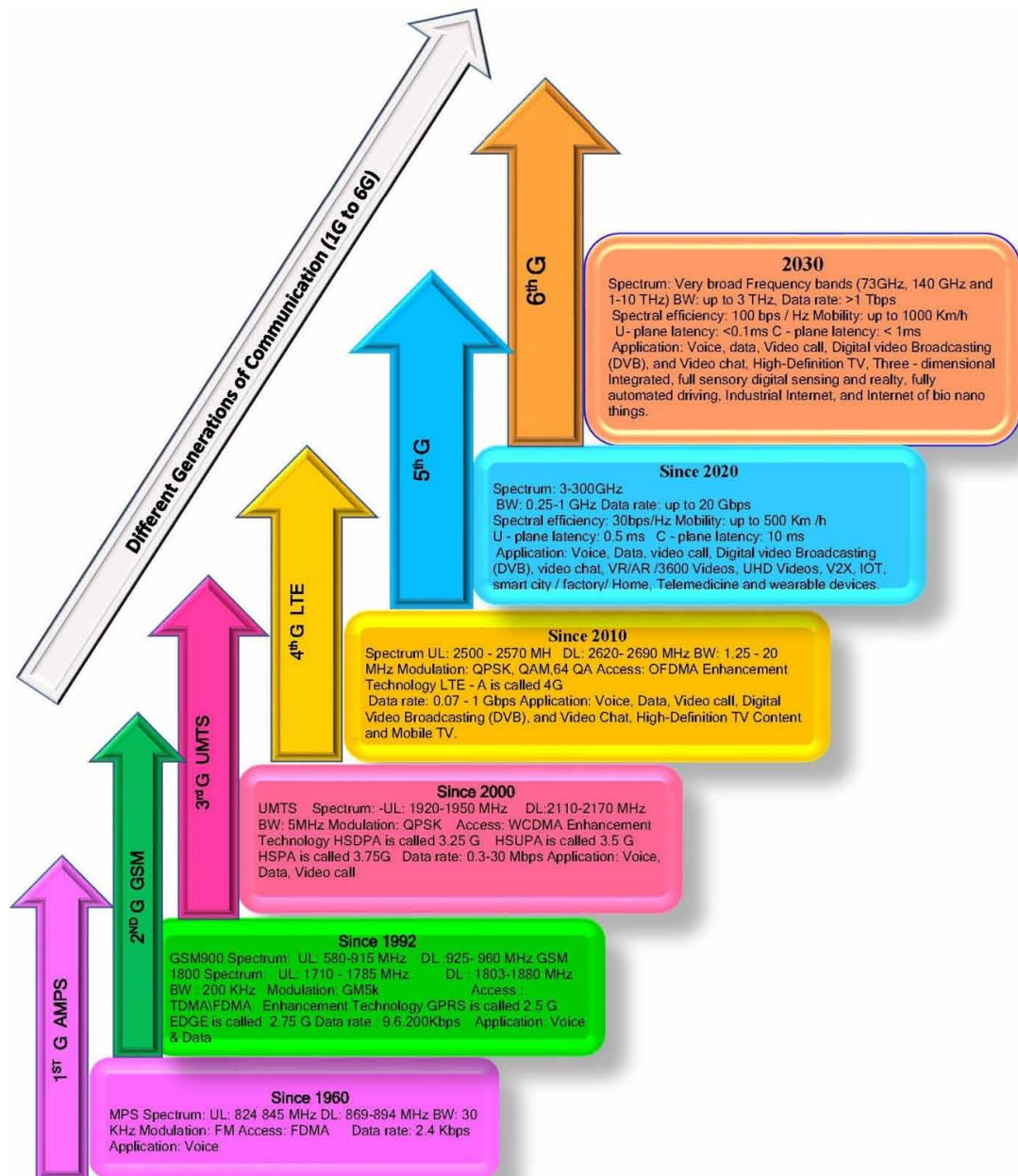
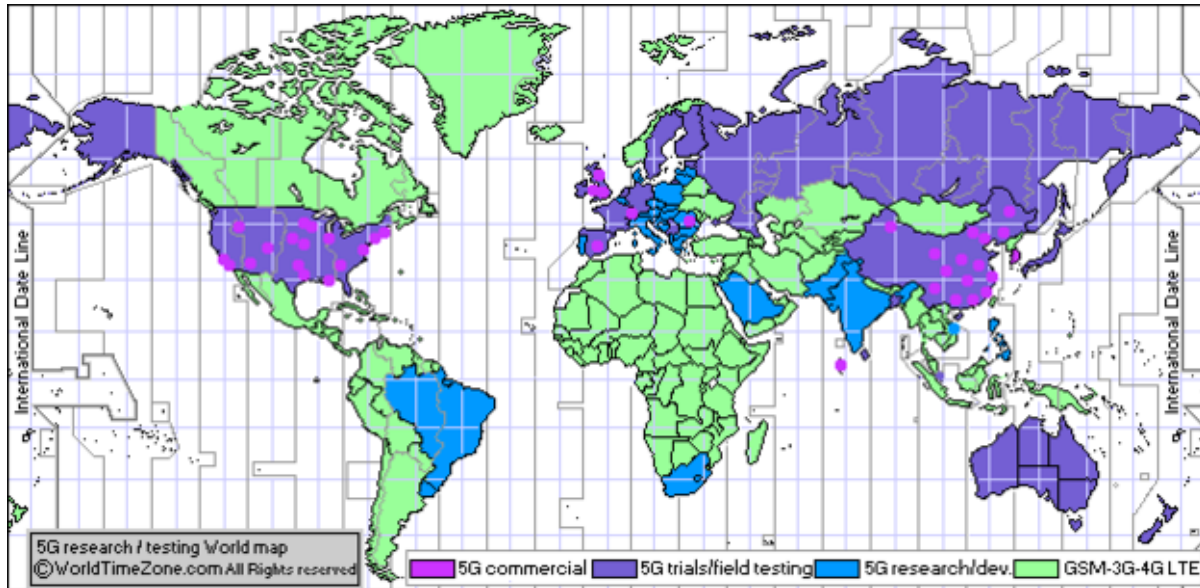


Figure 2. Map of commercial 5G network coverage around the world (December 2019) (World Time Zone., n.d.)



RESEARCH ACTIVITIES

This part gives an undeniable level outline of 6G examination. A few 6G ventures have been set up internationally by organizations and governments fully intent on creating and characterizing 6G innovation just as reshaping the remote framework's structure and plan of action. The US Federal Communications Commission (FCC) has intended allocating the 95 GHz to 3 THz range for 6G assessment, placing the US before the pack in the race. Different affiliations have started real assessment concerning 6G affiliations. The 6Genesis Flagship Program, driven by a Finnish consortium, and the Terabit Bidirectional Multi-Client Optical Wireless System (MU-OWS) for 6G LiFi, which began in mid-2019, are two striking names. In March 2019, the presentation 6G Wireless Conference was held in Levi, Finland (*1st 6G Wireless Summit.*, n.d.), which may be viewed as the beginning of the scholarly 6G appraisal race. Different small studios and meetings, for example, the Huawei 6GWorkshop, the Globecom 2018 Wi-UAV Workshop, and the Carleton 6GWorkshop, have been facilitated all throughout the planet to concentrate on the conceivable outcomes of 6G notwithstanding the previously mentioned exercises.

An investigation bunch working on the EU's Terranova project is by and by zeroing in on a reliable 6G association fit for sending 400 Gbit each second in the THz band (Chen *et al.* (2020). LG Electronics has revealed the opening shot of 6G assessment workplaces at Korea Advanced Institute of Science and Tech in Daejeon. Samsung announced the start of its 6G progression in June 2019. In 2019, SK Telecom molded a 6G investigation simultaneousness with Nokia and Ericsson. In late 2018, China's Ministry of Industry and Information Technology communicated that it means to lead the distant correspondence market during the 2030s by developing 6G investigation spending. Additionally, a Horizon 2020 ICT-09-2017 financed EU-Japan project called "Frameworks organization Research Beyond 5G" explored the shot at employing the THz range from 100 to 450 GHz. The intelligent arrangements with

Evaluation of Sixth Generation 6G Wireless Networks

6G exchanges are highlighted in Figure 3. Plus, IEEE revealed the IEEE Future Network in August 2018, with the saying “Enabling 5G and Beyond.”

Figure 3. Research initiatives into 6G communications.

Japan	• Japan readies US\$2 billion to support industry research on 6G technology. • NTT and Intel have decided to form a partnership to work on 6G mobile network technology.
Finland (2018)	• Finnish 6G research activity is coordinated by the University of Oulu, where a 6G initiative was launched.
EU (2019)	• A research group based on the EU's Terranova project is now working toward the reliable 6G connection with 400 Gbit per second transmission capability in the terahertz spectrum. • An EU–Japan project under Horizon 2020 ICT-09-2017 funding, called ‘Networking Research beyond 5G’, also investigates the possibility of using the terahertz spectrum from 100 GHz to 450 GHz.
United States (2019)	• The Federal Communications Commission opened the spectrum between 95 GHz and 3 THz to create a new category of experimental licenses. • IEEE launched IEEE Future Network with the tagline ‘Enabling 5G and beyond’. • ITU-T Study Group 13 also established the ITU-T Focus Group Technologies for Network 2030 intending to understand the service requirements for future networks round 2030.
China (2019)	• The Ministry of Science and Technology planned to set up two working groups to carry out the 6G research activities; the first is from government departments to promote 6G research and development, the second is made up of 37 universities, research institutes and companies, focusing on the technical side of 6G.

THE ARCHITECTURE OF 6G NETWORKS

Here, we propose a speculative 6G engineering (displayed in Figure 4) that incorporates network knowledge, subnetwork advancement, and insightful radio.

From Network Softwarization to Network Intelligentization

6G will, we accept, hoist network softwarization to another level, to be specific organization knowledge. The “non-radio” part of 5G is turning out to be progressively significant, and it has been a main impetus behind later “softwarization” endeavours. SDN and NFV are two significant 5G advances that have moved present day interchanges networks toward programming based virtual organizations. They additionally encouraging group of people cutting, a refined virtualization procedure that permits a few virtual organizations to be based on top of a solitary actual foundation. Softwarization will presently don’t do the trick for networks past 5G if networks become more convoluted and different. Organization elements should give a wide scope of abilities to serve AI-based applications, including interchanges, content reserving,

handling, and surprisingly remote force conveyance. 6G will likewise incorporate special radio access interfaces like THz correspondences and wise surfaces Letaief et al. (2019). It additionally needs to manage progressively complex Internet of Things (IoT) components like detecting, information assortment, examination, and capacity. All of the previously mentioned difficulties need a plan that is versatile, flexible, and, above all, wise. Existing innovations like SDN, NFV, and organization cutting should be worked on further to resolve these issues. By empowering quick learning and transformation, AI-based advances will make network cutting fundamentally more versatile in 6G organizations. The 6G design will be worked with a “Man-made intelligence local” approach, which will permit the organization to be keen, nimble, and ready to learn and adjust to changing organization elements through intelligentization. It will end up being a “organization of subnetworks,” taking into consideration more effective and adaptable redesigns, just as another system dependent on astute radio and calculation equipment division to deal with heterogeneous and upgradeable equipment capacities. Both of these parts will utilize AI methods, which will be talked about more meticulously in the subsections that follow.

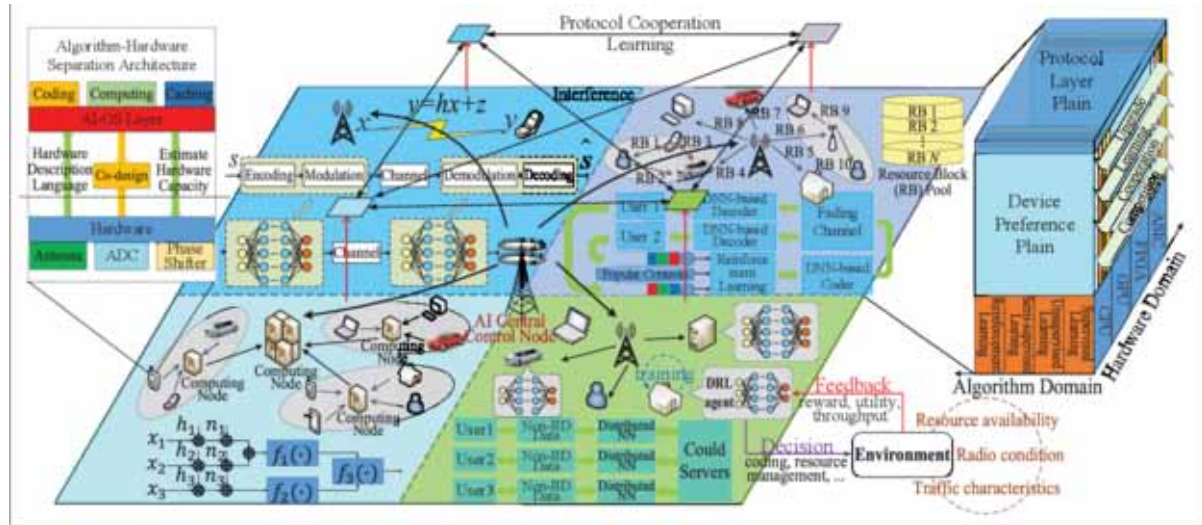
A Network of Subnetworks: Local vs. Global Evolution

Given its normal super high heterogeneity, 6G’s capacity to utilize adaptable subnetwork-wide advancement to effectively adjust to nearby conditions and client needs, coming about in a “organization of subnetworks,” will be a key element. Nearby subnetworks, specifically, in 6G, may develop independently to update. Nearby development can happen in a couple of adjoining cells or even a solitary cell, taking into consideration the adaptable execution of state of the art propels in inventive waveforms, coding, and multi-access conventions in subnetworks without the requirement for extensive examinations. The advancement cost can be significantly decreased in light of the fact that the whole framework shouldn’t be supplanted. To accomplish this objective, we should beat the accompanying three deterrents:

1. Each subnetwork will accumulate and investigate nearby information, like remote conditions, client demands, development designs, etc, prior to utilizing AI ways to deal with upgrade itself locally and powerfully.
2. It is accepted that when the nearby MAC or PHY conventions are updated, the between subnetwork communication will keep up with the new between subnetwork coordination. To guarantee subnetwork redesign combination, one proposed arrangement is to use gaming and learning approaches in 6G.
3. The nearby development of 6G requires a normally steady control plane to allow advancement at the “organization of subnetworks” level. Alpha Zero’s “gaining without any preparation” idea is one way that has been introduced. Each subnetwork update ought to be explored by the 6G control plane, and afterward an organization level learning interaction ought to be utilized to decide the best technique for each subnetwork, considering neighbourhood conditions and client conduct.

At long last, subnetwork progression at the nearby level velocities up the sending of new physical and MAC layer shows and obliges better reaction to geologically and momentarily unique radio conditions and client requests. With the subnetwork-wide levels of progress, we expect that a smooth change from 5G should 6G without a doubt.

Figure 4. The architecture of 6G (Letaief et al. (2019) 6G and beyond: the future of wireless communications systems.



Towards Intelligent Radio (IR)

Arising equipment upheavals, incorporating as those in RF and circuit frameworks, will constrain 6G to take action accordingly and completely deed the quick update of gadget and base-station-level equipment. A calculation equipment partition engineering, we feel, will be fundamental in 6G. A handset calculation, specifically, will be prepared to do freely assessing the abilities of the handset equipment over which the convention runs and afterward designing itself appropriately. Interestingly, somewhere in the range of 1G and 5G innovations, the equipment and handset calculations are grown together. The quantity of radio wires, RF chains, and stage shifters, just as the goal and test paces of ADCs, just as the handling limits of decoders, have customarily stayed semi static in past cell ages. In the interim, ongoing advances in cutting edge circuits and receiving wires are accelerating and extensively expanding equipment abilities, permitting the 6G BS and cell phone to be different and upgradeable inside 6G. All in all, the exemplary joint engineering won't be utilized in 6G, as it doesn't take into consideration lithe transformation to different and upgradeable innovation.

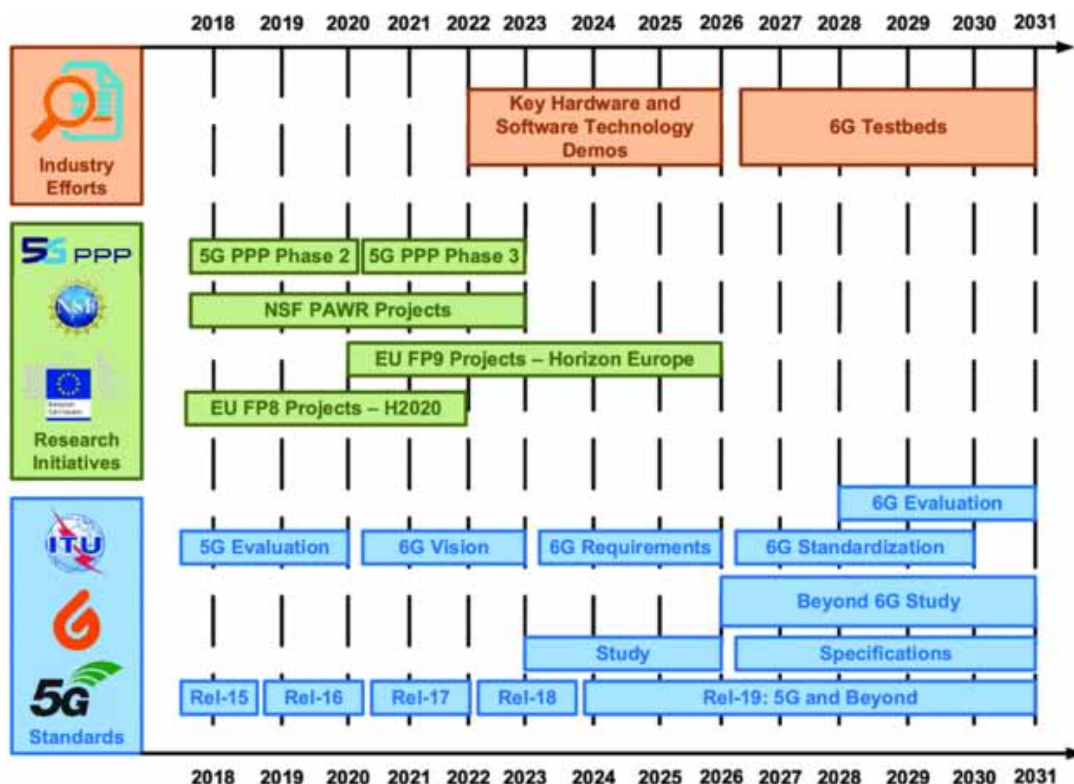
We present a working framework (OS) between the gadget equipment and the handset calculations, where a handset calculation can be seen as programming running on top of the OS, to address the inadequacies of joint equipment calculation plan and receive the rewards of the calculation equipment detachment engineering. Not exclusively can the OS inspect the capacities of neighbourhood RF chains, stage shifters, ADCs, and receiving wires, yet it can likewise quantify their simple characteristics naturally. From that point forward, the OS will actually want to arrange its handset calculations utilizing an interface language dependent on equipment information and AI techniques.

Tentative for 6G Timeline

Up until now, we've discussed what cultural necessities will mean for the progress from 5G to 6G, just as a plenty of new and future use cases that 6G will best serve. We likewise went through a portion of the primer 6G KPIs, just as the key empowering advances that will be important to accomplish these cutting edge KPIs. The expanding innovative preparation and worldwide organizations of 5G frameworks have made ready for an intensive assessment of things to come of remote interchanges. Albeit the focal point of 3GPP guidelines for the following not many years, up to and incorporating Release 18 of every 2024, is relied upon to be centered around 5G, the ITU has now dispatched the Focus Group on Technologies for Network 2030 (FG NET-2030), which will take a gander at network capacities in 2030 and then some. As we've seen in past segments, each of the previously mentioned significant advances has acquired generous foothold as far as innovative work, laying the basis for the group of people yet to come of remote interchanges. Both the National Science Foundation (NSF) and the European Commission's Platforms for Advanced Wireless Research (PAWR) programs are relied upon to assume a vital part in the improvement of 6G.

Additionally, we anticipate a critical ascent in industry interest in the improvement of these advances before long, finishing in huge equipment and programming innovation demos by 2025, trailed by full-scale 6G testbeds in 2026 and then some. These testbeds, we accept, will be great for exhibiting 6G's guarantee and helpfulness being used cases like multi-tactile holographic teleportation, continuous far off medical care, mechanical computerization, and shrewd foundation and conditions, to give some examples.

Figure 5. Timeline projections for 6G and beyond technologies



6G will go past portable Internet and will be needed to give pervasive AI administrations from the organization's center to its end gadgets. Basically, AI will drive the turn of events and improvement of 6G structures, interfaces, and tasks Dang *et al.* (2020). The objective of this examination is to grandstand the latest best in class accomplishments as far as vision, difficulties, and potential arrangements, just as 6G correspondences research exercises. It endeavors to incorporate a wide scope of suitable thoughts as a response. To make exact, concrete, and on-the-spot results, this concentrate completely analyzed intriguing exploration fields by digging into their specific sub-areas.

KEY FEATURES AND VISION FOR FUTURE 6G NETWORKS

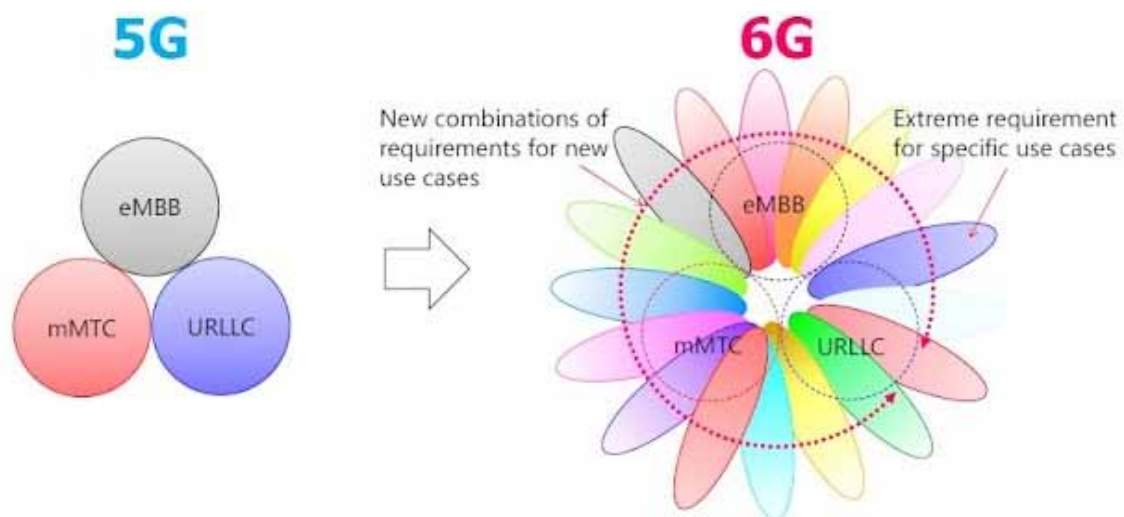
From the tremendous capacities of 5G cell compact remote trades associations and their likely progression, is there any persuading protection for 6G associations? In the event that that is the circumstance, what are the missing 5G and LTE units that 6G necessities to fuse? Scholastics, industry, and assessment bundles have made investigation procedures for itemizing, portraying, arranging, and recognizing critical focus enabling advances that will drive the dispatch of a “past 5G” or 6G system (Chen *et al.* (2020), Albreem *et al.* (2020). This part covers a wide scope of subjects from ongoing distributions on the vision and key qualities of 6G correspondences. To start, this part gives a speedy outline of the projected applications that 6G interchanges would empower, which will prompt the distinguishing proof of the key components needed for such correspondences.

The following are five application scenarios that 6G communications is expected to support:

eMBB-Plus

In 6G, eMBB-Plus (Strinati *et al.* (2019), Gui *et al.* (2020) will supplant eMBB and give a great encounter (QoE) in information utilization and principles, supplanting eMBB in 5G. Other basic parts of remote correspondence, for example, network enhancement, handover, and obstruction, should have the option to profit from large information ideas to make these activities simpler.

Figure 6. Technological development towards 6G



Other additional items, like exact inside route and an all around the world adequate association across numerous portable working organizations, are relied upon to be given to arrange clients at a modest expense. It is necessary to establish a plan for eMBB-Plus communication services that does not jeopardise network subscribers' security, secrecy, or privacy;

Over a ten-year period, telecommunication systems typically evolve to the next generation; communication service providers began exploring the commercial launch of 5G in 2010. In 2018, the company completed successful radio wave propagation trials at frequencies of around 150 GHz, which are expected to enable the substantially faster and higher-capacity communications that 6G requires. 5G technology's ultra-high-speed, massive, ultra-reliable, low-latency, and vast device connectivity capabilities will continue to be improved by providers. This will extend its scientific research of 5G advancement and 6G technology, with the goal of realising technological improvements such as:

- Achieving a combination of connection breakthroughs such as ultra-high speed, big capacity, and low latency
- The invention of new frequency bands, such as thz frequencies
- Growth of communication coverage with in air, sea, and space
- Communication with ultra-low energy and ultra-low cost
- Ensuring extremely reliable communications
- The ability to connect and sense a large number of devices

Big Communications (BigCom)

Because of the flighty innovations utilized by 6G correspondence frameworks, like totally gigantic transmission capacity (THz waves) and a high AI that will incorporate functional and natural viewpoints, BigCom (Chen *et al.* (2020) in 6G expects to give an enormous inclusion of metropolitan and far off regions while keeping up with asset balance, permitting endorsers of speak with each other wherever at a high information rate speed.

Secure Ultra-Reliable Low-Latency Communications

SURLLC might actually extraordinarily help vehicular correspondences on 6G (Liang *et al.* (2020). SURLLC in 6G is an update of URLLC and mMTC in 5G, joining more severe guidelines for trustworthiness (more noteworthy than 99.9999999 percent) and latencies (under 0.1 ms) in a security structure.

3D- Integrated Communications

As recognized engendering models showed, gadget correspondence elevations were minor preceding the advancement of 6G organizations. The 6G 3D-InteCom model proposed by Yuan et al (2019) and Chowdhury et al.(2019) might be moving because of the present situation. This accentuates the requirement for a significant change from a few measurements, where the degrees of correspondence hubs should be considered. Satellites, automated airborne vehicles (UAVs), and submerged interchanges are only a couple of instances of significant innovations that have effectively incorporated this measurement. Subsequently, the insightful system dependent on stochastic math and diagram hypothesis that was set up for 2D remote interchanges should be re-changed in the 6G climate. Since gadget tallness is

considered, full-dimensional MIMO plans can be utilized to give stature beamforming, forestalling the requirement for a different organization enhancement methodology;

Unconventional Data Communications (UCDC)

UCDC's true meaning and composition are currently unknown. The following points, however, must be addressed: communications that are holographic, haptic, and human-to-human.

Holographic Communications

Holographic interchanges are one part that will add shimmer to the 6G future. A visualization is a three-dimensional picture made by controlling light pillars focused on an item and catching the subsequent impedance design with a recording gadget. Without even a sound system voice, communicating 3D pictures is inadequate to pass on the qualities of in-person presence. In the 6G future, reassembly sound system sound will drive the improvement of a stage for catching various actual appearances in each setup. As such, substances have a ton of slack with regards to speaking with others and controlling holographic information and video that they get. Holographic information is relied upon to burn-through a great deal of data transfer capacity and should be conveyed through dependable organization lines Wakunami *et al.* (2016).

Tactile Communications

Holographic correspondence empowers for the transmission of a close ongoing virtual perspective on individuals, occasions, and areas. Without the presentation of a material Internet that empowers for ongoing picture transmission, the film experience will be deficient Aggarwal and Kumar, (2019). This innovation is relied upon to help teleoperation, agreeable independent driving, and relational connections. Utilizing correspondence organizations, a haptic touch might be essentially delivered for these advancements. The execution of this innovation could spell the finish of the open frameworks link network worldview and the presentation of a cross-layer correspondence framework plan. The cross-layer configuration ought to have the option to meet these advances' severe standards. The formation of novel actual layer (PHY) advancements to work on the execution of sign frameworks, including waveform multiplexing, might be incited by a particular circumstance. Something else to contemplate is the means by which to plan exercises like buffering, queueing, booking, handover, and interfaces to address the issues of 6G organizations. Over-the-air fiber correspondence alternatives should be examined in light of the fact that current remote specialized strategies are unequipped for accomplishing these necessities Holland *et al.* (2019).

Human-Bond Communications

Human-driven correspondence is projected to be one of the essential drivers of 6G correspondence. People ought to have the option to get to and additionally exchange actual components, just as express actual occasions in their regular condition, utilizing this innovation. The five human detects will unavoidably be joined into this undertaking. This procedure is exhibited by the "correspondence by breath" project, which permits specialists to investigate a person's profile utilizing breathed out breath and even interface

with the human body by breathing in unpredictable natural synthetic compounds Khalid *et al.* (2019). Comparable advances empower infection conclusion, feeling acknowledgment, organic trademark assortment, and distant commitment with the human body as a characteristic outcome. To construct a correspondence framework that can mimic the five human detects, interdisciplinary examination joint efforts are required. The prior examination would definitely bring about half breed correspondence frameworks equipped for separating an assortment of actual amounts and circulating them to a picked collector across secure channels.

Therefore, 6G interchanges are relied upon to outperform 5G correspondences as far as organization information accessibility, portable information throughput, and consistent omnipresent network. Also, 6G interchanges will utilize a surprising correspondence method to get worthiness for an assortment of portable information classes and give them by means of customary upgraded radio-recurrence organizations. This kind of gadget would consider the novel remote transmission of sentiments, just as virtual presence and communication. Yastrebova *et al.* (2018) imagines an assortment of future remote systems administration situations for the 2030s, including holographic conversations and a material Internet.

Given the sorts of utilizations that will be upheld, 6G will convey a similar degree of unwavering quality and low piece mistake rate as link broadband. Figure.7 portrays the critical components of conceivable 6G organizations. The THz remote correspondences organization, Artificial Intelligence, and programmable canny interfaces stand apart among the squares showed in Figure. 7 (Rappaport *et al.* 92019). These headways address a significant take-off from past plan standards and execution principles in the versatile remote media communications businesses.

Extremely Large Bandwidth (THz Waves)

In 6G, remote broadband throughput and the quantity of associated gadgets are relied upon to increment by a few folds, most eminently in the scope of many gadgets per cubic meter. Likewise, information concentrated applications like communicating holographic movies require range transmission capacity that is quickly inaccessible in the millimeter-wave range. The present circumstance presents critical difficulties as far as region and spatial-unearthly proficiency, just as the recurrence range groups important for availability. Subsequently, a more noteworthy radio recurrent reach transmission capacity is required, which is just open in the sub-THz and THz districts, regardless called the initial band between the microwave and optical spectra Elayan *et al.* (2019). Figure 8 shows the electromagnetic reach and frequencies of terahertz and millimeter waves.

Utilizing essential wave conditions, THz waves are described as having little frequencies and radio frequencies bigger than millimeter waves. Therefore, THz waves transport more information quicker, however they likewise require an answer for beat their intrinsic short engendering qualities. To sum up, joining THz waves into a telephone network territory might give replies to cases in which 5G innovation neglects to meet high information throughput or super solid low inertness prerequisites Elmeadawy and Shubair (2020). Subsequently, THz wave specialist co-ops were projected to be utilized for correspondences in regions with a high thickness of gadgets or a lot of information. With the rising reception of savvy homes, designs, towns, and networks, 6G might have the option to deal with the developing interest for human-to-machine and machine-to-machine (M2M) correspondences, particularly as robots and self-coordinated automated ethereal vehicle frameworks become more normal. The Internet of Everything idea joins this innovation (IoE). One may expect that 6G will convey super thick association, considering uncommon organization adaptability and the capacity to wisely retain various methodolo-

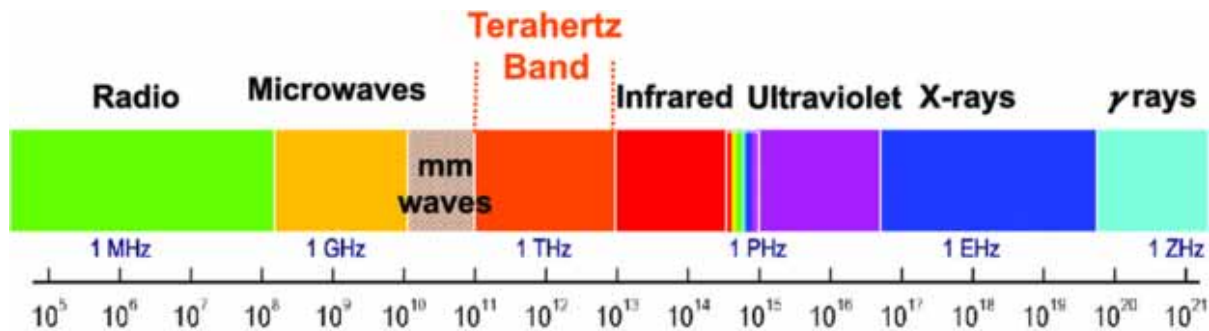
Evaluation of Sixth Generation 6G Wireless Networks

gies continuously to address the issues of changed application situations. Then again, expanded THz range correspondence innovation can assist with both large scale and small size activities, for example, terabit WLAN and Nano-sensor arranging (Akyildiz *et al.* (2018), Rappaport *et al.* (2019), Akyildiz *et al.* 2018)) give a thorough assessment of the THz band in the 0.1–10 THz range for supporting Tbps high speed trades.

Figure 7. Key attributes of 4G, 5G, and future 6G

		4G	5G	6G
Usage Scenarios		• MBB	• eMBB • URLLC • mMTC	• FeMBB • ERLLC • UmMTC • LDHMC • ELPC
Applications		• High-Definition Videos • Voice • Mobile Tv • Mobile Internet • Mobile Pay	• VR/AR/360° Videos • UHD Videos • V2X • IoT • Smart City/Factory/Home • Telemedicine • Wearable Devices	• Holographic Verticals and Society • Tactile/Haptic Internet • Full-Sensory Digital Sensing and Reality • Industrial Internet • Space Travel • Deep-Sea Sightseeing • Internet of Bio-Nano-Things
Network characteristics		Flat and All-IP	• Cloudization • Softwarization • Virtualization • Slicing	• Intelligentization • Cloudization • Softwarization • Virtualization • Slicing
Service Objects		people	Connection (People and Things)	Interaction (People and World)
KPI	Peak Data Rate	100 Mb/s	20 Gb/s	≥1 Tb/s
	Experienced Data Rate	10 Mb/s	0.1 Gb/s	1 Gb/s
	Spectrum Efficiency	1x	3x that of 4G	5-10x that of 5G
	Network Energy Efficiency	1x	10-100X that of 4G	10-100X that of 5G
	Area Traffic Capacity	0.1 Mb/s/m ²	10 Mb/s/m ²	1 Gb/s/m ²
	Connectivity Density	10 ⁵ Devices/km ²	10 ⁶ Devices/km ²	10 ⁷ Devices/km ²
	Latency	10 ms	1 ms	10-100 μs
	Mobility	350 km/h	500 km/h	≥1,000 km/h
Technologies		• OFDM • MIMO • Turbo Code • Carrier Aggregation • Hetnet • ICIC • D2D Communications • Unlicensed Spectrum	• Mm-wave Communications • Massive MIMO • LDPC and Polar Codes • Flexible Frame Structure • Ultradense Networks • NOMA • Cloud/Fog/Edge Computing • SDN/NFV/Network Slicing	• THz Communications • SM-MIMO • LIS and HBF • OAM Multiplexing • Laser and VLC • Blockchain-Based Spectrum Sharing • Quantum Communications and Computing • AI/Machine Learning

Figure 8. “Electromagnetic range and frequency of terahertz and millimeter waves (Elayan et al. 2019)”.



In any case, there are various difficulties that should be tended to while using that range. One such method is to organize the THz range transfer speed dependent on the ingestion and reflecting qualities of its sub-groups to make it more productive and reusable for interchanges and different applications. Broadening consonant qualities, for instance, ought to be allowed in circumstances when numerous different applications are being served, and this condition can be met through cautious recurrence arranging. Recognizing weak signs when affectability lessens in the THz frequencies is extremely challenging. Therefore, ecological assimilation maxima above and under 500 GHz may be forcefully separated into valuable range windows in the THz radio range Oyeleke et al. (2020). Figure 8 outlines that the increment in free space misfortunes while moving into the THz range from 30 GHz onwards is irrelevant. By utilizing a high addition radio wire and keeping the transmission and getting receiving wire regions consistent, the free space misfortune can be diminished. Beside free space misfortune, one more issue that should be tended to at higher frequencies is RF equipment intricacy and parallelism, just as decreased pillar width, which causes signal catch and bar observing worries in versatile applications as stated by Saxena *et al.* (2020). For effective remote frameworks, remote correspondence not set in stone that the high-recurrence range ought to be appropriately controlled using multi-cell geography (Latva-aho and Leppänen (2019)). The principle procedure is as per an overall example away from the cell RF band and toward the mm-wave, THz radio reach, and evident light reach. THz/free-space-optical half and parts will presumably end up being more typical in combination electronic–photonic handsets at 6G. This strategy is outlined below, the optical laser can either create a THz hail or send an optical sign (Sengupta *et al.* (2018). Signal transmission utilizing THz-wide data transfer capacity and invulnerability from troublesome climate conditions are two of the benefits of utilizing a cross breed association as proposed by Nagatsuma (2019).

Also, because a view affiliation isn't required, THz transmission accepts a huge part in the uplink. According to the perspective of the channel model, the current circumstance will move 6G advances into the Rayleigh channel model, basically reducing the requirement for the Rician channel model. Instead of the infrared strategy, which requires an after and arranging structure, the use of THz ensures a reliable uplink correspondence associate in observable light correspondence (VLC) associations. A mutt VLC/terahertz development presents a strong trades advancement that can bear including light, in the end inciting decline in the VLC system's sign-to-upheaval extent. Moreover, extraordinarily, short-range putting together advances will be the driving variable behind 6G, a region where higher-repeat gatherings

would expect to be a critical part later on. Sub-nuclear digestion appears to enormously influence way disaster, particularly over longer distances (1: 10 dB/km for repeat up to 400 GHz) (*Terranova Deliverable D3.2.*, n.d.). A photonic course of action is a functional decision for high data rates with unimportant inducing inadequacies, however the contraption size is two huge degrees greater than that required for the THz band application. Because of their extraordinarily little size and capacity to perform at very high data rates, plasmon-based THz interface parts, on the other hand, present a sensible alternative for THz correspondences. In addition, considering plasmonic waveguiding is genuinely lossy at commonly long partner lengths, they might be clearly joined with photonic advancement, very dielectric wave guiding. Lallas (2019) totally surveyed the current chief arrangements of plasmonic development and blend blends, emphasizing the future positions of plasmons in THz band far off correspondence and distant THz Nano-applications.

Communication with Energy and Efficient

6G will intend to outperform various objectives, similar to the plan of predominant, particularly to the extent unpreventable usage of the Internet-of-Things (IoTs) and an eco-course of action of different second sensors. Also, growing the limit furthest reaches of cells is basic, considering the way that their capacities and abilities to oversee complex media signal planning skip in quantum hop as their energy use increases as stated by Alsharif *et al.* (2017). In this manner, low energy use and expanded battery charge life length are two audit districts in 6G to handle the step by step re-empowering issues for most specific contraptions and further foster correspondence needs. Thus, 6G requires a total energy-proficient remote correspondence approach. An essential target of 6G correspondence is to execute sans battery interchanges at whatever point and at every possible opportunity, with a correspondence productivity of 1 pico-Joules per bit. 6G correspondence benefits from high-power THz-waves, just as engaged bar interchanges by means of MIMO radio wire clusters, permitting gadgets to convey power radiates a particular way. This methodology can give adequate energy to contraptions inside network inclusion. As per the 6G procedure and headings given in David and Berndt (2018), research exertion ought to be centered around battery life expectancy and administration classifications in 6G rather than information rate and idleness.

To decrease the force utilization, client hub registering capacities should be moved to savvy ground stations with a reliable force supply or worldwide brilliant radio space van Huynh *et al.* (2018). Agreeable transfer interchanges and organization densification may likewise be huge in lessening the sending force of organization hubs by diminishing the per-bounce signal proliferation hole Qi *et al.* (2016), Su *et al.* (2016). Accomplishing broadened battery length in 6G includes a blend of different energy-collecting advancements that take energy from surrounding RF flags as well as from miniature vibrations and daylight as proposed by Niyato *et al.* (2017), Ulukus *et al.* (2015). Significant distance remote energy charging is additionally a decent competitor for broadening battery life (Ulukus *et al.* (2015), Alsharif *et al.* (2019). Also, spread laser charging is apparently a method ready to do securely giving 2-W power and showing up at an extent of 10 m for cells. Table 1 summarizes the critical remote charging techniques (i.e., spread laser charging, alluring resonation coupling, inductive coupling, and microwave radiation).

Table 1. Different wireless charging techniques.

Technique	Advantage	Disadvantage	Effective Charging Distance	Applications
Magnetic inductive coupling	1. Its implemented simply. 2. It considers safe for human.	1. Its charging distance is very short. 2. Chargers and charging device need tight alignment. 3. Its effective in Heating.	It effective from a limited millimetres to a limited centimetres.	It used to develop Mobile electronics Such as smartphones and tablets and it develops RFID tags, contactless. Smartcards.
Magnetic resonance coupling	1. It is equipped as Loose arrangement. 2. It used for Nonline-sight charging 3. It used for charging numerous devices instantaneously on different power. 4. It provides High charging efficiency	1. Its charging distance is limited. 2. It's had complex implementation	It specialised for distance from a limited centimetres to a limited meters.	It used to develop Mobile electronics. Also used for developing Home appliances TV and desktop It can be used for developing Electric vehicle charging.
Microwave radiation (Non-directive RF radiation)	1. It used for Stretched effective charging distance. 2. It can be suitable usage for mobile applications.	1. It has Line of-sight charging. 2. Its capable of Low charging efficiency. 3. It's viewed as Not protected when the RF thickness contact is high.	It tends to be appropriate for Typically, inside various many meters, up to Various kilometers. What's more, its Suitable for Portable applications.	It utilized for creating RFID cards, Wireless sensors, embedded body gadgets and LEDs.
Distributed Laser charging	1. It specifies with High power, safety protocols. It contains Multiple-Rx charging. 2. It's very Compact in size. 3. Its free of EMI. 4. Its SWIPT-ready. 5. It can be suitable usage for mobile applications.	1. It required Line of-sight 2. It effective in low charging	It can accessible Up to 10 m.	This technology apt for developing Mobile devices such as mobile phone, laptop, tablet, wearable devices, drone etc.it apt for developing Consumer electronics such as projector, speaker). Also, it develops Wireless sensors and LEDs.

Artificial Intelligence

AI (ML), combined with AI and neural organization (DNNs), is reshaping innovation and giving new exploration regions in fields like 6G correspondences and IoTs. Simulated intelligence and ML are being utilized to foster connection and framework level answers for 6G availability. Man-made intelligence fueled 6G is projected to add new provisions like self-design, collection, astute arrangement, and setting mindfulness. With the utilization of ML calculations, the ability of radio motioning with maximal insight to keen radio sign can be totally acknowledged through AI-empowered 6G as reported by Nawaz *et al.* (2019). Besides, wise and adaptable materials are projected to be utilized to foster the equipment basics for remote advances reported by di Renzo *et al.* (2019). they are normal as MIMO 2.0 and completely researched. There are synopses of ML approaches for gadget to-gadget (D2D) interchanges, enormous MIMP enhancement, and heterogeneous organization plan. Besides, (Han *et al.* (2017) fostered a clever organization plan for specialized gadgets for breaking down huge information examination, and such

investigation can support actual layer enhancement. The creators of (Basar (2020)) proposed fusing list tweak as a method for further developing 6G organization effectiveness. The accompanying three characterizations feature the advantages of clever 6G abilities in remote and non-remote correspondence administrations:

Operational Intelligence (OI)

Rather than utilizing customary strategies, this innovation utilizes multi-target streamlining methods to proficiently dispense assets (groups and ability) to accomplish palatable organization activities, which can genuinely act in the intricate and dynamic nature of 6G because of its heterogeneity, thickness, and versatility. These multi-target execution prioritization upgrades are regularly NP-difficult issues that are hard to screen progressively (Shi *et al.*(2015). Today, progresses in AI advances and AI strategies, for example, profound support learning (DRL), can help leaders recursively refine and ultimately enhance their choices utilizing input produced by a circle established by DRL, which can be alluded to as AI's significant application in 6G. By supporting smoothing out, such learning estimations could be used for useful resource dispersion (Mao *et al.* (2018). Luong *et al.*(2019) has referenced an assortment of arising difficulties, including information dumping, storing, and versatile adjustment.

Environmental Intelligence (EI)

With advancements in keen radio spaces and materials, unavoidable and conveyed insight turns into a chance in all-encompassing innovation, fusing remote correspondence conditions. Insight based administrations could understand a wide scope of utilization situations, including server farms, IoT gadgets including such automated elevated and road vehicle types, and auto-robots with self-arranging and self-mending abilities, while additionally expanding the unwavering quality of D2D correspondence for a 6G organization utilizing keen systems. Probably the latest progressions detailed in (Basar *et al.* (2019) incorporate versatile techniques dependent on detecting for radio wave custom fitted changes utilizing reconfigurable shrewd surfaces. These progressions lay the preparation for particular stuff that can be utilized for EI. The removed starting qualities for DNNs are passed to edge or potentially cloud hardware; notwithstanding, handling these components is a troublesome endeavour because of the gadgets' processing and correspondence abilities, just as their heterogeneity.

Service Intelligence

The vital advantages of 6G knowledge establishments in a human-driven organization are correspondence administrations, for example, e-wellbeing, situating (inside and open air), multi-gadget the board, data chasing, and security. Administration insight can assist with the canny and customized expansion of all human-driven applications to support consumer loyalty, for example, profound learning calculations that can advance position precision, particularly in indoor conditions (Belmonte-Hernández *et al.* (2019)). Likewise, e-wellbeing personalisation can be helped by astute IoT and information assortment by means of a multi-model-based design. SI can be improved by exploiting the elite center organizations that support 6G as reported by Alzenad *et al.* (2018), Kishk *et al.*(2019).

High Security, Secrecy, and Privacy

Until far, research in 4G and 5G interchanges has generally focused on fundamental organization properties like throughput, reliability, dormancy, and the quantity of overhauled clients, with security, mystery, and protection concerns getting little consideration. The two best procedures for working on these boundaries, as recently referenced and perceived, are expanding network thickness and sending refreshed images at a higher recurrence. Standard encryption approaches subject to Rivest Shamir–Adleman (RSA) public-key cryptosystems are at this point used in 5G associations to give transmission security and protection. RSA cryptosystems have become unsure on account of the premium for Big Data and AI developments, but astute security protection procedures are as yet far from being totally advanced in the 5G time frame. Thus, these original advances are relied upon to increment 6G organization security, mystery, and secrecy. PHY security procedures and quantum key course through VLC ought to be utilized to defeat information security worries in 6G organizations. This component will, true to form, become a flimsy spot in human-driven 6G innovation, with possibly deadly results if reasonable shields are not given. To resolve this issue, blockchain innovation in 6G organizations is relied upon to give total namelessness, non-dissemination, and untraceability as stated by Henry *et al.* (2018).

Late exploration endeavors, then again, have focused on certifiable common-sense organizations like various access procedures, actual air interfaces, and 6G server farms. (Giordani *et al.* (2019) (Yaacoub and Alouini (2019) characterizes 6G organization plans, in which taking on cell-less geography, disseminated allotment, and 3D super-availability are essentially projected in 6G organizations. Mahmood et al (2019) examines machine-type correspondences (MTCs) and vertical-explicit remote organization discoveries for 6G; According to the discoveries, 6G may speed the foundation of the very first earth shattering standard prepared to do completely subbing existing modern unequivocal conventions and giving a coordinated arrangement that considers the consistent availability of all prerequisites in vertical enterprises.

CHALLENGES AND POTENTIAL SOLUTIONS

Organization security and information insurance authorization, accomplishing a savvy way to deal with quick access organization and advancement with an attention on remote yet additionally independent regions, bringing down the expense of versatile correspondences use, and ways to deal with expanding portable hardware battery limit life span are for the most part difficulties related with 6G interchanges. Clearly, it is difficult to meet all models; be that as it may, a framework should be worked to expertly adjust these viewpoints. This segment analyses a portion of the expected 6G correspondence challenges, just as likely arrangements.

High Intelligence vs. Privacy and Complexity

As humanoid affiliations, the changing among assurance and data will be fundamental in 6G affiliations. Oddly, AI calculations should chat with private data and refine them to manufacture network supportive-ness, change network figures, and arrangement more unmistakable kinds of help as reported by Alsharif et al (2020). Accordingly, protection would be forfeited for higher knowledge. A potential methodology is utilizing a delegate's mediator between end-client information and AI calculations. Such an arbitra-

tor should be an outsider, ideally free, and work in a dispersed way. A transitional arbitrator specialist will anonymize any close to home and delicate information. Likewise, the upgraded mind given by AI calculations and shrewd hubs decreases the opportunity accessible to people. Doubtlessly, the client's inclination would not be continually calibrated with the better option provided by AI calculations. At the point when a few clients are thought of, the clashing situation turns out to be more troublesome. In 6G correspondences, this issue may be displayed as tracking down the perfect balance among personalization and insight (Letaief et al (2019)). Customization is acquiring fame, and AI calculations and savvy hubs require insight versus costly methods and knowledge versus subroutines. Such schedules and sub-schedules should be referenced in the 6G organization's most fundamental techniques. Clever portfolios can promptly be given inside the admissible limit utilizing this methodology.

In addition to network complexity, high intelligence has a cost (Chowdhury *et al* .(2019)), which could translate to higher network operator and device vendor costs. Customers will face higher device costs as a result of such improvements, ultimately putting an end to the dream of providing low-cost electronics. Technical breakthroughs in intelligent structures are required to meet this issue. New business plans, moreover, are necessary. Clients will actually want to trade accessible anonymised information at a lower information cost after security, secrecy, and protection have been gotten.

Security vs. Spectral Efficiency

A couple of reach move speed preventive measures ought to be embraced to guarantee beginning to end, attack verification distant data correspondence, achieving a lessening in the available reach data for data transmission. Determination the right development to deal with the security and terrible execution hardships of far off correspondences will take a lot of work, yet there are three decisions. Most importantly, the encryption systems made by security experts are depended upon to be significantly successful. As the encryption calculation improves, executing such strategies might turn out to be somewhat more perplexing. Second, security experts should create a way for implementing spectral loss in PHY security solutions. Finally, AI algorithms are capable of expertly detecting network faults, which might be essential in establishing a security fortification plan for 6G networks.

Spectral Efficiency vs. Energy Efficiency

A few remote correspondence studies have all endeavored to track down an adequate harmony between range productivity and force effectiveness that isn't harming to one or the other perspective. This upgraded challenge has overwhelmed the first remote ages, as proven by the writing, and will keep on gathering huge review center in 6G interchanges Al-nahari et al (2019). In contrast to 1–5G interchanges, 6G correspondences can bring a game-evolving, energy-gathering answer for extensively dial down this exchange. Shopper hubs will actually want to catch radio, vibrational, and sun powered energy from the surrounding climate on account of energy collecting, tending to the intricacies of energy utilization. The ecological advantages acquired from omnipresent savvy surfaces may be basic in limiting the range energy compromise by acclimating to continually developing radio proliferation conditions.

Transceiver Design and THz Signal Generators

One of the serious issues in taking advantage of the THz band is the current handset structure. In different terms, the current handsets are as yet unfit to work at THz frequencies. To deal with the huge transmission misfortune at THz band frequencies, for instance, progressed signal preparing is required. Different attributes, like greatest voltage, high affectability, and commotion figure, should be thought of. Besides, transmission force and reach should be completely explored. Using silicon germanium-, gallium nitride-, gallium arsenide-, and indium phosphide-based types of progress in THz rehash bundles is exceptionally feasible, yet modelers should consider the restricted force gains in adaptable affiliations (Huq *et al.* (2019)). In such frameworks, transmission range is in like way bound. In this way, an astute handset plan that considers the nonlinear intensifier, stage disturbance, and change list is required. To sum up, current handset models are unsuitable for directing THz sources, and new developments are basic, especially for the medium-to-high THz get-togethers (> 300 GHz). Standard essential metal-oxide-semiconductor pushes, correspondingly as of late found nanomaterials like graphene, can be utilized to make uncommon handset topographies for THz-empowered gadgets Mumtaz *et al.* (2017).

Potential Health Issues

Quick correspondence organizations can exploit the gigantic information rate (terabits each second) and available data transfer capacity in the THz range. From the fact that specialists feel that 6G organizations and applications are as yet in their earliest stages, exceptionally high-recurrence range might help 6G. (100 GHz to 1 THz). Subsequently, it's basic to ponder human wellbeing, which could be hurt by THz wave proliferation. THz radiation is likewise nonionizing because of an absence of photon energy (0.1 to 12.4 meV). As such, the energy level of an ionizing photon is multiple times that of a nonionizing photon (Wu *et al.* (2015), Wu *et al.* (2015)). THz radiation's natural and compound consequences for the climate should likewise be painstakingly thought of. Electromotive power move (Chiaraviglio *et al.* (2018)) is one more clever procedure that will be executed in 6G to address wellbeing concerns.

3D Fundamentals of Networking Reliability-Latency

To help and convey 3G applications, you'll need 6G. For instance, 3D base stations will be on show. Directing examination on perception and information driven demonstrating of an engendering climate is pivotal. In conditions where 3D organizations contrast altogether from conventional 2D organizations because of new height measurements and levels of opportunity, network plan and 3D recurrence usage ought to be concocted. Moreover, the rate-unwavering quality inactivity compromises and SE, which are significant 3D exhibitions of 6G frameworks, should be tended to. To support the chose driving applications, this investigation should appraise the range, force, and correspondence necessities that 6G should meet. Ongoing exploration (Bennis *et al.* (2018), Kasgari and Saad (2019)) gives basic data around here.

The Poisson point measure (PPP) appears to enjoy a critical benefit in logical manageability and is used in demonstrating network rollout and inclusion likelihood. The numerical items, then again, are haphazardly dispersed in space. Multi-level heterogeneous applications show irregular dispersions in true applications. Collaborations among ground station areas could show as repugnance and fascination. At the large-scale cell level, repugnance is seen to address provincial and metropolitan organizations, yet fascination is seen in little cell organizations to portray client driven area of interest areas. In exception-

ally minuscule cell settings, this dissimilarity will be more articulated. The confided in PPP, then again, won't give a 6G systems administration climate since it is to a great extent restricted to the 2D plane. Arising execution circumstances will be executed in 3D later on. Notwithstanding, owing of the checks and very coordinated pillar designs at the THz recurrence range, such a situation is testing.

CONCLUSION

Mechanical and educational facilitated exertion has begun imagining the cutting-edge time of far off correspondence systems (6G) to beat the anticipated issues of huge extensions in distant data traffic during the overall sending of 5G associations. 6G development licenses bitrates of up to Tbps with a dormancy of under 1 ms, in any case a flood of new organizations. This investigation began by complementing a fantasy and key arrangements for future 6G in the space of understanding, spooky capability, security, secret, and assurance, sensibility, and customisation. Then, we discussed different likely hardships with 6G development, similarly true to form deals with any consequences regarding future 6G development. Finally, worldwide assessment projects focusing on portraying a fantasy for future 6G associations are examined.

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Chapter 2

Towards 6G: A New Paradigm in Blockchain– Based Wireless Communications

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ABSTRACT

Sixth generation (6G) wireless communications have commenced in research after the deployment of fifth generation (5G). It's anticipated that 6G networks can take abundant heterogeneous devices and infrastructures with greater efficiency and safety over various resources, storage, computing. Conversely, this objective is hindered by a number of trust-related issues that are frequently ignored in network plans. Blockchain is a distributed ledger technology that has arisen in the recent decade with fundamental traits (e.g., transparency, traceability, immutability, decentralization, anonymity). Blockchain can inaugurate cooperative trust among distinct network entities and simplify various intrinsic features like privacy protection, tracing, trusted data interaction, verified certification for trusted users, monitoring functionalities for wireless networks, thus awarding a new paradigm towards 6G. This chapter provides the role of blockchain in wireless communication technologies.

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INTRODUCTION

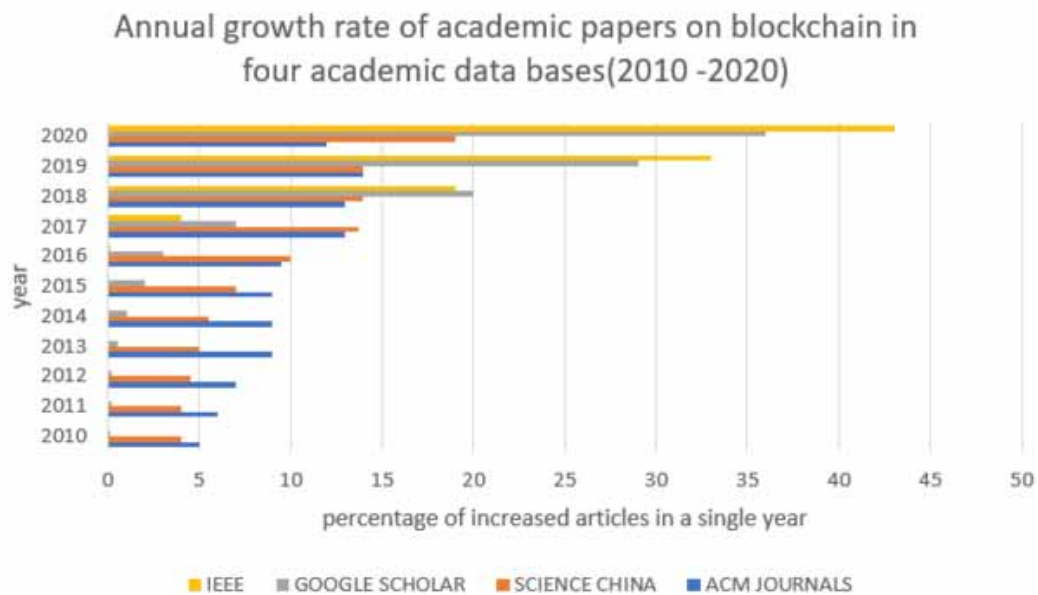
In the past decades there is an exponential growth of a variety of wireless traffic and also there is an upsurge of a wide range of wireless devices (Anderson, E. W., 1994) especially smart phones and this has saturated almost the capacity of long-term evolution. In other words, the 4th generation wireless network and an accelerated evolution of fifth generation mobile communication system. In order to achieve the enhanced targets the 5G communication system has undertaken a number of key technologies like MIMO, mm wave communication which has been fixed over the last periods. But since 2020, the 5th generation network technology has started to deploy commercially worldwide in order to give mMTC, uRLLC services (Wang C, Haider F and Gao X et al., 2014). At that instant, in order to meet up the necessities in 2030 and beyond, the 6G wireless communication research has begun formally. The basic studies on 6G technologies attained agreement that the key performance indicator like energy efficiency, connectivity etc., will be surely exceeded by 6G wireless communication and thus reached a milestone in comparison with the present 5G technology. 6G technology is expected to provide global coverage through terrestrial satellites.

Numerous heterogeneous devices as well as infrastructures are included in 6G networks to give indifferent wireless connections with extremely low latency, high-reliabilities., It also facilitates the future Internet Of Things (IOT) and combine internet with every possible device. Many significant challenges are being brought in the 6G networks due to the rise in scope, heterogeneity, toughness etc., one among those is technique to manage vast resources like energy, storage and promote sharing of resources in a vast manner. Even though there are many non-theoretical solutions for managing the resources, there is a big obstacle in practice for distinguishing the anchors of Mobile Network Operators (MNOs), Mobile Virtual Network Operators (MVNOs) (Marzetta TL., 2010) from the owners of these resources. Many security issues like accessing the control, privacy protection, exchanging the data etc., are also being faced by the 6G technology. These security issues exasperated the separation between networks, sub-networks and hosts and thus it makes the resource sharing harder. In history, many efforts are taken to study the highly efficient network resource sharing approaches but because of the challenge (He S, Wang J and Huang Y et al., 2017) in 6G technology only few of those approaches has come into practice, for example is Cognitive Radio. It allows the underutilized data of secondary networks to be shared by secondary networks. But there are some trust related issues among the network entities. Luckily, the current technology on block chain ensures an optimistic belief on present 5th and 6th generation technologies.

As a distributed ledger technology (DLT), block chain has been deeply recognized by the public as the basic promoter of crypto currencies. In the year 2008, Satoshi Nakamoto, proposed a combination of cryptographic elements. It is trusted to be a false name to produce the former successful WPS called bit coin. In the trivial decade the bit coin witnessed a success as the former non-theoretical crypto currency. Block chain was created like a developing catalogue containing files of data which are connected with the help of cryptographic mechanism and it hence it grew as a pillar of Bit coin. Block chain helps to secure, store and manipulate data in a wide way and it also helps to build a public and unhampered ledger. In recent years, many enhanced versions of block chain are being developed like Hyperledger and Ethereum with many functions.

Block chain with its essential attributes like ensuring tamper-free network, tracking the transactions, etc., builds trustable and safe domain. It also enables many innovative applications and services. Nowadays many areas like logistics, digital voting, tax regulation etc., are using Block chain (Azaria A, Ekblaw A and Vieira T et al., 2016).

Figure 1. Blockchain increased academic related papers

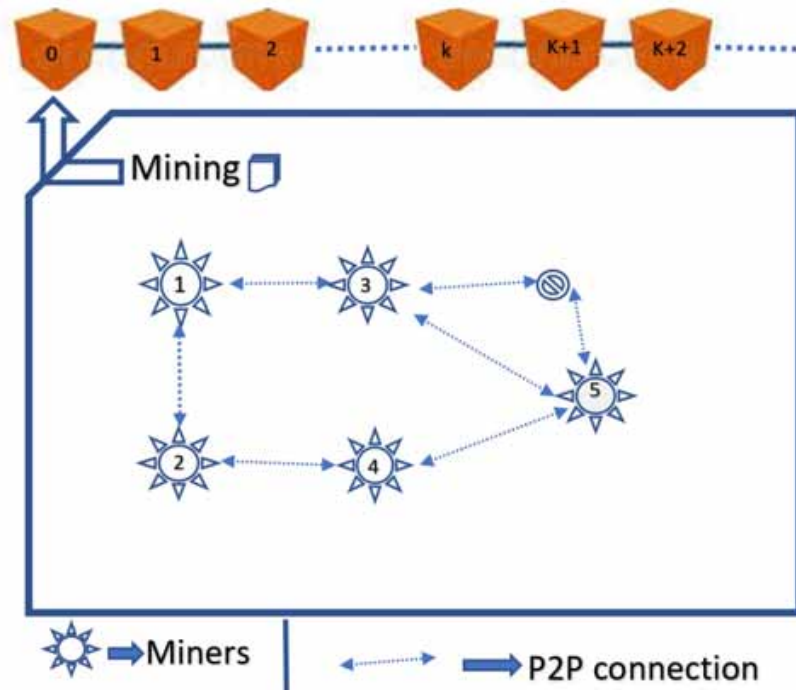


In the past few decades, 5G technology has started to deploy and the 6G technology has started to emerge. Along with the improvement in 6th generation wireless communication, there has been current developing curiosity among people in collaborating the block chain as wireless communication network. The Mobile World Congress (MWC), (Saad W, Bennis M and Chen M., 2019). The Federal Communications Commission's (FCC) in US explained the expectation of using block chain in 6th Generation technology in 2018. It also highlighted that block chain is expected to play a major role in wireless communication. In order to support digital tracking of professional tasks in the entire chain of supply for corporations American Telephone and Telegraph company bombarded with a successful block chain solution in 2018. In 2015, Alibaba began the AC (Ant Chain) Project in China in order to give the fundamental block chain services for communicating and storing the Data etc., Tencent brought the former white paper in block chain in 2016. It focused on establishing the block chain as a primitive key of service to give a perfect remedy to the end users. Block chain is aimed to be the upcoming important technology in the field of wireless communication in industries and research areas. Figure 1 shows the number of research works connected to block chain in various academic databases that has been continuing to develop in the recent few years. In a wide discussion related to the chances put forward by block chain to entrust 5G services ((Yan F, Liu W and Tian L., 2011; Zhao X, Yang H and Guo H et al., 2019) and systems was bestowed. So far, application of block chain to one or several application scenarios are only focused by most existing research works, but there is lack of emergence of technologies related to Wi-Fi.

This chapter mainly focuses on the improvements and threats to incorporate block chain with wireless communications network, and particularly bring in a combined structure of B-RAN for upcoming 6G networks (S. Madumidha, P. S. Ranjani, S. S. Varsinee and P. S. Sundari, 2019). We first discuss about the fundamentals and architecture of block chain and concept, consensus and mining. After summarizing the advantages and disadvantages of existing works, a unified framework of BRAN which is a hopeful paradigm for 6th Generation networking (You XH, Wang CX and Huang J et al., 2021) will be presented

by using the technologies of block chain. By bringing the full belief among various resource hosts and heterogeneous network entities through blockchain. Varied network resources are shared between BRAN and sub networks to form a multisided platform.

Figure 2. An abstract view of block chain



FUNDAMENTALS OF BLOCKCHAIN

This section covers about the basics of block chain and its architecture and concepts, mining and smart contracts and consensus protocols and finding the risks of using block chain in practice.

Architecture

Block chain is also known as a distributed ledger. Blockchain is a chain which consists of many blocks linked together. A block is a separate set of information which is registered as a list of computerized activity overtime. In the block chain, each and every block contains the hash of the former block. The mathematical properties of the hash tampers with any data in the block leading to the breakage of the link which is demonstrated by the hash directors (Madumidha, S., SivaRanjani, P., Rajesh, S., & Siva-kumar, S., 2018). Mining is a concept in which the miners will check the computerized activity and group them to make the chain compatible and invariable. Figure 2 represent the block chain which is linked by blocks. The data in the block is accumulated by the list of computerized activity overtime. (S. Madumidha, P. S. Ranjani, U. Vandhana and B. Venmuhilan, 2019)

Types of Block Chain

In general, anyone can join public block chain. In case of private block chain processors have the dominant role to access the blockchain. The key difference between the public and the private block chain is in authentication. But in the case of permission and permissionless block chain the key difference lies in authorization. In permissioned blockchains only the legitimate organization are allowed to take part. (Peck, M. E., 2017). But in permissionless block chain any body can modernize the data available in the block chain. There are different types of block chain. In practice respective block chain is selected according to its applications.

Mining and Consensus

In block chain consensus mechanism implies a set of guidelines or rules used to set proper accordance on the state of block chain in between different things that are important to the above mentioned. Here, we are discussing various consensus that are categorized as shown in Flowchart 1.

- **Proof-based consensus mechanisms**

Proof-based consensus mechanism needs a node called miner node to show that it's efficient than other nodes to attach a fresh block to the block-chain. It includes Proof of Work (PoW) which gained popularity due to success of 'Bit-coin' which is invented to tackle the problem of spam. The miners had to solve hash operations to append new blocks. Proof of Stake (PoS) was first introduced in Peer-coin. A Peer-coin generally uses the potential of a miner to generate blocks based on miner's stake. Proof of X (PoX) (Ling X, Wang J and Bouchoucha T et al., 2019) is another consensus mechanism that includes the framework of both PoS and POW. It requires all nodes on the block-chain system to verifiably demonstrate ownership or responsibility of some quantifiable assets other than the Hash operations. Under the PoX framework, a lot of alternative mechanisms based on cost, respect for the environment, equity as well as performance have been proposed. For the wireless environment, the consensus mechanism is carefully selected and designed with a high cost block, allocation of resources and power restricted mining equipment in mind.

- Voting based consensus mechanism: Typically used in consortium block-chain, the blocks are originated based on the majority of the nodes used. Different types include Crash fault tolerance (CFT), Byzantine fault tolerance (BFT), and practical Byzantine fault tolerance (PBFT) (Schneider, M., 2017).

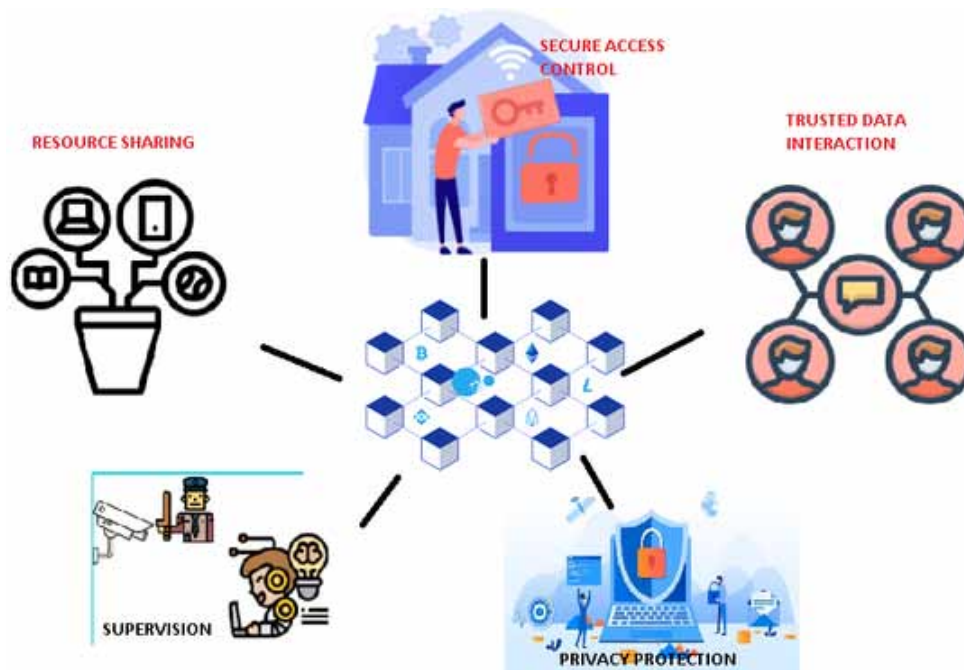
Smart Contract

In most cases, a smart contract is depicted as a cryptographic box. That may be opened only when few constraints are fulfilled. It was introduced in Ethereum, allows taking digital actions in block-chain. It follows a script allowing for automation of multistep process. After a smart contract has been activated, it doesn't rely on a middle man party or a main central node. Smart contracts have a lot of flexibility and variety due to which, the weak version of smart contracts forms a distributed virtual machine beyond a simple transaction. Smart contracts help in easily authenticating and authorizing with the help

of digital signatures. With the rise in popularity of Ethereum the smart contract became a crucial part of new and emerging block-chains and the functionalities also improved noticeably (Storoy, J., Thakur, M., & Olsen, P., 2013).

Although it is beneficial for most part, the smart contract has its fair share of potential risks. After a careful examination of prominent risks three key values: deterministic, isolated, terminable were put forward for a healthy smart contract. There were seven main attacks that targeted smart contracts in block chain and many methods that were recommended are advancing. In terms of implementation, an extensive assessment of existing domain-specific programming languages of smart contracts for beginners and analyzers as research is being conducted, surveyed for metrics measuring the attributes.

Figure 3. Different consensus algorithm



Potential Risks

Just like any other distributed system, block-chain is vulnerable to security threats. Here we summarize and briefly discuss them.

- **Alternate history attack**

It is launched by an adversary by privately mining an alternative fork and making it vulnerable to security threats and exposing weaknesses. The adversary can divert the actual transaction if the fraudulent chain is long enough to replace. In PoW, if the contender has more than half of the computational power of block-chain, it's enough to launch alternative history attack (Thakur, M., & Hurburgh, C. R.,

2009) also known as gold finger attack. PoS can change the course of past of the block chain and cause irregularities in block-chain. By finding and gathering the oldest account private key that has accumulated majority equity in past, the attacker can spit a chain that overlaps the present main block chain. To limit such attack the checkpoints were suggested in case of long-range attacks.

- **Selfish Mining**

The concept of selfish mining generally uses the idea of wasting the power of honest miner on public chains. It is continued till a valid block is found and the attacker withholds it without releasing the newly generated block. The situation is tackled using Markov chain model, where the state transition of public and private chains in selfish mining. This model (Tian, F., 2017, June) is used to determine and analyze the profits involving various selfish-mining pools in Selfish mining.

- **Cryptanalytic attack**

As the name “Cryptanalytic attack”, suggests the attackers’ main goal is to decrypt the cryptographic algorithm and uncover its keys. It usually happens when the random key generation too weak or the algorithm is vulnerable or easy to break. To avoid such attacks it suggested using strong random key generators. Furthermore, the growth in the field of quantum computing has a significant effect on long-established algorithms and hence the scheme of an anti-quantum transaction authentication was suggested.

- **Nothing at stake**

The economical consensuses such as PoS are more at risk to this kind of attack. It works in a way that if something is at stake, it is lost or else the contender has nothing to lose. This allows the adversary to work on multiple branches simultaneously. This issue was recognized and addressed by Buterin who proposed an algorithm called ‘Slasher’. Slasher requires validators to issue a down-payment that is withheld for some time. Similarly, in coin-age accumulation of PoS, where the attackers usually hoard the coins to increase their influence in block-chain, by introducing a cap on coin-age is a solution so the attacks can be avoided.

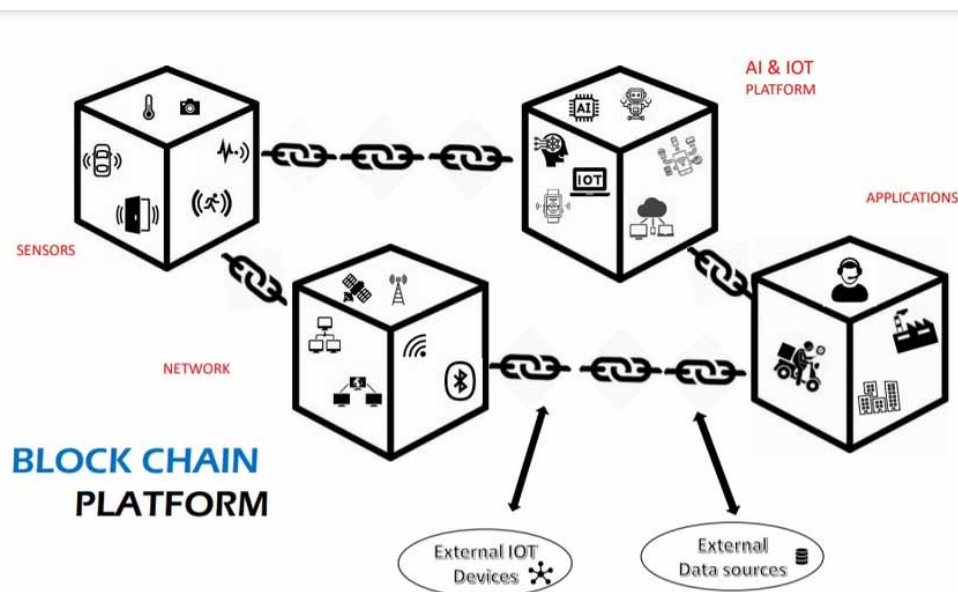
- **Traditional cyber-attack**

They include general attacks like DDoS (distributed denial of service) where many number of Block-chain nodes are overwhelmed by unwanted or spam requests so their usual operation is suddenly disrupted. The reply attacks copies the information on its way and the MTIM attackers modify the data packets and insert new content on its way. A Sybil attack is launched when a malicious entity creates many fake profiles. An eclipse attack solely focuses on cheating one network target and creates a bad impression of block-chain.

BLOCKCHAIN NETWORKING

As a disruptive technology, block chain can solve many problems related to trust and security in communication networks, promote more efficient exchange of resources, the interaction of trusted data, secures access control and protection of privacy, and provides Track and certify functions and monitoring of 5G and future 6G networks. There is a significant rise in modern days to implement the block chain technology in wireless devices. This section provides a review of same (Zheng, Z., Xie, S., Dai, H., Chen, X., & Wang, H., 2017, June).

Figure 4. Block chain Application in Networking



Resource Sharing

The immense rise in different mobile services requires an enormous quantity of network resources such as frequency bands, bandwidth, spectra and infrastructure. Due to the deficit of spectrum resource, the efficient management of resource is very crucial. In 5G network resource sharing are done using Software Defined Networking (SDN) and Network Function Virtualization (NFV) (Liu Y, Yu FR and Li X et al., 2020). It has been a steady rise in types and quantities of network resources, which has made sharing resources a bit difficult. On the other hand co-ordination among the network entities, security, safety and trust related issues limits resource sharing. Dynamic resource sharing (DRS) is used in 6G as next generation network. This improves the resource utilization far better than the static resource allocation. The Integration of Block chain in 6G has enabled the network to achieve better utilization DRS including improvised distribution, high security and enhanced network sharing.

- **Spectrum Sharing**

One of the key factors in meeting the requirement for 6G is the spectrum (Xu H, Klaine PV and Onireti O et al., 2020). The control over the spectrum is necessary in order to minimize the interference over transmission. The perks of 6G can be achieved by two methods- either by increasing system bandwidth or by improving spectral efficiency. One of the methods to enhance the spectrum management is Opportunistic Spectrum Access (OSA). The block chain is a new paradigm and it is going to revolutionize the spectrum sharing and resource sharing by eliminating the central authority which is replaced by distributed authority, therefore reducing the costs and improving network security. Block chain finds its application in spectrum sharing for recording the data. It stores data as transaction, while spectrum management relies on location based databases for securing the user in TVWS. Block chain provides more opportunities to dynamic spectrum management (DSM), which further improves conventional spectrum management and data integrity.

- **Computing and Storage**

Cloud computing and Multi-access Edge computing (MEC) are the latest generation of technology with an extensive IT infrastructure. Their services are provided based on “need basis”. These services are cost efficient, highly secure, and have ultra-low latency and high bandwidths. Block chain utilizes cloud computing very efficiently leading to improved collaboration among entities in sharing computing resources. A research on data analytics is highly required in order to analyze and extract data from the enormously large stack of data for efficient and accurate data processing. Predictive analytics, Diagnostic analysis, Descriptive analysis and Prescriptive analysis are the various methods for analyzing the data. The real challenge is to combine these analytic methods with distributed block chain based storage.

- **Infrastructure and Device**

Block chain has been a crucial factor in managing heterogeneous devices and infrastructure in 5G, IOT and IOE. Internet of everything (IOE) is more general than Internet of things (IOT) and connects people, process data in an effective way (Jingyu F, Xinyu Z and Kexuan C et al., 2020). In IOT, the information is sent from a device to cloud and processed using analytics procedures and sent back to IOT device. Block chain offers inherent security guarantees, resistance to various attacks and tamper resistant data. A trusted block chain enabled trading ecosystem including energy; computing and communication can be built to provide an efficient and sustainable 6G network.

- **Network Slicing**

Network slicing is a promising technology in future cellular architecture. It is a unique form of virtualization that allows multiple logical networks to run together in shared network architecture. It allows the Mobile Network Operators (MNO) to slice a physical network into multiple virtual networks. Distribution based network slicing (DBNS) is an end to end leasing of resources to support service continuity while meeting quality of service requirements. High performance can be achieved by dynamically leasing resources. Utilization of block chain overcomes the trust and security issues associated with implementa-

tion of network slicing for coexistence of various applications. This reduces the collaboration and trust barrier among the networks and helps to provide effective and efficient infrastructure.

Trusted Data Interaction

Due to the significant upraise in wireless traffic and connection density, data must be shared with various network in order to collaborate and provide services. The main challenge is providing a secure and trusted platform among the data holders to interact. Securing the data interaction, verifying its authenticity and reliability is the priority for establishing a trusted data interaction. Recent researches proved that block chain helps us to provide a secure channel for data interaction in wireless networks. It has two ways, one by ensuring the credibility of each network and the other one is by improving the authenticity of the transmitted data.

- **Identity Credibility**

Each node is provided with its credibility value before entering the network to ensure identity credibility. Using block chain, the node's historical behaviors are analyzed and then the permission is granted based on the value. There are certain ways to cope with internal attacks caused by the compromised nodes. One of the effective methods is Trust management mechanism. By this mechanism, only the nodes with specific trust degree are given access to interact with the other nodes while the malicious nodes are detected and expelled. Secure and Lightweight Triple-trusted Architecture (SLTA) is another method which is based on a triangle of consensus, authorization, and the chain storage. This method provides trusted data collection, validation, trusted identity management and trusted data transmission. Data Identity mechanism is combined with an underlying layer of block chain, allowing any entity on the block chain to independently create and manage its own identity.

- **Data Authenticity**

The Data authenticity is the process of validating the origin and the integrity of data. Consensus mechanism could be utilized to ensure data accuracy. Block chain based trusted data management scheme utilizes mutual authentication protocol and user defined sensitive data encryption in Edge computing.

Secure Access Control

The upsurge in enormous wireless networks and heterogeneous devices raises a threat in mobile communications system. These factors exploit the access control and leads to security risk. In order to access resources from a network it must be authenticated. Only on the validation of the Id, the access is granted. In the centralized authentication a single point of failure leads the ways for the hackers to the resources. But in block chain, a decentralized ledger offers a more secure access to control as no one can alter its transactions providing a better authentication. (Qian P, Liu Z and He Q et al., 2020)

- **Device, System And Data Access Control**

Device access control helps us to prevent the devices from malicious devices trying to compromise the security of the system. The framework includes three smart contracts to safely add, update and delete network entity identities. System access regulates who can view or make changes to resources in a computing environment. Block chain prevents the single point of failure as it records the distribution of attributes. Data access control is the security process which protects the data from being exploited. It verifies whether the user is legitimate. It has two phases, authentication- which verifies the user's identity and authorization- the level of access the user has and the actions one can perform. The access control methods are listed as followed: Discretionary access control, Mandatory access control, Role based access control (RBAC) and Attribute based access control.

Privacy Protection

Privacy protection is a crucial factor which provides trust and confidentiality among the users. Malicious entities cause threat to entity identities, confidential data and may intercept, relay or tamper the data. Therefore, the requirement for privacy protection has gained significant attention. Block chain provides privacy protection for entities identity and confidential data by asymmetric encryption. Block chain is divided into permission and permission less. The permission block chain allows only the authorized nodes to access the data but the permissionless block chain allows all entities to join freely.

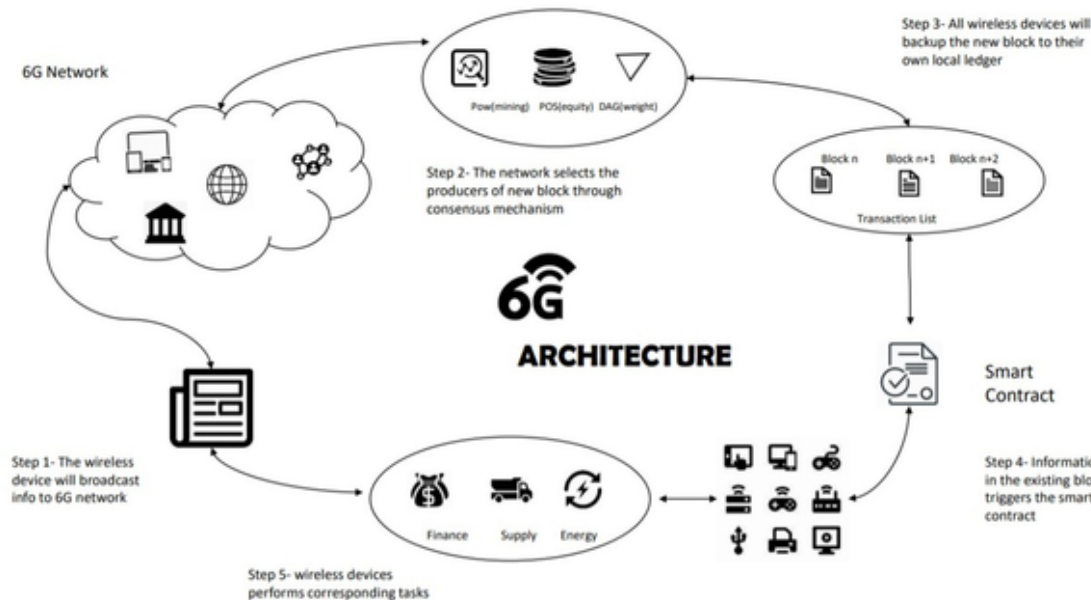
- **Identity And Data Privacy**

In block chain each node has a unique key that can be retrieved to communicate with other nodes. The users use a hash value of randomly selected public keys as identifiers to hide their real identities. Utilizing pseudonyms in private block chain to hide user's identity is an efficient process, where each user may create various pseudonyms with data related to these pseudonyms. The asymmetric encryption method encrypts the user data record as a block chain transaction to provide data privacy for confidential data in the network. Anonymity is the crucial factor in identity privacy.

Tracing, Certification and Supervision

Due to the large-scale development of the mobile networks and various services, the need for data traceability has attained more priority. These protect the data from the attackers from accessing the data illegally and manipulating it. There are many third-party services that have trouble reaching the necessary requirements. Block chain architecture has the features such as transparency, immutability which seems to provide solutions for the problems discussed earlier. The block chain is capable of providing records and security assurances for tracking network entities via smart contracts and consensus mechanism. The mobile service providers are able to preserve and certificate devices by using block chain. The architecture naturally meets the requirements of data supervision.

Figure 5. Block chain enabled B-RAN in wireless communications



BLOCKCHAIN RADIO ACCESS NETWORK FOR 6G

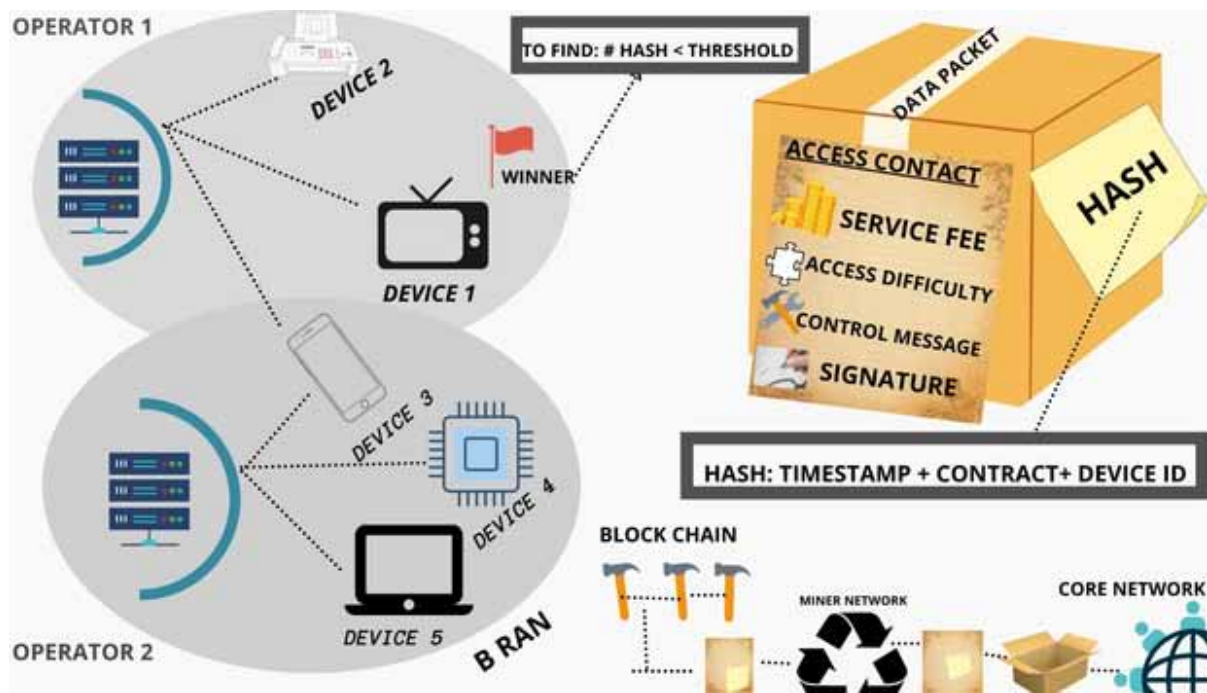
The 6G networks are expected to accommodate a wide range of heterogeneous devices and infrastructure with enhanced efficiency. The advantage of 6G wireless communication will be the high data speed and low latency. But still it has various security issues that need to be dealt. Block chain is a revolutionary technology which has gained enormous pace in recent years. Its nature of decentralization, immutability and traceability can establish trust and coordination among the entities. The important aspects of B-RAN are consensus mechanism, smart contracts, trustworthy access, data tracking, auditing, mathematical modeling, cross network sharing and intelligent networking.

Paradigm for 6G

The 6G network will be able to provide wireless connections with ultra-high data speed, ultra-reliability and ultra-low latency and facilitate the Internet of things (IOT) and Internet of Everything (IOE). There various challenges like managing spectrum, storage, devices and infrastructure. A major real time problem is the differences among resource hosts which are Mobile Network Operators (MNO's), Mobile Virtual Network Operators (MVNO's), cloud service providers and individual users. They don't make their resources available outside the network due to capital and operating expenditures. The security reasons also aggravate the separation among the networks. The block chain presents the ideal solution to solve the trust problems in wireless networks. The Block chain establishes a unified framework of B-RAN for 6G as a novel paradigm shift (Pinna A, Ibba S and Baralla G et al., 2019).

By establishing the cooperative trust among the heterogeneous network entities, B-RAN facilitates cross network resource integration and enhanced wireless roaming, accessing, sharing and security across the networks. It supports a wide range of applications beyond B-RAN such as IOT, Mobile edge computing (MEC) and vehicle networking. It establishes a multifold trust for B-RAN among the networks. B-RAN form a multisided platform (MSP). The Edge Super Data Center (ESDC) consists of powerful band units (BBU's) and Edge Servers (EDGE) which absorbs the various innovative technologies such as AI and Big data. The Multi Edge Access Computing (MEC) embedded block chain architecture provides real time data privacy, integrity, and authentication between IOT, IOE, MEC and cloud. In IoT, B-RAN establishes the trust among the various IoT devices and access points (AP's). In Unmanned Aerial Vehicles (UAV) will play an important part in 6G as high data rate wireless connectivity is required. Block chain plays a significant role in contributing to the protection, security and privacy protection of the information collected. The role of block chain in AI will be to make the decision process of the machine learning methods more understandable and to trace back the decisions that are made.

Figure 6. An architecture of 6G enabled with B-RAN



Consensus Mechanism

The definition of consensus in a block chain network is based on the distribution of the addition of data to the block chain among the network participants, and the validation of the accurate account of transaction of these data. The section 'Mining and consensus' manifests that great resource consumption makes PoW robust. However, Traditional consensus mechanisms like PoW and its variants does not support the mobile environment, since latency acts as a major issue.

A special consensus mechanism PoD was developed for the sake of B-RAN. Unlike PoA, this consensus mechanism reduces the resource consumption as well as acts efficiently. Every device in the B-RAN performs the hash query only once and a winner is the one who finds the hash value less than the available threshold value. Multiple devices present in the B-RAN are verified with the help of a unique hardware identifier (ID) which takes care of letting the device to participate in solving the query only once. Using the Hardware Security Modules (HSM) the built-in device ID is secured, allowing neither the users to modify while verification nor the attackers to lay hands on it. At times of any malpractices, the HSM destroys the information preventing it from reaching the hands of hackers.

In order to increase the coverage area and connectivity, innovation in the consensus protocol was done by introducing satellite system. The Terrestrial blockchain network constantly receives oracles from the satellites. An oracle decides the winning miner by generating a random number; this miner will generate unique blocks and transmit to peer miners. Massive hash queries are avoided by this method which reduces the energy consumption during the consensus process. This process also has an added advantage of achieving higher throughput than PoW (Mayer H., 2016) and is not less in security than PoW. Also, the terrestrial P2P network delay is too long while the satellite-communication delay is fixed and is more controllable. Hence, for the space-terrestrial 6G network, B-RAN might use this consensus protocol for better efficiency.

The consensus mechanism can be used to reduce the need to perform meaningless hash queries and optimize various schemes in B-RAN by constructing proper tasks. It manages and organizes the functionality of the network on the whole.

Smart Contract Enabled 6G

A Smart contract is a self-executing computer protocol to enhance the negotiation and transactions between the buyer and the seller without any third parties. The block chain and mechanisms in B-RAN takes care of the processes like resource sharing, data exchange and user access. Verifiable software codes are used that make the program execute automatically and thus the backdoor viruses are prevented from entering into the B-RAN system. FSCD and HTLC are two mechanisms in B-RAN which ensure its security and effectiveness.

1. FSCD: Fast Smart Contract Deployment (FSCD) is a high-level mechanism that works for system acceleration and security in B-RAN. FSCD effectively prevents the block chain from accepting the forged and malicious requests thereby reducing the potential risks in service request procedures (Li A, Wei X and He Z., 2020).
2. HTLC: The Hash Time Locked Contract (HTLC) utilizes the time-bound restriction in block chain applications to exclude the counterparty risks. In B-RAN, fair resource exchange is done between service providers (SPs) and clients with this concept. The HTLC even works outside the block chain to provide a safer environment for transaction by forming a 'restraint' between the two transistors which prevents breaching. Hence, HTLC convincingly enhances the safety of resource trading.

Apart from the security and efficiency, B-RAN still possesses few unsettled shortcomings that are being investigated such as a shortage of resources for safe isolation of private information. This issue occurs since B-RAN is a multisided platform (MSP) that coordinates a host of networks or sub networks. A pre-computing attack in PoD is malicious, where an attacker predicts a valid block well in advance

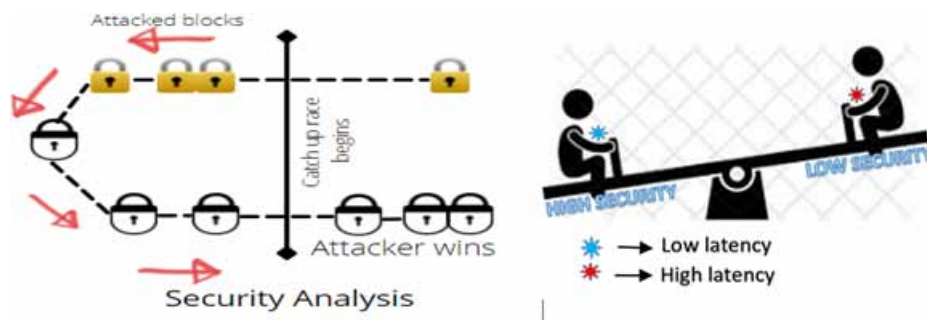
using the future timestamps. Effective and robust smart contract designs are essential for executing automatic penalties for violations.

Trustworthy Access

Multiple varieties of devices are present in the 6G network many of which may ignore the pre-defined protocols and conflict for the restricted resources. In case of mistrust of devices, the selfish devices reduce their back-off period in random access to shorten the access latency. There happens to be major network congestion due to the increase in selfish devices which leads to Rogue's Dilemma.

Rogue's Dilemma is treated by washing out the lack of trust among client devices. A Hash access scheme and its mathematical analysis were proposed in the B-RAN framework. In order to get access to the current slot, each device had to solve the hash query and obtain a hash value lesser than the given threshold. Here, the threshold plays a major role because it determines the hardness for each device to access and thereby controls device traffic in B-RAN (Biryukov A and Tikhomirov S., 2019). The malicious rogue devices cannot create a forged hash value to get access in the network due to the implementation of the Hash Access scheme. Hence, trust is created between the client devices by ceasing the work of selfish rogue devices. It also keeps track of multi-party cooperation and integration of cross-network resources (Luo J, Wang X and Yang M., 2012). The Figure 6 shows the various devices competing to solve the hash query and find a hash value which is lesser than the threshold value and enters into the block chain network after being verified by the block chain miners. A block consists of its own hash value, data and the hash of the previous block.

Figure 7. Hash access illustration



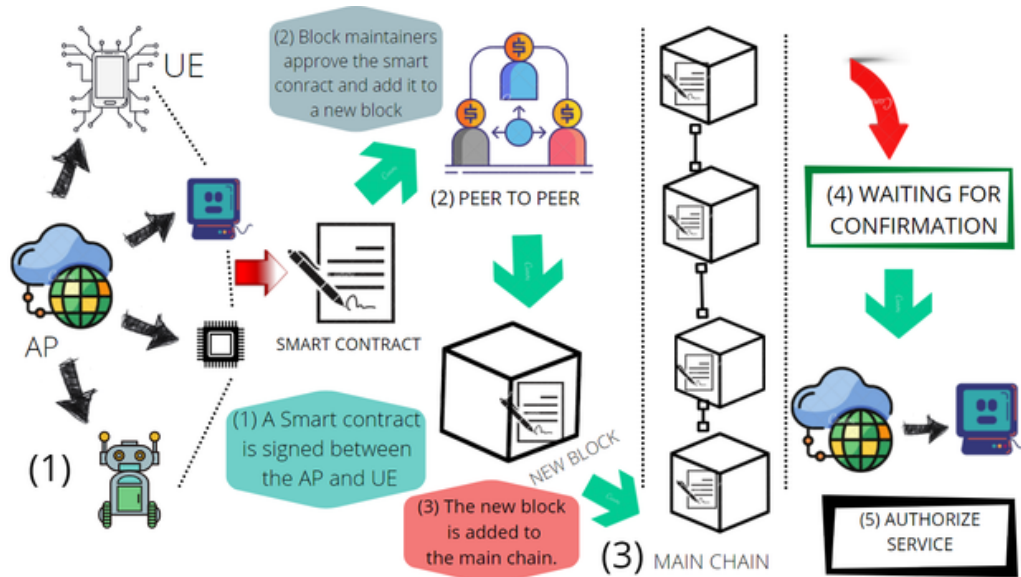
Apart from the above-mentioned issues, there are numerous risks involved in the security of a wireless network system as discussed in the 'Secure access control' section. In case of 6G technology, highly secure and firm device access control is to be developed as part of the evolution. As of now, B-RAN acts as the best platform to test and integrate several access methods and protocols into the 6G framework and also ensures security among heterogeneous entities.

Mathematical Modeling

Even though the present research area is booming with Block chain-based networking, tasks like mathematical modeling and fundamental analysis are still in a doomed state. The RANs developed so far have not been affected by the impacts of decentralization even after the introduction of block chain, but analytical characterization and determination of accuracy is necessary (Yu W, Fu X and Graham S et al., 2007). Some studies have explained that B-RAN can have service latency as a critical issue as a result of decentralization. But the duration and control methods and security haven't been discovered yet. Therefore, the analytical model becomes the need of the hour which enables us to explore the B-RAN characteristics (i.e. security and latency) and formulate protocols for implementation.

An attempt for mathematical modeling of B-RAN was done and its properties and outcomes were studied. The block generation was modeled through the Poisson process and examined by real data. The Poisson process is a type of counting procedure used for uncertain structured events. A queuing model inserted by never-ending time-homogeneous Mark off process was incontestable for B-RAN. The queuing model in turn produced a general state transition graph that estimated the latency at service level and provided an insight on the effects of critical conditions on the B-RAN latency. Also, the attacker's strategy is analyzed and the security level of B-RAN is improvised (Tian F., 2016 & Voigt P and von demBussche A. 2017).

Figure 8. Latency-security trade-off



A latency-security trade-off curve is derived from the above analysis which gives a picture of the intrinsic relation between them. In regard to the block generation time, request latency of B-RAN is quasi-linear in nature and it is directly proportional to verification confirmation number or block generation time. But there is a need for more confirmations to lessen the occurrence of a victorious attack and they are essential in leveling the latency of a requested service and security of the system in B-RAN. Such

compromise between the request latency and confirmation number further enhances the performance of B-RAN. The analytical model (Keshk M, Turnbull B and Moustafa N et al., 2020) might be a motivation to design futuristic block chain-based wireless networks considerably discarding the security and access latency issues. As in the figure 7, latency and security lay in contrast with each other. There is a high security when the latency rate is less and with high latency, the security lowers.

Cross-Network Sharing

In order to augment resource sharing across sub networks, B-RAN employs a great number of service providers (SPs) and clients avoiding an oligopoly system. The advantage of higher economic incentive due to the increased number of clients attracts more SPs to join the network which uplifts the Quality of Service (QoS) and again, interests many clients. By growing the network in a massive range, B-RAN becomes a Multi-Sided Platform (MSP), (WeissMBH, Werbach K and Sicker DC et al., 2019) enabling the multilateral groups to interact among themselves and this approach fetches way for different sources of income for B-RAN. The various works of multiple participants are put together in the B-RAN's massive resource pool and simulated through the smart contract and this enables the promotion of more resource pooling and sharing. Let's take a look into some important resources in B-RAN.

1. **SPECTRA:** The spectrum assets are digitized in B-RAN. A spectrum asset transmits spectra in a particular frequency range in a provided coverage area within the allotted time duration. Rather than the spectrum from a single source, the employment of multiple spectrum holders is most preferred for its efficiency.
2. **INFRASTRUCTURES:** Base Stations (BSs) and Access Points (APs), Mobile Edge Computing (MEC), cloud servers, backhauls, etc. build the B-RAN. Multiple infrastructures owned by different workers can be transferred across SPs and individuals through network access services, data storage, computational offloading. This type of coordination among the users reduces the usage redundancy and enhances network efficiency.
3. **DEVICES:** Clients with mobile devices are utilized to analyses data and draw out information for the services of the Service Providers and various applications. Devices of IoT/IoE are exploited for crowd sensing. This method enables to achieve more clients which again attract the SPs and the B-RAN network keeps on growing.
4. **CONTENT:** B-RAN efficiently supports the transfer of media files, software, documents, applications, etc. It also supports live streaming between users. B-RAN also allows the clients to provide their own content. The content is made resistant to any changes and can be accessed only by authorized clients. This is achieved with the help of the security system and privacy protection measures of B-RAN.
5. **CONTROL:** Block chain manages the whole process of control in the vast framework of B- RAN. The devices that carry out the packet forwarding function can be accessed by all allowed devices that possess a sharing key. Here, block chain plays a major role in controlling mishaps.
6. **ENERGY:** Energy needed for B-RAN is basically electrical energy that is obtained from fossil fuels and renewable resources like solar, wind, etc. Devices with overflowing energy supply their energy and obtain payment. B-RAN also provides a secure platform for interaction so that amateurs in this field can seek the help of professionals and get benefitted.

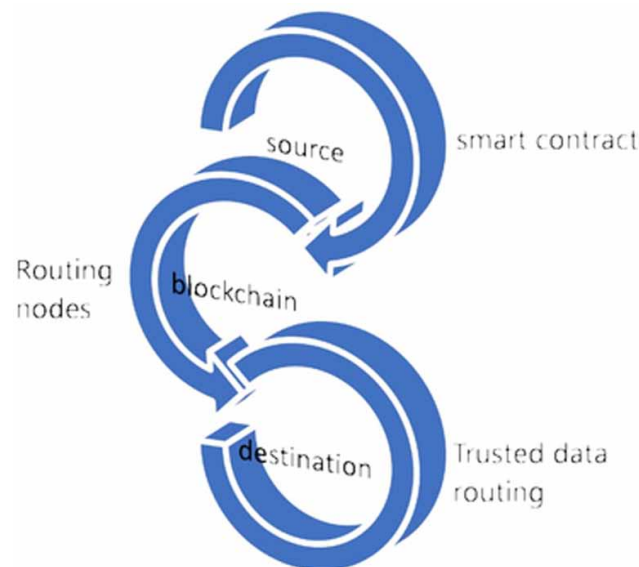
7. **INTELLIGENCE:** Trustable learning models and skills like computing, communicating, caching and performing algorithms are referred to as intelligence by B-RAN. The learning process can be done in an organized manner in diverse devices and also the learner's data privacy is ensured.

The following is a basic technique for using B-RAN to assist user equipment (UE) in requesting services from an SP (Zhang Y, Kasahara S and Shen Y et al., 2019).

1. A Service-Level Argument (SLA) between UE and SP is carried out which specifies the service types and compensation rates. After this accessing procedure, a smart contract records the service terms and fees which is sanctioned by digital signatures of both parties.
2. The block chain maintainers must check the smart contract's legitimacy, until it is connected to the network of block chain.
3. Once the present course of consensus is achieved, the smart contract is verified by the block chain workers and it is added to a new block.
4. When a considerable number of blocks are built as an approval, the block gets integrated in the main chain. Then the smart contract enters the Service queue.
5. Finally, the request data in the smart contract is fulfilled and the SP delivers access to the UE.

The network pooling principle determines the high efficiency of B-RAN which requires resilient offloading and sharing between sub networks. Since UE gained the trust with SPs, now they are capable of accessing pooled resources of various SPs in B-RAN and their charges for trading and roaming would be compensated by smart contract from time to time. The block chain maintainers make way for the mobile devices to access their suitable SPs that deliver higher-quality connectivity for the UEs in their present location by devising algorithms to distribute the polled resources.

Figure 9. Basic procedure of B-RAN



Data Tracking and Auditing

The rapid ascent of data has brought many beliefs to companies, societies, and governments in the era of big data. Data breaches (i.e., breakage of data) occurs often leading to security risks. As a result of openness and mobility in the wireless networks leading to the risk of data leakage and mischievous. Data leakage is noticed through data tracking and auditing thus, the demand for data security is needed. There are certain regulations to be followed on data usage to check the leakage of data by some countries and organizations. For example, the European Union released the GDPR in 2018, and the US issued the NSPDPA of 2019 on data transmission and protection.

We use deep packet inspection for data tracking and traffic analysis for auditing. Due to the rapid growth of big data traffic analysis are affected from problem solving techniques and the process of implementation. DPI schemes require manual works on characteristics of traffic and processing the data. We should note that to trace network flows we use data marketing techniques.

There are few studies helps to make it viable by using block chain for crypto currency, food supply chains and healthcare. (Kotobi K and Bilen SG., 2018)

In B-RAN, data are distributed by many paths a by-way-of number of devices and infrastructures. Block chain having alternative parties can report its routing direction of the data collected in a sincere and obvious manner and so it is reasonable for monitoring and auditing information. By statistic marking technique, of tracking and auditing is clearly shown in fig 9. The scheme lets routing nodes, might be from different operators and manufactures take part in B-RAN and record their routing information to the block chain using the help of protocol regarding smart contracts. To safeguard the origin and authentic data, we insert TPM (Javaid U, Siang AK and Aman MN et al., 2018) inside the device which create fixed digital label for data transmitting, these are recorded by smart contract and its source. Similarly, every relay node must include its digital sign as a proof and perform the ultra-modern agreement, which makes a strong hope on a routing path. Thus, the information in relaying path is jointly viewed by some parties in B-RAN and can infrequently be hard or changed since the data are protected. This path can facilitate the violation tracking and data review organized by the directing government.

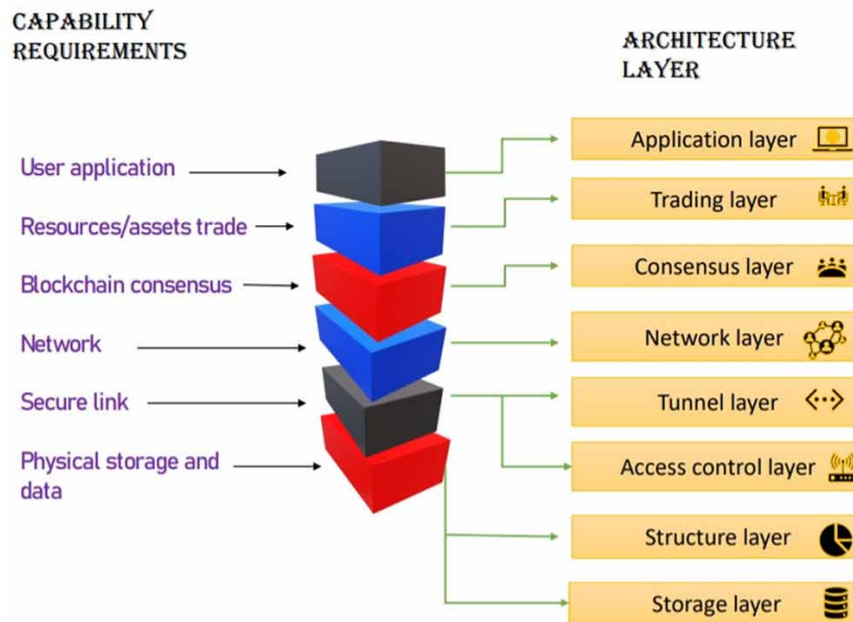
Intelligent Networking

An intelligent resource provisioning mechanism is controlled by B-RAN. The supporters in B-RAN can record the condition of resources and enhance resource through the technology in machine learning. As mentioned about the intelligent consensus of B-RAN provides trustworthy hope for infrastructure and spectra sharing, which helps us to give better customer service. In auxiliary, trading, offloading, and sharing is done by B-RAN.

Federated-style learning is assisted by the distributed nature of B-RAN. It can interchange trust models and the capabilities for machine learning, leading to the adept of Federation-style learning. Manifold credence is introduced by block chain, where the network can share intelligence in consistent manner and it can trace the complete activity of the data, so it can gain the trust.

B-RAN gives the community pleasant and provides wise offerings. In response to the request of the customers, they timetable and assign offerings through a manner called distributed learning approach, which leads to a flexible smart network. It can accumulate the user information to modify problem solving methods, while carrier plan is performed as a federated learning undertaking amongst distinctive community entities. Clients can choose the sign transmission medium.

Figure 10. B-RAN data tracking



Additionally, B-RAN can keep track the frame of network and make use of distributed learning to keep away from traffic congestion which helps us to identify the fast fault locations. To balance between restricted community sources and service quality of service, information packages are need to be preferred to make sure the best experience for the operators in network and the users. This can be accomplished by using AI (Cinque M, Esposito C and Russo S., 2018). The proliferation of gadgets and users, fault vicinity has ushered in new demanding situations because of the spatial correlation of alert messages and the interactions between failures by machine learning algorithms, consisting of the learning vector quantization neural network and the deep neural evolution network.

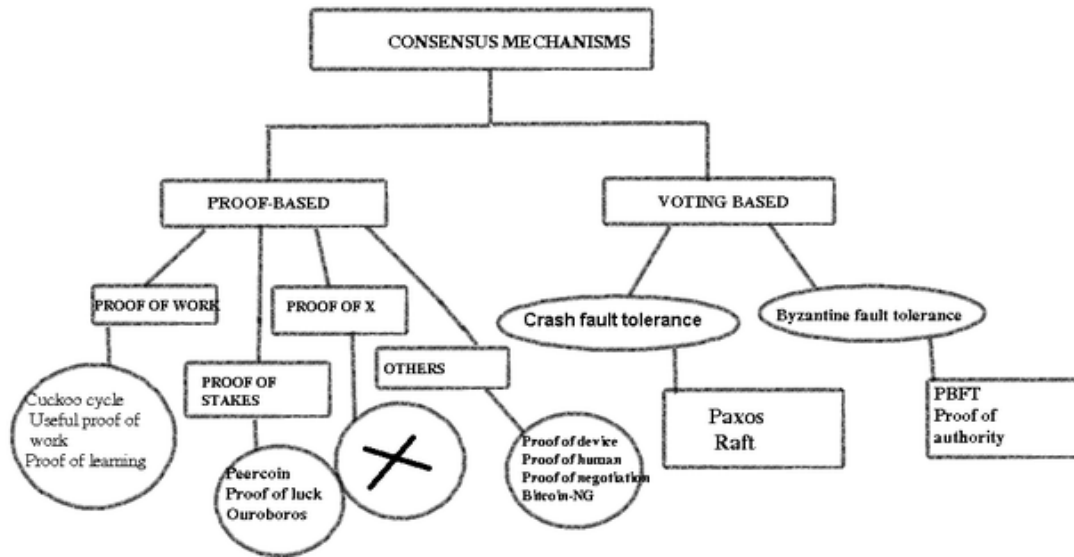
Prototype Design

To implement our proposed layout and test its performance in higher range, we need to check the basis of capability and assemble them according to the prototype. There are six aspects designed in our prototype design as designed in the below diagram. We also use traditional network system layer to support and balance the basic operations of our prototype. According to the situation, we comprise the FSD mechanism, hash access and HLC into the architecture to make better the execution of prototype. The below figure 10 represents the basic capability needs and architecture layer design of B-RAN.

1. PHYSICAL STORAGE AND DATA:

Facts related to B-RAN include the ordered transactions, digital actions, and cryptographic keys from the structure layers data is stored by servers or electronic devices present in the layer of storage. No longer all gadgets will keep a complete copy of the block chain; storage of partial statistics is present in mobile phones as lightweight nodes.

Figure 11. Architectural layered design of B-RAN



2. SECURE LINK:

The different sides of the secure link are introduced by B-RAN. By the attachment of the assumption of HTLC inside the tunnel layer, the mechanism of payment present among workstation and APs is totally trust-free. In the access control layer, the transmission reliability is ensured by the error correction and control flow. The duration of association, prices or physical transfer media are instructed to flow the way of clever contracts.

3. NETWORK:

Network is constructed by combining the sub networks. The nodes and the links present between them are needed for the disclosure of communication, to maintain a proper network which is distributed. (Shi P, Wang H and Yang S et al., 2019)

4. BLOCKCHAIN CONSENSUS:

In B-RAN consensus, oversees producing and validating the blocks and making sure that the members reach a consensus on behalf of the transactions occurs in broadcast. All the maintainers need to follow the policies which are based on the consensus layer, helping to decide the block which will be inserted to ledger.

5. RESOURCES/ASSETS TRADING:

The performance of the sources and the assets trading is performed by underlying policies to maintain the transparency between the SPs and our customers. Such equity is entrusted by smart contract-agreements in the layer of trading.

6. USER APPLICATION:

Consumer applications on the pinnacle are designed for customers to interconnect with the block chain and smart contracts. The interfaces will be provided for developers to execute other desired functionality apart from access services.

CONCLUSION

In this chapter, we have spotted the vital trust related issues in Wi-Fi network that obstruct the growth of modern-day 5G to protected 6G networks. Beginning with the detailed information of the fundamentals of block chain, we have deeply gone through the research work on block chain to Wi-Fi network from various factors, along with sharing the resource, data instruction in trusted mode, secured control of access, privacy protection, tracking, testament, and management. Then a merged framework of B-RAN was suggested as a reliable and secured prototype for 6G by using block chain. We detailed the essential parts of B-RAN, like trustworthy access, consensus mechanisms, smart contracts, cross-network sharing, mathematical modeling, data tracking & auditing, intelligent networking and provided the prototype design of B-RAN.

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Chapter 3

Analyzing the 6G Technology: A New Evolution of Wireless Communication

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ABSTRACT

Due to increasing demand and faster access, the 6G technology is under invention, and as expected, it will come into functioning in 2030. This new paradigm of network communication brings more changes to the digital era with the aid of artificial intelligence. The architecture of 6G is compared with 5G technology and an analysis of 6G technologies in various applications domains is done. Various technologies integrated along with 6G including IoT, blockchain, big data, artificial intelligence, machine learning, robotics, quantum communications are analyzed. This chapter describes the requirements for new generation networks 6G technology as well as key performance indicators required for 6G networks. The research challenges are explored under different attributes for future contribution of new technology towards the wireless evolution.

INTRODUCTION

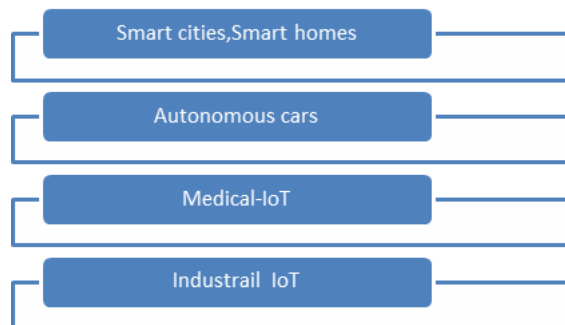
Future Generation Communication system integrated with IoT devices proves its power in various factors like high spectral density; latency level is low and more efficiency of energy level. IoT starts from the Internet of people and reaches the Internet of Everything (IoE), to accommodate such a vast collection of things there is a need for such powerful communication technology. Even 5G technologies struggle to

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support IoT devices in a few applications and its limitations are identified and rectified in 6G networks (Viswanathan & Mogensen, 2020). IoT support is needed for services like traffic alignment, observing environmental factors, virtual reality or virtual navigation, medical field, digital sensing, high definition, and full HD video transmission in connected drones (Rappaport, 2019; Heath, 2019; Zhang, 2019; Yrjola, 2020).

To enhance the performance, the communication algorithm should be modified. IoT system in 5G System can able to connect 50000 devices. Hence 6G communication technologies are the best area for the researchers to show their inventions and make innovations in various areas which make humans live sophisticated and also improve the business technology (Ziegler,2020; Zhang,2019). In this paper, an analysis is done in the application areas and the techniques needed as well challenges or difficulties faced while implementing 6G technology. Deploying of 5G technology is carried out now in most of the countries. But there is the necessity to satisfy the Internet of Everything (IoE) requirements. Henceforth, 6G came into the scene.

Figure 1. IoE applications



Internet of Everything (IoE) Requirements

The four main needed of IoT are people, process, data, and things. IoE is the connection of billions of devices together with people which consists of a machine to machine (M2M) communications, machine-to-people (M2P), and people-to-people (P2P) communications [9-10]. IoE is defined as the smart connection of four that is people, process, data, and things. IoE represents using sensors to access all the objects connecting different networks by adopting protocols.

Internet of Everything (IoE) Components includes four first one is people which are very essential components to connect with others. The second component is data which is collected and transformed into information with intelligence. The third one is the process that is needed to convert the data into intelligence and to send it to its destination i.e people component. The final component is Things which represents all the physical devices connected to the internet. The devices include all the objects also.

Let us compare IoT with IoE now. IoT is defined as a distinct collection of objects and data is accessed via the Internet. Normally the objects include various embedded devices for their functioning and so that it can do sensing process then communication takes place successfully. But IoE is built using four pillars where IoT sits on the top pillar. Then, IoE demands high power to improve industrial needs and business needs.

Wireless Technology from 1G to 6G

Wireless communication starts from 1G (First Generation) and moves to 4G and 5G under the final deployment stage, finally 6G technologies are going to emerge and under research. Table 1 depicts the various technology evolutions of wireless communication technologies.

Table 1. Wireless technology from 1G to 6G

Technology	Features	Year of Innovation	Services	Concept adopted	Maximum data rate
1G	Analog wireless cellular network	1980	Voice calling	• Advanced Mobile Phone System • International Mobile Telecommunications Standard • Point to Call	2.4 kb/s
2G	Services such as voice and data with quality	1991	Text messaging	GSM,GPRS,EDGE, GSM	144 kb/s
3G	Services such as video and remote supervision	2000	Internet access	• Wideband Code Division Multiple Access • Universal Mobile Telephone Service	2 MBPS
4G	video streaming, online gaming,	2009	Internet of applications	GSM,UMTS,CDMA	1GBPS
5G	video streaming, online gaming,	2019	Broadband and IoT	Massive MIMO	36GBPS
6G	Hologram	2030	The fully connected digital world	OFDM(orthogonal FDM)	100GBPS

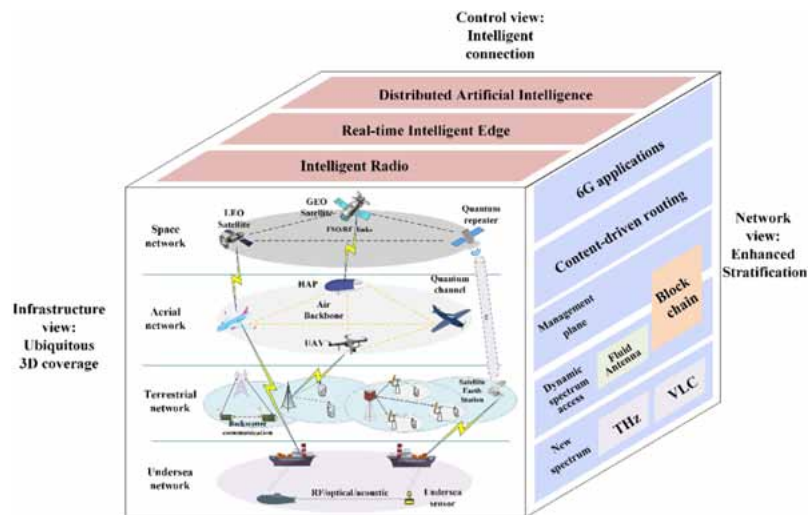
6G SYSTEM ARCHITECTURE

The ultimate aim of 6G technology is to make IoT as IoE. IoE enables every smart device in this world like smartwatches, smartphones, smart laptops, etc., to be connected via wireless access networks. This type of network provides services with multiple access points(AP). These APs are also known as Base station(BS) which is located densely in the 6G network as per the requirements. Multiple APs are deployed in case of overlapping coverage areas.

In recent days cloud services are provided for accurate access which can be added to 6G. Therefore perfect frequency allocation, proper handoff, and proper handling of interference are required while designing 6G networks (Yang et al., 2019; Huang et al., 2019). Next is an infrastructure that requires 3D coverage which includes both terrestrial and non-terrestrial infrastructure including drones, satellites, etc,

The architecture to be proposed for 6G technology includes not only human needs but also should satisfy industrial needs. The building blocks of 6G architecture covers layers like physical, service and promote security and automation in nature. To provide 6G services there is a need for modification in all layers like user data plane, management plane, and control plane especially higher level of KPIs to be defined (Chen et al., 2020).

Figure 2. 6G architecture (Huang, 2019)



The modifications in all layers are as follows:

- The control plane is modified to support efficient signaling and high precision manufacturing. New path routing protocols and algorithms are proposed to provide efficient sessions.
- The Data plane should provide efficient user data transmission
- and it should be able to adapt to different operating modes.

ASPECTS OF THE SIXTH GENERATION WIRELESS COMMUNICATION TECHNOLOGY

There are various parameters to be considered while 6G technology is adapted. Few of the parameters are discussed in this section.

Data Rate

6G technology should provide a superfast data rate of 1000 Gbps and user data to 1Gbps. There is a need for enhanced spectral efficiency to enable access to multimedia services by the users more efficiently. Hence this should be increased double the times higher than 5G networks.

Latency

Latency should be reduced to 5G technology to provide delay-sensitive real-time applications to run more reliable. Low latency is required in case of emergency response and automation operations in the industry. The user latency of 5G will reduce to 1ms, whereas 6G technology will reduce to less than 0.1ms.

Reliability and Accuracy

Network coverage and reliability are enhanced in 6G to make efficient interaction among the more number connected devices. The mobile devices can support 500 km/h in 5G whereas in 6G the speed is increased to 10 devices/Sq.m. so that M2M(machine to machine) interaction is possible with 100 times more reliability than 5G.

Energy-Efficiency

The most important parameter to be taken into consideration is energy. As 6G technology includes big data for processing huge volumes of data, Artificial intelligence in networks requires more energy. Hence there is a need for harvesting, charging, and conservation of energy. Integration of energy computation, communication, and harvesting solve the energy constraint. The smart devices proposed can also harvest energy to their needs. One such advantage is the utilization of artificial intelligence in 6G to reduce the consumption of energy in the network because these AI algorithms are low compute-intensive and require less power.

Capacity

6G enables huge traffic since it connects billions of smart devices which will reduce QoS. To overcome this issue capacity is a big challenge that can be overcome by enhancing bandwidth, the efficiency of the spectrum as well as reusing of the spectrum and network node density. By enhancing the above parameter the network capacity will be increased. The efficiency of the spectrum is enhanced by implementing a new modulation technique (Matinmikko-Blue et al., 2020). In 6G networks, Orbital angular momentum (OAM)(Kalsoom et al.,2020) is a proposed resource for modulation. The next parameter is node density which refers to the deployment of nodes in the region in such a way as to reduce the load of the mobile nodes.

POTENTIAL TECHNOLOGIES

In this section, the important technologies associated with 6G communication networks are discussed.6G technology improves the performance of many devices connected which includes drones, robots, smart home devices, and smart displays. It also enables to easy use of devices like AR glasses and VR headsets.

Artificial Intelligence

The ultimate aim of the innovation of 6G technology is to add the real-time applications of AI. Huge data collected through various connected devices will enable telcos to embed AI into a different range of networks and services.6G technology uses OpenRAN technology to provide a personalized network experience to the users. 6G technology expects a peak rate of 100 Gbps and it extends up to 1 Tbps whereas the latency level attained is 0.1 ms to satisfy the future needs like holographic service, digital replica, etc.

Analyzing the 6G Technology

The role of AI is considered as distracting technology that laid as the foundation of 6G design and includes all the flexibility as in 5G. AI and ML together utilized to monitor the characteristics of the radio environment to optimize various networks functions. Let us consider one application that AI-based beamforming decisions made to enhance the utilization of spectrum and various fuzzy logic algorithms are formed to handover decisions. Some other options include MIMO precoding, channel coding, and channel estimation. Industries in most of the countries have started to adopt the 6G with its features by doing various research (Stoica & de Abreu, 2019; Letaief et al., 2019).

IoT

IoT refers to the Internet of Things which is an interconnection of various devices with the Internet. Advancement in Wireless communication leads to the applications of IoT in almost all fields. IoT pays attention to the future part of the Internet which provides users with all its needs in the sophistication of the future world using automation and intelligent operations of devices. IoT offers various features such as mobile broadband service, Low latency communication services, and also 5G services also (Alshari et al., 2020).

The services offered by IoT with 5G technology are with high throughput and low latency. But 5G doesn't satisfy all the requirements like intelligent service, autonomous service, etc. There is a need for more advanced services than 5G for applications of IoT such as robotic surgery, flying vehicles, etc. To satisfy all the needs of IoT applications 6G technology emerges. In 6G new form interaction such as holographic communication, Human-computer interaction, and five sense technology other than text, image, audio, and video available in 5G networks are explored. 6G technologies join hands together with IoT and will promote to introduce smart cities, smart homes, smart healthcare, Autonomous driving, and remote education. This is possible by linking cyberspace communication systems with the physical environment (Gyongyosi & Imre & Nguyen, 2018).

Quantum Technology

Quantum technology is an advanced technology in communication that utilizes the properties of quantum mechanics. Quantum mechanics refer to the collaboration of molecules, atoms, protons, and electrons (Gyongyosi & Imre & Nguyen, 2018). The application of such technology leads to the production of devices and systems such as ultra-accurate clocks, medical imaging, and quantum computers. Researchers attempt to connect quantum computers with their idea on various sensors and the internet which leads to the evolution of quantum Internet (Zhang et al., 2017).

Quantum Internet starts its evolution in 2018 and deployed a Pan-European QC infrastructure that makes quantum cryptography to protect data as well as the transfer of information between different countries. The main important service provided by QC is an increase in channel capacity and introduces various multiple access technologies. The quantum computer fixes its role in applications like coding of channel and estimation, routing localization, load balancing, and multiuser transmissions (Dang et al., 2020).

Blockchain

The recent digital world leads to the introduction of the next important trending technology is Blockchain. Blockchain brings changes to many industries, banks. The main concept is promoting business by providing features such as trust, security, autonomy, and transparency to all the stakeholders of that business (Raja & Jamshed & Pervaiz & Hassan, 2020). Blockchain produces tremendous innovation in the telecommunication field (Strinati,2020; Berardinelli,2020).

It automates the smart contracts in Ethereum by generating automatic code words and also it automates billing, accounting, SCM, and roaming. Fraud-level traffic is blocked by this technology so that it saves bandwidth. Blockchain technology can able to support the 6G technology by providing new digital services. It can able to give solutions to a problem that arises in spectrum management and also it solves the energy constraints.

Not only this it also integrates IoT to provide mind-blowing innovation i.e. Tactile Internet which integrates M2M and H2M communication. Tactile Internet is also termed as Internet of Sensors (Hewa et al., 2020). This type of network offers good performance with low latency and extremely high security and reliability.

The innovation in IT fields also touches the healthcare to produce innovative and human-friendly products and applications. Blockchain, the Internet of Things (IoT), and the Cloud are the recent technologies in the field of Information Technology which is used in healthcare which makes the healthcare center function independently and provides better treatment for the patients. IoT plays a vital role in the healthcare industry by connected healthcare, remote patients monitoring, and alerts passed to doctors. Blockchain and cloud technologies provide additional security to medical data. All the healthcare organizations are shifting towards cloud technology to improve information security management, efficiency, and advantages over other technologies.

KEY PERFORMANCE INDICATORS

In 6G technology, there are a few parameters are termed as Key performance indicators (KPI) and they are as follows.

Peak Data Rate

This implies how fast the communication serves. The data rates are increasing day by day i.e. from 1G to 5G networks. There is a need for certain standards and communication protocols to accommodate such high data rates so that downloading process happens in a few seconds.

Mobility

Handoff should occur without any disturbance. Data sharing may happen anywhere in mobility either in airplanes or trains. The standard should support such high data rates which are greater than 1000Km/hr for 6G.

Massive Connectivity

Domain where IoT enables M2M communication where humans are not needed. The Messages are passed from one machine to other in terms of command. The new generation networks should accommodate as many devices to be connected.

Area Traffic Capacity

As massive connections are possible there is a need for an increase in channel capacity to overcome the traffic. This massive connectivity also leads to the development of autonomous vehicles known as (V2X) vehicles to infrastructure. The vehicle needs to interact with another vehicle, with pedestrians, and many other sensors installed in the vehicle. The communication requirements so far discussed are extremely reliable and with low latency and security. The minimum area traffic capacity limit for 6G is 1000Mbps/m² [28].

Extremely-High Reliability and Low Latency with Security (eRLLCS)

High reliability with low latency is possible if processing delays of packets are less. The 6G enables applications like intelligent robots smart cities, smart homes, smart industries, and online games all require high reliability and low latency. This is accomplished by integrating mMTC and URLLC in 5G to greater reliability more than 99.999%(Xua & Klainea & Oniretia, 2020; Series, 2015)

A QoS-Aware Spectral Efficient Network

Future 6G enabled applications like intelligent robots smart cities, smart homes, smart industries, and smart hospitals all require high spectral efficiency. When the data rate is increased then there is a need for high bandwidth which results in scarcity of wireless spectrum.

Energy-Efficient Network

Energy is the most important constrain where all the autonomous robots and devices will operate with high power. There is a need for a continuous supply of energy without any break in those applications. More research is going on in implementing such an energy-efficient network.

APPLICATIONS OF 6G

Multisensory XR Applications

XR stands for Extended Reality (XR) which falls like an umbrella covering the entire computer extended reality functions. The function of extended reality includes AR, MR, and VR.XR comes under different terminology.

Augmented Reality (AR)

The process of doing enhancement to the real-world objects by using computer features or else sensation derived. Examples for AR are Face filters on Instagram.

Virtual Reality (VR)

VR can be defined as a complete-sensory simulation of the real world by using various wearable like headsets and hand gloves so that the user can feel as real in simulation.

Mixed Reality (MR)

MR is the combination of VR and AR. An example of MR is a hologram of a person in a meeting room.

Immersive Reality (IR)

IR is the creation of XR reality in a way the persons can feel it as a real one and cannot feel the difference.

Normally all the real, as well as virtual environments generated by wearable devices and computer graphics, are Extended reality. The XR needs to provide a multisensory application which is possible in 6G. XR technologies explore to incorporate smell one of the sense of human beings into the user experience. Such innovations can be found in devices like face masks. Olfactory Virtual Reality (OVR) Technology is used to create such innovations by using various optical engineering algorithms (Sliwa & Falkenberg & Wietfeld, 2020).

Connected Robotics and Autonomous Systems (CRAS)

Robots normally evolve from stationary devices and it does manufacturing tasks to the mobile, information collection, computing, and decision making. CRAS not only includes robots but also drones and driverless cars. The ultimate aim of CRAS is to promote industrial operation through robots. If the industry gets automated the production will get improved and labor costs will get reduced (Series M, 2015)

E-Health and Biosensors

The innovation of biosensors helps doctors and patients to monitor their health of patients. In case COVID-19 the virus is detected by the development of biosensors. Biosensors are medical devices termed as diagnostic tools for disease detection. More efforts are put into finding intelligent biosensors for all categories of health care actions. There is a need for nanotechnology devices for applications such as biosensor-based diagnostics purposes.

The healthcare devices are equipped with various sensors and connected to the Internet for patient monitoring. Such healthcare tools provide support to all for better health. Bio-sensing based on MEMS approach investigates Nanoparticles in terms of Nano-toxicity it also includes investigation in cell physiology in terms of exposure of external factors such as inhalation of pollutants particle and viruses. In biomedical applications, various biosensors are used for optimizing nanoparticles based on advanced chip technology (Xie et al., 2020; Ma et al., 2015; Zhang et al., 2019). IoT Data Transfer and Automation

Analyzing the 6G Technology

is one of the new emerging technology for such sensing strategy. It consists of sensors, cyber systems, and cloud computing with IoT.

Holography

Holography is a technology that records and reproduces 3D images based on interference and diffraction principle. In medical applications, it is used for remote surgeries by doctors and teachers for remote classrooms (Li R, 2018). 6G uses holograms in health care as a communication medium, emotion-sensing wearable devices will be the future building blocks of wireless networks. The perfect holography technology enables us to view objects in the naked eye and if needed headset or AR/VR technology can be used. Based on 6G this technology will be integrated for various applications such as telemedicine, communication, and games.

Brain-Computer Interactions (BCI)

BCI is a system to measure the central nervous system of humans and transform it into artificial output that restores, enhances, replaces, or improves the output and changes the interaction between the central nervous system and environment (Henbest, 2013; Moro-Aguilar, 2014; Hassan & Hong, 2019). One best example of BCI is mind-controlled drones developed by RAND Corporation. Future communication technology can support more research in BCI and uplift to the next stage.

Communication in Space and Deep Sea

The most interesting application is traveling to space by Humans. Not only is this unbelievable target there to launch hotels, hospitals in space (Scott & Stevenson & Lupa, 2012; Rüßmann, 2015). 6G technologies make this true by expanding its services throughout the globe by replacing intelligent and autonomous robots. Exploring oils and minerals around the globe is the next innovation in communications.

Robotics and Automated Vehicles

Most of the industries planned to build completely automated machinery for easy operations and maintenance. Such automated machines need to organize themselves by including different processes such as NFV, IoT, cloud, and slicing. 6G technology put hands together with this technology to promote industrial automation. Automation and robots reduce the workload of humans to a great extent and the main contribution is by Robots, Drones, and autonomous vehicles which help the process, operations, and maintenance process in cost-effective, highly reliable, and efficient way (Lu et al., 2018; Wollschlaeger et al., 2017; Sliwa et al., 2020).

Blockchain and Distributed Ledger Technologies (DLT)

One form of DLT is Blockchain which is needed for the Internet of Everything. The role is to transfer ownership, record transactions, track assets, and ensure transparency, security, and trust. Blockchain is distributed in nature and it is of the immutable ledger. In spectrum management, the blockchain records the required information. Information from sources like records of spectrum access history, spectrum

sensing outcomes, and auction results of the spectrum is made available to the users (Nguyen et al., 2020; Manogaran et al., 2020; Sekaran et al., 2020). Blockchain together with 6G enables to monitor the networking functions to share resources efficiently.

Accurate Indoor Positioning

With the development of IoT and 6G, indoor location-based services are possible.

6G technology enables the indoor positioning services more reliable when compared with 5G technology. An outdoor positioning system is also developed accurately by using GPS.

Tactile Communications

This is a new form of communication in nonverbal form. It is a type of body language to convey the message from sender to receiver. This type of language includes actions like touching, handshaking and kissing. A touch-based system is developed for communication by deaf and blind people with humans and robots.

IoNT

IoNT refers to the Internet of Nano-Things connecting small devices of an interrelated system to transfer the data. More number of nanotechnologies are integrated with IoNT and used for different applications. Example of such application includes monitoring of temperature, measuring the humidity range and water quality can be detected by IoNT devices (Pramanik et al., 2020). Just like IoT, IoNT can also come into use for most applications as early as possible.

Consider IoT smart home applications, Fire caused in a home can be detected early by using IoNT and it will alert us by sensing the nanoparticles. Thus the IoT applications can be enhanced further to great extent by using IoNT. Thus sensing of nanoparticles is done by Nanosensors not by normal sensors available now. A few other examples where Nanosensors are used for smart applications are it is used to track the movement of animals on the farm which helps the farmers to locate the movement of animals for grazing. It also tracks the growth of plants, crops, and trees. It is mainly used to detect viruses that cannot be detected by normal sensors like coronavirus too. Then Nanosensors are also used to detect the temperature of living cells in the human body (Mohsan et al, 2020).

Intelligent Internet of Medical Things (IIoMT)

IIoMT is an area to connect the medical devices and applications to the health care networks to transfer the data over the network. This technology reduces the burden on patients as well as doctors. 6G provides high-speed communication for IIoMT to help remote doctors including holographic communication, tactile communication, and AR/VR to assist remote doctors (Habibzadeh et al., 2020). Employing mobile hospitals, ambulance services can be taken back. Future applications include designing specific medical devices to perform particular tasks so that doctors can avoid direct contact with harmful viruses.

REQUIREMENTS OF 6G-IOT

To move successfully to 6G intelligent massive device connectivity and coverage and autonomous system by 2030 there is a need for some advanced powerful requirements which are listed as below.

IoT Connectivity

IoT connectivity drives the development of smart mobile devices and the fast development of wireless technologies (Singh AP & Nigam S & Gupta NK, 2007). Mobile traffic all over the world can grow exponentially and in the year 2030 it is expected to cross 500 Exabytes (White Paper, 2019). The traffic of mobile phones will also get more than 80 times in 2020.

In the future, various sensible devices need large-scale communication which is accomplished by combining broadband platforms along with satellite platforms which are enabled by low earth orbit satellites (Singh AP & Nigam S & Gupta NK, 2007). UAVs are also required to support this property over the longer-term large-scale IoT networks wherever mounted base stations cannot manage to ensure stable and reliable device communications in moving IoT networks. For instance, a distributed UAV preparation prototype is given by Holma H & Toskala A, & Reunanen J (2016).

Ultra-Reliable Low-Latency IoT Communication (URLLC)

URLLC has been introduced and implemented in 5G-based IoT applications (Al-Dulaimi A & Wang X & Chih-Lin I, 2018) and should be developed to further support applications in 6G-IoT organizations, for example, fully independent IoT and flying IoT frameworks. For example, in the future private transport agencies, where vehicles are self-regulating and continuously monitored, large URLLC is critical to sending video care from cameras to cars and organizing traffic on computerized and secure roads way.

In the future, the efficiency of data transfer will be greater involving a savvy connected community where the visible web will dominate to provide haptic connectivity to IoT strategic managers through ongoing communication and promotion. As a case study, the work done by Mourad A et al., (2020) created IoT entertainment based on the URLLC of large 6G IoT organizations by setting up short accessibility and limited communication cycles of more than 0.1 ms. -10-6.

The thick IoT state is considered for up to two gadgets per m² using a range of GHz range to provide maximum local support. By directing a feasibility study to a less sophisticated framework, it is found that the process length is x10 more limited than the idle focus of 5G radio design used imaginatively in future low-density IoT systems such as independent driving, continuous health monitoring, and modern equipment.

Improved 6G IoT Communication Protocols

The introduction of the latest vertical IoT applications on smart networks in the future puts major headline changes on current mobile networks to simultaneously support the spread of solid needs. In such a situation, network connectivity standards and agreements play an important role in the use of the 6G IoT ecosystem to a large extent due to its integration with important computer resources such as edge/cloud computing and wireless technology. For example, the Business Specification component of the Telecommunications Standards Institute has launched an initiative called ETSI Multi-access Edge

Computing(Viswanathan H & Mogensen PE, 2020), which aims to develop a computer-based and seamless network of IoT-based applications from vendors, developers, and third-party service providers. This step could be a major step forward in preparing for future IoT applications network brings the 6G network closer to where IoT computer and storage square measure is expected to be removed from the network center to the edge of the network.

Recently, the active IEEE 802.11 team began discussions on the next cathartic generation. For standard Wi-Fi, enhanced as IEEE 802.11 be high output, which can meet the long-term requirements set for future IoT applications during the 6G period. This square measure of communication levels is expected to positively support service providers in deploying intelligent IoT resources at the end of the network.

Extending Coverage of IoT Network

Within the future IoT-based society, artificial intelligence and UAVs are the keys to accomplishing complete wireless insurance wherever the previous is ready to deliver self-sufficient and intelligent answers on the network edge, while the latter may be accustomed build flying base stations to grow the insurance of current cellular networks from solely second in present terrestrial networks to three-D in an incorporated terrestrial-satellite-aerial gadget.

In an upcoming IoT-based community, it is charming to reap full coverage on the long way terrestrial networks, from victimization big-dimensional area-air floor-underwater networks. Edge intelligence and UAVs are key to accomplishing complete wireless coverage wherever the first one is ready to provide independent and intelligent solutions at the edge of the network, and the latter will become accustomed to building flying stations to expand coverage of current mobile networks.

For example, high-altitude UAVs will be used as aging platforms to address much-needed offshore coverage (Yang et al., 2019), as a promising solution for secure coastal-based ports primarily to facilitate the marine communications infrastructure. To provide coverage where distributed vessels are needed, UAVs have been integrated to upgrade near vessels to make certain long-term broadband services. Here, an oil-powered fixed-wing UAV was adopted which could make 740 clicks in the coastal area with approximately 370 clicks. Once the information transfer mission has been completed, the UAV flies back charging station and continues to provide the next-to-ship user online. This communication pattern is unique from traditional UAV networks wherever the IoT user area unit is usually connected or has random distribution.

Futuristic Smart IoT Devices

6G-IoT networks in the future are expected to trust good devices wherever edge intelligence and computing are accomplished at the devices. Various challenges are imposed on the operations of wireless communications and implementing a device-centric network will help to a great extent mainly in network management. Such a wireless solution enables device-to-device communications or multi-hop cellular networks that square measure parts of the 3GPP roadmap (Stoica & Abreu, 2019).

Within the 6G innovation, every IoT device will act as an end-user terminal which might give connectivity and services to various devices at the network side without the need of a centralized controller (Loven et al., 2019). Then further extension is done to demand-driven networks to support different users as well as different services. It also supports different network demands which include a decrease in energy level and increases in the spectrum at the end-user side. Further action is in smartphones which

changes day by day as per the user requirements. It undergoes various updating functionalities by the use of IoT applications.

RESEARCH DIRECTIONS

In this section, a discussion on the deployment of 6G networks is done to find the research gap to be solved in the future.

Hardware Complexity

Futuristic mobile networks will integrate more devices that require variable packet sizes to be transmitted but previous networks support fixed-length packet size of data for transmission. Hardware complexity and processing time will get increased in case of variable packet size. The bandwidth range covered by the 6G communication network ranges from 3GHz to 60 GHz. For processing such data multiple RF filters are needed which would increase the size of the chip and hardware (Taleb., 2020). More research can be done to overcome the problem of designing hardware networks to accommodate futuristic needs.

Variable Radio Resource Allocation

The next important challenge is frequency propagation. Since the QoS requirements are variable then radio resources are to be assigned on demand. Due to the propagation of frequency, there is a possibility of high penetration loss in 6G. There are more obstacles for the frequency to penetrate walls and houses. Research can be done to develop fast and stable algorithms for this variable resource allocation to be done perfectly.

Designing High-Performance Circuits

Considering latency-fault-finding circumstances in the way that made or done by machine cars and healing/health putting a substance on another, the communication needs expected skilled inactivity in less time of involvement. Such circuits will try to satisfy the latency of various time seconds exists. Henceforth to attain low latency as well as more reliability, it exists the power to cultivate the needed processors with less capacity.

Preemptive Scheduling

In the case of a wireless medium of communication, there exists a node that provides the required level of radio resources based on the importance of needs (R. Lin et al., 2010). Normally 6G wireless networks attempt to connect more devices by assigning a value of priority to all the devices and also maintaining the requirements for packet delay and delays. 6G will be a real challenge.

Unified Existence of Multiple RATs

Through the availability of expanded interfaces, 6G networks can include diversified RATs. 6G networks join hands with some other additional technologies such as Wi-Fi, Bluetooth, IoT, and sensor. To implement such a dynamically changing networks airwave communication is adopted which is still undergoing invention. The idea point to be considered here is to guarantee interoperability parameters when the intersection of KPI happens.

Security and Privacy

IoT devices are emerging day by day and all devices include IoT as a part of their application. Henceforth security and privacy issues may arise. Mainly in health care applications data confidentiality is needed. In the case of other devices, safety measures are required. The next main attack is DDoS which is the most common that requires security and trust in the network. In 6G the security in those areas is still a challenge which expects more solutions to overcome and to sustain in the global market.

CONCLUSION

Wireless technology brings unexpected changes to the modern world and it goes on evolving its version. Few worlds are in the progress of deploying 5G technology while few countries are researching 6G the next generation technology which has sparked the interest of the industry to make the comparison of older generation networks. 6G technology puts its role in almost all applications. Blockchain, IoT, and AI form building blocks of 6G. The architecture of 6G relies on the above-said technology. Among them, the various openings provided by 6G technology which join hands with IoT in various applications are also stated. Communication is focused on almost all areas from homes, people to the industry. 6G technology provides reliable, safe, secured, and holographic network infrastructure. Various new technologies like VLC, tactile and holographic communication are explored. In this chapter, an analysis of 6G technology along with various parameters are discussed for future development.

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Analyzing the 6G Technology

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Chapter 4

6G–Based Mobile IPTV Using Adaptive Hybrid Transmission

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ABSTRACT

The arrival of the 6th generation (6G) technology will revolutionize the digital transformation of society. It offers speeds of several gigabits per second, with small latencies less than 5ms, ultra-reliable transmission medium, while it is able to handle a huge quantity of nodes simultaneously connected to the network. 6G will be accepted for commercial launch within 10 years. 6G will be industrialized in retort to progress the dispersed radio access network (RAN) and longing to use terahertz band to increase the number of users. On proposing an adaptive hybrid transmission (AHT) arrangement about 6G with mobile internet protocol television network (MIPTVN), the proposed algorithm uses a hybrid mechanism. The AHT mechanism is the combination of the multichannel multicast and unicast process which increases the service over service probability of blocking the service and reduces the overall bandwidth consumption of MIPTVN on demand over 6G.

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INTRODUCTION

By the necessity of internet-based requests raises everywhere in the universe, IPTV proposed by (Soohong Park et al., 2008) become more famous & committed to transferring multimedia data with clients when needed data in all the aspects. In Internet Protocol Television (IPTV), mobile handling users the person who have any kinds of Internet Protocol (IP) devices they can get the video content whatever they needed where ever they are discussed by (S. Ando et al., 2015). IPTV can be adapted to wireless and wireless networks with considering to mobility device called mobile IPTV considering relevant technical problems. With the mobile IPTV, receivers can use IPTV services whatever they want and wherever they are using the Internet Protocol address. Recently, ITU-T FG IPTV is at the front head of IPTV standardization. This helps out the IPTV content provider to consider the technical issues and obstacles while providing the service to the users. On the other hand, an application was designed and developed with multimedia content over wireless communication that becomes an emerging technology. It has involved much attraction with the convergence of broadcasting according to (J. W. Wong, 1988) and networks IPTV, a broadcasting facility utilizing Internet Protocol (IP) network are famous in emerging professional methods. In addition, an IPTV requirement with cable-less service is increasing proposed by (L. S. Juhn & L. M. Tseng, 1998). Today, widespread IEEE 802.11 technology is available with cable-less networks for the preceding mile influences, which is promising for the delivery of IPTV.

On the theory of telecommunication standardization sector ITU-T IPTV service provider scenarios, Video-on-Demand (VoD) service is defined that it is a video service that allows the end-users whatever they want where ever they are at any point in video time. The end-user has full control over the video content that the user wants to watch and at which point of the time the user wants to watch the video content. Video content has to be provided with metadata content and with content protection by the service provider to the user. The service provider transfers the video content according to the agreement which deals between the content provider & service provider. When end users request a particular video, the service provider checks whether the video content is already transmitted through the multicasting method. If it is already transmitted through the multicasting method the service provider finds the multicast address and joins the new request client to that particular address. This method may add service negotiation with the customers. If the particular video is not transmitted through a multicast group the service provider transmits the particular video content through the unicast method. If the particular video receives more requests after a certain period the video content is transmitted from unicast method to multicast method. The video is transmitted through the unicast method or multicast method is based on the service request rate of the particular video proposed by (W. T. Wong et al., 1995)

MEDIUM ACCESS CONTROL PROTOCOL

The second layer of the OSI model is the data link layer. The main purpose of the data link layer is to transfer packets from one node to another node. Additional responsibilities of the data link layer are framing, error control, flow control, access control & physical addressing. Framing is the process of dividing the huge data into small manageable data units. The data link layer can be divided into two parts. The first part is Logic Link Layer (LLC) & the second one is MAC discussed by (Thanzeem Mohamed Sheriff et al., 2021). MAC layer regulates & controls the medium which is shared by more nodes. MAC deals with the hardware & control of the medium. This link or medium which controls the shared nodes

may be wired, twisted pair cable, optical cable, or maybe wireless. The main purpose of the MAC layer includes delimiting and identifying the frame, addressing targeted stations, accurate data transfer of LLC, avoiding errors, and control of access to the physical transmission link. Owing is the process that plays an evil role in the MAC layer. MAC layer should adopt the network if the load is increased highly. It must reduce the congestion control in the network. On the other hand in case of sudden overload in the network, energy will be wasted. For energy efficiency, the MAC uses dynamic power management. Dynamic power management works in the mode of active, idle, and sleep mode. Whereas power time management is a modification of dynamic power management, in which the device is put into sleep mode to consume less power. A sensing node is kept in the network for sensing the frame. Based on the sensing output the power time management may go to an active mode or sleep mode. Due to this switch operation, consumption of power is very less. The duty cycle defines the fraction period the system completes on condition. In MAC the duty cycle operates in on/off conditions. Due to that, we can avoid idle listening so that we can reduce power consumption. If the nodes connected to the medium have a separate individual link then there is no necessity for MAC. But when the nodes are connected to the medium which shares a common link then there is no control in the medium.

Each node thinks that the medium is free and starts to transfer the packets. If each node thinks that the medium is free and starts to transmit the packets there is a chance of congestion in the network. To avoid congestion, MAC layer is used. MAC layer checks the medium whether the medium is free or not. If it is free MAC layer allows a system to transfer the packets. Till that the other nodes are not allowed to transfer the packets. Once the first eligible node is complete is transmission MAC layer once again checks whether the medium is free. After the confirmation of the medium MAC layer allows the next node to transmit the packets. This process repeated continuously. With the help of MAC, we can avoid the congestion in the common medium which is connected by more nodes.

More reliable multicast MAC protocol is suggested recently. A slight development is there for MIP-TVN with resources allocation. The main objective of this chapter is to create novel resources provision schemes for MIPTVN that increases the possible quantity of clients similar to (Vijaya Raja et al., 2011). To propose Quality of Service (QoS) for a definite IPTV facility, the Television watching features of clients are examined by choosing an assorted MAC procedure with a multicast facility. On analyzing the numerous IPTV facilities, the Video-On-Demand (VoD) proposed by (Tseng et al., 2002) facility, that propose viewing designated audiovisual at any moment using cable less network admittance. Since clients choose to admit gratified on-demand, more secure methods of VoD proposed by (Xiangyang Zhang et al., 2010) facility are intended to transfer audio visualizing unicast scheme to encounter in all aspects of required faces. From a system point of view, it is humble and the whole thing operates well when the capacity is sufficient and the number of facility requests is abstemiously little. Though, if audiovisual needs are high, when the well-known content, the huge count of unicast brooks for the similar gratified is conveyed through network discussed (Jose Anand et al., 2011).

VIDEO ON DEMAND SYSTEM

Result because enormous disorganization of together media server and bandwidth ingesting of the cable-less scheme that has incomplete source associated to the reinforced network. For mobile VoD according to (Tseng et al., 2002) facilities the holdup is observed in cable-less entree networks slightly than multimedia servers. To overwhelm the drawback, the AHT scheme is proposed that is a joined process

of unicast and multicast communication. Video content required is communicated through the multicast method, and unpopular video is communicated through the unicast method. Action on what video content is transmitted by multichannel multicast is concluded by the projected adaptive reserve distribution technique, which leads to the lowermost likelihood of blocking according to (S. N. Dhage et. al., 2014).

The VoD process is divided into True VoD (TVoD), worked with the unicast process, and Near VoD (NVoD) worked created on either broadcast or multicast process similar to (V. Vijaya Raja et al., 2011). In TVoD the services from server to each user dedicated transmission channels obtained. So that the user can receive video content without any late through dedicated channels by their Vapor Compression Refrigeration (VCR). This may easily run out of the transmission path, the channels can never grow the number of customers. In an additional way, in NVoD users have to delay a certain period due to the video data being transmitted through multicast on multiple stations with a periodic series. Broadcast contras mission channels are based on the permissible users to come minutes, not the count of needs. So the method is further suitable for high request content video which may be proposed by numerous spectators at a convinced amount of period. The popularity of the video object access model is precious to deliver the contents of video effectively. So that dissimilar videos are asked at various rates at various times. Video contents are split into most general and less popular video that needs top 05, 10, 15 videos that contain 70 to 90% of the overall request. This is critical to recovering the facility efficiently of most popular videos discussed by (N. F. Mir, et. al., 2011).

At present numerous NVoD processes have been applied, which kind that the staircase broadcasting, harmonic broadcasting, and staggered broadcasting according to (L. S. Juhn& L. M. Tseng, 1998). This process can differentiate into three methods to deliver NVoD facilities, as broadcasting, batching, and patching according to (L. S. Juhn& L. M. Tseng, 1998). In Batch, the approach gathers the requests from a group that arrives some period and gives on one transmission station. In the patch, the video appeal is first provided by a unicast scheme and then merged into a multicast scheme. On the other hand, broadcasting, the video is broadcasted in regular intervals with the dedicated transmission channel with a pre-defined process similar to (K. Cleay, 1995). The main aim of the VoD process is to improve the overall efficiency of transmission service by solving the drawbacks of concentrated demand and irregular spurt demand. As the outcome, owing to the broadcast features, NVoD is better able to take over unrestricted access to users with a broadcast situation. The on-demand multicasting is suitable for the IP-enabled network with efficient congestion control with perfect options over the cable-less networks according to (V. Vijaya Raja et al., 2011).

The overview of the existing VoD system has to be improved by its characteristics for the 6G technology similar to (N. F. Mir et al, 2011) On basically, the VoD system can be split into True-VoD where it follows the operation of the unicast method. The NVoD system follows the operation based on broadcast or multicast transmission. The TVoD system is based on the reservation-based protocol according to (Thanzeem Mohamed Sheriff S., et. al., 2021). The system reserves dedicated channels for the client. When the users request the channel the system transmits the video content data through the dedicated channel through VCR. On the other hand, it is possible for the channel shortage because the number of channels cannot be increased when the service request rate is high which is requested by the end-users if it is multicast over several channels with a periodical cycle. The broadcast channels are based on the waiting time of the users and it is not based on the number of service request rates by the end-users. This approach is more suitable for most popular videos which have a high service request rate. The popular video and unpopular video are based on the request rate of end-users. If a video has a high service request rate it is assumed to have the most popular video. If a video has a low service request rate it assumes

has an unpopular video. Based on this process the system determines the effectiveness of video content delivery. Different videos are requested at different times. The videos are divided based on the service request rate. If it has a high service request rate it considers has high popular or hot videos. If it has a low service request rate it considers has low popular or cold videos according to (P. Sumari et al., 2002). The most popular videos are transmitted through TVoD which is based on the reservation-based method. The less popular videos are transmitted through the NVoD method similar to (S. Ando., et. al., 2015). At present some of the NVoD methods have been proposed, for example, staggered broadcasting, pyramid broadcasting, fast broadcasting, staircase broadcasting, harmonic broadcasting, etc. This process can be divided into three main methods to achieve NVoD methods, such as batching, patching, and broadcasting. Batching is a method that collects a group of service request rates for a particular time and closes the time loop are served them all together with the video content. Patching is the combination of both unicast & multicast streams according to (L. S. Juhn & L. M. Tseng, 1998). According to the low service request rate first, it transmits the video content in the unicast method. After a certain period when the service request rate becomes high it switches the transmission from unicast to the multicast method. Broadcasting is the predefined method. It transmits the video content periodically and continuously. Moreover, all the VoD system tries to provide efficient and real-time video service and try to avoid burst and congestion problems. Due to this, the VoD system tries to increase more number of users with the limited capacity proposed by (P. Sumari, et. al., 2002). The AHT schemes are combined of True VoD which implements the unicast transmission and NVoD which implements multicast transmission. The more popular video hot content is transmitted through TVoD and the less popular video is the cold content transmitted through NVoD schemes. The VoD system is divided into NVoD and TVoD based on their operation of unicast & multicast schemes proposed by (W. T. Wong, et al., 1995).

MOBILE IPTV VoD SERVICE SCENARIOS

On the basics of IPTV service scenario VoD process states, are filters as end clients to pick and watch video content where ever they are and whatever they want. The end client is high switch over selecting that video or clips to timepiece and deciding which position to guard similar to (A. Yarali, et. al., 2005). A recommended mobile IPTV facility model for MIPTVN.

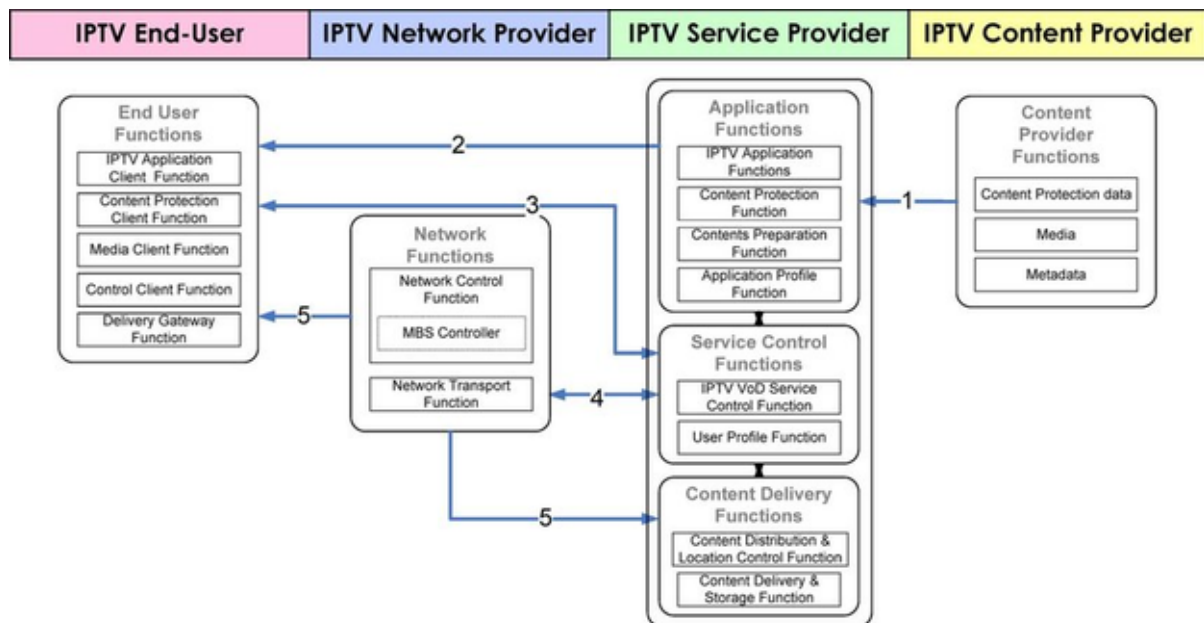
- The video with its data and the security data developed and achieved by the video gratified supporter are transferred to the facility supporter.
- The facility earner makes the video as per the request among the video contented supporter and the facility supporter.
- On the other hand, the end client chooses a VoD material the requests are delivered to the service supporter and verifies that the demanded video gratified is previously transferring by multicasting proposed by (N. Bhuvaneshwari & A. Aryaputra, 2013). If it exists with the multicast process, the server transfers the video through multicast discourse and the users are adding to the multicast process according to (S. Park, et. al., 2008).
- No multicast process for the content, the facility supporter contacts with the network supporter and verifies with the reference threshold value through another new arrival rate from IPTV VoD control function – to choose the video is a more requested video content or not. At this moment the video has not had a number request rate then it is transferred through the unicast scheme.

6G-Based Mobile IPTV Using Adaptive Hybrid Transmission

This process adds the resource registration to authorize the thin facility-level according to (N. Bhuvaneshwari, et al., 2013).

- After completing stage 4 the facility supporter provides the contented authorized information example: multicast addresses which will be used to transfer the video content proposed by (A. Panchihewa& A. M. De Silva, 2010) and the end client can obtain the content as shown in figure 1.

Figure 1. Service scenario for mobile IPTV VOD



IPTV is an upcoming emerging technology that plays an evil role in wireless communication technology. It will be useful to the business model users & it will be emerging technology in the market. The success of mobile IPTV will depend on its characteristics & the nature of IPTV which the user can receive the video content whatever they want & where ever they are according to (A. Yarali & A. Cherry, 2005). Moreover, the success depends on a large capacity, mobility, & content provider who provides the video content, a service provider who connects the content provider and the end-user. Moreover, the content provider deals with an agreement to the user, and according to the agreement the user will receive the service. The business model of IPTV provides a guarantee, service providers' profit, and survival. The business model is based on efficient package and delivery of IPTV contents and services to end-users similar to (S. Park, S. Jeong & C. Hwang, 2008).

6G WIRELESS COMMUNICATIONS

The technology has started to move, fifth Generation 5G proposed by (Ashvin Gohal et al., 2013) communications due to the real-time requirements. Due to the drawbacks in the fourth generation, the

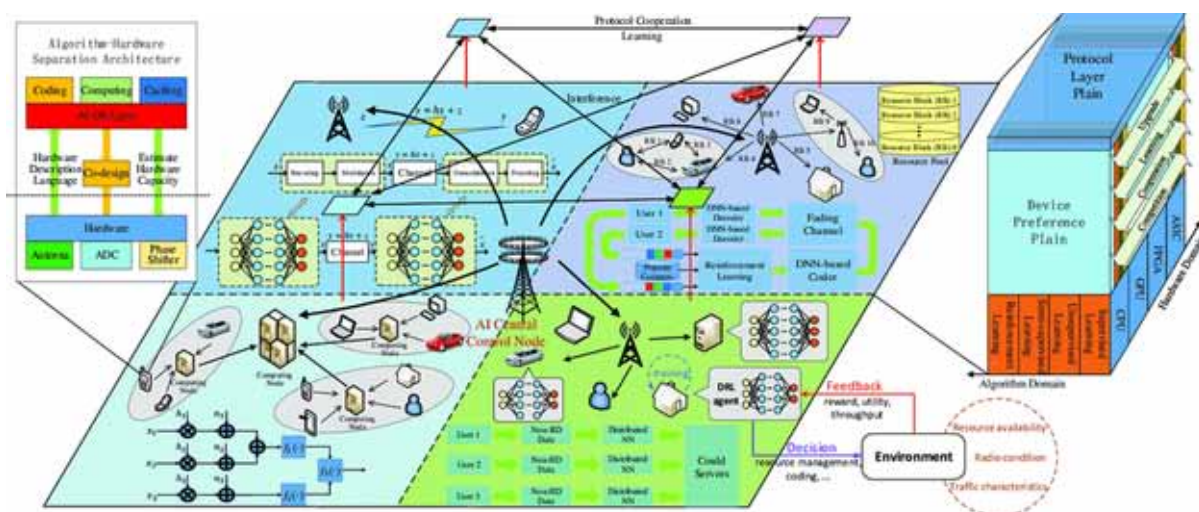
users started to shift to 5G. A new pattern was developed in cable-less information conveying system, 6G communication model with the provision of Internet of Things (IoT). The implementation of 6G in real-time is expected in 2028 around the world. On focusing on 5G characteristics some basic issues which to be considered in next-generation are improved user capacity, increased data rate. Moreover the increased security and improved QoS compared to the 5G system structure. 6G assists artificial intelligence, free-space optical communication technology according to (Do Eun Cho & S. Yeo, 2011). Moreover, 3D networks, quantum wireless communications, cellular free communications, and also includes the integration of wireless content and integrated wireless sensing and communication system, dynamic net sharing, holographic big data. This parameter is contributing 6G style expansion as assuring the QoS as shown in figure2. Beyond the expected applications of 6G system requirements, more powerful possible technologies are presented clearly. On implementing 6G technology the focus is on trials and the exploration instructions for attaining the objective according to (B. O. Obele, et. al., 2009). The main benefit of 6G is that it supports the growth of numerous developing requests, such as AI, simulated reality process, 3D radio, and the Internet of Everything (IoE) which gives the path to the massive volume traffic.

The platform which needs 6G systems comprises are the following.

- Human-machine interfaces.
- The interface between local devices and the cloud.
- Various sensor data fusion
- Wireless Sensor technology to regulate automatically.

To achieve the objectives of 6G and to overhead the drawbacks of 5G, we focus on trials and research directions for achieving the goal. The 6G wireless technologies will overcome the lack of 5G schemes by developing novel ideas of upcoming platforms such as wireless detecting intellect and human-machine interfaces, introduction of AI and terahertz communication platforms according to (Harsh Tatria, et al., 2021).

Figure 2. 6G architecture



Moreover, it supports 3D interaction, quantum infrastructures, holographic technology, Intelligent Reflecting Surface (IRS), and active hoarding. The important terms of 6G are the collection of all the historical topographies. It includes net compaction, increased quantity, increased reliability, low power consumption, and effective connectivity according to (Harsh Tatria, et al., 2021). The 6G technology will carry the trends of the previous generation, moreover, it includes the new service with the adding of the novel skills according to (Md. JalilPiran, &Doug Young Suh, 2019). The novel facilities comprise AI technology, independent weapon, automation vehicles, calculating realism strategies, wireless sensor technology, and a 3D charting facility. The greatest challenge term for 6G wireless nets is the capacity of treatment of high data with high data rate.

The architecture of mobile IPTV VoD service over multiple base stations is complicated. The 6G standard defines two types of multiple base stations: single base station access and multi-base station access. On concerning, multiple base stations it includes an MBS zone in 6G similar to (G. Ramesh et al., 2009).

The base station can transmit multicast information simultaneously with the common Connection Identifier (CID) and Security Associate (SA), carrying MBS data in the same MBS zone. When all base stations are in the same MBS zone, they have the same Multicast CID (MCID) for the same MBS multimedia stream transmission. The multi-BS MBS does not require the Mobile Station to be registered to any Base station. The multi-Base Station access allows all Mobile Station to utilize common multicast connection Identity when handoff occurs in one MBS zone. Moreover, the Mobile Station can receive the MBS packets during the device is moving within the MBS zone according to (G. Ramesh et al., 2009). 6G standard defined criteria only for the physical and MAC layers, moreover to propose a design for the end-to-end which uses Internet Protocol data cast of video over mobile 6G. To accurately manage mobile VoD services, 6G has to include an extra functional entity namely an MBS controller, and the proposed Adaptive Hybrid Transmission mechanism is exploited here for the suitable control of the system. The functions of each entity in the proposed architecture are described in detail as follows.

The MBS controller operates on 7 functions: service explanation, membership management, Mobile Broad System zone management, MCID and IP address management, security management, session management/transmission, and content chopping as described in the following. Service Announcements: this function describes the types & names of the user and types of services available by the service provider. Popular content such as live sports, games, is transmitted through multicast channels using MCID. Contents ID, respectively proposed by (G. Ramesh et al., 2009).

Membership Management

This function authorizes the user to get the MBS services and activities. It describes what type of services are available, and under which scheme which user is activated. MBS Zone Management: The MBS controller provides an MBS program to more than two MBS zones, simultaneously each of which consists of multiple BS of a 6G network. Mobile Station that uses the simultaneous MBS channels in the common zone shares a single 6G multicast transmissions. So the MBS must have the awareness of congestion & interference when the data is transmitted through a common channel & common ID in a different zone. MCID and IP Address Management: The main objective of this function is to map between IP address & channel ID. By mapping the IP address & channel ID we can reduce the interference and congestion. The data can be transmitted effectively. Security: This service provides integrity, confidentiality, authorization to the users while transmitting the metadata zone. This function uses both

public-key cryptography & private key cryptography discussed by (Md. Jalil Piran, & Doug Young Suh, 2019). Session Management/Transmission: MBS controls the mobile station and provides the MBS services. If the user moves from one place to another device MBS uses the handoff process. Handoff's a process that transfers the control of a mobile station from one base station to another base station. The Mobile Station identifies each session by the channel ID and MCID. By using this channel ID the mobile station transmits each session of the video without any interference. Chopping: It is the process of switching a video content from unicast to multicast transmission proposed by (B. O. Obele, S. H. Han, J. K. Choi & M. Kang, 2009) When the service request rate becomes very high for a particular video content automatically, the content will be switched off from unicast to multicast transmission. The main function of the base station is to give connectivity to the users and control the subscriber station.

The mobile station is equipment that provides wireless communication between the user and the base station. The mobile station is assumed that it can have the storage and buffering option. So it can provide data delivery effectively without congestion and blocking probability. When the video content is switched from unicast to multicast, the multicast stream ID has given to the user. Then the user joins the multicast stream ID and receives the data through Near VoD method. The channel switcher creates the MCID according to the selected content and indicates the MAC layer & physical layer to decode the Mobile broadcast station associated with the selected Mobile channel Identification. After receiving the first segment S1, then the channel starts to receive the remaining segment concurrently. After receiving the entire packet the MS starts to decode the data according to the standard H.264/AVC video decoding. VCR plays the main role in this data transmission & decoding.

In the VCR function fast forward & fast-backward option plays an evil role in the VoD system. This function uses to choose the position of the video content. Moreover, it is easy to move from one position of video content to another position. In True which is based on unicast transmission, it is easy to provide VCR function. On the other hand in the True VoD system, it is very difficult to provide VCR function due to the characteristics of multicast transmission. In the VCR function fast forward & fast-backward option plays an evil role in the VoD system. More number of schemes have been proposed in recent years to reduce the difficulty in True VoD due to its characteristics of multicast transmission according to (Md. Jalil Piran, & Doug Young Suh, 2019)

In the proposed Adaptive Hybrid scheme it combines both unicast & multicast transmission. Meanwhile, AHT has to support the True VoD system for cool videos & Near VoD for the most popular videos. The cool videos and hot videos are divided based on the service request rate of a particular video. If a particular video has a high service request rate then the video has assumed hot videos and it is transmitted through Near Video On-demand which is based on the multicast transmission. If a particular video has a low service request rate then the particular video is assumed to have a cold video and it is transmitted through True Video On-demand which is based on the unicast transmission.

In multicast multichannel, each video is divided into N segments and the segments are transmitted to channels equivalently. Each terminal will receive packets equally. After receiving the segments it is important to arrange the packets in the order on the client-side. By using this mechanism several packets and several videos can be transmitted simultaneously to more users. Moreover, the client can join the multicast group the same approach should be used on the Internet or any multicast-capable routed network, e.g. within a site when content has to be broadcast to a large number of receivers. After receiving the packets on the client-side segmentation and reassembly is important on the receiver side. When the packet is divided before the transmission each packet is labeled with the segmentation number. During the multiple channel multicast transmission, each segment will travel in a different channel.

So reassembling packets on the client-side is necessary. By using the segmentation number the packets can be reassembled on the client-side. After reassembling the packets in order then the video content is transmitted to the end-user.

The new features have to be added to the VoD system due to multicast transmission. By implementing the Real-time Transport Protocol (RTP) for the multi-session transmission we can transmit multiple channel multicasting effectively. The major step forward for the next generation could be the combination of more than 2 transmission technologies such as TVoD and NVoD. The Adaptive hybrid transmission mechanism is a mechanism that is the combination of both unicast and multicast transmission. More popular videos are transmitted through multicast transmission & unpopular videos are transmitted through unicast transmission. More popular videos and unpopular videos are divided based on the service request rate of a particular video. Multiple channel multicasting transmission can be achieved through NVoD and unicast transmission can be achieved through TVoD.

The 5G beyond will develop further and increased in 6G. Moreover, the 6G technology will improve its performance and maximize user QoS when compared to 5G. It can secure the data and system and provide authentication. The 6G technology can fulfill global wireless communication. 6G systems are expected to provide 1000 times more wireless connectivity than 5G. On the other hand, long-range communication with low latency is predictable. The greatest supporting facility of 6G is Artificial Intelligence & autonomous networks. Video content data type plays an evil role amongst numerous data traffic schemes in 6G technology. The powerful skills that will be supported to 6G are Terahertz Band Artificial Intelligence, optical networking, 3 Dimensional communication, unmanned vehicles, and wireless energy exchange.

The key terms used to identify the 6G wireless communication are as follows,

- Artificial Intelligence
- Perceptible internet.
- High energy power consumption.
- Less network congestion.
- Authentication & data security.

The 6G technology can fulfill global wireless communication. 6G systems are expected to provide 1000 times more cable-less connectivity than 5G. On comparing to the extent of broadcasting in 5G are predictable with 6G to provide worldwide service facilities.

6G NETWORKING FEATURES

Satellite Integrated Network

The necessity of satellite transmission provides worldwide reachability. Moreover, the coverage area of satellite communication covers the entire world. And it can also support different geographical areas such as land, air, sea, sky, etc. So to deliver on-broadband worldwide moveable service it is predictable to hybrid land and satellite communication to obtain the aim of 6G. In the process of hybrid of earthly, and air medium grids into a homo wireless scheme resolve lead to critical state to 6G.

Connected Intelligence

It contrasts to the traditional wireless message system, 6G is transparent, and upgrade the wireless promotion from linked things to artificial intelligence. Artificial Intelligence is created in every stone of the common unique procedure and wireless reserve organization. The process of Artificial Intelligence resolve harvests a novel model of the message system. On comparing 5G a whole Artificial Intelligence (AI) system is required for complex networking for 6G. In addition, permitting intellectual message plans to obtain and achieve the reserve distribution procedure.

GENERAL CHARACTERISTICS REQUIRMENTS

Micro Minor Cell Networks: A micro minor cell networks concept was developed to upsurge the established signal strength on the base of system throughput, power energy and power spectral efficiency in microcellular technology according to (Jose Anand, A. et al., 2009).

Based on the outcome, microcell networking is an important distinction between the fifth generation and outside wireless networking systems. So, the sixth-generation technology system supports these wireless network characteristics.

Ultra-Dense Heterogeneous Networks: This network will be of a complicated nature in a 6G wireless communication system. Multi-channel networks having heterogeneous wireless networks will increase the total QoS and decrease the cost according to (Jose Anand et al., 2008).

High Capacity Connectivity: The high capacity connection is analyzed by a great-capacity backhaul system to coordinate a manageable capacity of 6G information traffic rate. The increased haste of visual fiber networks and free-space networking systems are possible solutions for this problem. Based on the outcome, microcell networks are an important characteristic to the fifth generation and beyond wireless communication systems. So that, 6G technology systems support these wireless network characteristics

SENSOR AND RADAR TECHNOLOGY CONVERGENCE WITH WIRELESS MOBILE TECHNOLOGIES

With the increased accuracy localization with wireless communication plays the important role in 6G wireless communication systems. Hence sensor and radar systems will have a convergence with 6G networks as shown in figure2.

Convergence of Software and Virtual

Software and virtual are complex characteristics that are the basics of the implementation in 5GB wireless connections to verify programmability, restructuring, and flexibility.

Source Allocation Method

Based on television viewing, characteristics proposed allocation method is implemented.

Multicast Transmission

The main advantages of multicast transmission are, with the same IP address we can transmit data to multiple destinations. This initializes from the transmission of the spectrum allocation, that a host's communication is transmitted to all the neighbors' nodes in the coverage area. This identifies the number of spectators that appeal to the common channel; for example, based on its great admiration the network traffic is transmitted deprived of any extra resource according to (Jose Anand et al., 2008). The merit of multicast is additional provision for IPTV for the wireless networks when compared to the wired networks.

MAC Protocol

The concept of random access-based MAC protocols reservation-based MAC protocols is to make sure that QoS guaranteed service will be provided respectively similar to (Jose Anand et al., 2009). On the other hand, the MAC procedure in 802.11 protocols is not suitable to provide QoS.

On the other hand, promised multicast transmission, reservation-based MAC is needed to book the periods for the greatest prevalent channels. On beyond, the random-access MAC level does not reproduce data info from the higher level, based on the client characteristics. The heterogeneous MAC protocol is highly ensuring that the unpopular videos are transmitted through unicast transmission. If a particular channel service request rate is increasing, then the video content will be transmitted through multicast transmission discussed by (Ponmalar A et al., 2021).

So that the viewers can receive the unpopular video content in the unicast scheme and most popular video content through the multicast scheme. A random-access MAC procedure is provided for excellent resource distribution method for equally IPTV facility and finest exertion internet facility.

On the basics about the routers, it has two interface options. One is used in reservation-based MAC procedure for famous videos and the other is for an accidental-based MAC procedure for example Carrier Sense Multiple Access Collision Avoidance (CSMA CA) for disliked video channels and finest effort internet facility. The video stations are allocated in a descendant edict based on the admiration of net cards which will be functioning on the booking-based MAC procedure similar to (Niranjana et al., 2021). The guarantees QoS & guaranteed IPTV facility to a huge amount of clients will be achieved when the entire amount of clients cumulative. The quantity of stations to be allocated which is built is based on the spectrum channel bandwidth. On the extra hand, the disliked broadcast channel spectators and top exertion internet clients use the transmission average by argument at the CSMACA method. More users use the same stations with the earmarked time slot. The remaining users will be decreased in the remaining channels. Though the random-access MAC procedure is created for the finest effort facility, a High Definition (HD) excellence of traffic distribution through the CSMACA procedure SIMILAR TO (Jose Anand, et al., 2014).

THE HYBRID VOD TRANSMISSION MECHANISM

The traditional transmission method which is used in the communication network is unicast & multicast. Unicast is the best transmission method when the service request rate is low. It is not suitable for high request content. It will lead to high traffic & congestion. Whereas the multicast transmission is perfect once the facility appeal rate is high for particular video content. But it is not suitable once the facility

appeal rate is very low. It will lead to a wastage of bandwidth. With these drawbacks of traditional methods, we propose a hybrid transmission device that is a mixture of both unicast & multicast broadcast appliances. It supports both the situation low service request rate as well as high service request rate. The multisession multicasting scheme creates a concept of video subdivision with multi stations (based on IP net) through the Fast Broadcasting arrangement, later it was adapted for on-demand-based multicasting purposes. We can provide more amounts of needs for the most prevalent videos by the secure amount of session which involves the next stages.

Step 1: Arrange the video based on the appeal rate and admiration. The statistic is reliant on the facility supporter's rule for the arithmetical service appeal past data manipulation procedure.

Step 2: Based on the volume, list of video content, facility appeal relations, and remaining ecological parameters, show the finest video distribution ratio which reduces the facility appeal blocking likelihood.

MULTI-SESSION MULTICAST

This session analyzes the concept of multi-session multicasting. The operation of multi-session multicasting is explained in the following three algorithms which support IPTV.

Server Algorithm before Transmission

Step 1: Count the number of terms, n_i , which is mandatory for the i^{th} video content, V_i , span L_i which means that the condition for the VOD joining time, $ct < 10$ sec by the eq.:

$$[n_i] = \log_2 \left(\frac{L_i}{ct} + 1 \right) \quad (1)$$

Some of the parameter values given for the number of sessions needed for the multi-term multicasting are shown in Table 1.

Step 2: Split the video content V , similarly into $Y_n, -1$ sections, where n_i is the intended amount of terms for V , in step 1.

Step 3: Assign the sections to the proper terms. The units are owed uninterruptedly and occasionally to its terms from S_1 to S_{11i} , by a geometrical sequence of 1, 2, 3 4, ..2A(ni-1) -1.

Step 4: Continue the previous steps from one to three videos owed for the multi-session multicasting.

Server-Side Communication

Step 1: When a client is requesting a video through a multicast transmission & there is no streaming then the server starts to provide the V video with n session according to (Jose Anand et al., 2014).

Step 2: If the video is already transmitted by multicast group and the client intimated to join the multicast stream by referring Internet Group Message Protocol (IGMP) association join message and intimate to obtain the video session discussed by (S. Islam & J. W. Atwood, (2006).)

Step 3: By chance, if there is no client to receive video content V_i , in a multicast group the server halts flowing and continues ready as ready state with n_i terms.

Table 1. Different parameters for multicast- multisession session schemes

Video Duration	Maximum connection time	Number of sessions required	Maximum waiting time
7200	10	10	7.1
3000	10	9	5.8
300	10	6	4.7

Client-Side Algorithm

From the client-side, external storage is needed for the buffer purpose for the designated video and smear the subsequent steps.

Step 1: When the receiver receives the video's multicasting address, it is conversant by the server. The client sends the Internet Group Message Protocol (IGMP) membership join message to the server. Then the client starts to obtain the multicast stream of the selected video v . The receivers obtain the first section from the term, S_i , at its first incidence and also obtain other connected sections from the rest of the terms concurrently with its buffer as shown in figure-3.

Step 2: Once the client starts to receive the video it starts its video session & delivers it periodically.

Step 3: Once the video content is ended by the receiving the stream and then the client sends the IGMP permission message, once they consume conventional the $(2An, - 1)^{th}$ segment according to (Wanjiun Liao & De-Nian Yang, 1999).

Figure 3. Slot allotment of the multi-session multicasting arrangement

Playback time (Length) L_1									
Popular video N									
←---→ Maximum waiting time									
S1	1	1	1	1	1	1	1	1	1
S2	2	3	2	3	2	3	2	3	2
S3	4	5	6	7	4	5	6	7	4
S4	8	9	10	11	8	9	10	11	8

TYPICAL SYSTEM UNITS AND ARITHMETICAL ANALYSIS

To evaluate the planned scheme, take the parameter of a group of K video content which the length L (each video) with dissimilar influx rates correspondingly. All the videos are conveyed through C channels. The service request rate of the videos improves exponentially with the service request to VI generations being the smallest content and V_k being the most-popular gratified according to (C. Zhou et al., 2018). The video substance's admiration is based on the service request rate for that particular video at different times. The service provider gives the rank to the video based on his service policy. For the calculation, each video follows Zipf dispersal. Created on the audiovisual appeal perfect, we compute the obstructive likelihood by Erlang's loss formulation with the national interplanetary S and $M/MiC/C$ perfect.

Table 2. Notation for numerical analysis.

NOTATION	EXPLANATION
C	Total Scheme Capability
K	Quantity of video Content
M	Quantity of multicast contents
M	Quantity of kept station for a multicast stream
X	Quantity of influences in the coverage.
Li	Distance of video i
μ_i	Service amount of stream.
μ_{mi}	Average provision amount of unicast stream
$P_{- \mu mi}$	The likelihood that the unicast video V_i is being helped.

Let R_x mean the steady-state likelihood, we can obtain

$$R_x = \begin{cases} \frac{1}{x} \cdot \left(\frac{\sum_{i=1}^{k-m} \lambda_i}{\mu_{uni}} \right)^x \cdot \frac{1}{x} \cdot \frac{1}{P_0 \prod_{j=0}^{K-1} (j+1) \mu_{mi}} = P^x & \text{for } 0 \leq x \leq C - M \\ 0 & \text{for } x > C - M \end{cases} \quad (2)$$

We estimate the average facility appeal amount as follows.

$$\mu_{mi} = \begin{cases} \left(\frac{\sum_{i=1}^{k-m} \lambda_i}{\mu_{uni}} \right)^x \cdot \left(\frac{\sum_{i=m}^K \lambda_i}{\mu_{uni}} \right)^{C-x} \cdot \frac{1}{x} & \text{for } C - M \leq x \leq C \\ 0 & \text{for } C \leq x \end{cases} \quad (3)$$

The likelihood of steady-state will not relate to facilities concerning distribution servicing time and is related to the average service period. To evaluate mean service requests, as

$$\mu_{uni} = \sum_{i=1}^{K-m} P_{\mu ni} \mu_i \text{ where } P_{\mu ni} = \frac{\lambda_i}{\sum_{j=1}^K \lambda_j}, \mu_i = \frac{1}{L_i} \quad (4)$$

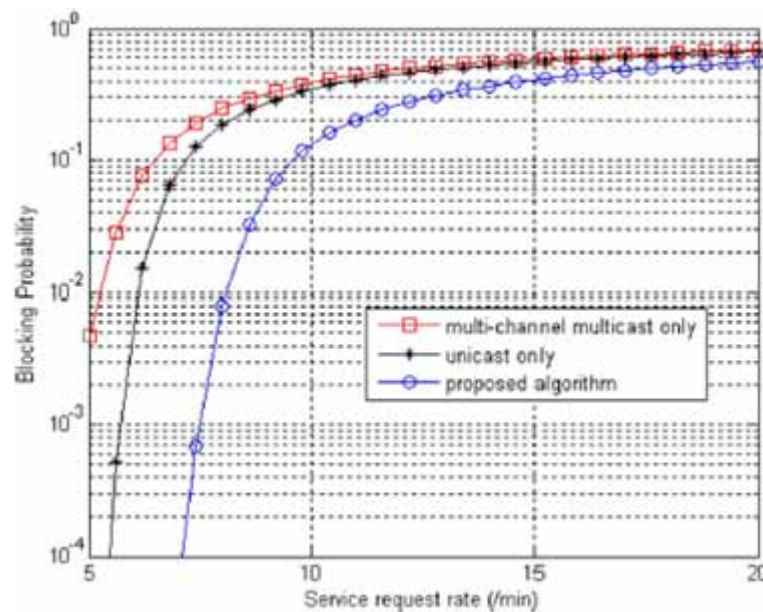
$$P_{blocking} = \frac{\rho^{C-M}}{\sum_{i=0}^{C-M} \frac{\rho^i}{i}} \quad (5)$$

where

$$\rho = \frac{\sum_{i=1}^{K-m} (\lambda_i \cdot P_{\mu ni})}{\sum_{i=1}^{K-m} (\mu_i \cdot P_{\mu ni})}. \quad (6)$$

On the other hand, the planned on-demand scheme sub-splits video innards into two subgroups popular content and unpopular content. Moreover, the previous subcategory is allocated M channels for multi-channel multicasting and the last subcategory is allocated the enduring C-M Channels for unicasting similar to (P. K. McKinley et al., 1994).

Figure 4. Comparison of traditional unicast and multicast with our hybrid transmission mechanism-blocking probability



PERFORMANCE ANALYSIS

In the process of recital assessment, we consider a few strictures with identified standards. The video content supporter able to provide 200 concurrent channels per time. Each video content's average length time is 180 minutes (10800 seconds). The service request rate differs from 5/60 to 20/60, and is intended by Zip distribution. As an outcome we compare the traditional unicast & multicast with our proposed hybrid transmission mechanism according to (Monisha Veronica Arokiamary & Jose Anand, 2021) (S. A. Azad & M. Murshed, 2007). As shown in Fig. 4, the VOD facility obstructive likelihood upsurges as the entire facility appeal amount surges. However, as facility request amount upsurges, their obstructive likelihoods become dissimilar. The proposed procedures will propose the little obstructive likelihood.

CONCLUSION

In this chapter, we provide an efficient AHT mechanism for the MIPTVN service. Adaptive Hybrid algorithm is the combination of both unicast multicast transmissions. From the arithmetical examination, suggested algorithms are related to old-style unicast and multicast structures. Thus the suggested procedures increase the probability of IPTV facilities.

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Section 2

Research Challenges and Directions of 6G Mobile Core Networks

Chapter 5

6G With Integration of Sensing and Communication

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ABSTRACT

The framework should work under both function cooperation and function convergence models, support cloud-network-terminal cooperation and convergence, and bring the basic radio capabilities of cooperative sensing, cooperative machine learning, and deterministic transmission with higher reliability and data rate. Integration of sensing and communication (ISAC) offers two advantages over dedicated sensing and communication functionalities: 1) gain in integration to more effectively use crowded resources and 2) gain in coordination to balance dual-functional performance. ISAC has lately been proposed for a variety of new applications such as automotive networks, environmental monitoring, remote sensing, IoT, smart cities, and indoor services such as human activity and gesture detection, all of which benefit from these two benefits. More crucially, ISAC has lately been highlighted as a key enabler for B5G/6G and next-generation Wi-Fi systems. The goal of this study is to figure out how sensing and communication can work together to give 6G new capabilities and services.

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INTRODUCTION

The integration of sensing, communication, and computing is an E2E information processing framework, where information delivery will be performed along with information acquisition and information computing. It can be divided into function cooperation, function fusion, and function reconfiguration. In traditional information service architecture, the terminal is responsible for sensing. The network is responsible for communication, and the cloud is responsible for computing. The integration of sensing, communication, and computing is addressed in terms of cooperation of cloud, network, edge, and terminal as discussed by T. S. Rappaport et al.. Actually, cloud services, edge computing, network slicing, non-public network, and the internet of vehicles (IoV) have introduced such cooperation capabilities. Furthermore, the concept of multifunctional radio has been proposed according to the integration of sensing, communication, and computing, where the air interface extends its core function from wireless access and transmission to wireless sensing, positioning, synchronization, and computing.

In practical design, the following key issues should be addressed for the integration of sensing, communication, and computing as introduced by (P. Kumari et al, 2018).

Technology for Integration of Wireless Sensing and Transmission

The natural idea for the integration of wireless sensing and transmission is to design a unified waveform to enable them to work in the same spectrum bands. They can share the radio resources and hardware resources, and realize wireless sensing and transmission functions through interference cancellation, interference isolation, and other technical means effectively.

Deterministic Information Processing

Deterministic information processing is an E2E task-centric information processing technology including deterministic sensing, deterministic transmission, and deterministic computing. It is expected to ensure service experience from the system level by jointly reducing sensing delay, transmission delay, and computing delay, and jointly improving sensing reliability, transmission reliability, and computing reliability. The key issue is to solve the problem of ultra-high precision synchronization and joint resource scheduling.

Technologies for the Multi-Dimensional Resource Management and Scheduling

Sensing resources refer to the radio and hardware resources such as radar, camera, various sensors, and detectors. Communication resources refer to the radio and hardware resources of access, forwarding, routing and synchronization. Computing resources refer to special or general software and hardware resources such as computing and storage. These resources inside or outside the network can form a resource pool through virtualization for multi-party sharing. This can improve resource utilization and provide new capabilities such as cooperative sensing, cooperative communication and cooperative computing. Blockchain is a better tool for resource sharing. The key problem is how to perform modeling, optimization, decomposition and allocation for a sensing task, a communication task, and a computing task according to the service requirements.

Technologies for Service Continuity

Service continuity refers to the functional continuity of sensing, communication, computing, and application. Sensing continuity refers to the ability of continuous information collection, positioning, and tracking for the sensing objective, which requires sufficient sensing coverage of the base station or mobile terminal. Communication continuity traditionally refers to the handover of access points, which can be achieved by multiple-connection over high and low-frequency bands and increasing base station density as pointed by (M. Koziol et.al, 2019). Computing continuity refers to the ability to decompose and migrate computing tasks in real-time due to the dynamic changes of computing resources. Application continuity refers to the ability of real-time migration from a local platform to another platform due to the change of service environment.

Capability Exposure

The capability exposure of sensing, communication, and computing can further enhance the information serviceability of 6G. The capability exposure framework architecture can be divided into resource layer, capability layer, and application layer. The resource layer includes all kinds of sensing resources, communication resources, computing resources, and various data resources. The capability layer is the core layer, being responsible for capability modeling and encapsulation, capability arrangement and operation and maintenance, and capability announcement. The application layer is the underlying capability demander, which requirements are proposed to the capability layer through the API interface.

Challenges

The primary challenge for the integration of sensing, communication, and computing is to answer the coupling relationship between them and the integrated function gain boundary as discussed by (J. A. Zhang et al, 2017). Secondly, the integration of wireless sensing and transmission in the millimeter-wave, visible light, and terahertz bands faces the challenge of signal processing and devices challenges. Thirdly, the integration of sensing, communication, and computing is facing the challenge of heterogeneous computing environments and chips. Fourthly, resource scheduling and collaborative machine learning meet the challenges of algorithms. Finally, trusted information processing should be addressed to create trustable sensing, communication, and computing environments. With the breakthrough of the above key issues, the integration of sensing, communication, and computing is expected to be applied in the following 6G scenarios:

- Inter-AT interaction: providing information and data exchange and sharing, supporting cooperative machine learning, focusing on solving the problems of 3D perception, model training, reasoning, and decision-making required by machine learning (ML). Inter-AT interaction is the fundamental capability for unmanned services.
- Human-machine interaction: supporting interactive XR and holographic communication, focusing on solving the problems of 3D perception, modeling, and display. Human-machine interaction is the fundamental capability for immersive services.
- Virtual-physical space interaction: supporting the key information exchange between the virtual space and physical space, focusing on solving the problems of multi-dimensional perception,

modeling, reasoning, and control. Virtual-physical space interaction is the fundamental capability for the digital twin services.

With the accelerated development of information technology, sensing, communication, and computing have become the three essential functions to provide mobile services as described in white Paper, “6G services and requirements” 2020. The emerging services, such as artificial intelligence (AI) services, unmanned services, digital twin services, and immersive services, are showing stronger coupled characteristics of sensing, communication, and computing, which then bring the technical requirements on functional integration. This paper attempts to find how sensing, communication, and computing work integrative to bring 6G new capabilities and services.

INTEGRATION OF SENSING AND COMMUNICATION

Essential Elements of Information Processing

Information Acquisition: Sensing

Information acquisition is an essential prerequisite to E2E information processing, for the purpose of deeply understanding and transforming the physical world. Generally, it refers to the behavior of information collection from sensing objects by using sensing devices, data interface, and/or the ability of data analysis. Information acquisition usually works in three typical scenarios. First, it is a component of the information service framework to provide service content (such as IoT services). Second, it is an underlying function to support information delivery and information computing, especially to provide the operation parameters. Third, it is one of the key enablers for AI to provide big data and data sets for model training and reasoning. Information acquisition mainly collects the service attribute and state, user attribute and state, network attribute and state, terminal attribute and state, environment attribute and state. The service attribute and status include service delay, service reliability, service transmission rate, service throughput, service application ID, service type, IP address and port of transmission data, space-time distribution of service, time to establish service, and performance requirements, etc.

The user attribute and status include user personal information and user behavior information, etc. The network attribute and status include throughput, spectrum efficiency, energy efficiency, network average delay, network capacity, network reliability, transmission rate, uplink transmission rate, downlink transmission rate, the computing power of network, network coverage, wireless resource allocation, cache resource usage, cell handover success rate and network interference relationship, etc. The terminal attribute and status include power consumption, location information, terminal's international mobile equipment identity, sending rate, receiving rate, signal-to-interference and noise ratio, bit error rate, battery capacity, number of terminals connected to the network, number, and type of applications installed on the terminal, etc. The environment attribute and status include indoor environment, outdoor environment, high-speed environment, climate status, distribution status of trees and buildings, etc. Sensing in the context of 6G has multi-dimensional, multi-level and distributed characteristics.

Information Delivery: Communication

Communication refers to the information delivery behavior through certain methods and media. Information delivery is the fundamental function of a mobile communication network, which has hardly changed from 2G to 5G. A mobile communication network is a typical system composed of several network nodes with a certain network topology. Its development is a process of continuously expanding media (new spectrum resources and optical fiber resources), updating and upgrading transmission and access methods, reconstructing network structure and node functions, to improve communication ability in a mobile environment. Network nodes are the basic elements for communication, which have independent functions, such as access function, transmission function, forwarding function, control function, and computing function.

Information Computing

In a broad sense, information computing refers to the calculation behavior for a specific task through special or general hardware and software. In addition to the computing work related to information acquisition and delivery, information computing mainly includes application layer processing, data storage, big data analysis, ML with modelling, reasoning, decision-making, etc. Cloud computing, edge computing, terminal computing, and fog computing are common computing paradigms. Distributed cooperative computing is a key technology for the E2E information processing with the challenge of heterogeneous computing.

The Basic Concept of Sensing and Communication

Definition

The integration of sensing, communication, and computing is an information processing framework to implement information acquisition, information delivery, and information computing simultaneously in the E2E information processing. It includes the sensing behavior and corresponding resources to enhance the performance of communication and computing, the communication behavior and corresponding resources to enhance the performance of sensing and computing, and the computing behavior and corresponding resources to enhance the performance of sensing and communication as discussed by (H. Sarieddeen et al, 2020). The integration of sensing, communication, and computing includes three modes: function cooperation, function convergence, and function reconfiguration

Function Collaboration

Function collaboration refers to the working mode, in which sense, communication, and computing functional entities exchange or share information through interfaces in order to enhance their performance. It also includes collaborative computing, collaborative sensing, collaborative positioning, and cooperative communication between different entities.

Function Convergence

Function convergence refers to the integration of sensing, communication, and computing functions in the same process through unified signal and hardware design.

Function Reconfiguration

Function reconfiguration refers to the function virtualization of sensing, communication, and computing supported by software-defined hardware architecture. It is the highest level of integration of sensing, communication, and computing, where the hardware resources are interconnected to form a relatively fixed functional path so that the objective function can be carried out in a way close to a “dedicated circuit”. It is expected to be realized by a software-defined chip with both software flexibility and hardware efficiency.

Integration of Cloud, Network, Edge, and Terminal

For the purpose of E2E information processing, integration of sensing, communication, and computing implies the integration of cloud, network, edge, and terminal. In fact, to realize the 5G features, the integration of cloud, network, edge, and terminal has been partially addressed. For example, E2E network slicing and cloud applications need cooperation between cloud and network. Edge service continuity needs the cooperation of edge and terminal. 5G non-public network needs the cooperation of cloud, network, edge, and terminal. IoV needs the cooperation of cloud, network, edge, terminal, and even road. In practical design, such cooperation can be decomposed into multi-dimensional cooperation, such as multi-access cooperation, resource scheduling cooperation, data cooperation, service traffic cooperation, capability exposure cooperation, security cooperation, orchestration cooperation, etc.

Integration of Cloud and Network

Integration of cloud and network refers to the cooperation mechanism where the network is able to acquire the service attribute and status to optimize resource allocation, while the application layer is able to learn about network attributes and status to optimize the service process. It embeds computing into the network and selects the optimal computing node in the context of the network to ensure service QoS, such as cloud XR, cloud games, and cloud video monitoring.

Integration of Cloud, Network, and Edge

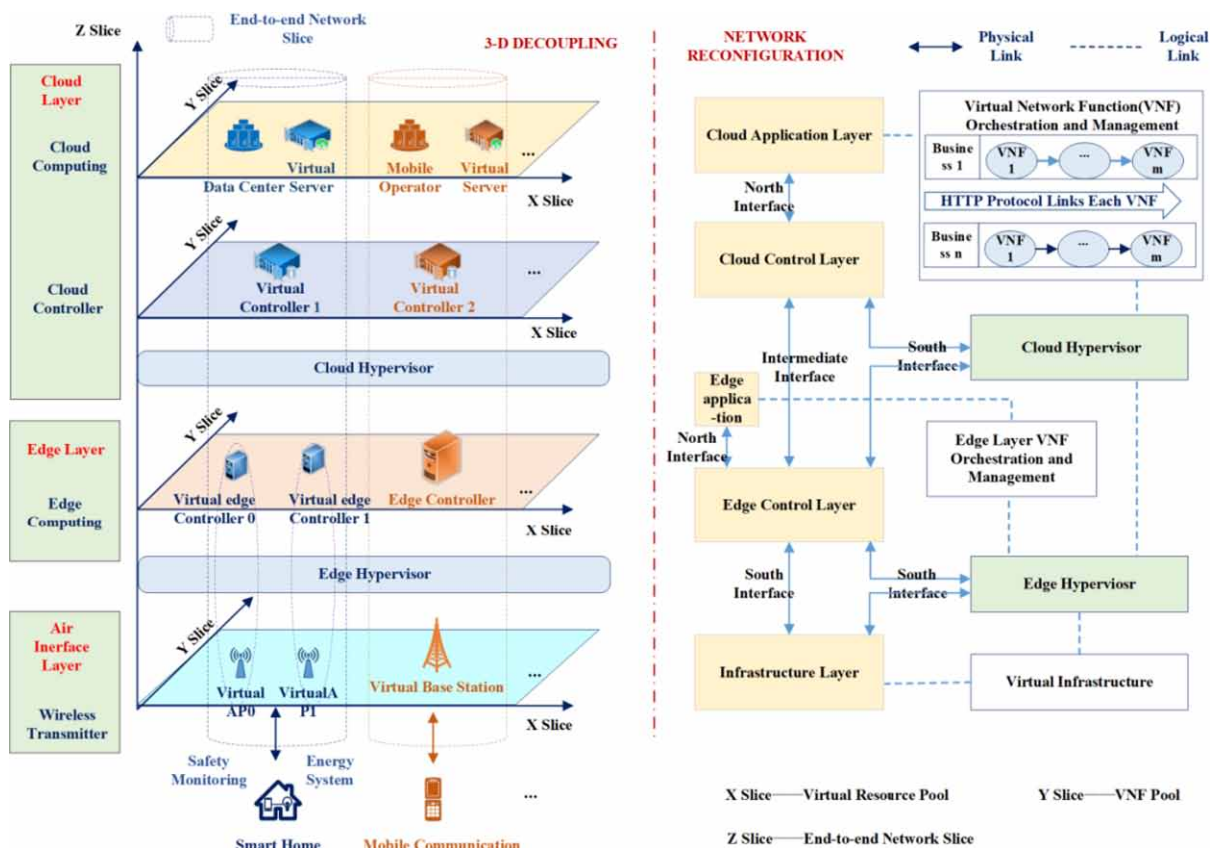
Edge computing expands the ability and scope of cloud computing. However, the efficient collaboration of cloud/edge computing requires the network to be flexible and reconfigurable. In order to solve the coordination of cloud computing and edge computing, better meet the requirements of application scenarios, it's necessary to realize the integration of cloud, network, and edge.

Cloud-network-edge collaboration, which refers to the deep integration of cloud computing, edge computing, and other network architectures, can provide integrated cloud-network-edge services for users, whose architecture is shown in Fig. 1. Among them, three-dimensional network slicing technology can support the deep decoupling and flexible reconfiguration of the network, serve the efficient

collaboration of cloud/ edge computing, and provide diversified services for users as discussed by (A. Bekkali et al, 2011). And cloud computing schedules network resources according to the requirements of applications. Edge computing provides computing services on the edge of the network and relieves the pressure of cloud computing and network bandwidth costs.

Relying on software-defined networking (SDN), network function virtualization (NFV), E2E network slicing, and AI, cloud-network-edge collaboration provides an E2E, flexible and extensible solution for cloud-edge collaboration to achieve flexible deployment of their facilities on demand while improving resource utilization and business reliability. It also provides three-dimensional decoupling of resources, network function, and virtual network based on virtualization technology. The SDN control plane and virtual machine manager (Hypervisor) deployed in domains and hierarchies can fulfill the orchestration and provide fine control granularity, and improve the resource utilization and maintenance efficiency of the system.

Figure 1. Integration architecture of cloud-network-edge



The cloud-network-edge collaboration includes the docking of edge computing infrastructure and cloud infrastructure to realize the virtualized collaboration of network physical resources. It includes the docking of edge computing platforms and cloud platform to realize network data collaboration, intelligent collaboration, application orchestration collaboration, and traffic management collaboration.

It also includes the docking of edge computing software and software running on the cloud platform to realize the collaboration of services in the network. In this way, it can provide optimal resource scheduling strategies according to the traffic requirements, to obtain a flexible and scalable dynamic resource management solution as discussed by (T. S. Rappaport et al, 2019). Furthermore, cloud-network-edge collaboration can enhance the openness and security of services by means of collaboration and sharing, and it can also realize convenient and safe connections among cloud, network, and edge, and solve the problems of low resource utilization of multiple service sources and low service access efficiency under large amounts of data. Cloud-network-edge collaboration can finally achieve the multiple-cloud server, edge server, multiple-user and multiple-terminal in multiple networks slicing optimized collaboration and efficient connection in the network.

Integration of Cloud, Edge, and Terminal

Integration of cloud, edge, and terminal mainly refers to the distributed cooperative computing among cloud, edge, and terminal. The interaction and cooperation among ATs/virtual spaces require multifold computing power, and the computing task should be decomposed and assigned among the cloud, edge, and terminal.

Multifunctional Radio

In cooperative sensing and ML, a large amount of data and information need real-time or non-real-time transmission and computing. The 6G radio should support the following essential functions:

- Stronger wireless transmission: Support enhanced eMBB and URLLC on the uplink, downlink, and sideline with the sensing ability and potential technologies.
- Deterministic transmission: Support integration of synchronization network and RAN, and co-existence with other TSNs. Support high-precision timing and positioning message delivery. Support integrated traffic and computing power scheduling.
- Cooperative computing: The computing resources at the edge and terminal should be easily perceived and scheduled, even in the heterogeneous computing case.
- Multidimensional sensing and 3D positioning: Support multi-sensor operation and cooperative positioning with the help of wireless transmission. Support camera, Lidar, mmWave Radar, ultrasonic, and other sensors. Support wireless positioning, GNSS, and local positioning by (chiriyath AR et.al, 2019).

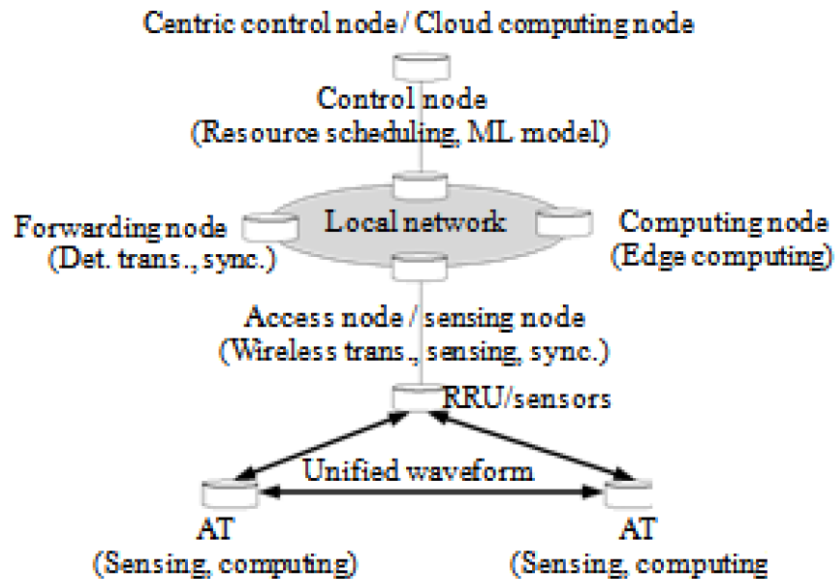
Multifunctional Radio Architecture

To address the challenge, we propose the multifunctional radio as a solution for 6G radio, as shown Fig.2. It is a conceptual framework aiming to expand radio function from wireless transmission to computing, sensing, and positioning. It is expected to achieve the following objectives by (S. Denis et.al, 2019):

- Enhance radio resource management. The RAN state space and resource allocation space will be redefined by the perception and prediction ability of sensors. This benefits network capacity improvement.

- Reduce E2E transmission latency. The proposed radio covers HMI and MMI, as well as the traditional air interface (up/ down/ sideline). This will reduce the latency interval between information acquisition and transmission. The transmission latency and computing time will be further reduced when data dimensionality reduction is performed over the radio.

Figure 2. Multifunctional radio framework



From a functional point of view, 5G NR has four kinds of functions (nodes): access function, transport function, control function, and computing function as discussed in (FuTURE Forum, 2020). The corresponding nodes form RAN, transport network, and core network, respectively. The proposed multifunctional radio framework is shown in Fig.2, where new functional nodes are introduced, namely sensing nodes, synchronization nodes, and computing nodes. These new nodes form a synchronization network, deterministic transport network, and computing-aware network, respectively, and then form a multifunctional RAN, rather than the traditional RAN supporting only wireless transmission.

The sensing nodes support multidimensional sensing with the multi-sensor operation, such as camera, ultrasonic, Lidar, Radar, other sensors, and other wireless detection devices. These sensing nodes also support positioning, such as GNSS, wireless positioning, and cooperative positioning with ATs. They can be deployed independently, or be located with the access nodes. An access node equipped with both RRU and sensors can be considered as a super AT.

Similarly, a synchronization node may be an access node or a forwarding node. It delivers the crucial timing messages through the local network to enable local deterministic transmission. One of the ATs associated with one task should be selected to receive the timing messages and forward them to other ATs. The proposed framework adopts two-level multi-domain distributed architecture for the control function, where the centric control node and local ones cooperatively manage information acquisition, delivery, and computing as discussed by (S. Denis et al, 2019). These control nodes will take part in cooperative sensing and ML to do computing task scheduling. Such operation is defined as cloud-network-terminal

cooperation. For example, the model training task will be assigned to cloud and edge, while the reasoning and decision-making tasks may be handled at ATs.

Moreover, the proposed radio framework extends from air interface to MMI and even HMI. The design of a unified waveform is needed to support the convergence of wireless communication and sensing, not only for uplink/downlink but also for side link. This can help reduce the E2E latency, improve spectrum utilization, enhance radio resource management, improve network capacity and simplify the hardware architecture.

Function Separation Architecture

With the rapid development of mobile communication technology, the space-time span of the wireless network in the future is becoming larger and larger, and the number of users and network traffic is increasing exponentially. Besides, the business types tend to be diversified and emerging application scenarios are constantly emerging, which requires higher coverage and energy efficiency.

To meet the requirements of a wireless communication network in the future, a new network perception, communication, and computing separation architecture emerge. The architecture separates the perception from the general control signaling transmission on the basis of the traditional control and user plane separation network architecture to realize the separation of perception, communication, and computing. The traditional base stations are divided into three groups: low-frequency perception base stations (PBS), medium frequency control base stations (CBS), and high-frequency traffic base stations (TBS). They work in different frequency bands and perform different tasks.

PBS's broadcast in the low-frequency band to sense the location of users/airbase stations (UAV and airship), wireless environment, available resources of edge/cloud, and so on. By using intelligent beam, dynamic cooperative relay, and other methods, the transmission energy efficiency of TBSs is improved, and the flexible extension of wireless coverage is realized so that CBSs and TBSs can provide better control and data services for users.

CBS works in the medium frequency band and sends low rate control coverage signals to users to ensure the users' access to the network. According to the users' service requesting status, TBSs are selectively turned on and off, and TBSs with the best performance are selected to provide services for users. The coverage of CBSs is large as discussed by(Y. Miao et al, 2020).

TBSs send high-frequency and high-speed service signals to users to provide data services. According to the requirements of different application scenarios, TBSs can provide differentiated services for users, such as high-throughput requirements, delay-sensitive requirements, and compute-intensive requirements. The coverage of TBSs is small.

In addition, through the dynamic deployment of unmanned devices, the traditional coverage is dynamically extended to realize the joint optimization of perception, communication, and computing, and the blind spot coverage problem and mobile coverage problem of the land-based network can also be solved.

Perception, communication, and computing separation architecture is a multiple domain and full band system designs and architecture with better energy efficiency and better delay. It comprehensively utilizes the different coverage characteristics of the high, medium, and low-frequency band signals to adapt to the differentiated requirements of wireless coverage and greatly improves the coverage ability of the network. The base stations working in different frequency bands perform their respective duties without interference with each other, which greatly reduces the network energy consumption and improves the network performance and transmission rate.

KEY TECHNOLOGIES AND CHALLENGES

Unified Design for Wireless Sensing and Transmission

The integration of wireless sensing and transmission requires not only new system architecture and protocols but also the development of devices and the support of key technologies, which are listed in detail as follows:

- Unified waveform design
- Communication demodulation algorithm and sensing algorithm
- Joint signal detection and interference cancellation
- Antenna array and precoding/ beamforming scheme
- Channel measurement and modeling for wireless signal and sensing signal
- Hardware architecture and scheme for device sharing

The key issue of unified waveform design is to minimize the interference between communication signal and sensing signal to guarantee communication and sensing functions and improve spectrum efficiency on the premise of ensuring system performance. The unified waveform can be multiplexed with orthogonal resources, including time-division multiplexing, frequency division multiplexing, space-division multiplexing, code division multiplexing, and can also be designed with a fusion form. The latter design should find the performance balance point between sensing and communication. It is necessary to consider which function is primary.

Generally, the unified waveform is mainly divided into a single-carrier waveform and a multi-carrier waveform. Single-carrier waveform is usually combined with spread spectrum technology, such as direct sequence spread spectrum (DSSS) and chirped spread spectrum (CSS). DSSS is widely used in communication systems to obtain higher security and robustness, and provide stronger anti-jamming and anti-interception capabilities. It can also realize multi-user access. Some problems on single-carrier waveform design based on DSSS should be addressed as discussed by T. S. Rappaport et.al (2019).

- Keep low sidelobe level when pulse shaping
- Select the sequences with good autocorrelation/ cross-correlation characteristics (e.g. m sequence, Gold sequence, Kasami sequence, Golay complementary sequence) and appropriate spread spectrum factor to meet the sensing accuracy and dynamic work range
- Design data frame structure reasonably to limit the length of correlation sequence and reduce the Doppler influence in case of the sensing system design based on the echo signal

CSS technology is based on chirp signal, which is more used in radar sensing applications to help improve the balance between resolution and maximum search range. CSS signal is used to realize the orthogonality of sensing signal and communication signal. For example, a chirp signal with the same carrier frequency but opposite polarity frequency modulation slope is used to represent communication signal and sensing signal respectively. Besides chirp signal with opposite polarity frequency modulation slope, a unified waveform can be designed by using a chirp signal with a different initial frequency of the same frequency modulation slope. There are also schemes based on the communication frame structure

to realize the sensing function. Such schemes reuse the training sequence of the communication signal such as pilot to complete the sensing, without the spread spectrum method.

A typical multi-carrier waveform is the Orthogonal Frequency Division Multiplexing (OFDM) waveform, which has many advantages over the single-carrier spread spectrum waveform, in terms of higher spectrum efficiency, flexible bandwidth resource allocation, no range-Doppler coupling effect, etc. To ensure sensing capability, the frame structure should be designed with the careful setting of subcarrier spacing and cyclic prefix length. In addition, some new waveform technologies, such as Orthogonal Time Frequency Space (OTFS), can be combined with OFDM for unified waveform design.

In addition to waveform design, joint detection of communication signals and sensing signal is also a key issue for the unified system design. Due to the random access and different resource division, the communication signal presents fragmentation and discontinuity in time, frequency, and space, which increases the difficulty of sensing signal detection. For communication systems, typical channel estimation algorithms, such as LS, MMSE, only estimate composite channels with limited unknown parameters, which are usually combined with interpolation schemes, so the accuracy is limited. However, the sensing system, especially radar, usually uses optimized or unmodulated transmitting signals to obtain the specific channel state information in terms of amplitude, angle, Doppler, delay, etc. A joint detection scheme needs to choose appropriate algorithms to guarantee the function division of communication and sensing and reduce the mutual influence. Conventional detection algorithms such as sequence correlation matched filtering (MF), MUSIC, ESPRIT can be considered.

For the integrated system architecture, a better joint detection algorithm is further needed. In the practical channel, multipath helps to improve the freedom of communication but brings about clutter interference for the echo-based sensing system, which needs to be suppressed at the input of the sensing detection module. Moreover, the mutual interference between the communication signal and the sensing signal needs to be addressed. Serial interference cancellation (SIC) is commonly used, where echo signal in the received signal will be first canceled according to the prior information, and then the communication signal is detected (demodulated and decoded), reconstructed, and eliminated from the original received signal to obtain the sensing signal, which is detected finally. When detecting the sensing signal, the problem of perception ambiguity caused by time non-synchronization problem is necessary to consider by Y. Miao et.al (2019).

Cooperation of Wireless Sensing and Transmission

Electromagnetic waves, including light waves, can be used not only to transmit information but also to sense and image. Compared with the electromagnetic wave-based approach, visible light-based imaging technology appeared even earlier (Niepce in France made the world's first photo on a photosensitive material in 1822). Based on visible light, holographic imaging is available now. In addition to visible light waves, infrared waves and terahertz waves, etc. can also be used for imaging. Besides that, some of the features of the target object can be sensed by using the electromagnetic wave as well. Thus, radar, remote sensing, and other technologies have been developed.

6G will continue to develop towards even higher frequency ranges. In the research of 6G, THz band and even visible light band have recently attracted great attention. In the 6G, communication and connectivity are no longer the only missions. Sensing based on electromagnetic waves, also known as wireless sensing, can be used to acquire some target object's information, such as location, shape, size, posture,

color, material, environment information, etc. Such valuable information can be acquired by continuous sensing and be utilized by upper-layer applications or wireless communication itself.

The application scenarios of convergent communication and sensing can be divided into three categories: transparent transmission scenario, open-capability scenario, and air interface fusion scenario.

Transparent transmission scenario: mobile communication system only provides a channel for sensing data transmission. Open-capability scenario: the communication system provides an open interface for the applications, and thus the sensing capabilities of the system can be used for the applications to provide some new network services.

Air interface fusion scenario: deeper fusion of wireless sensing and wireless communication will be carried out on the air interface. The new capabilities after fusion can be provided to the communication system itself or to the applications by the capability opening. The air interface fusion scenario can be further divided into passive sensing, active sensing, cooperative sensing, and alternative communication.

Passive sensing: the perceiver, network nodes, or terminals, receives the electromagnetic wave (such as infrared) emitted or reflected by the target object.

Active sensing: the perceiver, network nodes, or terminals, sends electromagnetic waves, and receives the echo for sensing after being reflected by the target object.

Interactive sensing: the perceiver (network nodes or terminals) interacts with the target object (network nodes or terminals) after agreement on the subject, time, frequency, format, and other parameters of electromagnetic wave transmission. And the perceiver senses the received electromagnetic wave.

Alternative communication: by wireless sensing, the perceiver (network nodes or terminals) uses image acquisition and recognition technology to acquire the original image or its corresponding information instead of transmitting the information via a wireless network. In some certain scenarios, it's expected that the demand for air interface communication can be reduced.

Wireless Communication Assisted Sensing

Sensing capability can be enhanced with the help of a wireless communication system, especially the communication mechanism. There are multiple approaches to improve sensing performance. In terms of the overall system architecture, the network can sense through terminals and sensors, or directly through network nodes such as base stations, where the communication signal can be used for sensing. The communication information carried by the communication signal can help devices to have a preliminary understanding of the surrounding environment. Therefore, the device can lock the target more quickly and complete the sensing of its surroundings in a shorter time. Further, through wireless communication, the sensing data can be quickly aggregated, and the instructions formed after sensing can be quickly distributed, so as to better serve future applications with strict requirements on latency or real-time data. The lower the fusion level (such as the physical layer), the lower the expected latency. Specifically, with the assistance of wireless communication, the sensing performance improves in the sensing range, sensing accuracy, and sensing speed.

In terms of improving the sensing range, the sensing range of the network can be improved by sharing the sensing information among nodes. Wireless communication can help network nodes share sensing information.

In terms of improving the sensing accuracy, the collaborative sensing of the same region can improve the sensing accuracy of the network. The communication information transmitted by communication signals is one of the prerequisites for realizing collaborative sensing. In terms of improving sensing

speed, the target location information carried by communication signals can reduce the time to lock the target, thus speeding up sensing.

Collaborative sensing is one of the key techniques to expand the range of sensing and improve sensing accuracy. Since the sensing environment is rapidly changing and the sensing information has certain timeliness, it is necessary to complete the cooperative sensing in a short time. Rapid diffusion and efficient fusion of sensing information are the prerequisites for realizing rapid collaborative sensing. Therefore, the main challenge in improving network sensing performance lies in how to realize the rapid diffusion and efficient fusion of sensing information.

However, superabundant sensing information entering the network will occupy excessive network resources, resulting in a large number of redundant sensing information, and thus affecting other services of the network. Therefore, how to reasonably allocate network resources for collaborative sensing is also a key problem to be solved.

Sensing Assisted Wireless Transmission

Sensing assists wireless transmission in multiple approaches. On the one hand, the transmission parameters such as network beam management and resource allocation can be optimized according to the sensing information of propagation environment, terminal orientation, mobility trajectory, and attitude, etc., so as to improve the performance of wireless transmission in terms of network capacity and network speed. On the other hand, the wireless signal based on the integrated waveform design can sense the physical space of communication objects and realize wireless transmission at the same time. Wireless communication with known physical spatial information of communication objects has higher security. Overall, with the assistance of sensing information, wireless transmission performance can be improved in terms of network capacity, networking speed, and communication security.

In terms of improving network capacity, the physical environment information obtained by sensing can assist the network to optimize beam management parameters, and the electromagnetic environment information obtained by sensing can assist the network to optimize resource management parameters such as spectrum, power, etc. Then, the probability of data packet collision and congestion will be reduced, so as to improve network capacity.

In terms of improving networking speed, the number and location information of surrounding nodes obtained by sensing can accelerate the convergence speed of neighbor discovery and multiple access schemes, shorten the neighbor discovery and multiple access periods, and further improve networking speed.

In terms of improving communication security, the integrated waveform design technique can make the nodes know the physical space information of the communication object while communicating, which can help to identify the malicious nodes. The physical space and digital space information of the communication object can be obtained by sensing and communication, separately. With the assistance of the integrated waveform design, the functions of perception and communication can be realized simultaneously, which is helpful to realize the coupling of physical space and digital space information of communication objects, so as to improve communication security.

Based on sensing information, nodes can obtain the position, speed, trajectory, and other information of surrounding nodes, which can help beam alignment and tracking, which result in more efficient neighbor discovery, MAC, and routing design algorithms to realize fast networking. However, the reliability of the sensing information cannot be fully guaranteed, the improved algorithm proposed above

needs to be compatible with the traditional algorithm to adapt to the situation without the assistance of sensing information.

In addition, through the sensing of location, speed, and other physical information of the surrounding nodes, the received message source and characteristics can be estimated, which can be used to determine whether the message comes from a specific node, thus enhancing the information security. In order to improve communication security, how to realize the efficient coupling of physical space information and digital space information is a key problem to be solved. Moreover, unifying the security decision criteria is also essential.

Deterministic Information Processing

Deterministic information processing has been discussed preliminarily in 3GPP in terms of deterministic transmission, which focuses on latency and jitter control. To meet the E2E latency requirements, there has been some research on deterministic sensing, deterministic computing, deterministic positioning, and deterministic wireless transmission. Deterministic information processing implies the network transformation from resource-based to service-based.

The features of deterministic sensing, deterministic transmission, and deterministic computing are respectively field-level processing, E2E processing and distributed processing.

Synchronization

Clock and time synchronization are the basis on which deterministic information processing can be achieved. 3GPP has discussed the clock/time synchronization for the integration of 5G network and TSN. 5G NR supports air interface capabilities such as ultra-short frame structure, large-scale antenna, carrier aggregation, high-precision positioning and massive terminals. It requires that the inter-BS clock synchronization accuracy should be up to 100ns. The dual backup synchronization mechanism is commonly used, which considers both the satellite reference source and dedicated optical fiber network reference source of national high-precision ground-based time service system. The generalized precision time protocol (GPTP) is used in TSN, which should be developed towards 6G network.

In the integration scheme discussed in 3GPP, time synchronization is divided into two parts: the network-wide time domain and the local clock domain. The former is equipped with a master clock, which can theoretically be located in any device of the whole network, and the time synchronization information is delivered to the whole network through a deterministic support function. The latter covers all local devices associated with the same task, such as robots, AGVs, sensors, and controllers. One or more local devices are set as a UE to access the 5G network and receive the time synchronization information. The local clock domains operate independently, and different synchronization accuracy can be set. A UE supports the simultaneous connection of multiple local clock domains. Similarly, a base station also supports the simultaneous connection of multiple local clock domains. When two or more local clock domains overlap, for example, when a mobile device enters from one clock domain to another, it needs to decide whether to merge multiple clock domains according to the synchronization accuracy requirements of the task process. If the accuracy is tighter, clock domain merging is needed.

In AT interaction scenarios, the coverage of local clock domains will be dynamically overlapped. Two kinds of clock domain merging methods can be considered. One is to merge multiple clock domains with reference to the master clock at the same time; the other is to select a device with UE function in the

local clock domain to send synchronization information to the merging domain to realize multi-domain merging. The latter is suitable for the case of temporary interaction or low synchronization accuracy, such as the cooperation between UAVs or autonomous vehicles in the process of unmanned logistics.

Deterministic Sensing

Sensing is a typical field-level information acquisition processing, no matter for the internal sensors and external sensors which are equipped within an AT. An unmanned service supported by AT interaction depends on these sensors with sensing on time and in time. Compared with the E2E information delivery and distributed information computing, the main performance of deterministic sensing is the sensing response time with a certain sensing accuracy and range. In cooperative sensing for cooperative ML, deterministic sensing also means the time synchronization among ATs and among the internal sensors.

Deterministic Transmission

IEEE began to study the TSN network since 2006 and has been expanding from the audio and video field to the industrial field, IoV field and MNO's transport network. The key issues for TSN are time synchronization, traffic scheduling, and network control and management. Technical standards have been released respectively on timing and synchronization, frame preemption, enhancements for scheduled traffic, cyclic queuing and forwarding, per-stream filtering and policing, stream reservation protocol enhancements and performance improvements, path control and reservation, seamless redundancy, and link aggregation.

3GPP R16 defined integration architecture of TSN and 5G network to provide key industrial IoT functionality. In the case of unmanned manufacturing, the deterministic transmission between machine tools should meet the requirements in terms of latency of 100us~50ms, availability of 99.999% and a synchronization accuracy of 1us.

DetNet is the generalized TSN applied into the IP and MPLS networks. It is composed of terminal node, edge node, and forward node that jointly provide DetNet services. These nodes are interconnected through transport nodes (i.e., routers) as an endpoint, and connected to the subnets. These subnets, such as TSN and OTN, support DetNet flows. Multi-layer DetNet is possible, where one underlying DetNet appears as a subnet and provides services for higher-level DetNet. In DetNet, critical data streams with extraordinarily low packet loss ratios and E2E latency are guaranteed through resource reservation (node buffers, node schedulers, and link bandwidth) via configuration, management and protocol action. Critical data streams and other best-effort streams can co-exist within a single network if the former do not take up too much network resources.

TSN is also introduced into 5G network for the deterministic fronthaul. Moreover, the work item "deterministic mobile networking" has been set up in ETSI to identify the requirements of 3GPP mobile network towards deterministic networking capabilities for URLLC applications. Its target is to provide holistic architecture including functions, interface and protocol to realize E2E deterministic transmission across RAN, core network, backhaul or transport, and virtual networks within a data center. Based on this, 6G is expected to be a deterministic network.

Deterministic Computing

Deterministic computing refers to the information computing on time and in time within a task process. An integration of cloud, edge and network, as well as computing resource allocation algorithms are needed to ensure deterministic computing.

Resource Management

6G needs a mechanism for multi-dimensional heterogeneous resource management and scheduling.

Sensing Resource

The most important means for sensing is to use sensing devices, i.e. sensors. The generalized sensors include Radars, cameras, detection devices, positioning modules, and other kinds of sensors. In detail, Radar includes ultrasonic Radar, millimeter-wave Radar, Lidar, etc. Detection devices include X-ray detection devices, infrared detection devices, sonar devices, terahertz detection devices, radio detection devices. Another kind of sensors includes a pressure sensor, temperature sensor, humidity sensor, gas sensor, acoustic wave sensor, photosensitive sensor, etc. These devices with related spectrums form a sensing resource pool for sharing and scheduling.

Communication Resource

Communication resources include routing resources and radio resources. The latter includes spectrum resources, power resources, antenna resources, slot resources, code resources, etc.

Computing Resource

Computing resources will be the native resources of 6G and can be scheduled as a service. In order to meet the diverse computing requirements, this kind of resource is distributed among cloud, edge, and terminal, in terms of CPU, GPU, NPU, FPGA, ASIC, etc. Storage resource is also a kind of computing resource. For different applications, a variety of computing power combinations have been extended from single-core CPU to multi-core CPU, and to CPU+GPU+FPGA, etc. Faced with a variety of heterogeneous computing resources distributed in the network, a unified metrics system, and an abstract representation method should be designed for computing resource management and scheduling.

In the case of computing virtualization, the computing carrier has developed from a virtual machine to a container and unikernel. The mirror size is gradually reduced from the GB level of the VM to the MB level of the container to the KB level of the unikernel.

The computing-aware network is a framework solution on how to provide such services. Through the API call mode, it provides a real-time calculation service with an ultra-low delay at the nearest edge node, and a non-real-time calculation service at the cloud node. Ubiquitous field-level edge computing provides users with intelligent access and real-time data processing, and network-side edge computing provides users with rich computing power. Abundant network resources and computing resources will continue to integrate and complement each other, providing the ultimate user experience for new services.

Joint Resource Scheduling

To ensure the user's SLA requirements, the real-time communication resource status, computing resource status, and sensing resource status should be comprehensively considered for joint resource scheduling.

Joint resource scheduling (namely resource allocation) is a typical optimization problem. The problem may become more complex if the sensing resource, communication resource, and computing resource are jointly optimized, and there are multiple optimization objectives. ML (e.g. reinforcement learning) can directly be used for resource allocation. In this case, the most challenge is to find a suitable ML algorithm and define the resource status space and solution space for it. The problem can be simplified and decomposed into subproblems, such as computing node selection, radio resource allocation for wireless transmission, sensing, and positioning, and radio resource allocation for the sideline, uplink, and downlink, respectively.

Blockchain-Based Resource Sharing

The current mobile communication network is based on the resources controlled by each operator, and the service that each user can enjoy directly depends on the ability of its terminal. Due to the continuous enrichment of user application scenarios, the cost of a single operator to master all operating resources, as well as the complexity and price of each terminal will be higher. Therefore, various resources may be managed by different parties, and different application systems and services can be built through resource sharing.

The multi-party cooperation scenarios include single-type resource sharing and multi-type resource sharing, both of which can occur between different operators and different users.

In terms of communication resources, different operators can share communication resources and serve their own users. If the coverage in a certain region is unsatisfactory, one operator can use another operator's base station and spectrum resources to serve its users, so as to improve the service quality. Similar problems can be solved by sharing communication resources between terminals. One terminal can seek the help of another terminal based on device-to-device (D2D) to complete its communication through the assisted communication link. Both cognitive radio and interference management can be attributed to spectrum sharing.

With the rapid development of integrated circuits and sensing technology, a large number of multi-functional sensing devices have emerged, which can complete multiple sensing tasks at the same time. The sensing devices deployed for a certain professional purpose may also be used for other purposes, and the related terminal can contribute to various large-scale data acquisitions. For example, environmental monitoring can be carried out through a large number of users' temperature sensing data with temperature sensor sharing. A terminal without a positioning function can get positioning information from surrounding terminals to complete its navigation task.

Computing (storage) resource sharing also exists between operators and users. When an edge computing operator cannot afford the services due to computing resource shortage, a part of the computing task can be transferred to the edge platform owned by other operators around. On the user side, personal computing resources can be rented to other users (or even operators) in idle periods to maximize resource utilization. Furthermore, computing service providers can rent edge nodes or user equipment to carry out computing services without hardware resources by (H. Sariaedeen et.al 2020).

In addition to the above single-type resource sharing, the combination of multi-type resources has more application scenarios. In the case of network slicing, a logic private network with different SLA requirements can be built with various link resources owned by different cooperates. Operators with camera resources can cooperate with roadside radar operators and positioning service providers to improve the accuracy of target recognition and tracking.

There are two key issues in multi-party resource sharing. One is how to confirm whether the resource owner has provided the corresponding resource (or transferred the right to use the resource) according to the contract, and the other is how to confirm whether the resource user has completed the payment to the resource provider according to the contract. In general, if there is a trusted third party, then the parties can complete the transaction under its coordination. However, there is no such trusted third party in many practical scenarios. The central third party may abuse its resource allocation right, and a single point of failure usually causes a huge security risk.

In the absence of a trusted third party, blockchain technology can coordinate multiple parties to jointly maintain a unified transaction book, so it is very suitable for resource sharing. Especially, an alliance chain is a better solution for different operators to build resource-sharing platforms.

The alliance chain is constructed based on the interests of all parties in the resource transaction, where all participants determine the resource sharing rules and transaction mode, solidify the transaction execution steps and conditions in the form of smart contract, and independently execute the smart contract, complete transaction books and maintain their consistency based on consensus. The verifiable transaction data is constructed based on resource sharing logic. The identity of the resource owner and transaction sender is guaranteed based on a digital signature. By doing so, the alliance chain transforms the trust among multiple owners into the trust of chain data and smart contracts. All transaction behaviors are well documented and cannot be denied. All rules are automatically implemented without human intervention. The reputation of each resource-sharing participant can be objectively evaluated based on transaction records. With a reasonable incentive mechanism, the alliance chain will attract more operators or individuals to contribute their own resources, thus greatly improving the resource utilization efficiency and expanding more sharing economy modes.

Service Continuity

Service continuity management is required to support the continuity of AT interaction services. The continuity includes coverage continuity, sensing continuity, computation continuity, and application continuity. Coverage continuity refers to the access point handover, sensing continuity refers to sensor handover or mobile sensing, computation continuity is for computing task reassignment, and application continuity is for application relocation.

Each sensor has a limited sensing range with certain requirements on sensing performance. To support service continuity, the sensors (e.g. mmWave Radar, camera) equipped on BS, or the radio sensing signal should be designed to ensure seamless detection coverage by (F. Zafari et.al 2019).

Communication Continuity

In order to ensure communication continuity, coverage mechanisms, including inter-frequency and intra-frequency service continuity and mobility management mechanisms are should be considered. That is to say, increase communication coverage or access point switching management. First of all, us-

ing Non-Terrestrial Networks (NTN) can expand the network coverage, providing service continuity to reinforce the service reliability. NTN is expected to serve areas that cannot be covered by the terrestrial networks (isolated/remote areas, onboard aircraft, or vessels) and underserved areas (e.g. sub-urban/rural areas). Then, dual-connectivity mechanisms can improve wireless resource utilization, reduce system switching delay, and improve user and system performance. If the UE has TN and NTN connectivity capabilities, the dual-connectivity mechanisms between NTN and TN can be considered. Finally, except for the UE switch within the TN or NTN, the studies are should focus on the mobility mechanisms for the cases where UE's connectivity changes from the NTN to TN and where UE's connectivity changes from the TN to NTN.

Computing Continuity

Cooperative ML needs computing task decomposition and assignment among the cloud, edge, and AT. In case of task process change, access point switching, or computing resource scheduling, the computing tasks may be migrated or reallocated. Here, the allocation algorithm needs to guarantee the continuity of reasoning and decision-making.

Application Continuity

Due to the access point switching, or the need for traffic and computing power balance, the application instances and contexts need to be migrated from one platform to another.

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Chapter 6

Potential Applications of 6G–Enabling Technologies and Challenges

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ABSTRACT

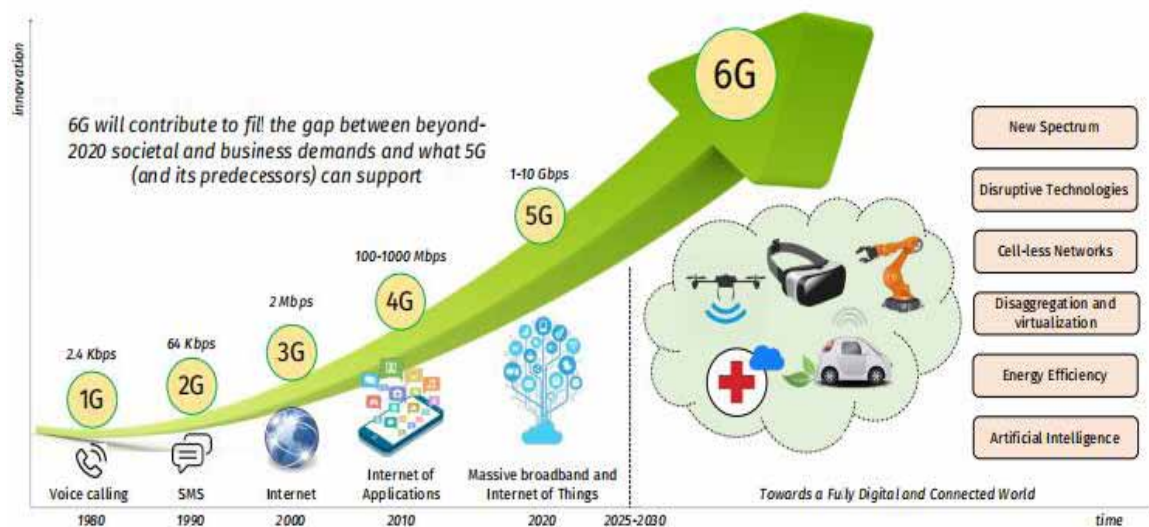
Through specific technical approaches, 6G will provide people with high quality of service (QoS) and high quality of experience (QoE), so as to make human life better. The author predicts the huge potential and development trend of 6G wireless communication technology combined with the healthcare field. 6G is a promising communication technology, and it is expected to revolutionize many sectors, including healthcare. Currently, time and space are the primary barriers to healthcare, and 6G has the potential to break these barriers down. The authors first introduce the background and related obstacles of the current healthcare development field and then prove the huge potential of 6G in its development field. Further, they reveal how 6G technology can be utilized for remote surgery, epidemics, and pandemics. Finally, there are related challenges. Similarly, the cell free communication in AR/VR helps in 360 video scenes.

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BACKGROUND

Each generation of mobile technology, design has influenced the growth in automated based on the need of the end users impact is shown in the figure1... Right from the automated vehicle on roads to airspace, AI to cloud devices is embedded with 5G technology. Huge amount of data at very high speed can be transferred due to advancement in the network. the advancement in the network technology from 1G to 6G. The technology plays very vital role in various field with different applications like Internet of things, some of the personalized communication, wearable devices for health, sensors with robotics, integrating the intelligence with network, Innovative network architecture, holographic telepresence, industry 4.0, Tele medicine and so on .Though the 5G has all the trade-off like latency, high throughput, energy and hardware complexity, the configuration in 6G may provide a better or ultra reliability, capacity and efficiency. Hence this chapter details the different perspective of the 6G application in various fields.

Figure 1. Development of cellular networks, from 1G to 6G, with a representative application for each generation.(Giordani, 20210)



It's know that the speed of light equals wavelength multiply frequency ($c = \lambda \nu$) since the speed of light is constant; when the wavelength is small enough, the frequency is going to be extremely rapid. 6G will apply Terahertz (THz) signal which wavelength is $300\mu\text{m}$ (Nayak&Patgiri, 2020), so the operating frequency of 6G will be about 10 times faster than 5G, and its data rate will be 1000 times faster than 5G. Besides, with the utilization of mURLLC (Massive Ultra-reliable and Low Latency), mMTC (mas-sive Machine Type Communication) and other technologies, many aspects of 6G performance will be significantly improved as shown in the Table 1.

Therefore, 6G will be a network with larger coverage, faster transmission and greater compatibility, which can help education and assistive technology evolve.

Table 1. The classification of 6 G performance compared with 5 G

Requirements	5G	B5G	6G
Application types	•eMBB •URLLC •mMTC	•Reliable eMBB •URLLC •mMTC •Hybrid (URLLC + eMBB)	•MBRLLC •mURLLC •HCS •MPS
Device types	•Smartphones •Sensors •Drones	•Smartphone's •Sensors •Drones •XR equipment	Sensors and DLT devices CRAS XR and BCI equipment Smart implants
Operating frequency	3-300 MHz	500 MHz	1 THz
Spectral efficiency	$10 \times$ in bps/Hz/m ² /Joules	$10 \times$ bps/Hz/m ² /Joules	$1000 \times$ in bps/Hz/m ³ /Joules
Data Rate	1 Gbps	100 Gbps	1 Tbps
End-to-end delay	5 ms	1 ms	<1 ms
Radio-only delay	100 ns	<100 ns	≤ 10 ns
Processing delay	100 ns	50 ns	≤ 10 ns
Mobility range	100 - < 500 km/h	500 km/h	1000 km/h
Wavelength	3 mm	1 mm	300 μ m
Architecture	Massive MIMO	Massive MIMO	Intelligent surface
Core network	Internet of Things	Internet of Things	Internet of Everything
Satellite integration	Partial	Partial	Full
Artificial Intelligence integration	Partial	Full	Truly Artificial Intelligence Driven
XR integration	Partial	Full	Full
Haptic communication integration	Partial	Full	Full
Highlights	Extremely high rate Streaming	Extremely high rate Streaming	Security, secrecy privacy

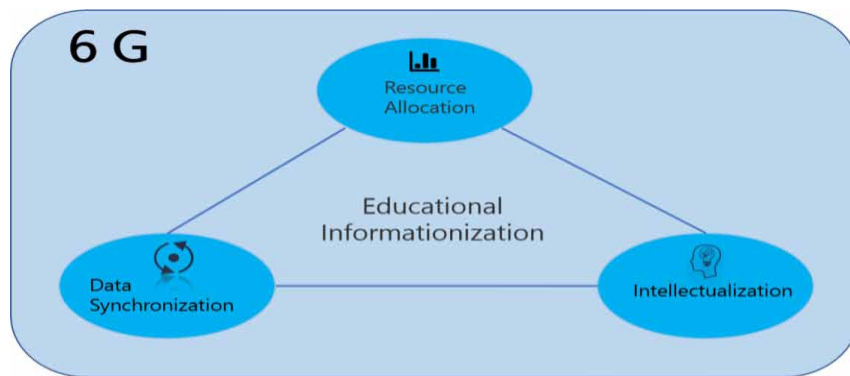
6G TECHNOLOGY IN THE FIELD OF EDUCATION

Steven Jobs had asked: “What’s wrong with Education Cannot Be Fixed with Technology” (2008). Although social problems were the main reason why jobs raised this problem, the network environment at that time also prevented the impact of technology on education to a certain extent. When 6G appears in society, the network will break the barriers to education and help more people receive better educational resources. Figure 2 shows the technology in education.

Educational informatization construction: Due to the excellent characteristics of 6G, its emergence will strengthen the construction of educational informatization from the following three perspectives: The educational environment will be more intelligent and actively adapt to individual needs. Through ubiquitous communication networks and sensing devices, it can intelligently perceive the environment and characteristics of learning individuals, and actively create a learning atmosphere, plan learning methods and push appropriate learning resources for each student. All kinds of data and information of education will be fully synchronized. Data analysis is the basis for the realization of intelligent education services, and the construction of educational informatization will establish norms and standards for the

collection and analysis of all kinds of data. The perception of the physical environment helps realize data aggregation and cross-domain transmission, strengthen the adjustment function of educational services, and break the restrictions of time, space, content and media. (Lu & sun, 2019)

Figure 2. 6G promotes educational informatization.



The speed and breadth of 6G communication make the supply of educational resources more uniform and sufficient. Educational informatization enables high-quality educational resources to circulate quickly on the network. As long as it is properly managed, more people can receive the high-quality education. In addition, educational informatization can promote learning outside the classroom and enable people to discover new knowledge in their daily lives.

Internet of Everything (IoE) is a more advanced concept than the Internet of Things (IoT). The IoE focuses on connections among people, processes, data, and things (Dave, 2013). Only 6G with incredible speed and width can implement IoE in real life. In addition, you will build the base of E-learning across the educational establishment, offering students more accessibility and benefits that include more feedback and monitoring of the learners' progress (Dave, 2013). For example, the Hunan University of Chinese Medicine researchers mentioned that 5G-oriented IoT could enhance physical education, as figure 2(Lei.et .al. 2021).

However, with the 6G-oriented IoE, physical education can be largely expanded with higher precision and lower delay. 6G terminals can be mounted on wearable devices, sports devices, and mobile phones and record the information generated when users move. These large amounts of data will be uploaded to the cloud (server), analyzed with AI, and finally sent back to the user's device. The extremely high transmission rate of 6G will make this process happen in an instant so that users can enjoy the best experience.

Role of 6G in Augmented Reality and Virtual Reality

At present, the technology of Augmented Reality and Virtual Reality is not mature enough, which is partly due to the limitation of the current network. Take Augmented Reality products as an example. Today, the relatively mature AR glasses on the market include Maigoo from Google, Hololens Two from Microsoft, and Magic Leap One from Magic Leap. However, due to the lack of technical capability, the display of these three glasses is disappointing, such as low picture resolution, jitter of display picture, and

Figure 3. IOT based sports education System. Note. By Lei, 2021, picture, from paper “5G-oriented IoT coverage enhancement and physical education resource management”



unable to present overly complex 3D models (he, 2021). If 6G exists, these AR glasses can completely transmit the collected information to the server. With the support of powerful algorithms and technology, like mURLLC and MBRLLC, AR glasses can present the results returned from the server to the user within 10ns. As for VR, like AR, 6G will make the presentation of VR technology perfect. In the future, 6G will make VR live broadcasting possible. An efficient network will significantly reduce the buffer and delay time and ensure the integrity of the data package. In that case, future VR live will bring users an extremely real experience. Mature AR and VR can be widely used in education, such as AR books, AR / VR gaming and VR classroom. These applications will significantly improve the efficiency and interest of teaching and enhance students' cognition and understanding of new things. Figure 3 shows the IOT based sports education System. (Lei et .al. 2021)

Besides, in healthcare education, the trainee and inexperienced surgeons could do surgical training with VR surgical simulation system. VR can simulate the reality of actual operation to reduce the incidence of errors in surgeons' actual operation in the future (Hsieh&Lee, 2018). Figure 4 and 5 depicts the role of 6G in with VR and AR in class room learning.

- **Holographic Telepresence**

The Holographic Telepresence is a new invention that allows viewers to see three-dimensional holograms without special glasses. However, a raw hologram, without any compression, with colours, full parallax, and 30 fps, would require a 4.32 Tbps data rate (Giordani, 2020). There is an increasing bandwidth necessity in the reach between 100 Gbps and 1 Tbps with the expansion of the viable pixel count, which is straightforwardly corresponding to the system performance such as displayed 3D object size, viewing angle and parallax effect (Xu, 2011). Such required data rate and bandwidth can only be

Potential Applications of 6G-Enabling Technologies and Challenges

satisfied by 6G. After Holographic Telepresence is implemented with 6G, it will greatly contribute to education, especially in architecture and medicine, because the relative position of the building and the human organs can be graphically displayed to the students.

Figure 4. The application of 6G with AR and VR in education

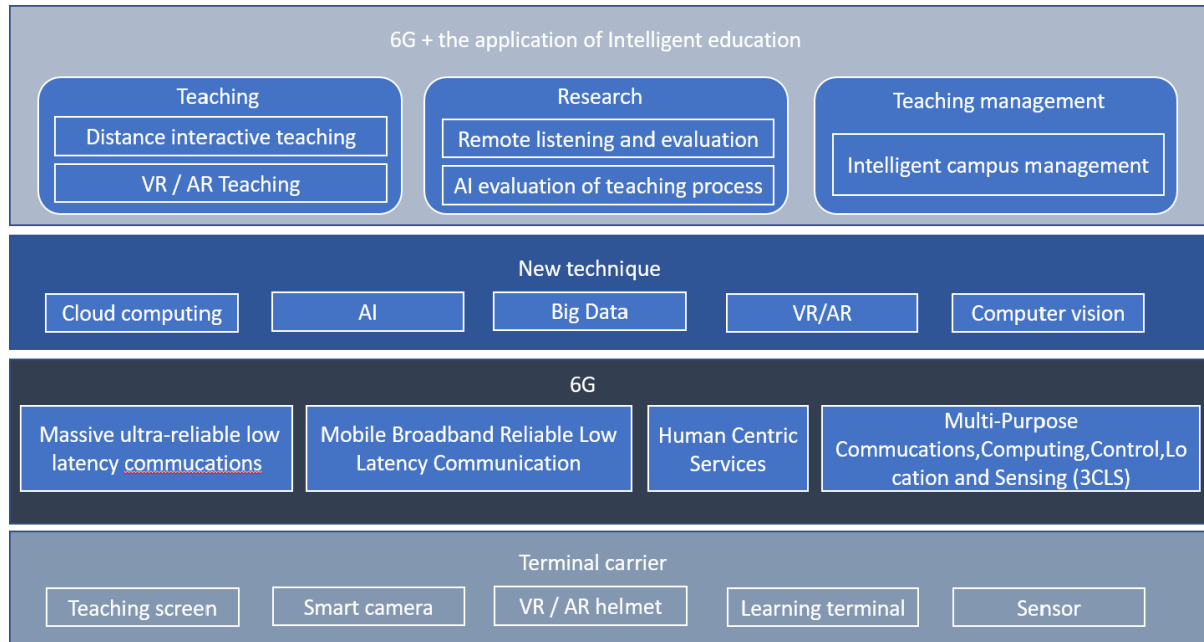
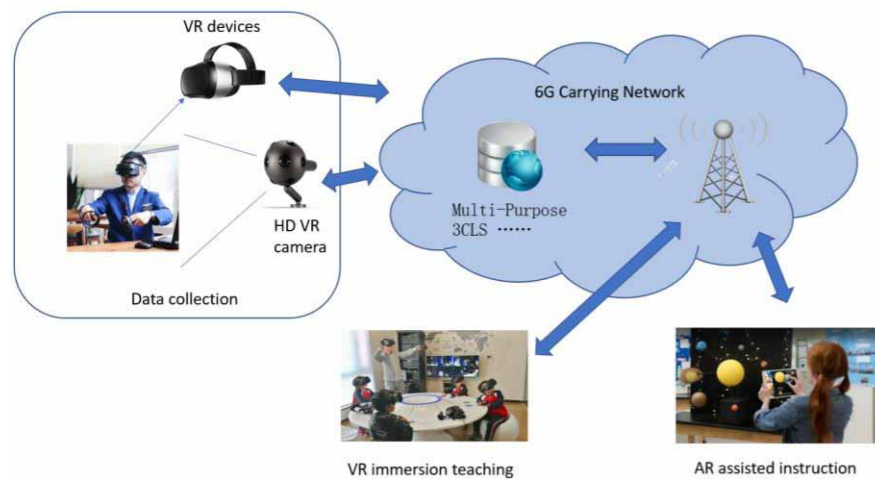


Figure 5. AR and VR in education helps in assisting the classroom learning



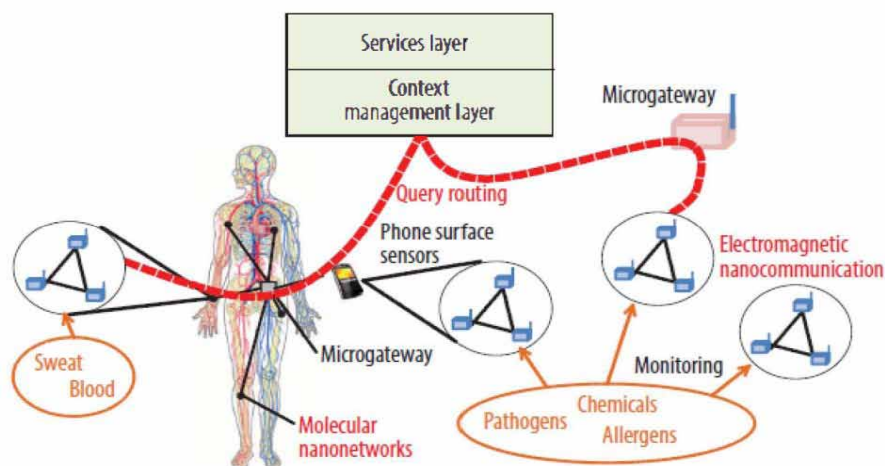
REMARKABLE CONTRIBUTION IN ASSISITIVE TECHNOLOGY

The AT (Assistive Technology) means the assistive, adaptive and rehabilitative devices which often used for people with disabilities or the elderly population. The wide frequency bands and fast data rate of 6G enable the assistive technology to become more alert and intelligent. Moreover, 6G will make assistive technology better serve the elderly and disabled.

Assistive Technology to the Elderly

In the past, Assistive Technologies (AT) has made remarkable contributions to the lives of older people in care institutions or at home. Various kinds of assistive devices, like video monitoring, remote health monitoring, electronic sensors and equipment such as fall detectors, door monitors, bed alerts, pressure mats and smoke and heat alarms, guaranteed older people's safety and ability to cope at home (Miskelly, 2001).

Figure 6. The Internet of nano things. "Realizing the Internet of Nano Things: Challenges, Solutions, and Applications." (Balasubramaniam et al.2013)



In the future, with more effective devices and 6G internet. The quality of life of the elderly will be further improved. Besides, 6G will witness the transformation from IoT to IoE and even to IoNT (Internet of Nano Things), so the health and safety of the elderly will be protected in an all-around way. For instance, intelligent assistive technologies can compensate for the specific physical and cognitive deficits of older adults with dementia (Bharucha, 2009). Furthermore, if the IoNT was realized with 6G, the information inside the body could be collected and analyzed by the cloud server. With the utilization of Nano-networks and the combination of Nano-sensors and diverse objects, a medical method will be applied (Miraz&Ali, 2021).

Assistive Technology to the Disability with 6G

When 6G network and AI are combined and applied to assistive technology, AT will overcome the limitations of technology availability and help disabilities reduce social exclusion and marginalization. Therefore, the disabled will be more easily integrated into society (Ravneberg & Söderström, 2017). In addition, the 6G-oriented IoE will greatly increase the QoS to the disabilities. For example, In the future, people with visual impairment can convey their instructions to intelligent devices connected to the 6G network through voice. The intelligent device can collect all the details of the voice and send it to the server, and then the server will analyze the voice and quickly return exact demands. This fully reflects the concept of Human-Centric Service (HCS) of 6G.

CHALLENGES IN ASSISTIVE TECHNOLOGY

Through the above analysis, the prospect of 6G is extensive. However, if we want 6G to serve people ideally, people still need to overcome various challenges:

Lack of Technology is one of the main pit falls in the growth of assistive equipment. Many 6G implementation technologies only remain theoretical phase, and there are still many problems that cannot be solved, such as how to transmit continuous terahertz signal, the energy loss of terahertz signal, stability of underwater communication, design of transmitter and antenna (Nayak& Patgiri, 2020). These practical problems need to be solved in a plenty amount of time and money. Cost effectiveness would be another challenge, taking the current 5G as an example, the power consumption of the 5G base station is about three times that of the 4G base stations, and the coverage area of 5G base stations is smaller than that of the 4G base station, which leads to the high price of commercial 5G. Therefore, 5G has not been widespread in society. So can 6G make its cost the same as or even lower than 5g while its performance is nearly 1000 times improved? 6G can build the Internet of everything, but will it be cheap enough to be used by everyone? Finding ways to reduce costs is the key to the development of 6G commercialization

6G is the primary driver to realize IoE. The high-speed data transmission and low delay mean that 6G oriented IoE will generate a massive data flow. Naturally, it will lead to network congestion and quality of service degradation. In order to solve this problem, the possible effective ways are 1. Increase the spectrum bandwidth; 2. Improve spectrum efficiency; 3. Spectrum reuse. However, these schemes are not perfect. They will be disturbed by the environment or produce new problems. In addition, colossal data flow means huge data quantity, and the data needs to be stored in the warehouse. The existing database capacity will be completely unable to accommodate the amount of data generated by 6G generation. There are two solutions: 1. Expand the data station, but it requires huge cost, especially when the amount of data increases exponentially; 2. Develop advanced decompression technology but requires a long time of research and development and some randomness.

Privacy also plays very major role in people's life .In the 6G era, collecting information is not difficult, but do people be willing all information of them to be collected and analyzed. The premise of 6G's customer service is the big data provided by customers. However, if people are not allowed their lives to be monitored every time by 6G oriented IoE, 6G's service will be limited to a large extent. No matter how fast the network is, the users will always come first, and the user's privacy has the right to be protected. If we can find a way that does not need to spy on people's privacy but still serves people well in the future, it will help the popularization of 6G.

CHALLENGES IN CELL-FREE COMMUNICATION TECHNOLOGY

From 1G to 5G, cellular technology continues to advance, is a phase change; 5G is highly integrated to provide universal high-speed coverage and extremely high user experience. It has been proven since the first generation that the simple and efficient way to increase network capacity is to reduce the size of the cell. In the 1980s, the size of cells was about a few hundred square kilometers. Then the size of cells kept shrinking. By now in urban areas, these volumes are typically less than a tenth of a square kilometer (Andrews, 2014). The purpose of using small cell networks is to improve the throughput, energy efficiency, and spectral efficiency of the cellular system, thereby improving the quality and smoothness of the received signal (Chowdhury, 2018) (Mahbas, 2019).

There are now three types of Small Cell Technology, Femtocells, Picocells and Microcells, of which Femtocells are the smallest, with a coverage range of only 10-50 meters and support for 8-16 users. Therefore, 5G cellular technology is characterized by a high degree of integration, with a dense distribution of base stations but a small coverage area, serving only a small number of users to give users a high-speed and smooth experience. For waveform plan, i.e., flagging and numerous entrances. 1G utilization FDMA. 2G utilization both FDMA and TDMA, yet we actually allude to it as TDMA because of the prevalent utilization of TDMA's time multiplexing. 3G's standard prevailing methodology is CDMA (Gilhousen, 1991), however assuming CDMA limits the progression of high velocity information, there is a shift towards TDMA, saving negligible range development and adding huge channel-mindful planning (Bender, 2000). 4G frameworks fundamentally use OFDM and consolidate it with FDMA and TDMA. What's more, 5G will utilize OFDM and OFDMA, which likewise makes ready for 6G to utilize sans cell-free massive MIMO systems.

Because of the exploration of millimeter-wave (mmWave) correspondence, 5G will likewise utilize some MIMO. millimeter wave not exclusively can have a ton of open broadband at higher frequencies, yet in addition can restrict the obstruction between cells, lessen transmission postpone and further develop security. The utilization of MIMO is a taste to track down the most reasonable harmony between energy proficiency (EE) and ghastly productivity (SE) (Singh & Rawat, 2014). In the event that the quantity of radio wires is fixed, the ideal number of motors can build the SE to the greatest. MIMO improvement becomes perplexing and variable when mystery execution is to be considered (Patwary, 2020).

Comparison between Cell-Less Communication in 5G and 6G

The high speed and low latency of 5G has brought great breakthroughs in smart technologies such as VR, but the coverage and energy consumption are still relatively low. In 2017, researchers proposed a 5G converged cellular-free communication network to support mobile terminals in smart cities for the deployment of 5G ultra-dense wireless networks. In smart cities, various different types of information are to be smoothly transmitted through heterogeneous wireless networks with different data transmission speeds and energy losses (Han, 2015). One of the best cases is high speed and low energy loss. The simple interconnection scheme can no longer meet the demand of different types of information for transmission technologies in smart cities, so the communication networks in smart cities need two levels of heterogeneity to cope with the wide variety of information and its transmission technologies. One level refers to the use of different transmission technologies when transmitting many types of information, such as mmWave, Bluetooth, etc. Another level is the use of different configurations and parameters for the same transmission technology to adapt to the transmission of various types of data information in

different situations. The traditional cell communication has always had a constant basic point, the mobile terminal (UE) must be connected to the network through a base station (BS) or access point (AP), so as to achieve the purpose of data interaction. In traditional heterogeneous cell communication, the UE can only switch up and down between heterogeneous network levels, or switch directly between adjacent cells. This leads to the problem that switching between different types of networks requires complex transformations and algorithms to support address switching. Some studies have used SDN technology to break the technical differences and rationalities between heterogeneous networks and to fuse 5G with cell-less communication to form new communication solutions to address the challenges in smart cities (Han,2017). Some studies have shown that 5G and cell-less communication converged communication networks have better network coverage and lower energy consumption than 5G.

The huge demand for data rates in cities has led to a high concentration of BSs and APs, and UEs have become diverse as technology has evolved, and environmental differences between indoor and outdoor environments have affected the choice of transmission and channels for wireless communications. mmWave, MIMO, and high-density BSs and APs provide extremely high speeds for users, but also create a large number of channels for wireless communications. Switching among many networks inevitably introduces additional latency, which can also create significant overhead for wireless communications. There are also serious interference problems, and complex electromagnetic interference in the city can bring a lot of noise to the network (Han, 2015). These disadvantages can be solved by cell-less communication.

The UE in the cell-less network will combine with one or more BS or AP. The UE is able to communicate through multiple BSs or APs, and the SDN controller helps select multiple BS combinations together for transmission based on the busyness and density of the surrounding BSs and APs. In contrast, in traditional cell networks, the UE can only connect to one BS or AP. In cell-less networks, UEs do not need to switch communication networks frequently, which avoids delays and energy consumption, and SDN's intelligent scheduling can reasonably use idle resources; there is no regional division between BSs and APs, which improves coverage and user experience and truly gives users a smooth and high-speed data transmission experience.

Cell-Free Communication in 6G

Although it is said that 6G may also use small cell technology, the high speed and low latency of 5G has made a huge impact on our lives, as people's demand for data and information transmission grows, the current 5G is still a bit far from the IoT requirements of 1 million devices per kilometer, and researchers are forced to research higher speed and lower latency technologies. A brand-new technology has come to the forefront, and that is Cell-free Communication.

Cell-free communication is similar to the cell-less communication mentioned above. 6G systems tightly integrate multiple different frequencies and different communication technologies, allowing users to switch between networks at will without any manual configuration. Among the many complex communication technologies, the system automatically selects the fastest and most stable network. The above are the basic concepts, but in the technical implementation the researcher has adopted a combination of several different technologies.

One of the faster progresses is cell-free massive MIMO, which not only affects the network coverage but also reduces the speed of data transmission due to the boundary effect of cell network. Some studies have proposed cell-free massive MIMO to overcome the effect of boundary effect on the network. A

study shows that massive MIMO communication schemes outperform network MIMO in terms of signal stability, intensity and cost for UE reception (Hosseini, 2014).

Cell-free massive MIMO is based on massive MIMO, and the large number of APs gives cell-free massive MIMO more freedom and high multiple utilization benefits. Since the APs are distributed throughout the network system, the system can provide high-speed stable and uniform network connectivity (Matthaiou, 2020). The researcher proposes to build cell-free massive MIMO communication based on distributed MIMO and coordinated multi-point communication. Cell-free massive MIMO communication significantly reduces interference between cells by weakening cell-free massive MIMO communication significantly reduces the interference between cells by weakening the boundary restriction between cells, so that a UE can freely dock multiple APs and multiple APs can cooperate to provide services to a UE. Each UE is served by at least one proprietary AP, which greatly improves the performance of signal transmission. Moreover, it has been shown that cell-free massive MIMO technology will improve UE throughput by 95% over small cell technology in correlation shading (Hosseini, 2014). Each AP contains multiple antennas, so the system can not only reduce energy consumption but also reduce component costs than base stations equipped with a large number of large antennas. The ultimate goal of this research is a cost-reducing and an extensible system. Achieving these two goals requires scalable data transmission protocols and efficiency control techniques. Distributed AP design is also essential to improve efficiency and reduce energy consumption.

In user-centric cell-free massive MIMO, all APs are connected to one or more CPUs to provide network services to users. How to break the scalability is the difficulty of this system. For now, the user-centric direction is the best approach for cell-free massive MIMO. (1). the heart of cell-free massive MIMO is scalable power control, which manages proximity effects and inter-user interference to optimize what we want to achieve (e.g., maximum-minimum fairness or total energy efficiency). (2). One of the long-term objectives of advanced distributed SP cell-free massive MIMO research is to develop an SP scheme that performs well and can be distributed. Otherwise, the system will be incapable of scaling. (Matthaiou, 2021).

Cell-free communication has commonly been displayed to have critical execution upgrades. With the persistent turn of events and development of RF contraption, cell-free communication can be accomplished and framework unwavering quality can be altogether improved by utilizing invalid port adjustment. Nonetheless, the use of cell-less communication on millimeter wave actually has numerous issues, like impedance and joint effort between RPU. Cell-free communication is a significant device to tackle the impedance issue looked by CCFD organizations, yet there is still a ton of work to be done to settle the obstruction presented by the more free and adaptable duplexing strategy.

APPLICATION OF 6G WITH INTERNET OF THINGS (IoT)

Internet of things (IoT) refers to the connection of any object to the network through information sensing equipment and according to the agreed protocol, and the objects exchange and communicate information through the information transmission medium to achieve intelligent identification, positioning, tracking, supervision and other functions. IoT connects Ubiquitous Devices and Facilities to IoT domain names through various wireless and/or wired long-range and/or short-range communication networks to achieve interconnection (M2M), application Grand Integration, and SaaS operation based on cloud computing, etc. Intranet), private network (Extranet), and/or the Internet (Internet) environment, the use of appropriate

information security mechanisms to provide safe and controllable and even personalized real-time online monitoring, and other management and service functions to achieve the “efficient, energy-saving, safe, environmentally friendly” management, control, camp” of “everything”. The integration of “management, control and management” of “everything” is realized.

As 4G’s cellular network cannot afford the massive data flow of IoT and is not able to meet the requirements of multi-device connectivity and low latency, module cost and energy consumption are relatively high. The high speed and low latency of 5G greatly improves the performance and reliability of device connections, opening the first door for the development of IoT. The first part will review 5G and IoT related technologies and their shortcomings.

Emerging Growth of Internet of Things with 5G Network

There are millions of mobile subscribers today, and the number is predicted to reach 80 billion by 2030, expanding at a rate of roughly 25% each year. Wireless communication, as we all know, has become one of the most important trends in the development of an intelligent world (Hong, 2017). By 2020, each person will have about 6-7 devices, and roughly 20.4 billion IoT devices are connected via M2M, which brings a massive number of devices to IoT (Egham,2017).Communication technologies from 1G to 4G solve people’s communication problems. However, 5G is not limited to the field of communication, it will also promote the interoperability of information between people and things, and things and things.5G defines three major application scenarios: eMBB, URLLC, and mMTC, which mainly provide high speed (10Gbit/sec), low latency (1ms), and large connection services (one million/square kilometer).There are three keys in IoT application, which are sensing layer, network transmission layer and application layer. Such the smart home, which is common in life, belongs to the application layer of IoT, and 5G is the network layer access of IoT.

To enable large-scale IoT and crucial IoT connectivity via typical cellular IoT or low-power wide area networks (LPWAN), the majority of connections use fixed and short-range communication technologies. LPWAN is widely utilized in IoT for 5G because of its large area coverage, high energy efficiency, channel bandwidth, data throughput, and low power consumption. Traditional Wi-Fi and cellular networks aren’t an issue. SigFox, Ingenu RPMA, and LoRa are some examples. To strengthen and enable 5G IoT, LTE Cat-M1 (also known as eMTC), EC-GSM-IoT, and NB-IoT (also known as LTE Cat-NB1) are employed. Emerging technologies including software-defined wireless sensor networks (SDWSN), network function virtualization and cognitive radio (CR) act as network enablers to help 5G overcome such limitations to traditional networks for mobile networks for the Internet of Things.5G currently faces these additional challenges: scalability, network management, interoperability and heterogeneity, security and privacy, network mobility and coverage, and network congestion and overload (Kobo,2017)(Akyildiz,2006)

Growth of Internet of Things in 6G

When cutting-edge IoT applications such as augmented and virtual reality, autonomous driving, etc. emerge, there is also a huge demand for communication technology that comes with them. These IoT applications transmit large and dense data, requiring higher transmission rates and lower latency. Obviously, 5G communication technology can no longer meet the needs of the current applications for the transmission of data and information. Then communication technology should think about 6G network

development wireless communication and network technology to support the future of large-scale high-precision IoT networking devices.

As IoT continues to evolve, the physical environment is gradually being connected to communication networks for applications such as healthcare, distance learning, autonomous driving and smart homes, and 6G is playing a pivotal role as these applications slowly reach out to human life (Qi, 2020). 6G will expand its capabilities on top of 5G with Tbps data rates, sub-millisecond latency, cm-level localization, etc. This will greatly improve the ability of large-scale IoT devices to operate and switch quickly under numerous demands. Then 6G will use more diverse and complex use cases, which will make different applications and their components conflict with each other and create interference. Today, 6G also has several major developments (Guo, 2021). More spectrum and more highly aggregated networks; 2. Convergence between communication, control, sensing, and positioning; 3. Compatibility and convergence of different types of communication systems; 4. A gradual shift to intelligent networks that will generate a lot of AI; and 5. A shift from highly aggregated to distributed arrangements.

Faced with large-scale IoT, 6G will need to develop a new network design. That is, not simply staying on the ground, but also at sea, on land, in the air, and at high altitude. Devices such as satellite sets will be required to support high air. Drones can be used in the air. Optical communication, such as fiber optics, will complete the underwater and sea communication systems (Yan, 2020). This new network architecture ensures that all active areas are covered, but it also necessitates real-time operation and decentralized services. And, in order to establish an intelligent approach to managing the IoT, these needs can be met via machine learning. Machine learning and block chain are the two most critical enhancements in the 6G technology breakthrough. Machine learning has been widely used in various layers of IoT, sensing layer, network transmission layer and application layer. Machine learning is mainly used in resource management and motion control. The network intelligence and automation brought by machine learning is the most critical goal for 6G implementation. Recently there are studies using machine learning to solve the IoT communication challenges (Strinati, 2019).

Another major breakthrough in 6G is distribution, which will determine the core of IoT systems. Today's devices use a single gateway to connect to servers and transmit data through them, but highly aggregated in the face of huge numbers of IoT devices and data interaction will face the disadvantage of low rates and high energy consumption, and may also face serious security issues. Block chain can then help 6G to achieve a distributed layout. Firstly, blockchain is characterized by decentralization and low cost, and then block chain has uniformity in the underlying layer, which can improve the compatibility and operability between different types of IoT systems and reduce interference and delay. Finally, the high confidentiality and anonymity of block chain can greatly improve the security performance (Zhaofeng, 2019) (Xie, 2019).

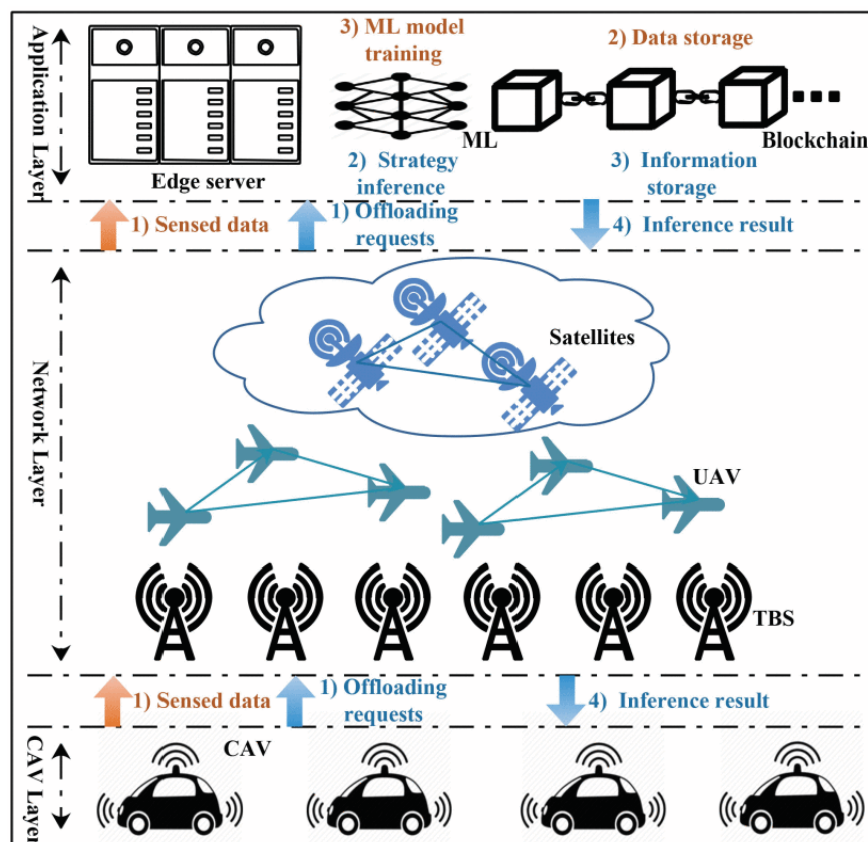
5G took the first step for the initial IoT, and 6G is a huge enhancement on top of each of the 5G foundations. Compared to 5G's augmented reality and virtual reality technologies, 6G enables full-sensory communications. 5G's connected cars evolve into autonomous driving in 6G. 5G focuses communications on the ground, while 6G turns 2d into 3d, providing communications for all devices in vertical space. Both AI and block chain will have their limitations and will affect the implementation of 6G functions if they are not properly integrated. So it is important to integrate AI and block chain properly to make the most of their advantages. Most AI approaches have depended on centralized models for training and inference, with data collected by edge devices being uploaded to data centers. Because of the centralized nature of the system, there will be a lot of communication overhead and the chance of data tampering. As

a result, AI conclusions may be delayed and highly inaccurate. In this setting, distributed AI that protects privacy and decreases network traffic congestion by avoiding data upload to central servers is critical.

Popular Use Case for Autopilot

The figure 6 below shows a case study of 6G autopilot, which is one of the trending technologies soon, can also be launched in air vehicle launching.

Figure 7. Proposed 6G autopilot vehicle architecture with CAV's



Connected autonomous vehicles (CAVs) sense data such as the position and speed of other vehicles, road conditions, and traffic lights using the terahertz spectrum or other unlicensed spectrum. The sensor data is then communicated to the application layer through the network layer, which has the features of high data rate, low delay, full coverage, and high reliability, thanks to the space-space-earth-water network. To preserve CAV's privacy, this data can be stored on the block chain. Machine learning models are trained on the block chain using the sensor data. CAV uses space, air, ground, and underwater/ocean networks to outsource computer workloads to edge servers. The application layer makes intelligent decisions for the driver's helper, such as lane changes and overtaking, using trained machine learning

models (i.e., strategic reasoning). To give auditions and power for the unloading service, the unloading operation is maintained on the blockchain. The network layer transmits inference results, such as control information, to the vehicle. That is completely self-driving. Furthermore, block chain can be used to restrict access, data sharing across multiple cars and edge servers, and resource sharing, all of which can improve the system's performance.

FUTURE OUTLOOK AND CHALLENGES WITH 6G TECHNOLOGIES IN IOT

Everyone has realized the shortcomings of 5G and needs a more perfect technology to promote the development of China's artificial intelligence, Internet of Things, smart driving, smart manufacturing and other industries. And 6G will not just be a communication technology, it will integrate satellite communication, block chain, AI, IoT and other high precision technology needs in one, forming a huge network with dead-end communication for everything in the future, by then, IoT will really have the root of networking, and will also usher in a real explosion period.

Although the current medical system is very developed, it is also accompanied by huge hidden dangers and problems. In order to understand where the next step in the development of the medical system is, we must clarify what difficulties are currently facing. See for examples, the growth and aging of the global population the current healthcare system will not be sustainable in the future. The natural disasters created by infectious diseases have a formidable impact on people and societies. Without affecting the city infrastructure, pandemics leave the places abandoned because of the shortage of human resources, either due to deaths, illness, or unwillingness to work because of health risks. (Janjua, 2020) The shortage of infrastructure such as hospitals has caused many problems such as difficulty for patients to see a doctor and the inability to afford expensive medical expenses. These problems seem to have feasible solutions. The continuous population growth has caused a high burden on the medical system. Through remote medical treatment (Nayak, 2021), our timely response to the prevention and control of infectious diseases can prevent losses due to the spread of the virus. From the first report of influenza cases in 1918 to the current 2019 pandemic corona virus disease, COVID-19, the system that has played a key role in saving human lives has been healthcare. But these methods have great difficulties. In order to provide patients with diagnosis, treatment and multiple health services in the hospital and remotely, all medical care units must be equipped with advanced technology. There is also a need for a rapid response unit to handle patient thrusts and inquiries during the disaster (Janjua, 2020). The establishment of an epidemic prevention and control system, such as the new generation of healthcare Internet of Medical Things (IoMT), requires large-scale and intelligent connections, huge bandwidth, low latency and ultra-high data rates, and a better healthcare experience quality. These technical requirements are something we cannot achieve in the current technical environment.

The current medical services framework depends vigorously on the fourth-age (4G) organizations to empower keen medical care applications; in any case, because of restricted data transmission assets, these organizations can't uphold the fast development of these applications over the long haul. Contrasted and 4G, fifth-age (5G) networks offer better administrations as far as transfer speed, unwavering quality, idleness, and information rate (Li, 2019). 5G administrations are extensively sorted into upgraded portable broadband (eMBB), ultra solid low dormancy interchanges (URLLC), and enormous machine type correspondences (mMTC). From the medical care framework viewpoint, 5G administrations: (I) give web availability to the web of clinical things (IoMT) gadgets through mMTC; (ii) offer top notch

Potential Applications of 6G-Enabling Technologies and Challenges

video calling for remote healthcare and increased reality (AR)/augmented reality (VR) for better perception in finding and therapy through eMBB; (iii) support drones and independent vehicles for both the reconnaissance and crisis situations with URLLC (Ahad, 2019). In the case of a large amount of resource tilt, 5G also has specific practices in remote surgery. Based on the report of Insider, In March, 2019, a doctor in the Chinese city of Sanya implanted a stimulation device in the brain of a Parkinson's patient nearly 1,900 miles away in Beijing. Shown in figure.7

Figure 8. Remote surgery using 5G in China earlier this year. (South China Morning Post/YouTube)

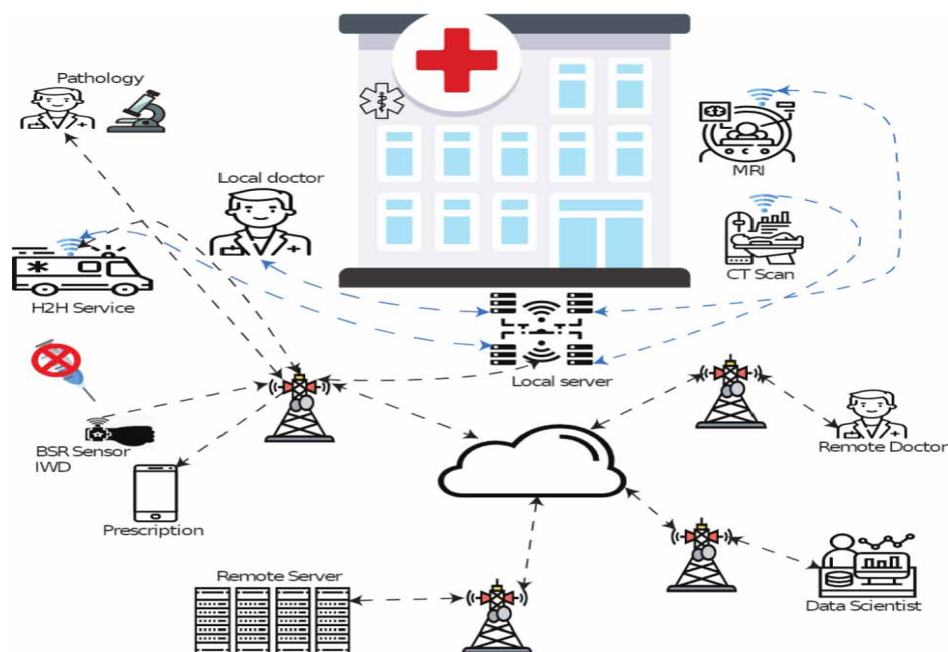


Although many medical methods are being updated under the pace of 5G comprehensive deployments, the speed of development still cannot keep up with the growth of people's medical needs. Specifically, due to the difference in computer and network signals, the general communication of remote healthcare in basic areas is relatively low. The difference is that it is difficult to ensure the safety and stability of remote healthcare services (Nayak, 2021). Besides, ambulance service is only a carrier of patients with oxygen facility and street traffic need which can be served by a normal car as well. Plus, the old help is very unsatisfactory in current situations. The older assistance requires intensive care from clinical staffs. Be that as it may, it is inaccessible till date. Most of patient passes on in rescue vehicle while going from home to clinic or before rescue vehicle arriving at the spot. Likewise, the accident discovery framework is inaccessible in current healthcare systems. The mishap location framework requires genuine time detection to offer clinical types of assistance on schedule and on the spot. The current medical care framework is giving essential facilities and the critical obstruction of the current medical services framework is time and space. This is unavoidable in the current situation (Janjua, 2020). Therefore, set up a new intelligent healthcare system is a proposed direction, such as figure.8. 6G can help us overcome many difficulties and achieve this goal.

6G Technology: Configuration in Remote Surgery

The current communication technologies, such as 5G, are not suitable for future healthcare - because of their high cost and lack of real-time tactile feedback, and, due to their slow speeds, mmWave cannot guarantee consistent connections (Nayak, 2021). However, with 6G enhancements, smart Health applications will be enabled through innovations such as mobile edge computing, virtualization and artificial intelligence (Janjua, 2020). According to (Chen,2019), 6G technology for future healthcare will provide high data speeds ($\geq 1\text{Tbps}$), high operating frequencies ($\geq 1\text{THz}$), low latency ($\leq 1\text{ms}$), high reliability (10^{-9}), and high mobility ($\sim 1000\text{km/h}$), and wavelength of $\leq 300\mu\text{m}$. Therefore, in theory, it can meet the requirements of remote surgery for real-time communication, and smart health services can also be deployed as shown in figure 8.

Figure 9. A standpoint of intelligent healthcare systems.



Including smart medical Internet of Things, blood sample reader (BSR) sensors, smart wearable devices (IWD), online prescriptions, MRI, CT scans), and home-to-hospital (H2H) services to realize mobile hospitals, pathology, local doctors, and remote doctors And data scientists. 5G and B5G will not be able to support smart medical care, and both can make substantial progress with the support of 6G. 6G correspondence innovation will revolutionize medical care totally and healthcare will completely rely upon correspondence innovation. Present status of the workmanship healthcare system can't give telesurgery because of communication innovation. Besides, emergency vehicle administration is to be supplanted. Wear-capable gadgets should be reclassified. The emergency clinic is required to rebuild. Online real-time health services could be available. Health monitoring and elderly services need to be redefined.

Nowadays, discussion on the application of the sixth-generation (6G) network in smart medical care is a hot topic. A key motivation is to develop communication from a social and humanitarian perspective, namely to design communication technologies to improve the quality of life in all aspects (Benevides, 2020). In this regard, some 6G-based technologies will be introduced in one section, such as holographic telepresence, haptic Internet, Bio-Nano Internet of Things (IoBNT), uncoordinated network, and radio frequency (RF). Based on the reliability, ultra-large-scale connectivity, continuity, scalability, and flexibility brought about by 6G, it constitutes a theoretical foundation for the construction of intelligent medical infrastructure. Especially for electronic medical applications, physical security must be considered to ensure the security of the communication link (Vora,2018).

Healthcare Technology with 6G

The core of 6G technology is a new generation of wireless communication technology, and its original intention was to make it and other timely integration inevitable. Next, we will discuss some technologies in the field of intelligent medical care that can be realized under the enhancement of 6G.

Remote Healthcare

At present, the medical system still uses patients to seek medical treatment at hospitals as the main form of service, but the burden of the entire system is also increasing. However, based on the purpose of providing medical services to remote areas, remote healthcare is popularized globally. This service is implemented in two main ways, remote healthcare and remote health monitoring (Pramanik, 2019). In remote healthcare, doctors use remote meetings or check electronic health records to evaluate, diagnose, and treat patients, which avoids face-to-face diagnosis. Therefore, video conferencing is the main way of consultation. However, with the development of communication technology, holographic television is expected to be applied in the near future. For remote health monitoring, IoMT technologies such as wearable devices and wireless body area networks (WBAN) have begun to be widely deployed.. Similarly, the popularization of sensors based on electronic health recorders will help protect the lives of the elderly. However, the development of this technology is limited by economic factors, hardware and software, and communication technology adaptability. These technologies require safe and reliable links to ensure the privacy and safety of patients.

Remote healthcare services are completely dependent on communication infrastructure. The arrival of COVID-19 has also objectively promoted the development of remote healthcare. With the emergence of COVID-19, all walks of life are promoting remote healthcare to reduce the spread of infection in hospitals and the burden on patients.. Therefore, due to communication challenges such as the large-scale connection and interference of IoMT, the ultra-low-power communication of biosensors, the reliability and low latency of digital medicine based on haptic Internet, and the high data rate requirements, a large amount of real data has also Accelerated the development of these technologies. However, the existing problems have always been obvious. How to protect the key information and privacy of patients? Wireless communication links are vulnerable to security threats such as eavesdropping, interference, and deception. Especially in remote healthcare, all devices and sensors send data to medical staff in the hospital or upload it to an online portal. If the communication link is not secure, the eavesdropper can obtain critical information about the patient. Therefore, it is also necessary to overcome difficulties to ensure the security of the physical channel.

Edge Intelligence

6G claims to have high capacity to provide smooth services to billions of smart devices (Ullah et.al, 2012). This can also realize Edge Technology's innovation. Edge technology collects, calculates and analyzes health data in real-time at its edge nodes (Ma et .al, 2020). This user-generated data is transmitted to the Edge node. At the same time, the Edge node calculates health data and analyzes the data to determine appropriate operations. For example, the Edge node will receive user health data transmitted by smart medical devices and determine whether the user has any defects. Health data is continuously transmitted to edge nodes. Edge nodes monitor health-related data. Edge nodes also filter health-related data and transmit important information to cloud storage. Edge technology reduces the cost of communication and computing (Illa, 2018). Some other advantages of Edge technology include low latency, reliability, privacy, scalability, and adaptability. The combination of edge computing and artificial intelligence gave birth to edge intelligence (zhou, 2019). Edge nodes receive a large amount of health-related data, and artificial intelligence is used to discover patterns or calculate them for analysis. With the help of artificial intelligence, edge nodes can develop image, data, and video edge analysis. At present, the execution of artificial intelligence algorithms requires a lot of computing resources and power consumption, which is limited in edge nodes. Therefore, they rely on the cloud to perform. However, the Edge node will be one of the network nodes in 6G. All 6G network nodes will enable artificial intelligence to provide intelligent services for the healthcare system. In addition, 6G will have real-time intelligent edges, which will greatly enhance the healthcare system. It will calculate and analyze real-time data (Huang, 2019).

Tactile and Haptic Internet

Tactile and haptic technologies use force, motion, or vibrations to create virtual touches for the user. Virtual touches can be transmitted by the tactile internet to another user, whether he or she is a human or a robot. The haptic Internet requires high-speed communication to interact in real-time. The technology used in remote surgery can help doctors use touch for diagnosis. Haptic human-computer interaction (HCI) is divided into three types, namely desktop, surface, and wearable (Wang, 2019). In the desktop HCI, remote doctors will be able to use virtual tools for surgery or diagnosis, and at the same time can issue commands to the robot to interact with the patient. In wearable HCI, for example, tactile gloves are used by remote doctors. Tactile & haptic technology will also help provide healthcare during disasters. For example, during the global blockade caused by COVID-19, expert doctors can remotely perform complex operations through tactile & haptic technology. The use of robots can be used to interact with patients or care, and medical staff will not directly contact patients. And all of this must be based on the low-latency communication characteristics of 6G.

Internet of Medical Things (IoMT)

The IoMT is a smart device powered by AI, which is consistent with the AI-driven 6G technology (Gui,2020). IoMT supports that almost every medical supply can be connected to the Internet. For example, MRI and CT scans. The scanner will scan the device and send the data to the remote location via 6G technology, as shown in Figure 2. When all medical support is connected through IoMT, and decisions can be made immediately by doctors. Therefore, IoMT will be able to overcome time and space barriers and truly reduce costs. Another example, based on interaction with remote treatment.

Currently, detecting whether a cancer patient is benign or malignant takes time to wait for the test result. However, using 6G technology to combine related sensors and IoMT, patients do not need to go to the hospital for testing on the spot. At the same time, doctors can treat cancer patients remotely. Set up for joint diagnosis with doctors from other regions. This scenario applies not only to cancer but also to many diseases. For example, cardiovascular therapy. However, inventing such a sensor requires a large investment of resources and needs to consider security and privacy issues.

CONCLUSION

Through comparison, we found that 6G has significant advantages over 5G and B5G. The excellent framework and performance of 6G will undoubtedly improve the development of education and assistive technology. In the field of education, 6G will promote the completion and improvement of educational informatization, and it will make AR, VR and holographic technology more mature and serve education well. In the field of assistive technology, 6G will make IoE and even IoNE possible. In this case, 6G + AI can provide high QoS for the elderly and the disabled, and it will protect the health of these vulnerable groups and improve their social tolerance. Meanwhile, the implementation and application of 6G also confront many challenges. In order that 6G can successfully serve human education, assistive technology and other fields in the future, finding solutions to overcome these challenges is the primary goal of 6G development at the current stage.

In the context of population growth, epidemic diseases and other factors that continue to threaten the current medical system, the construction of the intelligent healthcare framework has become an inevitable trend. But when the current communication technology represented by 5G cannot solve the barriers brought by time and space to healthcare, we must explore the development and prospects of emerging healthcare technology with the support of 6G technology. 6G-supported healthcare communications can minimize adverse effects and provide rapid response in future pandemic situations. In particular, the convenience and cost reduction brought by remote healthcare, the timeliness and comprehensiveness of medical assistance brought by IoMT, and edge intelligence and tactile & haptic Internet technologies guarantee the authenticity of medical methods. There are also some other technologies, such as holographic imaging. With the addition of 6G, AI can help healthcare communications solve multiple problems such as capacity, security, and reliability. However, the development of new medical systems, the design and manufacture of necessary sensors, medical devices, and the training of doctors who master new communication technologies all need to overcome a lot of difficulties. In the future of 6G technology, we must continue to explore.

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Chapter 7

Cell-Free Cooperative Non-Orthogonal Multiple Access for 6G Wireless Systems

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ABSTRACT

The diversified opportunities and challenges in various sectors necessitate development of sixth-generation (6G) wireless systems with extremely high data rate, massive connectivity, minimal latency, good coverage, high reliability, optimal resource allocation, good spectral and energy efficiency. Multiple access is a key technique in the wireless technological evolution that provides access to multiple users with the available resources. Even though 5G system promises data rate in Gbps and latency below 1 ms with a wide bandwidth ranges from 30 GHz to 300 GHz, its range of coverage was limited. Hence, the infrastructure needs to be rebuilt to overcome the limitation. NOMA is the key enabler for bringing down the interference effects and sharing the spectrum among multiple users in an efficient way. Cooperative communication is another promising technology that can improve coverage and capacity of the wireless system. Cell free communication with cooperative NOMA architecture is proposed in this chapter to meet 6G requirements at THz band.

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INTRODUCTION

The revolution of wireless industry paved the way for successful deployment of 5G networks in various sectors such as defense, healthcare, agriculture, education, commerce, entertainment etc. The diversified opportunities and challenges in these sectors necessitate development of sixth-generation (6G) wireless systems to meet the requirements such as extremely high data rate, massive connectivity, minimal latency, good coverage, high reliability, optimal resource allocation, good spectral and energy efficiency.

Multiple access is one of the key techniques in the wireless technological evolution which provides access to multiple users with the available resources. Older generations involved frequency division multiple access (FDMA), time division multiple access (TDMA), code division multiple access (CDMA), space division multiple access (SDMA) and Orthogonal Frequency division multiple access (OFDMA). FDMA, TDMA, CDMA and SDMA wasted the resources significantly and increased the design complexity. Even though OFDMA offers more flexible multicarrier communication designs in eliminating inter symbol interference, it needs complex equalizer at the receiver which increases cost of the system and fails to achieve good coverage due to non-linearity in RF power amplifier. The requirements put forth by 3GPP is kept alive by various technologies like Massive MIMO, Internet of Things (IoT) and Device-to-Device (D2D) communication which makes use of highly directional antenna. Data rate and user capacity has been significantly improved by the use of beamforming techniques for short distance communication. Even though 5G system promises data rate in Gbps and latency below 1ms with a wide bandwidth ranges from 30 GHz to 300 GHz, its range of coverage was limited. The performance of the system degrades in long distance propagation when its operating frequency is from 30 GHz to 300 GHz. Hence the infrastructure needs to be rebuilt to overcome the limitation.

Non-orthogonal multiple access (NOMA) is the key enabler for bringing down the interference effects and sharing the spectrum among multiple users in an efficient way. Cooperative communication is another promising technology which can improve coverage and capacity of the wireless system.

Background

Multi antenna NOMA system can be designed with successive interference cancellation (SIC) and interference rejection combining (IRC) to achieve gain in capacity and spectral efficiency (Saito, 2013). NOMA increases the capacity of the entire network and throughput of the downlink of the user equipment located at the edge of the cell. Optimal power allocation takes an important role in increasing the cell throughput of NOMA system. NOMA with fractional transmission power allocation (FTPA) and tree-search based transmission power allocation (TTPA) achieve overall cell throughput gain of 30% and 35% correspondingly over OFDMA. NOMA can serve multiple users at the same time, same frequency and with same code, but with different power levels, which provides a significant spectral efficiency gain over traditional orthogonal multiple access (OMA) practiced (Ding, 2017).

Low-complexity cooperative diversity with amplify and forward (AF) and decode and forward (DF) relaying protocols has been introduced to reduce the effect of multi-path fading. It allows a pair of wireless nodes to fully exploit spatial diversity in the channel. For fixed low data rates AF and DF based cooperative communication offer 1.5dB optimal power savings while compared to non-cooperative communication. Outage behaviour and average information rate of cooperative network in AF and DF relaying mode is evaluated. This literature laid down an important milestone in the evolution of half duplex one way relaying cooperative communication (Laneman, 2004).

The cooperative communication has been implemented in NOMA with better channel conditions. It involves two phases such as direct transmission phase and cooperative phase. (Ding, 2016). The key features and the engineering feasibility of NOMA cooperative communication with AF and DF relaying schemes is explained in (Dehuan, 2018) with different configurations. Uplink, downlink and composite architectures for OMA and NOMA based cooperative communication system are depicted. It reveals that the power utilization of NOMA is 30% greater than OMA. Multiple relay with unicast and multicast cooperative NOMA is introduced in (Long, 2017) with fixed and dynamic power allocation.

Performance analysis of traditional cooperative relaying systems (CRS) is compared with the NOMA-based CRS in the presence of Rician fading channel in (Ruicheng, 2017). The comparative studies presented in the literature says that the achievable rate is approximated efficiently using Gauss-Chebyshev Integration which makes the NOMA-CRS to perform well when compared to traditional CRS.

The optimal power allocation between the nearest node and the farthest node in NOMA-CRS in accordance with the global energy efficiency aspect improves the Quality of Service (QoS) through achieving better bit error rate performance (Qian, 2018). Cooperative NOMA can be deployed with successive node relaying also. Optimization of power split factors between the nearest node and the farthest node improves fairness of the outage behaviour as well as the data rate. The process of successive interference cancellation is studied from this literature (Qian, 2019). NOMA CRS with energy harvesting wireless nodes with multiple antennas which are adopting AF and DF relaying strategies along with maximal ratio combining achieves better capacity (Abdelhamid, 2021).

REQUIREMENTS OF 6G

Due to the advancement in technology, there is a marvelous groundbreaking progress in wireless communication systems during the past decade. The design challenges such as peak data rates, massive device connectivity, good area coverage and variety of use cases made a thirst to commercial service providers, academic research groups, standardization bodies, and end-users to have a paradigm shift beyond 5G wireless technology. Though 5G touches the horizon, further advancement in the wireless industry opened up the opportunities for the next generation. The commercialization of the 6G wireless evolution is expected around 2030. The crisp of 6G would be fully automated system with remote access management. The mobile data traffic volume is expected to be around 50 EB / month in the next decade. The requirements of 6G system over 5G are enhanced mobile broad band with ultra-low latency, massive machine type communication, Artificial Intelligence (AI) based embedded communication system, tactile internet, extremely enhanced data throughput and security.

Table 1 shows the comparison of design specification for 5G and 6G wireless systems (Dogra, 2021). The key performance indicators of the parameter system capacity primarily deal with system throughput which includes peak data rate, experienced data rate, peak spectral efficiency, experienced spectral efficiency, maximum channel bandwidth, area traffic capacity, and connection density. The important metrics such as experienced data rate and spectral efficiency should be guaranteed to 95% of all user locations. System latency parameters include end-to-end latency metric, along with delay jitter. System management class of performance indicators principally deals with metrics related to the management and orchestration of networks such as energy efficiency, reliability, and mobility.

Table 1. Comparison of design specification of 5G and 6G wireless system

Design Specification	Key Performance Indicators	5G	6G
System capacity	Peak Data rate	20 Gbps	1 Tbps
	Experienced data rate	0.1 Gbps	1 Gbps
	Peak spectral efficiency	30 bps/Hz	60 bps/Hz
	Experienced spectral efficiency	0.3 bps/Hz	3bps/Hz
	Maximum bandwidth	1 GHz	100 GHz
	Area traffic capacity	10 Mbps/m ²	1000 Mbps/m ²
	Connection density	10 ⁶ devices/km ²	10 ⁷ devices/km ²
System latency	End-to-end Latency	1 ms	100 μ s
	Delay jitter	-	1 μ s
System management	Mobility	500 km/h	1000 km/h
	Packet error rate	10 ⁻⁵	10 ⁻⁹
	Energy efficiency	-	1 Tb/J
	End-to-end reliability	99.999%	99.999999%

Since 5G is initially designed for terrestrial mobile communication. It also has the limitations on radio coverage. The 5G standalone architecture operates in the mm wave frequency. Even though it supports a drastic increment in its capacity, it can be highly suitable for short range communication up to 2km. In the upcoming days, Internet of Everything (IoE) is expected to have a great impact in the modern wireless industry. Due to the combinations of key enabling technologies like, AI, block chain and cloud computing, IoE can be built successfully in 6G. So, the upcoming mobile communication system should have coverage over the entire surface of the earth which includes, versatile landscapes like oceans, mountains, deserts, forests and air space. 6G technology is planned to solve the limitations of its predecessor. It mainly focuses on the coverage region around the globe as well as internet connectivity for the entire world through IoE.(Chowdhury, 2020)

In the upcoming days not only the handheld devices, but also each and every modules of the industry are going to act smart. Hence, there is no need for any human interactions because the complete system would be fully automated. Along with the aid of the cutting-edge technology like Artificial Intelligence, it could be feasible to integrate various networks like, satellite communication, terrestrial communication, deep sea communication and D2D communication. This may yield betterment in terms of coverage around the earth with mobile broadband.

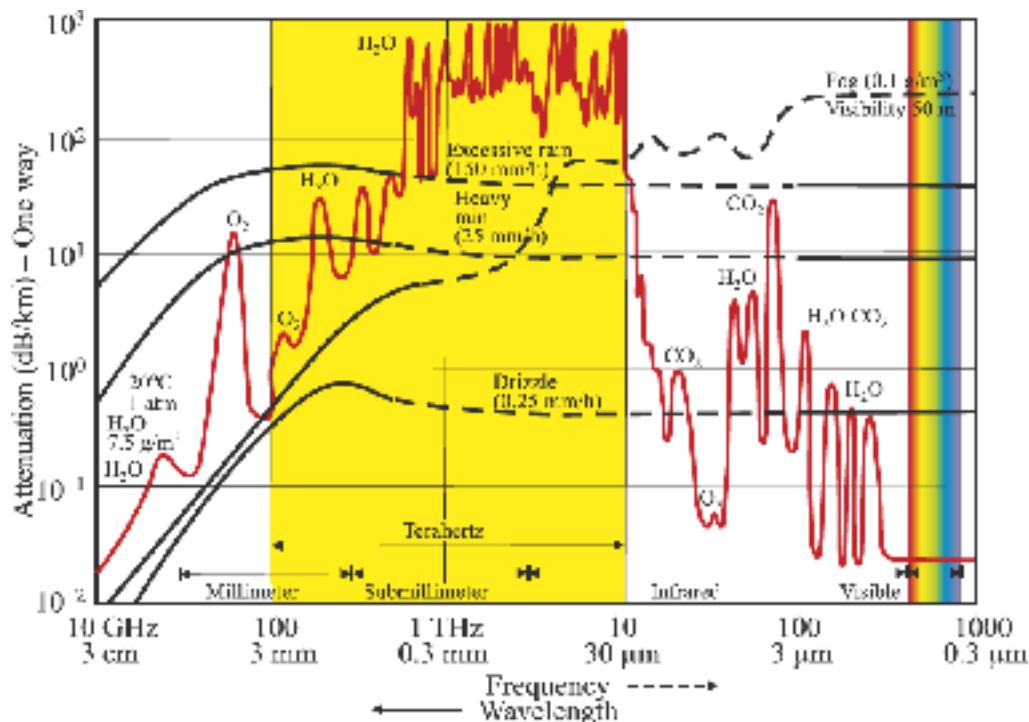
The main challenge of 6G includes, overall system coverage, capacity improvement, increase data rate, spectrum efficiency and energy efficiency. One of the optimum ways to enhance data rate is to integrate satellite and mobile communication. This yields wider coverage around the globe with minimal implementation cost. The other key promising technological breakthroughs required for the successful deployment of 6G network are pervasive artificial intelligence, machine learning, block chain-based resource allocation, Tera Hertz (THz) communication with wider spectrum resources, cognitive communication systems with active signal transmission and reception, spectrum reconfigurable front-end for dynamic spectrum access, optical wireless technology, Cell free communication, 3D networking, etc.

THz Communication

A histrionic exponential growth in wireless data traffic has been observed in recent years which is caused by numerous exhilarating technological advancements in wireless communication system. It creates demand for higher data rates and better coverage. The demand for cloud applications, ultra-speed wireless downloads and seamless connectivity are expected to increase in the 6G networks. Among emerging trends in wireless technology, terahertz (THz) band communication has been envisioned as one of the key enabling technologies for the next decade. The frequency band for THz communication ranges from 0.1 THz to 10THz. This band is expected to provide data rate in Tbps. It operates between optical and RF spectrum and it would fill the gap between the above two spectra. Also, it can interconnect fiber optic links with handheld devices like laptop with transparency. 6G cellular communication system is expected to operate in 90 GHz to 1 THz frequency. (Elayan, 2020). Recently, the Federal Communications Commission (FCC) has released the frequency bands above 95 GHz for research purposes.

As the frequency of carrier signal is increased, the Doppler effect is very minimum when compared with the previous generations. Also, data rate is increased tremendously. Also, it can encourage non line-of-sight communication. So, it can be preferred to establish connectivity even in unfavorable climatic conditions like fog and dust. The relation between attenuation and frequency is shown in fig. 1.

Figure 1. THz band attenuation characteristics. (Elayan, 2020)

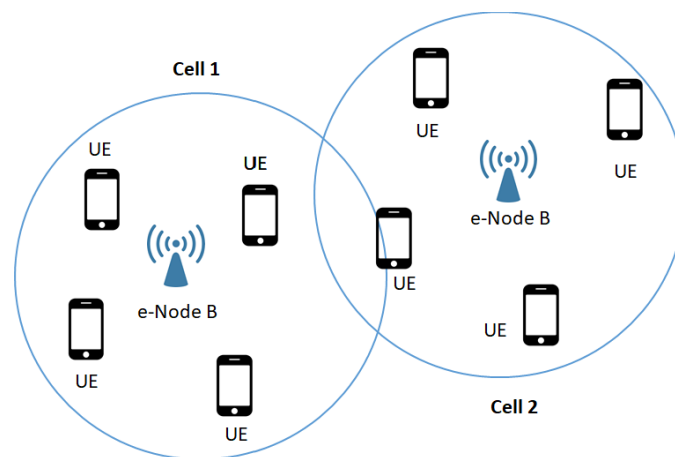


Cell Free Communication

Over the past four decades from the first generation to the fourth generation, cellular topology is the conventional method of providing mobile communication services to the subscribers located in a specific geographical area. In the wireless technologies up to the fourth generation (4G) systems, the geographical area is divided into smaller regions and the separated regions are controlled by the base stations as shown in Fig (2). The size of the geographical area is consistently reduced from larger cell deployments to smaller cell deployments as the new wireless generation is evolved. Each base station is assigned with dynamic channel groups to serve a given number of user equipment using beam forming techniques. Key indicators such as spectral efficiency, energy efficiency and data transfer rate decided the performance of each cellular network topology in a competitive manner. Each network topology often needs to adopt new technologies to improve the performance in order to overcome the limitations such as variations in quality of service, inter-cell interference, and huge occurrence of random hand-offs. (Hope Ikoghene Obakhena, 2021)

A feasible solution to the aforesaid challenges is addressed by deploying a number of distributed access points densely over a given geographical coverage area to optimally serve for a smaller number of user equipment. This novel network topology referred as cell-free communication which is a key enabling technology for future wireless communication system. The densely distributed access points are controlled by central processing units (CPU) through front-haul connections and CPU carries the traffic to the cloud server system via back-haul connections. The term “cell-free”, here is referred to the wireless communication strategy in which there is no cell boundaries for the user equipment to achieve mobility.

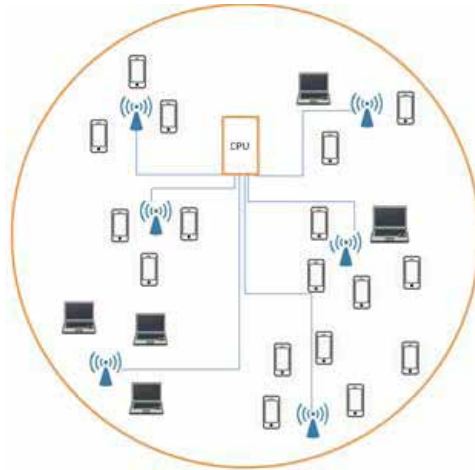
Figure 2. Cell based wireless system architecture



Though such system provides effective communication between users, the level of interference is severe especially at the cell edges which affects QoS. In 5G, Massive MIMO (MMIMO) is introduced to enhance the capacity of the network. Since the base station nodes are distributed in every cell, it is termed as distributed MMIMO. Cell free MMIMO is a cutting-edge technology, which would expect to have a vital role in the upcoming 6G networks. In cell free MMIMO, there is no cell boundaries. The entire

available service antenna has the capability to serve all the user terminals coherently. The technology behind the cell free MMIMO includes the combination of Time Division Duplexing (TDD), MMIMO, dense distributed network topology and user-based transmission system design. The proposed cell-free system architecture is shown in fig. 3.

Figure 3. Proposed cell free wireless system architecture



MULTIPLE ACCESS SCHEMES FOR 6G

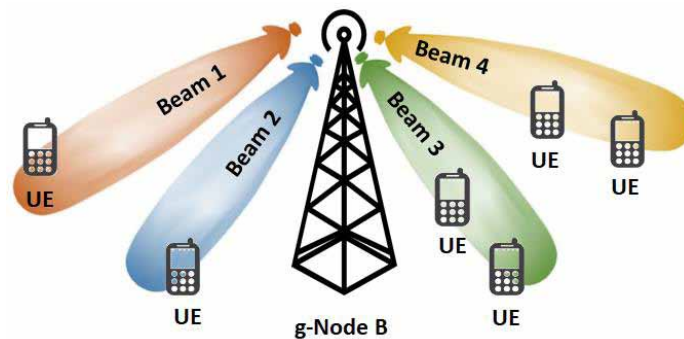
In order to compensate the scarcity of radio spectrum, multiple access schemes have been introduced in the previous generations. Frequency Division Multiple Access (FDMA), Time Division Multiple Access (TDMA), Code Division Multiple Access (CDMA) and Orthogonal Frequency Division Multiple Access (OFDMA) are the different multiple access schemes which has a leading role from the first generation to fourth generation of cellular networks. The multiple access techniques for 5G and beyond are discussed further.

Beam Division Multiple Access (BDMA)

Apart from this the R&D department of Korea introduces BDMA scheme for 5G mobile wireless communication system. This scheme never encourages sharing of time and frequency resources. In this method, the g-NodeB allots unique antenna beam for each and every mobile device. At first, mobility of the handset, speed of motion and position of the mobile user equipment are calculated. According to this information, the g-NodeB manipulates the beamwidth and direction of the beam to be allocated for all the available mobile users. It is an excellent mechanism to enhance data rate in case of line-of-sight (LOS) communication in 5G. In BDMA, all the users are allocated with unique beam. So, all mobile users can transmit their data at same time and frequency at different angles. This can be achieved using phase array antenna and beam forming techniques.

The concept of BDMA is depicted in fig. 4. When g-NodeB and mobile user are in line-of-sight and g-NodeB has the knowledge of the location of the user equipment, both can establish an effective communication without generating any disturbances or interferences to neighboring users. Moreover, the mobile user periodically updates its information to g-NodeB. Thus, the g-NodeB can track and transmit the beam to the user equipment. To increase the number of users in the network further, the entire available beam should be divided. If large number of mobile users is located at the same angles, they will share a single beam to establish a communication with g-NodeB using TDMA. With the marvelous support of BDMA scheme, the over-all channel estimation and design complexity of the transceivers are highly reduced in 5G system. In short, if the beam width of the system is very narrow, the capacity of the system increases tremendously. The beam width and the number of beams also depend on the propagation environment.

Figure 4. Concept of BDMA



Space Division Multiple Access (SDMA)

Space division multiple access provides an excellent performance in terms of spectral efficiency especially in MIMO systems. This technology is highly recommended for mm-wave and satellite communication systems.

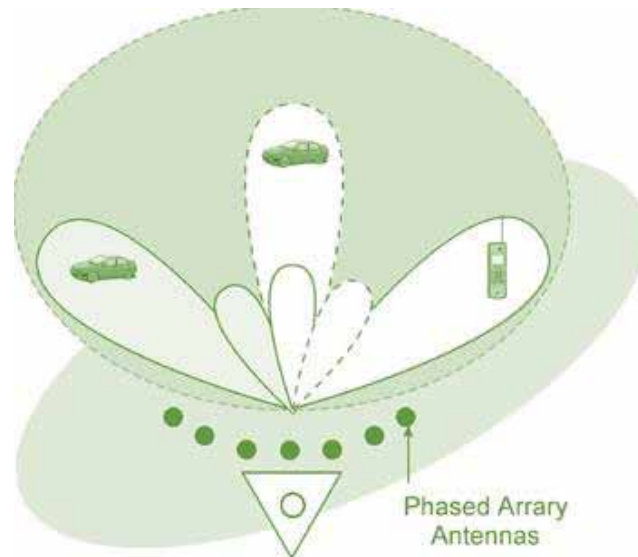
Benefits of SDMA are as follows:

- All the users in the communication system can share the same time and channel.
- Effects of inter-cell-interference is almost null.
- Directional spot beam antenna is used for signal transmission. So tracking is excellent.
- Energy radiated by all the users are monitored and controlled.

The basic principle of SDMA is indicated in Fig.5. The SDMA encourages reuse of same set of frequency within a location which is separated by an optimum distance. It supports narrow beam transmission which enhances the system capacity. Similarly, smart antennas are incorporated with pointed beams at the direction of user equipment. It provides services to different users within the same region. Another added advantage of using SDMA is, because of narrow beams, this multiple access schemes enhances the radio coverage along with less amount of power consumption. Also, the narrow beam ends

with high gain and high quality of reception. Further, SDMA technique reduces the interference effects from unintended users.

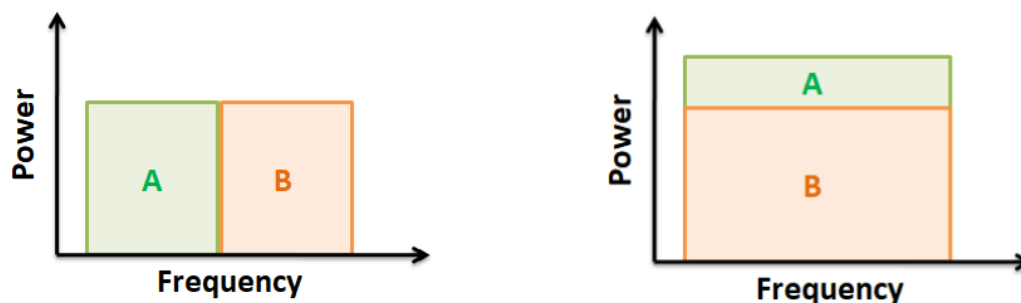
Figure 5. Principle of SDMA



Non-Orthogonal Multiple Access (NOMA)

The multiple access schemes and radio resource management mechanisms in the 6G is considered to improve the spectral efficiency and data throughput. The 4G cellular network utilizes Orthogonal Frequency Division Multiple Access (OFDMA) in downlink applications. Even though OFDMA results with uncountable benefits in 4G, it ends with poor performance in 5G system due to its orthogonality effects. The next choice of multiple access schemes for 5G network is Non-Orthogonal Multiple Access (NOMA) scheme. Fig 6(a) and 6(b) shows the spectrum of OFDMA system and NOMA system with two nodes namely A and B.

Figure 6. (a) Spectrum of OFDMA system; (b) Spectrum of NOMA system



Massive users can be potentially engaged in NOMA system by accommodating them in a single resource block. It permits every user to access entire allocated channel bandwidth which facilitates the resources allocated to users with bad channel conditions can still be accessed by the users with good channel conditions. Thus, the spectral efficiency of the system could be improved considerably.

NOMA maintains a good balance between system throughput and user fairness (Naveena 2019). The radio resources with different channel conditions can be effectively utilized by users in a timely manner. This satisfies the 5G requirements such as low latency and high-speed connectivity. At very first, g-NodeB transmits the mixture of signals of different users. In case of NOMA, users with poor channel conditions are allotted with more transmit power. This ensures that every user can detect the signals intended to them and treat other signals as noise components. This facilitates the NOMA system to yield higher throughput than OFDMA. Besides this feature, channels with poor quality are engaged with a low data rate. This could yield excellent performance for IoT applications since many devices are served with a low data rate.

In the 5G system, available bandwidth is split into a number of sub-bands. Then each sub-band carries signals from g-NodeB to different users with different power levels. The SINR is an important factor that contributes a lot to the system performance. In NOMA, each user operates in the same frequency, at the same time and is distinguished by their power levels. Here every user is allocated with a unique power level. The intensity of power to a particular end user depends on the gain of the channel. The user with poor channel quality is often assigned with a large power level and vice versa. In the receiving end, the users are separated based on the power difference between them. This could be achieved through the successive interference cancellation (SIC) technique. So, the end user can detect the strongest signal meant for it and deduct the signals of other users as interference. The 5G system follows CSI at both transmitter and receiver side. So, the order of SIC should be updated periodically.

The achievable data rate of an orthogonal multiple access (OMA) system with two user equipment UE_A and UE_B are given by R_1 and R_2 consecutively.

$$R_1 = \frac{1}{2} \log_2 \left(1 + \rho |h_1|^2 \right) \quad (1)$$

$$R_2 = \frac{1}{2} \log_2 \left(1 + \rho |h_2|^2 \right) \quad (2)$$

In the above equations the term ρ denotes the transmit signal to noise ratio (SNR), the terms h_1 and h_2 are the channel gains of UEA and UEB respectively. At very high SNR, the sum rate of orthogonal multiple access system is given by

$$R_{sum} = \frac{1}{2} \log_2 \left(\rho |h_1|^2 \right) + \frac{1}{2} \log_2 \left(\rho |h_2|^2 \right) \quad (3)$$

The achievable data rates of NOMA system with two user equipment UE_A and UE_B are given by the following expressions.

$$R_1 = \log_2 \left(1 + \frac{\rho \alpha_1 |h_1|^2}{1 + \rho \alpha_2 |h_1|^2} \right) \quad (4)$$

$$R_2 = \log_2 \left(1 + \rho \alpha_2 |h_2|^2 \right) \quad (5)$$

In the above equations the terms α_1 and α_2 are the power split factors. At very high SNR, the sum rate of NOMA system is given by

$$R_{sum} = \log_2 \left(\rho |h_2|^2 \right) \quad (6)$$

The sum rate of NOMA system is larger than the sum rate of orthogonal multiple access system. (Zhiguo Ding, 2017)

In 6G, all the available subcarriers are assigned to all the users at the transmitting side and SIC is done at the receiver side (Molafet, 2018). To solve resource allocation problem, power and subcarriers are allocated separately at each iteration. For efficient power allocation, successive convex approximation is considered here.

PROPOSED COOPERATIVE NOMA FOR CELL FREE SCENARIO WITH UNKNOWN CSI

Fig 7(a) shows the generalized architecture of NOMA system with two nodes. Let us consider the co-operative NOMA with CSI unknown in cell-free scenario. Let us consider a small part of cell free cooperative NOMA communication system with one access point (AP) and two user equipment namely A and B as shown in Fig 7(b). Assuming that the user equipment A is near to the AP which has strong channel conditions whereas the user equipment B is far-away from the AP which has weak channel conditions. In cooperative NOMA scheme the stronger user can act as a relay for the user equipment B to improve the coverage (Ganapathy, 2021).

Figure 7. (a) NOMA system; (b) Proposed cell free cooperative NOMA



Assume that the end to end communication is achieved in two time slots. At first, the access point T radiates the signal $s_1(t_1)$ with power p_1 to both A and B. The received signal at A and B are given in equation (7) and (8),

$$P_A(t_1) = \sqrt{p_T} h_{TA} s_1(t_1) + n_{TA} \quad (7)$$

$$P_B(t_1) = \sqrt{p_T} h_{TB} s_1(t_1) + n_{TB} \quad (8)$$

In the expressions (7) and (8), the terms h_{TA} and h_{TB} are the channel response between APs and the user equipment A and B respectively whereas the terms n_{TA} and n_{TB} are Additive White Gaussian Noise (AWGN) noise with zero mean and variance σ^2 .

Now the received Signal to Noise Ratio (SNR) at node A and B are,

$$\gamma_{SNR,A} = \frac{p_T h_{TA}^2}{\sigma^2} \quad (9)$$

$$\gamma_{SNR,B} = \frac{p_T h_{TB}^2}{\sigma^2} \quad (10)$$

In equation (9) and (10), the term p_T is the total power of the transmitted signal. In the next time slot, the relay node A transmits the signal s_2 to the destination node B. Now, the received power at B is calculated as per the equation (10),

$$P_B(t_2) = \sqrt{p_A} h_{AB} s_1(t_2) + \sqrt{p_A} h_{TB} s_2(t_1) + n_{AB} \quad (11)$$

Table 2. Time slots required for all the nodes in down-link process

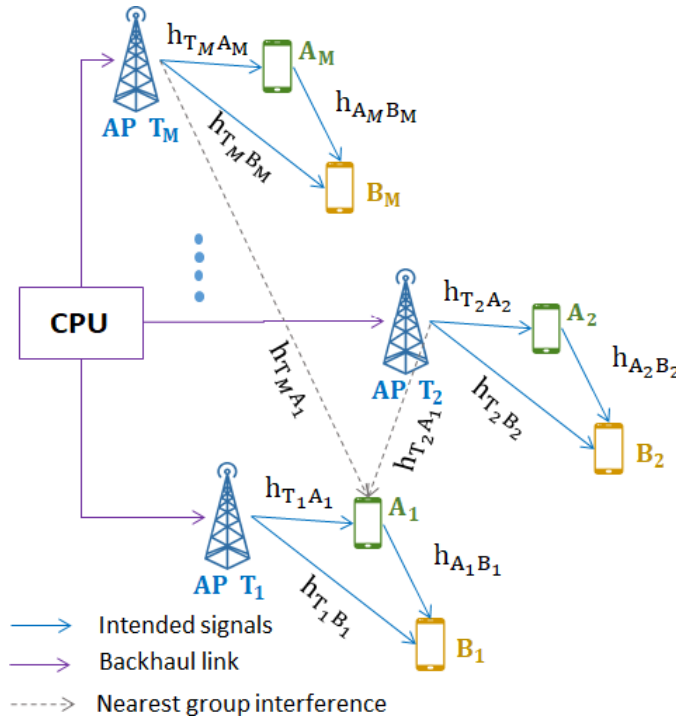
Node	Time Slot 1	Time Slot 2
AP	Tx - s_1	Idle
User equipment A (Relay Node)	Rx - s_1	Tx - s_2
User equipment B	Rx - s_1	Rx - s_2

At the receiving end, Successive Interference Cancellation (SIC) based decoding operation is executed. At first, the signal s_1 is decoded, whereas signal s_2 is treated as noise. Further s_2 is decoded and s_1 is considered as noise. The overall Signal to Interference Noise Ratio (SINR) of the received signal is expressed in equations (12) and (13),

$$\gamma_{TA,s_1} = \frac{p_T h_{TA}^2}{p_T h_{TB}^2 + \sigma^2} \quad (12)$$

$$\gamma_{TB,s_2} = \frac{p_T h_{TB}^2}{p_T h_{TA}^2 + \sigma^2} \quad (13)$$

Figure 8. Cell free cooperative NOMA under interference scenario



Let us consider a cell free cooperative NOMA with interference scenario as shown in the fig (8). In this scenario, there are M number of access points $\{AP_1, AP_2, \dots, AP_M\}$ is providing service to two nodes each. The nodes $\{A_1, A_2, \dots, A_M\}$ are the relay nodes which are near to the access points for which the access point needs to spend less energy to transmit data, whereas the nodes $\{B_1, B_2, \dots, B_M\}$ are the destination nodes which are far from the access points for which access points need to spend more energy to transmit data. Each access point along with two nodes is called as group. The groups are $\{group_1(AP_1, A_1, B_1), group_2(AP_2, A_2, B_2), \dots, group_M(AP_M, A_M, B_M)\}$. During the first time slot of user cooperation, the downlink channels are active between the access point and the nodes. During the second time slot, the cooperative links are active between the relay node and the destination nodes. The down-link and cooperative link channels are assumed to be Rayleigh fading and the noise considered is AWGN. The down-link channels of the $group_1(AP_1, A_1, B_1)$ is considered for the analysis of sum rate.

The received signal at node B_1 of the first group in the cooperative link at the second time slot is given by

$$P_{B_1} = \sqrt{p_A} h_{T_1 A_1} s_1 + n_{T_1 A_1} \quad (14)$$

The interference within the first group due to the transmission of AP_1 is given by

$$I_{SG} = E \left\{ \left| \sqrt{p_T} \left(h_{T_1 A_1} h_{T_1 B_1}^T - E \left[h_{T_1 A_1} h_{T_1 B_1}^T \right] \right) \right|^2 \right\} \quad (15)$$

Self-interference of the relay node during cooperative link in the first group is given by

$$I_S = E \left\{ \left| \sqrt{p_A} \right|^2 h_{T_1 A_1} h_{T_1 A_1}^T \right\}. \quad (16)$$

Interference due to the transmission of access points located in the nearest groups is given by

$$I_{NG} = \sum_{m=2}^M E \left[\sqrt{p_T} \left(h_{T_1 A_1} h_{T_m A_m}^T + h_{T_1 A_1} h_{T_m B_m}^T \right) \right] \quad (17)$$

The signal to interference noise ratio of the cooperative link the destination node B_1 is given by

$$SINR_{CL} = \frac{\left| \sqrt{p_A} E \left[h_{T_1 A_1} h_{T_1 B_1}^T \right] \right|^2}{1 + I_{SG} + I_S + I_{NG}}. \quad (18)$$

The achievable data rate of the cell-free NOMA cooperative (Sayyari, 2021) link is given by

$$R_{CL} = \log_2(1 + SINR_{CL}) \quad (19)$$

To brief the necessity of NOMA in 6G cell free network, data rate, spectral efficiency and Bit error rate (BER) performance are analyzed in the proposed system. Consider a scenario, where the downlink communication between two users is focused. Also assume that, among the two cellular users, one is treated as near user and the other as far user. The proposed system assumes that, at high SNR, all the available time and / or frequency resources are allocated to every user uniformly. The over-all sum throughput of both Orthogonal multiple access (OMA) and NOMA is expressed mathematically as follows,

For OMA system,

Table 3. Simulation environment

Tools	Types	Version
Simulation Software	MATLAB	R 2020 (64 bit)
Operating System	Windows	10 Professional (64 bit)
Processor	Intel Core i5	core i5 3470 (3.60GHz)
RAM	LPX	DDR4 (16Gb)

$$R_{t,OMA} = \log_2 \left(\rho \sqrt{|h_A|^2 |h_B|^2} \right) \quad (20)$$

and for NOMA system,

$$R_{t,NOMA} = \log_2 \left(\rho |h_B|^2 \right) \quad (21)$$

In order to enhance the spectral efficiency of the cooperative NOMA system, power allocation algorithm is employed in the proposed system further. Here, water filling algorithm is opted for power allocation. Also, the NOMA system allows all the users to share the entire transmission bandwidth during data transmission and reception. While considering proper power allocation to every subcarrier, it is assumed that, each and every subcarrier of all the users are arranged in the descending decoding order with respect to the gain of the channel. The same phenomenon is applied for successive interference cancellation technique also. Thus the users with the highest channel gain will be considered for decoding first. In the meantime, the signals received from the weak users are treated as interfering components.

Simply, the spectral efficiency of the NOMA system is calculated as,

$$SE = \frac{R_{t,NOMA}}{\text{Bandwidth}} \quad (22)$$

Further, to enhance the spectral efficiency, power optimization is done in the proposed model based on the following constraints,

The constraints are,

$$\sum_{k=1}^K \sum_{s=1}^S p_{k,s} \leq P_t \quad (23)$$

where $p_{k,s} \geq 0$ for all k and s

In the equation (23), the term K represents number of available users, the term S represents the number of subcarriers and the term P_t represents power of the access point.

SIMULATION RESULTS

The performance of the proposed cell free cooperative NOMA (CO-NOMA) system with unknown CSI is compared with power domain NOMA (PD-NOMA) system. The system is simulated in MATLAB 2020 environment. The details of simulation environment are shown in table (3). The 90GHz band is considered in the simulation with Rayleigh fading channel.

The result in fig. 9 shows that the proposed Cooperative NOMA system leads the PD-NOMA system in terms of data rate in 6G cellular network. It is evident that data rate ranges from 1Gbps to 9 Gbps is achieved in cooperative NOMA based cell free communication system over a span of SINR interval from 0dB to 30dB. Moreover, nearly 1Gbps data rate is additionally gained by the cooperative NOMA when compared to power domain NOMA. Hence cooperative NOMA can effectively improve the throughput of cell free communication with optimal power allocation.

Figure 9. Performance comparison chart between CO-NOMA and PD-NOMA

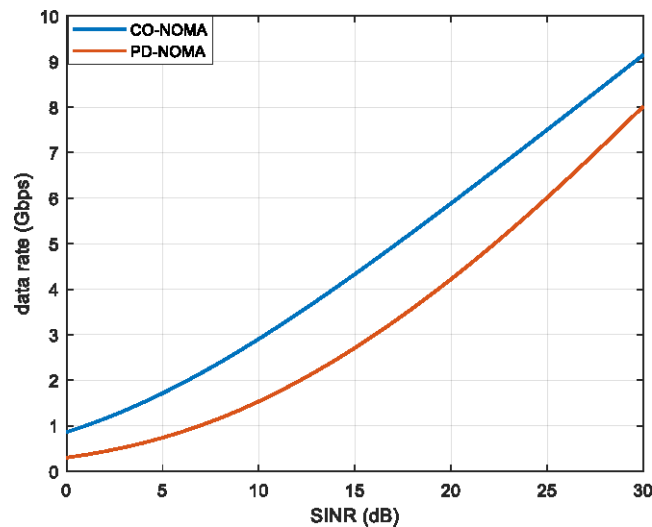


Fig. 10. shows the spectral efficiency performance of OMA, PD-NOMA and Cooperative NOMA. When the channel gain of the far users is greater than that of the near users, the sumrate of the NOMA system leads the OMA system. From this, the results conclude that, always the NOMA system achieves improved spectral efficiency performance than the OMA at high SINR. Also, the cooperative NOMA enhances the reliability of the users even in the worst condition of the channel. Next, BER performance of near and far users are considered. It is mathematically manipulated using the below equation,

$$P_e = \frac{1}{2} \left[Q\left(\sqrt{\gamma_A}\right) + Q\left(\sqrt{\gamma_B}\right) \right] \quad (24)$$

In equation (24), γ_A is the SINR of near user and γ_B is the SINR of far user

Figure 10. Spectral efficiency vs SINR

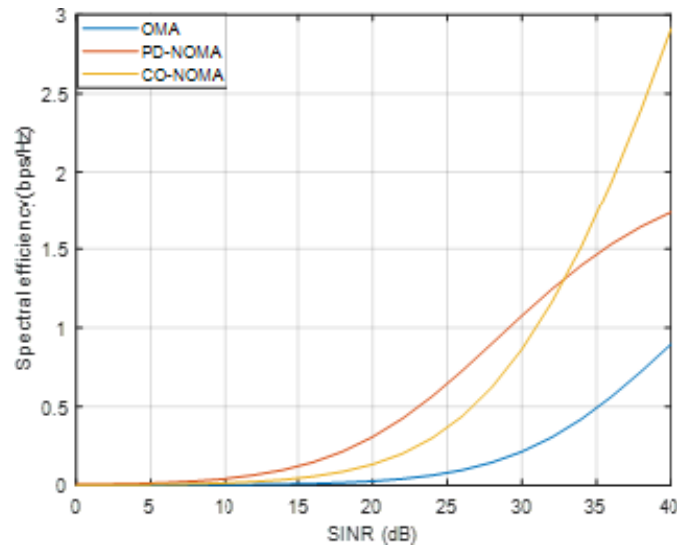
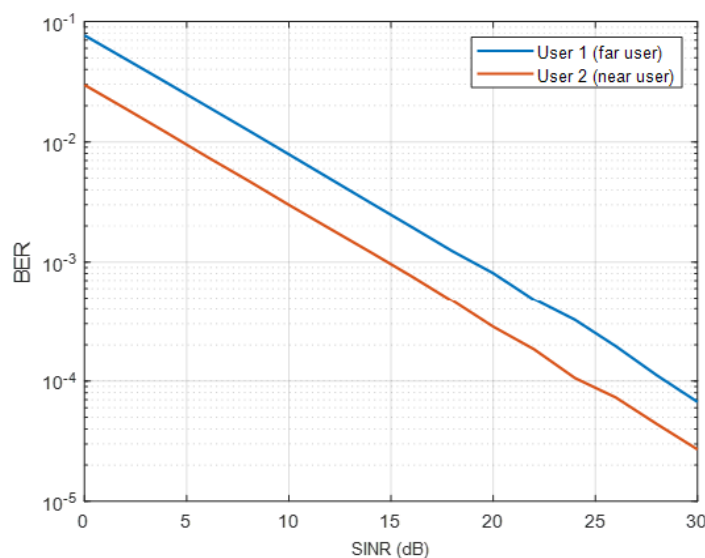


Fig. 11 shows the BER performance of the cooperative NOMA system with respect to SINR. In this proposed system, only one far user and near user is considered for analysis. The experimental result explores that, the BER performance of the cooperative NOMA system is get improved, when the SINR is increased. Since CO-NOMA is executed in two time slots, the performance of the far user also approaches closer to the performance of the near user. This is the result of repeated transmission of near user in second time slot. Also a large amount of power is assigned to the far user than the near user. In summary, all these results conclude that, CO-NOMA system ends with better performance than the PD-NOMA in all aspects.

Figure 11. BER vs. SINR performance



CONCLUSION

The architecture of cell free communication system for implementation of 6G wireless networks using cooperative NOMA technology is proposed here. It emphasizes the achievement of enhanced data rate and better spectral efficiency by the cooperative NOMA over power domain NOMA which is the important design constraint to switch over from 5G technology to 6G technology. It is also evident that the quality of service is improved by achieving good bit-error-rate for both user equipment near and far-away from the access points of cell-free cooperative NOMA system. With the result presented in this chapter, the proposed methodology of cell free cooperative NOMA wireless system not only benefits various 5G use cases like enhanced mobile broad band, ultra-reliable low latency communication and massive Internet of Things through performance improvement but also created a roadmap for the deployment of 6G wireless communication. Further, there is a scope to improve the efficiency of Cooperative NOMA in cell free communication system using flexible power allocation strategies, scheduling algorithms and beam forming techniques.

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Chapter 8

Future Directions of 6G Architecture With Integration of Sensing, Communication, and Security

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ABSTRACT

5G is being marketed the world over currently with research institutions initiated to go ahead of 5G and 6G evolving as green networks with excellent energy efficiency provide the quality of services. As communication growing day by day with the 5th generation communications deployed worldwide, 6th generation (6G) communications have become more attractive towards both industry and academia. The main objective of the research is to increase the speed of sensing and communicating. In the future, vehicular communication or VANET, smart cities, healthcare, gaming, public safety and security, transport and industrial needs, and robotics will play vital roles in the integration of sensing and communication. While comparing with 5G, 6G will have more advantages such as higher transmission rate, wider frequency band, larger capacity for connection, lesser delay, more coverage, and added robust anti-interference capacity, fulfilling different specification of networks.

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INTRODUCTION

The need for wireless communication has increased dramatically during the last two decades. Shortly, fifth-generation (5G) communications will be extensively implemented, with improved characteristics over fourth-generation (4G). A new wireless communication paradigm, 6G with AI assistance, will be used between 2027 and 2030. 6G communications grabbed the interest of industry and academics, while 5th generation communications worldwide are not prevalent currently. 6G offers a more excellent range of frequencies, a higher rate of transmission, enhanced robust anti-interference, better spectrum efficiency, and better capacity for connection establishment, as well as shorter latency and a wider range of coverage, to suit a variety of network requirements (Zhao et al., 2020).

Information acquisition is an essential prerequisite to E2E information processing for profoundly understanding and transforming the physical world. Generally, it specifies the behaviour towards collecting the sensing object information by using sensing devices, data interface and analysis.

As 5G communication networks become more widely implemented worldwide, industry and academia focus on 6G communications.

5G wireless technologies face considerable hurdles due to the increasing rise of data-centric intelligent systems. The ubiquitous ultra-broadband of the mobile, ultra-high density of data, and ultra-high-speed, communication latency of 5G cannot fully meet the high compute, low latency, and other requirements of 6G applications (Zhao et al., 2020).

Compared with 5G, 6G has stricter requirements in power consumption, lower latency, higher reliability, privacy and security, etc. Also, it provides better service of quality (QoS) and broader coverage than wireless communications in the past. Technology enhancement brings intelligence, leading to 6G as a revolutionary generation of wireless communication; autonomy will bring new vigour and vitality.

6G is based on AI to provide data-driven machine learning (ML) solutions to a large-scale distributed network of heterogeneous nature. On the other hand, machine learning systems involve centralized data gathering and centralized server data processing, and rising privacy concerns provide a bottleneck for large-scale applications that meet everyday needs.

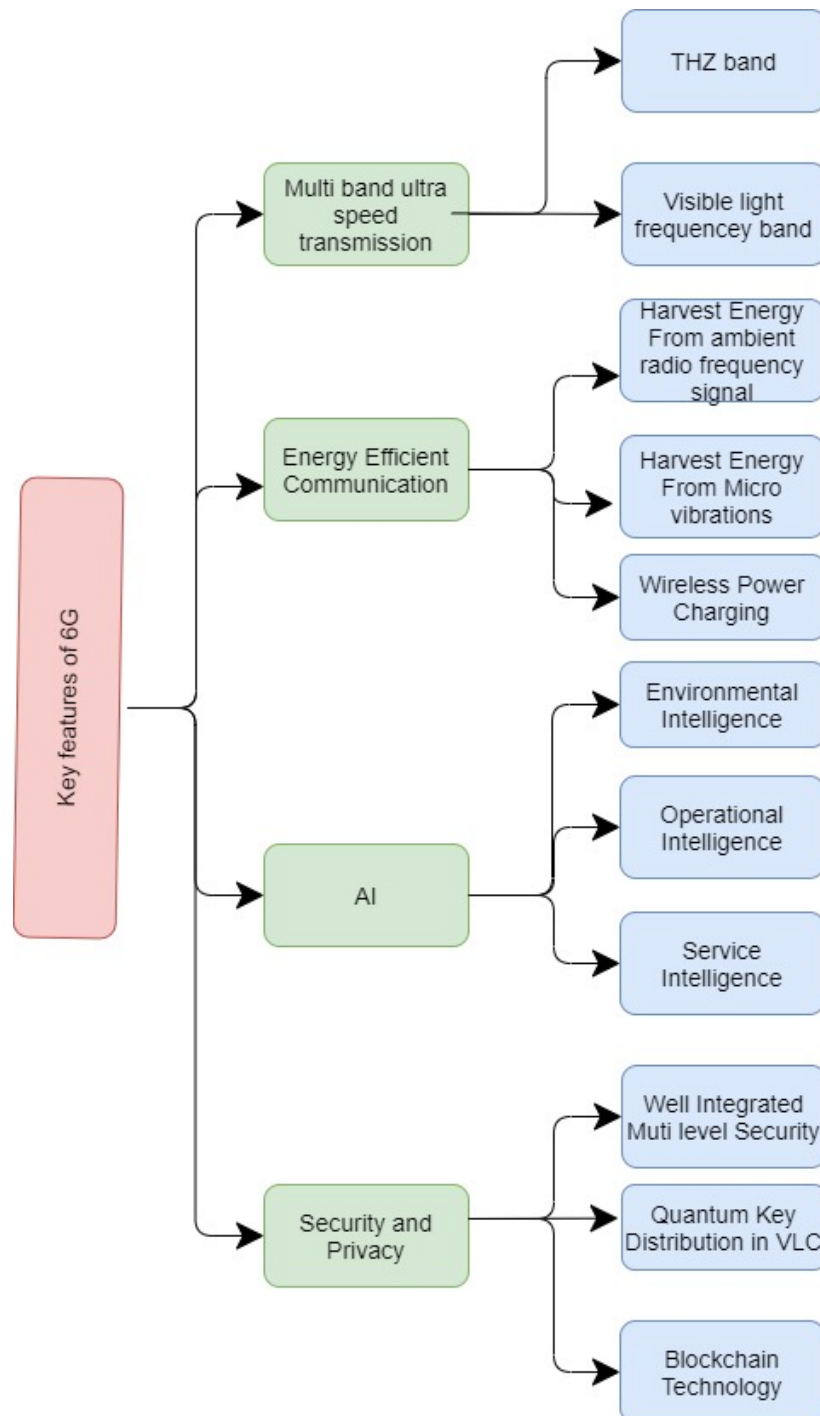
Simultaneously, ML and AI will take advantage of tremendous data and computer capabilities to solve the most difficult challenges in wireless communication networks. Localization, sensing, and communication cohabit in envisioned 6G systems, sharing common time-frequency-spatial resources. 6G is an intelligent wireless system enabling localization with a higher level of accuracy and higher resolution in sensing services in addition to ubiquitous communication.

Significant expansion in the count of IoT devices, the next-generation communication system aspires to achieve excellent spectral and efficiency in energy, level of latency is low, supporting huge connection. In linked drones and robots, IoT devices enable sophisticated services making traffic smarter, monitoring environment behaviour and control, virtual reality (VR), telemedicine, sensing are digitalized, high definition (HD), and full HD transmission of video. By 2025, the count of usage of IoT devices will increase by 25 billion, leading to a problem in accessing current multiple access strategies handling huge IoT devices. Even the world's current fifth-generation (5G) communication systems cannot support substantial IoT devices.

EVOLUTION OF VARIOUS GENERATIONS OF COMMUNICATIONS

The various generation communication networks are given below(Huang et al., 2019):

Figure 1. Evolution of various generations



1G

The first generation (Kulkarni & Kulkarni, 2021) of mobile telecommunications was established in 1979, allowing everyone access to wireless technology. In the fall, the launch of international roaming allowed people in various countries to communicate wirelessly. Signals modulated in 1G can be digitally or analog modulated. Transfer of information via analogue signals in 1g. This confines over voice conversation speed ranging 2.4Kbps and 150MHz frequency, resulting in huge coverage, excessive latency, and efficient energy usage. However, vocal quality was unsatisfactory. It might be transported in a usual manner.

2G

In 1991, the second generation (Kulkarni & Kulkarni, 2021) of mobile telecommunications was launched, including GSM (Global System for Mobile communication). Digital modulation replaces analogue modulation in 2G. 2G employs TDMA (Time Division Multiple Access) and CDMA (Code Division Multiple Access) to perform multiplexing. It had a 900MHz frequency. It made it possible to incorporate SMS into voice calls, increasing call quality. If a cell phone needs to send data to another cell phone, it uses a BTS administered by a BSC, a higher tier of the GSM network. All BSC were under the control of MSC, which was in command of the entire network used its databases and communication systems. GPRS, or General Packet Radio Service, was first introduced in 1993 and is based on packet-switching technology. 2G birthed multimedia message services, allowing customers to send huge files because of its high speed. In 2003 release of G Edge is done.

3G

The third Generation (Kulkarni & Kulkarni, 2021) launched in 1998 to increase the network's speed. WCDMA-UMTS was the first 3G standard. The initial iteration used CDMA and packet switching, with three bands of frequency like 850, 1900, and 2100 MHz. WCDMA is based on GSM, UMTS is a brand-new standard. The data transfer rate varies between 384Kbps and 2Mbps. Customers of 3G were charged depending on the amount of data sent rather than the time it took to send it. It released two more standards, HSPA and HSPA+, in the following years.

4G

The 4th generation (Kulkarni & Kulkarni, 2021) mobile technology, often termed LTE, was developed by the International Telecommunication Union (ITU) in 2004 and commercially commercialized in 2009. Two primary standards are LTE and WiMax. LTE uses OFDMAMIMO, ultimately packet-switched via IP. It features a speed range of 100Mbps to 1Gbps and a frequency range of 2 to 8 GHz. Data transmission has become faster due to the low latency and high speed.

5G

The fifth Generation (Kulkarni & Kulkarni, 2021) was planned to be introduced in 2020 and employs a new radio standard for the Air interface. Instead of FTD, it uses time division duplexing, allocating

a slot uplink to every three downlinks. 5G achieves more incredible speed, capacity, energy-efficient compared to 4G, supporting interactive streaming like multimedia and audio.

6G

The sixth-generation (Kulkarni & Kulkarni, 2021) wireless communications technology standard, which will enable cellular data networks, is being developed. A plan to install 100 trillion sensors that connect to the internet is possibly made by 2030 to revolutionize 6G. As a result, it requires a 1000-fold price reduction to create a smarter society in the long run. Compared to 5G, 6G requires lower latency, higher frequency and data transfer rates, faster mobility, and better spectrum efficiency.

Table 1. Comparison of various generations

Comparison of 4G, 5G and 6G			
Issue	4G	5G	6G
Per device peak data rate	1 Gbps	10 Gbps	1 Tbps
E2E latency	100 ms	10 ms	1 ms
Maximum spectral efficiency	15 bps/Hz	30 bps/Hz	100 bps/Hz
Mobility support	Up to 350 km / hr	Up to 500 km / hr	Up to 1000 km / hr
Satellite integration	No	No	Fully
AI	No	Partial	Fully
Autonomous vehicle	No	Partial	Fully
XR	No	Partial	Fully
Haptic communication	No	Partial	Fully

SIGNIFICANT FEATURES OF 6G:

100 Gigabits per Second (Gbps)

People mostly view that the mobile broadband network is only for watching movies and TV shows and quickly downloading large files – whenever and wherever they want. They necessitate speed(Kulkarni & Kulkarni, 2021).

Is this something you should anticipate? Not in the least. For more than two decades, telecommunication firms have touted speed as a significant selling point to entice customers.

We continue to distribute more – and more extensive – (video) files over the Internet. According to estimates, one billion hours and more of YouTube videos monthly are viewed. Seventy-five percent of YouTube users use mobile devices as an access medium(Kulkarni & Kulkarni, 2021).

People want to be able to download videos at any time and from any location and watch them in the highest quality available. Thus mobile broadband enters the picture.

The spread of 6G networks continues, with download speeds of 100Gbps projected (M. W. Akhtar et al., 2020). That's ten times quicker compared to the 5G network speed of download and three hundred times faster compared to 4G(Michael Peeters, 2021).

Frequencies of 100GHz (and More)

Suppose the frequency range is more extensive, automatically the bandwidth availability is more. As a result, we'll have to employ higher radio frequencies to reach those bandwidths.

For example, 4G networks have a frequency limit of 2.5GHz, but 5G networks employ 28 and 39 GHz, bands. Furthermore, 6G seek to use frequencies greater than a hundred gigahertz.

A Latency - Few Microseconds

People experience on mobile is based upon the quantity of data downloaded. The latency of the network is a crucial element in most applications. When watching live television, latency either induces or reduces the customer's interest. For example, none of the people ever wish to miss a game-winning penalty kick in the World Cup soccer finals(Kulkarni & Kulkarni, 2021).

To be sure, the emergence of 5G networks (with their sub-millisecond latency) should stop such delays. Even yet, 6G promises a latency improvement of only a few microseconds (M. W. Akhtar et al., 2020).

This will be especially important as the count of Internet of Things (IoT) applications grows. Considering a system with closed-loop control, which uses real-time sensor data to control machinery and complicated industrial processes, or time-constrained and sensitive IoT applications in the field of medicine like processing, interpretation of electrocardiogram (ECG) or electroencephalogram (EEG) signals.

Devices Connected within km² is Ten Million

Linked sensors and devices count determines the IoT's power. The power brings out an expectation for a massive expansion here as well. Market survey firm Statista on IoT analyses almost 31 billion devices employs IoT by 2025, increasing from twelve to thirteen billion devices. Towards ever-augmenting count of devices, connecting it to the Internet per m²/ km² becomes a bottleneck. The connection density is the name given to this figure.

The connection density of today's 4G networks is over 100,000 devices per km². 5G already outperforms 4G, enabling the connecting of one million devices per square kilometre (M. W. Akhtar et al., 2020). With the launch of 6G, the devices connected per km² are a massive figure of 10 million devices.

Consumption of Energy Not Greater than One Nanojoule per Bit

6G networks resort to greater radio frequency to support the need for more significant bandwidths. One issue is that the chip technology does not work in specific frequency bands with efficient energy

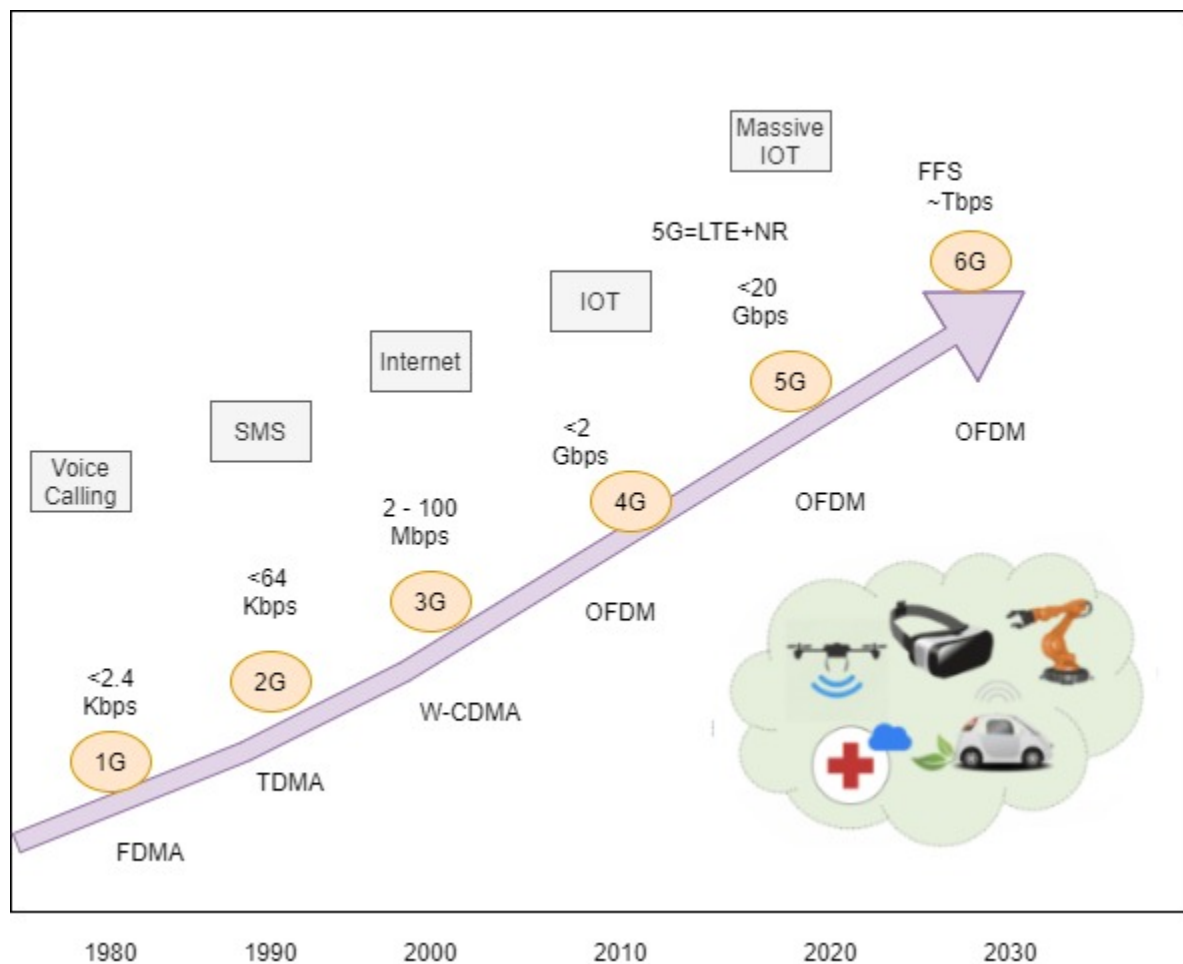
usage, even though efficient energy usage is a severe issue in the telecom industry. In a recent analysis, telecommunications behemoth Ericsson predicted that mobile networks' energy usage would skyrocket, putting the environment and network expansion costs at risk.

Despite this, the telecoms business is not dormant. By 2025, the adoption of new technology and software, according to telecom operator Orange, could lower 5G network consumption of energy as a factor of ten (per transferred gigabit) than 4G. In the year 2030, the number may have risen to an aspect of twenty.

On the other hand, a recent effort to improve the efficiency of mobile networks energy is due to the addressing of a vast amount of emerging data. Data centres have been fighting a similar conflict for years, with optical fibre connections to achieve greater efficiency in energy while handling a large volume of data. Fibre optics today runs with several hundred femtojoules for each bit in test configurations. (one femtojoule = 10^{-15} joules).

The goal of 6G researchers is to bring down the consumption rate of energy below one nanojoule (10^{-9} joules) for each bit.

Figure 2. Key features of 6G



6G SPEED

5G is scarcely incorporated in most countries globally since the technology is progressing only in the early stages of development (*What Is 6G Network: The Answer Is Here!*, n.d.).

- 5G and 6G require greater frequencies for transmitting data on a wireless spectrum. 5G occupies broadband frequency in the range of 6 GHz to 24.25 GHz.
- 5G enables IoT to bring reality to devices practically used in everyday life. 6G attracts widespread traction by speeding up the process, ensuring that smart devices work optimally.
- Previous generations of networks functionality are neither replaced by 5G nor 6G. Each network struggles to meet its infrastructure requirement and enhance connectivity issues (*What Is 6G Network: The Answer Is Here!*, n.d.)

SECURITY AND PRIVACY

In 6G, every edge device connects to the Internet, and edge devices will widely use AI applications. Most AI applications are data-driven, which raises the concern of the security and privacy of the collected data (Sun et al., 2020). For example, wearable devices may collect clients' health status every day, but these data are private and sensitive. Data leakage may compromise clients' privacy (McMahan et al., 2017). Moreover, in Akhtar et al. (N. Akhtar & Mian, 2018), adversarial attacks that occur in deep learning models are investigated and illustrated how it happens in real-time. Loven et al. (Loven et al., 2019) identify the challenges of edge AI and the well-defined security systems aiming to improvise edge computing and AI-based security approaches. Zhou et al. (Zhou et al., 2018) Combining the functionalities of deep learning and edge computing leads to a mobile crowdsensing of robust nature that performs an efficient validation of data and local processing. Sattiraju et al. (Sattiraju et al., 2019) to enhance the security in the physical layer, analyzed the flexibility to use an efficient technique in ML in the physical layer like recurrent neural networks and proposed an algorithm for unsupervised learning (Zhao et al., 2020)

Applications of 6G

Machines that are intelligent and sophisticated have an impact on modern society. These machines are capable of communicating with one another and with humans. They can be used to assist humans in various areas, including the field of medical care, e-health, transportation, food service business, agricultural sector, educational sector, and so on (M. W. Akhtar et al., 2020). The critical 6G usage scenario in various domains is listed as follows:

1. E-health and digital/bio-sensing

An exhaustive corona virus pandemic, causing illness to humans and animals, had recently induced severe menaces to humanity's health and survival (W. Li et al., 2003). COVID-19 virus is of SARS (Severe Acute Respiratory Syndrome) virus family, infects both humans and animals' respiratory systems. With the rising frequency of COVID-19 infections, biosensors are in huge demand which detects and monitor

infectious diseases precisely and accurately. These devices are susceptible and user-friendly. Biosensors in mobile phones with 6G features provide precautions steps to overcome the pandemic.

6G networks can successfully detect viral illnesses by tracking the body temperature of sick individuals by integrating QC, ML, and biotechnology. Optical biosensors monitor pathological function. It identifies the biorecognition compounds like antibodies, enzymes, entire cells, and DNazymes to accurately predict various disorders (Long et al., 2013). 6G is also helpful in several different aspects of e-health (N. Akhtar & Mian, 2018), like the state of the environment (e.g., temperature, gases%, and condition of light). Usage of autonomous robotics to assist during various medical activities, including emergency medical services, medical exams, microbial surface contamination cleaning, and drug distribution in rural locations (M. W. Akhtar et al., 2020).

2. Robotics and automated vehicles for beyond industry 4.0 era 2

The fourth industrial revolution has termed Industry 4.0. Cloud computing, NFV, slicing, and industrial IoT are all part of Industry 4.0 plants, including equipment that is automated fully and capable of organizing and optimizing by self. Beyond the Industrial 4.0 era, 6G will usher in a new industrial revolution (M. W. Akhtar et al., 2020).

Robots and fully automated vehicles are highly efficient and cost-effective to perform diagnosis, the process of monitoring, and activity related to maintenance. Automation's reliability and self-organizing capabilities pervade all parts of day-to-day life. Swarms of UAVs, with hardware in an advanced level, and by incorporating ML and QML techniques to bring out operations like controlling fire, construction, emergency medical services, and agriculture (M. W. Akhtar et al., 2020).

3. Holographic transmissions

Holography is a method of acquiring a full 3D image of an object. Merely it documents the amplitude and intensity distribution of a photograph; the conventional one records a picture's two-dimensional image. As a result, holography records intensity and light pulse phases. Holography stores effects of physical light like interference, reflection, refraction, and diffraction, and the archive is known as the hologram (R. Li, 2018). Multiple times each hologram is viewed. Even though a hologram lacks physical likeness, it contains all of the object's information in optical form. Communication through video calls and recording of video, like movies, is supplanted through holography, just like mobile cameras replacing still cameras (M. W. Akhtar et al., 2020).

4. Communication in space and deep sea

Economically and scientifically, space tourism is going to boom with massive potential in the coming decade. Humans from all walks of life will venture into space. For space tourism, several companies plan to launch sub-orbital commercial flights. Following a series of fruitful and economically viable space launches, the next stage ensures that clients access space hotels and space hospitals. Aside from commercial space trips, another potential application is space research. It has been using simple, efficient communication tools, 6G broad sits activity range available worldwide. Intelligent robots play an important role in severe environments for communication and research objectives. The powerful and

massive capacities of 6G networks help to address the world's secrets. Deep-sea probes, like an exploration of oil and mineral, also could be addressed (M. W. Akhtar et al., 2020).

5. Super-smart society

6G's superior qualities will hasten the development of smart societies, resulting in improved quality of life, monitoring environmental factors, and automation carried out using AI integrated M2M communication. All uMUB, uHLSLLC, mMTC, and uHDD services can use to describe this application. Deploying smart mobile devices, driverless vehicles, etc., with 6G wireless connectivity makes civilization super smart. Furthermore, air taxis using 6G are deployed in various cities worldwide. Smart homes have become a reality because of the control of every appliance in a distant location through a command (M. W. Akhtar et al., 2020).

6. Automation and manufacturing

6G will deliver complete AI-based automation. Automatic process control equipment has referred to as "automation." The 5G revolution kicked off the 4G revolution, defined as cyber-physical, an industrial process that is automated and data interchange. With its disruptive technologies, 6G fully characterizes the automation system. The 6G automation systems will use the high rate of data, and provisioning of latency is low, such as uHLSLLC, mMTC, and uHDD services, to deliver highly reliable, scalable, and secure communications. It assures the integrity of the network by ensuring the error-free transmission of data and no loss of data between transmission and receipt (M. W. Akhtar et al., 2020).

7. Energy-Efficient Communication

More expectations to be satisfied and exceed with 6G, which includes high energy delivery, particularly IoT usage (Qian et al., 2018; Sliwa et al., 2020) and eco-system comprising more sensors of tiny in size. Also, expanding the battery-recharge capacity of smartphones should be addressed to adapt complex multimedia signal processing leap. Making energy consumption lower and battery charge life longer becomes a primary research focus in 6G to solve the day-to-day challenges of recharging encountered with communication devices. 6G necessitates an efficient strategy for total energy saving in wireless communication to achieve the above mentioned. The ultimate aim of communication through 6G brings out communications battery-free to the extent possible, and efficiency in communication is one pico-Joule/bit (Alsharif et al., 2020).

In addition to directing beam communication with MIMO antenna arrays, 6G communication provides merits of rich-power THz-waves, permitting devices to dispatch power beams in a particular direction. This approach possesses the potential to give up enough energy for the devices inside the network coverage location. According to the 6G vision and directions released, researchers have an enormous scope on the lifetime of battery and service classes compared to that of data rate and latency in 6G. Base stations should compute user node details efficiently with a reliable power supply or universal smart radio space to reduce energy consumption. Cooperative relay communication and network densification are crucial in minimizing the per-hop signal propagation gap and lowering the mobile nodes transmission power. The prolonged life of the battery in 6G needs divergent energy-harvesting technologies that take energy from ambient RF signals, micro-vibrations, and sunshine. Also, long-range wireless power charging is a

viable option for extending battery life. Furthermore, distributed laser charging technique safely delivers 2-W electricity to mobile devices across a distance of 10 meters.

CHALLENGES IN 6G

For 6G deployment, will necessitate extensive modernization of various existing network designs and the development and deployment from new 5G systems. However, there are many more obstacles to overcome before 6G can be adopted successfully and efficiently(*6G-Wireless Flagship? — Navixy Talks*, n.d.).

Some concepts involve the use of terahertz and VLC technology, which could result in a tremendous increase in access point density. The primary challenges are:

- Ongoing technology and protocol development.
- Network band standardization and certification.
- Connected metrology development.
- Regulatory legislation.
- Dynamic topology.

Furthermore, as long as 5G technologies command the majority of consumer, investor, and engineer interest, they may ignore the 6G notion(*6G-Wireless Flagship? — Navixy Talks*, n.d.).

Currently, 6G technologies and standards are being explored and debated. 6G monitored by most EU countries, including the United States, China, Japan, and South Korea. Samsung Electronics has opened a research and development centre for 6G mobile networks. 6G is undoubtedly a hot topic in academic study, with Finland's flagship programme, Finland's flagship programme, starting 6G research at the University of Oulu(*6G-Wireless Flagship? — Navixy Talks*, n.d.).

FUNDAMENTAL ENABLING TECHNOLOGIES OF 6G

6G enables terrestrial, aerial, and maritime communications as a dependable, fast network that can serve many devices through ultra-low latency requirements. Researchers from all over the world proposed AI, ML, quantum communication/quantum machine learning (QML), blockchain, tera-Hertz and millimeter waves communication, tactile Internet, non-orthogonal multiple access (NOMA), small cells communication, fog/edge computing, and so on as critical technologies in the realization of the Internet of Things.

According to the mobile phone network history, 6G networks are similar to 5G design, incorporating the merits of 5G. Additionally, new technologies are incorporated, while others from 5G upgrade to 6G. As a result, various technologies will power the 6G system. A handful of the most essential 6G technologies are listed below.

Artificial Intelligence

The fundamental property of 6G autonomous networks is intelligence. As a result, AI technology incorporates 6G communication systems(Niknam et al., 2020). In developing 4G communication networks, AI is not in use. Partially or the following 5G communication systems will support very restricted AI.

However, AI will fully assist 6G in terms of automation. The entire potential of radio transmissions will be realised with AI-enabled 6G, allowing the transition from cognitive to intelligent radio. Advanced intelligent networks to create real-time communication in 6G thanks to advances in machine learning. AI improvises the transmission rate of real-time data (Chowdhury et al., 2020b).

AI determines how difficult a target task accomplish using a variety of statistics. AI improves efficiency and minimizes its time for communication stages to be processed. AI may be used to quickly complete time-consuming processes like handover and network selection. M2M, machine-to-human, and human-to-machine communications get benefitted from AI. It also encourages BCI communication. Meta-materials, intelligent structures, networks, devices, cognitive radio, autonomous wireless networks, and ML enable AI-based communication systems.

As a result, AI will aid in implementing uMUB, uHSLLC, mMTC, and uHDD services in 6G communications. Thanks to recent advances, machine learning can now be used in RF signal processing, mining of spectrum, and mapping the spectrum. Combining photonics and ML will accelerate the advancement of AI in the autonomous network 6G, allowing for the development of a photonics-based cognitive radio system. Encoder-decoders implemented using AI, channel estimation carried out using deep learning, and automatic modulation categorization used in the physical layer.

Allocation of resources implemented using deep learning, traffic prediction, and controlling is intensively investigated in meeting the 6G needs required for data link and transport layers. The combination of ML and BDA to discover the optimum route in transmitting detail to end-user through predictive analysis would drastically minimize latency (Chowdhury et al., 2020b).

Optical Wireless Technology

Beyond RF-based communications, OWC technologies are envisioned for 6G communications on every potential device to enable access to networks and these networks to backhaul or fronthaul connectivity of the network. Since 4G communication networks employ OWC technologies. However, to satisfy the demands of 6G communication networks, it is intended to be used more broadly.

V2X communication, interior mobile robot location, VR, and underwater OWC are just a few of the applications that will use these communication technologies. The research finds a better performance while implementing this technology in an application by providing a solution to its demerits. Wireless optical communications can deliver extremely high data speeds, low latencies, and secure connections. LiDAR becomes a powerful technology providing resolution rich 3D mapping in 6G communications due to its optical band.

Advancements drive the OWC in 6G in light-emitting-diode (LED) technology and multiplexing techniques. In 2026, microLED technology and spatial multiplexing techniques predict the effective cost. Through wavelength division multiplexing, white light based on various wavelengths achieves benefit throughput performance, potentially leading to hundred and above giga-bits per second for ultra-large-data-rate VLC access points. Incorporating microLED arrays parallel in huge level boosts the data rate in 6G communication target of tera-bits per second. (Chowdhury et al., 2020b).

Blockchain

Blockchain is a necessary technology to manage a huge volume of data in future correspondence in communication. Blockchain is the subset of distributed ledger digital system technology (Aste et al., 2017;

Miller, 2018; Nguyen et al., 2020). A distributed ledger is a database spread among multiple computers. Every node duplicates the ledger, and saves identical replication. Blockchains manage via peer-to-peer networks. It does not need to regulate through centralized authority or a centralized server for its existence. Data of blockchain collected then organised into blocks. Cryptography connects the blocks securely. Better security, privacy, interoperability, dependability, and scalability becomes a supplement to IoT. Blockchain technology will provide numerous features, including interoperability across devices, large data traceability, autonomous interactions among multiple IoT enabled systems, and reliability for massive connectivity of 6G communication systems to achieve the purpose of uHSLLC service(Miller, 2018).

Blockchain eliminates the need for trusted intermediaries by establishing confidence between networked apps. The inherent characteristics of blockchain, like decentralized tamper-resistance and secrecy, enables it to be perfect, covering a wide range of 6G communication applications. Allowing transparency confirmed transactions and avoiding unwanted access will allow a secure and authentic method for managing the spectrum. Blockchain represents prospective capabilities not available in previous systems by combining network formation in distributed nature, consensus mechanism, and advanced cryptography. The distributed nature reduces the risk of a single point of failure and improves security. The throughputs (101000 transactions per second) are the critical hurdle of blockchain networking in 5G. Another issue occurs due to the wanting of local and international standardization and the regulation of blockchain's widespread implementation in 5G. Nonetheless, 5G considers the problem of seamless interoperability among various blockchain platforms. It is solved when implementing 6G by employing algorithm consensus, implementation of the unique architecture for blockchain, techniques for sharing data, and expanding the network's size of the block(Chowdhury et al., 2020b).

Quantum Communications

Quantum technology performs ultra-accurate clocks, images in the medical domain, and quantum computers possible by utilising quantum mechanics' features, like the interaction of molecules, atoms, and even photons and electrons. The full potential, however, has yet not been realized. Quantum internet is a network that connects quantum computers, simulators, and sensors to securely distribute information and resources around the world. Advanced level quantum communication technologies protect from various cyber security-related attacks(Dang et al., 2019).

In 6G wireless networks, QC and QML could be prominent actors. QC gives solutions for 6G networks to enhance the channel's capacity, such as new multiple access technologies like NOMA and RSMA, which require a lot of power during run time for SIC computation. Similarly, in the realm, 6G estimates of the channel, channel coding (quantum turbo codes), localization, load balancing, routing, and multiuser transmissions, the significant role is played by QC and QML. QC and QML may handle complicated challenges like multi-object exhaustive search in ad hoc sensor networks and Cloud IoT by delivering rapid and selecting the best path to data packets in the communication network core (Chowdhury et al., 2020b).

Unmanned Aerial Vehicles (UAV)

Drones, termed UAV, take a significant position in 6G wireless communications. UAV technology delivers huge-data-rate wireless connectivity in numerous instances. The BS entities are used to offer cellular communication in UAVs. Easy deployment, robust line-of-sight connectivity, and degrees of freedom

with controlled movement are all qualities of a UAV lack in fixed BS infrastructures (B. Li et al., 2019). Implementing terrestrial communication infrastructures in an emergency situation (Tariq et al., 2020), like natural disasters, will not be feasible economically, and it is sometimes impossible to bring out any type of service in hazardous circumstances. These situations are easily handled by UAVs. In the sphere of wireless communication, UAV becomes a new standard. A core criterion of wireless networks, such as uMUB, uHSLLC, mMTC, and uHDD, is met using this technology (B. Li et al., 2019). UAVs utilise for various reasons, including improving network connectivity, fire detection, disaster relief, security and surveillance, pollution monitoring, parking, accident, etc. As a result, UAV technology is considered the most important in 6G communication (Chowdhury et al., 2020b).

In Y. Zeng et al., (Zeng et al., 2016), Backscatter communication facilitated by UAVs is used to help with a variety of communication jobs (e.g., providing ambient power and creating favourable channel conditions to remote sensors). An air-interface appropriate for 6G wireless networks using non-coherent detection methods and applications of UAVs. Furthermore, deep reinforcement learning-based resilient resource allocation is an excellent option for achieving UAV to support 6G intelligence.

Cell-Free Communications

In 6G systems, smooth integration of different frequencies and communication technologies is critical. Ultimately, the user can have a smooth from one network to another without undergoing any device setups manually. Traditional cellular and orthogonal communications concepts will replace cell-free and non-orthogonal communications in 6G. The available communication technology selects the best network automatically. In dense networks, handovers are required for the user to switch from one cell to another cell, resulting in handover failures, delays, loss in data, and the effect of ping-pong. 6G cell-free communications overcome the handover failures, delays, loss in data, and the impact of ping-pong, which will deliver greater QoS. Multi-connectivity, multi-tier hybrid approaches, and diverse, heterogeneous radio in devices will enable cell-free communication (Chowdhury et al., 2020b).

Integration of Wireless Information and Energy Transfer (WIET)

WIET is a revolutionary technology in 6G connectivity. Wireless communication technologies and WIET uses the standard fields and waves. Sensors and cell phones use wireless power transfer for charging during communication. WIET brings potential solutions in increasing wireless charging systems battery life. As a result, 6G networks connect battery-free devices. Furthermore, in the medical field, near-field enabled apparel allows for continuous physiological monitoring through battery-free sensors (Chowdhury et al., 2020b).

Big Data Analytics (BDA)

A problematic technique, BDA performs massive data set analyses, often known as big data. This approach discovers details like unforeseen correlations hidden and client inclinations to ensure thorough data management. Massive data comes from many places, including videos, social media, photos, and sensors. This technology is commonly employed in 6G networks to handle huge amounts of data. 6G networks employ advanced automation and self-optimization to enhance the potential to leverage vast amounts of data. The E2E delay reduction is an example of using big data analytics. E2E delay can be

reduced in 6G systems ML and BDA by performing predictive analytics identifies the correct path of the data of a user (Chowdhury et al., 2020b).

Integration of sensing and communication

The capacity required to continually perceive the changing environmental circumstances and information exchange between several nodes is a fundamental driver for autonomous wireless networks. 6G facilitate autonomous systems through the firm integration of Sensing and communication. (Chowdhury et al., 2020a; Kobayashi et al., 2018).

Industrial Internet of Everything (IIoE)

The internet of everything (IoE) refers to the smooth integration and autonomous coordination of a vast count of computing elements, sensors, devices, processes, data, and people over internet infrastructure(Snyder & Byrd, 2017). By altering the standard mobile communication structure, 5G has revolutionary IoE goals. 5G, on the other hand, is seen as the start of IoE and handles a wide range of issues, from standardization to commercialization. 6G supports IoE in its entirety. IoE, essentially a type of IoT, encompasses the four elements like data, people, processes, and physical devices under one frame(CISCO, 2013). IoT is necessarily concerned with connecting physical devices, and IoE adds intelligence to the network, bringing four elements together as one system. Societies termed smart if smartness persists in automobiles, health, industries as they rely on IoE. The main restriction which supports extensive IoE connection in 6G is the usage of energy-efficient sensor nodes. A Low-power wide-area network (LPWANs) provides a broad range of coverage to twenty kilometres, battery life is long more significant than ten years, and the cost of deployment is low. As a result, LPWAN supports IoE use cases on a commercial basis. This application is carried out based on the features of uMUB, uHLSLLC, and uHDD of 6G communications(Chowdhury et al., 2020a).

During Emergency Conditions

Services provided by 5G were inadequate to cater to the needs of the healthcare domain and disaster circumstances. In emergency conditions, like natural disasters, deploying terrestrial infrastructures for establishing communication is not considered economically. It is not feasible to give up any service for the environment of volatility. 6G networks provide communication based on the attitude satisfying the society and human needs to lead a quality of life. Due to natural disasters, 6G offers an insight into the location where damage incurs and its severity level.

UNCONVENTIONAL DATA COMMUNICATIONS

Holographic Communications

One component of the 6G future that will add glitz is holographic communications. A hologram is a three-dimensional image created by manipulating light beams directed on an object capturing resultant interference patterns using a recording device. In reality, broadcasting 3D visuals with stereo voice is

necessary to carry the features stating the presence of a person. Reconfigurable stereo audio steers the platform's design to capture physical facts of multiple people in each configuration in the 6G future. In other words, if the necessity arises, entities have plenty of freedom in interacting and modifying received holographic data and video. Holographic data consumes large bandwidth and reliable network for transmission (Alsharif et al., 2020).

Tactile Communications

Holographic communication allows for the transmission of a virtual view of people, events, and settings as close to genuine as feasible. Tactile Internet permits transmission of the real-time image to make the movie experience complete. Teleoperation, cooperative automatic driving, and interpersonal communication are all predicted to benefit from this technology. These technologies employ haptic touch built with communication networks. Implementing this technology brings demise to the open systems interconnection network model, which brings a boom in cross-layer communication-system design. The cross-layer architecture has to satisfy these technologies' rigorous requirements. This situation could prompt the development of a new physical layer (PHY) approach that improves signalling system designs and waveform multiplexing implementation. The next consideration is to identify the process involved in designing operations like buffering, queuing, scheduling, handover, and protocols to satisfy the requirements of 6G networks. Existing wireless communication methods are not capable of meeting these requirements, so must investigate fiber communication systems (Alsharif et al., 2020).

Human-Bond Communications

The key enabler of 6G communication is likely to be human-centric communication. Humans must have the desired permission to access and share features of the technology. The five senses of humans get involved in this effort. The "communication by breath" initiative, for example, makes it possible to read the bio-profile of a human using exhaled breath and interacts with the human body through inhalation of volatile organic chemicals. As a result, the technology makes disease diagnosis, emotion detection, biological feature gathering, and remote contact with the human body more manageable. Interdisciplinary research collaborations must design a communication system that can replicate the five human senses. Such efforts would inevitably evolve in hybrid communication systems that have the potential of extracting diverse physical quantities and distributing them to end-user through secure channels (Alsharif et al., 2020).

Table 2. Comparison between 5G and 6G

Features	5G	6G
Spectrum	wireless medium of the spectrum is used for data transmission at a more significant rate using low band frequencies (6 GHz – 24.5 GHz and more)	wireless medium of the spectrum is used for data transmission at a more significant rate using high band frequencies (95 GHz to 3 THz)
Performance	operates at GHz frequency bands	operates at THz frequency bands and hundred times faster than 5G
IoT implementation	The reality in IoT implementation is made possible with an extensive 5G solution.	through 6G expectation emerges that within a square kilometre positively able to connect devices of ten times more leading to an enhanced count of connected devices
Latency	5 milliseconds	1millisecond to 1microsecond

Above table 2 shows the various comparisons of 5G and 6G features such as spectrum, performance, IoT implementation, latency.

CONCLUSION

Technology brings a prominent influence on the lifestyle of humanity. Wireless technologies have radically changed businesses, the living standards of humans, infrastructure, and several different aspects of human life. Still, a constant struggle always prevails in humanity to bring out an efficient solution for numerous problems and find new avenues to bring progress in solving problems. Humanity desire has brought into the technology 1G to 5G, and still the development progress forward around the globe researches putting their hard work in developing technology 6G that it rolls out in the globe by the beginning of the year 2030.

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Section 3

Technologies in Design and Deployment of 6G Mobile Core Networks

Chapter 9

Vision, Challenge, Futuristic Approach of Machine Learning in 6G Wireless Technology

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ABSTRACT

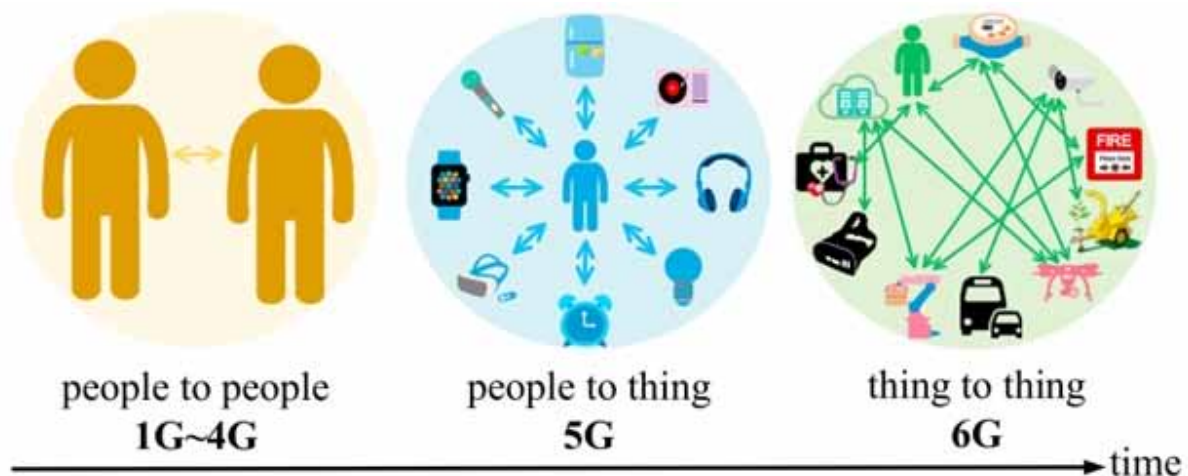
In recent years, the machine learning approach has been a major surge of research interest in intelligence, data-driven advanced dynamic approaches, and automation of low-powered gadgets. The goal for 6G is a massively linked complex network capable of reacting quickly to user service requests by real-time learning of network status as given by the network edge, user-side, and air interface. Most machine learning application 6G vehicular networks are intended to generate a rapidly evolving and intelligent system that allows networks to adapt to various application requirements and service types. In the autonomous driving age of 6G, ML is used to design a route, and 6G's improvements in response time, roaming range, network energy efficiency, and connectivity provide a better experience for users. Scholars are afraid about this problem due of privacy concerns. Overall, the chapter includes the basic and advanced levels of machine learning including the unsupervised, supervised, and reinforced learning and the challenges of ML for 6G.

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INTRODUCTION OF 6G

The worldwide marketing of the fifth generation of mobile cell networks (5G) has drawn wide-ranging interest from both academia and business, research efforts to identify important drivers, performance requirements, and technical breakthroughs in the area of 6G. With a view to 6G, the ITU has set up a research group for the 2030 network. A study group was explore the future of the 6G network design and technology for novel solutions like essential and holographic communications(Katz, Matinmikko-Blue, and Latva-Aho 2019). The Federal Communications Committee agreed to forTeraHertz 6G-spectrum in the United States and proposed that blockchain be used to allow flexible and dynamic spectrum distribution. Meanwhile, the 6G primary characteristic of satellite communication is to create integrated air-space networks and to offer complete coverage worldwide(L. Zhang et al. n.d.).

Figure 1. The projection of 6G communication(Zhou et al. 2020).



While there has been a lot of debate about 6G, the characteristics of 6G should have remained unclear. In every future generation of mobile communication networks, potential services will always be key drivers. We can observe that mobile communications systems are always increasing their service capacity from 1G to 5G. 1G can only provide phone services using analog communication techniques, whereas 2G can offer text and audio services. 3G is aimed towards cellular multimedia services with the growth of the Internet. With 5 MHz bandwidth and sophisticated communication technology, it offers data transfer speeds of up to 2 Mbps, like strong turbo codes, however, the speed of 3G communication remains restricted. With a bandwidth of 100 MHz and Orthogonal Frequency Multiplexing Division (OFDM) technology-based completely new air interface, 4G has increased the speed of transmission capacities by up to one Gbps.

Wireless Internet-enabled by 4G is realized. As illustrated in Figure 1, 1G–4G, only “people” will get services. 5G begins working on communication between “people” and “things” via developing the Internet of Things (IoT). It is common knowledge to note that 5G have 3 possible services, i.e., URLLC, improved Mobile BroadBand, and huge machine-type Communications (mMTC)(Popovski et al. 2018).

As such, 5G's service capacity is improved to offer both people and objects communication services. Because it has a 400 MHz bandwidth and more sophisticated communications technologies such as high-scale modulation and LDPC (such as 256QAM), a throughput of 10 Gbps, which is good for eMBB situations. But latency becomes a key performance requirement in the URLLC situations that cannot be achieved via conventional communication methods (Du, Song, and Zhu 2019). Still, if the data is massive, it would take some time to transfer it to the cloud server to begin its analysis. The combination of mobile edge computing's (MEC) cellular communication and computing networks utilizes the cellular calculative capability to serve as a countermeasure to the effects of cloud computing and provide immediate local processing. In the future, however, even 5G will not satisfy all the new services' needs.

There is a significant need for communication between "things" with the development of IoT, as is the connectivity of all equipment in a plant. Various "things" have completely different communications needs. For example, reading smart meters needs less than 100 kbit per day, while Augment/Virtual Reality (AR/VR) devices will send tens of Gigabit data/second. In IoT, new functionalities and needs that cannot be met by 5G are anticipated to bring up ever more services. One of the key issues is that present mobile network designs for specific established and recognized services are generally fixed, preset, and optimized. New services with completely distinct characteristics are unlikely to function effectively. For instance, for the wireless broadband transmission, 4G is optimal. With its famous mobile messaging program, WeChat, which features common and short messages, communication effectiveness is very poor. WeChat uses a lot of 4G signaling resources with little data transfer, which places a high load on the network. For this, future mobile networks will thus be required to be able to serve different IoT applications. Future networks must thus first be smart and can independently study and understand the features of the service. Then the architecture and functionality should be open, so that the modifications may be readily updated. Each node must be able to handle the processing, caching, and communication requirements to allow for advanced management and continual self-evolution to build an intelligent, open, and flexible 6G network. A 6G network, which is both smart and open, will be created using a variety of innovative technologies, allowing for the efficient use of the resources of the networks. The reconfigurable liquid metamaterial approach helps for more applications covering wireless communication.

INTRODUCTION TO MACHINE LEARNING APPROACH IN 6G COMMUNICATION

The rapid growth of traffic can only meet the challenge of fifth-generation (5G) communication networks around the world with the theatrical growth of smart terminals and artificial intelligence (AI) driven bids, like smart cars, (Liu et al. 2017) airspace-to-air networks, smart health care, and a comprehensive digital realism the sixth generation (6G) technology, industry, and academics are already working together. In contrast to earlier mobile networks generations, 6G is necessary for a broad array of AI applications from networking to terminal devices, which will turn 'connected things' into 'connected intelligence. In 6G network optimization also AI will play a significant role. The advent of 6G and its core technologies will bring significant human lives transformations (Kato et al. 2019)(P. Yang et al. 2019). 6G is a very broad spectrum, supports full-fledged applications (AI, Machine Learning, big data technologies, etc.), and provides worldwide coverage (space-air-ground networks). Considering the technical objectives of 6G are mentioned below.

- The latency shall be 10-100 μ s.

- The maximum data rate shall be a minimum of 1 Tb/s.
- The user-experienced data rates shall be as high as 1 Gb/s.
- The mobility shall be greater than 1000 km/h.
- The energy efficiency of the network shall be 100 times the 5G.
- The connectivity density is 10⁷ devices per km².

At the same time, researchers are attempting to use AI and other methods to predict channel data, expanding network capacity and area by making use of ultra-massive MIMO to achieve performance gains of 6G. But, they may play a bigger role in terms of offering more functionality and being able to provide new network needs with the help of a faster connection. In a fully-autonomous 6G driving setting (El Sallab et al. 2017), for example, ML may be used to create and provide exceptional user experiences by leveraging improved network connectivity through higher latency, mobile connectivity, energy efficiency, and connection density. Furthermore, VR, AR, and AR all combine to make up the “whole-sensory digital worlds” in 6G. The peak data rate, novice user data rate, regional traffic capacity, and spectrum efficiency were of concern, including ML, high peak data rate, experienced user data rate, and area traffic capacity that allows efficient implementation of VR technology (Lin, Lee, and Tsai 2014).

To achieve interaction between patients, devices, and institutions, intelligent healthcare must also be integrated with high network energy efficiency and connection densities. The incorporation of ML helps identify diseases and collaborative research and thus supports 6G. In 6G, ML is essential that will offer infinite comfort for the future. These comforts depend on rich heterogeneous connections and a large flow of data at the same time. The scenario poses a threat to the privacy of numerous researchers, which has prompted worries (Lin et al. 2016). ML is a field in AI that's one of the oldest and maturing. Turing presented the option of ML [14] in the 1950s. Since then, AI has through various phases from the provision of machine logic reasoning (Newell and Simon 1956) to know machines to the autonomous learning of knowledge by machine (ML). Today ML develops in three areas, via an ongoing study by many scholars: supervised learning, uncontrolled education, and improved learning. 6G technology can be implemented through ML capabilities linked intelligence. A lot of ML techniques will be used to implement 6G network functions, and ML is more influenced by 6G fundamental functions and common situations for applications (Z. Zhang et al. 2019). From the comprehensive and prospective 6G views of various academics, we can clarify that 6G and ML benefit each other. The ML services may be supported by 6G. ML will, however, optimize the 6G design and have a significant part in the 6G structure. The word “privacy,” which implies concealment, hidden acts or seclusion, or mystery, is derived from the old French “private.” Privacy has been a notion for a long time. The significance of “privacy” has progressively altered with the development of contemporary awareness and sophisticated civilization. Privacy now implies the capacity of people or organizations to seclude themselves or to selectively communicate their information, particularly for individuals. The idea of privacy is thus profoundly entrenched in the lives of individuals. But the issue of privacy breaches is always occurring all around the globe in the current age of big data (Dato 2018). Privacy is at all times a priority for every technology. 6G has a complex structure that presents serious data protection problems.

The prosperity of ML, which uses big data to increase system performance and learns and generates models for decision-making, is one of 6G's major sources of privacy issues. The 6G structure will certainly survive many exchanges of data and omnipresent AI APPs (Calvanese Strinati et al. 2019) and both terminal and communication data sets that include private information are endangered. The large flow of data needed by ML in 6G will now represent an important issue for the privacy of individuals,

which has drawn the attention of governments, companies, and academics. For instance, the General Data Protection Regulation (GDPR) of the European Union has been established and laws on data protection are also in existence in other countries. In China, the WeBank is advancing the development of the IEEE P3652.1 standard and the Federated AI Technology Enabler (FATE) open-source framework to enhance ML technology that respects privacy protection. Handset manufacturers like Apple Inc. employ Differential Data Protection (DP) technology to ensure user privacy.

The application of sensory information and even emotional information to AI and the deployment of various forms of privacy in this environment may be possible thanks to the 6G technology. To ensure that ML balances between privacy and efficiency, a balance must be found (David and Berndt 2018). ML may be used as a supporting tool or object for 6G. ML may be a protector for privacy purposes. There are two sides to ML, like any technology. It may compromise privacy or preserve privacy when utilized by various individuals. In contrast to earlier networks of communication, 6G creates an age of linked intelligence, and 6G also has new privacy concerns. Firstly, the value of data from elements such as data mining has been taken into account, and today many details are focused on certain businesses. The 6G era breaks the data monopoly and creates a wide market for data sharing and data trading. Higher privacy-control needs and, at the same time, regulatory difficulties and even crimes against data are being triggered by massive sensitive data and decreased data difficulty. Second, more smart apps will operate on mobile devices and network boundaries, which increases the danger of attacks. It is a significant problem to protect the privacy of the users with such restricted resources. It is also essential to combine high-precision services with privacy protection, which includes securing smart transport and medical information from risk. A balance must be struck between how much data can be accessed, who owns it, how much oversight is there, and what kinds of policies may be put in place. The future of 6G services and apps is fueled by the protection of privacy. In 6G, therefore, ML is more directly linked to the preservation of privacy. In this book chapter, we intend to provide an extensive overview of ML in 6G and give our opinions that allow beginners and researchers to grasp and inspire them to create 6G technology and privacy protection in this area.

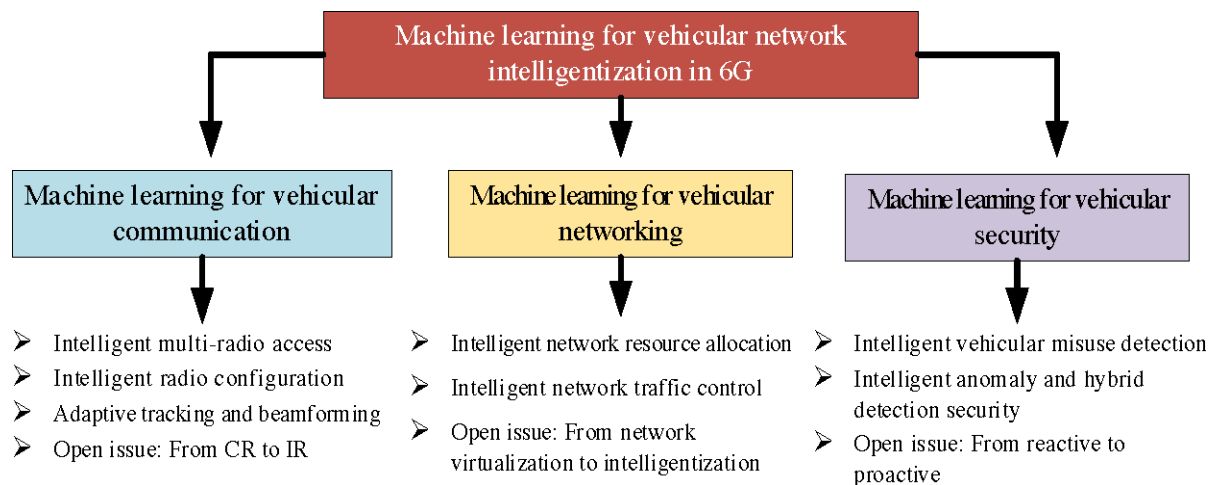
APPLICATION OF MACHINE LEARNING APPROACH FOR 6G VEHICULAR NETWORK

Vehicle-related recent projects, such as autonomous driving, cooperative vehicular networks, and the Internet of Vehicles (IoV) have attracted the attention of academic and industry specialists. Future intelligent transportation systems (ITS) and intelligent vehicle-to-everything pathways are being opened up by the AI-enabled vehicular network feasible due to vehicle-related activities (IVTE). The 6G vehicular network intends to provide a dynamic and intelligent system that is adaptable to changing applications and service types including mMTC, uRLLCs, and improved mobile broadband (eMBB)(F. Yang et al. 2014)(Brown et al. 2004).

Different developments need to be handled. Unlike traditional vehicle networks focusing primarily upon V2V and V2I, the 6G network has been developed with a superior heterogeneous space-to-air and air-to-air structure, including underwater vehicles. In addition, vehicle networks are enabled by 6G. AI may have a beneficial effect on the connection between different people around the world. Like intelligent living, intelligent grid, and human socializing. secure communication, self-optimization, and dynamic adaptiveness-enabling are key for such big 6G vehicle networks and the fast reaction capabili-

ties to improve the service QoS and reduce delays. To accomplish this objective, several sophisticated methods are suggested in 5G for example network virtualization function, cognitive radio, and vehicle reactive network control. Nevertheless, new important 6G network performance indicators (KPIs) need additional development in network intelligence, smart radio (IR), and proactive self-learning (J. Wang, Liu, and Kato 2019)(Calvanese Strinati et al. 2019).

Figure 2. Machine learning for the vehicular network in 6G communication.



Machine Learning is the auspicious AI technique that adds acumen to many commonly used systems that have shown effectiveness in several domains, including pattern recognition, natural speech processing, and independent driving and gaming IT. Present ML technologies are developing effective data recognition methods and quick correlation recovery and may serve as viable instruments for meeting the high demands of secure communication, active adaptability, and rapid response to a 6G Smart Vehicle network (Bisio et al. 2018)(Galway, Charles, and Black 2008). The chapter provides an extensive review for using ML technologies for intelligence on vehicular networks. For communication, networking, and security concerns, we coordinate ML-enabled trends for vehicle networks. In the first section, the present situation and new problems in-vehicle networks are illustrated. To overcome the above-stated difficulties in communication, networking, and security aspects, possible Smart Solutions for the 6G vehicular networks based on ML technology are then examined. Table 1 provides a summary of the flow of vehicular challenges.

Vehicle Networking Challenges

- V2X contains heterogeneous V2V, V2I, V2P, and V2N communications, which is the future intelligent vehicle network 6G. New criteria for network algorithms are met via a viable and diverse vehicle network topology. In this part, we present problems in smart vehicle networking from the distribution of resources and elements of network traffic management.

- Network traffic management: Traffic control in traditional wireless networks has been extensively studied, including network routing, congestion avoidance, and traffic reloading the approach for traffic control gets more complicated in a vehicle network, given the dynamism of network topology. The location information and network topology are important parameters for designing routing protocols for a high dynamic vehicle network, rather than traditional routing protocols such as routing information protocol (RIP), intermediary system-to-intermediate system (IS-IS), and open shortest path first (OSPF) (Perkins and Bhagwat 1994).
- Allocation of network resources: Wireless network resources like time slots, channels, computer capabilities, and amount of power, are distributed uniformly in networks and the user needs are varied in networks. A traditional issue in the wireless network is how to distribute the appropriate resources in a wireless network (Y. Zhang et al. 2013).

Vehicular Network Challenges

- The communication, networking, and security elements of vehicle network technology have been examined. Depending on various methods and guidelines of study, the present status and problems of vehicle communication and networking are being studied(Bisio et al. 2019). For many years the communication technology between vehicles and other equipment is extensively explored to support the vehicle network. Initially, common communication technologies such as WiMax, Wi-Fi, and Bluetooth with no licenses have been used to promote vehicle cellular connection. The current methods do not, however, meet unique needs, including high adaptability and sensitive vehicle network collision prevention capabilities(Ghosh et al. 2010).To resolve the issue, the DSRC for V2V and V2I communications, vehicle communication methods are widely used short-range wireless communication technology on a vehicle network. Furthermore, Long Term (LTE) has been created via 3GPP to enhance the speed and capacity of a long-standing Wi-Fi network, based upon orthogonal frequency-distribution multiplexing (OFDM).The difficulties tracking the flow of radio access.
- Radio Configuration Challenge: The traditional system of radio communication considers various blocks of radio configuration, such as signal modulation, channel equalization, and space-time decoding. Communication blocks have separate communications functions, and the radio is gradually constructed as a chain of functions (O'Shea and Hoydis 2017).
- Multi-radio access challenge: in a dynamic environment for high mobility users, a fast and accurate partition of the channel and multi-radio access is crucial. In the recent past, the new generation dynamic channel network has extensively studied and promoted the technology of the frequency-based channel, power, and time divisions, such as duplex, OFDM, and non-orthogonal multiple access(NOMA). In addition, the spatial MIMO and mass MIMO multiplexing to allow many antennas was deemed the key technology in a network of high-density vehicles in 5G (Li, Seshadri, and Ariyavisitakul 1999)(Li, Cimini, and Sollenberger 1998).
- Beamforming Challenge: mmWave will be extensively utilized in future vehicle communication. Specific high-dynamic communication systems are required for beamforming and gigantic MIMO technologies. The mmWave develops in high motion vehicle communication systems are critically disabled by the mutative vehicle position and the high overhead of frequent beam training. A recent study has shown that traditional straightforward formation techniques produce significant overload in-vehicle communication for mmWave and are not smart for adapting to constantly

changing vehicle scenarios. The new smart ML technology may be a possible answer to make the mmWave and the associated stray formation approach smarter.

Network Security Challenges

- The typical study subject in the cyber system is cyber-physical security, which is also important in vehicle grids. Car users' attacks and bad conduct create severe repercussions, not only affecting the network but also putting vehicle security at risk, and more stringent demand is imposed on vehicle networks in ML-based security algorithms. The vehicle network may introduce particular restrictions as follows.
- **Heterogeneous Structure:** The vehicle network is built using different equipment and technology and is integrated with various resources. The way the different resources of the security strategy are balanced amongst the nodes is a major problem. For example, how to increase safe applicability may be regarded as a fuzzy game in a powerful, computing, or storage constrained vehicular network and is difficult to solve optimally (He, Wu, and Khosla 2004).
- **Privacy Requirements:** Security and confidentiality in cyber systems are always combined. In a vehicle network, vehicle drivers directly influence the security of the network via permission and data accuracy. To identify and differentiate errors and anomalies from fuzzy information, the safe method uses a lot more resources without guaranteeing data correctness (Sun et al. 2016).
- **Large Scaling:** The vehicle network scale is growing rapidly. The large network is anticipated to link millions of cars by 2020. However, the large network is not covered by an established worldwide authority and standard. In addition, the growing network size raises both the security algorithm's calculation and communication cost, creating a response delay and an error rate of detection (Sakiz and Sen 2017).
- **High mobility:** High dynamics of vehicle nodes are the most essential feature of the vehicle network. Vehicle links are often disrupted and the traditional reputation-based security system can hardly be used. The strong change of topology impacts both safe routing and intrusion detection of packets via network traffic. In addition, excessive mobility leads to unexpected node movement that hampers the transmission of safe information in real-time (He, Wu, and Khosla 2004).

Machine Learning in Vehicular Communication

The main objective of future vehicle networks in 6G is network intelligence. To solve the difficulties and make way for future automotive communications, ML is later used as a high intelligence technology in the wireless system. In this part, we examine ML applications in-vehicle communications to overcome obstacles and suggest possible paths for future IR use in 6G vehicle networks are shown in the table-2. Multi radio channel estimate designs, including MIMO, NOMA, TDD, and OFDM, and, are extensively explored in wireless media. The typical configurations for multi-radio access, owing to high vehicle network dynamics, are not readily compliant with a stringent vehicle network requirement. ML has been studied extensively recently to allow intelligence in these methods of multi-radio access.

To balance the channels intend to use supervised multilayer perceived (MLP) by intelligently rebuilding symbols sent (Chen et al. 1990). In wireless communication non-linear equalizing supporting vector machine in which a temporal correlation exists in collected inter-symbol interference information (Sebald and Bucklew 2000). The machine learning-based methods evaluate just single transmission in a multi-way

transmission environment without regard to spatial variety. The channel estimation in a MIMO context presented the SVM-based multiple regression method[48]. The suggestion allows for rapid convergence using the SVM method and provides a better estimate precisely compared to conventional medium square error algorithms(Li, Cimini, and Sollenberger 1998). Feng and Chang, Innovated from SVM (Feng and Chang 2012) suggested calculating the channel noise on a wireless network based using parallel hierarchical SVM (H-SVM) using ML. However, two assumptions are based on the SVM algorithms: (a) fading channel is slow (b) No ISI in the channel model. However, both the ISI and rapid fading should be addressed because of the high dynamics in the vehicle network. For considering OFDM with sparse non-null components in the channel model alongside SVM, a sparse Bayesians (SBL) channel estimating technique was created(Prasad and Murthy 2010)(Prasad, Murthy, and Rao 2014). Another researcher has given the slim character in a large wireless MIMO network the liaison signal was about scarce and that a Bayesian study could precisely evaluate the associated channel condition. In an underwater setting (Huang et al. 2014) compared channel estimated sparse recovery methods with the comparable sparse channel model of OFDM. The sparse multiple access code (SCMA) proposed by NOMA has been extensively investigated to enhance spectral effectiveness as the potential multi-radio access technique. The SCMA uplink systems were suggested for Wang et al.(Y. Wang et al. 2015) to decrease overhead requirements via SBL based user identification and channel estimation. Kim et al. have suggested a deep-learning approach to improving NOMA efficiency in the Density environment in consideration of SCMA utilizing the Deep Belief Network (DBN). The training may be done in a single step to improve computing time and learn in-depth and can be successfully learned to decrease the transmission bit rate (BER).

Table 1. Machine learning application in vehicular communication.

Sr. No	Machine learning Method	Roles in vehicular communication
1	Reinforcement technology	NOMA dynamic power allocation (Gui et al. 2018) CR transmission scheduling (Zhu et al. 2018) CR spectrum sensing (Choi and Hossain 2013) CR channel adaption (Galindo-Serrano and Giupponi 2010)
2	Supervised Learning	Beamforming configuration (Gaudes et al. 2007) OFDM channel equalization (Sebald and Bucklew 2000) CR signal classification(Ramón et al. 2009) adaptive OFDM configuration(Daniels, Caramanis, and Heath 2010)
3	Unsupervised learning	Joint CR configuration(Thilina et al. 2013)

DISADVANTAGES OF ADVANCING MACHINE LEARNING TECHNOLOGIES TO 6G.

The following new 6G services have been defined: Event Described uRLLC (EDuRLLC), Contextually Agile eMBB Communications (CAeC), and Computation Oriented Communications (COC). In general, the service kinds that 6G supports have not yet been confirmed, although it is assumed that they will be much more strict. The metric that will be monitored should start at the transceiver, and not just in the 5G system primary network component. Another KPI to think about is connection latency, bandwidth, and security. Future services will also be assessed on their usefulness and practicality, as well as their ability to gain or use knowledge, whether or not its use or need results in storage or computational cost.

Additional technologies and infrastructure components, as well as the different needs for various indications, are causing the machine learning usage of networking to become more expedited. Next, we'll talk about machine learning methods and show their performance metrics(Letaief et al. 2019). The graphene-based photonic devices help for designing the terahertz photonics devices.

Security

The internet has become a vital element of people's occupations, and security has therefore gotten greater attention. The proven effectiveness of deep learning in threat detection has only added to the pressing need for context-aware security protections for future communication services that incorporate diverse information acquired from the people and organizations they interact with within their daily lives and workplaces. Moreover, new techniques for message safety are always being developed, making the task of selecting a security configuration more complex. This is because message security often leads to some loss of network QoS (Kato et al. 2020a).

Intelligence

System awareness of potential congestion and environment changes is required to provide competent services since future cellular networks will be more dynamic. First, a federated learning capability is required to keep up with mobile customers' ever-changing service requirements in real-time. Next, although upgrading the existing system is important for responding to new circumstances, implementing system improvements, both planned and unplanned, is necessary for getting ahead. Third, to achieve the full potential of machine learning methods, heterogeneity in software and hardware must be addressed.

QoS

In contrast to 5G, QoS will include measurements that are above and above the specifications included in 6G. The longest delay, most completed transactions, and highest packet loss rate are all considered QoS KPIs. To deal with the increasing need for intelligence in the 6th generation future, processing power and storage will also need to be addressed. Furthermore, in the future, instead of being required to have top-tier performance in a single area, future 6G systems will work to maximize multiple performance measures, for which the mathematical models to determine the connection are unable to handle. Several purpose-based learning methods should be employed to help solve this problem(Kargathara 2015).

Proactiveexploration: Machine learning training is performed via supervised learning, which imitates the present technique using a baseline dataset to educate the agent to make intelligent decisions. As a consequence of performing regular activities, training on a large dataset leads to significant content classification and function fitting outcomes. Training classification and fitting skills, in addition to the acquisition of training data via offline techniques, are, however, held down by the large amounts of training data that may be collected by conventional methods.

Distributed / Centralized

From a centralized network control system to a distributed network control system, the development in recent decades has been very notable. For quite some time, both centralized and distributed approaches

have seen increased focus. New distributed networking technologies such as mobile edge computing (MEC), content delivery network (CDN), Device to Device (D2D), and blockchain are being considered in future distributed network systems to support higher capacity networking and computing resources as well as network scalability, security, and feasibility. While on the other side, with regards to consistent and effective data management, SDN/NFV and 5G promise more control in the data center and cloud computing beyond network technologies. The algorithms employed in distributed and centralized systems have both seen a surge in recent years due to the popularity of machine learning. People know that machine learning is successful at predicting the location and time in which a state exists. Neural network (CNN) and generative adversarial network (GAN) have the strong correlation-recovery ability in the spatial domain, enabling machine learning-based networking functions to use just local and adjacent data to estimate the concealed correction and unknown information. In many networking blocks, such as congestion prediction, channel identification, and link scheduling, the spatial machine learning-based approach is utilized.

Generation of Dataset

To make use of machine learning, training data is required. Online training data is made up of data resulting from continuous and discontinuous actions. However, wireless networks cause substantial problems for both human-labeled training data and the feedback provided via online training. With terascale networking data, the former technique calls for a significant amount of human resources, while the second technique results in unnecessary signaling overhead. Another important challenge for future networks is how to enhance both training and networking efficiency by acquiring and organizing useful training data. Edge nodes in the distributed deep learning-based traffic management system, should communicate the traffic patterns across time slots and intervals. Additionally, these patterns should be collected and transmitted to the controller in the centralized system [52]. It is only when the information is provided in an integrated traffic flow pattern that the training time is reduced and overall efficiency is improved. However, this approach adds transmission delay and signaling overhead. Finally, training efficiency should be evaluated by inspecting the training data's format. Considerations may include how often packets arrive, the amount of data the network has left in the buffer, and the coordinates at which the dataset is built. Training data sets that include periods of longer and shorter intervals of traffic patterns influence network performance as well as training accuracy. A challenging new research issue is how to determine the training data time interval (e.g., traffic patterns) and the training interval. This has to be balanced to achieve maximum training accuracy with little computational/networking cost (Tang et al. 2018)(Kato et al. 2016).

Scalability for Global Intellect

In general, the most realistic models are derived from particular situations. Future 6G access methods, service needs, hardware designs, and network topologies will all have various amounts of 6G capacity. Reduced network accuracy is a further potential problem since rapid mobility and frequent virtual sub-network rebuilds are common. In addition, future 6G systems will require enormous amounts of effort to design sophisticated algorithms for each function. It is critical to ensuring global intelligence that machine learning models be made scalable. Although on the next page you'll learn about difficulties with scalability when working with machine learning-based algorithms, increasing scalability is a very

significant goal. Machine learning models come in numerous varieties, with varying scalability and efficiency characteristics. Using only a few input points, shallow neural networks may accurately anticipate results. Many researchers, however, have questioned the effectiveness of these models in the face of complicated dynamic situations. This is because while many variables such as network architecture and available resources are essential to implementing advanced features, many analysts misunderstand the interplay between such variables, and as a result, they end up with basic implementations. Geometric deep learning may allow AI to take into account changes in the network, changing network resources, and other variables needed for dynamic applications, resulting in efficiency and accuracy. For global use, however, it is necessary to overcome the expense and inflexibility of computer systems. Transfer learning is an efficient method when faced with nearly identical circumstances, although the rate of accuracy is variable. (Bronstein et al. 2017).

Computation Overhead Deployment

Network design, especially concerning the usage of proprietary hardware and algorithms, has remained almost unchanged for decades. A generic hardware-based architecture should be used to enable in-time network modifications and machine learning-based techniques that can self-adapt to dynamic network conditions. A second problem that is becoming more and more of a concern is the increased computational cost in training and running machine learning models. Next-generation 6G services will provide significant processing and storage capacity, which will be one of the key characteristics of these services. Thus, the need for efficient computation will be as important as communication capability. Despite these considerations, resource sharing will be a popular choice because of the many different devices and expensive computer servers. Once we've figured out how to place the resources where they're needed, we still have to figure out how to manage and allocate computing resources to different subnetworks. The challenge here is that our decisions must take into account the relative time and computational precision of the resources. Due to the high cost of new computer platforms to replace the current communication infrastructure, it is not viable. Other new devices, like Mobile Base Stations (MBSs), will be loaded with processing power to enable these algorithms to operate locally. Compute-intensive approaches like traditional compute offloading, which are typically concerned with server deployment, have to contend with the issue of heterogeneous computing resources because intelligent algorithm design and practical deployment are both influenced by machine learning-based strategies. The network control technique also influences the way computing is conducted, which leads to variations in the communication overhead. Because of this, we can say that future intelligent 6G systems will provide a major computation deployment challenge because the computation has to be addressed when it comes to a communication process, machine learning model, and other operations.

Feasibility Verification

In terms of Feasibility Verification, machine learning-based 6G systems may have major issues. Machine learning that uses potential "deep structure" methods is a black box: It is unseen, and it does not lend itself to post-hoc interpretation. As well, because of the many different communication and networking technologies and structures in the network area, the learning system has to have exceptional repeatability and broad applicability. Network resources are limited, and to enable machine learning-based network

operations, network performance, including communication latency, signaling overhead, and throughput must be guaranteed.

Design And optimization of Architecture

There are three types of machine learning training methods: supervised learning, unsupervised learning, and reinforcement learning. Multiple models with varying efficiency and for different situations have been created for each training method. After deciding on a training method and model for a specific issue, the architecture's parameters must be tweaked to maximize the accuracy rate. Experimenting with real-world deployment following simulations is also required to achieve complete intelligence in future 6G systems.

When setting out to use machine learning to address a problem, it is important to focus on a clearly defined issue from the beginning that will have a substantial impact on the process and difficulty of training. In the presence of supervision, supervised learning techniques are used for linear regression and classification, whereas unsupervised learning techniques are applied for clustering issues. When modeling a problem as a Markov Decision Process, reinforcement learning is the most effective approach (MDP). The cost function is essential because it determines how long the training lasts and how accurate the prediction is. The third step of the machine learning model's development is to modify the proposed model's parameters, especially the activation function, learning rate, and initialization function, as well as parameters such as parameters.

It is difficult to maximize learning efficiency since there are a growing number of options at each stage. Furthermore, since the full work theory of machine learning is yet unknown, the efficiency of any decision can only be discovered via trial and error. Furthermore, existing simulation-based development is insufficient to maintain learning efficiency after the suggested algorithms are implemented in practice (Kato et al. 2020b).

Physical Layer to Application Layer

The whole communication process is based on the conceptual Open Systems Interconnection (OSI) paradigm, which transforms electrical impulses from the physical environment to machine-readable data in cyber-systems. Machine learning has been widely utilized in recent years at all OSI layers, from physical to application, to enable intelligence in the information transmission process. At the physical layer, machine learning is widely used to enhance signal transmission via intelligent configuration techniques such as AI-assisted data coding, channel estimation, signal identification, and beamforming. In the physical world, the complex environment with its many dimensions and dynamics makes it challenging to analytically explain communication and networking processes using a precise mathematical model. By converting the environment parameters into multidimensional tensors, machine learning techniques, especially those with deep structures such as deep neural networks (DNN), are capable of simulating communication and networking processes with strong nonlinear approximation. For example, in a typical Non-Orthogonal Multiple Access (NOMA) system, deep learning with a long short-term memory (LSTM) network is used to enhance automated encoding, decoding, and channel identification in 5G and beyond (i.e., 6G) systems. Additionally, machine learning methods have the potential to be a viable solution for data coding and passive eavesdropper detection at the physical layer of security (Gui et al. 2018).

FUTURE DIRECTION OF 6G

Intelligent Offloading

Intelligent offloading invasion may enhance the current condition of terrestrial task allocation to greater levels in the 6G-SAGIN. For the SAGIN ecosystem, we should enforce quality of experience (QoE), quality of service (QoS), and centered offloading methods. This would allow the SAGIN to operate more effectively while also improving overall job load distribution. In this respect, edge analytics, together with machine learning-based traffic monitoring, may be included in our system. It may be possible to make better use of SDN if used correctly. Ensuring the robustness of a communications connection should be taken into consideration while using intelligent offloading methods in the 6G-SAGIN. Task management modules that are capable of providing real-time delay-tolerant task management have been assigned the responsibility of executing the optimal offloading method(Ray 2021).

Under-Water Communication

6G communication will change the connection of all sectors, particularly underwater communication. Seamless connection with the subsea network may be necessary for 6GSAGIN. Thus, the use of VLF signals between 3-30 kHz, which may penetrate the sea waters to 20 m, should be envisaged. The VLF signaling communication range of the current submarines should be extended. To get the signal from the underwater, the broadcast antenna should be big enough. The G2SM channels should be transmitted on a one-way basis, however, one might create such a bidirectional link climbing to periscopic depth. Only 300 bps may be perceived through VLF. Only text messages and basic voices at a lower data rate can be transmitted. 6G can influence the larger coverage area and the right combination with VLF is anticipated to be placed in the right location. For certain military uses 3-300 Hz extremely low frequency (ELF) for hundreds of meters of seawater. We can utilize the UAVs to establish a viable connection with the underwater antenna array. The Ramon deity of NATO gates may be used to connect with the underwater modems at a frequency between 60 and 900 Hz. The possibilities are nevertheless available for the usage of acoustic radio-acoustics and the combination of 6G-SAGIN(Ray 2021).

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Blockchain

A new technology known as blockchain is attempting to make the Internet more secure, protect consumer privacy, and foster openness. It was agreed that 6G-SAGIN must store activity records on the blockchain in an immutable fashion in a decentralized manner. Block storage media may be made utilizing satellite, UAV, and ground station facilities while applying cryptographic hashing. Depending on the specific needs, the use of private, public, or consortium-based blockchains is permissible inside the SAGIN ecosystem. 6G-SAGIN nodes may use decentralized consensus techniques, enabling users to accept or reject authentication via consensus. Mass collaboration among SAGIN components is made possible by a robust procedure. We greatly reduce malicious incursions into duplication spending and repetition (Pin Tan et al., 2021). With the enhanced data quality and best-effort computational trusts, the primary utility of blockchain in the SAGIN architecture is its decentralized character. Consider MVCC for decentralized ledgers on the SAGIN platform. When smart contracts are installed on the fly into UAVs and satellites, an inquiry should be carried out to discover a solution. New software development tools and SAGIN-based crypto money should be utilized to incentive network operators. (Pin Tan et al. 2021).

CONCLUSION

The proposed book chapter includes the benefit of using Machine learning in the 6G communication technology. This book helps in setting goals for 6G services requested by the real-time learning services. *The fundamentals related* to the requirement of 6G communication along with the machine learning approach helps for an application like vehicular networks, artificial intelligence, and many more. The machine learning application in the 6G vehicular network is investigated along with the intended to generate a rapidly evolving and intelligent system that allows networks to adapt to various application requirements and service types, such as massive machine-type communications (mMTC), ultrareliable and low-latency communications (uRLLCs), and enhanced mobile broadband (eMBB). The network security challenges, vehicular network challenges, and vehicle network challenges are also investigated. The limitations for advanced machine learning for the 6G communication is include which guide the researcher during designing the network structure. Overall book chapter includes the basic and advanced levels of machine learning. Including the unsupervised, supervised, and reinforced learning and the challenges of ML for the 6G.

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Chapter 10

6G With Artificial Intelligence and AI-Enabled Smart Architectural Design

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ABSTRACT

Modern networks may not even be equipped to fully satisfy rapidly increasing traffic needs due to the fast growth of intelligent endpoints and systems and various programs with diverse needs. As a result, a study on 6G technology has already been undertaken by businesses and academics. AI (artificial intelligence) has subsequently been used as a paradigm shift to optimise high-intelligence 6G technology. To realize information exploration intelligent resource planning, automatic network adaptation, and astute service configuration management, the authors proposed an AI-enabled smart architectural design for 6th generations systems; here, it is categorized into four tiers: data mining, intelligent sensing layer, smart application layer, and intelligent control layer. The author also discussed modern technology in the mobile generation, uses, security, opportunities, and challenges.

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INTRODUCTION

The way people comprehend and engage with and with each other has altered with mobile telephone technology. It is difficult to imagine a technology that influenced 21st century life more profoundly. Mobile standards are presently being used in chosen places across the planet with the newest technology of the fifth generation. And that creates an evident question. What will fuel mobile technology development in the sixth generation? How will 6G be different from 5G, and how will 5G enable interactions and activity?

Some researchers have delineated the 5G constraints and the variables that they believe influence the 6G growth. Their assumption is that the primary driver of digital technology is AI (artificial intelligence), and also that 6G is the enabler of a completely new generation of device information capabilities.

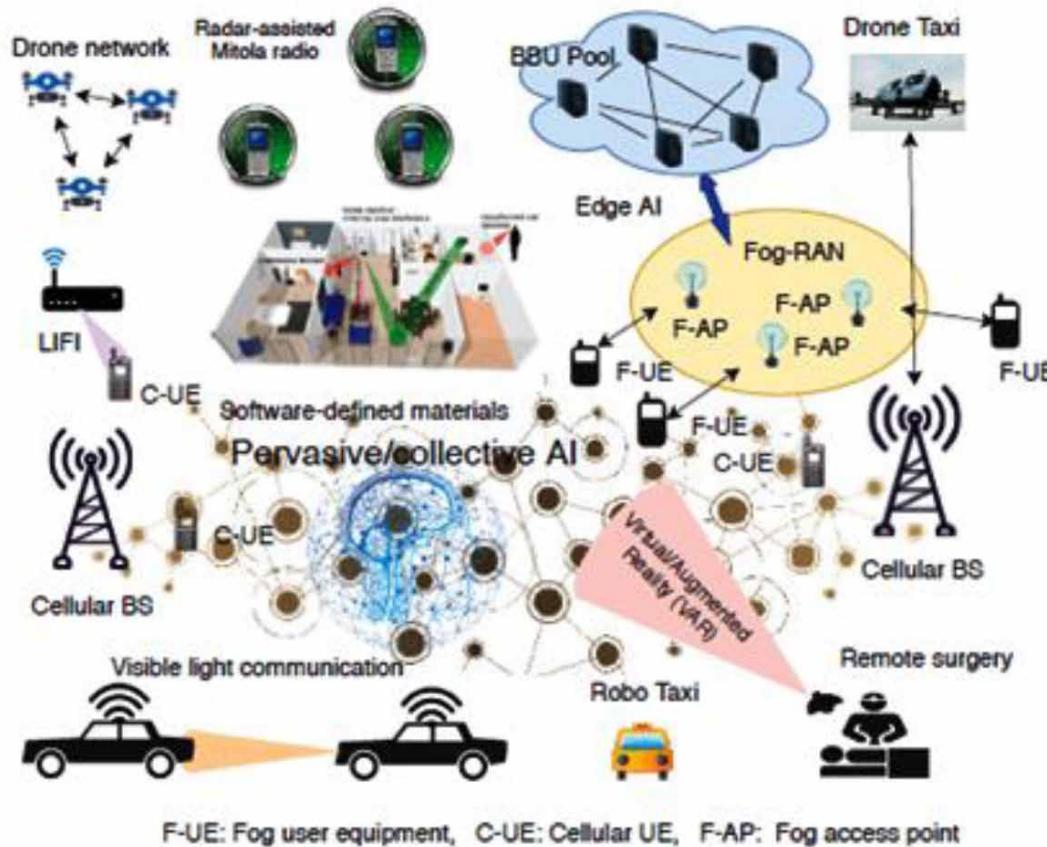
5G is a substantial improvement against the preceding 4G standards, depending on any criterion. The initial five-gym connections have up to 600 megabits per second download rates and therefore can grow much quicker (Andrews, 2014). In comparison, 4G usually works at up to 28 Mbits/s. For causes that are not always obvious, most smartphone consumers encounter this grinding pace to 0 from time to time. In this regard, 5G is superior and can even eliminate many connections.

However, the greatest advantages go further than these numbers. For instance, 5G base units are intended to accommodate one million links, compared with 4000 that 4G base units can manage. In important meetings like sports events, protests, and so on, it should create a change, and it might make possible all sorts of web applications for everything. The time required for the transmission of signals across the connection is therefore delayed. 5G has just one millisecond latency, compared to 50 milliseconds or even more in 4G. Every player will remind you how essential it is because it enables gaming persona remote control more sensitive (Andrews, 2014). But many telecommunications providers have shown that the very same benefit allows drones to be controlled with greater precision, even by means of a mobile network, for telemedicine. With reduced power needs to start, all that should be feasible, and recent estimates indicate that 5G devices have ten times the battery life of 4G gadgets.

So how might 6G improve it? Of course, 6G will provide even higher download rates – they can reach 1 terabit per second. However, what sort of changes might it offer? The answer showed that partnerships between smart entities that solve difficult flying issues and negotiate complicated issues quickly change in large numbers. Take the issue of the coordination of cars in a large town. This is a major issue since about 2.7 million cars arrive every day in a metropolis like NY.

The upcoming self-driven cars must be conscious of their position, surroundings and how this is evolving, and other drivers on the road like bicyclists, pleaters and self-driving automobiles. You need to navigate crossings and plan your path so that travel hours are minimized. This is a major computer problem. For instance, as they encounter a certain intersection, vehicles will have to establish on-the-air networks quickly, and afterwards nearly immediately leave them (Kato et al., 2019). Simultaneously, they will be components of wider systems that calculate routes and time, etc. “Thus, huge numbers of connections will be required to address major dispersed issues when immense connection, big quantities of data and extreme low-latency far beyond 5G networks would be crucial,” Stoica and Abreu said. That’s also just one scenario that will enable 6G to work together. Stoica and Abreu face a variety of additional difficulties, dispersed by this type of strategy. These are built on huge quantities of data being generated in real-time and processed in partnership. One apparent use in network management is the capacity to anticipate and respond to occurrences as they happen – on a formerly unthinkable scale – to financial sector surveillance and preparation, improvement of medical and “now-casting”

Figure 1. Artificial intelligent in 6g



Artificially intelligent entities are obviously intended in our society to perform an essential role “Cooperative Artificial Intelligence is essential to exploiting the full potential of these creatures,” said Abreu and Stoica. However, it is obvious by the essence of the 21st century mobile culture that wireless technology alone is possible to accomplish this cooperation. The view of the coming years is intriguing. There’s so much to negotiate, and trade before a series of 6G specifications can ever be defined or completed. But if Stoica and Abreu are right, the motivating factor behind the communication systems of the future is AI.

5G is anticipated to provide a maximum data throughput of 20 Gbps and an observed data rate of 100 Mbps for users. However, 6G will provide 1000 Gbps with a maximum data rate. The user perceived data rate will also rise to 1 Gbps. Therefore, the frequency spectrum of 6G is more than two times the effectiveness of 5G(Boccardi et al., 2014). The improved spectral effectiveness will allow many customers to immediately and concurrently access sophisticated multimedia services. To promote improved speed efficiency, the internet providers have to update their existing framework.

Latency is reduced to 1 millisecond with 5G. The ultra-low latency enhances the effectiveness of several applications in real-time. However, WiFi technology of the 6th generation reduces the users’ latency to less than 0.1 milliseconds. The significant decrease in latency will enhance many lags respon-

sive real-time programs' usefulness and effectiveness. Furthermore, reduced latency helps respond to emergencies, distant operations and factory equipment. At the same time, 6G will successfully operate the retardant real-time apps by improving the connection 100 times more stable than 5G.

5G seeks to improve individual customers' mobile experience and facilitate M2M engagement. However, 6G is intended as main consumers by addressing devices. With the optimum data rating and minimum 6G's lateness, many network gadgets as well as machines – robotics, drones, driver-less cars, intelligent displays, household appliances, or intelligent sensing technologies – will increase their capability and usability (Kibria, 2019). The wireless connection will also permit human customers to quickly use mobile gadgets from the future generation, such as high-faith holograms, AR glasses and VR headgear.

MODERN TECHNOLOGY OF MOBILE GENERATION

Enough of the discussion now being held in the smartphone business concerns the advantages of 5G deployments globally. However, many customers will recall the newest mobile connection innovations in 2G, 3G and 4G. The evolution of mobile networks was marked by each generation of the network, which we described hereunder.

1G

Network operators of 1G relied on analogue radio technology, which indicated that consumers could only do telephone calls, neither send nor receive SMS messages. The 1G connection was initially launched in Japan in 1979 and then implemented in 1980 in many other nations, including the United States. Cell towers have been constructed throughout the nation to create their function, so that signal reception from larger ranges may be achieved. The network was nevertheless unstable and had certain security problems. For example, mobile coverage would frequently decrease, additional radio signals would conflict and could simply be hacked owing to missing encryption. This implies that discussions may be overheard and recorded with several instruments.

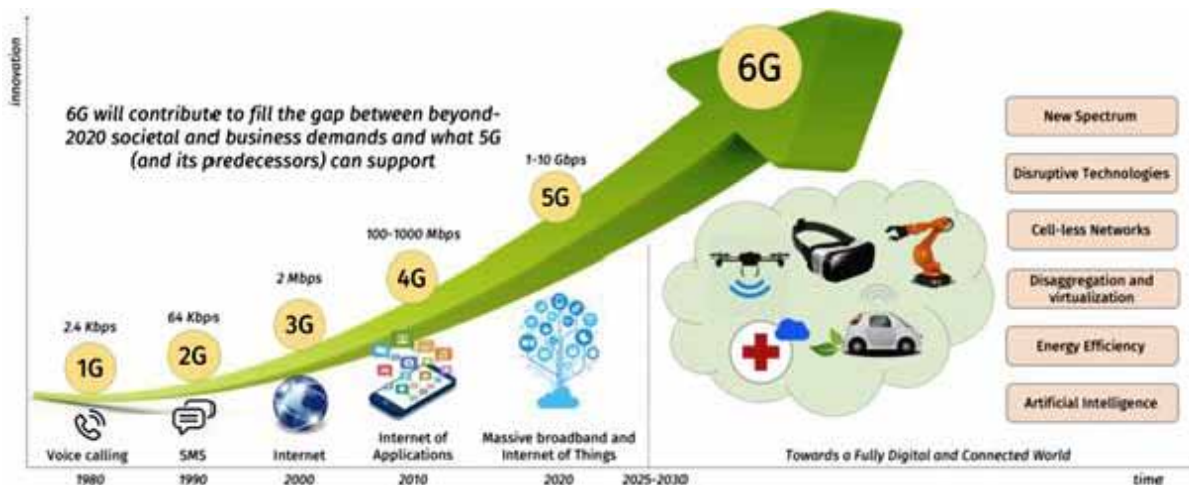
2G

The 1G connection was not flawless but lasted until 1991 when 2G was substituted. This modern data connection has operated on a digital and non-analogue signal, significantly improving its security and performance. Consumers could send SMS and MMS conversations over 2G and consumers could send and receive e-mails on the go when GPRS was launched in 1997.

3G

Mobile networks of the 3rd generation are still in operation today, although the better 4G signal usually fails. 3G has transformed mobile connection and smartphone possibilities. 3G was considerably quicker compared with 2G and was able to transfer more data (Kato et al., 2019). This implies that first-time customers can call video, exchange files, browse the web, watch Television online, and download online smartphone games. They focus on social connection, under 3G, cell-phones, where talking and messaging are no longer really about.

Figure 2. 6G will unlock the power of “AI-for-Everything”



4G

The 4G was a step farther than the groundbreaking 3G. The bandwidth may theoretically go up to 100Mbps and is five considerably better than the 3G network. The Internet, which provides desktops and phones and phones, should accommodate all devices launched in 2013. Under 4G, consumers may enjoy improved latency, better voice quality, easy accessibility to instant messenger and social networks, streaming reliability and quicker downloads.

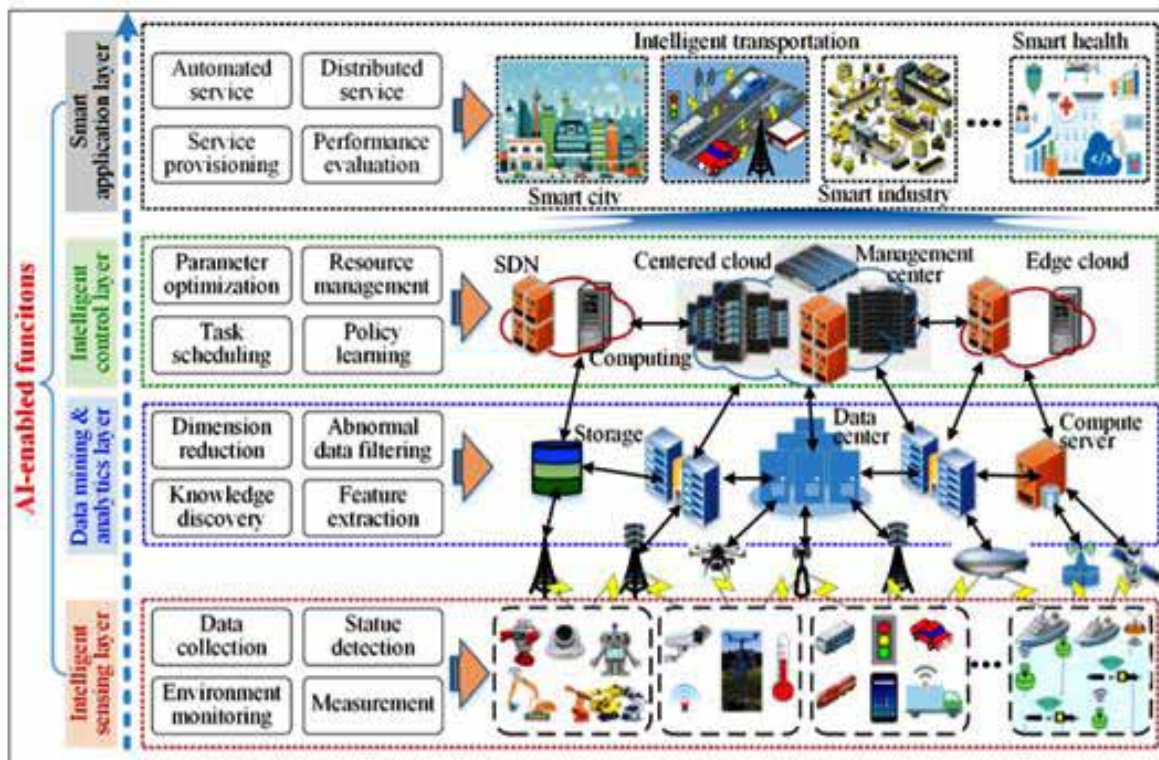
5G

The 5G system is underway as well as the mobile sector is very much expected. Many analysts say the connection will alter the way we use our phones and how people connected our gadgets to the network. Enhanced system bandwidth will herald new IoT developments, including linked vehicles, to enhance IoT throughout the home and workplace.

ARTIFICIAL INTELLIGENCE ENABLED 6G NETWORK

6th Generation systems will be huge, multi-layered, highly sophisticated, dynamic, and diverse in growth. Furthermore, 6G networks must enable seamless connection, meet a wide range of QoS criteria for a high number of gadgets, and also handle enormous amounts of data produced in physical settings. AI methods with strong analysis, learning, optimization, and intelligent recognition capabilities may be integrated into 6G technologies to effectively carry out functionality, information retrieval, advanced learning, structure organisation, and complex strategic thinking (Letaief et al., 2019). An artificial intelligence-enabled intelligent architecture is proposed for 6G networks, split into four levels as illustrated in Fig. 2: “intelligent sensing layer, data mining and analytics layer, intelligent control layer, and smart application layer”.

Figure 3. The construction of Artificial Intelligence-enabled intelligent 6G networks



Firstly, we shall go through few of the most popular AI methods. Interdisciplinary methods such as deep learning, machine learning, game theory, optimization theory, and meta-heuristics are included in Artificial Intelligence techniques. Machine learning and deep learning are two of the most prominent Artificial Intelligence disciplines, and they are extensively used in wireless devices.

Supervised Learning

Supervised learning builds a learning framework using a collection of exclusive labelled information, which is split into regression and classification disciplines. Characterization analysis comprises tree structure, support vector machines, and K-nearest neighbours, attempting to give a category label to each input pattern. Support vector regression and Gaussian process regression methods are used in regression analysis to predict or anticipate attribute variables depending on statistical characteristics.

Unsupervised Learning

Unsupervised learning is split into a grouping with dimensionality compression to discover concealed trends and extract usable characteristics from raw data. Segmentation is the process of grouping a collection of specimens into distinct groups based on their similarities. The most common clustering techniques are K-means grouping and multilevel segmentation. Feature extraction reduces a high-dimensional infor-

mation structure to a low-dimensional one while preserving as much information as possible (Liu et al., 2018). Two well-known dimension reduction techniques are main component evaluation and isometric projection. Reinforcement Learning: In RL, every entity understands to map circumstances to actions and develops appropriate choices about which actions to perform by engaging with the surroundings to maximise long-term reward. “Markov decision making process, Q learning, policy learning, agent critic, DRL, and multi-armed bandit” are examples of classic RL algorithms.

Deep Learning

It is an Artificial Intelligence feature that mimics the humanoid mind’s ability to comprehend data representations and generate connections using “artificial neural networks”. The learning model may be guided, semi-supervised, or unsupervised, and it is made up of several tiers of neurons. “Deep neural networks, convolutional neural networks, recurrent neural networks, and long short term memory are examples of traditional deep learning methods”.

1. Intelligent Sensing Layer

Detection and sense seem to be the most basic functions of 6G networks designed to effectively perceive and identify information from physical surroundings through massive equipment or masses of people. Radio waves utilisation recognition, ecosystem surveillance, spectrum sensing, intrusion prevention, intervention detection, and other Artificial intelligence sensor technologies and sensing applications are competent of logically accumulating huge volumes of active, varied, in addition to expandable information by straight connecting with the physical surroundings.

Because 6G networks must offer ultrahigh dependability and ultralow delay telecommunications services, extremely precision sensing, real-time detecting, and robust detection are all of considerable importance (Yang, Xiao, Xiao et al, 2019). Furthermore, fluctuating 6G networks cause spectrum characteristics ambiguity, making robust and precise sensing challenging. Fuzzy SVM, as well as “nonparallel hyperplane SVM”, are reliable to climate complexities, “CNN-based” collaborative detection can enhance detection precision with simple structure, the mixture of K-means segmentation and SVM can achieve real-time detecting by exercise “low-dimensional input data, and Bayesian learning” can achieve precise, real-time, and robust data transmission.

Spectrum sensing, for instance, is an essential method in 6G technology to enhance spectrum use effectiveness and solve spectrum shortage issues. Spectrum sensing in large-scale 6G networks, on the other hand, is very difficult due to the huge number of equipment attempting to sensor spectrum at the same time, and the immense spectrum use detections resulting in high-dimensional search difficulties (Zhang, 2019). In this instance, artificial intelligence may recognise spectrum features and effectively create appropriate training models to detect spectrum functioning states. In further context, AI-enabled learning models identify spectrum operating state by classifying every vector into one of 2 classifications: “spectrum idle class” or “spectrum purchase class,” besides embracively updating the learning representations depending on changing settings.

2. Data Mining

This tier is a critical job that attempts to handle and analyse enormous quantities of unprocessed data produced by a massive number of sensors in 6G technology to accomplish semantic derivation and information retrieval. Because the massive amounts of data gathered from external structures can be diverse, discontinuous, and high-dimensional data, data gathering and analytics can be used in 6G technology to tackle massive processing amounts of data and analyse the data for information retrieval.

On the one side, transmitting or storing large original information in dense networks is expensive. As a result, the raw data must be decreased in dimension, anomalous data must be filtered, and a much more acceptable dataset must be produced. “PCA and ISOMAP” are two popular AI techniques that may significantly assist 6G networks in transforming higher-dimensional input into a lower-dimensional subspace, reducing computation time, storage capacity, and complexity of the model (David & Berndt, 2018). Enormous gathered network data, congestion movements, pictures and recordings from devices, gadgets, and social networks, such as high-dimensional information, may be reduced into a slight number of usable characteristics of the uncooked information employing “PCA or ISOMAP”. Furthermore, aberrant data may be found in the data gathered from physical surroundings, processed using “PCA or ISOMAP”.

Furthermore, information analytics effectively analyses gathered data to uncover relevant information and create valuable information. Substantial data is gathered in 6G technology from the real world, the digital revolution, and social networking sites, including important information and significant characteristics. Ultimately, useful trends or principles may be identified as information to supply a feasible strategy for resources planning, protocol adaptation, architectural cutting, cloud computing, signal processing, as well as a variety of other applications. ISAGUN, for example, can effectively analyse the movement trends of “UAVs” in the sky, construct the network route damage model of the “satellite–ground connection,” and forecast expedient behaviour in-ground systems using the newly found information.

3. Intelligent Control Layer

In a nutshell, the intelligent control plane comprises learning, improvement, and decision-making. This layer utilises suitable understanding from lower layers to allow huge entities to intelligently understand, optimise, and get the most corrective action, with dual features to assist diversified social media network assistance. AI methods are used in 6G networks to provide this purpose, with each agent having a sensible brain that can learn to make choices on its own.

Learning is the procedure of utilising or integrating new experience and knowledge to enhance the behaviour of every device or service centre, allowing 6G networks to smartly realise optimum system slicing, end-to-end PHY layout, network virtualization, strategic planning, diverse network design, and so forth, based on the needs of varied uses (David & Berndt, 2018). Intelligence is a key feature of 6th Generation channels since an amalgamation of Artificial Intelligence, with 6th Generation channel may study to accomplish self-configuration, self-organization, and self-healing, ultimately improving practicality. In 6G technology, for example, post-massive multiple-input multiple-output will allow several transfer data antennas along with “mmWave or THz” broadcasts. It’s difficult to find the most energy-efficient beamforming parameters while also avoiding RF nonlinearities. RNN analyzes the discontinuities of energy amplifier range then optimise minimum communicated energy requirements at transmitters, allowing an RNN-based solution to capture the non-linearity of RF components

The goal is to operate an acceptance in addition rule-based channel with global objective-based stricture development. Traditional optimization methods use sophisticated measured models that might not be appropriate for 6thGeneration channels, far more diverse and uncertain. Rather than laborious calculation, AI methods may be used to improve network characteristics and designs in AI-enabled smart 6G networks. AI technologies offer the best chance to practice auto-learning designs for 6G wireless communication enhancement, enabling “providers or operators” to optimise model limits, assets, or configurations to adjust facilities for gadgets better, and ultimately making 6G networks intelligent, agile, and self-adapting(Nassar & Yilmaz, 2019). Deep learning, for example, may transform “SDN/NFV” into an intelligent network infrastructure able of rapid learning, adaptability, and self-healing model limitations as well as topologies to accomplish smart softwarization, claudicating, virtualization, including segmentation.

Decision-making is a critical intellectual activity that allows large agents to cognitively analyze, strategize, and choose the best options to fulfil high-quality service needs. Every agent in decision-making tries to acquire new information from other machines while also selecting the worldwide activities with the greatest advantage depending on current information. Choosing the ideal preceding variables in “mmWave or THz transceiver” structures, selecting the appropriate routing protocol for vibrant “ISAGUN”, and choosing the versatile spectrum administration structure for huge multi-access scenarios are altogether choices problems that can be efficiently addressed using Artificial intelligence in 6G technology.

4. Smart Application Layer

This layer’s primary tasks include providing software services to humans according to their diverse needs, assessing the provided services, and feeding the assessment findings directly to the intelligence mechanism. The momentum of AI may be used to support a wider range of high-level intelligent systems, like mechanical facilities (Russell & Norvig, 2010), intelligent cities, intelligent industries, intelligent transit, intelligent grid, intelligent health, in addition control administration activities for all smart kind of program. To achieve network self-organization, the smart program layer manages all operations of smart devices, terminals, and infrastructure in 6G technology using AI methods.

An additional goal of this layer is to assess service quality, which may include a variety of criteria and variables like “QoS, QoE”, the excellence of gathered information, in addition to the integrity of acquired information. Simultaneously, the rate aspect measure in relations of energy effectiveness, like spectrum usage productivity, computationally efficient, power generation, and storage efficiency, must be considered. All of the assessment criteria described above may be used to enhance intelligent inventory administration, automated network slicing, and intelligent service offering.

6G SECURITY

Although security privacy protection is essential for all types of data transmission, 6G poses several unique difficulties. The 6G network is utilised as an all-embrace sensor that blurs the boundary from the tangible to the digital realm. This would lead to data destruction, the lack of control of the gadgets, financial loss, damage to property and even bodily risk to persons since a security breach in the 6G network is impossible(Challita & Dong, 2018). Under the worst scenario, cyber-warfare in the material realm may cause chaos with a serious influence on the security of national life.

For all these problems to be addressed, confidence, security and privacy must increase considerably in 6G networks than in modern current data networks, which need study in various fields.

Trusted Networking Challenges

- The Internet is free, and the legislation is not enforced.
- Scalability of embedded systems, diverse trends of use, diverse kinds of networks.
- Trust management spans many fields, particularly the use of zero confidence techniques.
- Software that has fewer risks along the value chain.
- Uniformity of trust evaluation for the physical goods of confidence at least (e.g., confidentiality, trust measurement, various service situations, etc.).
- Intangible issues about confidence and perception like radiation and health.

New Architectural Challenges for the Network

- Challenges for postquantum, e.g., postquantum encryption standard, to guarantee quantum-safe encoding.
- The integration of software and AI defined security features, virtualization, deep learning, and artificial intelligence leads to active safety that identifies threats and responds effectively to such attacks. Simultaneously, assailants are using the same instruments to develop better assaults that lead to an “arms race.”
- Increased cloud computing, including cloud download functions, leads to security concerns regarding data secrecy, data security, system credibility, and privacy protection. This may be addressed by developing or improving distant authenticating points, hardware confidence anchors, trusted running environments, platform certification, and remote certification support.

Physical Safety Level Challenges

Security systems for 6G cover one of 6G’s most critical application areas: human-centered Wireless Networks, such as on and in-bodies, wireless body sensor networking. The human being is thus part of the design process of the network (Yang, Xie, & Kadoch, 2019). And safety is extremely essential as a result.

For 6G, for instance, to guarantee privacy and security, many fields of study are required in the field of physical safety:

- Advancement and collaboration of distributed safety protocols.
- Prevents cell free MIMO attacks and smart reflection surfaces.
- As a comparable technique, visible light communication.
- How can I guarantee the platform safety while numerous antennas are dispersed?
- Locking security for jamming detection and mitigation.

Data Protection Challenges

- How can one quantify the necessary or supplied levels of personal protection?
- Specify the personally identifiable information criteria.

- How to allow people to specify simply the information they are prepared to disclose or with whom?
- There can be no understatement of the significant effect that safety, privacy and confidence have upon the adoption of 6G. Unless the problems mentioned above are addressed, the benefits and potential of 6G cannot be achieved.

6G NETWORKS, ARTIFICIAL INTELLIGENCE TECHNIQUES

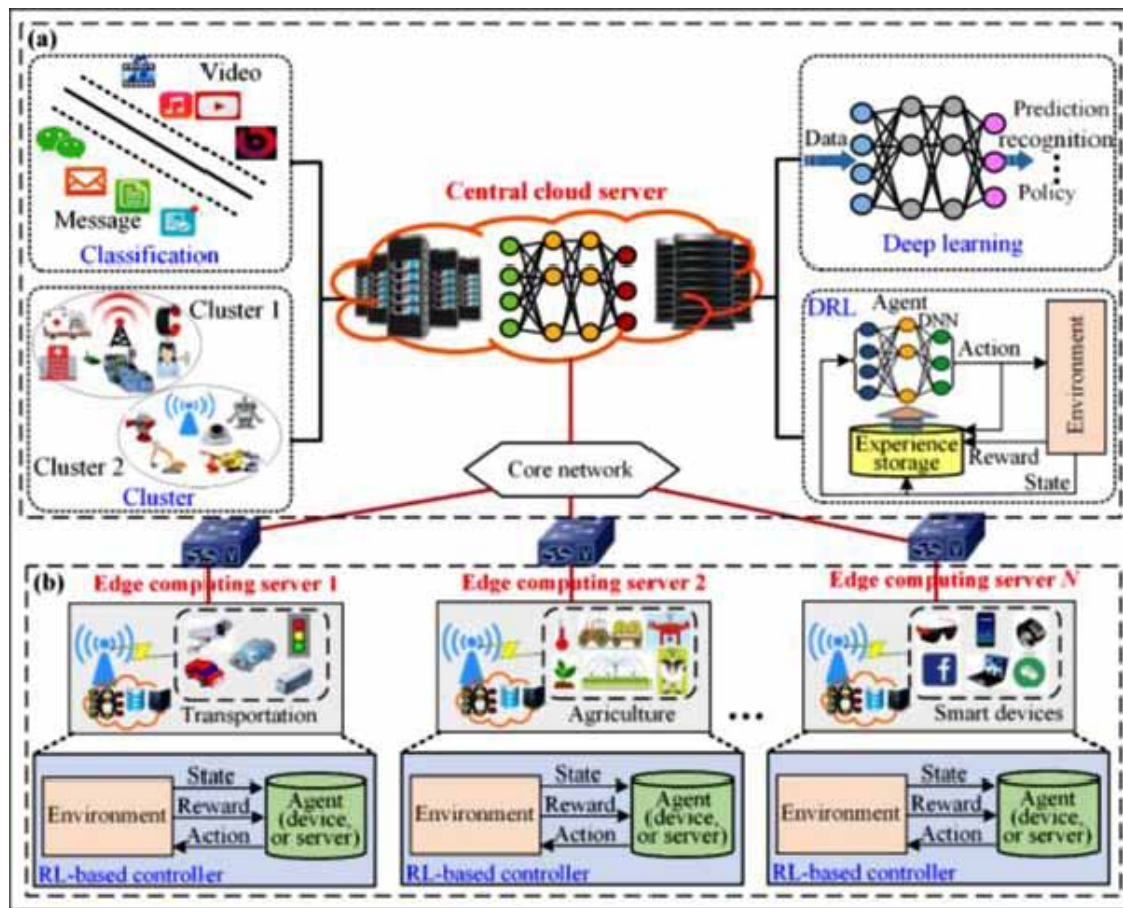
In terms of AI-enabled mobile edge computing, intelligent mobility and handover management, and smart spectrum management, the AI techniques provide preliminary intelligence for 6G networks.

Mobile Edge Computing with AI

Mobile edge computing (MEC), which can provide processing, management, and analytics facilities inside a RAN or SDN in close proximity to various devices, will be a crucial enabling technology for the emerging 6G networks. Due to the multi-dimensional, randomly unpredictable, and dynamic properties of MEC networks, decision making optimization, knowledge discovery, and pattern learning are sophisticated. In such complicated networks, standard algorithms (e.g., Lagrangian duality) may be limited. In MEC, AI approaches may extract useful information from collected data by learning and supporting various functions for optimization, prediction, and judgement. Figure 3 depicts the AI-enabled mobile edge computing framework, which includes both central cloud computing and edge computing. Because of their restricted capabilities, edge computing servers can use lightweight AI algorithms to provide smart applications for edge scenarios (such as transportation and agriculture), as shown in Fig. 3.(b). RL-based edge computing resource management, for example, is a model-free technique that does not require past knowledge and can be used to learn the dynamics of the environment and make appropriate control decisions in real-time. The possible resource management solutions (e.g., energy management, resource allocation, and task scheduling) are contained into the set of possible actions in the RL framework at each step after obtaining the state (e.g., device mobility, requirement dynamics, and resource condition) by interacting with environments. Complex centralised large-scale AI algorithms can be used to provide diverse learning tasks in the central cloud server, because it has powerful computation capabilities as illustrated in Fig. 3. (a). Because MEC networks have such a broad and dynamic set of service applications, AI-based classification can be used to efficiently modify traffic flow decisions for distinct service characteristics. Furthermore, MEC server association can be acquired via an AI-based cluster rather of an individual decision, which will drastically reduce the number of players. The central cloud server may receive large amounts of data from edge computing servers, which must be trained to extract features and uncover knowledge automatically. Deep learning can be used to train computer models for service recognition, traffic and behaviour prediction, security detection, and other applications in this scenario.

Furthermore, in complex and dynamic MEC networks, analytically defining the relationship between resource management decisions and their impact on the physical environment is difficult. Under high-dimensional observation spaces, DRL can be used to find the best resource management policy. In DRL, experience replay is used to improve learning efficiency and accuracy by utilising historical information, allowing the MEC to support high-quality services for edge devices.

Figure 4. AI-enabled mobile edge computing framework



Handover Management and Intelligent Mobility

6G networks will be very dynamic, multi-layer, and large-dimensional, handovers will be frequent. Mobility and changeover management are likely to be two of the most demanding concerns for 6G networks. To ensure communication connectivity, AI approaches can be used to intelligently achieve mobility prediction and appropriate handover solutions. UAV communications, for example, will be integrated into 6G networks, and UAVs' high-speed mobility may result in frequent handovers. Furthermore, the different service needs in terms of high data flow, high dependability, and low latency make efficient handover processing more complex. At the same time, the great mobility of devices and unmanned aerial vehicles (UAVs) creates uncertainty about their whereabouts. DRL (DRL combines DL and RL to learn from experience) is one of the AI technologies capable of solving complex decision-making tasks. It learns to optimise handover strategies in real-time by displaying dynamic temporal mobility behaviours of devices or UAVs in an online manner, while minimising transmission latency and ensuring reliable wireless connectivity. In large-scale vehicular networks, 6G networks must fulfil high-speed mobility and delay-sensitive requirements of cars, therefore efficient mobility management is a crucial evaluation to satisfy vehicular communications dependability, continuity, and low latency requirements. Deep learning

(such as RNN and ANN) based predictive mobility management and fuzzy Q-learning based handover parameter optimization can successfully avoid frequent handovers, handover failures, and connectivity failures by learning the mobility patterns of high-speed vehicle users. Furthermore, LSTM is a potent AI tool for handling handover problems because it uses both previous and future mobility contexts of vehicles to learn a sequence of future time-dependent movement states, then predicts vehicle trajectories to optimise handover parameters to avoid frequent handovers.

FORCES ENABLING 6G WITH AI

Complex Scenarios in Channel Modeling

The accuracy of channel models that represent real communication settings is critical to the wireless communication system's performance. Although existing channel models may represent common characteristics of standard wireless channels, they have flaws and nonlinearities in some complex cases. For example, in large MIMO communication, the rising number of antennas has changed channel parameters, making accurate channel modelling impossible. Furthermore, inflexible mathematical models are difficult to characterise the channels in projected 6G situations such as molecular or underwater audio communications. As a result, it's time to look into new ways of designing a communication system that don't rely on explicitly defined channel models. As a result, the data-driven paradigm does not require an exact model to address the problem because the solution can be extracted straight from network data. DL can optimise radio link performance by employing a large training dataset and a data-driven model instead of a mathematically tractable channel model.

Signal Processing Fast and Effective

THz communication is important for 6G in order to provide ultra-broadband real-time applications such as XR and distant holographic communications for mobile users. Future advanced 6G systems will require real-time large-scale signal processing. Regrettably, traditional iterative reconstruction technologies, such as MIMO data detection algorithms, result in a computational bottleneck for real-time systems. Neural networks, on the other hand, can be implemented using low-precision data types and highly parallelized on concurrent architectures. It has been shown that this form of DL algorithms can be implemented faster and at a lower energy cost than their programmed counterparts. As a result, parallel signal processing technologies are important for future radio interfaces to improve efficiency and accuracy. The DL can draw accurate inferences in milliseconds because to graphics processing unit (GPU)-based parallel computation.

Resource Utilization that is Efficient

The existing smartphone-centric communication environment is transforming into a 6G IoE ecosystem that includes drones, connected vehicles, sensors, and other devices. Data traffic will expand at an exponential rate as a result of the change. 6G networks will use a variety of spectrum resources, including low radio frequency, mmWave, Terahertz, and visible light spectrum, to enable high data rates. In dynamic network contexts, efficiently utilising varied spectrum resources for various applications/users

is extremely difficult. Furthermore, the available radio resource is extremely restricted, despite the use of high-frequency spectrum such as mmWave and THz. As a result, the limited network resource must be used wisely and flexibly to meet a variety of and changing user needs. Tiny cells are also likely to be implemented in 6G to increase spectrum reuse and improve network capacity. However, effective management of rising inter-cell interference is required. As a result, 6G should allow for a paradigm change away from traditional network resource scheduling and toward AI-based intelligent resource management. Various spectrum resources can be efficiently utilised to carry diverse traffics with different requirements with the help of AI. Deep reinforcement learning allows for the creation of a closed-loop automatic optimization system that optimally utilises multiple network resources.

Reduced Usage of Energy

Increasing the energy efficiency of the mobile network can assist to reduce operational costs and carbon emissions, which is important for long-term sustainability. The energy consumption of 6G is particularly troublesome due to the data explosion and the growing number of small devices. Furthermore, rising end-user applications and the complexity of transceiver processing may result in increased energy usage.

Many strategies, such as dynamic cell operation and traffic unloading, can enhance energy efficiency. Meanwhile, green energy resources can be used to reduce energy usage. To harness green energy from natural resources such as the sun and wind, methods such as energy harvesting and simultaneous wireless information and power transfer (SWIPT) have been proposed. User mobility and traffic characteristics must be addressed when taking proactive energy management strategies to overcome the shortage of stochastic and intermittent natural resource availability. The machine learning algorithms can be used to learn about the wireless environment and choose the best configuration to get the desired results. It is critical to study dynamic user traffic patterns and mobility patterns, weather conditions, and generate predictions about future traffic demand and green energy supply in order to optimise energy consumption while ensuring user experience. Traditional optimization approaches and heuristic algorithms, on the other hand, are insufficient to complete these difficult jobs .

Fortunately, machine learning methods can be used to discover the best policy for achieving the energy-saving goal in complex and dynamic radio network situations.

Quality of Service/Quality of Experience (QoS/QoE) Criteria

6G is expected to support a variety of new IoE applications, including augmented reality, intelligent manufacturing, smart surroundings, and more. Understanding, evaluating, and ensuring satisfying QoS/QoE of developing apps is difficult.

The majority of existing QoE models are limited to traditional mobile broadband services like VoLTE and streaming. User expectations and characteristics of new apps should be thoroughly studied in order to build an accurate Quality of Service (QoS)/ Quality of Experience (QoE) model. Finding relationships between application-level QoE measurements and network-level QoS indicators and understanding the influence of QoS on QoE have both been proven to be useful with machine learning approaches. Furthermore, because 6G is planned to provide numerous services with integrated 3D coverage throughout space, air, land, and sea, it will be extremely difficult to provide a consistent and enjoyable user experience in such complex and dynamic network conditions. A proactive QoS/QoE management method based on user behaviour knowledge, network state awareness, and future demand prediction is critical

in addition to existing reactive QoS/QoE management systems. By forecasting user behaviours and traffic demands, machine learning has been shown to be an effective strategy for meeting extreme and diversified requirements from a variety of novel applications.

Networks that are Complex and Flexible

6G is planned to be a space-aerial-terrestrial-ocean integrated network with many access networks each with their own set of features.

Furthermore, as a result of ultra-dense networks and flexible control data plane separations, the number of network nodes to be managed by network operators has increased significantly in various formats such as macro-station, micro-station, Feta station, central unit (CU), distributed unit (DU), and active antenna unit (AAU). Conventional systems, which mainly rely on human labour, are becoming increasingly difficult to create and manage such massive networks. Using machine learning and deep learning to achieve the vision of a self-sustaining network, which is expected to not only adapt network functions but also sustain network resource usage to maintain long-term performance autonomously, is one possible solution for improving the intelligence of the network management system. Additionally, network slicing enables the delivery of a variety of bespoke services over common physical network infrastructures. To meet changing client demands, the running network slice instances must be scaled dynamically. Operators are finding it more difficult to manage and orchestrate sliced 6G network resources as the number of network slice instances grows across space, aerial, and terrestrial network domains. ML is a potential approach for enabling intelligent network management and slice orchestration in this regard.

USES OF 6G

6G is replacing 5G mobile network – 6G networks may employ wider bandwidth than 5G nets and offer much greater capacity and reduced latent ability. One of the 6G Network objectives is to enable one micro-second delay transmission 1000 times as quick as one millisecond.

The 6G internet will develop significantly in the fields of imagery, presence technologies and local awareness. The computer network 6G can independently identify the optimum place for computers to be performed in combination with AI, including data storage, processing and sharing choices.

6G wireless communication systems should be carefully used to monitor uptake and change frequencies appropriately using various frequencies (Yao et al., 2019). This is feasible as atoms or molecules at their specific frequencies transmit and absorb electromagnetic waves, the frequencies of absorption and emission of each material being equal.

6G will have a significant impact on numerous community security including vital asset protection solutions in government and business, like:

- Identification of threats
- Surveillance of healthcare
- Face detection
- Taking a judgment
- Assessment of pollution levels
- Detection of gas and toxicity

- In such areas, improved technology, like intelligent towns, independent automobiles and the virtual worlds, may also be improved.

OPPORTUNITIES AND CHALLENGES

Opportunities

Around 10 years ago, the term ‘beyond 4G’ (B4G) was created about the requirement for the LTE protocol to go far beyond the development presently envisaged for 4G. Because the implication of 5G was not apparent and only Research & development models were currently under construction, the term B4G took time to describe what could be feasible and perhaps beneficial after 4G. Strangely, the LTE technology continues to evolve, and some elements are being utilized in 5G.

The same manner as “B4G, beyond 5G (B5G)” is a route to 6G technology, which will blur the capabilities of the fifth generation and 5G services. The numerous private Wireless deployments incorporating developed LTE, 5G and edging computing for business and industrial clients are among the areas in which 5G lays the foundation for 6G technologies. This step is being taken by the future generation 6 G wireless communications (Yang, Xiao, Xiao et al, 2019) with the internet of telecommunications suppliers, most of which have self-support due to the co-production of PV solar energy inside the intelligent grid.

Because of 5G integration, edge computing, programmable networks (PNs), and simultaneous public and private networking problems, the Datacenter currently faces huge changes. Some corporate clients, for instance, may desire a mix of RAN and hybrid premises, hosting of edge and core processing, and hosting network infrastructure features for private company networks or alternative network operators in the datacenter.

6G radio networks will deliver the methods of computing and information collection needed to obtain details; however, a control framework will be needed throughout the 6G technology industry, which involves predictive analytics, AI and HPC, and quantum computational power succeeding generation.

Apart from significant changes inside the RAN, several technological advances converging with 6G the fundamental networking fabric will also alter. Most significantly, the 6G will be the focus of Artificial intelligence (Boccardi et al., 2014). There is debate about the possibility of a shared computational base that includes both HPC and AI aspects to arise from a “nano-core.” To achieve this possible vision, the nano-core does not have to be a network control unit, however a conceptual collection including a network of computer assets that are used by several networks and systems.

Data centre development will be essential with far more data generated from 6G than 5G networks and computational evolutions to incorporate cooperation between the border and core platforms. Next-generation capacity 6G will produce huge quantities of data to handle on behalf of network operators, network operators and database holders in the field of sensing, imagery and position identification.

Everything for which you now utilize a wireless network is enhanced significantly on a 6G network. All improvements brought by 5G will be made to a 6G network as a stronger, upgraded version.

We already are designed to have much more sophisticated 5G VR and AR technologies, smart buildings, agricultural farms, and Artificial intelligence at your fingertips, intelligent factory robots, car-to-car connectivity, and more. 6G will enable all these sectors while also giving even more bandwidth to extend innovation eventually, maybe even into domains we have not yet explored.

Marcus Weldon, for instance, of “Nokia Bell Labs said that 6G is a sixth human and machine sensory experience where biology meets AI”.

Many of the factors that make 5G so large include its low power consumption of approximately 4 ms, but 6G network could further reduce this to the extent that we can confidently claim that almost no latency is present (Cao & Zhang, 2019). The launch date for films, television and games is restricted so far as the display is powered on, and video chats may be as clear as present before the other individual. The capability of a connection is growing, as we have seen before with 3G, 4G and 5G, so are its uses. This will have a fantastic impact on which new goods and services may be developed to advantage the 6G speed and other characteristics fully.

Challenges

1. Limits on Flexible Radio Access

OFDM numbering options may be limited by cell size plus frequency response. Using numerology with high substratum spacing on one axis is often better suited for lower cell sizes than the big cells because of its lesser delay expansions (Kibria, 2019). However, a bigger area sub computer may be utilized for huge numbers of virtual cells and cheaper efficiency. It is also important to recall that the diameter of cells with high-frequency transporters is limited due to route dispersion difficulties and Doppler spread when movement is high.

2. Network security issue

The safety of 6G wireless connections is a significant problem, especially in using the STIN method. Security is a big issue. In 6G, additional kinds of privacy, such as coherent information security, must be evaluated together, in addition to conventional physical series protection. A new approach to safety must thus be strengthened, which relies on minimal effort and a high degree of security. To this aim, several physical safety laying methods designed for 5G may be extended to the systems 6G, for example, with a safe MIMO mass depending on LDPC; for “UM-MIMO and THz spectrum applications” Mm-Wave Safe can also be utilised. Integrated security needs to use different functional methods for various security mechanisms to have a proper administration objective (Letaief et al., 2019). A potential STIN method that takes multi-cultural management into consideration and certificates fewer communication keys is a central distribution management technique. Both physical and network-level safety techniques may integrate this comprehensive safety solution, efficiently managing and applying secrecy on 6G networks.

3. Resource as a Service (RaaS)

The introduction of SDN and Network Functionalities (NFV) software networking makes progression to a resource-oriented assignment named RaaS easier. The outcome is the division of connections in the physical properties to create a virtual network. It allows phone companies or service providers to allocate digital network resources to meet accurate service requirements (Liu et al., 2018). The network's resources presumably include configurable metro settings and software specificity. Consequently, the network screening with configurable software and metro specified surfaces from a Cloud access system triggered by a machine (C-RAN) will be included in the NFV emerging technologies throughout 6G cycle.

4. Heterogeneous High Frequency Bands

There are several new open issues with the usage of mm-Wave and THz in 6G. The mm-Wave system is an open central issue for supporting high motions with mm-Wave frequencies. Novel approach and dispersion concepts are required in the event of THz. The high performance, high accuracy, and low transmission noise strength to solve the significant route loss of THz are important characteristics. When these components of the physical series are understandable, protocols for the network layer and new connections should be created to improve cross-frequency resource usage, capturing the highly changeable character of “mm-wave and THz” settings. The cohabitation of THz, the millimetre wavelengths and the microwave in each series is an additional meaningful method.

5. Tactile Communications

Then use the holographic transmission to convert digital images close to realities such as persons, activities, surroundings, etc. It is good for tangible information to be remotely exchanged through Internet access in real time. Telecommunications, automatic collaboration lecturers, and interpersonal interactions, which should enable randomized control to be applied throughout communications systems, are anticipated. To fulfil these stringent criteria, the effective architecture of the communication network between rows must be done. To enhance transmission and driven protocols, new physical layer (PHY) diagrams must, for example, be developed for the development of signalling networks, waveform overcrowding, etc. Wireless transmission systems cannot fulfil these criteria, and wireless fibre communication technologies are needed.

AI can optimize the network performance based on its powerful learning ability and strong reasoning ability. In this section, we outline some future research topics and potential solutions for AI-enabled intelligent 6G networks.

Efficiency and Accuracy in Computing

Massive volumes of data collected and complicated network topologies provide problems for AI-enabled learning and training in 6G networks. Furthermore, limited computational resources may be insufficient to process huge high-dimensional data at the required accuracy rate for training. Deep learning also has a high computational cost, which makes it prohibitively expensive to implement. As a result, figuring out how to create efficient AI learning schemes that improve both computing efficiency and accuracy is a major research topic. Residual networks, graphics processing, feature matching, and offline training have recently been identified as viable strategies for promoting convergence speed, decreasing difficult computations, and improving training accuracy using high-performance computing tools.

Learning Frameworks' Robustness, Scalability, and Flexibility

In various aspects, such as BSs affiliations, wireless channels, network topologies, and mobility dynamics, 6G networks (e.g., vehicle networks and UAV-enabled networks) exhibit high dynamics. Devices or terminals that join or depart networks, in particular, may have varying QoS and QoE requirements. All of the aforementioned risks in dynamic networks necessitate regular modifications to AI learning algorithm settings. Learning frameworks must be extremely resilient, scalable, and flexible in order to

accommodate an endless number of interacting entities and provide high-quality services in real-world dynamic networks. As a result, the question of how to create robust, scalable, and flexible learning frameworks for 6G networks remains unanswered.

Development of Hardware

When designing 6G networks, the corresponding hardware development is quite difficult. On the one hand, when working in the mmWave and THz bands, hardware components consume a lot of energy and are expensive. Some devices/terminals, on the other hand, have limited storage and computing power. Despite the advantages of AI learning algorithms in terms of learning and recognition, they usually necessitate a high level of computational complexity, power consumption, and computing resources. As a result, collaboration between hardware components and AI learning algorithms should be encouraged, which will necessitate major research efforts. It's worth noting that the graphics processing unit (GPU) is well-suited to learning computation because it can efficiently handle matrix computations and transfer learning-enabled intelligent communications that can adapt to various hardware constraints by transferring one learning framework to other hardware components.

Management of Energy

Some devices on the ground can be charged by power stations in 6G networks, but infrastructures undersea, air, and space, as well as some sensors, cannot be connected to power stations. Furthermore, 6G networks must be able to connect a large number of smart low-power devices in a flexible manner. Advanced energy management systems become extremely important in 6G networks in this circumstance. AI approaches have the potential to assist these infrastructures and devices in maximising their utilisation time by intelligently controlling their energy consumption or gathering energy (e.g., energy harvesting and wireless power transmission). As a result, energy management is a critical but difficult problem for 6G networks.

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Chapter 11

6G With TeraHertz Communications

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ABSTRACT

The terahertz band is the next frontier in wireless communications for its ability to unlock significantly wider segments of unused bandwidth. It offers the enhanced transmission bandwidth when compared to mmwave band in 5G networks. Terahertz communication reduces the problem of mmWave bands where the propagation loss is more due to molecule absorption of electromagnetic waves. The development of Reconfigurable MIMO techniques, subwavelength guiding structures, nanoantennas, superlenses, hyperlenses and light concentrators, communication distance can be increased in THz systems. 6G wireless networks will consist of a multitude of small radio cells with shorter communication distances. Base stations of radio cells in the 6G network need to be connected with high-speed wireless, enhanced data rate, minimum energy consumption, and low electromagnetic emission links. These broad band links can be implemented by terahertz waves in 6G networks. Terahertz bands are inevitably going to be the next in line. THz communication will contribute to enabling interesting and needed applications.

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INTRODUCTION

6G Requirement and Enabling Technologies

Advancement in the technology inquired by any communication systems will enable efficient spectrum, low latency, and enormous connectivity. The Internet of Things plays a major role in connecting many devices over the internet and enabling communication between them. IoT has to handle traffic efficiently, monitor the environment, enable navigation virtually, sense things and transmit signals. Such massive activities can be achieved using new algorithms to enable better performance than the existing technologies. It is also possible to connect more than one hundred devices in 6G within a cubic meter. The lifetime of the battery can be improved by around twenty years. (Latva et al 2019)

The earlier generation of communication i.e., 1G to 4G provides services to humans alone. 5G could make communication between machine and man (Popovskiet al, 2018). But, the challenge that 5G faces is that it requires a long time to upload data to a cloud server, and hence it works on Mobile Edge Computing (MEC). Even then, 5G is not capable of providing new services which need different requirements that cannot be supported by them. Another issue in 5G is that it may not work satisfactorily where the system requires a very high data rate in terms of terabytes and the latency should be in microlevel. It will be overhauling for 5G to achieve connectivity density to handle when moving from Industrial automation 4.0 to industrial automation X.0.

The new 6G can offer higher bandwidth, ultra-reliable, and low latency services. 6G can transform human conditions in terms of the physical, digital, and biological universe of experience. It can provide solutions with improved data rate, bandwidth and handle traffic for different applications such as augmented and virtual reality. The leading performance attributes of 6G are factories, worksites, and ecosystems, Health monitoring and services, logistics and transportation, media and entertainment, etc.

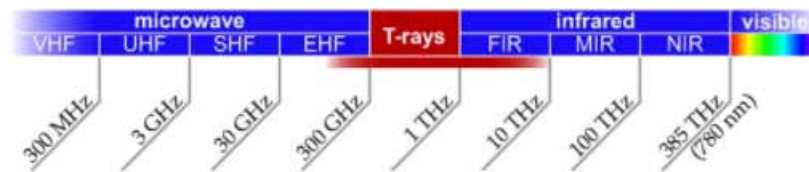
THz

Terahertz band will play an essential role in the 6G wireless communication system (Chowdhury et al, 2020). The frequency range between 0.1 and 10 THz is the terahertz band with 0.1-0.3 THz as sub-THz region and 0.3-10 THz as THz region. Many materials do not respond to these frequencies and hence, it is called the THz gap. It can also be called Tera Waves or T – Waves. Frequency band between 30-300 GHz refers to mmWave band and it shares the same characteristics as THz wave in the range 100 – 300 GHz. It has a wide bandwidth, broad directivity, large path loss, and blockage effects, atmosphere absorption, and more diffuse scattering. Frequency band between 30-300 GHz refers to mmWave band and it shares the same characteristics as THz wave in the range 100 – 300 GHz. It also has large bandwidth, high directivity large path loss and blockage effects, atmosphere absorption, and more diffuse scattering (Haung et al, 2019, Rappaport et.al, 2019, Huq et al, 2019)

Figure.1 specifies the Terahertz band and its neighboring designations.

The data rate of mmWave ranges between GBPS covers several hundred meters and bandwidth is several GHz. In contrast, THz waves can have data rates around TBPS. And that of THz waves is TBPS, covering tens of meters, and bandwidth is around tens of Gigahertz. mmWave and THz radiations are non-ionizing radiations with photon energy less than 0.1 to 12.4 meV. This small amount of energy is not sufficient to eject electrons from an atom but the amount of heat generated will be a risk.

Figure 1. Electromagnetic spectrum around T wave.(Withayachumnankul et.al,2007)



THZ FOR WIRELESS COMMUNICATION

The Terahertz band is the least explored technology that can support wireless communication to satisfy the increasing bandwidth demand. The bandwidth is of the order of magnitude greater than the mmWave system. It offers higher link directionality, lower eavesdropping. Terahertz communication is well suited for uplink even under bad weather conditions such as fog, dust, and turbulence(Federice et al,2010). It also allies with non-line of sight propagation. As a new technology, the non-availability of THz devices, they are used in specific areas only such as imaging and sensing(Elayan et al,2020)

THZ TECHNOLOGY AND THZ COMMUNICATION

The lack of high-power signal transmitters and high sensitivity detectors working at room temperature is the major obstacle in the design of THz transceivers. Advancement in Electronic technologies that include Standard Silicon CMOS technology and their families helps to design transceivers, mixers, and amplifiers to work near the THz range. Complementary MOS and SiGe(HBTs) also generate THz signals. High Mobility Electron Transistor(HEMT) or Heterojunction Bipolar Transistor(HBT) can generate THz frequencies. 300 GHz frequency signals are generated from III – V HEMT or HBT.

Quantum Cascade Laser is the direct method to generate the THz frequency range. An alternate method with Voltage Controlled Oscilloscope along with a frequency doubler or multiplier may not be suitable for the generation. Instead, Femtosecond pulses can also generate THz waves. Field Effect transistors with two different bow tie antennas can be used to amplify and or detect THz pulses.

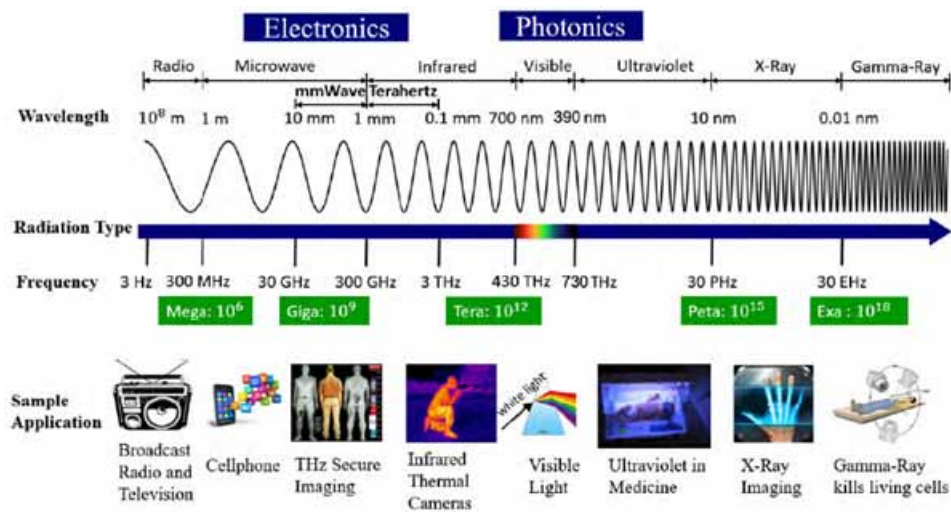
STANDARD

The IEEE 802.15.3d-2017 was proposed in 2017, which is the first standard for THz fixed point-to-point links operating at carrier frequencies between 252 and 321 GHz using eight different channel bandwidths (2.16 to 69.12 GHz and multiples of 2.16 GHz). For the advancement of nano-network standards at THz frequencies, *IEEE P1906.1/Draft 1.0* was suggested for nano-scale and molecular communication frameworks.

SPECTRUM

A high data rate over a certain distance necessitates more spectrum with minimum noise per hertz of the spectrum. Reusing the spectrum and spatial reuse improves spectrum allocation. The THz spectrum must be accessible to provide ultra-high data speeds across longer distances(at least up to a few meters). Moving up in frequency leads to larger channel bandwidths, but it also increases route loss and sensitivity to obstructions, lowers geographical coverage. Moving beyond the THz spectrum into the infrared and visible light bands exacerbates these issues and expose them to increased susceptibility to noise from the sun and ambient light(Singh *et al.*,2019).

Figure 2. The electromagnetic spectrum and applications(Rappaport *et al.*,2019).



The THz band shown in Figure.2 fills a gap between a too crowded lower frequency spectrum and a yet higher frequency spectrum. The frequency range from 0.095 THz to 10 THz is defined as the Terahertz band in an electromagnetic spectrum which is a mix between microwave and infrared bands.

SPATIAL TRANSFORMATION OF THZ

The terahertz frequency can be generated, detected, and manipulated using the equipment. Time-domain spectroscopy is a laser source that emits and detects broadband terahertz radiations. Laser pulses of sub-picosecond duration are generated and can be detected coherently with better SNR. Terahertz frequencies and non-ionizing radiation are not hazardous to humans when exposed. Hence it can be used for medical diagnosis and screening purposes. Their absorption spectrum shows that they can be used for identifying systems. Materials such as wood, fabrics, cardboards, plastics, etc, which are dry, non-polar, and non-metallic surfaces are transparent to these radiations. Hence it can act as terahertz sensors for the identification of devices. The spatial properties of the THz waves are modified according to the ABCD parameter when the pulse propagates through optical devices.

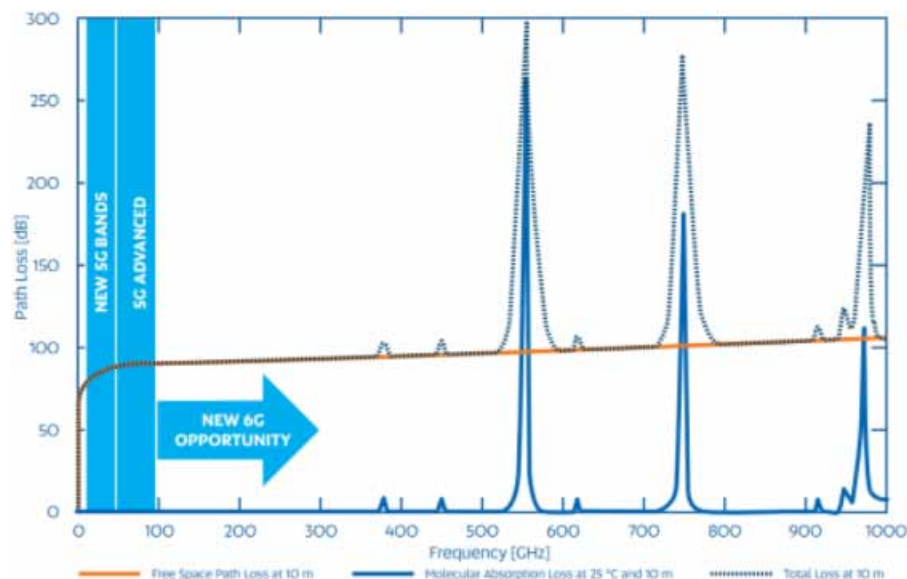
THz COMMUNICATION

Channels and Characteristics

The TeraHertz channel modeling and characteristics drew attention to 6G wireless communication. The propagation path loss is a free-space path loss that includes atmospheric loss and spreading loss. The channel characteristics are diffusion scattering and specular reflection, diffraction and shadowing, weather influences, and scintillation effects. Spreading loss increases quadratically with frequency when considering antenna aperture shrinkage whereas it decreases with the square of frequency when the area of the antenna is fixed. Polar gas molecules are reasonable for atmospheric losses. This is because the gas molecules absorb the THz wave energies. Maximum loss occurs due to water vapor and oxygen. At THz, the wavelength reduces to the millimeter and sub-millimeter when impinging on rough surfaces. This diffusion scattering can travel both in the forward and backward directions. Specular reflections correspond to the scattered rays that exist along the identical angle as that of the incident angle. The loss depends on the electrical thickness of the surface. Multipath propagation is influenced by diffuse loss. Sharp shadows that are formed due to the surface walls of tall buildings reduce the diffraction efficiency. At high frequencies scattering loss is large and this, in turn, increases shadow fading variance. The line-of-sight probability is almost independent of frequency, but the transmission power decreases with frequency due to the skin effect.

Airborne particulates are the major source of attenuation of THz waves. When compared to Infrared or free-space optics, this THz wave can propagate through the particles present in mist, fog, rain, etc, and hence it is immune to weather influences. The scintillation effect occurs due to thermal and turbulence near the ground. Inhomogeneities of temperature and pressure across time and space also produce scintillations. The transmission distance of a free-space optical communication link is influenced by scintillation, but THz waves are less susceptible to it.

Figure 3. Effect of water vapor absorption and free space loss(Latva-aho et al,2020)



1. *Channel Modelling and PathLoss:*(ShuchiTripathi et al.,2021) The project proposed three-channel models, namely
 - a. The map-based
 - b. The hybrid model,
 - c. The stochastic model is suitable for frequencies up to 70 GHz,

The map-based model is suitable for frequencies up to 100 GHz. In 2017, a 3GPP 3D channel model for the sub-100 GHz band was proposed. NYUSIM is one more channel model created with the assistance of real-world propagation channel estimation at mmWave frequencies ranging from 28 GHz to 73 GHz in various outside situations. Statistical channel models for UM-MIMO are categorized into

- i. Matrix Based models and
- ii. Reference-antenna-based models.

Matrix-based models describe the properties of the complete channel transfer matrix. The reference antenna-based models consider a reference transmitting and receiving antenna first and analyze the point-to-point propagation model between them. Then, the complete channel matrix is analytically developed.

2. *Co-channel Interference:* Although THz radios have a lower transmission range than microwave radios, frequency reuse in the THz band is far more adaptable and even possible between transceiver pairs nearby. Omnidirectional antennas on the NLOS channels and the usage of directional antennas without the proper spatial arrangement cause co-channel interference in the frequency reused THz band. Co-channel interference results in a low signal-to-interference-plus-noise ratio (SINR) or signal-to-interference ratio (SIR), which ultimately degrades signal detection and network reliability (Ye *et al.*,2021). Emerging cases of co-channel interference in the THz region are visually depicted in Figure.4.

Co-channel interference can occur in the THz communication system as a result of misalignment, hardware limitations, and user equipment mobility. As a result, co-channel interference models comprising one targeted THz channel and several interference channels are driven by these distinct features molecular-absorption loss, spreading loss, dynamic shadowing, and multi-path fading bands. By precisely setting its reflection coefficients, the reconfigurable reflecting surfaces (RIS) technology may be used in both frequency-flat and frequency-selective fading channels resulting in a more complex channel model than those employed in low frequency to improve the desired signal strength or minimize co-channel interference(Huang *et al.*,2020). The performance and properties of a co-channel interfered THz system integrated with ultra-massive multiple input multiple output antenna array processing techniques that support efficient beamforming for NLOS propagation, non-orthogonal multiple access techniques, and other promising technologies are still being investigated.

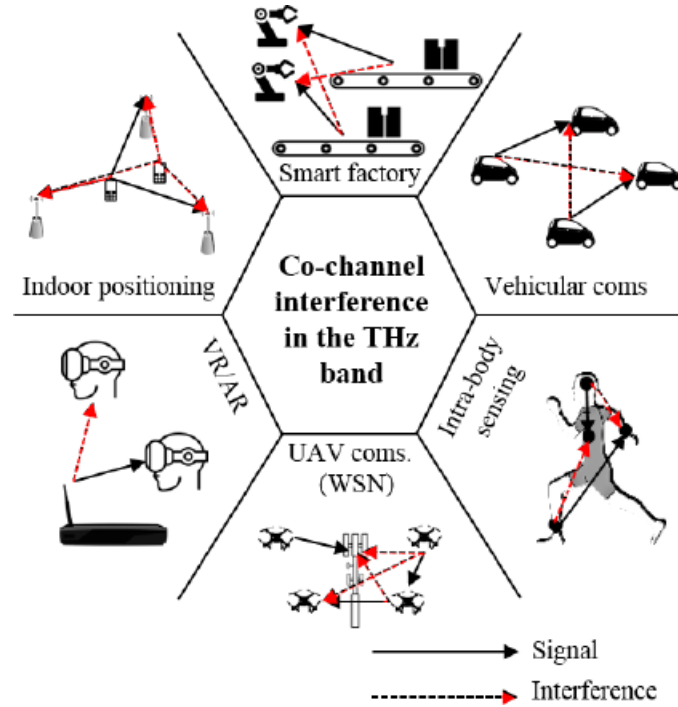
3. *Propagation:* Jornet(2011) is formulated the SNR of multi-ray THz signal propagation with the carrier frequency(f) and the distance between transmitter and receiver(d) is affected by spreading, molecular absorption, reflection, and scattering.

Spreading: Spreading loss $\psi(f,d)$ in the THz-band is represented as follows,

$$\psi(f, d) = \left(\frac{c^2}{4\pi f d^2} \right) \quad (1)$$

where c is the speed of light in a vacuum.

Figure 4. Emerging cases of co-channel interference in the THz (Ye et al., 2021).



Molecular Absorption: The molecular absorption loss $\beta(f, d)$ using the Beer-Lambert law can be characterized as

$$\beta(f, d) = e^{-\frac{1}{2}k(f)d} \quad (2)$$

where $k(f)$ is the molecular absorption Coefficient.

Reflection: For estimating the reflection loss of THz waves, the Kirchhoff theory is employed. The Fresnel reflection coefficient $R(f)$ and the Rayleigh roughness factor $\rho(f)$ are used for calculating the reflection loss, Thus, the reflection loss $\Gamma(f, d)$ can be represented as

$$\Gamma(f, d) = \sum_n \psi(f, d) \cdot \beta(f, d) \cdot R(f) \cdot \rho(f) \quad (3)$$

where n is the number of rays.

Scattering: Scattering affects THz signals based on the roughness level of the surface that it reflects. The scattering coefficient $S(f)$ is based on Beckmann-Kirchhoff's theory.

The scattering loss $\xi(f,d)$ as

$$\xi(f,d) = \sum_n \psi(f,d) \cdot \beta(f,d) \cdot R(f) \cdot S(f) \quad (4)$$

Thus, the scattering loss can be obtained by considering the spreading, molecular absorption, the Rayleigh roughness factor, and the scattering coefficient of n rays, and is represented as

The path-loss model is calculated by summing the attenuation loss $\alpha(f,d)$ of each signal propagation effect (spreading (ψ), molecular absorption (β), reflection (Γ) and scattering (ξ) in dB, and represented as

$$\alpha(f,d) = 10(\psi(f,d)) + 10(\beta(f,d)) + 10(\Gamma(f,d)) + 10(\xi(f,d)) \quad (5)$$

Based on this, the Signal to Noise Ratio (SNR) at the receiver is represented as

$$SNR(\alpha,d) = P_{tx} + G_{bs} + G_{rx} - \alpha(f,d) - \gamma - N \quad (6)$$

where P_{tx} is the transmission power, G_{bs} is the antenna gain in the transmitter, and G_{rx} is the antenna gain in the receiver, $\alpha(f,d)$ is the attenuation loss, N is the noise and γ is the loss resulting from shadowing.

- a. *Terahertz Potential Field(THzPF):* The THzPF is a reactive model that defines a spatial gradient between two points such as a transmitter, a metasurface reflector, and the receiver. The potential function has a continuous gradient when there are no obstacles, but rises in the potential field in the presence of any blockages or signal turbulence. An essential element in THzPF gradient calculation is detecting, profiling the obstacles using sensors and image processing techniques. Obstruction is the largest limitation in THz links which results in insufficient signal coverage.

An interference model from the partial reflection from an obstacle to user equipment (UE) is illustrated in Figure.5.

The difference in reflections between a flat object and a curved object, as illustrated in Figure 5, is the beam-spread angle of the reflected beam. The curved surface causes the reflected signal to spread at a wider angle, causing the signal strength to decrease as the angle increases.

Pengnoo et al.,2020 proposed a digital Twin which is a virtual model of THz Signal Guidance System in Figure.6 provides accurate decisions on the best signal paths from the transmitter to the metasurface reflector through SNR map and THzPF calculations and redirects the beams to the receiving point in the presence of obstacles. Surfaces such as walls and ceilings in indoor settings are constructed with metamaterial reflectors to enhance the reflection and redirection of THz beams from the source to target LOS propagation. The invention of Programmable metasurfaces and mechanical control reflectors play a vital role in the re-direction of beams.

Figure 5. Top view of partial interference due to (a) flat obstacle and (b) curved obstacle (Pengnoo et al.,2020).

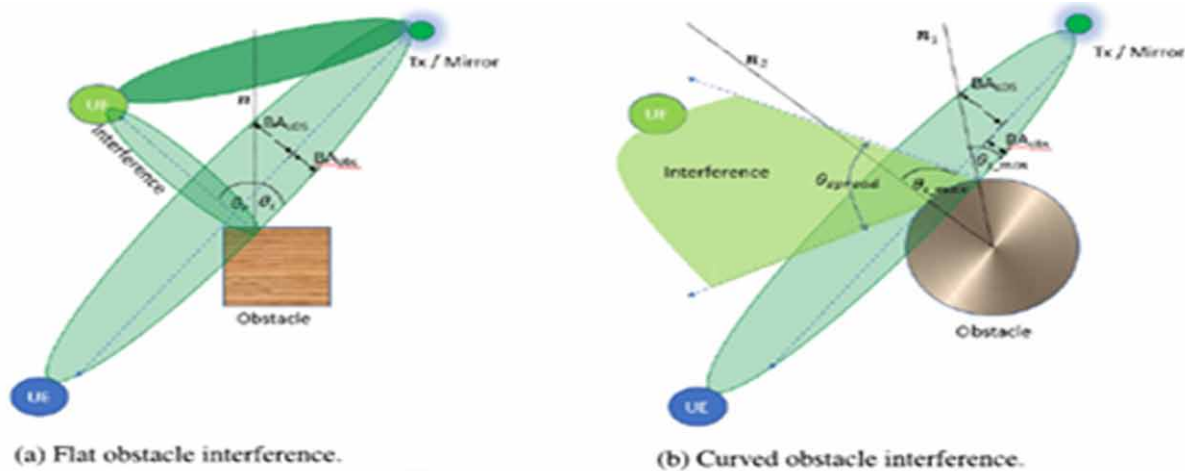
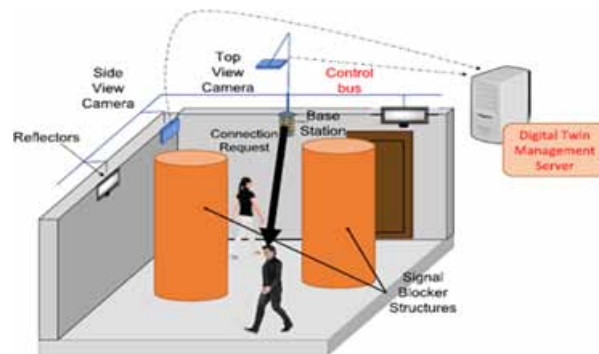


Figure 6. Indoor model for Digital Twin system to construct virtual THzPF (Pengnoo et al.,2020).



- b. **Link Budget Analysis:** Link budget analysis is very important in measuring different losses due to the signal propagating from the transmitter to the receiver. In RF system design, the link budget is analyzed thoroughly, ranging from several hundred MHz for RFIDs up to many THz for broadband wireless. To study the link budget, the gains and losses from the transmitter, through the medium (in this case the human body) to the receiver in a telecommunication system should be considered (Kari Rikkinen et al., 2020). A fixed point-to-point link or an indoor system operating in upper mmWave or terahertz band usually assumes a line-of-sight (LOS) connection between transmitter and receiver. Even molecular absorption spectral lines disturb link budgets around 60 GHz (oxygen) and above 300 GHz (water). Rain attenuation is a great time and location-dependent and it has to be added as a margin in long-distance link designs. Link budget analysis of fixed wireless links concludes that a high bit rate connection over a one-kilometer distance is possible but requires very high gains for the transmit and receive antennas. A simple link budget is intended to analyze potential link distances, system bandwidths, bit rates, and support for mobility concerning THz band transceiver technology capabilities and physical characteristics, like free space loss and molecular absorption,

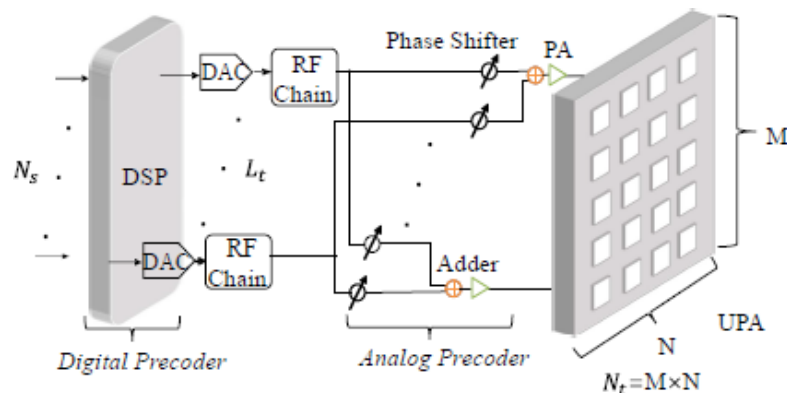
of the propagation medium to give a better view on challenges and opportunities. But, for other channel non-idealities like beam misalignment or reflections a parameter describing link margin has to be calculated propagation scenarios. But, the analysis shows that when extremely high data rates, bandwidths, and carrier frequencies are needed simultaneously the link budget will not allow similar margins that are anticipated in current cellular or local area communications below 6 GHz or not even below 100 GHz.

- c. **Precoding:**(Jingbo Tan and Linglong Dai.,2020) For THz correspondence, precoding is a very important technique to avoid path loss to give good coverage. There are three THz application situations including indoor, portable, and satellite communication. Then, at that point, the significant contrasts between millimeter-wave and THz channels are the vital difficulties of THz precoding, for example, the distance-dependent path loss, the beam split impact, and the power utilization. To address these difficulties, three THz precoding methods, i.e., analog beamforming, hybrid precoding, and delay-stage precoding, are broadly explored as far as their various architecture, pattern, latest outcomes, pros, and cons. By producing directional beams with high cluster acquisition utilizing large-scale antenna arrays, precoding can think the communicated THz precoding can create pencil beams with exceptionally limited bar width and extremely high array gains, which reduces the path loss of THz signals. Subsequently, THz precoding is a vital procedure for future 6G organizations

To complete precoding, the most broadly used signal processing parts to acknowledge stage shifts are analog phase shifters(PSs). This impact will bring about significantly more extreme cluster gain loss for THz precoding, also, therefore lead to the unsuitable corruption of the reachable rate execution. When there is a large-scale antenna array, power consumption is more for precoding.

Hybrid Precoding:(LongfeiYany et al., 2020)In the THz band, hybrid precoding combines both signal processing of analog and digital domain to give a better system, since the number of RF chains is less than that of the fully digital precoding while achieving comparable performance. The architecture of the fully connected(FC) hybrid precoding is shown in Figure.7. where each RF chain connects to all N_t antennas.

Figure 7. The FC hybrid precoding architecture (LongfeiYany et al.,2020).



N_r and N_t are the number of antennas at the receiver and transmitter, respectively. The performance of the digital precoding on spectral efficiency is optimal and treated as the upper bound of the performance of the hybrid precoding. At 60 GHz, 0.3 THz, and 0.9 THz, the CBC algorithm performs well and the spectral efficiencies are a little lesser than the digital precoding. While analyzing this some issues are there:

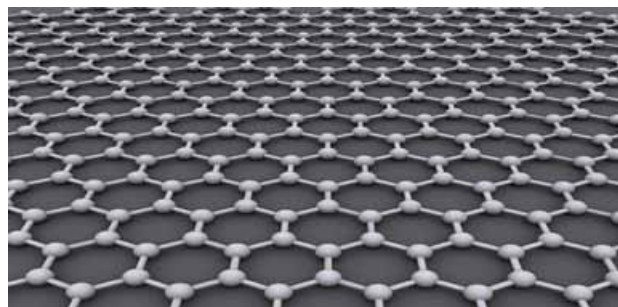
- The hardware and energy-efficient hybrid precoding architecture are required for the THz band.
- Due to the high frequency and ultra-massive antennas, the attainment of channel state information(CSI) is very hard for THz wireless systems.
- Rather than narrowband communications for lower-frequency counterparts, examination of wide-band hybrid precoding is necessary for THz wireless systems.
- The milli-degree-level beam estimation and tracking are also to be considered for the analysis. In the THz hybrid precoding system, due to the use of ultra-massive antennas, the beam is very narrow and almost razor-sharp. The ultra-narrow beam enlarges the performance loss of the beam misalignment and increases the difficulty of beam tracking.

MATERIAL FOR THz

Nanomaterial: Alternative materials are needed to support developing technologies as the size and performance of silicon transistors approaches their physical limits(Amos Kingatua.,2020). Carbon nanomaterials, such as graphene and carbon nanotubes(CNTs), are essential quantum electron systems in which carriers are confined in two dimensions(2D) and one dimension(1D).

2D Materials: Graphene is one of the materials being studied because of its outstanding electrical, mechanical, and thermal properties, making it an appealing channel material for field-effect transistors. Graphene is a two-dimensional, single carbon atom layer substance that is commonly found as closely packed atoms in a two-dimensional honeycomb or hexagonal lattice(Amos Kingatua.,2020)

Figure 8. Structure of a graphene layer (CORE-Materials[CC BY-SA 2.0])



Graphene and other 2D materials such as hexagonal boron nitride(h-BN) transition metal dichalcogenides(TMDs), silicone, phosphorene, molybdenum disulfide (MoS₂), and WSe₂ can achieve all functions namely creation, modulation, and detection of photons for integrated photonic circuits. These functions, when paired with their unique electrical features, such as gapless band structure and

ultrahigh carrier mobilities, and other outstanding mechanical, chemical, and optical qualities make for a powerful combination for producing photoreceivers, emitters, modulators, and THz switches.

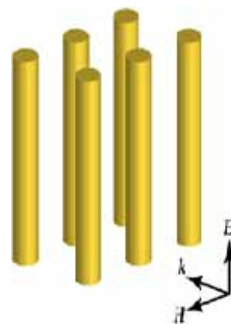
1D Material: Carbon nanotubes(CNTs) can be metallic or semiconducting with controlled band gaps. The THz response may be altered further by the development of CNT bundles or by the degree of connectivity among CNTs or their bundles because the spatial layout of CNTs impacts the measured response through effective medium effects. THz devices based on advanced carbon nanotubes may require highly aligned arrays of homogenous nanotubes with defined chirality(Petr Kužel* and HynekNemec 2019).

Other Materials: Semiconductors such as GaAs, Si, and InAs are used as dielectric metamaterials. Composite metamaterial such as InAlN/AlN/GaN/AlN/GaN is used to obtain an ultrafast THz modulator. Vanadium Dioxide (VO₂) undergoes an insulator-to-metal transformation while heating and provides a high conversion efficiency of linear polarization waves at the THz band. The ease of fabrication and sub-picosecond response time of VO₂ make it an attractive solution for tunable devices in the terahertz region when compared to transistors and 2D materials (Lan Wang et al.,2019). Superconducting material such as yttrium-barium-copper oxide(YBCO) films and niobium nitride(NbN) and niobium(Nb) lead to a metasurface in the field of THz due to less loss, a higher figure of merit(FOM), and a new prodigy of superconductivity, modulation or switching.

Meta Material: Metamaterials are artificial composites that acquire their electromagnetic properties from embedded subwavelength metallic structures which do not appear in natural materials. Various types of subwavelength resonators such as thin wires, Swiss rolls, Split ring resonators(SRRs), electric SRRs (eSRRs), pairs of rods, pairs of crosses, and fishnets are introduced for forming building blocks for metamaterials. Metamaterials can be used to replace traditional components in terahertz devices such as filters, absorbers, switches, modulators, and sensors.

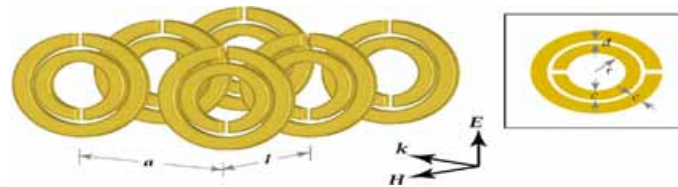
Thin Wires: A metamaterial structure composed of a lattice of thin metallic wires with parallel electrical fields can dilute the plasma cloud and shift the plasma frequency to a lower portion of the spectrum, resulting in negative permittivity at lower frequencies.

Figure 9. Thin wire lattices(W. Withayachumnankul and D. Abbott et al.,2009).



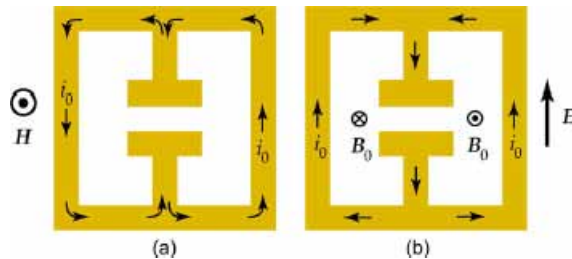
Split-Ring Resonators(SRRs): Metamaterials, such as split-ring resonators(SRRs) and cut-wire pairs can exhibit magnetic dipoles and negative permeability in response to magnetic waves up to the optical regime. The original twin SRR unit cell is made up of two concentric metallic rings with opposing splits or gaps. The loop inductance and gap capacitance of SRR which is equivalent to an LC resonant circuit generates a current flow and causes a strong magnetic response at its resonance.

Figure 10. Double SRRs(W. Withayachumnankul and D. Abbott et al.,2009).



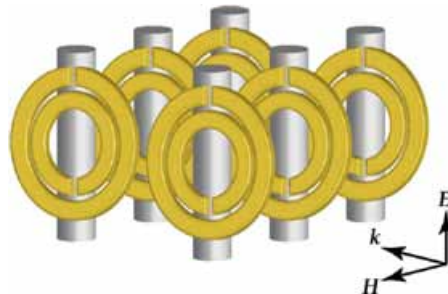
eSRRs: eSRRs are employed when just an electric response is required. The circulating currents in the adjacent loops are equal and mutually null under uniform magnetic excitation. Magnetic dipoles are opposite in the adjacent loops, resulting in net-zero magnetoelectric coupling.

Figure 11. eSRRs(W. Withayachumnankul and D. Abbott et al.,2009).



Wires/SRRs Combination: Negative-index materials (NIMs) have less than zero permittivity and permeability at the same frequencies. Metamaterials can produce negative-index materials because of their freely adjusted electric and magnetic responses. The combination of wires and SRRs generates the overlapping negative refractive index, permittivity, and permeability which are not found in nature.

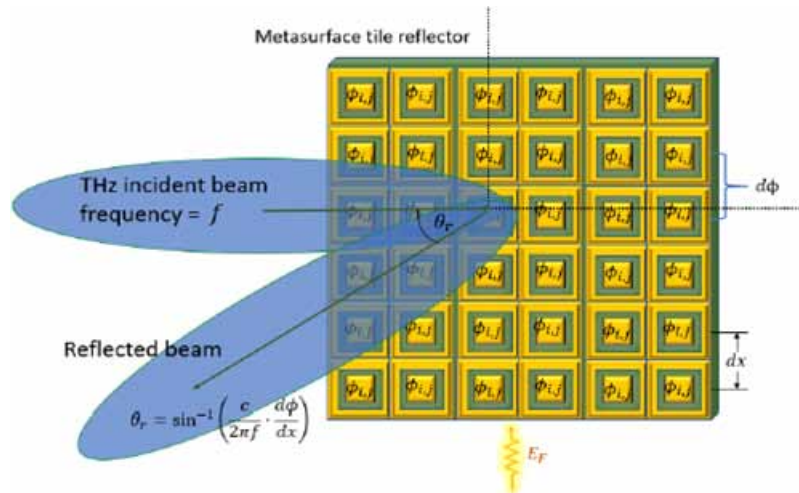
Figure 12. Combination of thin wire lattices and SRRs(W. Withayachumnankul and D. Abbott et al.,2009).



Metamaterial Wall or Metasurfaces: Graphene-based metasurface reflectors can achieve dynamic switching of THz beam reflection through tunable metasurfaces that can be electronically controlled. A specific group of reflector elements in an array is activated by applying a Fermi-energy EF to direct

the THz beam. The metasurface wall is illustrated in Figure.13. consists of a grid of graphene-based tiles(reflector elements) with varying geometry.

Figure 13. Structure of the metasurface reflector(Pengnoo et al.,2020).



Metasurface reflectors have variable THz signal reflections. The range of reflected angles that can range from 0 to 2π will depend on the arrangement of size tiles that can be arranged across the width of the reflector.

Other Metasurfaces: Semiconductors such as GaAs, Si, and InAs are the most frequent dielectric metasurfaces.

Composite metamaterial structures based on an InAlN/AlN/GaN/AlN/GaN obtain an ultrafast THz modulator. Metasurfaces integrated with Vanadium Dioxide(VO_2) not only enable amplitude and phase modulation of terahertz waves but also realize other functionalities, such as a THz quarter-wave plate and chirality manipulation.

In place of metallic materials, superconducting metamaterials with a negative refractive index are employed. High-Tc Superconductors such as yttrium-barium-copper oxide(YBCO) films can be combined with a Dynamic Tunable Metasurface. Low-Tc Superconductors such as niobium nitride(NbN) and niobium(Nb) can be combined with a Dynamic Tunable Metasurface.

4. *Meta Surface Optimization:* It was considered a smart radio environment where meta-surfaces are utilized to give better performance of wireless networks working at sub-THz frequencies.

A smart radio environment(SRE) is a progressively designed environment, where the interaction between radio waves and objects can be controlled in a programmable manner, using programming characterized intelligent reflecting surfaces(IRSs) made of thin layers of meta-materials that could be incorporated inside the walls of a room or a building. An IRS is a 2-D meta-surface, consisting of a large array of passive scattering elements, called meta-atoms with explicitly planned physical structure. These

meta-surfaces can control fully, using software-defined systems, the phase shifts applied by individual meta-atoms to the incident signal.

IRSs can control the impinging signal towards an ideal direction and can act in collaboration with M-MIMO systems and also it allows to move part of the intelligence of the system from the transceivers to the environment while working on the range sharing limit in multiuser communications.

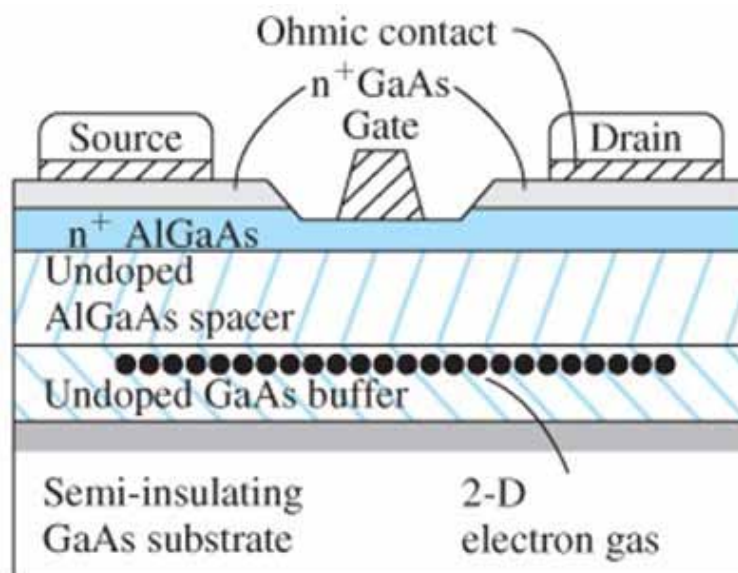
THz DEVICE TECHNOLOGIES

1. *High electron mobility transistors(HEMT)*: HEMT has a hetero-junction that consists of different materials with the same lattice constants on either side of the junction. Gallium arsenide is preferred more than silicon because of its high level of electron mobility. A HEMT has a structure such as shown in Figure.14.

Two-dimensional electron gas is formed due to the formation of electrons thick layer close to the hetero-junction while electrons move from the n-type region through the crystal lattice. Electrons can move freely within this region without the donors. Thereby mobility of the electrons in the gas is very high.

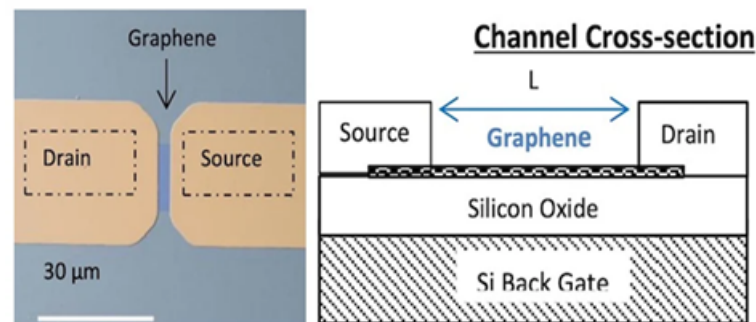
Metamorphic indicates a gradually changing lattice constant from the surface of the substrate to that of the higher bandgap material. A pseudomorphic HEMT is one in which this rule is compromised(pHEMT). Materials with differing lattice constants are used as a buffer layer between the substrate and the channel in metamorphic HEMT(mHEMT). The buffer layer is constructed of AlInAs, with the indium concentration graded to meet the GaAs substrate and GaInAs channel lattice constants. A low indium concentration in the channel results in low noise, whereas a high indium concentration results in a high gain for the different applications(surafelberhanu abegaz.,2020)

Figure 14. Structure of AlGaAs/GaAs HEMT(surafelberhanu abegaz.,2020).



2. *Graphene field-effect transistors(GFET):* Graphene can switch from electron conduction to hole conduction from n-type to p-type solely with gate bias due to its zero-band gap. The basic GFET is a three-terminal device that functions similarly to a standard FET. It's made up of three parts: a source, a drain, and a top or back gate. Unlike a silicon-based transistor, the GFET has a thin graphene channel with a thickness of tens of microns between the source and drain metal electrode (Amos Kingatuas.,2020) as shown in Figure.15.

Figure 15.Cross section of Graphene-based transistor(Amos Kingatuas.,2020).



These transistors can switch at speeds approaching terahertz, which is several times faster than silicon-based FETs. Traditional semiconductor materials' lattice structure has inherent constraints that cause them to dissipate more heat at higher frequencies. However, graphene's hexagonal lattice structure, high electron mobility, and other properties allow it to operate at the terahertz frequencies.

COMPONENTS

Since THz frequencies lie between microwaves and infrared optic regions, THz-waves utilize the features of Electromagnetic and optical waves (i.e., as waves and photons) for generating, propagating, and receiving scenarios in THz communication. THz components are divided into two categories namely sensors and sources.

1. *Frequency Sources and Detectors:*

THz Sources: Photoconduction and optical rectification are two techniques for generating broadband pulsed THz beams. High-speed photoconductors are used as transient current sources in photoconductive methods for radiating antennas. Typical photoconductors are high-resistivity GaAs, InP, and radiation-damaged silicon wafers. Metallic electrodes are used to bias the photoconductive gap to form an antenna. Mukherjee et al.,2008 preferred the following THz sources:

- Quantum cascade laser with GaAs/AlGaAs heterostructures can be used for the generation of THz signals above 10 THz. Wide bandgap SiC is used for fabricating solid-state sources at THz frequencies. Research on IMPATT THz sources is still at the simulation level.
- Frequency mixing in Electro-optic rectification produces THz radiation. A semiconductor along with a femtosecond pulse source can generate THz radiation.
- Optically Pumped Terahertz Laser (OPTL) consists of a grating-tuned carbon dioxide pump laser and a Far-Infrared (FIR) gas cell mounted in a laser resonator operating at frequencies from 300 GHz to 10 THz.
- Free electron lasers (FEL), synchrotron light sources, and optical parametric sources are also used for the generation of THz signals. GaSe, ZnGeP₂, GaP, LiNbO₃ can be used in optical parametric processes to generate more than hundreds of watt THz power.
- Direct multiplied sources: Frequency multipliers are used to generate low-power (<100 μ W) continuous-wave THz radiation frequency up to 1 THz through the process of upconversion of lower-frequency microwave oscillators such as voltage-controlled oscillators and dielectric-resonator oscillators. It can be achieved through a chain of planar GaAs Schottky-diode multipliers.

Sensors or Detectors: Heterodyne sensors are preferred to increase signal-to-noise by reducing bandwidth. Here, a downshifted signal is generated by mixing the received signal with THz frequency from a local oscillator source. Photoconductive antenna detectors are used for pulsed THz detection over 60 THz.

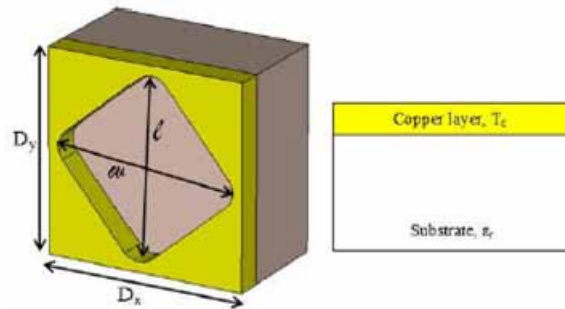
Direct detectors are used for broadband detection based on thermal absorption. High-sensitivity detectors must require cryogenic cooling to reduce thermal background for operation in the terahertz range. Such systems are helium-cooled silicon, germanium, and InSb bolometers. Pyroelectric infrared detectors may also be used at THz frequencies.

2. **Filters:** Multilayer aperture arrays are used as high-quality narrow bandpass THz filters. One aperture array pair consists of 2D periodically spaced circular holes on a square lattice, while the other pair consists of 2D randomly spaced circular holes. Additional resonances associated with the layer spacing are used to provide complex THz spectral filtering properties.

THz plasmonic high pass filter consists of high-aspect-ratio micron-sized wire arrays fabricated by micro stereolithography. The subwavelength 2D cubic lattice of metallic wire arrays has a plasma frequency of 0.7 THz. This plasmonic property of the microstructure material can be used as high pass filters at desired frequency by varying the geometrical parameters of the structure. These 2D metal wire arrays can also be used as a high-efficiency polarization filter in THz optics because of their anisotropic response to the electromagnetic wave.

Frequency Selective Surface (FSS) Filters: Frequency Selective Surfaces (FSS) are periodic structures that are used as a spatial filter by adjusting their element to either patch (band stop) or slot (bandpass) element. Terahertz bandpass filter is designed using FSS structures such as cross slot, rectangular, ring, U Shaped, and Jerusalem-shaped periodic array with a high transmittance peak at terahertz range (N. S. Ishak et al., 2019). To enhance antenna performances in 6G applications, FSS can be integrated with low-profile antennas. The diamond slot FSS structure is shown in Figure.16.

Figure 16. A unit cell of FSS and side view of FSS(Ishak et al,2019).

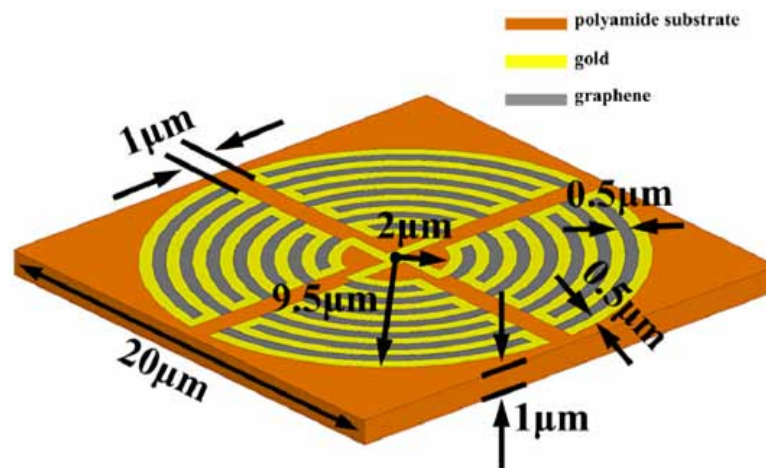


Impact of Parameter Changes: i) The bandwidth decreases as the periodicity of FSS increases. ii) The resonant frequency is inversely proportional to the diameter of circular slot FSS. iii) There is no severe effect in FSS transmission or frequency as the copper thickness changes.

Tunable Miniaturized-Element FSS: Traditional varactor diodes are not applicable in the THz frequency band due to their limited frequency performance. The Varactor diode is replaced with graphene due to its tunable surface conductivity within the THz frequency range.

A graphene-based THz miniaturized-element tunable FSS is shown in Figure.17 consists of convoluted metallic strips with graphene embedded between adjacent metallic strips and exhibits a band-stop state around the resonance frequency. The circular structure makes the device more stable when receiving the incident waves from different directions.

Figure 17. A graphene-based miniaturized tunable THz FSS element(Yanbin Luo et al.,2019).



In comparison with traditional metal FSSs, the graphene-based FSSs show excellent reconfigurable capability in THz applications. The resonance frequency of the FSS can be dynamically adjusted by changing the chemical potential of the embedded graphene. Tunable band-stop FSS enhances the isolation of the MIMO system. The conventional ground plane in the MIMO system is replaced with FSS

for improving the isolation between the antenna elements and reducing the MIMO antenna radar cross-section(Yanbin Luo *et al.*,2019)

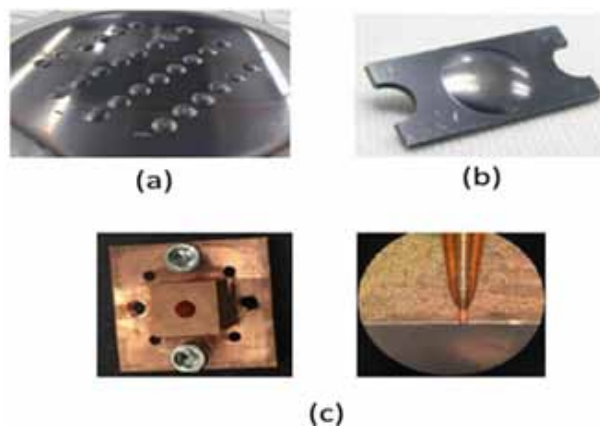
3. *Antennas:* The antenna is one of the key components that support THz systems and demands a great deal of accuracy. Low latency and high data throughput THz wireless communication systems require compact high-gain antennas.

Antenna Types: The planar dipole and Slot-ring antenna integrated with a photo-diode and Schottky-barrier diode operating at 120 GHz can be used as transmitter and receiver respectively with a range up to 1 meter and data rate of 10 Gbps. A bow-tie antenna combined with resonant tunneling diodes(RTDs) on an Indium Phosphide(InP) substrate and Silicone(Si) lens significantly increase the gain of a planar antenna. Non-metallic antennas using photonic crystal slabs on Si substrate can be utilized in the 300 GHz range(Withayachumnankul *et al.*,2017). A Gaussian-optic lens antenna with a detector-diode and photo-diode were assembled into hollow waveguides to exploit a horn antenna as a feeder enhances the coverage range. To attain a high gain while lowering the overall antenna size, waveguides with slot array antennas operating at 120 and 300 GHz are investigated.

A reflector antenna over 300 GHz band with a coverage area of 100 meters and 50 Gbps data rate can be used. An ultra-wide circular microstrip patch antenna on Si wafer, Graphene microstrip antenna, On-chip antenna, Cassegrain antenna, and Leaky-wave based Fabry-Perot cavity antenna can be used in THz band.

A reconfigurable multi-beam Yagi-Uda antenna, circular polarized(CP) lens antenna, and dual polarization-based on-chip antenna can be used over THz frequency. A linear polarized pyramidal horn is used to feed the CP lens antenna operating over 300 GHz. A linear scaling methodology to scale up the microstrip patch and slot GHz antenna to THz antenna are devised. Graphical illustration of 2×2 arrays, microlens antenna, and leaky-waveguide antenna can be seen in Figure.18.

Figure 18. Graphical illustration of (a). 2×2 array, (b).microlens antenna and (c).leaky-waveguide antenna(Jamshed *et al.*,2020).



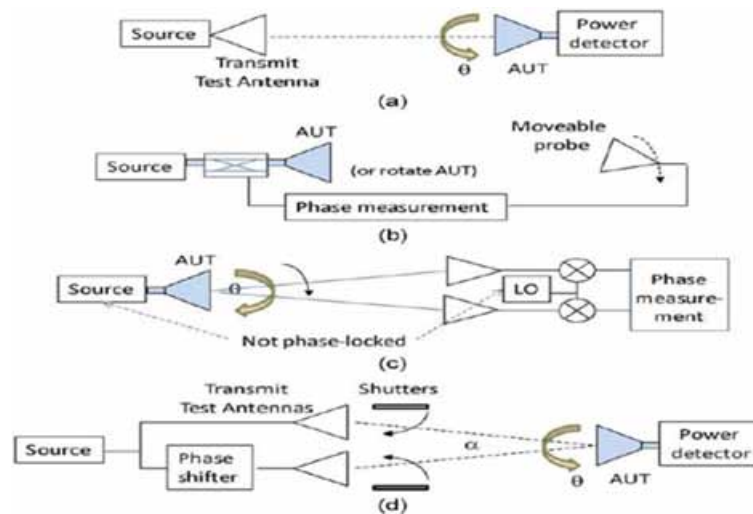
Antenna Materials in THz Band: Graphene and Carbon nanotubes(CNT) are the best alternative to Copper for the fabrication of THz antenna. Graphene has the following properties at THz frequency: i) High electrical conductivity; ii) generator of plasmon-polariton waves at the THz frequency; iii) surface conductivity can be controlled by chemical doping or electrostatic biasing.

The CNT uses the π -bond of Carbon atoms to perform conduction and reduce the skin-effect at THz frequencies leading to an increase in antenna efficiency. The CNT supports miniaturization of the antennas with low wave propagation modes.

Fabrication and Measurement Techniques: Although THz-enabled antennas increase system performance, manufacturing and measurement limit the antenna designing. A low cross-polarization and high gain horn antenna are developed to overcome the fabrication difficulties. The accuracy and the precision of the fabrication process can be effectively increased by Si-based micromachining processes.

Another difficult challenge is testing the performance of the constructed antenna at THz frequency, as shown in Figure.19. The THz band antenna may simply be tested in reception mode rather than transmission mode, minimizing the coupling between the few coherent sources and the feed-points.

Figure 19. Graphical illustration of THz antenna measurement setup (Jamshed et al.,2020).



A measuring setup is built utilizing a micromechanical compression pin to change the wafer alignment to evaluate the performance of micromachined-based wave guided circuits adjusted at 500-750 GHz operating frequency. Two hologram-based antenna test ranges centered at 322 GHz and 650 GHz are used to test a THz antenna.

MIMO Configurations and THz Antenna Arrays: MIMO antennas have solved the problems of low power and short communication in the THz regime. The Graphene patch in the MIMO antenna provides flexibility in tuning the antenna parameters to develop a reconfigurable MIMO antenna suitable for THz-based wireless communication. The liquid crystalline polymer substrates are utilized to create a basic microstrip patch antenna array that operates in the THz frequency range. Figure.21 depicts several of the described designs.

Figure 20. Illustrations of THz antennas measurements setups (Jamshed et al.,2020).

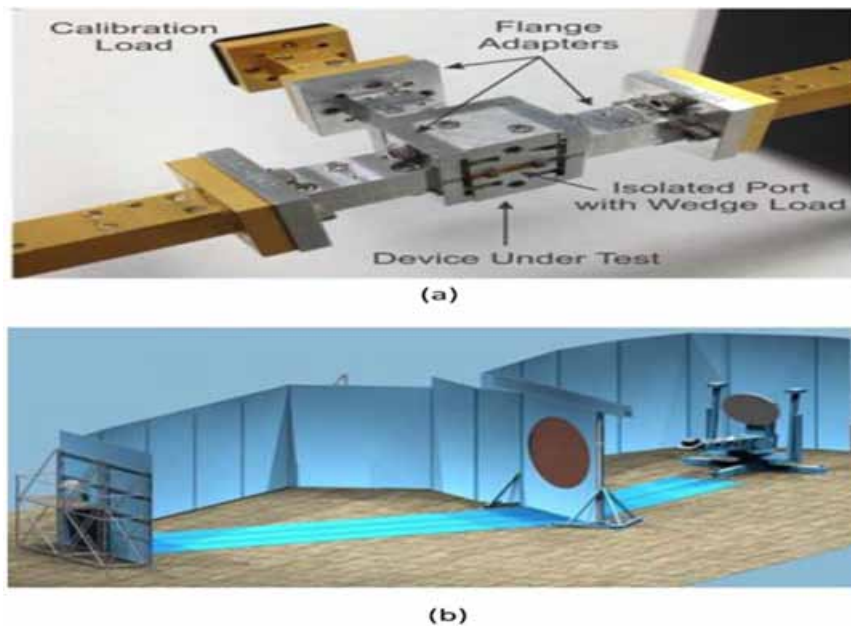
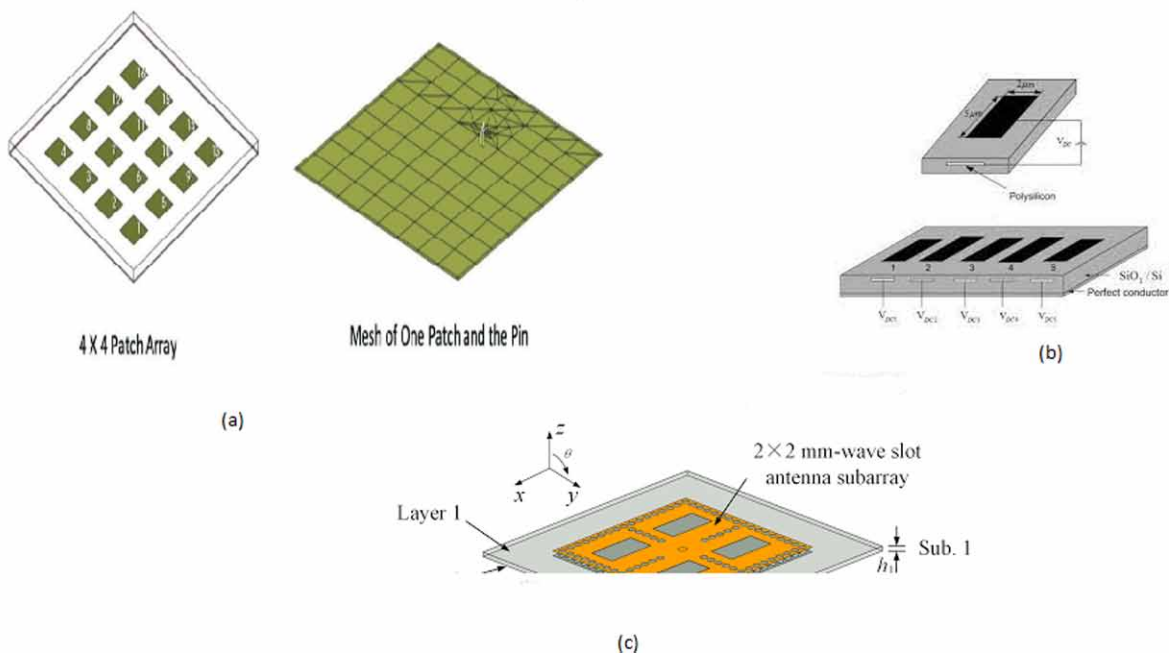


Figure 21. MIMO Antenna arrays (a).Microstrip patch antenna array, (b).Reconfigurable MIMO antenna,(c).2 x 2 slot antenna array(Jamshed et al.,2020).



The mechanism of shifting the phase before the frequency is converted to THz overcomes losses due to the presence of semiconductor-based switches. This technique requires the development of spatial phase modulators, constructed using liquid crystals and graphene (Wu et al.,2020). Some of the techniques employed in microwave and mmWave based phased array technologies, such as lens antennas, pattern reconfigurable antennas, multibeam switching mechanisms, mechanical scanning, and so on, are still relevant in the THz range. The use of reconfigurable metasurface technology overcomes the losses due to the beam steering functionality of the phased array (X. Fu et al.,2019).

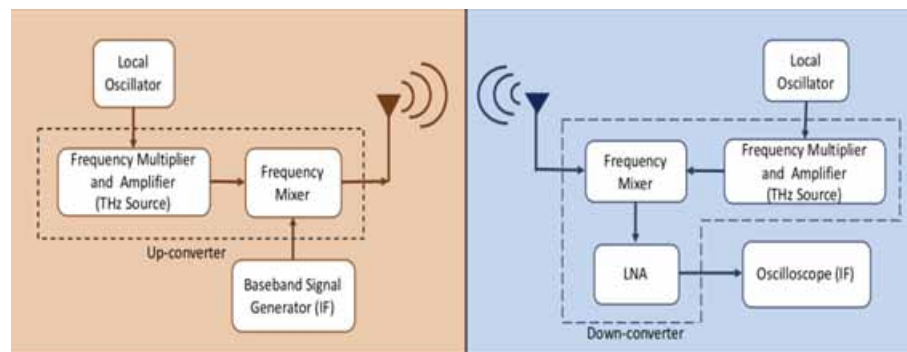
4. *Transceiver:* In 6G communication, many Terahertz(THz) band transceivers have been recorded. Photonic-based transceivers with OOK modulation are developed at a carrier frequency of 300GHz and a data rate of 1Gbps. Terahertz communication link is achieved with a bandwidth of 30 Gbps at 340GHz (Guo et al.,2015). Researchers from San Jose State University developed an OOK 210GHz transceiver using CMOS technology.

To bridge the THz gap, Surafelberhanuabegaz(2020) developed a transceiver based on Schottky oscillators. Digital phase modulation is employed to obtain higher bit rates than with OOK, ASK, or Phase Shift Keying(PSK). The author implemented the Double conversion and single conversion transceivers in the THz band using microwave oscillator, GFET mixer, Power Amplifier(PA), Low Noise Amplifier(LNA), IF, and baseband amplifier designs. Schottky THz transceivers based on GFET technology are a promising contender for 6G wireless communication.

Single Conversion Transceiver: A single conversion superheterodyne has a single IF and hence a single mixer. In principle, a single conversion can have any low-frequency center, although a DC center frequency is most often used, resulting in Zero-IF. The single conversion architecture presents numerous problems.

The IF at a frequency other than DC is susceptible to the image issue. Conversion of IF to a higher frequency than the maximum baseband frequency by 35% or more and the usage of selective band select filters can solve this image problem as a result of considerable frequency separation of the picture from the intended band and the image falling in the band select filter's stopband. Figure.22 shows the Single conversion transmitter and receiver in the THz band.

Figure 22. Single conversion transmitter and the receiver in THz band.



In Low phase noise microwave oscillator, the microwave transistor GaAs pseudomorphic High Electron Mobility Transistor(pHEMT) is selected with the highest Figure of Merit(FOM). To maintain frequency stability, the buffer connects the microwave oscillator output to a multiplier. The GaAs pHEMT source follower arrangement is utilized as a buffer with a high input impedance and a low output impedance. Frequency multipliers are used to create the harmonics of the input function for THz production. Varactor multipliers are employed in three stages to create 185.9 GHz from a source frequency of 23.23 GHz because they have low noise, great efficiency, and narrow bandwidth. Because of its low junction capacitance and low series resistance, the GaAs Schottky diode is utilized in all multipliers. Schottky Barrier Diode(SBD) diodes with high electron mobility and low loss are the type of diodes utilized at THz frequencies due to their quick switching capabilities.

The BJT baseband amplifier works in the Ultra High Frequency(UHF) band, a Class A GFET power amplifier with high order modulation linearity, and the intermediate frequency(IF) amplifier in the oscillator is incorporated in transmitter and receiver designs to maximize the gain. Frequency translation is accomplished in a GFET mixer by multiplying the carrier frequency with the input IF or RF signal in the time domain.

Double Conversion Transceiver: The name suggests that there are two Intermediate Frequency(IF) phases in a double conversion to achieve Higher IF filter selectivity to bandwidth in the THz band. Narrow filter selectivity at higher frequencies is difficult to achieve in the single conversion architecture whereas Double conversion mitigates this problem by using a second lower IF.

For the double conversion, two mixers are designed such as a diode and a GFET mixer. The diode mixer is selected for the microwave mixer which has low conversion loss, less component complexity and the oscillator power at that frequency is high enough to forward bias the diode. Mixing with low oscillator powers is possible with FET mixers.

THz APPLICATION

THz enabled networks will enable super-fast download speeds for both wired and wireless networks. There are promising applications for future THz systems likely to evolve in 6G networks, which increase the efficiency, enable reliability and high-capacity connectivity. THz applications are categorized into wireless cognition, sensing, imaging, wireless communication, and position location / THz navigation(Rappaport et al.,2019).

Wireless Cognition: It provides a communication link that enables massive computations to conduct remotely from the device or machine that is doing real-time action.

Sensing: THz will enable new sensing applications because they allow very fine resolution in all physical dimensions like range, angle, and Doppler. Both active and passive sensing and imaging are possible(De Lima et al.,2021). More interesting applications are enabled by active radar imaging such as body scanning for security, smart shopping, and gaming.

THz-specific spectral fingerprints in biological and chemical materials bring a great deal of potential to THz wireless sensing, to study water dynamics via rotational spectroscopy. THz time-domain spectroscopy(TDS) is typically used in sensing applications, such as miniaturized radars for gesture detection and touchless smartphones, spectrometers for explosive detection and gas sensing, THz security body scanning, air quality detection, personal health monitoring systems, precision time/frequency

transfer, and wireless synchronization. Commercial applications for transportation, shopping, and other retail use real-time maps of any environment for mapping and sensing the world.

Imaging: Radar at THz frequencies are more effective due to the smaller impact that weather and ambient light have on the THz channel. It can be used for assisting driving or flying in foul weather, as well as in military and national security. THz waves can augment human and computer vision which enables unique capabilities in rescue and surveillance, autonomous navigation, and localization. THz imaging can see 360 degrees through sufficient reflection or scattering paths.

THz imaging is gaining interest in Healthcare applications which has the potential to be transformed by digital health technologies, including highly compact and wearable biosensors, heart rate sensors that provide continuous, home-based monitoring of biochemical markers in biofluids, such as sweat, tears, saliva, peripheral blood and interstitial fluid which can be provided by THz imaging and spectroscopy(De Lima et al.,2021).

Precise Positioning: Leveraging THz imaging for localization has unique features which highlight the potential of merging imaging and communications for precise positioning in 6G systems and beyond.

THz communication can provide extremely high throughput which will enable a plethora of new V2X applications (Noor-A.-Rahim et al.,2020).

Ultra-Broadband Wireless Communications: THz band provides ultra-high data rate. So, it can support bandwidth-intensive applications like virtual/augmented reality and holographic remote for both static and mobile users. It also meets the fronthaul/backhaul capacity requirements of wireless access points(Zhao et al.,2020). In wireless personal area networks, it is possible to establish TBPS links among devices in proximity on the THz band(hang et al.,2019). In addition to the promised TBSP-level links for cellular systems, the THz-band spectrum can also be leveraged for the Local Area Networks, Personal Area Networks, Data Center Networks, Data Center Networks, Nano-networks, and Inter-satellite Communications(Akyildiz et al.,2020).

Secure Wireless Communications: Considering the beam of a narrow THz signal, the transmitter beam should perfectly point to the receiver antenna to successfully deliver the information. So, the eavesdropper cannot receive the THz signal from the transmitter or even cannot notice the THz transmission when the eavesdropper is located outside the transmitter beam. The wide bandwidth which is one of the inherent features of the THz band makes communication be hidden to jammers, hence it is resilient to jamming or difficult for the eavesdropper to wiretap the information. This guarantees the good anti-jamming performance of THz signals in an open radio environment(Zhang et al.,2019).

Jamshed et al., (2020) showed the taxonomy of THz band applications which shows the Macro and Nanoscale applications. The nanoscale application includes plant monitoring, bio-medical, health monitoring, chemical, and biological attack prevention, military, nano-sensor network, and system-on-chip wireless networks. The nano-scale sensors can be used to detect diseases and to monitor glucose, cholesterol, and blood pressure levels. The nano-sensors can also be used to detect infected tissues, by using the THz communication it is possible to detect before the infection. agricultural monitoring, defense monitoring, and biological attack prevention also come under nanoscale applications. The major applications in macro-scale THz include radars, sensing, wireless communication, etc.

THz: CHALLENGES AND OPEN RESEARCH ISSUES

Terahertz communications: The research on terahertz communications needs further investigation, the achievement of which relies on various aspects. The issues mentioned with standardization and measurements (Tekbıyık et al., 2019).

High Propagation and Atmospheric Absorption of THz: The Hz frequencies provide high data rates which require a new design for the transceiver architecture for THz communication systems. A minimal gain with effective area antennas is the main challenge of THz communication (Chowdhury et al. 2020). Health and safety concerns related to THz band communications also need to be addressed.

Channel Modeling of Sub-mmWave(THz) Frequencies: The propagation characteristics of the mmWave and THz are subject to atmospheric conditions which are highly unpredictable. THz signals suffer from a high free-space path loss (Samsung, 2020), which arises from both the spreading loss and molecular absorption loss (Han and Chen 2018) and suffers from only the additive Gaussian white noise (AWGN). This feature limits the use of THz to short-distance transmission such as indoor communications. The Doppler shift will be more severe at THz frequencies, as the channel coherence time decreases, the channel status will change fast and needs to be updated more frequently. Statistical modeling (Mao et al., 2020) for sensing and imaging at THz will require much greater spatial resolution (Rappaport et al., 2019) than ever used before in channel modeling. Many challenges need to be resolved before the actual implementation of narrow beam directional antennas. Thus, the channel modeling of this band is relatively complex (Guo et al., 2021), and this band does not have any perfect channel model (Chowdhury et al. 2020).

Yuan et al. also identified a few challenges with THz communication such as severe path-loss, weak diffraction effect at short wavelength, excessive attenuation from the resonance of molecules in the air, weak diffraction that result in sensitivity to blocking and shadows, superfast channel fluctuation.

Beam Management in THz Communications: Beamforming through large MIMO systems is a promising technology for supporting high-data-rate communications. However, beam management in the THz band is challenging because of the propagation characteristics (Chowdhury et al. 2020). Moreover, for seamless handover, it is also important to choose the optimal beam efficiently in high-speed vehicular systems.

THz sources: It is challenging to generate THz signals and develop a full-function THz communication (Chen et al., 2019) system due to the lack of THz transceivers, making the THz band one of the least-studied electromagnetic spectrum. As such, existing terahertz signals are generated either from electronics or photonics-based devices. Recently, graphene-based technology emerged to generate THz signals due to the extraordinary electro-optical properties of graphene. The generated THz signals can be pulsed signals and continuous signals. In particular, the pulsed signal is widely studied in the existing literature on THz communications, in contrast, the generation of the continuous signal has a more stringent requirement on the size and complexity of the transmitter/antenna and thus needs more investigations to facilitate the THz communications in the future.

Hardware Design: Hardware materials need to comply with excellent high-frequency characteristics, the potential material of which is graphene. In addition, nanoantennas are desired to enable massive MIMO (Guo et al., 2021). THz outperforms mmWave in many ways, but faces stronger technical challenges, especially from the aspect of implementing essential hardware circuits that meet the compact physical size power efficiency (Matthaiou et al., 2020), including antennas, amplifiers, and modulators (Jiang et al., 2021). It is the most critical challenge for practical deployment of THz technologies, to efficiently

modulate baseband signals onto such high-frequency carriers with integrated circuits (Matthaiou et al.,2020).

Antenna Design: The fabrication and testing of THz band antenna arrays remain a relevant challenge(Akyildiz et al.,2020). The utilization of large antenna arrays of high directivity, focusing energy towards desired directions. However, such highly directional beams limit coverage in the angular domain, causing low energy efficiency at the transmitter. In parallel to the antenna design, other remaining challenges reside in the control and signal processing schemes associated with transceiver designs. On the one hand, real-time control algorithms are needed. On the other hand, communication protocols for coordination between the transmitter, receiver, and reflectarrays are needed. Furthermore, when highly directional beams are utilized at mobile transceivers, a relevant challenge arises from the limited field-of-view of antenna arrays for each transceiver to locate the next hop to forward its data; thus, new routing solutions are necessary for THz band communications to efficiently discover and establish links.

THz waves also suffer from high path loss, so highly rely on directive antennas and LOS channels while providing very limited coverage. However, when a satisfactory LOS link is available(Jiang et al.,2021), the high carrier frequency brings a bandwidth that makes it possible to simultaneously provide ultra-high performance in aspects of throughput, latency, and reliability.

The most important challenge(Jamshed et al.,2020) is a complete understanding of the physics of such structures and the issues related to the fabrications and achieving high throughput which needs to be tackled effectively. Hence, the design of nano-antennas is drastically different in comparison to the RF/microwave regime. Moreover, for such nanoscale antennas, the antenna theory requires new theoretical, analytical, and modeling tools, which accounts for the deviation from RF/microwave range to nano-antennas.

The main challenge in nano-scale applications(Jamshed et al.,2020) is the antenna designing on THz frequency. Efficient THz frequency usage, medium access control designing, channel propagation model, the interaction between nano-devices, efficient communication protocol, and safety constraints are additional challenges. challenges exist while using THz band for nanosensors in defense and industrial applications, which includes data acquisition, big data analysis at the molecular level, highly directive high gain nano-antennas, transmission range, and channel propagation model.

Medium Access Control(MAC) Layer Design: In terahertz bands, the properties of different carrier frequency windows will be different. The MAC layer protocols and network deployment schemes need to be redesigned(Guo et al., 2021) which includes new error control mechanisms and networking strategies due to the high path loss.

Network Deployment Modeling: The future network will be in 3D. Thus, the current Poisson point process will not be applicable, hence a new network deployment model is required to consider the above facts(Guo et al.,2021).

Handover and Connectivity: When comparing THz and mmWave systems, the performance of THz systems are more impacted by frequent blockages. This is due to a higher BS discovery time in THz systems, as well as the high cell association time caused by inefficient handover mechanisms. Additionally, the service reliability can be worsened by an inefficient handover, handover failures, and Radio Link Failures(H. Park et al.,2018). Therefore, it is important to study the impact of BS discovery time and handover latency of blockage-driven cellular networks, and their impact on QoS.

Security: THz faces security risks of authentication and malicious attack(Ma et al.,2018). Researchers can find new techniques to efficiently integrate THz with mmWaves. It can have a profound impact on 6G privacy and security mechanisms.

THz Sensing and Imaging: THz sensing can be piggybacked onto THz communications. However, many challenges need to be addressed, from a signal processing perspective to enable efficient joint THz sensing and communications (De Lima et al., 2021). THz sensing and imaging target small defects in material and security imaging which uses the contrast between water-based tissues and other materials. This poses specific challenges for the transmitters and the receivers (De Lima et al., 2021).

CONCLUSION

The exponential increase in data traffic with the growing number of connected devices due to novel applications demands higher bandwidths in terms of gigahertz. THz is considered to be the most promising technology for future requirements. Activities and efforts initiated towards the implementation of THz applications are beyond the imagination, to realize such applications, it needs higher-power THz sources, more sensitive THz sensors, and more functional devices and materials, creation of materials in the THz frequency range, THz measurement system, THz standards, and electromagnetic compatibility.

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Chapter 12

Challenges and Advantages of Implementing Blockchain Internet of Medical Things (B-IoMT) in 6G Networks

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ABSTRACT

The internet of things (IoT) has cleared the door for sophisticated functionalities to be introduced into the healthcare business. IoT systems handle a significant amount of data and require 6G network connectivity, power, and storage to convert it into useful information. The internet of medical things refers to the use of IoT-based internet-enabled medical devices in the healthcare business (IoMT). The lack of security standardization and energy-consuming cryptographic algorithms in man-in-the-middle attacks, session hijacking, and wireless encryption breaking are all possible security problems with IoMT. On the other hand, because of its decentralised nature, blockchain may be used to address IoT problems. The widespread adoption of decentralised blockchain technology in IoT has significantly reduced the danger of sensitive healthcare data being exposed. The authors combine blockchain technology with IoMT (B-IoMT) in this chapter to enable secure data transfer over a 6G network connection. The blockchain's security characteristics aid in achieving tamper-proof data transfer in IoMT.

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INTRODUCTION

High-speed internet is required for fast-developing smart applications and sensitive medical data management, such as data generation, data storage, and data analysis. A new wireless communication framework, the sixth era (6G) framework, is expected to be deployed between 2027 and 2030, with the help of artificial intelligence. The difficulties of deploying 6G technology, as well as network architecture, security processes, and environmentally friendly technological implementations, must all be considered. In the meantime, Blockchain is another developing technology that has begun to rule the transparent and safe data transmission. Because of its decentralized character, blockchain can be a beneficial tool for addressing IoT issues. Blockchain is a distributed ledger that has three primary characteristics: it is recorded, transparent, and decentralized. Participants in distributed ledgers were developed by blockchain to record transactions and connect with others in a trustless manner. The most important attribute of Blockchain is its security. IoT and Blockchain are two new approaches for sharing fundamental properties in apps. For the integration of blockchain and IoT, several existing works have been established. However, in state-of-the-art IoT work, Blockchain protocols failed to account for compute loads, delays, and bandwidth overhead, resulting in new difficulties. The Internet of Medical Things (IoMT) is a collection of Internet-based medical applications and services for the healthcare business Somasundaram et al. (2017). The combination of a 6G network, blockchain, and IoMT will open up new possibilities for improving the medical industry's performance.

CHALLENGES IN 6G NETWORKS

Despite the fact that 5G is still in its early stages of commercialization, which means that related technical features must be improved and the plan of action of Internet of Things and vertical industry application situations should be additionally explored, it is likewise essential for us to look forward to the correspondence needs of things to come data society and start arranging now. In this paper, we endeavor to survey the requirement for a fast beginning up of ideas and specialized improvement on the cutting-edge portable correspondence framework, named 6G.

To help the probability of new applications like forceful medication, PC calamity anticipating, and augmented reality, a 6G portable organization framework should give extraordinarily high rates, expanded limit, and non-nearness (VR). Due to the past pre-guideline of versatile organizations, the primary 6G connections will essentially be founded on the current 5G construction, exploiting the advantages acquired in 5G (for instance, the expansion in permitted recurrence groups likewise streamlined the plan of a decentralized framework) and changing the way we task and play Aiosa, G. V (2021).

Data will most likely affect our audiences around 2030, offering immediate and unrestricted cellular connectivity. As a result, 6G should boost current wireless technologies and achieve system compliance. As far as speed, 6G is relied upon to utilize a more refined recurrence range than past ages to expand information throughput expected to be 100 to multiple times quicker than 5G. To be more explicit, 6G frameworks will permit many GBs each second to associate with one another utilizing broadband range; for instance, the joined utilization of a band from 1 to 3 GHz, a millimeter-wave band (mm-wave) (30 to 300 GHz), and a terahertz band will permit many GBs each second to interface with one another (0.06 to 10 THz) Chen, S et al. (2020). "At the point when the remote connection is completely sent, the Earth will be loaded with incredible brains..." said Nikola Tesla in 1926. In 2030, in view of anticipated

advancement and motivated by fundamental necessities on an individual and social level. Tesla gauges can emerge out of anyplace on the planet, and 6G will assume a key part in this advancement by giving an ICT structure that will permit end shoppers to be encompassed by a monstrous fake cerebrum. It has the limitless capacity, virtual capacity, and mass cognizance abilities. This record incorporates a 6G vision just as an investigation of 6G's expected difficulties.

SECURITY AND PRIVACY IN 6G NETWORK

The security and privacy of the 6G network is major concern. It's an open network, which means that everything that is done in it can be monitored. This is not a good thing for companies who need to keep their trade secrets safe. The cost of implementing the 6G network is prohibitively high at this time, but it's only projected to get cheaper as the technology advances. There are many other challenges in creating and maintaining a 6G network, such as data throughput, frequency allocation, spectrum management, and power efficiency Tomkos et al. (2020). The 6G network's critical sectors that provide high dependability, low latency, and secure and efficient transmission services However, as also most of these technologies come at the cost of new security and privacy concerns Wang M et al. (2020).

COST OF IMPLEMENTING 6G NETWORK

6G networks are not just faster than 4G; they are also more secure and private. They don't use the same frequencies as current LTE networks which means that they can be operated without any interference from them. Adoption of 6G will also be cheaper since it is expected to generate less network congestion and thus reduce the cost of devices. The eco-friendly bandwidth in 6G networks is also more efficient than that of 4G networks.

There are many different challenges that come with implementing 6G networks, but one of the most important ones is security and privacy. With all of these new technologies comes an increased risk of cyber-attacks, so it's crucial to be prepared. To do this, you'll need to spend money on cyber security systems. There are also concerns about how much it will cost to set up a 6G network, as well as if they will be able to maintain their bandwidth. Eco- friendly bandwidth is also a concern, because many areas are limited on the amount of power they can use. The challenges that we will face in the coming years will be security and privacy in the 6G networks. One of the main factors that will need to be considered is the cost of turning over to an entirely new communication protocol and the time it would take for deployment. It is important to remember that as bandwidth needs grow so too does the need for an eco- friendly network.

INTERNET OF MEDICAL THINGS WITH 6G TECHNOLOGY

The Internet of Medical Things (IoMT) is a concept that can be observed in the growth of interconnected medical devices, biomedical equipment, and healthcare providers. The term "Internet of Medical Things" was first coined by MIT Technology Review. The term has grown in popularity over the years to signify the increasing trend of medical device connectivity. Internet of Medical Things with 6G Technology

is defined as the next generation of mobile communications technology Chen et al. (2021). It offers a much higher bandwidth, and can therefore support a much larger number of connections. Its speed, power efficiency and capacity make it a great candidate for use in IoT devices. 6G technology is the next generation of mobile communication technology. The rise of IoT will be enabled by 6G networks. IOMT (Internet of Medical Things) has many security challenges that need to be solved. The future of the Internet of Medical Things is looking brighter with the advancement in technology Somasundaram R et al. (2021). With 6G, it is expected that not only IOTs will be more connected but they can also perform more operations. All of this is made possible by the fast speed and higher bandwidth of this wireless technology.

IOMT APPLICATIONS AND SERVICES

IoMT is a technology that combines hardware and software to provide a variety of applications and services. The various services and applications provided by IoMT over a 6G network are discussed in table 1.

Table 1. Various services and applications provided by IoMT over a 6G network

Applications and Services	Descriptions
Ambient Assisted Living (AAL)	Ambient Assisted Living (AAL) is the use of equipment and methods to keep older people secure and able to age in place in their own homes. It comprises smart gadgets, wireless networks,
	Software application, computer, and medical sensors. These innovations allow people to age in situ.
Adverse drug reaction monitoring	An intervention related to the use of a medicinal medication that causes a substantial negative or unpleasant reaction that predicts risk from future administration and needs preventative treatment, such as gastrointestinal bleeding, fatigue/sleepiness, heartburn, or nausea.”
Wearable devices in IoMT	Patient monitoring, surveillance, screening, diagnosis, and therapy, post-treatment, and continuing management may all be done with wearable devices.
ECG monitoring	To check for various cardiac problems, an electrocardiogram (ECG or EKG) captures the electrical signal from your heart. Electrodes are implanted on your chest to record the electrical signals sent by your heart, which cause it to beat.
Blood glucose monitoring	It helps individual patterns of blood glucose variations are revealed by blood glucose monitoring, which aids in the planning of meals, activities, and when to take medications.
Oxygen saturation monitor	Pulse oximeter based on the Internet of Things that detects changes in your blood oxygen level quickly. Pulse oximeters are simple to operate.

The integration of blockchain and a high-speed 6G network over these IoMT applications helps healthcare workers to diagnose and treat patients in an accurate manner. These are just some of the benefits of 6G. With this technology, there is an information highway that is not only fast but also secure. This means that the data network will be highly resistant to cyber-attacks and there will be no delays in delivering critical information and medical records. The advantages of 6G for IoMT are clear: it is cheaper, more reliable, and offers connectivity without geographical restrictions. The IoT is a wireless communication infrastructure that links physical objects to the internet. The term IoT is used to describe a wide range of sensors and monitoring devices connected by networks such as Bluetooth, Wi-Fi, Zig-

bee, and others. In healthcare settings, it can be connected with wearable technologies that monitor your vital signs. The future of the IoMT includes ubiquitous sensor technology that can detect disease Somasundaram, R et al. (2018).

CHALLENGES IN IMPLEMENTING BLOCKCHAIN IN IOMT (B-IOMT)

Blockchain innovation is useful to the web of clinical things as far as security. Be that as it may, coordinating the two advances isn't paltry by any means and is confronting a few difficulties because of the clashing necessities of these two advances. This work incorporates blockchain technology together with IoMT to achieve safe data transmission by considering the challenges shown in Table 2.

Table 2. Challenges of implementing B-IoMT

S.No	Properties	Challenges
1	Processing	The processing is one of the key challenges when implementing the blockchain in IoMT. The mining process, which is a complex cryptography process, is used by Blockchain. This requires a high processing capacity, which is difficult for IoMT resource-constrained devices to afford.
2	Storage	IoMT devices monitor and produce a huge amount of sensor data continuously. IoMT devices have limited space for storage. It is also a difficult method to store this information in the blockchain.
3	Mobility	For static nodes, Blockchain has been developed to achieve a stable transaction. However, wearable and embedded IoMT devices are mobile devices that alter the network dynamically. This essence of mobility challenges the implementation of blockchain-based IoMT.
4	Real-Time	Generally, IoMT applications are crucial and involve a response that is real-time and immediate. Whereas, the construction of blocks is time consuming.

Security Attacks in Block Chain 6G Implementation

Taking into account the security needs and application-specific elements of future 6G networks discussed in the preceding sections, we now address the threat environment and potential security solutions connected to a few 6G technologies that have already attracted the greatest interest Porambage et al. (2021). The security flaws in Blockchain and smart contracts may have an unintended influence on 6G networks. The majority of these assaults are the result of software development mistakes, programming language limitations, and security flaws in network connectivity. Furthermore, both public and private blockchain networks might have security concerns.

Figure 1 depicts the major security attacks in the implementation of the 6G network. Security attacks such as majority attacks, double spending attacks, re-entrance attacks, privacy leakages, broken authentication, broken access control, and call stack vulnerabilities are more challenging to implement the blockchain in 6G based IoMT network.

Figure 1. Security attacks in blockchain 6G implementation



Advantages of Blockchain in 6G Organization

Blockchain expands trust, security, straightforwardness, and the recognized ability of information shared across a business organization — and conveys cost investment funds with new efficiencies. With blockchain, you currently have the capacity to associate with anybody to safely share esteem; however, the trading of significant worth should be seen by everybody in the organization. Though, with the Internet, it doesn't make any difference that else is on the organization as long as every individual can speak with its applicable gatherings.

Need for Blockchain in 6G Technology

The blockchain is quite possibly the most conspicuous advancement to release the capability of the 6G system. The abilities and qualities of the blockchain innovation to kill the potential difficulties examined in investigated in this part.

Intelligent Asset the Board

The organization asset the board is trying in the conceived enormous network requests later on media transmission biological systems. The asset the board activities, for example, range sharing, organization, and decentralized calculation need to be viable with a greatly enormous foundation.

Privacy Authentication and Access Control

The protection is a huge thought from the point of view of safety. Use of information protection is assorted in the complicated security necessities later on 6G organization biological system. In such a manner, proposed a protection safeguarding plan dependent on blockchain for content-driven 5G organizations. The entrance control of brought-together frameworks ensures adaptability impediments. Hence, access control with centralization is a critical test in the plan of future organizations.

Integrity, Availability, and Accountability

The information respectability of enormous information volume produced later on figuring biological systems is a chief. The help accessibility is a huge necessity later on correspondence biological systems. The responsibility of the 5G and past network environment is a key necessity. The security, observation, and administration of the organization can be carried out through the blockchain and circulated record innovation overall. The appropriated record stays as an unchanging and straightforward log for every occasion which can be used in the inspecting of occasions.

Adaptability

Adaptability is a significant prerequisite in 5G and past frameworks. The adaptability restrictions of unified frameworks can be killed by the blockchain and brilliant agreements to confront the conceived gigantic network interest in the future. The decentralized nature and the coordination comfort of edge and mist figuring hubs will further develop the assistance qualities in those organizations.

APPLICATION OF 6G SYSTEM USING BLOCKCHAIN TECHNOLOGY

The 6G vision involves a huge number of uses that can be empowered or improved through the use of blockchains. The reason of blockchains for giving/working on such applications in 6G originate from the capacities recorded in which are empowered by its center ascribes, i.e., decentralization, straightforwardness, unchanging nature, accessibility, and security.

Modern Applications for Beyond Industry 4.0 in 6G, the mechanical applications will be significant drivers for taking advantage of the conceived 6G abilities. The critical properties of blockchains and the difficulties talked about in Section II are particularly pertinent to modern conditions. For instance, holographic correspondences for modern use-cases, for example, distant support or monstrous network of mechanical assembling hardware requires decentralized designs which are dependable simultaneously Mahmood, N et al. (2019). Blockchains can give these capacities when they are coordinated into these applications or use-cases. Nonetheless, there are likewise significant exploration challenges concerning

blockchain-based arrangements, specifically idleness and versatility. They are impressive because of rigid execution necessities in modern applications and legitimate for mechanical organizations and IoT Yrjölä, S et al. (2019).

Consistent Environmental Monitoring and Protection Blockchains permit decentralized helpful ecological detecting applications which can be acknowledged on a worldwide scale with 6G. Such capacities can serve use-cases like shrewd urban communities or transportation just as natural assurance for the green economy. Blockchains likewise work with secure information dividing between parties (going from IoT gadgets to associations). Such enormous scope believed detecting and information sharing arrangements empowered by blockchains are pivotal for natural checking Chowdhury, M. Z et al. (2020). Additionally, combined and shared learning executed utilizing blockchains support the information examination and derivation measures for natural security in a decentralized way.

Brilliant Healthcare Smart medical care in 6G should make one stride further to settle officeholder issues in 5G organizations. The more profound and omnipresent incorporation of blockchains in ongoing

Organizations can propel current medical care frameworks and further develop execution as far as better decentralization, security, and protection. The impending among these specialized difficulties is the protection issue. Besides, honesty of medical care information is conceivable because of the permanence ability given by blockchains. In particular, client-controlled protection and secure information stockpiling can be empowered with blockchains without an incorporated trusted third party Chowdhury, M. Z et al. (2020). In Europe, GDPR mandates are significant drivers which will turn out to be tougher in the coming years. Better decentralization will empower higher security particularly as far as accessibility for this basic space.

Decentralized and Trustworthy 6G Communications Infrastructure and Solutions is plenty of utilization openings for taking advantage of blockchains in 6G frameworks itself for execution gains or empowering new administrations/use-cases. In particular, the decentralized organization the board structures: The decentralized blockchain-based organization the executives will give better asset the board and more proficient framework the executives Maksymyuk, Tet al. (2019).

Pricing, charging, and charging of organization administrations: Blockchains can empower charging and charging without an incorporated framework which is a more adaptable and effective design contrasted with traditional frameworks.

- Authentication, Authorization, and Accounting (AAA): When gigantic scope availability with heterogeneous and divided organization components are set up in 6G organizations, AAA capacities should be decentralized and substantially stronger for administration progression. For example, (bunch) key administration and access control systems can be offloaded to blockchain stages for better versatility (particularly for asset obliged end focuses) and straightforwardness.
- Service Level Agreement (SLA) the executives: 6G organizations will expand on virtualized and cut organization engineering like 5G organizations however yet carry out that at an amazingly huge scope. Additionally, these organizations are relied upon to serve an exceptionally wide range of use cases with different help level assurances. Consequently, SLA the board is a significant framework necessity. Blockchains will empower decentralized and secure SLA the board in this perplexing setting.
- Spectrum sharing: Capacity development and range spryness for 6G radio access (for groups going from MHz to THz groups) aren't apparent with concentrated administration structures and

awkward sharing plans. Blockchains and keen agreements can reduce the range sharing related collaboration and transparency issues Maksymyuk, T (2019).

- 6G organizations need to work with the spatial interpretation of many center administrations from the cloud to the edge networks for accomplishing amazingly low inactivity interchanges and moment organizations. The dependable coordination and straightforward asset accounting can be accomplished with blockchains in these frameworks.

Future Research Opportunities

The exploration extent of 6G is tremendous with different mixes of the software engineering and telecom research roads. The most conspicuous examination openings for 6G with blockchain innovation are talked about in this part. A. Web of Everything (IoE) The IoE is broader than IoT and has the reason to flawlessly associate individuals, cycles, information, and things in a canny way. The distinctive job of IoE talked about normal that the IoE will re-design business cycles and plans of action. In the first place, measures are streamlined and automatized because of computerized innovation. Second, because of the use of computerized innovation, new plans of action in various ventures become conceivable. It will be fascinating to examine according to a business perspective the outcomes of the various potential outcomes while presenting IoE. Specifically, there will be a serious need to rival uncommon business speed and deftness. In addition, the effect of adding blockchain-based advancements with the end goal of interoperability among various organizations, for example charging, requires further examination. B. Information stockpiling and investigation by executing the IoE, a large number of things and articles will ceaselessly produce ongoing floods of new information. As an outcome, in any case, adequate and effective concentrated and decentralized information stockpiling innovations are required. Blockchain empowered innovations can assume a significant part there. Notwithstanding, it isn't yet clear how to disperse and consolidate these advances in various areas (edge, mist, and cloud). Second, research on techniques for information investigation will be exceptionally required to break down and extricate the fundamental components out of this huge store of information for effective and precise choice preparation. The four principle classifications of techniques are elucidating examination, demonstrative investigation, prescient investigation, and prescriptive examination, and essentially rely upon the kind of use. Once more, it will be fascinating to explore the potential outcomes to consolidate these information examination strategies with disseminated blockchain-based information stockpiling, where the benefit of the brilliant agreements can be taken advantage of to mechanize the cycles.

AUTOMOBILE APPLICATIONS

Vehicle to Vehicle Communications

Intelligent Transport Systems (ITS) are unquestionably one of the significant applications that will get through in the following decade and will require the specialized capacities presented by a 6G organization. A blockchain-based way to deal with characterizes the trust the board of vehicles has been shown and assessed through re-enactment. The primary inadequacy of their methodology impeded specially appointed organizations, and in this way, further examination is needed to guarantee additionally the ar-

rangement in an independent manner, including testing portability settings, for example, a multi-junction street organization.

Unmanned Aerial Vehicles (UAV)

UAVs or robots will likewise introduce a significant part in 6G as high-information rate remote availability will be required. Here, blockchain can assume a significant part to add to the insurance of the security and protection of the robots and in this way gathered data likewise show the meaning of 5G in the UAV setting. IBM has even recorded a blockchain patent to address drone armada security. There are a few blockchain-based applications for drones. Above all else, blockchain innovation can assist with orchestrating the character of the executives. Then, air traffic on the board can be orchestrated in a solid, exact, and effective way. At long last, insurance agencies can utilize confided in records for debate goals.

Shareable assets are the new resources characterized by the dispersed assets administrators, which are not restricted to correspondence however energy and figuring segments. While the correspondence foundation likewise depends on the energy and figuring asset arrangement. Along these lines, a trusted blockchain-empowered exchanging biological system, including energy, figuring, and correspondence can be worked to empower a productive and economical 6G.

In the biological system, we can discover different floods of the blockchain exchange, energy, and figuring stream utilizing shared correspondence resources in the asset the executive's plot address the stream bearings, and they are begun with the supplier through the between area sharing plan to arrive at the last customers at both the nearby level with consortium blockchain and public or worldwide level using a public blockchain. The environment isn't restricted to the extent of energy, correspondence and figuring as it can extend itself to a more extensive territory through cross-field joining to reach, for example, auto, finance, fabricating, strategic chain, etc.

SERVICE-ORIENTED APPLICATIONS IN BLOCKCHAIN TECHNOLOGY IN 6G TECHNOLOGY

The 6G vision involves a large number of uses that can be empowered or improved using of usage of blockchains. The reason for blockchains for giving/working on such applications in 6G comes from the abilities recorded which are empowered by its center credits, i.e., decentralization, straightforwardness, Unchanging nature, accessibility, and security. A. Mechanical Applications for Beyond Industry 4.0 In 6G, the modern applications will be significant drivers for taking advantage of the visualized 6G capacities. The vital qualities of blockchains and the difficulties examined in Section II are particularly material to modern conditions. For instance, holographic interchanges for mechanical use-cases, for example, distant upkeep or gigantic availability of modern assembling hardware requires decentralized models which are dependable simultaneously Chen, S et al. (2020). Blockchains can give these capacities when they are incorporated into these applications or use-cases. In any case, there are likewise significant examination challenges in regards to blockchain-based arrangements, specifically dormancy and adaptability. They are imposing because of tough execution prerequisites in modern applications and substantial for mechanical organizations and IoT Mahmood, N et al. (2019). B. Consistent Environmental Monitoring and Protection Blockchains permit decentralized agreeable natural detecting applications which can be acknowledged on a worldwide scale with 6G. Such abilities can serve use-cases like bril-

liant urban areas or transportation just as natural insurance for a green economy. Blockchains likewise work with secure information dividing between parties (going from IoT gadgets to associations). Such gigantic scope believed detecting and information sharing arrangements empowered by blockchains are pivotal for natural checking. Besides, united and shared learning executed through blockchains support the information investigation and derivation measures for ecological insurance in a decentralized way.

Smart Healthcare

Shrewd medical care in 6G should make one stride further to settle officeholder issues in 5G organizations. The more profound and pervasive joining of blockchains in ongoing organizations can propel current medical services frameworks and further develop execution as far as better decentralization, security, and protection. The impending among these specialized difficulties is the security issue. Additionally, the uprightness of medical care information is conceivable because of the unchanging nature ability given by blockchains. In particular, client-controlled protection and secure information stockpiling can be empowered with blockchains without a concentrated confided- in outsider. In Europe, GDPR orders are significant drivers which will turn out to be more rigid in the coming years. Better decentralization will empower higher security particularly as far as accessibility for this basic area. Decentralized and Trustworthy 6G Communications Infrastructure and Solutions. There are plenty of utilization openings for taking advantage of blockchains in 6G foundations itself for execution gains or empowering new administrations/use-cases Aiosa, G. V et al. (2020).

Decentralized Organization the Board Structures

In the decentralized blockchain-based organization the executives will give better assets to the board and a more proficient framework for the executives.

Pricing, Charging, and Charging of Organization Administrations

Blockchains can empower charging and charging without a brought-together framework which is more adaptable and proficient engineering contrasted with customary frameworks.

Authentication, Authorization, and Accounting (AAA)

When enormous scope availability with heterogeneous and divided organization components are set up in 6G organizations, AAA capacities should be decentralized and significantly more vigorous for administration progression. For example, (bunch) key administration and access control components can be offloaded to blockchain stages for better adaptability (particularly for asset compelled end focuses) and straightforwardness.

Service Level Agreement (SLA) the Board

6G organizations will expand on virtualized and cut organization design like 5G organizations however yet execute that at an amazingly huge scope. Also, these organizations are relied upon to serve

an extremely wide range of utilization cases with assorted help level certifications. Accordingly, SLA the board is a significant framework prerequisite. Blockchains will empower decentralized and secure SLA the board in this mind-boggling setting. • Spectrum sharing: Capacity development and range deftness for 6G radio access (for groups going from MHz to THz groups) aren't apparent with unified administration structures and awkward sharing plans. Blockchains and shrewd agreements can reduce the range of sharing-related participation and straightforwardness issues. 6G organizations need to work with the spatial interpretation of many center administrations from the cloud to the edge networks for accomplishing amazingly low inactivity correspondences and moment organizations. The dependable coordination and straightforward asset accounting can be accomplished with blockchains in these frameworks.

The exploration extent of 6G is tremendous with assorted blends of the software engineering and media transmission research roads. The most conspicuous examination openings for 6G with blockchain innovation are talked about in this segment. A. Web of Everything (IoE) The IoE is broader than IoT and has the reason to consistently associate individuals, cycles, information, and things in a smart way. The distinctive job of IoE is talked about normally, the IoE will re-concoct business cycles and plans of action. To start with, measures are upgraded and automatized because of computerized innovation. Second, because of the utilization of computerized innovation, new plans of action in various ventures become conceivable. It will be intriguing to research according to a business perspective the outcomes of the various conceivable outcomes while presenting IoE. Specifically, there will be a serious need to rival phenomenal business speed and nimbleness. In addition, the effect of adding blockchain-based advances with the end goal of interoperability among various organizations, for example, charging, requires further exploration. B. Information stockpiling and examination by executing the IoE, a great many things and items will constantly produce ongoing surges of new information. As an outcome, in any case, adequate and productive unified and decentralized information stockpiling advancements are required. Blockchain empowered advances can assume a significant part there. Nonetheless, it isn't yet clear how to disperse and consolidate these advancements in various areas (edge, haze, and cloud). Second, research on techniques for information examination will be profoundly required to dissect and extricate the fundamental components out of this huge stack of information for effective and exact choice handling. The four primary classifications of techniques are spellbinding examination, demonstrative investigation, prescient investigation, and prescriptive examination, and rely upon the kind of use. Once more, it will be intriguing to research the potential outcomes to join these information examination strategies with conveyed blockchain-based information stockpiling, where the benefit of the brilliant agreements can be taken advantage of to computerize the cycles.

APPLICATION IN MODERN TECHNIQUE

Vehicle to Vehicle Communications: Intelligent Transport Systems (ITS) are positively one of the significant applications that will get through in the following decade and will require the specialized abilities presented by a 6G organization. A blockchain-based way to deal with characterize the trust the executives of vehicles has been exhibited and assessed through reproduction in the fundamental weakness of their methodology was the constraint to impromptu organizations, and consequently, further examination is needed to guarantee likewise the arrangement in an independent manner, including testing versatility settings, for example, a multi intersection street organization.

Automated Aerial Vehicles (UAV): UAVs or robots will likewise introduce a significant part in 6G as a high-information rate remote network will be required. Here, blockchain can assume a significant part to add to the assurance of the security and protection of the robots and consequently gathered data additionally show the meaning of 5G in UAV setting. IBM has even recorded a blockchain patent to address drone armada security. There are a few blockchain-based application for drones. As a matter of first importance, the blockchain innovation can assist with organizing the personality of the executives. Then, air traffic the executives can be organized in a protected, exact and productive way. At long last, insurance agencies can utilize confided in records for question goals.

APPLICATION IN ECOSYSTEM

Shareable assets are the new resources characterized by the dispersed assets administrators, which are not restricted to correspondence however energy and figuring segments. While the correspondence framework additionally depends on the energy and processing asset arrangement. In this manner, a trusted blockchain-empowered exchanging environment, including energy, processing, and correspondence, can be worked to empower an effective and feasible 6G.

In the biological system, we can discover different floods of the blockchain exchange, energy, and figuring stream utilizing shared correspondence resources in the asset the executive's plot address the stream headings, and they are begun with the supplier through the between space-sharing plan to arrive at the last shoppers at both the neighborhood level with consortium blockchain and public or worldwide level using a public blockchain. The environment isn't restricted to the extent of energy, correspondence, and processing as it can extend itself to a more extensive territory through cross-field reconciliation to reach, for example, car, finance, producing, strategic chain, etc.

Associations that plan to wire such assets can be perceived as Virtual Infrastructure Operators (VIO) since they don't claim each of the assets yet a seller of consolidated arrangements of assets. An illustration of VIO can be found in far off districts, where nearby foundation financial backers will, in general have off-network Distributed Generation (DG) units, for example, sun based and wind ranches and miniature Combined Heat and Power (micro-CHP) to offer energy and warmth to far off clients as Distributed Energy Resources (DER). Neighborhood-based coordination of such assets as otherwise known as, Virtual Power Plant (VPP) assumes the part of the merchants for power and heat and purchases from, or sells, to different matrices, with unfilled requests and abundance power. Since these foundations are a long way from the focal organization and come up short on a savvy method of exchanging in regards to the correspondence and conveyance cost, it is ideal to break with other neighborhood suppliers and trade the power for different merchandise. For instance, the correspondence hand-off assistance and registering administration of DG sensor are utilized as the trading of equipment power supply, to develop the environment while the inner interest develops. Notwithstanding the assets claimed by the administrator, there are numerous normal asset compartments among all members.

In any case, the blockchain environment needs to oblige the presentation and security prerequisites of the expected application. As far as the presentation and security, the agreement is a significant worry in the period of preparation. Distinctive agreements can be applied to the sharing plan. For instance, a public chain is more reasonable for between area exchanges on high-level administrators like the public framework and first-level MNO. Be that as it may, if the assets are nearby situated, the private chain can be facilitated for IoT and neighborhood/off-matrix hubs, where the data from a private chain is kept

inside the organization with certainty for outside examining. A biological system might present numerous agreements on various chains to accomplish its best outcomes.

Past the sending of blockchains, the genuine equipment assumes a significant part in the biological system, as current blockchain applications are intended for upper-layer applications. It does not have the comprehension of versatile answers for cell phones, like robots, vehicles, and IoT. Significantly, the remote ability for the blockchain is fundamental in 6G sending. Remote blockchain-empowered hubs enable the Machine-to-Machine (M2M) exchange among conveyed and shared assets; consequently, it becomes fundamental that the far-off hubs are remote empowered. Sooner rather than later, the VANET-empowered vehicle furnished with blockchain hubs can re-energize the battery from different remote charging focuses while moving and exchange the data it conveys, for example, the Light Detection and Ranging (LiDAR) planning information, handing-off the web access, edge figuring assets, and whatever can be utilized by the distant DG unit utilizing remote correspondence, D2D, and edge processing. The exchanges are kept in the blockchain and conveyed by the vehicular organization then, at that point, mined by the neighborhood foundation or base station blockchain hubs. Afterward, the mined squares will be transferred by satellite-connected base stations for an expense. The bartering of range and organization cuts can be found on information hand-off and short-range Vehicle to Ground (V2G) correspondence, which requires immense nearby data transmission to accomplish lower dormancy. This model means to give knowledge into the between space blockchain biological system, and further extra elements are completely made conceivable dependent on the between area exchanges.

However, the blockchain enjoys many benefits, a few elements should be wiped out when applied to the asset sharing and range the board situations. Here we feature a portion of the difficulties of applying the blockchain innovation in asset sharing and range the executives.

Capacity: Each imitation hub in the regular blockchain network should measure and store a duplicate of the finished exchange information. This can lead to both capacity and calculation trouble on IoT gadgets, which are by and large asset compelled, accordingly restricting their investment in the blockchain network.

Fundamental systems administration: Implementing an agreement component inside the blockchain is computationally costly, and it additionally requires critical data transfer capacity assets. In the meantime, assets are extremely restricted later on a network, Thus, meeting the asset prerequisite for huge exchange throughput may be difficult to accomplish with the current framework.

The adaptability of the blockchain network: The versatility of the blockchain network is a significant issue in current frameworks. The quantity of reproductions in the blockchain network relates straightforwardly to the throughput (i.e., number of exchanges each second) and inertness (i.e., the time needed to add an exchange to the blockchain). Thus, supporting the colossal volume of exchanges expected in blockchain-empowered future organizations requests answers for working on the throughput of the blockchain framework.

RESEARCH OPPORTUNITIES FOR THE FUTURE STUDY

Even though block chain-empowered IoMT is promising to battle the medical emergency, a few provoke should be tended to before the conventional reception of block chain-empowered IoMT arrangements in medical services frameworks. We examine a few future bearings in this part.

One of the principle impediments of current blockchain frameworks is the helpless versatility, which restricts the wide reception of blockchains in IoMT. The adaptability of blockchain frameworks can be normally estimated by exchange throughput, i.e., the number of exchanges each second (tps). Contrasted and mature business installment frameworks, like VISA and PayPal, which can reach 2000 tps and 170 tps, individually. The throughput of public blockchains should be improved to deal with the monstrous exchanges and real-time demands in IoMT. The countermeasures to the versatility of blockchain incorporate,

1. Utilizing more adaptable agreement calculations to work on the throughput
2. Embracing private or consortium blockchains, which are more versatile than public blockchains.

Adaptability of Blockchain

To second sorts of arrangements, private and consortium blockchains can handle exchanges quicker than public blockchains essentially inferable from the permission

Frameworks, which can agree more effectively than public blockchains. In this manner, private and consortium blockchains might be more reasonable for IoMT.

The monstrous accessible IoMT information contains colossal qualities. Information investigation on the evidence created by block chain-empowered IoMT can't just concentrate helpful data yet in addition upgrade block chain-empowered IoMT itself. It distinguishes potential framework deficiencies, weaknesses, and execution bottlenecks in the wake of investigating IoMT information and blockchain information. In any case, customary AI information investigation techniques regularly require broad element designing to remove highlights. The arising profound learning calculations that have fewer prerequisites on included designing can straightforwardly gain from the crude information. Along these lines, profound learning approaches are more expected in the future for block chain-empowered IoMT. In the meantime, the heterogeneity of IoMT information presents difficulties in information investigation. In this manner, diverse profound learning approaches might be embraced to deal with various kinds of IoMT information. For instance, a profound convolution neural network (CNN) has the qualities in investigating pictures that can be utilized for biomedical application, (for example, X-Beam and X-ray pictures) while recurrent neural network (RNN) and the variations of RNN can be utilized for time-series information, like electroencephalogram (EEG) information. Later on, the combination of different profound learning calculations will be an unavoidable pattern for examining blockchain-empowered IoMT.

Reliable Artificial Intelligence for IoMT

Despite the advances of profound learning and simulated intelligence, they likewise bring dependable concerns, predominantly on security and protection weaknesses of man-made intelligence models. Specifically, it is accounted for in that artificial intelligence models can be taken, misrepresented, and harmed (or polluted). In the short-term, IoMT information regularly should be moved to cloud workers which have the more grounded computational ability to measure and break down IoMT information. Nonetheless, cloud workers are regularly possessed by untrusted outsiders, which may inadvertently or deliberately spill protection delicate information to other people. In such a manner, the reconciliation of blockchain and simulated intelligence may be a solution to this issue. Specifically, blockchain frameworks may viably validate and approve information getting to when IoMT information is moved to cloud workers. In the interim, the verification and approval instruments can be likewise applied to the

administration of cloud workers which are needed to be approved through the decentralized blockchain framework. Additionally, the new advances in combined learning calculations carry the freedoms to settle this issue according to an alternate point of view. Rather than transferring IoMT information to remote cloud workers, united learning calculations can prepare simulated intelligence models from the gathered IoMT information locally at edge hubs, which are sent at base stations or IoT doors in estimate to clients. From there on, the prepared man-made intelligence models can be combined. Thus, the danger of security spillage is decreased since no IoMT information is moved to cloud workers which are frequently claimed by untrusted outsiders. It will be a future course to coordinate unified learning with blockchain, accordingly further upgrading the trust of IoMT frameworks.

As referenced all through this examination, the chance of uninhibitedly dividing delicate data among experts and wellbeing foundations would permit a stage forward for customized medication, exploiting the most progressive AI procedures that software engineering is advertising. We saw that there are various perspectives on the most proficient method to share information on the Blockchain: putting away information in its squares (yet undeniably challenging in reality because of adaptability issues); taking advantage of information provenance, by fundamentally putting away places of information in the blockchains rather than the information itself; and utilizing circulated stockpiles joined with the block chain, consequently utilizing them as off-chain stockpiling. In every one of the arrangements, there is a possibility to never get information across the organization that could be gotten to and utilized. The survey zeroed in on the capacity of Block chain of making explicit arrangements ready to empower the client to be the genuine proprietor of their information. Right now, what is obvious is the expanding interest in client-driven arrangements in any event, when it isn't the objective of the examination.

A few arrangements are attempting to expand the degree of responsibility for their information, yet the issue of making a full decentralized client-driven framework for wellbeing information remains. The utilization of Permissioned arrangements possessed by medical care establishments is now and then equivocal, perhaps empowering clients on dealing with their information however at last driving them to acknowledge consortium rules over information the board. In addition, this particular issue influencing security in Permissioned arrangements likewise affects the utilization of decentralized stockpiles that hazard being squandered since they lose their worth. On the off chance that the Block chain hazards are being undermined by members, the arrangements neglect to convey permanence and regardless of whether client information is on decentralized capacity, they cannot ensure a client-driven framework. A few executions underline this. Discovering a solution for this issue, perhaps through crossover executions among Permissioned and Permissionless executions, could be considerably more amazing when these organizations can compensate the members making them ready to be dynamic supporters of a local area with their information as the one of medical care. This vision additionally settles very well with an idea that has been found in one survey as it were: compensations for information commitment. As said already, at whatever point a singular uses an IoMT framework or an IoT gadget, it is never remunerated for the commitment it makes. Notwithstanding, to move the models from a framework-driven point of view, where a client is the purchaser of the application, to a client-driven viewpoint, where the client is above a shopper however a functioning member. It may very well be invigorating to have an answer wherein every client possesses the information, for instance, on a little gadget in their home or their cell phones. Assuming these gadgets go about as protected, decentralized capacity, each obscure substance could get to effectively the information put away in it, regarding rules presented by the clients that are proprietors of what they share.

Before, the requirement for a lot of information and security issues was more fragile: the conventional technique for information assortment was through accounts on paper, clinical science was not upheld by existing innovation, and there was no huge measure of information accessible to utilize, prompting no clarification for quite a long time. With cell phones, it is currently conceivable to gather an enormous measure of information that could be utilized to convey and find new arrangements and medicines. By presenting the Web of Clinical Things, possibly any information gathered by a client could be taken advantage of with a particular objective. The audit pointed specifically at summing up reviews and examination papers that endeavor to comprehend the condition of the business according to a down-to-earth perspective and which are the connected issues that presently go about as boundaries for a resulting venture towards client centricity. A few papers have been examined zeroing in on their methodologies with blockchain to go towards a client-driven framework. Looking at the arrangements proposed, DLTs are underlining that they could bring another method of taking care of protection and security in the medical care setting, just as making the sharing of data between various foundations simpler. Through the accomplishment of explicit objectives such as client centricity, security, adaptability, and interoperability, the blockchain can be the driving innovation through which to foster enduring and free stages for information sharing that can offer protection and commitments.

In this way, IoMT can embrace the weights of medical care frameworks while IoMT likewise is additionally confronted with security and protection weaknesses. Then again, blockchain advancements might conceivably upgrade security and ensure the protection of IoMT frameworks. The arrangements brought by blockchain-empowered IoMT according to five viewpoints like a pandemic beginning, isolating and social removing, keen clinic, clinical information provenance, and distant medical services and telemedicine.

CONCLUSION

The design of 6G wireless networks, driven by the enormous and heterogeneous demands of hyper-connected existence of everything, will indeed give rise to new business avenues. Accordingly, this paper highlights the new intriguing challenges and canvassed the key role of blockchain to mitigate some of them. The widespread adoption of decentralized blockchain technology in IoT has significantly reduced the danger of sensitive healthcare data being exposed. We combine blockchain technology with IoMT (B-IoMT) in this chapter to enable secure data transfer over a 6G network connection. The blockchain's security characteristics aid in achieving tamper-proof data transfer in IoMT.

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Section 4

Applications of 6G Mobile Core Networks in Smart Healthcare

Chapter 13

6G With Smart Healthcare, Haptic Communication: An Overall Perspective

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ABSTRACT

From 2030 onward, 6G is a potential communication technology that will dominate the whole health sector. Finland was the first to start a 6G experiment in 2018. Second, in 2019, the US, South Korea, and China launched the 6G initiative. Japan has just announced a 6G research initiative for 2020. In addition, 6G has spawned a slew of new algorithms. It is now critical to begin the 6G project in order to avoid falling behind other countries. On the other hand, 5G communication technology has yet to be fully deployed globally, and B5G has yet to be created. 5G and B5G will have a number of disadvantages when it comes to revolutionizing current lifestyles, society, and industry. For example, due to the reduced data rate, holographic communication is not possible. As a result, now is the best moment to think about the future of 6G communication technology. It is also important to consider future healthcare in order to ensure the well-being of society's citizens. It will rule not just the health industry, but also a variety of other industries.

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INTRODUCTION

Many academics are interested in 6G communication technology because of its unique characteristics and benefits. It will change a variety of sectors, and we will see the effects starting around 2030. Many elements of 6G have previously been addressed in a prime forum, and various needs for 6G communication technology are constantly being gathered (Saad et al, 2017). Furthermore, Nayak & Patgiri (2021) discuss the difficulties and obstacles associated with 6G communication technology. Many nations have previously begun the implementation of 6G communication technologies. Finland was the first to start a 6G project in 2018 (Shashika Manosha et al, 2019). Second, in 2019 (Dang, S et al, 2020), the US, South Korea, and China launched the 6G initiative.

Because of its unique characteristics and benefits, 6G communication technology has piqued the interest of many academics. It will affect a wide range of industries, with the first signs appearing around 2030. Many features of 6G communication technology have previously been addressed in a public forum, and additional needs for 6G communication technology are constantly being collected (Gui, G et al, 2020).

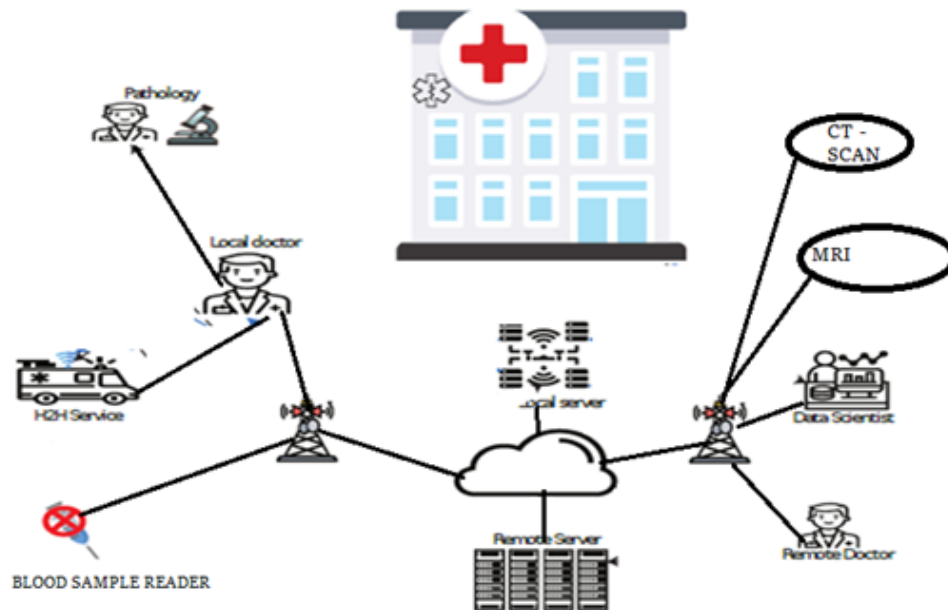
The current healthcare system only delivers basic treatments, and the most major impediments are time and distance. This is unavoidable in the current situation; nevertheless, it will not be a barrier shortly. Furthermore, the ambulance service is only a patient carrier with oxygen and priority on the road, both of which may be provided by a regular car. Furthermore, given present circumstances, the senior service is quite poor. Medical personnel must provide intensive care to the elderly. However, it is now unavailable. The majority of patients die in ambulances on their way from residence to hospital or before the ambulance arrives at the destination.

Furthermore, accident detection technology is currently unavailable in healthcare settings. The accident detection system requires real-time detection to provide medical aid on the spot. Furthermore, diseases and pandemic breakouts, such as COVID-19, cannot be managed to owe to a lack of technological infrastructure. A virus of this sort will develop in the future. As a result, it's vital to create an intelligent healthcare system.

6G communication technology for future healthcare (Chen, S et al, 2020) requires a high data rate (1 Tbps), high operational frequency (1 THz), low end-to-end latency (1 ms), high reliability (10⁻⁹), high mobility (1000 kmh), and a wavelength of 300 m. In particular, telesurgery necessitates real-time communication. Holographic communication and augmented/virtual reality will also aid intelligent healthcare systems. On the other hand, 5G and B5G will be unable to provide intelligent healthcare. Intelligent healthcare will be widely adopted in the 5G era, which will be a significant advancement. Rural connectivity, on the other hand, continues to be a challenge for both 5G communication technology (Yaacoub, E., & Alouini, M. S., 2020) and healthcare. Figure 1 depicts a landscape of intelligent health services, which shows how communication technology improves the performance of health services.

6G communication technology is predicted to fundamentally transform healthcare, with healthcare being reliant on communication technology. We shall see how communication technology has caused a paradigm change in healthcare. The existing state-of-the-art healthcare system is unable to do telesurgery due to communication issues. The ambulance service will also be phased away. Wearable technology has to be rethought. The facility has to be restructured. Real-time health care should be provided. Health monitoring and senior-care services need to be reconsidered. As a result, we expect 6G communication technology to be used in future healthcare.

Figure 1. Intelligent health care system



We also value the quality of service (QoS), quality of experience (QoE), and quality of life (QoL). We also predict the need for Hospital-to-Home (H2H) services, a Blood Sample Reader (BSR) sensor, Intelligent Wearable Devices (IWD), and a Business Model for Hospital Health Insurance (HIH). Artificial Intelligence (AI) and Edge technologies are also considered concerning healthcare.

The terahertz (THz) wave will be used for transmission in 6G (Gui, G et al,2020). The THz signal improves data rate and bandwidth. Furthermore, it will deliver three times the bandwidth of a 5G transmission, i.e. mm-Wave (Z. Chen. et al,2019). 6G will have a data throughput of at least one terabit per second (TBPS). The 5G and B5G communication structures are two-dimensional, but the 6G will be three-dimensional, i.e. time, location, and frequency. With the use of new technologies like edge technology, AI, cloud computing, and blockchain, 6G will be able to deliver 3D services. The 6G network will be pervasive and interconnected (Al-Eryani, Y., & Hossain, E.,2019).

6G will provide deeper and broader coverage through device-to-device, terrestrial, and satellite communication. 6G aims to combine processing, navigation, and sensing into a single communication network. In the sphere of security, 6G will address the security, secrecy, and privacy of Big data generated by billions of smart devices. However, there will be a shift from smart to intelligent gadgets.

REQUIREMENTS

The demands for 6G communication have been gathered and discussed by several researchers (Zhang, Y et al 2020 and Tomkos, I et al 2020). The fundamental specifications of 6G communication technology are 1 THz operating frequency, 1 Tbps data throughput, 300 m wavelength, and 1000 kmh mobility range (Saad et al, 2017 and Nayak, S., & Patgiri, R. 2021). The 6G design is three-dimensional, taking time, space, and frequency into account. End-to-end latency, radio delay, and processing requirements

for real-time communication are 1 ms, 10 ns, and 10 ns, respectively ((Rappaport, T. S et al, 2019). Furthermore, 6G will be a communication system powered by artificial intelligence (Nayak, S., & Patgiri, R. 2021). Satellite is expected to provide comprehensive support for 6G.

Intelligent Radio (IR) will take the place of the NRLite (Letaief, K. B, 2019). In addition, the Internet of Everything (IoE) will replace the Internet of Things (IoT) as the primary network (IoE). Many technologies are predicted to be enabled and revolutionized by 6G in the future. Transitions from IoT to IoE, Smart Devices to Intelligent Devices, and other many possibilities will be demonstrated. The following table depicts the comparison of 5G, B5G, and 6G.

Table 1. Comparison of 5G, B5G, and 6G technologies

Requirements	5G	B5G	6G
Application types	eMBB • URLLC • mMTC	Reliable eMBB • URLLC • mMTC • Hybrid (URLLC + eMBB)	MBRLLC • mURLLC • HCS • MPS
Device types	Smartphones • Sensors • Drones	Smartphones • Sensors • Drones • XR equipment	Sensors and DLT devices • CRAS • XR and BCI equipment • Smart implants
Operating frequency	3-300 MHz	500 MHz	1 THz
Data Rate	1 Gbps	100 Gbps	1 Tbps
End-to-end delay	5 ms	1 ms	<1 ms
Radio-only delay	100 ns	<100 ns	£10 ns
Processing delay	100 ns	50 ns	£ 10 ns
Mobility range	100 – < 500 km/h	500 km/h	1000 km/h
Wavelength	3 mm	1 mm	300 µm
Architecture	Massive MIMO	Massive MIMO	Intelligent surface
Core network	Internet of Things	Internet of Things	Internet of Everything
Satellite integration	Partial	Partial	Full
Artificial Intelligence integration	Partial	Full	Truly Artificial Intelligence-Driven
XR integration	Partial	Full	Full
Haptic communication integration	Partial	Full	Full
Highlights	Extremely high rate of Streaming	Extremely high rate of Streaming	Security, secrecy, & privacy

TRANSITION FROM SMART TO INTELLIGENT

6G will utilize terahertz (THz) radiation, also known as submillimeter radiation. Electromagnetic waves having wavelengths ranging from 1 mm to 0.1 mm are referred to as submillimeter radiation. THz has various advantages for 6G communication, including high bandwidth, high data rate (up to several

Gbps), high capacity, and high throughput (Chen, S et al, 2020). The efficiency of THz signals may be increased by recycling and sharing the spectrum. Cognitive radio and other spectrum reuse methods are already in use (CR). It allows numerous wireless systems to share the same frequency by using spectrum monitoring and interference management techniques (Chen, S et al, 2020). A spectrum that is temporarily underutilized or unlicensable as a result of spectrum sharing.

Symbiotic radio (SR) is a novel wireless networking technology that supports intelligent, heterogeneous networks. It will aid in the effective sharing of the spectrum. However, implementing these approaches in a 6G wireless network remains difficult. Furthermore, because of physical restrictions, continuous THz signal production is difficult. An antenna/transmitter is equally difficult to design. Furthermore, after a short-distance transmission, the signal is reduced to zero. It happens as a result of energy loss, which includes molecule absorption and spreading loss (Han, C., & Chen, Y., 2018).

6G is projected to be a true AI-driven communication technology, allowing for the introduction of the intelligent era (Nayak, S., & Patgiri, R. 2021). As a result, in the 6G era, all smart gadgets will be transformed into intelligent devices. We will see numerous transitions from smart to intelligent objects as AI and mobile connectivity become more prevalent. IoT will become intelligent after 2030, and IoE will take its place. Intelligent phones will take the place of smartphones. Intelligent gadgets will be AI-powered devices with Internet connectivity. As a result, the intelligent device (which may be a little gadget) will be able to forecast, make decisions, and share their knowledge with other intelligent devices. Therefore, there is a paradigm shift from the smart to intelligent era using 6G communication technology.

QUALITY OF SERVICES

Quality of Service (QoS) attributes of 6G technology is superior to those of 5G and B5G. QoS includes, for example, high data rates, extremely reliable and low latency communication (ERLLC), further-enhanced mobile broadband (FeMBB), ultra-massive machine-type communications (umMTC), long-distance and high-mobility communications (LDHMC), and very low-power communications (ELPC). QoS (Gui, G et al, 2020) also includes mobile broad bandwidth and low latency (MBBLL), massive broad bandwidth machine type (mBBMT), and massive low latency machine type (mLLMT). A wide range of applications might be revolutionized using these QoS service characteristics. As a result, 6G will be demonstrated to be a game-changing technology in several ways.

QUALITY OF EXPERIENCES

The Quality of Experiences defines a high level of service (QoS) and user-centric communications (QoE). QoE will be achieved by holographic communications, augmented reality, virtual reality, and tactile Internet, which require a high data rate with extremely low latency. Furthermore, QoE is expected to have a significant impact on fields such as intelligent autos, intelligent devices, intelligent healthcare, intelligent drones, and many others. Only until 6G technology achieves all of the essential qualities can a high QoE be achieved. 6G will be a true AI-driven communication technology (Nayak, S., & Patgiri, R. 2021), leading to significant changes in our lives, society, and businesses. Furthermore, 6G promises to enable five-sense communication, resulting in high quality of experience. As a result, 6G connectiv-

ity will be a watershed moment in healthcare. For vital operations, intelligent hospitals, and intelligent healthcare, high QoE is required.

QUALITY OF LIFE

Quality of Life (QoL) is described in healthcare as an enhanced lifestyle with QoS and QoE. 6G technology will deliver excellent QoL by utilizing communication technologies. Although QoL is not a significant feature of 6G communication technology, it will be in intelligent healthcare systems. 6G will be able to provide great QoE while also meeting the requirements for QoL metrics. Remote patient monitoring, particularly for the elderly, connection to intelligent wearable devices (IWD), intelligent accident detection, telesurgery, and precision medicine are just a few of the important areas of QoL, with many more to come. H2H (Hospital-to-Home) services are also an important part of QoL.

The mobile hospital will have to meet certain criteria to be classified as a hospital, including the presence of medical personnel. This service is critical for improving QoL and emergency services in today's society. In addition, a new health insurance policy called Health Insurance at Hospital (HIH) will be introduced to replace the present health insurance policy. HIH will boost trust in-hospital services and is also factored into QoL. Shortly, hospitals will be graded based on QoL factors.

Enabling Technology For 6G

Supporting technologies are necessary to deliver on the promises of 6G communication technology. 6G is an AI-driven communication technology (Nayak, S., & Patgiri, R. 2021) that requires AI to be integrated into its communication technology. Furthermore, the Internet of Everything (IoE) will be enabled by 6G, which will assist a range of sectors. For 6G technology to bring Cloud capabilities closer to intelligent devices, edge technology is also necessary. As a result, 6G communication technology incorporates several different technologies.

INTERNET OF EVERYTHING (IoE)

High-level sensing is becoming more popular. In the medical industry, it's essential for holographic communication. The captured data is converted to digital data, which is then kept in a local cache and sent to remote locations in real-time. Signals are occasionally converted from digital data and transferred to other devices for processing. Before the invention of computers, cognition aided in the formulation of viable judgments based on digital data intake. These are ingenious choices that make computing easier. The computed data is supplied to smart devices to help regulate the operations of smart devices in healthcare (Gui, G et al, 2020). For example, increasing public knowledge of diseases and pandemics.

It will rely on the merged and improved eMBB and mMTC core services. To support touch interactions in intelligent devices for healthcare, large data rates will be required. 6G will require IoE to have a massive capacity for connecting millions of intelligent devices, collecting tactile sensations, and converting them to digital data (Gui, G et al,2020). In healthcare communication, there is a lot of capacity for connecting sensors and actuators. Low latency is also required to ensure smooth interaction between them (Gui, G et al,2020).

When 6G becomes commercially available, it will no longer be the Big Data era, but rather Big Data 2.0. To compute and analyze enormous amounts of small-scale data produced by healthcare devices, Big Data 2.0 necessitates the use of a supercomputer (Nayak, S., Patgiri, R., & Singh, T., 2018).

EDGE INTELLIGENCE

6G will rely on Cloud computing for Big data storage, computation, and analysis (Nayak, S., & Patgiri, R. 2021). Intelligent gadgets send data to the cloud for storage, but this uses up communication resources and bandwidth. As data grows at an exponential rate, technologies are being pushed closer to the data source. This form of technology is known as edge technology. 6G promises a large capacity for delivering seamless services to billions of smart devices. 6G will use edge technology to provide seamless and high-speed Internet access to intelligent devices, which is critical in healthcare. Edge technology now gathers, computes, and analyses health data in real-time.

Intelligent medical gadgets are closer to these nodes. The data that the user generates is sent to the Edge nodes. The health data is also computed by the Edge nodes. The data is then analyzed by Edge nodes, which then decide on the best course of action. Edge nodes, for example, will collect user health data from intelligent medical equipment and assess whether the user is deficient in any way. Edge nodes receive health data regularly. The health-related data is monitored by the Edge node. The health-related data is also filtered by the edge node, which then sends the essential data to the cloud for storage. Communication and processing costs are reduced via edge technology.

Low latency, dependability, privacy, scalability, and flexibility are some of the additional benefits of Edge technology. As a result of the large number of intelligent devices that will connect to 6G Internet, all of the benefits of Edge technology will substantially assist 6G in meeting its criteria for high QoS in healthcare. Edge intelligence is the result of the union of edge computing and AI. Edge intelligence is applied in Edge nodes through the use of AI algorithms for analysis, which is referred to as Edge analytics. Edge nodes receive a large number of health-related data, which is analyzed using AI to discover patterns or compute them. Edge nodes may generate an image, data, and video Edge analytics with the aid of AI.

GigaSight is a video Edge analytics platform with decentralized hybrid cloud architecture. Xie et al. implemented video analytics with lightweight virtualization using container technology. Nikolaou et al. provided data filtering in Edge nodes using predictive Edge analytics. In a similar vein, Cao et al. developed descriptive analytics for mobile Edge nodes. On the other hand, AI approaches are computationally intensive. AI algorithms now need a large number of processing resources as well as a large amount of power, both of which are limited in Edge nodes. As a result, they rely on cloud computing to do their work.

In 6G, however, edge nodes will be one of the network nodes. All 6G network nodes will be AI-enabled to give intelligence services to healthcare systems. Furthermore, 6G will have a real-time intelligent edge, which will enhance the healthcare system greatly. In real-time, it will calculate and analyze data. It is crucial to execute AI algorithms at Edge nodes rather than the Cloud to decrease latency in providing services (Al-Eryani, Y., & Hossain, E., 2019).

HOLOGRAPHIC COMMUNICATION

A hologram is a three-dimensional light field that is a physical representation of an interference pattern formed by diffraction. The produced image has the parallax, depth, and other features of the original item. Holographic communication uses many cameras to create a hologram of an object. The unified and upgraded eMBB and URLLC core services will be used. Significant data rates will be necessary to provide optimal service quality and to stream high-definition movies. Furthermore, very low latency is essential for real-time voices and quick control reactions (Gui, G et al,2020).

Holographic communication will be a game-changer in the realm of medicine. This is a service that 6G will be able to deliver. 6G Holographic communication will allow people to communicate with one another. In the event of an emergency, doctors may have to wait for specialist doctor(s) to make a diagnosis. Using holographic communication, expert doctor(s) can diagnose the patient while traveling. And, if required, can monitor a doctor to receive immediate medical attention. Frequently, the patient must see numerous doctors acquire an appropriate diagnosis, or the therapy is not offered in that facility. It's conceivable that the patient will have to go to other states or nations. It becomes a financial and physical strain in such circumstances.

Traveling while ill is also very stressful for the patient. Doctors, on the other hand, can diagnose patients remotely using holographic communication. The patient's only option for treatment is to go to the hospital. Expert doctors will be able to provide services in rural areas while remaining in cities or towns thanks to holographic communication. 6G holographic communication, like 6G global coverage, will aid global healthcare connectivity. The professional doctor can give services immediately upon request, without having to change their schedule or travel. Furthermore, various doctors from around the world will be able to communicate and oversee each other in difficult medical problems.

ARTIFICIAL INTELLIGENCE

6G will be a true AI-driven communication network. Every component of network communication will become intelligent with 6G, allowing the system to become self-aware, self-compute, and self-decide in a circumstance. 6G aims to give worldwide coverage, including space, air, and water. Only by making many elements of communication "intelligentAI" will this be possible. The use of AI algorithms in communication networks has resulted in excellent accuracy and performance. True AI-powered communication can provide real-time communication, which is critical in today's healthcare. Clinical diagnostics and decision-making are improved by AI-driven healthcare. Healthcare necessitates the use of artificial intelligence (AI) to complete tasks.

It takes actual health data and computes it, allowing real-time data to be used as input. Furthermore, it computes a huge number of network parameters with excellent accuracy. Deep Reinforcement Learning is another AI method that is presently being tested on health data (DRL). The system creates a few decisions initially, then monitors the outcomes via reinforcement learning. The choice is recalculated based on the observation to arrive at an ideal decision. DRL is a hybrid method that combines the benefits of reinforcement learning with deep neural networks.

As a result, DRL delivers great performance in a short amount of time. Furthermore, federated AI will share their expertise with intelligent gadgets, enhancing healthcare. The performance of AI algorithms has been impressive. AI algorithms necessitate substantial investment in infrastructure. For proactive

caching, AI is also desirable. Parallelism in training should be investigated for Big Data. All AI algorithms require a lot of processing power. The high-computing task takes a long time and uses a lot of energy. 6G, on the other hand, is unable to give such comfort. The AI algorithms that will be used in 6G will have issues of their own. In a Neural Network, for example, there are a lot of layers

AUGMENTED REALITY AND VIRTUAL REALITY

Augmented reality (AR) allows virtuality to be added to real-world items. It is also combined with a variety of sensory abilities such as audio, visual, somatosensory, haptic, and so on. AR also allows for real-time interaction and properly displays 3D representations of virtual and real-world things. Virtual reality (VR) is the presentation of a made-up or virtual environment in which nothing is genuine. The fundamental service of integrated and improved eMBB and URLLC will be used for AR and VR. To ensure acceptable service quality, large data rates will be required. In addition, high-definition videos may be streamed. Furthermore, for real-time voices and fast control reactions, very low latency is necessary (Gui, G et al,2020).

MBBLL (Gui, G et al,2020)can deliver a peak data throughput of 1 Tbps and a user experience of >10 Gbps with >0.1 ms latency for AR and VR. Both AR and VR are currently in development. 6G, on the other hand, will offer up new possibilities for its application in the sphere of healthcare. AR will let doctors see into a patient's body without making any incisions. Furthermore, doctors can alter the depth of a certain bodily region. For greater visibility, the specified body area can be expanded. Doctors will be able to observe a patient remotely thanks to 6G. For improved diagnosis, AR and holographic communication can be merged.

Doctors may perform medical operations without a patient using virtual reality. It will be extremely useful if you are doing high-risk treatments or surgeries. All of these devices will be intelligent and connected to the Internet through 6G technology. As previously mentioned, 6G may be used to produce a seamless and high-resolution display for remote medical learning or diagnostics.

TACTILE/HAPTIC INTERNET

Haptic technology creates a virtual touch by applying force, motion, or vibration to the user. Tactile Internet is a technique for sending a virtual touch from one user to another, whether human or robot. Tactile Internet requires a high-speed connection as well as the use of the EURLC to gather tactile data in real-time. With this technology, telesurgery, or remote surgery, will be conceivable. It will also let doctors diagnose patients through touch without the need for them to be physically there. Desktop, surface, and wearable haptic human-computer interaction (HCI) are the three categories of haptic HCI.

The remote doctor will be able to use a virtual tool for surgery or diagnosis in desktop HCI. The movement in surface HCI is 2D rather than 3D. A flat-screen device, such as a smartphone or tablet, is used to issue commands. The robot may be instructed to engage with the patient by moving the hand on the screen. A haptic glove, for example, is used by the remote doctor in wearable HCI. Tactile/haptic technology will also aid in the provision of healthcare in the event of a disaster. For example, the COVID-19, when all nations are under lockdown and all communication with the outside world is prohibited, or natural calamities. Tactile/haptic technologies will aid healthcare in such instances.

Expert physicians can use robots to conduct complicated surgery from afar. Furthermore, medical professionals are put in grave danger during epidemics and pandemics. A little negligence might put them at risk of contracting the deadly/contagious illness. Robots can engage with or care for patients using tactile/haptic technologies while the medical staff is present remotely. All of this is possible thanks to the 6G high-speed, low-latency Internet.

Intelligent Internet of Medical Things

Under the 6G communication paradigm, the Intelligent Internet of Medical Things (IIoMT) will expand and support a range of human well-being goals. IIoMTs are AI-powered intelligent devices that use communication technology to make their judgments. IoE, which will enable medical equipment to connect to the Internet, will emerge alongside IIoMT. For instance, an MRI or a CT scan. As indicated in Figure 1, the scanner will scan the devices and use 6G technology to send the data to remote places. This information may be evaluated in real-time by a pathologist. Almost all medical gadgets will be able to connect to the Internet, enabling instant decision-making.

As a result, the IIoMT will be able to overcome time, location, and financial constraints. Patients with cancer, for example, can readily be treated by doctors who are located far away. Currently, determining whether cancer patients are benign or malignant takes time. Cancer can, however, be identified in real-time utilizing 6G communication technologies shortly. Furthermore, neither the physicians nor the patients are required to attend specialized hospitals. It requires both time and money. As a result, cancer patients will be treated by remote doctors in conjunction with local experts. Cancer patients who are detected early can have their death rate reduced to practical nil. Such sensors, on the other hand, must be invented. This scenario is not limited to cancer, but also applies to many diseases

BLOOD SAMPLE READER

Blood is necessary for life, and it may be used to diagnose the majority of disorders. Needles are used to collect blood from the human body in conventional blood sampling. However, needle-free blood collection equipment is the subject of a lot of studies. For diabetic patients, Lipani et al. developed a needle-free glucose monitoring approach. The Blood Sample Reader's (BSR) sensors will be a needle-free intelligent wearable device. The BSR sensors will permanently alter the healthcare industry. All blood parameters, such as WBC, RBC, and so on, will be precisely read by BSR. The BSR sensor will remain connected to the Internet via 6G.

A blood sample will be sent to a testing center for test results regularly, either automatically or with the patient's agreement. As a result, there will be no need for manual intervention while evaluating blood samples. This gadget will be critical in the intense care and monitoring of the elderly. Furthermore, utilizing BSR sensors, the COVID-19 epidemic may be readily terminated. Countries are running out of medical supplies as the number of patients rises into the millions. The medical personnel is exposed to the illness when they take a blood sample with a needle. This BSR sensor can readily monitor the COVID-19 virus's spread in real-time. As a result, it will be extremely useful during epidemics and pandemics. Therefore, BSR sensors will be the most demanded medical devices in the future.

INTELLIGENT WEARABLE DEVICES

Intelligent Wearable Gadgets (IWDs) are Internet-connected devices that give test and monitoring centers with psychological and physical data. These devices will keep track of your heart rate, blood pressure, blood tests, health issues, body weight, and food. The results of the tests will be received as quickly as feasible. IWD also uses a person's specific body history to suggest what they should do next, such as go for a walk or jog. IWD will monitor her health, food, and habits. As a result, IWD may provide recommendations for what to eat in the case of a shortage. If minor bodily difficulties, such as deficiency, are discovered, the number of hospital visits will be minimized.

As a result, hospital bills will be lower, and hospitals will be able to focus on more complicated disorders. In addition, IWD will read a blood sample, which will then be sent to pathological findings. As a result, IWD may be used to diagnose cancer early. As a result, IWD has the potential to improve health and extend human life. It is also critical in senior care since elderly care necessitates intense attention. IWDs in the future will integrate many functions into a single device. All of the functions will be contained in a single device. The initial cost of such gadgets will be high, but with time, the cost will fall and the general public will be able to buy them.

Hospital-To-Home Services

Ambulance services are now only used to transport patients who require oxygen and have a high priority for road traffic. Due to a lack of intelligence, it is unable to provide emergency services. As a result, ambulance services have no bearing on our lives. If we retain oxygen and an emergency signal in every regular automobile, we can get the same results. As a result, to enhance living, a new type of ambulance service is necessary. Hospital-to-Home (H2H) services will be developed to replace ambulance services. Hospitals may now reach out to patients at home on demand and in an emergency thanks to advancements in communication technology.

Future vehicles will be AI-driven to build intelligent autos. As a consequence, H2H will be implemented on a mobile hospital platform driven by an intelligent vehicle platform, with no dependency on hospitals, physicians, or nurses. This mobile hospital will take the place of ambulance services. A mobile hospital, for example, can identify and respond to an accident in real-time. Before arriving at the facility, the mobile hospital will begin treating patients. A mobile hospital can also recognize any emergency in real-time and react fast to save lives. It will also benefit modern lives. It's particularly critical in the care of the elderly. As a result, 6G connectivity transforms current lifestyles through H2H services.

TELESURGERY, EPIDEMIC, AND PANDEMIC

Telesurgery is becoming more popular, and it is an idea for the future. The doctor(s) characterize it as "remote surgery". Telesurgery necessitates the use of robots, nurses, and a remote doctor mediator. Telesurgery relies heavily on communication. It also needs a high data rate and URLLC. These criteria are not met by 5G and B5G. As a result, telesurgery necessitates the use of 6G technology. Furthermore, telesurgery requires real-time communication to be successful. The doctor can guide telesurgery patients using verbal, telestration, or tele-assist technologies. 6G communication technology can meet the needs of telesurgery, and 6G will demonstrate that surgery can be performed flawlessly.

Holographic communication may provide more engaging verbal instruction as a result of 6G. The doctor may be present during the procedure for training and can even walk around using holographic communication to have a better perspective of the surgical region. Telestration is a method of demonstrating a surgical procedure remotely, such as by video. In intelligent healthcare, AR and VR can be used for telestration. The doctor(s) can also tele-assist the procedure using tactile/haptic technologies. 6G communication technology can suit telesurgery's demands, and it will show that surgery can be conducted across boundaries.

In epidemics and pandemics, communication technologies will be critical. Epidemics and pandemics are mostly diseases spread from person to person. As a result, medical personnel is frequently referred to as "suicide squads." COVID-19 has recently claimed the lives of thousands of people, including medical personnel. COVID-19 outbreaks might be readily controlled with the use of IIoMT. For example, each person's blood sample is sent to a testing facility through a BSR sensor without exposing them to the outside world, and the results are delivered to their homes.

An intelligent wearable device (BSR sensor) will obtain a blood sample and communicate the data to the test centers. As a result, the human chain may be readily broken and the epidemic can be monitored in real-time. Currently, millions of COVID-19 positives have been discovered, requiring billions of tests. This worldwide catastrophe necessitates the implementation of intelligent healthcare systems and IWD.

PRECISION MEDICINE, NEW BUSINESS MODEL, SECURITY, SECRECY, AND PRIVACY

Precision medicine is the development of personalized medicine or treatment for a patient's better care (Z. Chen et al, 2019). Doctors/researchers research to create precision medicine by grouping patients based on common criteria. Precision medicine will benefit tremendously from the development of 6G technology. It also needs AI to deliver tailored healthcare (Al-Eryani, Y., & Hossain, E., 2019). Clinical trial participants' health data is needed for better therapy development. Cell therapy research, for example, is being conducted for the treatment of essential diseases.

IWD allows doctors and researchers to collect data. This data will be collected in real-time, allowing for more accurate health statistics to be provided. Furthermore, the study may be carried out anywhere in the world. A person's immune system is influenced by their geographical location. As a result, concentrating the persons under observation in one area will alter their surroundings. And this will have an impact on the research. As a result, the doctor/researcher will use IIoMT to observe the persons under surveillance all over the world.

6G will change companies, necessitating a rethinking of the hospital's traditional economic model. Currently, the patient or the health insurance policy pays the hospital directly for the treatment costs. A corporation manages the health insurance coverage. The corporation establishes a hospital network. This hospital accepts cashless payments, and any costs incurred are billed to the firm. Many illnesses and geriatric health treatments are not covered by most insurances. During treatment, this business model separates the hospital and the insurance company, and payment is paid to the hospital.

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geriatric health treatments are not covered by most insurances. During treatment, this business model separates the hospital and the insurance company, and payment is paid to the hospital. HIH has to take care of geographical locations while forming a network of hospitals.

Insurance premiums will be paid directly to the hospital on a yearly or monthly basis. The hospital will be able to operate with the funds provided by the insurance company. From birth until death, the hospital will look after a person's health. To go to the hospital, a patient can phone the H2H service. The hospital will check the HIH identity before admitting the patient to any of the partner hospitals. Priority will be given to the patient. The patient does not have to pay any medical bills after being discharged from the hospital.

QoL concerns such as IWD connection and monitoring, H2H services, telesurgery, surgery, pregnancy and delivery, immunizations, ICU, NICU, elderly, customization, and precision pharmaceuticals will also be addressed by this policy. Cancer, the flu, cardiovascular and neurological disorders, and other illnesses and accidents are covered by HIH. The number of treatments a patient can get will be unlimited. There will be no invoices, claims, or hassles because the coverage will cover OPD and all other medical charges, including pathology and pharmaceutical costs.

Security, secrecy, and privacy are essential features of 6G technology (Dang, S et al, 2020). As a result, 6G necessitates secure URLLC (sURLLC) for more secure communication. The highest level of security is promised by 6G communication technology. It will use federated AI, quantum machine learning, quantum computing, and THz communication to protect against assaults. THz communication is impenetrable to eavesdropping and jamming (Nayak, S., & Patgiri, R. 2021). For data transmission via the network in healthcare, a high level of security is required. Any tampering with health information has the potential to kill a patient. As a result, safeguarding health information from hackers is critical. Furthermore, 6G communication technology emphasizes the confidentiality of the most sensitive data.

Except for the data's owner, sensitive information is kept private. Administrators are also not allowed to see this sensitive information. Take, for example, family history. Furthermore, 6G focuses on privacy, which is one of the most important aspects of healthcare. Edge technology will be used in 6G to improve privacy. The Edge nodes are closer to the smart gadgets. In the same Edge nodes, the computed data is also examined. Because edge nodes have limited memory, all data is not concentrated in a single area.

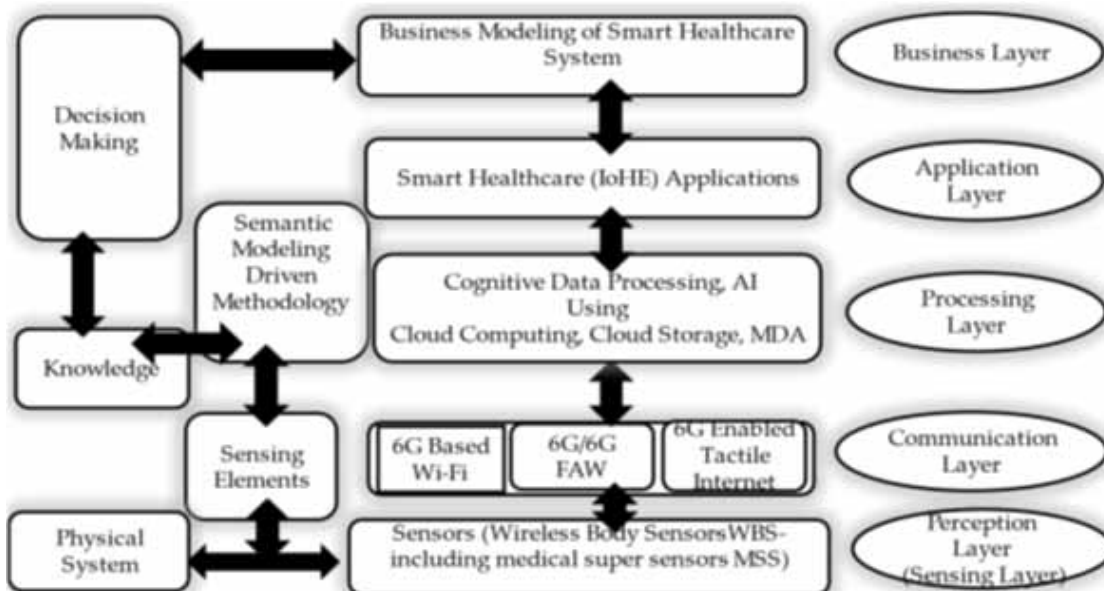
As a result, Edge protects the user's privacy. Another essential aspect to consider is data filtering by Edge nodes. Edge nodes filter data and send only the most critical data to the Cloud. It also means that less information about the user is stored in the cloud. As a result, Cloud makes it easier to ensure security for smaller amounts of data. Blockchain provides a high level of anonymity for health data in the current environment. It provides a safe environment for processing health information. Blockchain, along with more sophisticated technology, will be extremely useful in intelligent healthcare in the future.

SYSTEM ARCHITECTURE

Sensing Layer

The sensing (perception) layer involves multiple sensors for monitoring patient health parameters and communicating the knowledge to application devices. Even though a WBS, including MSS, senses data from the patient, this must be conveyed across the communication network to the processing node.

Figure 2. The architecture of the intelligent health care system(IoH)



Transport Layer

The 6G Tactile Internet, which combines speed, accuracy, real-time latency, energy conservation, and consistency among sensors and actuators close to a human body, would be at the heart of communication for the transport layer in the Intelligent Health Care system paradigm. By using different sensors to read a patient's health parameters, the 6G Tactile Internet, 6G Wi-Fi, or 6G FAW can contribute to minimizing healthcare expenses and increasing quality, thus raising the patient's quality of life.

Processing Layer

Cloud computing is a computing model that offers cloud services such as Software-as-a-Service, Platform-as-a-Service, Infrastructure-as-a-Service, and Database-as-a-Service through a pool of customizable resources that can be accessed to massive amounts via the 6G enabled Tactile Internet. Cloud computing is one of the Intelligent Healthcare System's software packages, and it presents significant advantages to health providers such as quick flexibility, self-healing, and self-configuration.

The five-layer IoH system is used at the processing layer, also termed as the middleware layer.

The plethora of sensors in the Internet of Things generates a substantial array of data that can be stored and processed with cloud infrastructure. Health researchers can keep a record of a patient's health by obtaining data from numerous sensors and preserving it in the cloud. Even though the cloud has many conveniences, one of the most key limitations is latency. The sensors' data collecting and assessment are accessed through the Internet, and physicians must be notified.

Application Layer

Although healthcare applications have special requirements, the five-layer architecture was chosen to have a direct impact on application performance. As a result, applications with equivalent themes and scope are classified into the following categories: real-time monitoring and alert production; (ii) telemedicine; (iii) serious illness detection and prevention; and (iv) home and aged healthcare. The role of the Intelligent Healthcare system and supporting technologies in each of these healthcare application categories is as follows: WBS can be deployed on a human body through the IoH to measure parameter settings, and data can be examined for prescribing appropriate medication to patients in disasters; and (ii) an e-health system is applied for continuous monitoring of ECG, temperature, foot pressure, and heart rate.

Business Modeling Layer Value Co-Creation through Business Models

The disease's essential business model concepts have parallels in technology-based firms that are similar to those seen in the ICT industry. Product advances forced many companies to restructure their business model, switching to providing services and solutions for smart healthcare. ICT, like healthcare today, was part of a generally maturing economy with disruptive innovation a generation ago. To identify opportunities for improvement and achieve excellent returns, one must re-imagine business models to build ways to innovate at scale and speed.

CONCLUSION AND FUTURE ENHANCEMENT

Intelligent healthcare must improve quality of life. IIoMT, IWD, H2H, and HIH are all parts of intelligent healthcare. All IIoMTs need high-quality mobile connectivity, AI integration, and Edge and Cloud Computing compatibility. BSR sensors are an important part of the IIoMT. Sensors for BSR have yet to be developed. BSR will be able to address a variety of healthcare concerns. As a result, the research community must pay close attention to the BSR sensor. IWD is another well-known IIoMT. IWD will be a game-changing technology in healthcare, featuring a variety of sensors, including BSR.

It will aid in the automated identification of numerous disorders and significantly enhance a person's health. Also, a person does not need to go to the hospital for routine checkups such as blood tests, blood pressure, sugar levels, and so on. IWD sends personal health data to a health monitoring center regularly to detect any abnormalities. In addition, an old person can be watched without the involvement of medical personnel. The integration of IWD with the healthcare system will automatically take care of the individual without the participation of medical personnel. Elderly service demands intense care.

IWD will also learn about the patient's medical history, eating habits, bodily structure, pollution levels, and any other abnormalities. The current ambulance service is only patient transportation with inadequate medical supplies. H2H services should take the place of this service. Because the H2H service has the potential to save billions of lives, it must be implemented as soon as possible on intelligent vehicles. Furthermore, by employing the H2H service, the accident death rate can be decreased.

Furthermore, intelligent healthcare necessitates a new hospital business philosophy. Hospitals' current business models are health insurance and direct payment. The health insurance only covers a limited number of illnesses, including COVID-19, the Ebola virus, pregnancy, and delivery. The HIH business model will be a genuinely hassle-free, cost-free therapy. However, for the HIH business model to suc-

ceed, much study is necessary. However, because HIH covers all expenditures connected to a person's treatment, the premium may go up.

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Chapter 14

6G With Smart Healthcare Systems

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ABSTRACT

6G is a sixth-generation telecommunications standard that is presently being developed for wireless communications technologies that support cellular data networks. The ongoing deployment of 5G technology has urged researchers to explore what occurs next. From 2030 onward, 6G is a prospective communication technology that will enable wireless healthcare to become a reality. The current trend in the smart healthcare system has obstacles like risk of failure, security, and privacy. Healthcare will be absolutely AI-driven and reliant on 6G connectivity technologies, transforming our lifestyle perceptions. In order to have access, creative solutions must be introduced to improve our way of life including intelligent wearable devices, hospital-to-home services, intelligent internet of medical thing, quality of life (QoL), and new business strategy. The proposed intelligent healthcare system is classified into three major modules: hospital atmosphere, remote medical care, and disaster retaliation.

INTRODUCTION

The latest 5G (Fifth Generation) wireless communication technology is being consistent and brought into play from 2020 across the globe. The 5G technology was framed with a new architecture design contributing three major communication scenarios eMBB (enhanced mobile broadband), mMTC (massive machine-type communications), uRLLC (ultra-reliable and low latency communications even though, 5G transmission communication will not encounter all the requirements in the future of 2030 to satisfy the

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future requirements there is a need to move beyond 5G wireless communication technology. To satisfy the requirements like higher data rate and ultra-high-speed communication. The current implementation of 5G is expanded and upgraded which leads to the development of new 6G (Sixth Generation) wireless communication technology which is an obvious revolution from 2030 onwards.

In day-to-day life the society and organizations are generating a large amount of data, this phenomenon trends to the next decade and revolution of technology which should support intelligence and automation with an excess of new applications and different challenges towards 6G technology. 6G technology's primary goal is with the evolution of Virtual Reality (VR) and Mixed Reality (MR) Services in the future. In 6G wireless communication technology, the desirable future events in 5G technology such as high data rate, connection density, communication reliability, area traffic capacity, end-to-end delay, spectrum and energy efficiency, etc. are the key performance indicators (KPIs) to enhance the performance of 5G technology. The pre-eminent role of newly generated KPIs in 6G wireless communication technology is to support Distributed Artificial Intelligence (DAI).

As discussed in Akyildiz, I. F., Kak, A., & Nie, S (2020)., the following KPIs function are the basic metrics to evaluate the system performance.

System Reliability

This category of KPIs is now mostly concerned with measurements of system throughput. Peak rate, experienced knowledge rate, peak spectral potency, experienced spectral efficiency, most channel bandwidth, space traffic capacity, and affiliation density are some of the phrases utilized. The experienced data rate and spectral efficiency measurements view the metric that should be certain to 95 percent of user locations in this factor.

System Response Time

Along with delay interference, it includes the end-to-end latency statistic. Jitter may be a new KPI for 6G that measures latency fluctuations inside the system that is not present in 5G.

System Management

They usually deal with network management and orchestration criteria such as energy efficiency, dependability, and mobility. We should note that whereas 5G does not identify a target KPI for the energy efficiency indicator, 6G does, with a target of one Tb/J.

We establish the following essential thrusts in particular:

New Radio Style Paradigms and Spectrum Usage

The need for higher knowledge rates and hence wider channel bandwidths will drive the introduction of rate (THz) and sub-THz spectrum into 6G, as 5G ensures the adoption of mmWave spectrum. At the same time, the introduction of additional spectrum bands will necessitate new radio modes capable of sensing and communicating throughout the entire electromagnetic spectrum.

Innovative Network Architectures

The conventional cell-based wireless network design is incapable of meeting the world traffic capacity and affiliation density requirements imposed by 6G. Instead, 6G will integrate communication infrastructure into the environment's natural materials.

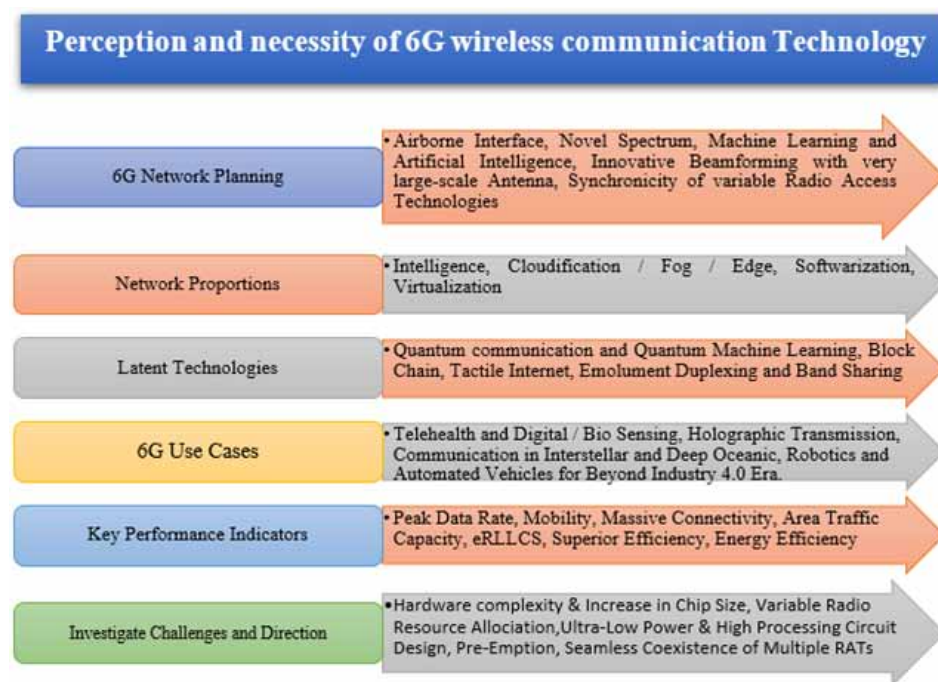
Increasing Intelligence and Automation

Because of strict channel capacity, stability, and delay requirements of 6G, physical network configuration is unfeasible. Rather, network intelligence and automation will take centre stage, assisting in the development of a more autonomous network.

Increasing Network Coverage Outside of the Terrestrial Domain

Increasing Network Coverage Outside of the Terrestrial Domain: In order to achieve full wireless ubiquity, 6G will go beyond terrestrial networks, encompassing both near-Earth and deep-space connectivity.

Figure 1. Potential coverage scenario of 6G wireless communication technology network and beyond



Nayak, S., & Patgiri, R. (2021) states that 6G technology is projected to transform the medical system entirely and it is wholly reliant on technology. Due to communication challenges, the current medical system is inadequate to prepare telesurgery. Furthermore, the ambulance service will be faded out. Wearable devices must be redesigned. Restructuring is requisite at the hospital. Medical care should

be delivered in real-time. Health monitoring and elderly-care services must be revised. As a result, we imagine future healthcare employing 6G communication technologies from this perspective. Smart healthcare involves a variety of stakeholders, including physicians, hospitals, and research institutions. Information technologies such as the Internet of Things, mobile Internet, cloud computing, big data, 5G, microelectronics, and artificial intelligence, as well as current biotechnology, are at the heart of smart healthcare. In all sectors of smart healthcare, these technologies are frequently used. Tian, S., Yang, W., Le Grange, J. M., Wang, P., Huang, W., & Ye, Z. (2019) states that patients can utilize wearable gadgets to keep eye on their health every time, look for medical care through a virtual attendant, and use remote houses to implement remote services; doctors can employ a variety of sophisticated clinical support systems to aid and enhance diagnosis.

6G TECHNOLOGY

The 6G transmission communication network technology is formulated with the extended features to support the terrestrial, airborne, oceanic, etc., which would provide a high spectrum with energy efficiency, low latency, and gigantic connectivity because of vast growth in the Internet of Things (IoT) devices. IoT devices are capable of supporting smart agriculture, smart traffic monitoring system, smart health care, smart parking system, smart city, smart digital sensing, telemedicine, drones, robots, High Definition (HD) video transmission, etc., it predicts that by the year of 2025 usage of IoT devices will reach 25 billion. Because of the extensive usage of IoT devices, it has become challenging for the existing system 5G, which can keep up at most 50,000 IoT and (NB/IoT) Narrow Band IoT devices for every cell. Based on this scenario, many algorithms were developed for 6G communication systems rather than 5G technology.

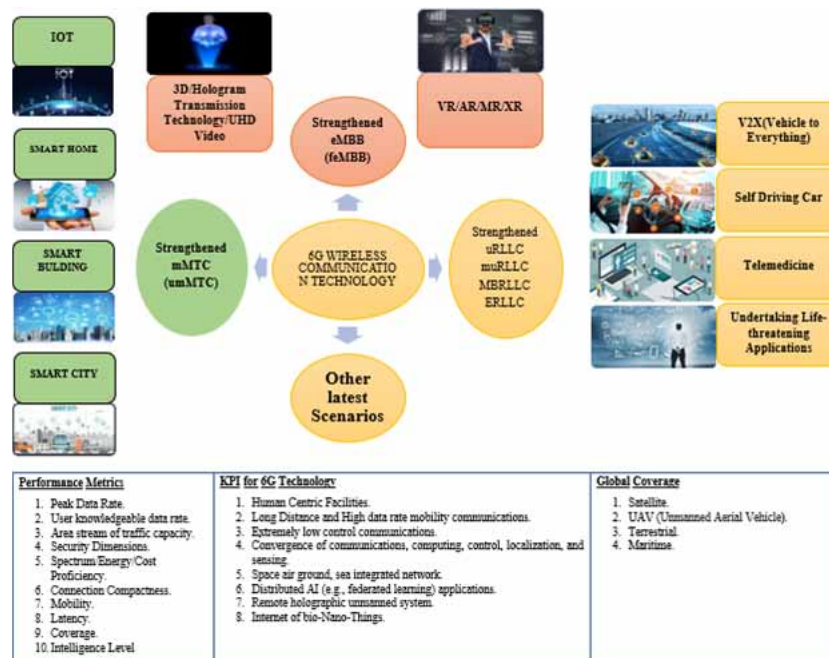
6G mobile communication is designed using millimeter-Wave (mmW), and terahertz (THz) as a frequency band, immense bandwidth, and extremely edict antenna as the latest application for the 6G transmission communication mobile device. Similar to the human eye and nose 6G is capable of performing high-end-imagination and path-finding sensors. 6G Technologies security and privacy is framed using the blockchain technology and the malicious issues upstretched with the blockchain technology like vulnerability attack, transaction confidentiality leakage attack, double spending problem are proposed with the new solution using 6G technology. Quantum computing's long-distance communication is decidedly suitable with 6G wireless communication technology. 6G technology is capable of creating a wireless cell to connect with another device.

TERAHERTZ COMMUNICATION

To achieve extremely high data rates, bandwidth, capacity, and throughput, Terahertz (THz) plays a major role with 6G wireless communication technologies. To enhance the signals in spectrum reuse and sharing, it is possible with the efficiency of THz signals. Sub-THz communication can increase the bandwidth by applying advantageous multiple-input, multiple-output (MIMO) technologies and with wide bandwidth. Another name given for Terahertz communication is submillimeter radiation and its electromagnetic wavelength range is between 1 mm to 0.1 mm. For cellular communication in the 6G Technology band range is increased from (27 GHz to 3 THz) to mmW (30-300 GHz). The band range 27 GHz to 3 THz

is not yet assigned in the globe for any purpose, this bandwidth is capable of extremely high data rates. The performance rates will at minimum increase 11.11 times when the THz band range is added to the existing mmW and this communication technology has the potential to perform with high frequency.

Figure 2. Perception as well as necessity of 6G wireless communication



KEY TECHNOLOGY OF SMART HEALTHCARE

Physicians and patients who are affected, clinics, and research institutions are among the players in the smart healthcare system. It's a natural whole with several dimensions, including preventing disease and monitoring, analysis and cure, primary healthcare supervision, fitness judgement, and scientific investigations. When integrated with existing biotechnology, information technology, IoT, mobile Internet, cloud computing, big data, 5G, microelectronics, and artificial intelligence, for example, form the cornerstone of smart healthcare. In every element of the smart healthcare system, these technologies are widely used. As of the patient's stand point, they could use wearable gadgets to display their fitness in any respect times, are searching for scientific help through digital assistants, and use far off houses to put into effect far off offerings; from the stand point of doctors, numerous intelligent medical choice aid structures are used to help and enhance analysis. Doctors can manipulate scientific records through an included records platform that consists of Laboratory Information Management System, Picture Archiving and Communication Systems (PACS), Electronic Medical Record, and so on. Surgical robots and coupled fact generation can help surgeons perform more precise operations. In hospitals, radio-frequency identification (RFID) generation can be used to manipulate employees' substances and the supply chain, as well as the use of integrated control systems to collect records and aid decision-making. Patients' experiences can be enhanced by the usage of adaptable medical systems. From the standpoint of medical

research institutes, it is feasible to use tactics such as device learning rather than guiding drug screening and to uncover appropriate themes with the aid of big data. Smart healthcare systems can reduce the cost and risk of scientific techniques, improve the efficiency of scientific sources, push the advancement of telemedicine and self-provider scientific care, and, in the long run, improved decision scientific offerings ubiquitous by leveraging these technologies.

6G WIRELESS TECHNOLOGIES AS MEDICAL SERVICES MEDIATOR

The system's adoption is designated by a vast network, high-speed data-driven paradigms, higher battery capacity, and ultra-low latency will influence the medical context leading to the distribution of medical models and customized medicine under control with the go-ahead nature of human beings. Abiliment and unified computerized devices, including bio-integrated, are required for instantaneous observation of health-related specifications.

The primary mediator of health-care system transformation is 6G. This provides services such as tracking, evaluating, and treating a person's medical condition. The human body will be considered as a network node containing physical, psychological, and social components in a holistic perspective of the human.

Mucchi, L., Jayousi, S., Caputo, S., Paoletti, E., Zoppi, P., Geli, S., & Dioniso, P. (2020) tells that the integration of information from restrained arbitrary clinical trials and information gathered from various location in the real world is essential for supervising the individuals' health records with the aim of wellbeing and treatment personalization. The real-world information may consider environmental, psychological, therapy, physical activity, and daily life habits information gathered using environmental sensors, mobile applications, public and private medicare providers, etc. The characteristics of this data may provide fresh insights into disease patterns, enhance healthcare recommendations, and improve the efficacy of prospective health engagement.

Machine Learning algorithms are used for data analysis by advanced systems, this allows a multipurpose inference of a huge amount of this diversified information. Emphasizing the latest communication technology, some illustrations of how 6G will equip these facilities are provided.

In-Body, On-Body, Off-Body Communications

The autonomous capture of information from an individual's body is a fundamental aspect in telemonitoring the medical issue of persons through the use of ICT (Information and Communication Technology) systems. The Body-Layer consists of in-body, on-body, and off-body communications that allow for the collection of various data via in-body and on-body sensors, as well as the transfer of information outside of the individual's body. On-body sensors are wearable devices for bio parameter measurement possession, whereas in-body sensors are nano-devices or implants, or molecules serving as biological communications networks. Nevertheless, off-body communication permits the user transparent and realistic transfer of information to edge devices and to the cloud for review.

Intelligent Nanoscale Inner Body Communications

Mucchi, L., Jayousi, S., Caputo, S., Paoletti, E., Zoppi, P., Geli, S., & Dioniso, P. (2020) express that the Internet of NanoThings is the result of the communication of nanodevices made of nanomaterials. Despite this, the peculiar nature of IoNT devices and the potential for negative health consequences has prompted researchers to focus on a new approach: the Internet of Bio-Nano Things. The communication and network engineering concepts are moved to the biochemical domain, where biological cells inside the human body enable intra-body sensing and actuation. Medical data is acquired and relayed to the healthcare provider, and necessary actions are initiated remotely depending on the data. For connecting heterogeneous bio-nano networks and interacting with the cyber-environment, new network topologies and protocols are necessary. On this basis, to allow information to flow between cells, Molecular Communications (MC) systems are required. Information signals are converted into chemical properties and shared among cells, considering chemical processes. The detachment among the spring (S) and the destination (D) is used to describe different cell signaling routes (D). Such are: intracrine (Within the same cell, S and D), juxtacrine (S and D are cells that are near one another), paracrine (S and D are near but not connected), or endocrine (S and D are isolated). In this regard, 6G technology is critical, as it will allow to connect IoBNT and IoNT to the IoT, enabling the revelation of the vision of “allThings associated.”

INTERNET OF MEDICAL THINGS

Technology has drastically transformed and simplified human life. Technology has impacted many aspects of life, with the healthcare industry being one of the most essential. Using powerful digital equipment, technology has made it effortless to diagnose inner disorders. Many developments have occurred in the medical field; with digital capabilities, doctors can treat patients remotely. Nowadays, Patients can use wearable sensors to keep track of their health status. Initially, the patient can take suitable action on his or her own.

The IoT unit is a device that consists of a microprocessor and a sensor that can connect with the real world to sense data. These systems can gather patient data and inputs from paramedical personnel or doctors in the medical field. IoT devices can connect with one another and conduct essential actions such as providing timely assistance or even saving a life. If a patient has an emergency, the IoT healthcare equipment can even call the healthcare service, which is especially useful when the patient is alone. Consequently, the IoT healthcare system enhances patient care, workforce efficiency of medical staff, and hospital processes.

IoMT devices are best suited for hospitals since they can increase the quality of the medical field while also providing a fair profit on investment. The efficiency and maintenance issues of X-ray machines, CAT scanners, MRIs, and other medical equipment can be supervised remotely. Early recognition of faults allows the manufacturer to execute preventative maintenance. IoMT is used by several industries for remote diagnostics, preventative analysis, and product upgrades. Wearable smart devices can now supervise a person's health with the help of improvements in bio-sensor technology. Depending on the type of sensor used, wearable sensors can be embedded in clothing or skin, or worn on the body.

Wearable devices do provide patients greater liberty while keeping a close eye on their health. At Home, Telemedicine enables medical services to be delivered outside the hospital limits. Remote monitoring eliminates the need for regular doctor visits and allows patients with chronic diseases and diabetics, to

receive therapy at home. The wearable medical devices can track a patient's blood sugar levels, heart rate, and mental stability from their place and inform the doctor if there is a serious problem.

The IoT's standard of living is higher than we can imagine right now. This epoch is about aggressive growth; the number of connected systems are expanding exponentially each year. Our humanity will be fully connected, efficient, and successful in the forthcoming years, with some exciting applications still to be explored. The benefits of the Internet of Things in medicine are numerous, but not exhaustive: Real-time accessibility, Cost-cutting on a per-patient basis, Swift check per patient, Overall, efficiency has improved. Good payoff.

DISEASE PREVENTION AND RISK MONITORING

Conventional disorder risk prediction relies on the health department's initiative to collect patient records, compare those records to the recommendations of a reputable body, and then release the forecast results. This methodology has a positive time delay and no longer provides consumers with accurate recommendations. Disease probability prediction is dynamic and customized in the smart healthcare system. It allows patients and clinicians to participate, actively display their disorder risk, and engage in behavior-based prevention based on their own tracking results. The latest disorder chance prediction version takes data via wearable devices and smart apps, uploads it to the cloud via a community, and analyses the results using big data-based algorithms to report back the expected outcomes to clients in real time via a short message provider. These measures have been proven to work. They support doctors and patients in changing their medical practices and lives at any moment, as well as decision-makers in expanding local fitness strategies with the goal of lowering disorder risk. For example, in a have a look at aimed toward stopping diabetes through predicting the postprandial blood glucose reaction, after tracking the blood glucose reaction of 800 human beings for 46,898 food for a week, researchers used algorithms that included blood glucose parameters, ingesting habits, anthropometry, bodily activity, intestinal microbiota, and different elements to correctly are expecting modifications in glycemic response and lessen the risk of diabetes through a personalized diet.

VIRTUAL ASSISTANTS

A digital assistant is an algorithm. It communicates with clients using speech recognition, relies on big data to reassess records, and responds based on the user's choices or preferences following calculations. Microsoft Cortana (Redmond, WA, USA), Google Assistant (Mountain View, CA, USA), and Apple Siri (Cupertino, CA, USA) are all digital assistants. They employ consulting experience and language-knowledge development to help consumers with a wide range of tasks, from setting reminders to automating their homes. Digital assistants in smart healthcare systems are particularly anticipating the role of a cross-over to communicate with doctors, patients, and medical institutions. They make medical services more accessible. For patients, the digital assistant may easily convert commonplace, everyday English into medical terms via their smart device, allowing them to find the appropriate medical professional with more precision. For doctors, the digital assistant can automatically respond to relevant records based on the patient's primary records, supporting doctors in more efficiently manipulating patients and coordinating medical procedures, allowing doctors to save time. Digital assistant software can help

medical institutions save time and money by allowing them to respond to the needs of all parties more quickly. Nuance generation can be deployed to communicate between unique digital assistants, primarily between trendy and obviously specialist assistants, so significantly improving the enjoyment of medical provider participants. They can be used to assist in the treatment of ailments, such as the use of digital assistants to improve people's intellectual fitness, which could help alleviate the shortage of human psychotherapists and bring spiritual fitness to more patients.

QUALITY OF EXPERIENCE

QoE can be achieved in 6G wireless communication technology by holographic transmission, augmented and virtual reality, Internet networking feature with low latency (Tactile Internet) and extremely high data rate, high Quality of Service (QoS) and user-centric communication. QoE is expected to be radical like intelligence in self-driving cars, intelligence in using devices, intelligence in robotics, drones, etc. 6G technology is considered as the massive breakthrough technology beyond the human sense. 6G wireless communication technology support to achieve the landmark of healthcare. Healthcare necessitates providing Quality of Experience for intelligence in hospitals.

SECURITY SECRECY AND PRIVACY

The prime point of Sixth Generation (6G) technology is security, secrecy and privacy. Nayak, S., & Patgiri, R. (2021), 6G requisite reliable URLLC (Ultra Reliability and Low Latency Communication) to have upgraded secure communication systems. This technology provides foremost security. It will fortify against attacks using federated Artificial Intelligence, Quantum Machine Learning, Quantum Computing and THz (TeraHertz) communication. THz communication is intruding and jamming proof. In this Medical care system, it is essential to have a superior level of safety for information that is transmitted over the network. Any tampering with medical information has the potential to ruin a patient's health. So, it is essential to protect medical information from intruders. Furthermore, 6G technology emphasises the confidentiality of the most sensitive information. These data are only viewable to the owner and even administrator is restricted to view the sensitive data. Likewise, 6G emphasis on privacy, which is amongst the significant aspects of healthcare. Edge technology will be utilized in 6G to increase privacy. Since filtering of data is done using this technology, the cloud contributes safety for lesser information. In the current scenario, Blockchain furnish high degree of seclusion for medical data. The infrastructure provided by blockchain helps us to yield more security for medical data. The future of Blockchain technology with its advanced technique assists us in an intelligent healthcare system.

The current state of the Internet of Things in healthcare can be divided into the following categories: The first is to locate, track, and maintain assets. The second is to increase medical service standards' efficiency. The use of wireless solutions connected via operating system interface to monitor health allows for easy examination of current medical status. In healthcare, the IoT uses appropriate algorithms and sensors to evaluate data, which is then wirelessly transferred to follow medical activities and suggestions. To monitor the patients admitted in the hospital, noninvasive IO (input-output) systems are used. Sensors that are utilised in this hospital management system are used to collect physiological data, which is subsequently examined. IoT provides an automated, continuous information flow system that

enhances medical treatment quality at lower costs. The devices in the medical field can be used for both monitoring and enhancing a patient's health.

Using the devices in this environment, patients can contact the hospitals via the internet and they can receive the medication remotely. IoT in healthcare enables real-time data incorporation and supervising of beneficial medical and non-medical information flow, as well as electronic health records. The execution of the Internet of Things with healthcare is still in its early stages. At the patient's house, the portable equipment can be installed to evaluate the important aspects of health monitoring data. Because of the various hardware obligations, signal formats, and interfaces, these hardware devices and solutions are frequently challenging to deploy.

PROBLEMS AND SOLUTIONS

Therefore the appearance of smart healthcare system, mature standards and structures had been made. However, with the rise of recent technology and novel issues, there may be nonetheless widespread room for improvement, and lots of demanding situations are actually increasing. Presently, smart healthcare system deficit macro steering and programmatic description, which ends up in doubtful improvement dreams and in the long run a misuse of sources. Moreover, scientific institutions, deficit evenly distributed requirements amongst exclusive areas and exclusive organizations, and enhancements are wanted in making sure statistics integrity. The quantity of statistics is simply too complex and too massive, which ends up in problems in statistics sharing and communiqué. From an affected person's angle, smart healthcare system lacks applicable felony norms, and they are dangers with reference to non-public records and privateness breaches. Few customers actually have problem the usage of the generation. Technically speaking, a few technologies associated with clever healthcare are nonetheless within side the experimental tiers and need a massive quantity of investment to be sustained and upgraded. There is an unspecified chance if carried out harshly. Therefore, to remedy the cited issues, we want to attention on factors: generation and regulation. Essentially, in phrases of generation, we are able to boost up the adulthood and balance of associated technology thru upgrades. Improving the cap potential to investigate records from massive statistics is likewise critical. Secondly, organizing a unified technical widespread to attain most compatibility among exclusive device and systems is critical. In this manner, we are able to enhance statistics integrity and put off boundaries to records exchange. In phrases of regulation, experts from applicable fields can paintings collectively to make clear the improvement dreams of the industry. Legislation is a sensible avenue to assure the privateness of applicable employees and make smart healthcare extra stable.

INTERNET OF BIONANOTINGS FOR HEALTH APPLICATIONS

Akyildiz, I. F., Pierobon, M., Balasubramaniam, S., & Koucheryavy, Y. (2014) tells about the extremely associated to IoNT, with its distinctive features and approaches, is that the thought of Internet of BioN-anoThings (IoBNT). Initially it was odelling in the year 2015; It has collected vital adhesion in its efforts to mix communications with health care solutions. It may be a collection of molecules which might transmit with every other. In applications with reference to smart-human healthcare system, it harbors several distinctive obstacles and opportunities. To begin with, the understanding base evaluation on every

communications and understanding analytics can remarkably facilitate the modelling of organic processes, in addition to neoplastic cell formations and Alzheimer's disease, and in addition fashion helpful control measures for such diseases. To continue further, even the expressions of genetic system at the cell and organ-level will differ exceptionally, during a manner analogous to numerous kinds of knowledge applications in wireless networks, communication models is evolved and utilised to conceive a usually appropriate health info network. To conclude with, the holistic specification unreal within the IoBNT can integrate elements at various levels including inside cells and tissues, organs, in addition as systems, before gradually connecting to the skin web for physicians to perform measure calculation. Internet for Physician offers treatment plans accordingly. Although, health care solutions that are to be analysed in such difficult biological and molecular environments ought to be designed upon a strong understanding of the physics behind molecular communication and advanced applied mathematics analysis tools so as to expose the standard behind the on the face of it random molecular movement.

Essential Communication Models in IoBNT

It is totally contrast from classic wireless-communication channels supported the promotion of magnetism waves; molecular communication (MC) channels accept the mechanism of molecular movement to transmit data. The most distinction between an rate channel and also the traditional wireless median is that the transmission medium presents totally different forms, admire fluids of many chemical compositions in blood vessels, plasma membranes of neurons, and so on. It supports the movement of molecules in such numerous mediums; end-to-end median models are enhanced to characterize the capacity, noise, and interference in varied communication eventualities. Specifically, within the diffusion-based rate model, info is encoded in various forms, for example, based on different concentration intensities and unique unharnessed times of molecules. The nano-device, which is acting as a transmitter emits then such encoded molecules to the wireless molecular median. At the receiver end, another nano-device decodes the signals based on the quantified received intensities or times of arrival, providing the channel remains stationary for the length of transmission. In such transmissions, some molecules will get spread within the channel and cannot be received by the target nano-devices, they're thence treated as noise, and median with such residual molecules are typified as channels with memory (Pierobon, M., & Akyildiz, I. F, 2014).

IoBNT in Public Health Applications

In late 2019 and 2020 have been the novel coronavirus unwellness termed COVID-19 unfold entire world, inflicting peak fatalities and a embarrassment of alternative public health issues. Additionally, such outbursts, as well as the severe acute metabolic process syndrome (SARS) in the year 2002, the center east respiratory syndrome (MERS) in the year 2012, the filovirus disease in the year 2014, and also the seasonal flu, raise query on the way within which general health systems ought to react to such epidemics and pandemics. The outbreak mayhem caused by pandemics implies effective means that to spot new varent viruses, perceive their mechanisms of microorganism infection, and devise economical tools for therapy and vaccination.

Scientist have examined at developing biosensors that can watch the cleavage of proteases inside infected cells so that to speed up the development of antiviral and preventive therapies. Proteases are produced when a cell is infected with an ordering of coronavirus, which could be a type of RiboNucleic

Acid virus. Synthesized poly proteins that can duplicate and transcript to produce more RNAs, as well as structural proteins strand that can build new virions, are examples of alternative byproducts. Corona viruses is the reason for respiratory disease and MERS (i.e., SARS-Cov and MERS-Cov) have two types of proteases: papain-like proteolytic enzyme and 3C-like protease. The luciferase-based biosensor is being used to look for possible broad-spectrum corona virus papain-like or 3C-like protease inhibitors.

The corona virus is caused by SARS-CoV-2 virions, which have a diameter of 50–200 nanometers and affect the human body through human-to-human transmission in the form of droplets from an infected person through coughs or sneezes. It has presented new hurdles in the development of testing, therapy, and immunising agents around the world. The IoBNT's Brobdingnagian potential in the molecular identification of raising viruses of this nature is phenomenal. The reverse transcription enzyme chain reaction on collected materials is examined using nanosensors, which could be firefly luciferase-based or other communicator genes. Alternative testing consist of using bio-nanosensors to detect antibodies in blood samples to determine if a person is infected (Kilianski et al., 2013).

In case of treatment, though non antiviral medicine are offered for corono diseases yet, research on contagious disease therapy can be light-weight, however, the IoBNT may assist in future answer growth. An important step for treatment is that the antiviral interference, that blocks the living thing signal pathways to stop flu viruses from duplication. A rumored solution preventing the virus from duplication is to use designed microorganism (i.e., enterobacteria coli) to entice the filovirus. Within the rumored work, the blood of an affected patient with the Ebola virus infection is transmitted to a microfluidic chamber tube outside the body that has the engineered bacteria. The spreaded bacteria will then win supermolecule binding with the Ebola virus exploitation chemical bind force and artificial protein binding receptors.

Importantly, the IoBNT serves a novel role as a holistic answer to not solely monitor restricted kinds of cells (e.g., squamous animal tissue cells from cavum swabs for corona tests), however across totally disticnt tissues and systems. It is also said that coronaviruses can even cause injury to biological process and neurologic systems. Hence, a series of communicated bio-nano-things consisting of varied kinds of designed microorganism can operate at the same time to boost take a look at reliableness and treatment efficiency.

Open Issues for IoBNT

Presentlt, IoBNT primarily focuses on research within the domains of physical layer median modeling, capability analysis, modulation and writing schemes, and nano-transceiver design. Eventually, analysis gaps with reference to the subsequent aspects got to be overcome the following:

- **Experimental Validation:** The theoretical models of molecular communications ought to be valid under realistic medium environments, which embrace experimental testing. Conventionally, these experimental result have posed high necessities on work instrumentality and also the nurturing method of cells and bacteria. Whereas the process for such an experiments ought to be strongly followed and executed, now and then the value for testing is astounding high. In those situations, simulations supported real time assumptions function an alternate means, that are usually adopted in research. The relationship between analytical and experimental approaches should be coupled efforts by scientist across area in telecommunications, medical specialty engineering, and signal processing.

- **Knowledge Storage and Management:** The big data sets gathered from experiments or simulations can have several management variables that need efforts to manage and update. Open databases have become a well-preferred fashion for sharing statistics to earnings the entire evaluation network for collaboration, and can be a predictable course for studies in the IoBNT.

APPLICATIONS OF HEALTHCARE SYSTEM

Healthcare is the most essential and elementary need in human life with high quality, which is applicable through smart healthcare systems for everybody and ubiquitous. Here three different healthcare applications were discussed such as Hospital Atmosphere, Remote Medical Care, and Disaster Retaliation.

Hospital Atmosphere

Hospital is a place where patients are taken care by the physicians, paramedics and professionally trained staffs. In COVID-19 epidemic situation, due to the rapid spread of the infection. Patients suffer a lot without a sufficiently trained staff and equipment for the treatment, due to this shortage it becomes worse to control the situation. Predominantly in pandemic situation the infection transfer from the patients to medical staff to overcome this scenario, it is better to avoid the physical interaction between patient and physicians. To avoid this type of infection spread it's healthier to deploy an Internet of Medical Things (IoMT) and Robots in Hospitals. AI supports the healthcare system, as (i) To collect the patient record electronically, (ii) Better decision making in diagnosis, (iii) Involving Robot in Surgery, (iv) Supports the physicians. IoMT plays an importance role in gathering the patient health record using the wearable device and sensors via internet to reduce the physical interaction between physician and patient. In near future using robots and wearing wearable sensor device by the patient to reduce the physical conduct between the physicians and patients. In case if any delay or connectivity issues has been faced means it leads to serious problem for the patient under emergence, for these application 6G wireless communication technology will support massively for the communication purpose with peak data rate.

Remote Medical Care

Due to the ongoing pandemic situation telemedicine and remote health monitoring are the two essential measures to monitor the health of the person who are in the remote area and with traveling limitations. With 6G wireless communication technology it is possible to use the holographic telecommunication, which can be able to connect with extremely high quality of video conferencing that can be used in the telemedicine to analyze the health condition of the person who is affected, with the help of the paramedic. Remote health monitoring systems help the senior citizen with technology adoption like wearing wearable sensors, which would help in monitoring the elderly people's current situation via sensors and (WBAN) wireless body area network.

Because of COVID-19 disease, remote health monitoring is being developed to diminish the spread of infection and to bring down the number of patients admitted in the hospital. Remote health monitoring completely depends on communication infrastructure, but still, some applications are facing challenges such as, low latency for tactile internet networks, low power communication for sensor devices, connectivity issues, and interference in Internet of Medical Things using existing communication technology.

6G wireless communication technology plays a vital role in providing holographic telecommunication with extremely peak data rate as (100 Gbps- 1Tpbs). To secure the patients data blockchain technology is used in 6G wireless communication technology.

Disaster Retaliation

In an emergency unit the response is given in the form of tele-medicine based on the emergency situation and it is functioned using the EMS(Emergency Mobility Service).EMS is one of the most important services, which can provide a quick response for the emergency cases. The services provided by EMS are purely based on severity of the cases, which can provide the service either by ground or air ambulance. EMS provides well-equipped medical equipment with advanced facilities. To diagnose with greater speed, first aid treatments based upon the scenario, updating the status to the medical expert with high quality video telecommunication and get the remote discussion from professionally trained medical staff with high cellular wireless communication infrastructure. It will help to prevent the patient through telemedicine.

Especially in the pandemic situation some countries implemented an advanced ambulance equipped with all medical facilities and advanced technology to save the paramedics from the spread of COVID-19 infection. In COVID-19 epidemic situation it is censorious to inform the emergency mobility service staff to stay in their home itself to prevent infection. It is obligatory to prevent the EMS staff from the spread while they are treating the patients. The key factor to prevent infection is maintaining social distance. Therefore, the public should ensure that they are sick-on to the preventive measure that is condemnatory to detect the contravention and take necessary steps to avert the spreading of the disease. Likewise, to detect the outbreak of COVID-19 disease thermal imaging can also be used efficiently. Presently, healthcare centers are used to isolate the infected patient and provide proper care for them. Instead of these drones and robots, can play an important role to perform various tasks like delivering medicine, food, medical kits, taking samples, sanitizing the person area, etc.IoMT based smart healthcare is armed with smart medical devices such as remote forbearing monitor, smart thermometer, smart wristband and so on are used to monitor the patient health. Moreover, healthcare physicians can discuss with an infected patient via remote healthcare and telemedicine services.

For communication purposes in the Emergency unit of the healthcare system various challenges are as follows: high mobility, massive connectivity, full coverage, network scalability, latency, reliability, etc. In self-governed ambulances, drones, robots, communication signals for smart wristbands, remote patient monitoring system communication problems can be overcome with the latest 6G wireless communication technology for the smart healthcare system.

CHALLENGES

Privacy and Security

Collecting records from in- and on-frame sensors and transmitting the gathered statistics closer to a cloud scientific Centre for similarly evaluation ask for brand spanking new safety answers.

In particular, because of the constrained sources of the frame sensors in phrases of strength intake and computation capabilities, reaching stable communiqué inside and at the frame nonetheless represents

an open studies area. The predominant demanding situations stand up from (Mucchi, L., Jayousi, S., Martinelli, A., Caputo, S., & Marcocci, P., 2019):

1. The constrained sources (power, computation, garage ability etc.) of nanodevices, which create infeasible the adoption of on-call for prime diffusion strategies and hard the enactment of pre-deployed key strategies; and
2. The want of presenting scalable community in a nano-domain. So, exclusive authentication strength green algorithms and shorter key duration cryptographic techniques collectively with new communicate and safety architectures are required.

Few research had been achieved withinside the network of molecular communications each for an initial assessment of the secrecy ability in a distribution-primarily MC machine and for featuring new reassets of encryption primarily based totally on organic molecules (e.g. DNA and RNA). However, in nano-scale contexts, similar research remains had to address molecules spontaneous response and uncontrollable scenarios.

Technological Aspects

The incorporation of observing, excessive decision imaging and excessive correct location on mobility, anticipated through the 6G generation, will open new offerings, especially withinside the fitness sector. The growing hobby of clinical studies to in-frame nano-gadgets (each moist and dry), which include biochemical communications, will force the destiny that means of frame as a part of the community. Communication and interactions among organic cells and electric nano devices is anymore possible. The opportunity to talk each the usage of electromagnetic waves or biochemical reactions/molecules distribution could make the human frame a communiqué surroundings, because the fiber or the ether. The Internet of BioNano-Things paradigm consists of each implants, nano-scale synthetic gadgets in addition to organic synthesized particles. All those are factors of a community and might talk thru particular networking gadgets. Interaction among inbody and on-frame nodes will permit to get better critical records from very in the frame and flow into it to the cloud. All those exclusive types of nodes, from very small to macro-scale, have very exclusive necessities to talk records. 6G generation might be the cloth that could make some of these exclusive factors a part of a unmarried community, permitting a non-stop, reliable and stable movement of records.

The research approximately people includes the emotion sphere. Psychological factors are extraordinarily critical for the fitness of a human being. The records receive through in- and on-frame sensors may be used to deduce now no longer handiest the fitness from a natural factor of view, however additionally from an emotional one. Data coming from non-stop tracking of human frame in the course of the regular lifestyles may be combined/correlated to gather a complete imaginative and prescient of the fitness reputation of the individual, and 6G generation can find the money for the connectivity for this, way to its inherent pervasive and scalable traits on mobility.

Attaining those dreams calls for to stand critical demanding situations shape the technological factor of view. Collecting statistics from very exclusive gadgets, from nano to macro, and speaking in heterogeneous form of medians, from chemical to radio or free-area optical, will face critical demanding situations, as

1. propagation in exclusive environments, from in the human frame to surroundings or fiber;

2. exclusive gadgets potential;
3. excessive correct location;
4. ultra-rapid calculation and shipping of records to target;
5. harvest strength in each surroundings and wi-fi strength transfer;
6. interference control and mitigation;
7. rapid device gaining knowledge of and synthetic intelligence;
8. get entry to schemes for large wi-fi networks;
9. cyber security.

Ethical Aspects

6G can enable, on a large scale, the usage of a couple of and heterogeneous statistics-pushed choice-making machine that could force the transformation of preventive and healthcare pathways closer to actual desires of people and society. To force such method professionally, it's miles essential to contain residents in a active method that calls for the growth of fitness literacy, and the empowerment of residents as statistics owner. Similarly, the virtual divide poses the assignment of fairness withinside the get entry to smart healthcare system. A more and more digitized global dangers leaving marginalized human beings behind. The growth in interconnectivity support our underlying interdependence, therefore Digital Cooperation throughout domain names and throughout borders is crucial to comprehend the transformational capacity of virtual technology, even as safeguarding in opposition to dangers and unintentional consequences. Therefore, organizing a usualregulatory framework is of paramount significance which will face the demanding situations of the imminent 6G era.

MULTI-DISCIPLINARY IMPACT EVALUATION

6G in comparison to 5G get the prospect to make a concrete leap forward in phrases of functionalities and first-class of the enjoy transferring the point of interest on offerings (and now no longer extra at the customers), implementing a provider's reliability, deploying VAR (Virtual Augmented Reality) on a large scale and concretely rooting Smart City components. This reasonscause an major impact on healthcare sector. The following subsections try and spotlight the capacity affects for 3 actors of the fitness domain, namely: a) patients, b) healthcare experts, and c) Society.

Patient's Factor of View

6G receives the prospects to provide a bigger effect at the first-class of fitness care acquired through patients and to considerable modifications within the manner wherein healthcare is supplied and will be a good sized enabler of a brand new form of "personalized healthcare" technique. The tons more potential to constantly accumulate affected person particular statistics and thepotential to method, examine and fast go back processed records and encouraged publications of motion to the affected person will supply patients more facilities to manipulate situations on their personal deliberating now no longer handiest fitness associated statistics however additionally environmental records. The personalization of healthcare additionally approach that physicians and different fitness care vendors might be capable of make "simply in time" diagnoses and tailor treatments extra carefully to a selected affected person's non-public

desires way to the better and extra dependable quantity of statistics gathered from an augmented form of reasserts (AI technology, IoT solutions, HBC sensors, in-frame, on-frame off-frame communiqué sensors etc.). This may want to open the doorways for a discount of the quantity of re-hospitalizations and presents the possibility to enhance sufferers' cash financial savings and mental stress. Additionally, 6G will energy the patient's non-stop tracking therefore enhancing the effectiveness of preventive care. In fact, thru 6G, non-stop tracking will put in force the improvement of recent extra statistics streams therefore implementing predictive analytics and intelligent (Mucchi, L., Jayousi, S., Caputo, S., Paoletti, E., Zoppi, P., Geli, S., & Dioniso, P., 2020).

Healthcare Experts' Factor of View

6G generation may also extrude the destiny healthcare machine permitting the success of brand new dreams from the healthcare professional's factor of view. Some of them are:

- The growth of the first-class of the number one and domestic care machine through actual-time tracking and records sharing of affected person's situation and pharmacological efficacy for a continuously up to date and revised care path.
- The development of the first-class of lifestyles through proactivity by preserving the affected person's residual purposeful capacities and stopping the deterioration and disabilities of patients' fitness.
- -The explanation of fitness expenses through the discount of unsuitable get entry to health facility and fitness offerings, the discount of costs for non-centered, specialized and diagnostic drug therapies, etc.
- The monetary and economic sustainability of a machine wherein persistent and noticeably personalized affected person care is particularly achieved on the affected person's domestic.
- The dynamic variation of fitness guidelines to the continued evolution of the populace desires through orienting sources closer to the implementation of offerings primarily based totally at the converting populace fitness.

Society

Yrjölä, S.(2019) states from the society factor of view, the foreseeable results from the 6G's deployment are many. Indeed, 6G deployment has the potentiality to absolutely regulate the healthcare machine laying the inspiration to an extra bendy and personalized machine wherein sources are well allotted in step with a "win-win" technique aimed toward lowering the misallocation of sources (human and economic sources) and their waste. In fact, because of the stepped forward personalization of fitness care, 6G has the capacity to effect on public healthcare machine and personal customers price financial savings and productiveness enhancements: that is the case if we recall the advanced control of long-time period and persistent situations. Additionally, 6G may want to support the locus of care shift from hospitals to houses and different lower-price settings therefore providing some other supply of price-financial savings. Furthermore, 6G, due to its disruptiveness, may want to underpin the extrade of the enterprise atmosphere through starting the marketplace to new stakeholders like micro operators and useful resource brokers, permitting many new enterprise fashions however additionally clean the antique ones.

CURRENT SITUATION

In the current situation, communication plays a crucial role. In recent days, the Intelligent Healthcare system is well received and wireless communication technology is the cornerstone for such systems. During this pandemic, widespread disease is caused by humans interacting with each other. On that account paramedical staffs are at high threat. Millions of people have died as a result of COVID-19 outbreak, including paramedical personnel. This outbreak can be stopped using IIoMT (Intelligent Internet of Medical Things). Case in point, each person's blood specimen is sent to a testing laboratory by BSR (Basal Stamp Rot) sensor without exhibiting them to the outer world, and the results are dispatched to their homes. As an outcome, the human chain may be readily broken and the breakout can be monitored instantly.

CONCLUSION

Finally, data security and privacy infringement caused by various devices and protocols are challenges that both makers and consumers of IoT devices must address. Patient data is stored in the cloud and can only be accessed via IoT numerous devices and protocols; as a result, these devices and protocols must be protected against vulnerabilities. The smart health care systems help us to monitor various vital signs of the patients. Para-medical staff can keep track on the patients in real-time even though they in remote area. In epidemics or crises, the technology can also help nurses and doctors because raw medical data can be examined quickly. The new system will enhance the present healthcare system, potentially saving many lives.

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Chapter 15

6G With Smart Healthcare, Haptic Communication

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ABSTRACT

Every healthcare division should be provided with sophisticated technology to offer patients appropriate diagnostics, therapies, and a variety of health services either inside hospitals or remotely. A quick responding division is also necessary to deal with the influx of patients and inquiries throughout disasters. This would control not just the healthcare field, but also a variety of other industries. Many industries, notably healthcare, are likely to be transformed by 6G. Healthcare and hospitals will be entirely AI-driven and reliant on 6G connectivity technologies, altering our perspective of life. Nowadays, time and area seem to be the most crucial hurdles to medical systems, which 6G would be capable of overcoming. Under the human-centric perspective of 6th-generation wireless technology, this chapter examines healthcare communication and networking issues and potential strategies for early warning and quick action in crisis scenarios. This chapter also discusses the problems encountered during the deployment of 6G, as well as applicability and future research directions.

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INTRODUCTION

Many researchers are interested in 6G communication technology because of its unique features and potential. 6G telecommunications networks are primarily characterized by abundant connectivity, high bandwidth, ultra-reliability, and low latency to satisfy the necessities of real-world applications namely robotics & autonomous vehicles, healthcare, transportation management frameworks, telepresence, AR, and VR. Many characteristics of 6G are already addressed in a prime forum, and several criteria for 6G communication technology are constantly being gathered. Furthermore, (Nayak & Patgiri, 2021) discuss the concerns and obstacles associated with 6G telecommunication technology. These concepts are also discussed in the works of (Saad et al., 2019).

Many countries have already begun the deployment of 6G communication technologies. Finland was the first to start a 6G project in 2018. Second, in 2019, the US, South Korea, and China launched the 6G initiative. Japan has recently announced a 6G research initiative for 2020. Furthermore, various 6G algorithms have been created which have been summarized in the works of (Quiet al., 2020). It is now critical to begin the 6G project to avoid falling behind other various countries. On the other hand, 5G communication technology has yet to be fully deployed globally, and B5G has yet to be developed. B5G and 5G have several disadvantages when it comes to revolutionizing current lifestyles, society, and industry as mentioned in the works of (Chen et al., 2020). For example, due to the decreased data rate, holographic communication is not possible. As a result, now is the best moment to think about the future of 6G communication network technology. It is also vital to consider upcoming healthcare to ensure the well-being of society's citizens as stated by (Dang et al., 2020).

The present healthcare system only provides basic services and space & time which are the most significant barriers. In the current environment, this is unavoidable; furthermore, it would not be a hurdle in the upcoming years. In addition, an ambulance facility is simply a patient rider with oxygen along with priority in road traffic that cannot be provided by a regular car. Furthermore, given current circumstances, the aged service is inadequate. Medical personnel must provide intensive care to the elderly. However, it is now unavailable. Most patients die in ambulances on their way from H2H or before the ambulance arrives at the destination. In addition, the accident detection method is not currently available in healthcare systems.

To deliver medical assistance on time and spot, the accident detection method needs real-time detection. Furthermore, due to a lack of technological infrastructure, epidemics & contagion outbursts, such as COVID-19 could not be kept under control. In the future, a virus of this type will emerge. As a result, developing an intelligent healthcare system is very essential. It is predicted that 6G telecommunications will radically transform healthcare, so the health care system will be wholly reliant on wireless communication. The fundamental change in healthcare because of the advancement of telecommunications will be seen. Owing to communication problems, today's conventional healthcare framework is unable to perform telesurgery. Furthermore, emergency services like ambulances will be phased out. Wearable gadgets must be reimaged. The hospital must be restructured.

To surmount the limitations of 5G for addressing the new issues, a 6G wireless communications with additional appealing characteristics will have to be created. The confluence of all previous aspects, including network densification, high throughput, high dependability, lower power usage, and enormous connection, would be the primary catalyst of 6G. The 6G telecommunication network will also carry on the earlier generations' pattern of innovative features with the addition of new technology. AI, smart wearables, implants, driverless cars, computational reality tools, sensing, as well as 3D mapping are

among the novel services (Saad et al., 2019). The capacity to control a large quantity of data plus a very high-data-rate connection per each device is the key essential requirement for a 6G wireless communication system (Mao et al., 2020). This chapter describes how 6G communication systems can be built, as well as predicts how 6G technology & research challenges are needed to fulfill the demands and expectations of the smart networks.

Contribution of the paper

1. This chapter describes the upcoming 6G communication technology.
2. This chapter gives information about the various application of the 6G network.
3. This chapter gives detailed information about the benefits of the 6G communication in the health-care sector.
4. This chapter depicts the hurdles, barriers, and future research direction in the field of 6G technology.

LITERATURE SURVEY

(Sodhroet al., 2021) focused on how the UT device can capture effective energy-managed communication and the user's QoE level during multimedia transmission. The first algorithm was a QJEEO approach. Secondly, a model and framework for modeling and evaluating QoE with acquisition time were established using a 6G-driven multimedia data structure framework and model. Third, a link was made among subjective test scores and objective performance indicators for IoT-related models for multimedia service mobility/speed. Fourth, a correlation model for combining QoS characteristics with evaluated QoE perceptions was proposed.

The results show that in 6G-based networks, while energy-efficient multimedia transmission, QoE was evaluated and modeled with acquisition time and connected with QoS parameters such as PLR as well as minimum transfer delay to improve customer satisfaction. (Mucchiet, et al., 2020) have answered some of the questions that were addressed in this article for the 6G health vertical. The world's population was growing and aging, making present medical institutions unwarrantable in the upcoming years.

Wireless health must be developed to allow all citizens to be tracked and controlled throughout their lives' health processes in an economically sustainable manner. 6G is envisaged as a technology that will enable wireless healthcare, as well the Internet of Bio-Nano-Things, allowing the human to join the "Net." Implantable/wearable gadgets will restore information about our lifestyle and health from anything that interacts with, from a bottle of water to a smart medicine, will become a part of our daily lives.

(Hewaetet al., 2020), have given an idea of how blockchain might help solve some of the most difficult problems in 6G, as well as future application possibilities and research areas. With the birth of the intelligent information period, the world is undergoing a profound change. Healthcare, smart cities, entertainment, and transportation are all awaited to improve service quality with a high-end user experience.

As a result, the telecommunication framework must achieve previously unheard-of service level requirements. Blockchain and distributed ledger technology are the most disruptive technology enablers for addressing the current limits and facilitating the functional requirements of 6G. (Huynh & Huh, 2020) provided an overview of the technologies that aid in conceptualizing MEC in upcoming 6G wireless networks, as well as problems and potential. The purpose of the 6G wireless communication system is to connect space, the atmosphere, land, and submarines. MEC is an important part of upcoming 6G wireless networks, allowing bandwidth-intensive, latency-sensitive, and compute-intensive gadgets to function.

Table 1. Recent research in 6G communication network

AUTHOR	FOCUSED AREA	CONTRIBUTION
(Navazet al.,2019)	A detailed analysis of ML, quantum computing & quantum ML as well as their feasible features, problems, including usage of cases in B5G networks was discussed. In addition, a quantum computing-based infrastructure for 6G communications systems was presented.	Quantum computing and ML
(Tariq et al.,2020)	A broadened perspective of 5G was provided, with a focus on the modifications necessary to enable 6G.	Cases with 6G
(Giordaniet al.,2020)	A limited 6G use cases are mentioned. It attempts to determine 6G needs.	Cases with 6G
(Li et al.,2019)	A detailed investigation of UAV communications over 5G/B5G wireless connections was offered.	UAV networks
(Lovenet al.,2019)	Edge AI's importance in future 6G networking and communication was presented.	AI
(Xiaet al.,2019)	For the THz band communications infrastructure, a time-efficient neighborhood detection approach was suggested.	Communication using THz band
(Yanget al.,2019)	The possible 6G approaches as well as a summary of the most recent studies on the potential 6G technologies that are emerging were reviewed.	6G technologies
(Stociaet al.,2020)	6G wireless communication networks based on AI future are explored.	AI
(Shafinet al., 2020)	Challenges, future scope, and road map to understanding the idea of AI-based cellular network for 6G as well as B5G	AI
(Tomokoset al.,2020)	The development as well as the convergence of 5G & IOT technology solutions into the 6G technology were explored.	Edge computing

(Gupta et al., 2021), investigated the reliability evaluation and availability prediction approaches utilized in modeling advanced wireless communication systems. Emerging wireless communication applications which leverage edge computing, fog computing, and cloud computing are being driven by 6G, B5G, 5G+, and 5G communication technologies. As a result, IoT applications and IoT devices have proliferated in a variety of important utilization systems, including intelligent transportation methods, e-commerce, and smart healthcare.

The reliability and availability of wireless connectivity in IoT nodes and devices are critical, as even a millisecond of node or user device unavailability could cause healthcare systems to fail, linked and autonomous vehicles to malfunction, or smart grid power distribution and generation to be compromised, all of which could result in fatal outcomes. Some of the recent research regarding the 6G communication and networks is depicted in Table 1.

6G SYSTEM ARCHITECTURE

mMTC will be enabled by next-generation wireless networks, which will have a large number of linked devices and BSs/ APs. A CoMP transmission is formed when multiple APs/BSs serve more devices at the same time (Al-Eryani& Hossain, 2019). Massive devices will generate enormous amounts of data, necessitating extremely high-performance units of processing and reliable backhauling networks. The backhauling lines might use optical fiber or photonic communications, and the central processing units could use AI and ML techniques. In 6G communication networks, a remote user will use numerous transmitters or relays to broadcast, and the SINR users can be enhanced by applying the diversity approach,

like in virtual MIMO methods. Every end device will be aware of the features and location of APs/BSs in their proximity, and every APs/BSs will be aware of the features, locations, and QoS requirements of gadgets in their vicinity, thanks to intelligent networking.

To improve the wireless network efficiency, robust interference optimization/management approaches are used. Data processing will take place at base-band processing units, which is quick enough to control and switch sources such as time, power, and bandwidth among various user's BPs. Figure 1 shows certain key components of the 6G process architecture, which result in a dramatic paradigm shift in the implementation of 6G models.

The air interface is the primary element that leads to significant advancements in wireless generations. While CDMA is the important player in 3G, OFDM played a crucial part in the 4G creation. Similarly, a novel air interface creation is also critical to the architecture of the 6G system. Another critical element of the 6G process design is AI and machine learning. ML and AI will play a crucial part in 6G wireless systems' self-healing, self-configuration, and self-organization. The 6G has also been urged to use a new spectrum for communication due to spectrum congestion.

As a result, this new spectrum will be crucial in the 6G network design. 6G will need to be compatible with all prior technologies because it will support a broad range of transmission devices, from IoT's to live HD video streaming. As a result, in the 6G network, a flexible and then multi-RAT process design is critical.

Air Interface

Because 6G will focus on the present terahertz frequency range, which has exceptionally broad bandwidths, it will present new challenges in terms of interacting efficiently at these frequencies. The solution will be to provide a secure transmission infrastructure with sufficient range and low power consumption. The availability of extremely broad bandwidths will shift the focus away from spectrally optimized solutions and toward systems with improved coverage.

The trade-off between power efficiency, spectrum performance, and coverage will be critical in building devices in these new frequency spectrums. It will result in the development of a modern air interface in which single-carrier systems will be given more consideration. The OFDM technique is reconsidered for lesser ranges of frequency, where spectral efficiency is crucial because the cyclic prefix which is a replication of information and does not carry any more information and does not use energy effectively. Furthermore, power amplifiers with a high PAPR are complex and expensive.

The NOMA method has been proposed by several academics since it is a viable novel technique for 6G/B5G mobile systems (Qureshi, et al., 2018). In NOMA, all users have access to the entire resource frequency band at the same time. RSMA has been proposed as a novel access mechanism for 6G communication systems by several researchers (Mao, 2018). The information is decoded for the user in both NOMA and RSMA using SIC. The SICs are used by RSMA to decode the ordinary message first, and then the personal message. Before they can be used in practice, both systems must be well-developed. The authors offered a smart air interface switching process for user enhancement of QoS in (J.B. Dore, 2020), where they presented a novel software-defined air interface that is based on AI.

Many waveform configurations and 2 frequencies sets are detailed in 3GPP release 15, which disclose the requirements for 5G- NR. We may provide the transmitter the ability to self-configure and self-organize based on channel states and service requirements by using variable numerologies like sub-carrier spacing, pilot spacing, and symbol duration. This comes in handy for a variety of measurements.

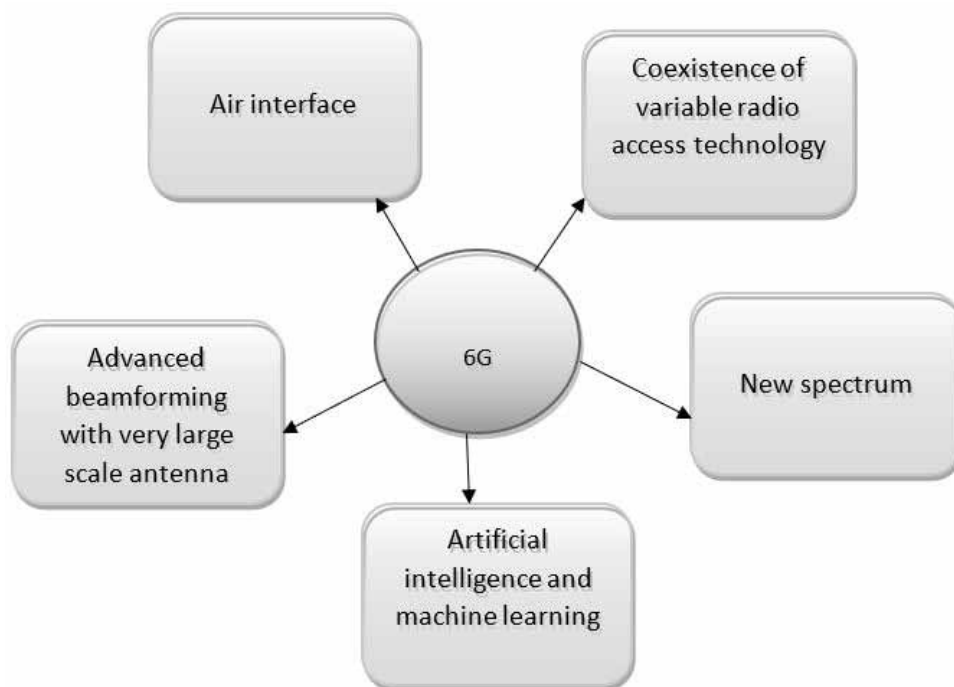
For example, low latency can be accomplished by shortening the symbol length, and in mmWave and sub-mmWave, enhancing the sub-carrier spacing which can assist to reduce phase noise. Optimizing the width of the sub-carrier will also aid with Doppler shift compensation in high-mobility scenarios.

A new spectrum has emerged. mm Wave is already a contender for 5G, but its full potential isn't being realized since beamforming algorithms aren't yet mature enough. When satellite connectivity and personal BSs are blended into cellular communication, network upgrades are required. Previously, the spectrum was partitioned for a variety of applications, including TV, military communications, and cellular communication (Nawaz & Hassan, 2019). As a result, the concept of applying an unlicensed spectrum, that is, simultaneously exploiting the THz band, mmWave, and visible light spectrum is presented. There is never any contact on these bands. The problem with the higher frequency range, on the other hand, is that the signal attenuates rapidly as it travels. A 4G or 3G BS, for example, will provide coverage of many miles, while 6G or 5G BS will provide coverage of a few hundred meters. The idea of using massive MIMO and beamforming to tackle this problem in mmWave and THz communications arose, as discussed in the following subsections.

Artificial Intelligence/Machine Learning

The networks of 6G wireless communication will be at the heart of society's digital shift by providing secure, ubiquitous, and close by proximity-instant wireless networking for computers and humans. Recent advances in ML research have enabled a wide range of new breakthroughs, including self-driving automobiles and voice assistants. The complexity of B5G/6G wireless networks has grown, necessitating smarter approaches for dealing with losses and features of the network, recognizing anomalies, and evaluating KPI patterns. It is accomplished by implementing SDN and ML solutions.

Figure 1. 6G system architecture



The decision-making process will be aided by ML/AI to maintain a specific amount of KPI. A new strategy is required for the implementation and operation of RAN for 6G. By incorporating AI into wireless techniques e.g., for channel estimate, CSI feedback, and decoding, among other things may result in a shift in the algorithms' direction. It can rapidly manage resources according to user demand by applying DL, AI, and ML approaches to the communication network. This increases the likelihood of selecting the best answer, allowing the network to maintain its optimal state. Figure 1 shows certain key elements of the 6G system architecture.

TACTILE/HAPTIC INTERNET

Using motion, vibration, or force on the user, haptic technology provides a virtual touch. Tactile Internet is applied to convey a virtual touch from one user to another, whether robot or human. Tactile Internet necessitates high-speed connectivity and the use of ERLLC to capture tactile data in real. Tele surgery, or remote surgery, will be possible with this technology. It will also assist doctors in diagnosing patients through touch without having to be physically there. The three categories of haptic HCI are desktop, surface, and wearable.

The remote doctor will utilize a virtual instrument for diagnostic or surgery on the HCI desktop. The movement in surface HCI is 2D rather than 3D. A flat-screen device, like a smartphone or tablet, is used to issue commands. The robot can be given an order to engage with the patient by moving the hand on the screen. A haptic glove, for example, is applied by the remote doctor in wearable HCI. Haptic/tactile technology will aid in the provision of healthcare in the event of a disaster. For example, in the Covid-19 where every country is on lockdown and all communication with the outside world is prohibited, or natural disasters. Haptic/tactile technology will aid healthcare in such situations.

Expert surgeons will use robots to do difficult surgery from afar. Furthermore, medical workers are put in grave danger during epidemics and pandemics. A little carelessness could put them at risk of contracting the deadly/contagious disease. Robots can interact with or care for patients using tactile/haptic technologies while medical people are present remotely. All of this is possible thanks to the 6G high-speed, low-latency Internet.

Consider a system of smart healthcare in which an injured victim will convey her emotions through mental visualization. In such a case, a smart headband will regenerate brain impulses and display them like a 3D movie of the victim's imagination, which the caregiver may see in real using mobile networks. Furthermore, people who do not speak the same language can communicate using their imaginations, and disabled people can utilize haptic communication to open doors or control gadgets.

These haptic communication methods will allow them to express information through touch. It is expected use cases for 6G systems, in which the system can sustain substantially higher data rates than 5G can. Other haptic transmission possibilities include brain-controlled computer interactions, in which humans use haptics to engage with their circumstances and manage the surrounding via digital devices like a brain-embedded wireless chip that responds to people's emotions.

With the development of mobile data, the Internet, and video sharing on mobile devices has become possible. The IoTs evolution, in which communication among smart devices is enabled, is the next stage. Tactile Internet is the upcoming step in the evolution of the Internet of networks, which integrated real-time H2M and M2M transmission by adding a dimension of haptic sensations and tactile to the mix.

The term “tactile Internet” denotes the transmission of touch across long distances. It was dubbed the “Internet of Senses” by some academics.

Humans and machines will be able to communicate in real-time with the surrounding within a specified range thanks to the tactile Internet. Tactile Internet will allow for haptic interactions. One of the Tactile Internet’s key challenges is applying pressure to the skin without using any physical objects. Intensely compressed sound waves are one way to create such a sense of touch. Ultra-haptics, a British business, is focusing on harnessing ultrasounds to create the haptic feeling. Multiple ultrasonic transducers can be used to generate a touch sense by producing ultrasonic waves in a controlled manner.

These transducers, which are linked to in-depth cameras, will find the body’s position and react accordingly. Air vortex rings, which resemble speaker diaphragms, are also being developed by Microsoft for haptic feeling. The focused waves from the minute holes will travel with a 4 inches resolution and an 8.2 feet distance, giving them a significantly wider range and smaller precision than the ultrasonic method.

INTELLIGENT INTERNET OF MEDICAL THINGS

The IIoMT will emerge under the 6G communication paradigm and serve a variety of objectives for human well-being. IIoMTs are AI-driven intelligent gadgets that make their own decisions utilizing communication technologies. Along with IIoMT, IoE will emerge, allowing medical devices to link to the web. CT and MRI scan, for example.

The scanner will scan the devices and communicate the data to faraway locations via 6G technology. A pathologist can study these data in real-time. Almost every medical device will link to the web, allowing for immediate decision-making.

As a result, the IIoMT will overcome space, time, and financial constraints. Patients with cancer, for example, can readily be treated by doctors who are located far away. Currently, determining whether cancer patients are malignant or benign takes time. Cancer is identified in real-time by utilizing 6G communication technologies soon. Furthermore, neither the doctors nor the patients are required to visit specialized hospitals.

It requires both money and time. As a result, cancer patients will be treated by remote doctors in partnership with local experts. Cancer patients who are detected early can have their mortality rate reduced to almost nil. Such sensors, on the other hand, must be invented. This situation is applicable to a variety of diseases, not just cancer.

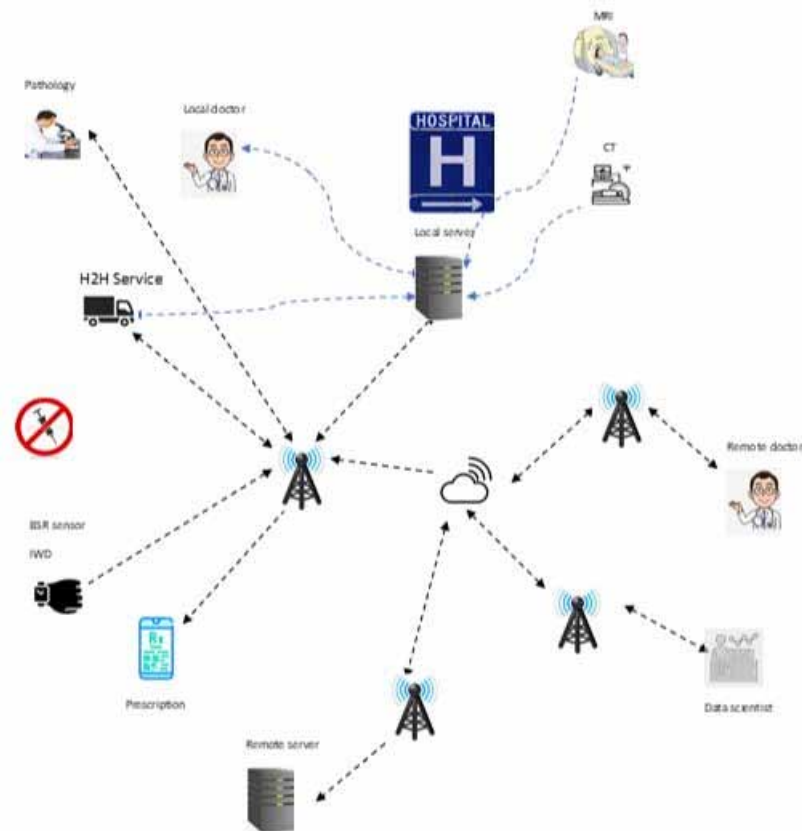
Blood Sample Reader

Blood is essential to humans, and it can be used to diagnose most disorders. In traditional blood sampling, needles are used to extract blood from humans. However, there is a lot of research being done on needle-free blood sampling equipment. Lipaniet al.,2018, for example, devise a novel needle-free glucose monitoring approach for diabetic patients. The sensors for the BSR are needle-free intelligent wearable gadgets.

The BSR sensors will change the healthcare industry forever. BSR will precisely read all blood parameters, such as WBC, RBC, and so on. This BSR sensor will continue to be linked to the Internet through 6G. A blood sample is sent to a testing center, where test results are on a regular basis, either automatically or with the patient’s permission. As a result, there will be no need for manual intervention

when examining blood samples. This technology will be critical in the intense care and monitoring of the elderly.

Figure 2. Architecture showing 6G technology in healthcare



Furthermore, utilizing BSR sensors, the COVID-19 spread may be readily terminated. Countries are running out of medical supplies as the number of illnesses rises into the millions. The medical staff is exposed to the disease when they take a blood sample with a needle. This BSR sensor can readily monitor the COVID-19 virus which is spreading in real-time. As a result, it is extremely useful during epidemics and pandemics. As a result, the BSR sensor is one of the most popular medical gadgets soon.

Intelligent Wearable Devices

IWDs are Internet-connected devices that send physical and psychological data to monitor and testing centers. Heart rate, blood tests, blood pressure, health issues, body weight, and diet will all be monitored by these gadgets. The test results will be received as soon as possible. IWD also learns from a person's personal body history and advises them on what to do next, such as going for a walk or running. IWD will keep track of her own health, habits, and nutrition.

As a result, IWD will advise on what to consume in the event of a shortfall. The frequency of hospital visits will be reduced if small body disorders, such as deficiency, are detected. As a result, hospital bills will be lower, and hospitals will be able to concentrate on more difficult disorders. Additionally, IWD will study a blood sample, which will then be sent to pathological results.

As a result, IWD may be used to diagnose cancer early. As a result, IWD has the potential to refine health and extend human life. It is critical in aged care because elderly care necessitates intensive attention. IWDs in the future will merge numerous functions into a sole device.

Every function is contained in a sole device. The initial cost of that devices is high, but with time, the cost will reduce, and the public is capable to purchase them. Figure 2 shows the 6G technology in healthcare.

HEALTHCARE SYSTEM APPLICATIONS AND CHALLENGES

It is a basic human need to have better healthcare, from diagnosis through treatment. Everyone and everyone should have access to high-quality healthcare, which is now achievable thanks to the development of smart healthcare applications. The healthcare method is divided into 3 key application areas in this paper: hospital environments, remote healthcare, and disaster response units.

Hospital Environment

A hospital is made up of highly trained personnel and medical equipment that are used to provide the best possible treatment to patients. Effective transmission between management, medical staff, patients, and doctors is necessary to keep the hospital running efficiently. Email, cell phones, two-way radios, and pagers are all commonly utilized technology for interdisciplinary communication within the hospital. Recently, new methods have been used to enhance hospital healthcare services; electronically maintaining and collecting health records helps to saves time, reduce human errors, and enhances communication among patients and physicians; introducing AI to create better diagnosis decisions; and incorporating robots to reach great precision in surgery, as we have seen (Tian et al., 2019; Boyle, 2006).

In catastrophic situations, hospitals soon become overburdened due to the enormous number of patients hospitalized. Controlling the situation is challenging due to a lack of medical personnel and equipment, and restricted patient capacity. Things get worse in pandemic scenarios since the infectious disease are transmitted from victims to medical personnel, therefore guaranteeing the safety of workers while providing medical care to infected victims becomes the most difficult task. Minimizing physical interaction among clinicians and patients is one method to solve this difficulty. This can be accomplished in the hospital setting by employing IoMT and Robots (Chamola et al., 2020). IoMT wearable sensors and devices can transmit and monitor patient health reports to clinicians via the web.

When there are fewer communications (Hassija et al., 2019). Robots are employed in a variety of ways, including delivering supplies, doing medical exams, and sanitizing the patient's surroundings. The robots and technologies are likely to be used on a large scale in the future to give support and safety to the hospital's medical doctors and personnel. These technological improvements are based on the hospital's communication framework and necessitate a dependable, secure, and high-data-rate transmission link.

In hospitals, RF-based wireless transmission is commonly adopted to improve communication mobility, capacity, location, and localization. Medical equipment, on the other hand, is susceptible to EMI,

which limits the usage of the Wi-Fi network. Similarly, the hospital's complicated physical design hinders high-frequency signal penetration through barriers, causing coverage concerns.

Furthermore, existing Wi-Fi systems are not built with the intention of handling the traffic load in a crisis. As a result, when there is a high volume of patients, a Wi-Fi system is inadequate to meet the transmission needs in terms of connectivity and capacity.

Further, real-time health record monitoring using IoMT devices necessitates extensive connectivity, excellent reliability, and minimal latency. In the event of an emergency, a slight delay and inadequate connectivity could have disastrous repercussions. In hospitals, extremely dependable and low-latency communication is required, especially to permit the employment of robot technology. It is vital to preserve the transmission link using advanced security methods to forbid unauthorized access to the patients' critical and private information.

Remote Healthcare

In the current circumstances, remote medical care is widely used to provide healthcare to persons living in rural places and those who are unable to travel. Telemedicine and remote health monitoring are two ways that this service is made possible (Pramaniket al., 2019). And in telemedicine, doctors utilize electronic health records or teleconferencing to evaluate, diagnose, and treat victims without having to see them in person.

Under the supervision of a paramedic, it is obtained from fundamental health institutions or homes. Currently, telemedicine relies on high-quality video teleconferencing; but, with the speedy advancement of hologram technology, holographic tele-presentation is projected to become commonplace soon. IoMT technologies like wearable devices and WBAN have begun to be widely used for remote health monitoring (Wei et al., 2020). Similarly, implementing real monitoring methods will improve the quality of life for the elderly by tracing emergency conditions via sensors and giving immediate assistance. Therefore, novel technology uptake, particularly among the elderly, is a significant impediment to attaining this goal. Furthermore, digital medicine's dose modification creates life easier for people who require regular care, such as diabetics.

To protect the patient's privacy and safety, these technologies need a secure and trustworthy connection. With the outbreak of COVID-19, remote medical care is being advocated to limit infection spread and hospital patient load (Ohannessianet al.,2020). Communication infrastructure is entirely reliant on remote healthcare services. Due to transmission challenges, like massive interference and connectivity for IoMT, ultra-low power transmission for biosensors, low latency and reliability for tactile internet-based digital medicine and remote surgery, and the requirement of high data rate for holographic telepresence, many applications have yet to be explored.

Among the problems, protecting and securing the crucial detail and privacy of patients is one of the most important. Wireless communication links are subject to security risks like eavesdropping, spoofing, and jamming, particularly in remote medical care, where every sensors and device communicate data to hospital staff/upload to an internet portal. When the transmission link is not secure, an eavesdropper or a spoofer will obtain the patient's crucial detail or change the data in the online database, resulting in fatalities. As a result, in addition to cryptography-based approaches, it is necessary to secure the physical channel.

Disaster Response Unit

A disaster response unit is a mechanism that provides healthcare services during the reaction to any emergency or hazardous event. It consists of crisis management centers, EMS, field hospitals, and public space monitoring, among other things. While a catastrophic event occurs, a disaster management center is built in a separate institution or a hospital for quick response, departmental communication, health services, and after-effects monitoring. The most important services of a disaster response unit are EMS. In the event of a medical emergency outside of the hospital, it provides prehospital care via land or air ambulance, based on the emergency severity.

Smart ambulances are equipped with advanced medical technology to increase the timeliness of treatment and diagnosis by adopting preventative steps, upgrading medical staff via high-quality video calling, and providing instant remote consultation via the cellular system. It will decrease the number of patients who need to go to the hospital by using telemedicine to provide care. Furthermore, autonomous ambulances equipped with modern technology have been adopted in several countries to provide rapid response and protection. Furthermore, the disaster response unit must connect with other EMS-related departments, such as fire, police, and insurance, for centralized control, which necessitates excellent communication and coordination.

During pandemics, it's vital to alert EMS personnel to take the required precautions before giving care to patients to avoid contracting the disease themselves. When it comes to pandemic challenges, keeping a safe distance between people is crucial to preventing illness from spreading. As a result, in addition to the EMS, observing the public to make sure that they are following epidemic precautions is crucial in detecting violations and taking the required steps to avoid disease spread. In the same way, thermal imaging can be used to spot breakouts.

Drone deployment from the emergency control center can do these tasks, as well as outside disinfection. The existence of a dependable communication system is required for the development of a quick response system. While a natural disaster strikes, particularly pandemics, medical care systems are hurt the worst because of the increased patient flow. In these instances, field hospitals can be critical in isolating pandemic victims, freeing up other hospitals, and making good management of scarce hospital sources like equipment. These hospitals are currently utilized to isolate infected individuals and offer necessary care. Drone and robot technologies are paving the way for clinicians and patients to interact less. These technologies are utilized to carry out a variety of duties, including delivering medical and food supplies, collecting test samples, sanitizing patient places, etc. IoMT-based smart medical devices, such as smart wristbands and smart thermometers can be used to monitor the patient's vital signs (Berardinelli et al., 2020). Furthermore, through remote medical care and telemedicine services, city hospital clinicians can consult with patients at the field hospital.

Several obstacles have been identified from the perspective of communication in a disaster response unit, as follows. Whereas, in the case of autonomous ambulances and delivery drones, increased mobility leads to a greater number of handovers, which increases latency and lowers the communication link's reliability. V2X connectivity must be dependable for these vehicles to be driven safely. Furthermore, the real-time transfer of data obtained from medical imaging in smart ambulances necessitates high data rate communication. Similarly, because of restricted or unavailable transmission networks, field hospitals frequently lack network connectivity. Signals utilized for dedicated short-range transmission in autonomous ambulances are controlled or manipulated for jamming radar or causing crashes, according

to security attacks. Smart wristbands are also utilized to monitor and track the locations of quarantined patients. Wristband communication signals, however, are susceptible to jamming and spoofing assaults.

POTENTIAL SOLUTIONS TO THE COMMUNICATION CHALLENGES

Capacity, connectivity, coverage, dependability and sense, low latency communication, privacy, and security are just a few of the significant communication issues that plague the healthcare system. This section discusses how to address the difficulties by bringing 6G technologies into the healthcare sector.

Capacity Enhancement

Following the early wave of the pandemic, system operators are concentrating their efforts on the planning and construction of network frameworks for catastrophic scenarios, with capacity enhancement being one of the most difficult tasks. For example, since the start of COVID-19, a Turkish network provider has seen a 35 percent rise in data usage. Because of greater patient loads and widespread adoption of IoMT gadgets, this growth is also evident in healthcare systems. The present RF communication framework depending on low-frequency bands is insufficient to service visitors and patients both remotely and in hospitals. As a result, ultra-massive MIMO and high-frequency bands are used to increase the network's overall capacity. VLC, on the other hand, can be used to increase interior capacity (Janjua et al., 2020). As demonstrated, this technology will supplement a present RF-based communication system by enduring the user load. THz's ultra-high bandwidth allows for extremely more data rates in holographic telepresence for remote medical care (Elayan et al., 2020). Aerial networks like HAPs are used to boost the capacity of the healthcare communication process for the field of hospitals by allowing for network scalability. When more capacity is necessary for hospitals after a crisis, RIS combined UAVs are deployed to enhance capacity. The ability of the RIS integrated UAV to provide panoramic full-angle reflection enables for reflection of signals in the air toward the hospital, and free mobility, allowing for increased capacity by utilizing applicable channels from neighboring cells. These devices can be supported by cognitive radios with the technology of AmBC, also called symbiotic radio, which means IoMT devices can use both AmBC and cognitive radios for ultra-low power communication and spectrum sharing, respectively. Thus, both energy efficiency and connectivity are improved at the same time. However, maintaining the QoS in these systems is difficult.

Coverage Enhancement

For a variety of reasons, seamless coverage and connection are essential in all locations in healthcare systems. Because of the hospital's complicated physical structure and sensitive devices, network coverage is limited. Within the hospital, Wi-Fi networks are now in use for communication. Severe EMI problems, on the other hand, limit coverage in sensitive locations. A hybrid VLC-RF communication system can be built to offer coverage in such locations. In addition to increasing coverage and safeguarding RF prohibited regions, RIS may be implemented at specific locations in hospitals, such as walls, ceilings, and so on (Basaret et al., 2019). In rural regions, when the network is not available or the QoS is inadequate, there are major coverage concerns connected to remote health. As a result, without coverage, there is no connectivity, leaving a vast population without access to telemedicine.

In field hospitals, similar coverage issues exist. Aerial networks, notably UAVs, HAPs, and satellites, are among the best possibilities for coverage augmentation in this regard (Zhou et al., 2020). By functioning as relaying nodes or base stations, these networks can improve coverage. Large-scale ad-hoc networks, mobile base stations, and D2D communication are some of the other approaches to improve coverage. NTN, on the other hand, has better coverage than other networks. As a result, hybrid aerial-terrestrial networks may be utilized in catastrophe circumstances to give network scalability and flexibility while the network backbone fails.

Reliable and Low Latency Communication

Enhancement of continuous transmission with low latency and great dependability is critical in healthcare systems for disaster response services and remote health. For example, soon, based on tactile or autonomous surgery via robots employing ML and AI would necessitate a very dependable and low latency connection. As a result, relocating services to the edge near patients and employing edge intelligence will minimize latency and improve the communication link's dependability (Nayak & Patgiri, 2020).

For real-time sensitive data transfer and monitoring, such as EEG and ECG, smart ambulances with the medical tool require very dependable and low latency connection with medical professionals at hospitals. A relatively recent idea called JRC is utilized to allow V2X communication and reliable sensing for secure self-driving of smart ambulances. Edge intelligence may also be utilized to provide very high mobility in autonomous ambulances and teleoperated vehicles.

Mobility may also be improved by using NTN platforms, which have a broad coverage area. Furthermore, changeover difficulties i.e., delay jitter caused by a patient's movement with implanted medical equipment may be handled using AI and REM aided cognitive radios. Furthermore, by exploiting the diversity in hybrid RF-VLC and terrestrial-aerial systems, the needed dependable and low latency transmission in both outdoor and indoor contexts may be achieved.

Sensing and Communication Enhancement

Due to a shortage of medical facilities and resources, certain nations saw long queues and congestion outside hospitals during the COVID-19 epidemic. This burden might be reduced by using IoMT devices for health monitoring. It does, however, confront two major challenges: enormous connectivity and a scarcity of IoMT devices. In these situations, Wi-Fi sensing can be useful for patient tracking and health monitoring (Adib et al., 2015). It will also reduce reaction time by eliminating the need for reusable medical equipment to be disinfected and reducing the battery restrictions of IoMT devices.

A similar technique might be used in the field of the hospital when there are no current medical services for health monitoring. Furthermore, Wi-Fi sensing may be used to get position and location (Hsu et al., 2019), which may be necessary for a big facility with many patients. At high carrier frequencies, JRC may also be used to monitor the surroundings and provide data for precise location. In COVID-19, another use of wireless sensing is detecting congestions in interior spaces using Wi-Fi signals to preserve social distance. Outdoors, a broader sensing notion known as REM can provide more information regarding social distance applications.

Furthermore, REM may be utilized for surveillance and monitoring of social distance breaches using teleoperated vehicles and drones. Furthermore, the sensor-based anomalous activity detection may be used to investigate catastrophe scenario pre-event indications. Similarly, AI and ML aided REM may be used

for early detection, launching a quick reaction, and gaining an understanding of the disaster's magnitude and location. The COVID-19 may also be detected non-invasively using sensing technology. Terahertz imaging is one technique to achieve this. Terahertz beams are focused across the person's chest to acquire pictures that demonstrate the Doppler effect of terahertz waves (Taylor et al., 2020). Advanced AI and deep learning algorithms may be used to classify these pictures and distinguish diseased and healthy cells depending on water content. THz has no adverse impact on live cells, unlike other screening methods.

Accurate Positioning and Localization

During the COVID-19 epidemic, indoor and outdoor placement might be critical in providing a quick reaction. The GPS may be used to accomplish outdoor positioning and localization. Due to the complicated electromagnetic propagation environment, GPS cannot offer precise inside locations. When hospitals become congested with patients because of a disaster, finding physicians, medical personnel, and patients become more difficult.

Wi-Fi real-time positioning process may be used to locate medical personnel and victims for real-time coordination among medical staff and patients and fast response to important patients. VLC access stations are placed in sensitive places whereas Wi-Fi access points are not available. Because VLC access points have a narrow coverage area, precise location and position may be determined, as illustrated in Figure 3C. Medical robots, old people's activities, and remote surgery are some of the other uses of positioning and localization.

Remote surgery needs extremely precise localization and placement. THz technology, along with simultaneous mapping-based and localization approaches, can reach such a high level of precision. For extremely precise positioning and localization, a hybrid VLC and THz system are built.

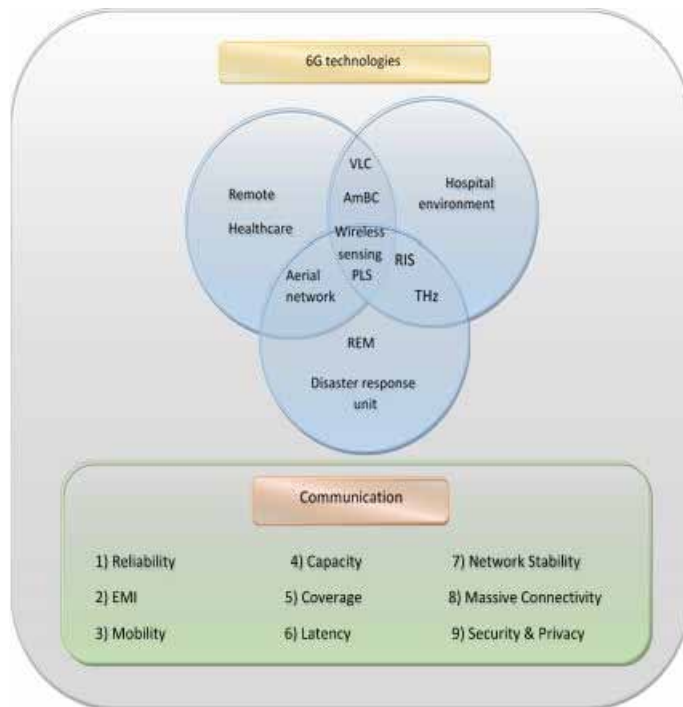
Ensuring Security and Privacy

Healthcare technology that will be available in 6G is resistant to privacy and security threats. For example, during remote surgery, end-to-end connection security is required since any assault might modify the information sent to the robotic apparatus, putting the victim's life in jeopardy. Cryptography-based approaches are now utilized in the healthcare system to address security and privacy problems. These algorithms, on the other hand, are quite complicated.

Highly secure transmission is developed for protection with the advent of quantum cryptography and low complexity methods. Security in healthcare systems may be ensured by using quantum key distribution methods and quantum random number generators. Physical layer security has been created in addition to cryptography-based approaches to protect communication links against jamming, spoofing, and eavesdropping.

To increase communication security, PLS approaches such as key generation and channel-based adaptation, cross-layer security, etc., are used. Because of the low computational complexity of ultralow-power communication technologies, these approaches are critical in healthcare. External devices, for example, can be employed to prevent eavesdropping on the IoBNT and WBAN by concurrently jamming and receiving information signals at places other than the intended recipient. To prevent unwanted access to the victim's essential detail, channel and then hardware-based authentication measures were also utilized (Furqan et al., 2019). Furthermore, edge technology can preserve patients' privacy by filtering crucial data before transmitting it to the cloud.

Figure 3. Challenges faced by 6G technology-based health care



For this, AI-based edge technology is utilized to separate medical information before transmission and store the private data in local memory. Locating BC technology in healthcare methods is another approach to safeguard data confidentiality. Instead of using a centralized database, BC will use digital and distributed ledgers to protect the security and privacy of the patient's essential detail.

Furthermore, because the medical devices and WBAN control unit communicate critical communications and patient medical detail, any security breach might compromise privacy or result in undesired behaviors.

In this instance, a smart cloak/vest with sophisticated RIS technology termed reconfigurable meta-surfaces, which will filter and modify signals against jamming and spoofing assaults, might be an interesting option for protecting WBAN communication (Di Renzo et al., 2019). Figure 3 shows the challenges in the 6G technology-based health care.

TRANSITIONS FROM 5G TO 6G: GAPS AND RECOMMENDATIONS

Due to 5G's capacity to serve existing industrial use cases, adoption has accelerated in most of the world's megacities. Nonetheless, soon, there will be numerous use cases, social requirements, and technical progress that will necessitate investigation beyond 5G's capabilities. Presently, terrestrial communication is the most important requirement in 5G systems; however, in 6G networks, it will expand beyond terrestrial to aerial and underwater, allowing for various times the capacity of 5G.

This level of connectedness will stimulate the growth of numerous verticals with difficult limitations, such as vehicle buying, holographic telepresence, underwater recreation, and ultra-real human-computer interactions. To meet the needs of these sectors, communication networks must be considerably more sophisticated than they are currently, such as 3D connection, extremely high bandwidth 10GHz, and data rate Tbps, multidimensional video 16K resolution, and so on. Furthermore, the present internet is incapable of meeting these demands. As a result, additional KPIs are required to address use cases along with multiple performance needs. To function successfully, real-time remote robotic surgery, for example, will require concurrent ultra-low latency, security, and huge data flow.

Furthermore, in terms of latency, congestion, security, and dependability, user apps have no direct control, resulting in a bad user experience. Simultaneously, there is an unpreparedness state for launching holographic data, which necessitates a data rate of various Gbps to Tbps, and then low latency, and the capacity to link to millions of customers in real-time. Thus, the period among the events and the creation of response also should be as short as possible, which is currently missing in cellular systems. Dispatching a command to operate the robotic arms and then the video broadcasts of the surgery, for example, must possess a temporal accuracy of a fraction of a millisecond.

When it comes to air, undersea, and terrestrial communication, there is a lack of interfaces and infrastructure for all-around network connectivity. Furthermore, intelligence has only been observed at the network edge like in 5G, while intelligence is lacking at single system levels or while network parts are dispersed.

PROSPECTS AND APPLICATIONS

AI is included in 6G communication networks. AI will be used to include all network instrumentation, physical layer signal processing, management, service-based communications, resource management, etc. It will help to further the Industry 4.0 revolution, which is defined as the digital conversion of industrial framing. Below are a few of the most significant 6G wireless communication possibilities and applications.

Smart Environment

Today's world scenario is moving towards a smart environment where every single detail and application of human life gets automated to minimize the sophisticated life of human beings. Artificial intelligence plays a key role in automation through various platforms of the Internet of Things, Cloud computing, etc. With the advent of 6G communication standards, a new dimension of these applications is all set to emerge ranging from replacement of handheld devices with smart glasses with are compact in area, size, and power, self-driving vehicles capable of making intelligent decisions, etc. Remote monitoring and control are going to reach their peak with the meritorious features of 6G future generation communication systems.

Extended Reality

Extended reality hereafter XR services, such as VR, MR, and AR, are key components of 6G networks. These capabilities rely heavily on 3D objects and artificial intelligence. 6G will deliver a completely

immersive VR/MR/AR experience through collaborative design integration and high-quality 6G wireless connectivity, in addition to meeting perceptual computing, storage, cognition, human senses, and physiological needs. VR is a computer-simulated 3D experience in which reality headsets are used to produce realistic feelings and mimic a genuine surrounding or construct an imaginative universe. All five senses are stimulated in a real VR experience.

AR is a real-time representation of a physical environment that is enhanced by computer-generated sensor inputs like video, images, GPS data, and audio. It takes the present fidelity and enhances it with the use of a certain type of technology. MR brings the virtual and real worlds together to generate novel environments and representations that can be interacted with in real-time. It is also referred to as hybrid reality.

The most distinguishing feature of MR is that real-world and artificial contents may interact in real-time. All integrated actual and virtual surroundings, and human-machine interactions, created by computer technology and then wearables are referred to as XR. It encompasses all its descriptive forms, like virtual reality, mixed reality, and augmented reality. It combines MR, VR, and AR into a single word. The 6G system's low-latency, high-data-rate, and extremely dependable wireless connectivity are critical for a true XR that is, MR, VR, and AR experience.

Autonomous Systems

Various automotive technology researchers are now looking towards automated and networked automobiles. The implementation of linked robotics and autonomous systems is aided by 6G systems. A system like this is the drone-delivery UAV system. The autonomous car, which uses a 6G wireless connection, has the potential to drastically alter our daily lives. The implementation of self-driving automobiles will be aided by the 6G system autonomous cars or driverless cars. LiDAR, GPS, radar, odometry, sonar, and a set of smart sensors are being utilized by self-driving cars to sense their surroundings. V2X and vehicle-to-server connections are supported by the 6G technology.

UAVs are a form of unmanned aircraft. The networks of 6G will facilitate the ground-based controller and system transmissions among the ground and the UAV. Military, business, science, pleasure, law and order, agriculture, aerial photography, product delivery, surveillance, drone racing, and disaster management are just a few of the sectors where UAVs are useful. Furthermore, when the cellular BS is unavailable or malfunctioning, the UAV is employed to provide high-rate and wireless broadcast communications.

Brain-Computer Interfaces - BCI

The BCI is a method for controlling everyday appliances in smart societies, particularly those utilized at home and in hospital methods. It's a direct line of communication among the brain and the rest of the world. BCI collects and analyses brain impulses that are sent to a digital device, then interprets them into other actions or commands. The capabilities of the 6G wireless connection will enable the full deployment of BCI methods for smart living.

Haptic Communication

The sensation of touch is used in haptic communication, which is a type of nonverbal communication. The remote users will enjoy haptic sensations through real-time interactive methods thanks to the pro-

jected 6G wireless connection. The better characteristics of 6G communication networks will make it easier to deploy haptic systems and applications.

Smart Healthcare

Medical health systems have benefited from 6G wireless networks since technologies like mobile edge computing, holographic telepresence, AR/VR, and AI will aid in the development of smart healthcare systems. The 6G systems will make a dependable remote monitoring process in the healthcare system possible. Using 6G connectivity, even remote surgery will be possible. The low-latency, high-data-rate, and ultra-reliable 6G system will assist in reliably and swiftly transferring large amounts of medical information, thereby improving both access and quality of care.

Automation and Manufacturing

6G will enable entire AI-based automation. The automated control of processes, systems, and equipment is regarded as “automation”. The 6G automation process will use low-latency and high-data-rate networks to deliver extremely dependable, scalable, and secure communications. The 6G technology will also maintain network integrity by ensuring error-free data transmission with no data loss in the transmission and reception stages.

Five Sense Information Transfer

Humans employ their 5 senses of sighting, hearing, smell, touch, and taste to perceive the world around them. Data collected through the 5 senses are sent remotely using 6G connection technology. Through sensory integration, this technology takes advantage of the neurological system. It receives feelings from the human and then the surroundings and makes effective use of the body in the context of the environment and local conditions. This application will benefit greatly from BCI technology.

Internet of Everything

The IoE refers to the autonomous coordination and seamless integration of a vast number of computer units and sensors, items or devices, processes, people, and data over the internet framework. The 6G method will support IoE in its entirety. It’s essentially an IoT, but it’s an umbrella word that encompasses all four characteristics, including data, people, processes, and physical items. IoT is primarily concerned with physical devices or things talking with one another, while IoE adds system intelligence to bring all people, processes, physical objects, and data together into a single system. Smart vehicles, smart health, and smart industries will all benefit from the Internet of Things.

CHALLENGES AND FUTURE RESEARCH DIRECTIONS

To implement 6G communication networks, several technological issues need to be addressed as future research directions. A few potential issues are mentioned briefly below.

Atmospheric Factors for Long-Distance Communication

6G communication systems are bound to communicate at high data speeds of the order of several hundreds of TeraHertz. Concepts like VLC when utilized in an indoor environment do not exhibit such complexity as it is basically a line-of-sight communication. However, atmospheric conditions like scattering, absorption loss, ionic propagation, and interaction play a dominant role when these media are used as carriers in long-distance communications. To overcome these issues, a highly efficient transmitter, and receiver configuration system is of prime importance. The transceivers being implemented need to carefully take care of the atmospheric factors to avoid any signal loss or data fade. However, in the case of mm-Wave communication standards, the development of such environment interaction-free communication is always a challenge as the modeling is quite difficult to adapt to changing environmental conditions. In addition, transceivers designed for these future communication networks should ensure a high level of spectrum utility as spectrum availability is already scarce in today's scenario.

Challenges Associated with Resource Management

Future generation communication systems offer data availability at high rates and connectivity from across the globe. These services demanded by users are fetched from resource pools and delivered to the consumers in the quickest time possible. Hence, the research issues associated with optimization of resource management, job and task scheduling, priority, and decision making based on consumer requirements need to be key points of consideration as far as the resource management module is concerned. Moreover, the data being communicated at such high speeds need to be very secure and robust towards a wide variety of intentional and unintentional attacks. Hence, concepts of optimization strategies involving metaheuristics (Manoharan, et al., 2020) need to be invoked as they closely mimic the real-time scenario as in the proposed case of resource management in an optimal manner.

Challenges Associated with Hardware

A wide variety of diverse types of communication systems will be engaged in 6G, including service delivery, communication topologies, frequency bands, and so on. Furthermore, the hardware configurations for mobile terminals and access points are vastly different. Massive MIMO is improved from 5G to 6G, which will likely necessitate a more sophisticated design. It also makes the algorithm design and communication protocol more difficult. ML and artificial intelligence will, nevertheless, be used in communication. Furthermore, the hardware architecture for various communication methods varies. A hardware implementation may also be complicated by unsupervised and reinforcement learning. As a result, integrating all the communication technologies into a single platform will be difficult.

Autonomous Wireless Systems

Autonomous systems have already evolved and grown a long way up with several unmanned vehicles and systems being put to test and usage in many applications. The key functionality in the efficiency of these autonomous systems is intelligent decision making which requires a set of complex and sophisticated hardware and software-based embedded systems onboard the device. With the advent of the 6G future generation of communication systems, the sector of autonomous systems and Industry 4.0 is all set to enter

a new dimension. Unmanned vehicles starting with the highly intelligent car without a driver, self-driven robotic platforms for various applications including healthcare, industrial requirements greatly depend on the voluminous features of the future generation wireless communication systems such as the 6G.

The Ability of the Communication Device

A lot of additional functions will be available with the 6G system. Smartphones, for example, should be capable of coping with the additional functionalities. Supporting 1 Tbps speed, XR, AI, and incorporated sensing along with communication attributes utilizing separate devices is particularly difficult. Few of the 6G capabilities may not be supported by 5G devices, and the cost of 6G equipment may rise as capability improves. Because billions of devices are attached to 5G technology, we must guarantee that those gadgets are also adaptable with 6G technology.

High Capacity Backhaul Connectivity

The dependence of devices in use today is immensely high for existing 4G standards and 5G standards of communication in some geographical locations. Due to the high data rates and seamless connectivity, the cluster density of devices depending on these standards is exorbitantly high causing a huge overhead on the back-end processing of fetching and storage of required services and information. With the advent of 6G future communication systems, the volume of devices is going to increase in an exponential manner causing an immense overhead on the backhaul systems. Hence, existing systems should upgrade their protocols, standards, and working principles to cope with the high standards required by 6G communication systems. Optic fiber systems are optimal choices for such backhaul processing of data. However, the load on them too increases considerably when used for such high cluster density-based applications.

Spectrum and Interference Management

Spectrum utilization has grown to be an increasing area of research concern due to the high degree of reliability of wireless gadgets being dependent on the scarcely available radio spectrum. Cognitive radio networks, thanks to effective research solutions put forward by researchers all over the globe, have provided an effective solution for such spectrum sharing, utility, and management solutions. With the advent of 6G communication standards, the quality of gadgets is going to a new uplift with cutting edge features which consequently increases the reliance on a huge bandwidth amidst existing conditions of spectrum scarcity. Hence, immense research needs to be focused on the concept of distributed spectrum sharing, high quality of service during the sharing process, minimized interference between primary and secondary users.

Beam Management in THz Communications

Massive MIMO methods with beamforming are a potential technique for enabling high-data-rate communications. However, due to the propagation properties of the sub-mm Wave, that is, the THz band, beam control in this band is difficult. As a result, for large MIMO systems, successful beam control against adverse propagation characteristics would be difficult. However, in high-speed vehicle systems, it is equally critical to pick the best beam effectively for seamless handover.

RECOMMENDATIONS BASED ON STUDY CONDUCTED

For future research on emerging communication technologies, the following points should be carefully taken into consideration.

- Any network implemented on the future generation of communication especially 6G communication standards should consider the terms like virtualization, autonomous decision making which involves a high level of intelligence that is quite capable of adapting to dynamic environments and automation. High speeds of data transfer, the integrity of data being communicated, seamless connectivity irrespective of geographical locations, reduced latency, etc. should be the benchmark standards to implement these future generations of wireless network communications.
- In the current scenario, the communication environment is a mix-up of several interfaces and standards which are mostly heterogeneous comprising of phasing out 3G standards, in-use 4G and 5G standards of communication each having its own protocols and interface for access points and routing devices. The future generation of communication technology should be able to blend and adapt well with the existing network which may be of a homogenous/heterogenous or private/public network.
- With the evolution of Industry 4.0 standards, the proposed future generation communication networks should be able to meet the communication metrics and standards put forward by this industry 4.0 and existing IoT communication standards.
- Cloud computing and big data have evolved to be major partakers in current data handling and processing services. Clouds are concerned with service provision to consumers and aim to keep the quality of service to satisfactory levels. Major research trends in cloud computing have yielded Edge and Fog computing platforms aimed to reduce the computational sophistication and complexity in cloud architectures. Hence, the proposed future generation of communication networks should be able to adapt themselves to the processing requirements of edge nodes and fog nodes. These technologies play a very vital role especially in terms of multimedia communication involving high-definition data.
- Artificial Intelligence has grown in leaps and bounds and has deep-rooted structures to every network implementation right down to terminal nodes and access points. They sense the scenario and take intelligent decisions thus reducing the human error and labor involved in it. Hence, existing standards which work mainly on IoT platforms that reflect smart systems are in a great necessity to migrate towards intelligent smart systems. The same is demanded when the associated communication technology changes over from 5G to 6G standards.
- 4G and 5G technologies have paved the way for handheld portable gadgets through which consumers could access seamless data connectivity from across the globe irrespective of time. However, augmented reality has emerged to be one of the major findings giving rise to concepts of holographic communications, virtual reality due to which the existing handheld devices may gradually phase out giving rise to smart glasses which are smart enough to handle the functionalities of the conventional handheld gadget. The future generation communication networks should ensure that their standards and data transfer rates are kept compatible with these smart glasses, and they exhibit a zero-tolerance towards error.

- New sources and mediums of communication have evolved in recent times namely the mm-Wave communication and the visible light communication concepts. They offer seamless connectivity at unimaginable data rates in the orders of TeraHertz. These platforms do not require access points as they are available in abundance everywhere such as in the case of visible light communication. Hence, the transition of dependence on access points for data access has to change in the case of future communication technologies. Multiple receiving units in the form of antennas with no specific geographic pattern such as the existing hexagon structure etc. may have to gradually phase-out. Hence, the related issues such as interference between cells, co-channel communication and interference, handoff related issues also phase out gradually in the future generation of communication systems.
- With evolving 6G communication technologies and their relative high data rates and several other meritorious features over existing 5G networks, applications are also prone to develop and evolve into super applications which may demand more accuracy, precision, zero tolerance towards data error rates, low latencies, robustness to attacks, etc. Hence, the implemented future generation of communication systems should be able to satisfy the requirements of these cutting-edge technologies which are to be dependent on them. The developed communication technologies should at the same time keep a check on the conservation of energy utilization, area optimization, and network lifetime.

With evolving future generation communication systems, the level of data handling and processing and its associated storage issues are going to be a great challenging issue and quite a burden on the computing platform. Hence, developments and research on parallel processing, decentralization of functionalities, autonomous decision making at various levels of the hierarchy need to be addressed with great concern to keep with the requirements of 6G communication technology.

CONCLUSION

With each version of the communication network, unique and innovative features and functionalities are introduced. The 5G telecommunications, which will be presented globally in 2020, has a lot of intriguing capabilities. Unfortunately, 5G would be inadequate to meet the increasing requirement for cellular networking in 2030. Thus, 6G will need to be deployed. 6G studies are currently in their development and even in the research stage. This chapter considered the possibilities and methods for achieving the aim of 6G telecommunication. This chapter included extensive details on the 6G-based healthcare architecture. In this research, the potential uses and technology for 6G communication were discussed. In addition, the potential obstacles and research avenues to achieve the 6G targets were discussed. Furthermore, the different technologies which might be used for 6G communication, in addition to describing the aim and vision of 6G communications were also indicated.

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KEY TERMS AND DEFINITIONS

Appalachia: A geographic and cultural region of the Mideastern United States. The population in media is portrayed as suspicious, backward, and isolated.

Ethnocentric: A belief that one's own culture is superior to other cultures.

Family-Centricity: The belief that family is central to well-being and that family members and family issues take precedence over other aspects of life.

Chapter 16

Smart Healthcare Technology Challenges and Future Perspective

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ABSTRACT

The vision towards future sustainability in healthcare has become an alarming factor owing to its imperfect system in place based on growth and aging. In order to follow and control every citizen in the health process of their lives, wireless health monitoring must be achieved. The aim of next gen is not just to make wireless healthcare a true technology, but will also enable bio-nano-internet, things allowing the human healthcare to form a controlled network. Less sophisticated wearable and/or implantable equipment would be an integral part of our day-to-day life, which can recognize the lifestyle and health data from all the possible means of interaction. The authors present a vision for a complete model that should meet the expanding healthcare hassles and a conceptual model that can solve these growing expectations in full. In conclusion, the latest developments in the healthcare domain are discussed, and the authors suggest upcoming avenues in this domain on par with the technological growth.

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INTRODUCTION

Despite the fact that 5G is still in its early stages of commercialization, which means that related technical features must be improved and the economic model for such Web of Things as well as specific vertical interactive platform should always be explored even farther, it is indeed important to search forward with towards the abilities of something like the future data. Society and then to initiate suggestion as well as technology investigations for the future generation communications networks. Researchers aim to determine the importance of accelerating concept as well as technical progress for next telecommunication system, termed has 6G. Protection is now becoming especially critical even as rates of chronic sufferers increases as well as the population is aging. Protection is described as both the practice of preserving a healthful lifestyles (physical activity, proper nutrition, as well as frequent health checks), and also preventing the deterioration of chronic conditions. The health - care system's objective would be to contribute actively towards individuals' wellbeing. In just this scenario, it really is vital to develop sophisticated information and communication technologies (ICT) approaches including evidence - based care, personal health assessment, including medical and lifestyle awareness which incorporate information through environmental, wearable, including even within sensors. It enables the establishment of a database of updated regularly clinical evidence about patients, assisting medical practitioners in making a decision (Tian et al., 2019).

To enable the potential for future technologies including such proactive medicine, computer-aided catastrophe prediction, including VR technology, a 6G mobile provider technology must provide extremely fast speeds, expanded capacity, as well as non-proximity (VR). Due to earlier pre-regulation of wireless services, that the very 1st 6G links would be frequently built on the present 5G structure, leveraging 5G's strengths (for illustration, the expansion in permissible frequency bands streamlined the construction of a decentralized system) and transforming how we choreograph as well as play (Pan et al., 2019). Before 2030, the consumers are expected to be impacted by data, which enables fast and infinite wireless communication. As a consequence, 6G is expected to enhance existing communications technology as well as ensure completed successfully. In terms of consistency, 6G is projected to employ a more complex available bandwidth than previous eras in order to achieve 100–1000 times the bandwidth utilization of 5G (Ray, 2021). To be somewhat more precise, 6G technologies will enable the connection of 100s of GBs per sec via bandwidth spectrum; for instance, the combination of a band between 1 and 3 Giga Hertz, a mm wave band (from 30 to 300 Giga Hertz), as well as a terahertz band would then enable the connection of 100s of GBs per second via bandwidth spectrum (0.06 to 10 Tera Hertz).

By 2030, there have been predicted toward being 97 billion machine-type devices, leading to a drastic growth in monthly worldwide mobile communications to 5.016 Zeta Bytes (ZB), up between 0.062 ZB in the year 2020 (Pan et al., 2019). As shown in a review, the globe's 43 metropolises will have a combined population of ten million individuals by 2030 (Hewa et al., 2020). As a consequence, Information Communication Technologies (ICT) ought to be adaptable as well as persistence in the face of the massive amounts of data created by smart phones as a consequence of urbanization as well as smart digital city ecologies including smart transportation, digital healthcare, as well as technology based buildings. Additionally, the data created would be accelerated by modern innovations including robotics, Industry 4.0, Artificial Intelligence (AI), and indeed the Internet of Everything (IoE), as few technologies, which all produce vast volumes of data. Cellular internet infrastructure would be a significant driver for these verticals in this scenario, because it will provide data rates, bandwidth efficiency, and quality of service (QoS) (Ray, 2021), (Hewa et al., 2020). Assume a few potential internet applications, including such self-

driving autos capable of communicating with one another. Each communication link in such a scenario takes tremendous network parameters, including such interconnection with something like a distribution flying vehicle to support in the distribution of urgent health facilities which either necessitates extraordinarily low transmission delay (less than 1 millisecond), as well as interconnection to roadside units (V2X), which requires high level of reliability (99.999 percent) to prevent crashes (Gardašević et al., 2020). Additionally, distant robot based surgery in a digital enabled hospital, distant holographic image transmission during a live public concert, data sharing via ultra-high density IoT (uHDIoT) as well as haptic online gaming, wearable devices as well as haptic meetings are possible. These use scenarios will be the primary focus in 2030, necessitating a high degree of autonomy as well as intelligence to meet a diverse set of criteria (Bhat & Alqahtani, 2021; Count et al., 2021; Gardašević et al., 2020; Khan et al., 2020). Thereby, to achieve these conditions, it requires a data rate of up to 1 Tera bites, an extremely high dependability of 10⁹, as well as an extremely low latency of less than 0.1 millisecond().

Regardless of the reality that such an available connection in between wireless radio device as well as the baseband module has really been presented, it is difficult to experience a truly developed public good radio access. As a result of these issues, a novel 6G architecture should always be built to accommodate them. The essential criteria for a 6G wireless system are shown in Figure 1, including downlink data rate, precision of localization, capacity, uplink data rate, as well as dependability in parameters of energy per bit, latency, frame error rate, as well as jitter (Nawaz et al., 2020). Countless instances of technological solutions and then use cases seem to be available. Additionally, Figure 2 summarizes several wireless mobile technologies, including their launch year as well as other distinguishing attributes.

Figure 1. 6G overview

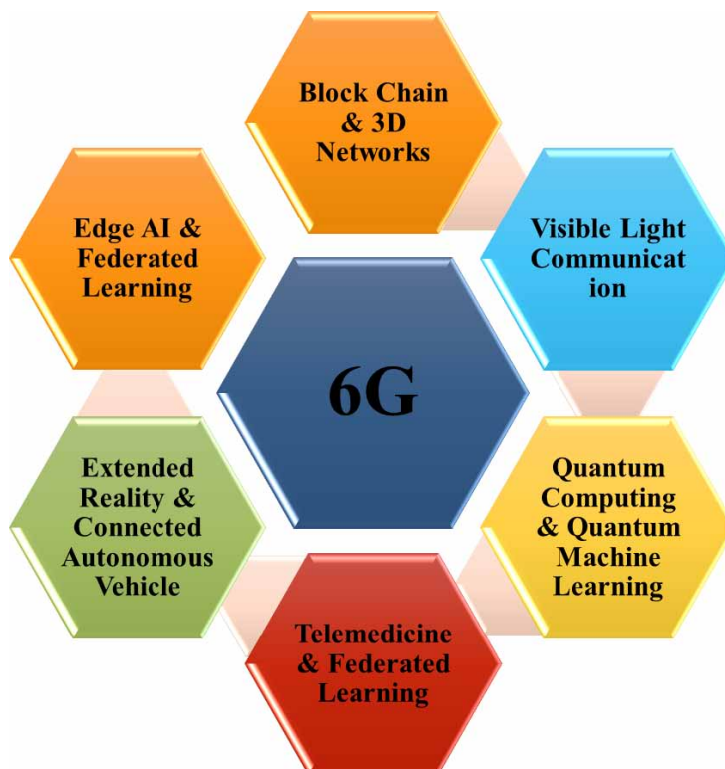
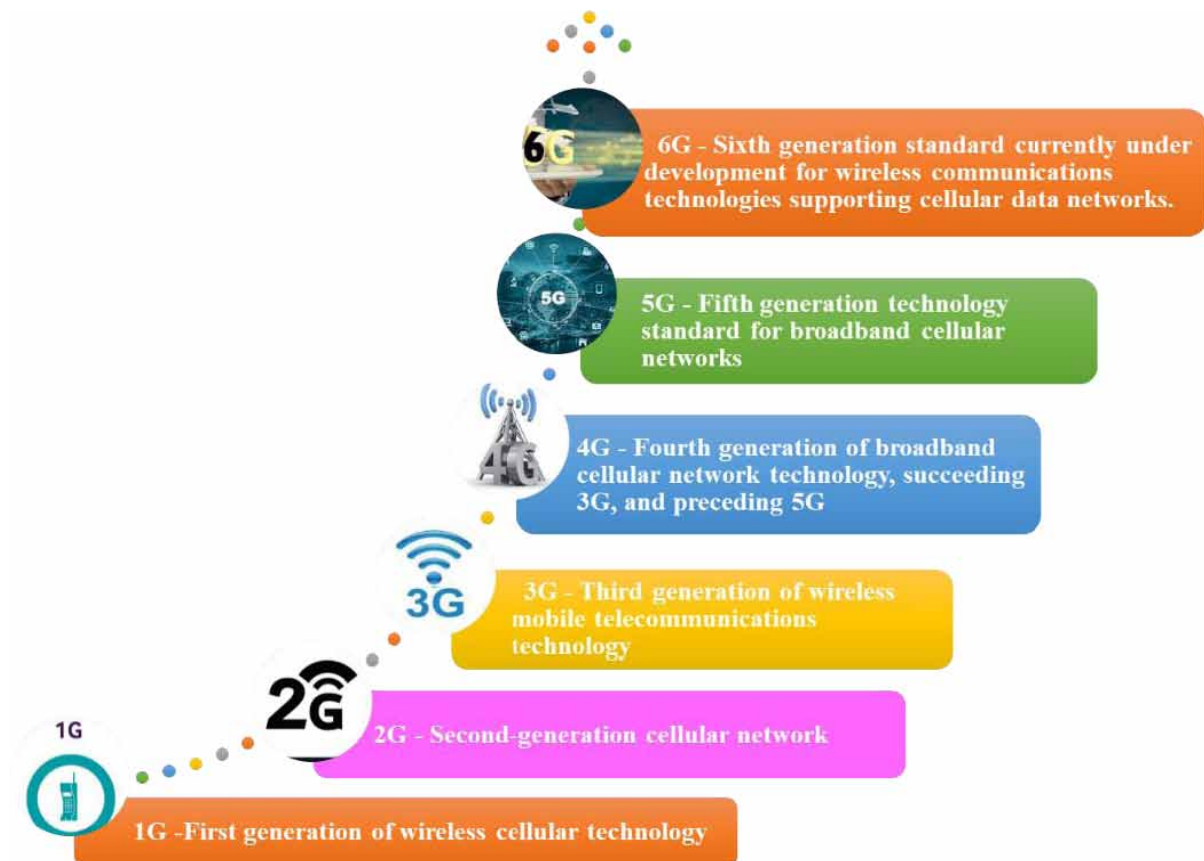


Figure 2. Evolution of mobile technologies



WSN-Based Healthcare Communication Technologies

LR-WPAN Regulations and Techniques

Wi-Fi Sensor Networks (WSNs) are quite a crucial component of the Internet of Things (IoT) and many are utilized in a broad variety of industries, include infrastructure monitoring as well as home and industrial automation. Additionally, they are employed in smart cities, smart transportation systems, as well as healthcare. Real-time distant monitoring of patient condition, contextual as well as environmental information, the prevention of crucial conditions, life enhancements for quality, the managing of medical equipment including prescription databases, and so on are all feasible with a WSN-based IoT healthcare system. IoT sensor devices should be capable of analyzing, controlling, and monitoring of the blood pressure, oxygen saturation, blood glucose level, electrocardiogram as well as other key health indicators in smart healthcare (). After pooling the data and extracting features, it is transferred to the Cloud and or Fog for additional analysis or to be used by machine assessable intelligence algorithms. The initial module of an IoT healthcare system is data collection, which involves the collection of physiological and environmental information via WBAN devices, but also by sensors implanted in the surrounding environment. WBANs are a critical component of the Internet of Things in healthcare, and establishing

dependable sensors is critical to the system's success (Bhat & Alqahtani, 2021). IEEE 802.15.6 is a standard methodology addressing Wireless Body Area Networks (WBANs) with the objective of enabling short-range, low-power, as well as highly reliable wireless communication both in and out of the human. According to the IEEE 802.15.6 standard, there are 3 PHY layers: Human Body Communications (HBCs), narrowband (NB), as well as ultra-wideband (UWB). TDMA - Time Division Multiple Access, CSMA - Carrier-Sense Multiple Access with CA - Collision Avoidance, and irregular access are all supported by the MAC - Medium Access Control layer (Nawaz et al., 2020). IEEE 802.15.6 classifies wireless body area network applications as medical or non-medical, and maybe they will range between military to sports to entertainment to healthcare (Zhang et al., 2014).

IEEE 802.15.4 is a reference standard for Low Rate - Wireless Personal Area Networks that describes capabilities at the PHY as well as Data Link Layer stages of the protocol stack (Tuli et al., 2020). ZigBee is a popular choice, especially for home automation as well as smart city projects. Typically, these networks have a transmission range of 10 to 100 metres, with transmission levels of power ranging from 0 to 20 dBm. Data transfer rates range between 20 and 250 kbps (868 MHz band) (2.4 GHz band). The term Low-power and Lossy Networks (LLN) is often utilized in the literature with respect to networks that are prone to loss and operate at low power levels (Mucchi et al., 2020). Above the IEEE 802.15.4 PHY along with MAC layers, standard higher layer protocols including such as Constrained Application Protocol (CoAP) (David & Berndt, 2018), 6LoWPAN - IPv6 over Low-Power Wireless Personal Area Networks (Tariq et al., 2019), as well as RPL - Routing Protocol for Low-Power as well as Lossy Networks (Akyildiz et al., 2020), can indeed be deployed.

In a multi-hop architecture, conventional IEEE 802.15.4 WSN systems don't really address the reliability of delivered packets. IEEE 802.15.4 MAC layer restrictions in mesh networking are almost always connected to the utilization of a single channel as well as significant power usage produced by always-on relay nodes, owing to the lack of prevention against interference as well as fading effects, ZigBee's dependability and resilience are restricted. Due to the fact that ZigBee activates in the similar frequency band as Wi-Fi along with Bluetooth, numerous studies have examined cohabitation from the 802.15.4 PHY layer's perspective (Alsulami et al., 2020). ZigBee 3.0 was optimized for M2M applications, along with low duty cycle as well as low latency operation (Yrjölä, 2019). Nevertheless, ZigBee-based technologies should always be significantly enhanced before they can be used to transmit emergency data and manage vital signs in healthcare systems.

A low latency in transferring data has become one of the major requirements for time-critical tasks in smart healthcare systems. As a consequence, prioritizing of traffic as well as Quality of Service protocols are required for the aforesaid systems (Sergiou et al., 2020). Additionally, accidents engaging communication networks may result in huge losses as well as potentially fatal outcomes. As a consequence, it is necessary to improve strong rules to confirm the safety as well as efficient operation of medical devices. Effective transmission techniques have been devised in new standard modifications such as IEEE 802.15.4m, IEEE 802.15.4e, as well as IEEE 802.15.4g, among others, so as to mitigate the detrimental belongings of interfering as well as multipath fading and also to increase consistency.

Wireless sensor devices had already progressed from simple tags to advanced technologies with advanced storage as well as processing capabilities, having applications in commodity identification, tracking, as well as other disciplines. The characteristics of next-gen sensor devices, including self-organization and cooperative data processing, considerably improve the performance of conventional WSNs, expressly in exact applications including industrial as well as healthcare-based IoT. Over the recent two decades, smart sensor technologies are being the topic of rigorous research with the goal of

developing the essential standards to aid the “plug-and-play” technique, in which sensors from versatile manufacturers are interchangeable as well as replacement is simple as well as effective (Rajatheva, 2020). Modern electrical systems have become such a vital aspect of IoT sensor networks due to the increased properties of the IC design along with packaging process, and also the low implementation cost. Sensor technologies’ processing as well as memory capacities have been increased as a result of advancements in semiconductor technology. MEMS - Micro Electro Mechanical Systems are predicted to accelerate their expansion, enhancing the performance as well as adaptability of sensor systems. There were already many numbers of small MEMS sensors available for monitoring a variety of chemical, physical, along with other variants of signals (Saarnisaari, 2020).

Developments in LR-WPAN Network System

Due to the excessive energy utilization of next-generation wearable sensors, relatively regular battery changes are required, causing network downtime as well as increasing deployment costs. MAC devices in WSNs, in general, depend on duty – cycling as an energy-saving method. Numerous strategies have already been devised to acclimate the MAC characteristics of LR-WPANs to a wide-ranging variety of purposes (Alsharif et al., 2020; Giordani et al., 2020). On either hand, energy efficiency as well as communication dependability usually conflict. The Wake-up Radio (WuR) protocol is a revolutionary technique that enables nodes to run at a thousand fold lower power consumption than conventional radios. The data link between clusters is enabled on-demand both by the sender and the receiver, leading to substantial energy savings and improvements in transmission reliability as well as packet delay (Peltonen et al., 2020; Shafin et al., 2019). Modern MAC sub-layer transmission algorithms, such as IEEE 802.15.4e - TSCH, provide an extreme – low cycle mostly less than 0.1 percent, potentially extending life of the battery over a decade (Al-Eryani & Hossain, 2019). TSCH integrates time synchronization as well as channel hopping to give probabilistic delay assurances, increased communication dependability (i.e., tolerance to interference as well as multipath fading), and enhanced network performance over other MAC protocols. IEEE 802.15.4e is a “MAC alteration” to IEEE 802.15.4 that improves the MAC sublayer architecture but leaves the PHY untouched. IEEE 802.15.4e is therefore a “software upgrade” to the IEEE 802.15.4 radio device that performs identically to some of the few preceding IEEE 802.15.4 radio chips. The TSCH network’s terminals were completely synced globally, assuring 99.99 percent communication dependability.

LP-WAN Standards along with Their Technologies

LP-WAN established to address the demand for least, long – range know-hows. Especially, applications requiring a ranging over a few kilometers’ as well as data rates as minimal as just few 10 bit / sec. As a consequence, LP-WAN networks must assure that the object operates at a very low power level in order to maximize the product’s life of the battery. The degree to which these components are active varies according to the medical application, as well as this should be taken into account while creating a system. Several of the design criteria is to maximize battery life while losing dependability. Additionally, in attempt to facilitate mass deployment, costs should be kept to a minimum. This allows for the adoption of non-sophisticated architectures along with their protocols while upholding the high levels of dependability essential demand by a health sector. Some other critical component of guaranteeing the system’s effective operation is the communication network, which must be created on a nationwide as

well as global scale to provide a consistent service for users or patients experiencing prolonged health issues. The government or a private corporation could operate the network. In any case, introducing infrastructure as well as a novel entity ought to be a straightforward as well as low-cost process. Some other critical characteristic of this type of communication networks is security, which in itself is critical in the medical field. As information is transmitted between users as well as the network, spoofing as well as blocking are possible, endangering lives and wreaking havoc on the medical system. This part discusses the fundamental characteristics of many Low – Power WAN (LP-WAN) protocols including whether they might be leveraged to enable certain patient monitoring solutions (Khutey et al., 2015).

Security Along with Their Privacy for Smart Healthcare

The safety problems associated with IoT-based smart patient education, on-body, or off-body, whether in-body, are the same as those associated with any other kind of communication apparatus that manages delicate information. To increase confidence, concerns about security, such as trustworthiness as well as data privacy, should be resolved. Breaches of confidentiality, authorization breaches, integrity breaches, authentication breaches, as well as availability breaches are all common concerns associated with active or passive threats (Kalbande et al., 2019). Eavesdropper, evil twin access points, as well as man-in-the-middle attacks are all instances of assaults that compromise the system's privacy, although DoS – Denial – of – Service, replay attacks, including frame injection attacks compromise the system's truthfulness. Beacon flooding, Radio Frequency (RF) jamming, especially association or authentication flooding have always had the capability to significantly reduce availability while risking patient safety and privacy. In other circumstances, malicious attackers may employ additional heinous and even unique tactics to steal sensitive data. With respect to reference eavesdropping on handwriting is possible with the use of adjacent mobile devices and acoustic signal processing and machine learning. According to the researchers, there really is a reasonable chance of obtaining 50–60% word identification in specified circumstances (Al-Eryani & Hossain, 2019). This investigation was expanded to include a hand movement tracking technique to boost eavesdropping effectiveness to 70–80 percent (Dang et al., 2019). Many of these types of attacks highlight how crucial privacy as well as security are to the lengthy viability of intelligent health-care.

In the perspective of intelligent healthcare, privacy could be characterized as a patient's ability to control how personal data is disseminated. Additionally, it suggests that all information shared inside the healthcare network, and any other personally identifiable data, should always be considered secret. Certain restrictions safeguard the participant's reasonable expectation of privacy, however considering the large as well as sophistication of the system that enables smart healthcare applications to function, this is challenging to implement in practice. As a result, privacy may be jeopardized when security is breached. Patients want their s-Health documents (SHRs) (Strinati et al., 2019) should become accessible only then to authorised expert healthcare personnel, as well as data confidentiality as well as privacy concerns have risen to the top of consumers' concerns when it comes to the smart health (s-Health) (Priya et al., 2022) ecology. Thus according source (), when conventional access control mechanisms are utilized, either security of data is compromised or only coarse-grained controls remain permitted. To solve this issue, the researchers developed a Privacy-Aware S-Health accessibility restriction system (PASH). PASH is dependent on the Ciphertext-Policy Attribute-Based Encryption (CP-ABE) method, wherein the standards of access policy attributes are hidden because only the names of the attributes are disclosed in encrypted s-health data (SHRs). To improve performance, the researchers created an

inexpensive decryption test which demands only a small quantity of encoded information prior to complete decryption. Thus according theoretical results as well as empirical data, PASH is further secure, effectual, as well as expressive that of current solutions.

5G mMTC - Massive Machine-Type Communications might well be mandatory to connect millions of these kind of healthcare-related sensors towards the connection. These sensors will indeed be susceptible to a range of threats, jeopardizing people's lives. Cyber espionage is and will continue to be a concern to 5G networks, as 5G networks are predicted to have a significantly greater number of attack vectors than previous 4G networks. Owing to the vulnerability of current public-key cryptography to its enormous processing power, it is anticipated that these threats will worsen as Quantum Computing (QC) technologies are evolving. As a consequence, it is important that action be taken immediately to safeguard critical communications from eavesdropping. Quantum Key Distribution (QKD) is a security technique that enables the secure distribution of symmetric encryption keys in future 5G and beyond networks. This will be accomplished by enabling the secure transmission of a cryptographic key among several geographically dispersed entities (Priya et al., 2021). The European Commission's European Quantum Flagship has indeed established a road plan for the commercialization of all quantum technologies, such as the QKD. According with plan, sophisticated quantum key distribution (QKD) as well as quantum random number generator (QRNG) solutions would be available enabling IoT as well as 5G networks (among some other capabilities) in a trusted-node network between six to ten years. This connection will be built using fiber, open space, as well as satellite communication. The end outcome will effectively provide end – to – end security across destination node. The network would be expanding over the Europe by utilizing (optical) repeaters along with satellites. Individual countries, including Japan, China, South Africa, Australia, as well as the United States, have implemented a similar method and performed a series of trials (Tariq et al., 2019). To provide safe, secure, as well as trusted smart healthcare, contemporary cybersecurity technologies as well as systems are required. Lacking them, smart healthcare IoT-based technologies will be unable to penetrate the shop.

USE CASES OF 6G NETWORKS

Consider several of those primary use instances for 6G technology, including the associated KPI considerations. Some use instances would involve the integration of KPIs to operate concurrently. As a result, these are difficult. In 2030, these following possibilities would be extremely plausible.

ULTRA SMART CITIES

Through numerous sectors, 5G services would enable end user - including application - specific QoS as well as quality of experience (QoE). Telehealth, intelligent agriculture, as well as intelligent manufacturing, for example, could obtain data services at a certain latency, priority or data rate. Nevertheless, whenever we consider futuristic eventualities inside an ultra - intelligent city, such as smart industrial, smart healthcare, or autonomous transportation, we might demand data rates inside the range of 1Tbps, 3D connection, localization under 1cm, and dependability of 99.999999 percent (Biral et al., 2015). 5G systems are incapable of addressing the KPIs required for some of various applications together in city of the future (Khan et al., 2019). We'll investigate a couple additional instances to help visualize them.

Network / transport demands for 6G would likely range between 240 and 1200 kilometers per hour. To synchronize whilst travelling at incredible velocities, a self-driving car must connect between road sensors as well as other automobiles in neighboring lanes. Additionally, the distribution UAVs upon this flight will also need to interact only with ambulances here on road in order to gather as well as transfer medical resources in urban areas. Inside another scenario, drones might well be required to approach the automobiles in order to operate as airborne cell towers or intermediaries for the transmission of data as component of inter-vehicular connectivity. It's worthwhile noting that both instances include communication systems across numerous things travelling at a high rate of speed (500 kilometers per hour). In the instances outlined previously, 6G systems would provide incredibly low delay in communication, which would be a critical condition for automated vehicles as well as decision - making process. Several examples illustrate some possible smart city situations and their associated communication considerations.

MULTI-DIMENSIONAL REALITY

Human engagements that involve ultra-high-definition graphical content, including such computer games which use AR - Augmented Reality or VR - Virtual Reality, produce a large quantity of data. We will soon see 3D games as well as multi-dimensional films that connect including all 5 of the body's sensory organs to give an impression of reality through the use of VR and AR to create a realistic virtual gaming experience. Inside a decade, those possibilities will be palpable, as even the computing power, storage capacity of smart phones as well as computer technology would multiply by a factor of ten. Nonetheless, when transmitting this enriched data over a wireless channel, it requires the high capacity, dependability, as well as high bandwidth which 6G systems would provide.

HAPTIC COMMUNICATION

Envision a sophisticated health service in which a wounded individual can convey her feelings solely through mental visualization. In this case, an intelligent headband could recreate those central nervous system impulses as well as deliver them towards the caretaker in instantaneously over wireless services as either a 3D film of the patient's fantasy. Additionally, a collection of individuals who may not possess a shared language could interact through their ideas, whereas people with disabilities could utilize haptic interaction to unlock doors or operate gadgets. Such haptic modes of interaction would permit individuals to convey knowledge by touching. This is among of the anticipated use instances for 6G networks, in which the connection can support substantially higher data rates than 5G can. Alternative haptic transmission possibilities involve brain-computer interfaces, in which humans communicate therewith their environments via haptics as well as understand the devices with technological devices including such brain-embedded wireless chips which response to individual feelings.

REMOTE SURGERIES AND TELEMEDICINE

5G networks could deliver ultra-low latency of less than 1 millisecond to mission-critical applications. Nevertheless, remote procedures are exceedingly sensitive, requiring a delay of less than 1 millisecond

(almost 0.1 millisecond). Robotically - assisted surgeries would necessitate extremely high data accuracy as well as dependability, as well as a high data rate for data interchange as well as control signals among 2 distant medical centers connected by a mobile network. Whenever telemedicine as well as remote healthcare are considered, the introduction of 6G networks will change the game significantly by alleviating space as well as time constraints (). Given that 6G's objective should be to offer data reliability of at least 99.999 percent and a data rate of 1 Tbps, this would be the most ideal choice to achieve the aforementioned standards. The primary concern with remote procedures is the required latency. Unlike earlier generations of networks, the 6G should aim for both minimal as well as maximal latency needs. This is because, throughout remote surgery, certain portions of the data transmission should reach at the target inside one defined maximal delay, while others must arrive with a specific minimum latency. The combination of these minimal as well as maximal latencies results in integrity at the reception, which would be a critical need for remote diagnosis.

HOLOGRAPHIC COMMUNICATION

With the maturation of AR/VR technologies, users will quickly find that perhaps a virtual environment does not capture the whole of reality's facets, and therefore that consumers require more. Currently, as a result of the COVID'19 pandemic epidemic, virtual presence (teleconferencing) have surpassed actual gatherings in popularity. This type of activity necessitates complex virtual reality technology, bandwidth, as well as computations in order to distantly display an item or person in instantaneously. As nothing greater than a futuristic trend, every cellphone would be outfitted with much more than 5 ultra-high measuring devices capable of capturing an event as well as rendering multiple-dimensional movies that provide an interactive environment of something like the action to all sensory organs. In other terms, a video could be a multi-dimensional genuine projections that simulates the audio-visual impression of a person or item being transmitted in a virtual conference. For example, to provide a truly immersive VR experience, movies with a quality of 16 K, a scanner rate of 240 Hz, as well as spherical coverage (360) must be sent as holograms. To broadcast these films or holograms, which demand data rates of several Gigabits per second, traditional 5G KPIs including such data rate, bandwidth, as well as dependability become irrelevant. These transfers entail a substantial amount of data. Apart from that, the projection angle and response time are crucial. For example, if the video or audio signal from either the holographic projection site must be transmitted back to the source, accurate as well as well synchronization seen between source as well as target with regard to the image's many layers is required. Considering another scenario: a large performance in which a faraway musician can be presented as a holographic presence to entertain others in his immediate vicinity.

TACTILE INTERNET

In 6G technology, communication amongst multiple devices would be highly engaging as well as sensitive in live time, allowing for legitimate data transmission, monitoring, as well as feedback, and also a sensation (Tariq et al., 2019). Thus, one can transfer touch, feelings (sense), and information simultaneously in order to provide a live experience of nearly anything linked to the data being given. To be more precise, tactile internetworking entails a sense of touch or taste in addition to audio, video, or other types of replies. For

example, educating astronauts using space facilities, gaining access to submerged vessels/containers, as well as performing distant surgeries using virtualized holographic representations all necessitate a sensation of touch in order to conduct distant instructing as well as restorations using ultra-low delay. Additionally, the communication of smell as well as taste in order to improve the customer experience would be a primary objective of the food sector as it seeks to digitize the user experiences of access to food.

SCENARIOS

The aforementioned circumstances are expected to create unique commercial prospects using 6G. Edge computing, Internet of Things, robotics, as well as artificial intelligence would become ubiquitous technologies that should be included into each and every electronic device as well as would be affordably priced to users could afford. As a result, such devices might be utilized to gather a range of data through consumers as well as analyze it locally prior transmitting it via the Internet. Following that, network management would enable up to 10,000 segments underneath the control of a wireless carrier. This would significantly increase income generated (Peltonen et al., 2020). Additionally, the implementation of effective alternatives would enable organizations to run independently as well as ease someone's life. To this end, general populace collaboration programs, decentralized collaborative strategies, especially peer-to-peer marketing strategies would be preferable appropriate than monopolized markets somewhere at local scale. Additionally, given the scarce distribution of innovation in remote regions, developing low-cost alternatives just at microeconomic scale may be an appropriate strategy. Nevertheless, 6G would then bridge the technology gap by promoting information technologies information exchange, allowing a 3D design of something like a device to be communicated in instantaneously with yet another lesser developed metropolitan area that lacks this same research labs required for manufacturing it can use its cheaper labor and sell it domestically and also in the country of source at a lower price than it would be possible alternatively. This promotes a circular economic as well as contributes to the development of a fairer future including both rural as well as urban places (Dang et al., 2019).

SCOPE OF 6G IN RURAL CONNECTIVITY

Communication in difficult rough terrain, outside beyond major towns, ought to be straightforward, inexpensive, as well as simply feasible. As a result, wireless networking seems to be the superior answer compared to cable based internet. Delivering communication to the final mile via the Low Earth Orbit satellites would cover a vast range. Nevertheless, this is not a cost-effective approach when combining throughput, latency, as well as cost. Rather than that, the use of massive power broadcasters (mega cells) across sparsely populated remote regions would be a realistic option. To accomplish this goal, additional safety and energy requirements will be required. Additionally, flying mobile base stations such as unmanned aerial vehicles (UAVs) or balloons would enhance mobile data services by functioning as relays or data caches (Strinati et al., 2019). Because remote locations face budgetary limits while maintaining a high level of service, a specific concentration upon economically viable (cost-wise) is required. Cost savings would be realized by utilizing natural renewable energy including like solar as well as wind energy to fuel the electric grid which function those backhauls. Additionally, cost savings as well as resources efficiencies can be realized by reserving the remote country's unique content for

the rural region. This enables domestically generated information to be cached on regional servers as well as network slicing to be provisioned. Local caching enables cost savings by reducing the reliance on backhaul connections. Additionally, numerous data serving strategies might be implemented via network slicing to improve connectivity when capabilities are scarce.

Concerning backhaul communication, while spectrum or microwave appear to become the best options, they might encounter difficulties in remote locations. Thus, Integrated Access & Backhaul (IAB) appears to be a much more attractive option, since it allows the provider using a portion of its spectrum towards backhaul as well as the remainder for mobile coverage at a significantly cheaper price than that of the previous contenders (Khan et al., 2019). As a result, 6G networking will rely on the IAB to save deployment costs as well as optimize resource use. With IAB, even just a subset of base stations would send backhaul traffic via connected lines (fiber / wire); while balance base stations would broadcast backhaul traffic over wireless channels via multi-hop relaying. It is considerably more feasible with 6G owing to the accessibility of enormous spectrum in THz channels, wherein accessing as well as backhaul communication can indeed be multiplexed using appropriate planning algorithms. As a result, network costs are reduced. The IAB would operate inside the sub-6GHz as well as mm-wave bands (Al-Eryani & Hossain, 2019).

6G RESEARCH WORLDWIDE HITHERTO

Whereas the 5G connection has been implemented globally, both business as well as academics have been ramping up research as well as innovation on 6G networks. 3GPP finalized development 16 of the 5G specification in March 2020, that would be supplemented by version 17 in 2021 to enable all 3 scenarios. As a result, 3GPP will undertake 6G development in the coming years. By 2027, global 5G network industry is expected to reach 47.75 billion USD. Samsung, Huawei, Nokia, Ericsson, as well as ZTE are the five most important companies in the 5G infrastructure industry. They have now moved their focus to the 6G connection in anticipation of the great potential and benefits which the 6G connection is expected to provide above the 5G network. Similarly, the FCC has agreed to stimulate 6G network development as well as trials in the THz range by creating a 95 GHz -3 THz experimental band (Priya et al., 2022). Samsung anticipates that the ITU-R would outline their authorized vision for the 6G network around mid-2021, with initial commercialization beginning even by end of 2028. Recently, in the 18 months since the inaugural 6G mobile conference in March 2019, academia have increased its focus on preliminary studies upon that vision, technology, difficulties, as well as possible trends of 6G systems.

FUTURE DIRECTIONS AND TRENDS

Numerous initiatives have already been designed to enhance efficiency of service in Fog scenarios, well with objective of increasing the reliability of sickness diagnosis as well as automating medication writing. Further research on developing novel algorithms to ensure that medical treatments are provided that with minimum possible Service Level Agreement (SLA) deviations as well as that findings are returned as quickly as possible. Numerous research initiatives also explore novel methods for enhancing the security as well as dependability of systems, such as. Additionally, modifications to the architecture of Wireless Body Sensor Nodes (WBSNs) which use innovative solutions have now been suggested to minimize energy utilization as well as increase efficiency. In aspects of prospective work, we suggest

incorporating multiple frameworks including such server less computing, device less edge computing, sensor networks, as well as data analytics, along with helping to bring simulation to sensors but instead wearable devices through the use of mobile computation nodes, as demonstrated in “my Signals.” This will also improve responsiveness, which would be advantageous in critical situations. Additionally, appropriateblock chain algorithms should always be established that are capable of operating in dispersed environments, given the processing capabilities of nodes there at network’s periphery. Various device or deep learning approaches should be explored in ability to forecast problems as well as maintain a constant level of QoS for cloud services. Other research avenues include the examination of paradigms such as quantum computing, enhanced as well as customized OS, processing-in-memory (PIM), and 6G. Figure 3 depicts the development vision of 6G.

Figure 3. Future directions of 6G



CONCLUSION

We discussed recent progress toward empowering 6G wireless networks, recognized a nomenclature based on numerous factors along with the offered several exposed difficulties as well as crucial guidelines. We infer that the 6G systems would be fully realize the possibilities of smart digital cities by facilitating Internet of Everything – based smart services. AI would be a critical component of something like 6G wireless architecture for resolving multifaceted network optimization algorithms. Tera-hertz transmission would be an essential telecommunication band for 6G technologies. The development of novel terahertz communication paradigms is crucial. Additionally, novel frameworks for quantum teleportation should be devised, as the field is still very much in inception stage.

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Section 5

Performance and Challenges in 6G Mobile Core Networks

Chapter 17

Artificial Intelligence and Machine Learning–Based Security Enforcement Techniques for 6G Communication

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ABSTRACT

The next generation 6G era is considered to be highly coupled with intelligent network management and orchestration, while 5G is completely renowned for micro-service architecture-based network cloudification. 6G has been revolutionized for satisfying the mandatory services and carry forwarding the potentialities of 5G to superior and intelligent level. 6G network structure is determined to be dynamic, densely deployed and extremely heterogeneous, and when integrated with a high degree of Quality of Service (QoS) completely transforms the complex architecture into a seamless operating process of classical networks. The immense role of Artificial Intelligence (AI) and Machine Learning (ML) is required for improving the paradigm of 6G for learning information from uncertain and dynamic environments. This integration of AI and 6G resembles a double-edged sword since the application of AI may positively influences the privacy or security of 6G on one side, and negatively introduces the possibility of security infringement into 6G on the other side. In specific, the self-sustaining networks in 6G are obtained by

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guaranteed application of intelligent security attack mitigation schemes and proactive threat discovery approaches that facilitate end-to-end future network automation. In this Chapter, a comprehensive review of AI and ML-based security enforcement techniques are contributed for improving reliability during robust data dissemination in 6G communications. It presents consolidated and solidified role of AI and ML towards the enforcement of security in 6G networks. In addition, it also demonstrates the challenges and solutions that are handled by the inclusion of AI and ML-based attack mitigation approaches concerning energy and security-based ultra-massive access.

INTRODUCTION

As 5G is used everywhere, efforts are made to look beyond 5G and conceptualize 6G. Academia and industry are expecting a more established cellular communication technique like 6G that is anticipated to offer better data rates of up to 1 Tb/s and frequency bands of about 100 GHz to 3 THz. 6G is the next-generation technology that supports communication (Yang et al., 2019). 6G covers a range of full spectrums (sub-6GHz, THz, visible light, mmWave), provides universal coverage (aerial, space, land and sea) and complete application (AI, ML, big data) (Saad et al., 2019). The peak data rate is around 1 Tb/s, latency is around 10-100 μ s, mobility is greater than 1000 km/h, data rate around 1 Gb/s, energy efficacy around 100 times of 5G, connectivity supporting 10⁷ devices/km², the traffic volume of about 1 Gb/s/m² and spectrum efficacy is 5 to 10 times better than 5G (Tariq et al., 2020, Ylianttila et al., 2020).

Moreover, with the substantial advancement of key communication factors, Artificial Intelligence (AI) is intended to be the most significant feature of 6G as the advanced Machine Learning (ML) technique is approved to be the best solution in many extreme scenarios (De Lima et al., 2021; Lu, 2020). ML is essential in 6G to offer infinite expediency in the future (Siriwardhana et al., 2021).

Network intelligentization focuses on the challenges of the rapidly increasing amount of associated heterogeneous devices. In contrast to the application of ML in diverse fields like games and smart networking, dealing with automatically organized cellular communication systems remains a challenge. Communication systems, ML architectures and computation efficacy are to be focused on the effective use of ML-based techniques in 6G. Smart 6G network develops as a progressing area of research. It is expected to experience an extraordinary conversion, making it considerably dissimilar from the former generations of wireless technologies (Guo, 2020). It is certain that 6G will go far beyond mobile Internet and will be capable of offering ubiquitous services to the devices in the network. 6G systems serve a huge variety of applications in varied situations which are defined in 5G. Furthermore, with the increase in the number of smart homes, cities, society and buildings, it is capable of meeting the demands of Human-to-Machine (H2M) and Machine-to-Machine (M2M) communications, particularly with the growth of robotic and drone systems. Though 6G is capable of providing several services, it is demanding to sustain consistency and satisfying user experience in complex and active network environments. Moreover present reactive management of QoS on QoE, awareness of proactive management based user behavior and network status, and upcoming demand forecast is the predominant factors to be focused on.

Research says that, by 2030, information society will be extremely digitized, intelligence stimulated and universally data-focused, assisted by near-instant and unconstrained wireless connectivity. 6G will enable this to happen by connecting everything, providing full-dimensional wireless connectivity and integrating functions that comprise detecting, communication, computing, storing, controlling, position-

ing, radar, navigating and imaging to provision complete-vertical applications. 6G will transform the wireless progress from ‘connected things’ to ‘connected intelligence’ with severe needs. The design is intrinsically personalized to meet the performance demands of the Internet of Everything (IoE) applications and their associated technological trends. 6G is anticipated to provide unparalleled IoE scenarios with tremendously different and challenging demands. For IoE, 6G seems to be an ultra-dense network with better flexibility by precisely integrating various techniques to instantaneously satisfy several service needs. Furthermore, 6G networks are decentralized and are based on the incorporation of terrestrial communication, aerial network and satellite system to handle emerging and instantly desirable services, and to comprehend global coverage and strict seamless admittance. It will serve as an autonomous ecosystem incorporating intelligence and perception like humans. It will grow from human-based to equally human and machine-based and will offer diverse ways like communication and interaction with smart terminals through fingers, voice, eyes and even brain waves.

ATTACKS ON PRIVACY IN 6G NETWORKS

6G network with universal intelligentization necessitates firm security constraints. There are some security needs which include confidentiality, authenticity, availability and integrity that should be satisfied. In a conservative network, security can be ensured with an increase in communication costs.

AI-based technologies in 6G are prone to malicious attacks. Attackers may employ diverse methods to cause attacks in varying stages (Sun et al., 2020). Training data and model can be extracted, followed by the wrong prediction which may involve modification of the dataset through active or passive attacks respectively. Based on the availability of data, the attacks may be classified into white box and black box attacks. In case of white box attacks, the opponent takes hold of the model parameters and the intermediary steps (Porambage et al., 2021). On the other hand, in case of black box tests, the adversary is unaware of both the algorithms and parameters but can carry out interaction. This kind of attack deteriorates the accuracy of analysis of big based on describing, identifying and foreseeing, thus breaking the privacy in many cases.

Poisoning Attack

The learning phase in the training phase has a greater influence on classification and prediction accuracy. The poisoning attack is an active attack and is a common one that affects the model by altering the training data. It deals with system resources or affects the process. The raw training data may be modified and the probability distribution is tampered thus undermining the data reliability and availability, altering decision boundaries, dropping the model accuracy, thereby leading to errors in test results. Besides modifying the existing data, additional malevolent samples may also be added. In this 6G era, smart terminals are used universally and hence ML-based credential systems are expected to emerge. Private data may be manipulated and AI may be misled to make false judgments. False alarms may lead to modification of the system sensitivity erroneously, thus increasing the likelihood of missing malevolent traffic. In case of smart resource allocation, false alarms will lead to misuse of resources and hamper the process of security systems.

Reverse Attack

Data can be obtained through Application Program Interfaces (APIs). The opponent can get access to the data and hence called reverse or inversion attack. In case of white box attack, the opponent can have access to the system model and master more data, and use the knowledge of the model feature vector to rebuild the original data. The black box attack relies on Oracle attack which deals with thieving models through APIs. This is made possible by sending queries using APIs or by solving the model. The classifier decision rules can be learned or the training dataset can be understood by identifying the model. In the case of ML-based anomaly identification, malware identification with increased accuracy is used. If models are extracted through these attacks, then security detection may be skipped by building relevant counter samples. As training data includes a huge amount of private information, mining data is the most effective method of working against providing privacy. Reverse attacks can take different forms like taking hold of identification-specific data, users' authentication profiles and facial images.

Adversarial Attack

The presence and production of adversarial attacks were first reported by Szegedy et al. (2013). A minor disruption applied to images can mislead a Neural Network (NN). Through the cautious formation of malevolent vector and alteration of the data source, an opponent can be successful in generating wrong judgments. The malevolent sample is called an adversarial example. It resembles the poisoning attacks in focusing on the model output. It differs in one aspect; the poisoning attacks happen in the training phase, while the adversarial attacks in the testing phase. This attack is not capable of altering the training dataset but can generate adversarial examples, aiding the classifier in recognizing errors. Its classification is related to a specified category, it is a targeted attack. If only misclassification of data is needed, it is a non-targeted attack. In case of a white box attack, the adversary is aware of the parameters and also the inner model structure, and can analyze and design samples. On the other hand, in a black box attack, the opponents have access to the model only via API interface through the oracle attack. The opponent perceives the input and conforming output data, and forms a substitute model resembling the target to get the finest adversarial example. According to Goodfellow et al. (2014), the adversarial samples are transitive, viz., a single sample may be applied to diverse models. Notwithstanding the better performance of intelligent applications, ML models are prone to subtle alarms and the smart machines are susceptible to getting deceived by counterexamples. These attacks cause misclassification and reduced accuracy. Akhtar and Mian (2018) have focused on these attacks against Deep Learning (DL)-based machine vision. Wrong detection of road signs, execution of wrong commands and getting access to surveillance cameras and face recognition systems are some examples (Sharif et al., 2019; Thys et al., 2019). The hazards on ML due to attacks should be focused on.

Membership Inference Attack

There is a special form of training data extraction. There are scenarios where complete information cannot be obtained, but it can be inferred whether the user belongs to a training center. Shokri et al. (2017) have come up with this attack focusing on the exposure of patient-related information. The opponent can deduce whether a record belongs to the model training set via API and data recording information. This attack does not demand a more detailed form of data until the attribution problem is noticed. Truex

et al. (2019) have dealt in detail with these attacks against the ML models. They are less powerful in some cases, but they affect the privacy of data. If training data demands hiding attributes, these attacks can be a threat. In the case of smart healthcare applications, the opponents can find whether a sample belongs to a particular training center or not. Similarly, people belonging to a particular group in a social network and planning in a smart transportation system can also be perceived.

SECURITY OF 6G ARCHITECTURE

The cells in 6G reduce in size, and closer positioning of these cells, formation of mesh networks, enabling multiple connections and Device-to-Device (D2D) become a standard. Adversaries are capable of attacking a distributed network with multiple susceptible devices that support multiple connections, thus increasing the threat. Sub-networks have their security policy, and ensuring security for all the devices in a sub-network seems impractical. The security mechanism should be capable of distinguishing between the securities demanded during communication at the sub-network level, and the sub-network to Wide Area Network (WAN) level. The Radio Access Network (RAN)-Core convergence leads to the centralization of functions at the higher layer and coexistence with other core functions like User Plane Micro Services (UPMS) and Control Plane Micro Service (CPMS) (Ziegler et al., 2020) at the edge. Opponents may focus on UPMS and CPMS, disturbing the multiple radio units assisted by micro-services. 6G networks are capable of coexisting with the Zero-touch network and Service Management (ZSM) framework (ETSI, 2019) to support the involvement of less market time, reduced operational cost and error. Complete automation with self-learning leads to attacks getting disseminated in closed-loops. Protection of privacy in ZSM is challenging owing to the predominant demand for automation involving the least human intervention.

6G trusts AI to implement autonomous networks completely. Several attacks on ML models are possible as discussed in Section 2 (Benzaid & Taleb, 2020a). Accumulation of an increased number of features improves the performance of AI-based systems. Unintentional use of the amassed data will cause privacy issues as data processing is hidden from the users. Blockchain is an essential technology that brings out the capability of 6G systems. It supports decentralized resource handling, spectrum distribution, service organization in immensely huge and distributed 6G networks (Hewa et al., 2020). As data in blockchain networks are publicly available, privacy protection becomes a challenge. 5G standard is not focused on the security issues of quantum computing but uses customary cryptography methods. As 6G marks the existence of quantum computers, the asymmetric key cryptography-based schemes are susceptible to attacks based on quantum computers (Dogra et al., 2020). Quantum-safe cryptographic algorithms are the need of the hour.

6G and Artificial Intelligence (AI)

Researchers have started focusing on the sixth-generation (6G) communication networks. AI and evolving smart applications like autonomous driving and virtual reality immediately demand a new, faster, consistent and flexible network. To satisfy these varied needs effectively, 6G is intended to be a space, aerial, terrestrial and ocean integrated 3D network with diverse types of slices empowered by novel technologies and paradigms to make the system smart and flexible. As these networks are complex, heterogeneous and dynamic, it is challenging to attain effectual resource utilization, seamless user

experience and automatic organization. With the growth of big data processing, computing power and the accessibility of rich data, it is usual to handle network issues by leveraging AI (Sun et al., 2020; Porambage et al., 2021). The drivers seem to be a convergence of former and emergent trends which comprises novel services and the latest revolution in wireless devices, AI, computing and sensing. The increase of varied mobile applications, particularly those based on AI is stimulating intense debates on the future of wireless communications. AI plays a dominant role in the design and optimization of 6G architectures, protocols and operations. It aids in managing and securing an information system-based network. As the demands and infrastructure of these networks become complex, the traditional and centrally managed methods will not be efficient in performing administration and optimization, as well as securing the future networks.

The quantity of data that is gathered and stored is voluminous. The operators involved in these activities could influence AI and ML to make the networks proactive instead of reactive, thus offering better reliability. Some corporates have already commenced transformation by including Virtual Network (VN) assistants that are power-driven by AI competencies like Natural Language Processing (NLP). AI also aids in ensuring energy proficient routing, forecasting network interruptions, intrusion identification and other security-connected issues (Szegedy et al., 2013). Nevertheless, much work is demanded to guarantee that the future wireless networks are effective and secure with an increase in the transfer of data and communication increase among consumers and devices. Moreover, infrastructure will also influence indispensable services. Appropriate application of AI demands human intelligence as the foundation for computer network-based operations. AI plays a dominant role in providing smart security and privacy in 6G networks. The role of AI in ensuring security afore 6G, architectures, technologies and ensuring 6G privacy are discussed below.

AI in Detecting and Alleviating Security Issues that Prevailed in 5G and Former Technologies

Identification and prevention of intrusion in a multilayered environment through Deep Reinforcement Learning (RL) and Deep Neural Networks (DNN) are feasible in Software-Defined Networking (SDN) and Network Functions Virtualization (NFV) supported networks (Abdulqadder et al., 2020). This overcomes attacks like IP spoofing, flow table overloading, Distributed Denial of Service (DDoS), control plane saturation and host position hijacking in contrast to various conventional methods. ML-based methods like Decision Trees (DT) and Random Forests (RF) can be used for identifying DDoS attacks in SDN as they involve less processing time with improved accuracy (Santos et al., 2020). These methods are suitable for these kinds of networks as 6G networks involve the adaptive assignment of virtual functions when needed. As the attacks may keep changing, rule-based systems are unproductive. The issues like resource limitations on devices, the difficulty of key organizations in huge heterogeneous networks and the amount of data produced from devices lead to the failure of conventional authentication systems. An anomaly-based system for identifying intrusion in Industrial IoT (IIoT) (Zolanvari et al., 2019) is capable of finding malevolent packets depending on their behavior. These systems based on learning involve several data features and are appropriate for identifying zero-day attacks. Communication link features and user behaviors can be used with ML for authentication and endorsement (Fang et al., 2019; Fang et al., 2020) in future networks with resource-restricted devices. In that way, devices do not utilize their limited resources to provide additional complex security. 6G networks are supported by these learning-based methodologies within a subnet or between subnets. These ML-based algorithms

positioned at the edge can take the behavior of sub-networks and identify malicious traffic from those sub-networks. Huge data transfer from one subnet to another might not be of any use as the network typically functions alone. A subnet shares the learned intelligence to ensure communication efficacy (Wang and Joshi 2018). Another subnet can use this shared intelligence, feed it into ML models, find the malevolent traffic of other networks, and apply dynamic strategies.

AI in Mitigating the Issues in 6G Framework

6G depends on edge intelligence in contrast to centralized cloud-based AI systems. The distributed nature permits the implementation of edge-based associated learning for security in device and data regimes (Ma et al., 2020), guaranteeing communication efficacy. 6G framework foresees the associated intelligence and uses AI at various levels in network hierarchy (Letaief et al., 2019). AI at the small cell level can overcome DoS attacks on lower-level cloud servers. Multiple connections in a device permit numerous Base Stations (BSs) to assess the behavior using classification algorithms and cooperatively choose the legitimacy based on weighted average mechanisms (Chkirbene et al., 2020). The behavior-based schemes decrease the overhead due to the recurrent key transmissions as smaller cells and multi-access tools lead to recurrent handovers. Diverse levels of agreement are probable for subnet and WAN levels with joined learning. The trust learned in the subnet level can be made public only when external communiqué is necessary. These schemes proposed by Abdulqadder et al. (2020) and Santos et al. (2020) can overcome the attacks prevalent in User Plane Micro Services (UPMS) and Control Plane Micro Service (CPMS), as the edge owns the data for smart service facility. AI-based model evaluation and AI engine for providing API security are the crucial security components that improve the security in ZSM (Benzaid & Taleb, 2020b).

AI in Mitigating the Security Issues in 6G Technologies

The prognostic analytics based on AI is proficient in predicting attacks on blockchain even before it happens. A quantum computer may demand more than asymmetric key cryptography. Nevertheless, they support exponential speeds for AI and ML-based algorithms, thus supporting the tasks that were earlier impossible. Quantum machine learning acts as a defense scheme against these kinds of attacks (Biamonte et al., 2017). RL-based smart beamforming schemes offer optimal beamforming policy to overcome the eavesdropper attacks in Visible Light Communication (VLC) systems (Xiao et al., 2019). Anomaly-based systems based on AI can be used to overcome Jamming attacks. Similarly, AI-based authentication and endorsement schemes are appropriate for circumventing node compromise attacks (Fang et al., 2020).

AI for Ensuring 6G Privacy

Networks supporting multiple connections and mesh networks with small cells permit concurrent communication for devices through several BSs. ML models based on the edge can be used in dynamically identifying the privacy conserving routes, ranking them and permitting devices to transmit data through those routes depending on the ranking. Federated learning (Wang & Joshi, 2018) permits data to be kept close to the user in contrast to centralized cloud-based learning to improve data and location privacies. In the case of subnet-level AI, privacy can be conserved within the subnet, and the learned intelligence

can only be shared to diminish privacy risks. Restraining data within a network is appropriate only for some applications. With a rapid increase in the number of applications and a huge amount of data to be fed into models, users demand varied privacy levels. Service-based privacy conserving methods that use AI (Liyanaage et al., 2018) are capable of supporting fully automated 6G networks.

6G AND MACHINE LEARNING (ML)

ML is an ancient and most established AI discipline. Since the 1950s, since Turing came with the option of ML, AI has come across diverse periods from logic reasoning, possessing knowledge and autonomous learning which is ML. Recently, ML-based algorithms are extensively applied in diverse fields like health, transportation and autonomous vehicles (Newell & Simon, 1956; Feigenbaum & Buchanan, 1994; Ashrafian & Darzi, 2018). In the case of the 6G vision, several intelligent applications based on ML technology will support rich varied connections, huge information storage and operations.

Predictive algorithms are used to deal with the 6G problems. ML is found to be effective in fulfilling the exciting and varied necessities from several new applications by forecasting user behaviors and traffic demands. ML techniques can be applied to chief issues that include innovative radio interface, smart traffic control, security, management and network optimization. As 6G supports diverse IoE applications, it is predominant to comprehend, assess and confirm the upkeep of the Quality of Service (QoS) and the Quality of Experience (QoE) of the developing applications. Many prevailing QoE models are restricted to traditional mobile broadband services like Voice over Long-Term Evolution (VoLTE) and streaming. To build a precise QoS or QoE model, the user demands and features of applications should be deeply learned. ML methods are found beneficial in determining the correlation among QoE metrics at the application level and QoS indicators at the network level and considering the influence of QoS on QoE.

Applying 6G network operations depends on ML algorithms which will enhance the impact of ML (Zhang et al., 2019b). It is understood that ML and 6G are jointly favorable. 6G supports ML-based services, while ML optimizes the 6G architecture and plays a dominant role in the 6G structure.

Though ML supports 6G, there are several chances of several privacy issues. With the fast growth of deep learning schemes, it is demanding to deal with the security issues in applying ML-based algorithms. While ML yields substantial merits for 6G, the security of AI models is not given much importance. As there are multiple real-world applications, security plays a dominant role. A secure ML structure or appropriate application of ML can offer privacy. Alternatively, ML may be confronted leading to privacy violation. The association amid 6G and ML may be reversible in some cases instead of undeniably invading or ensuring privacy.

The main privacy issue in 6G is that ML makes use of big data to enhance the systems' performance, learn and produce models to make decisions. The 6G structure supports an increased amount of data exchange and universal applications (Strinati et al., 2019). This may lead to datasets comprising of private information being vulnerable at the terminal as well as during communication. The data exchanged due to ML in 6G leads to a greater challenge to data privacy, thus attracting wide focus from governments, enterprises and academia.

The General Data Protection Regulation (GDPR) of the European Union is an example and other countries are also adopting data protection regulations (Voigt & Von dem Bussche, 2017). Similarly, WeBank in China is developing Federated Learning and Reference Architecture (IEEE P3652.1) standard and Federated AI Technology Enabler (FATE) to enhance the ML-based technologies that support

privacy guard (Wang, 2019). Apple Inc. uses Differential Privacy (DP) to defend user confidentiality. In addition, distributed security scheme that integrates privacy into AI, data communication security of THz signal (Zhang et al., 2019a), security at the physical layer are also applied to 6G networks.

Sensitive information may be gathered, and several classes of privacy may be employed. Hence, ML efficacy and privacy should be balanced (David and Berndt 2018). ML techniques can be used for protecting as well as violating privacy. Different from former communication networks, this 6G network leads to a period of connected intelligence with varied privacy issues. This era will disrupt data monopoly and generate extensive data sharing and trading market. Immense sensitive data and less effort in finding data lead to greater requirements on privacy ensuring methods, and also cause governing complications triggering offenses against data. Intelligent applications running on mobile devices and network edges increase the attack risks. Ensuring privacy in a resource-constrained environment is a challenge. Providing efficient services and ensuring privacy play a dominant role in shielding data from malicious use. It is essential to focus on providing data access rights and proprietorship, effective management and sensible regulations with balanced performance and protection.

PRIVACY PROTECTION THROUGH ML

With the growth of the Internet, intrusion of privacy on the Internet has developed and consideration to privacy has also increased. Consequently, to focus on defense by discovering attackers, privacy identification is incessantly designed. 6G supports the ubiquitous nature of smart devices and the restoration of AI and ML to implement various functions in a free setting. If ML is used appropriately, an improved and better communication environment can be built that contributes to the Internet of Things (IoT). Besides being protected as a beneficiary, ML can also be a protector in particular scenarios. Research is ongoing in threat identification technologies in areas of small-scale devices that are used daily, smart vehicles and IoT through ML. These technologies will play a dominant role in 6G.

IoT

Zhang et al. (2019c) have dealt with 6G that supports smart wearable devices and also improves huge IoT and completely independent vehicles. The main challenge in IoT lies in its heterogeneity, as diverse software and hardware need varied security testing and analysis approaches. Though ensuring security in IoT is challenging, ML methods can be employed to deal with them. Siboni et al. (2019) have focused on the complete process of IoT devices. A security testbed architecture using ML is proposed to observe different types of operations in IoT devices for perceiving susceptibilities.

Android

People have got attached to mobile devices. With the increase in malevolent applications, privacy identification for mobile phones has drawn much attention and incessant growth. 6G networks support diverse AI-supported Apps at several edge mobile devices. The universal nature of smart devices and the variety of Apps lead to a big privacy challenge. The Android platform controls the Operating System (OS) of mobile devices. The efficiency of Android malapps identification with ML, has improved. Ensuring the privacy of mobile phones has gained much attention from the government, enterprises and academia.

Currently, this technology is gaining much attention and many companies are developing App security identification platforms. An App called 'Appscan' is developed by 360 Security from China for scanning security risks. An APK file can be uploaded and a report of scanning 'Privacy security risk' can be created. With the increase in the involvement of AI and ML in 6G, privacy can be completely and reliably ensured in mobiles.

Intelligent Vehicles

With the growth of smart transportation, the predictions of smart networked vehicles have increased. Countries are investing more manpower and resources to increase the number of associated vehicles and have attained substantial results. Automatic navigation, independent driving technology, and self-propelled edge computing technology endorse the growth of smart vehicles. As vehicles are meticulously associated with human movement and play a central role, the data related to smart cars essentially includes user private data. Smart devices are not limited to mobile phones but also smart cars. Hence, besides the identification of mobile devices, research is carried out on intrusion discovery in smart cars, whose privacy challenges are considered. Nie et al. (2018) have focused on the dependability and security of VANETs that have gained much attention recently, and employ automobile privacy safeguard technology for smart transportation systems. Based on the rapid drive and short-term link features of VANETs, they have propounded a mechanism based on the Spatio-temporal features of the network traffic, thus designing an anomaly identification algorithm based on network traffic estimate. As Convolutional Neural Network (CNN) is employed, this method is effective. Zhang and Zhu (2018) have dealt with VANETs that are susceptible to many attacks like passive eavesdropping even active interfering. A privacy conserving ML-based cooperative intrusion identification scheme is proposed to mitigate the threats against the identification of malevolent behaviors. A classifier of distributed ML is trained to identify intrusions in VANETs. Earlier research was on exceptions, while the latter depends on the changes by malevolent behavior being identified.

ENSURING PRIVACY OF ML MODELS

6G demands advanced cryptography to guarantee effective steadiness amid AI and privacy (Strinati et al., 2019). Privacy improving schemes based on ML can be classified into cryptographic and perturbation approaches (Al-Rubaie & J. M. Chang, 2019). The conforming demonstrative schemes are homomorphic encryption and Differential Privacy (DP).

Homomorphic Encryption

The idea of homomorphic encryption was proposed by Rivest et al. (1978). Cryptographic operations are performed on particular algebraic operations to get an encrypted solution. Homomorphic encryption aids in performing computation on the ciphertext. Same computations are applied on the plain and ciphertexts. On decryption, if the same result is obtained, then it is called homomorphic encryption. Gentry (2009) has propounded a complete homomorphic encryption mechanism that depends on standards. This system acts as a prevailing tool to support cryptography and overcomes the confidentiality problem while assigning data and functions to third parties. Gentry (2010) have also propounded a

complete homomorphic encryption mechanism to represent data process deprived of access permissions. ML algorithm should solve this problem by ensuring privacy and security of data through encryption. The main aim of using ML in cryptography is to accomplish ML tasks on the encoded data and obtain results related to the plaintext. ML algorithms are combined with homomorphic encryption to preserve privacy. By using homomorphic encryption, Rahulamathavan et al. (2013) have propounded client-server data classification scheme based on SVM. Several authors have performed homomorphic encryption using neural networks (Wu et al., 2018), Bayesian classification algorithms (Raju et al., 2009; Aslett et al., 2015) and linear discriminant algorithms (Graepel et al., 2012). Diverse ML algorithms are used and apply them to several applications. Other algorithms include Cryptographic Neural Networks (Orlandi et al., 2007; Barni et al., 2011; Gilad-Bachrach et al., 2016; Wu et al., 2018), encrypted k-Nearest Neighbor (k-NN) algorithms (Zhan et al., 2005; Qi & Atallah, 2008; Kumar et al., 2008; Zhu, 2009; Utsunomiya et al., 2016), decision trees (Barni et al., 2011), and completely RF (Aslett et al., 2015).

Barni et al. (2011) have categorized ECGs using homomorphic crypto-NNs and k-NN. Gilad-Bachrach et al. (2016) have propounded an approximate NN for recognizing handwriting with improved accuracy. The privacy should be ensured with reduced computing costs, demanding a balance between these two. Cheon et al. (2018) have focused on balancing the computation overhead and ensuring privacy, and have propounded an enhanced ML architecture using homomorphic encryption. Deep learning can be combined with homomorphic encryption (Phong & Phuong, 2018). Homomorphic encryption supports the implementation of privacy conserving ML and can function with different fields like IoT. Jiang et al. (2018) have linked software and hardware protection for a biological application scenario along with homomorphic encryption. This architecture uses public cloud servers for storing biomedical data, and employs ML-based algorithms for learning and predicting. It also focuses on ensuring data security and computational efficacy. Shen et al. (2018) have propounded a privacy-aware phrase search technique using homomorphic encryption. They have dealt with solving the challenge of searching due to encryption in Apps by finding the location-based association of keywords. Wang et al. (2018) have focused on researching smart meters, data analysis and protecting the privacy of data generated by smart meters using homomorphic encryption. Furthermore, AI schemes namely, deep learning and reinforcement learning support enhancing the wireless communication ability in 6G (Zhang et al., 2019a).

Differential Privacy (DP)

Nowadays, sensitive data is hastily accumulated digitally. Though this offers many benefits, ensuring privacy becomes a challenge. Generating data to aid scientists and researchers supports social and scientific development. Still, these data may demand personal privacy. Hence, there arises a conflict between data and privacy. Further, in addition to genuine users, attackers also have access to the data. This threatens the confidentiality of data and hence needs to be protected. In the late 1970s, the mathematician Dalenius insisted that private data can be protected if users are not able to access precise information of individuals while accessing the databases (Dwork, 2011). It deals with offering a better vision for ensuring data privacy, permits forthcoming generations to focus in this direction, and K-anonymity is extensively used. The fundamental idea is to specify the features in the dataset, and the records are split into numerous equivalence groups, and every group's records include similar attribute values. A diversity of attack methods are proposed against providing K-anonymity. Furthermore, K-anonymity is not capable of providing firm proof and quantifiable computation of the amount of privacy defense, and hence demands improvement and exploration (Machanavajjhala et al., 2007; Li et al., 2007). Till

2006, Dwork propounded Differential Privacy (DP), a novel privacy description for preventing database privacy exposure (Dwork, 2011) that overcomes the deficiencies of the former scheme. The outcome of the computation results of the dataset will not be affected by the modification of a particular record. The query offers consistent results even when posted to a dataset with a single record. Two datasets are said to neighbors when only one record is different. If the results of the query algorithm do not provide DP protection, the invader can perform a DP attack by comparing them. If the query algorithm offers DP protection, the likelihood of the dataset getting a result of 0 is close, and hence the privacy of that record is ensured. DP guarantees data privacy as the target record is concealed and cannot be revealed to invaders with any kind of background knowledge. Furthermore, DP is an analytical model and can be quantitatively assessed. Using DP, analysts can execute aggregate investigation, while protecting personal privacy. Pathak and Raj (2012) have combined Gaussian mixture model-based classifier with DP which is realized by a huge margin loss function. Sarwate and Chaudhuri (2013) have focused on a variation of DP, local DP and have concentrated on the advancement made on differential ML. DP was initially combined with ML by Dwork et al. (2015) to deal with the over-fitting issue in ML. Researchers have focused on DP and ML. Zhang and Zhu (2016) have designed an ideal privacy scheme to examine the basic trade-offs amid privacy and accuracy, and also between privacy and utility. As a huge amount of data should be treated, DP schemes continuously develop with change in time. The prime focus is on privacy conserving disseminated training (Imtiaz & Sarwate, 2018).

CONCLUSION

This chapter has presented the attacks on privacy in 6G networks with the associated artificial intelligence and machine learning schemes propounded in the literature over the recent years with their merits and limitations. This chapter demonstrated the different scopes of the 6G network, the vulnerabilities that could be exploited by different attacks that are launched into the network and the possible solutions facilitated by classical and modern AI and deep learning techniques. It presented the role of homomorphic encryption and different privacy approaches with its indispensable role in guaranteeing security in the 6G network. It presented the impact of poisoning attacking, Reverse attack, Adversarial attack, and Membership Interference attack over the 6G with the possible solutions that could be handled through the employment of AI and ML approaches. It also presented different privacy protection approaches that could be formulated and deployed in 6G for achieving better network performance and user experience with improved throughput and minimized delay and jitter. It presented different security issues in 6G that can be handled by the current researchers of this domain with a careful understanding of the threat origin and its influence over the exploited vulnerability. Shortly, it is planned to formulate different attack detection schemes in 6G using hybrid deep learning architectures that have the maximized probability of improving the accuracy in attack detection on par with the existing AI and ML schemes contributed to the literature.

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Chapter 18

Analysis on 6G Networks Using AI Techniques in WSN to Improvise QoS

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ABSTRACT

In WSNs, attention is given to evaluating the first generation (1G) networks to 6G networks. AI techniques were applied to achieve network intelligence, closed-loop optimization, and intelligent wireless communication for 6G networks. DRL was adopted to preserve reliable wireless connectivity for UAV-enabled networks by learning the environmental dynamics. Hence, it is promising to adopt AI to 6G networks to optimize the network architecture and improve network performance. 6G networks utilize different spectrum bands to support high data rates. In 6G networks, the massive amounts of collected data and complex network architectures pose challenges for AI-enabled learning and training processes. Limited computing resources may be insufficient to process massive high dimensional data to meet the training accuracy rate, robustness, scalability, and flexibility of learning frameworks, which are crucial aspects for providing high-quality services in real-world dynamic networks. Thus, designing robust, scalable, and flexible learning frameworks for 6G networks is still an open issue.

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1. INTRODUCTION

Wireless Sensor Networks (WSNs) are a type of ad-hoc network technology which emerged more than 20 years ago (Rajatheva, 2020) for monitoring purposes in military applications (Rappaport et al., 2019). WSNs usually include a large number of sensor nodes (in short called nodes) which are fundamentally resource-constrained, but can connect to other nodes of the network for transmitting sensed data.

The main task of each node is monitoring the environment using the on-board sensors, besides its possible capabilities to act as a relay or data fusion node. Each node can be used as a router to forward data from neighbours to the sink or Base Station (BS). BS can process data locally or act as the gateway of the network to transfer data to remote servers. Thanks to the dynamic infrastructure and efficient transmission of data in WSNs, their application areas are quite diverse (Yang et al., 2019).

In the times of yore of two decades, an assortment of applications have been proposed for WSNs, such as environment monitoring (Letaief et al., 2019), healthcare (Calvanese Strinati et al., 2019), smart homes (Giordani et al., 2020), smart factories (Saad et al., 2020), and disaster management (Li, 2018). Although WSNs are considered highly dynamic ad-hoc networks, network topology management has been a fundamental challenge in these types of networks (Mohapatra et al., 2019), in particular resource management, scalability, reliability, and efficiency.

1.1 Artificial Intelligence

Using imitation of human thought processes and learning behavior, artificial intelligence (AI) enables wireless networks to become smarter and more automated. As 6G is envisioned offering full automation, AI becomes one of the critical and highly valued technologies in the future's 6G wireless communication systems. AI is also considered to be a tool for data analysis. By learning from big data, machine learning models are built to make correct decisions automatically.

Hence, AI technologies, such as educating machine will play an important role in networks that are too complicated and dynamic for humans to analyze on their own. In particular, scenarios involve complex processes such as the joint optimization in network design, resource management, and resource allocation Intelligent Surfaces. There are two kinds of intellectual surfaces, including the intellectual reflecting surfaces (IRS) and large intellectual surfaces (LIS). Both of them are considered as promising candidate technologies for 6G. They compare with beam forming technology with many other antennas which are required to make the signal a focused one. There is little restriction on how antennas spread in LIS environment, since it is electromagnetically active in the physical environment.

As a result, the LIS will not be adversely affected by antenna correlations. Despite this, the LIS consumes a lot of energy due to the surfaces' active nature, and is not energy-efficient. In the present day, increasing power consumption is a big issue and to overcome this, IRS is proposed by Wu et al. (Andersson et al., 2017) to replace the active antennas used by LIS. IRS uses passive reflecting elements to reflect signals intelligently such that the data rate and network coverage can be improved. Thus, IRS is considered to tune the wireless environments to increase spectrum and energy efficiency while consuming little power. Therefore, by controlling the incident waves' reflection characteristics, the signal quality can be improved significantly.

1.2 AI in Wireless Networks

In other essential layers of a wireless network, the existence of rich datasets lends itself to the applicability of machine learning-based solutions. In routing protocol design for wireless sensor networks, researchers have successfully utilized reinforcement learning methods to achieve a more energy-efficient routing scheme for underwater sensor networks. In the vehicular industry, autonomous driving has already been studied and become a reality in some cities in Arizona, US 2. With respect to vehicular communication networks, due to the constant movement of vehicles, a predictive model based on real-time data has superiority over traditional theoretical models in terms of accuracy. Artificial intelligence and its plethora of algorithms can be applied in varied ways in such networks: automatic encoder for predicting traffic flow, k -means clustering for traffic blocking control and Q -learning for intelligent resource management, among others. In the Internet of Space Things, with our envisioned multi-band communication capabilities in both inter-satellite and ground-to-satellite links, we have proposed a deep neural network-based resource allocation strategy to enable exiled scheme for Cube- Sates to stay connected without human intervention from the ground.

Apart from advancements in algorithm development, a potential issue dwells on the location of data storage and processing, which has largely happened in central data centers in the cloud. For devices distributed in a wide geographic range, this undoubtedly adds significant delays in performing tasks which require real-time operation. Moreover, a centralized computing manner is not desired from perspectives of data security and constraint in processing capacity (Nagatsuma & Carpintero, 2015). In order to relieve such challenges, edge AI pushes local devices to full operation and management tasks. Admittedly, this could lead to possible overburden in local devices, since they are not equipped with as powerful processing units as the cloud processing center, however, research efforts in this direction are dedicated to: acceleration in boosting the hardware's processing capability, and leveraging the coordination between other units and central processing units to optimization task distribution.

1.3 AI in Network Management and Orchestration

AI, or more specially ML, has an integral role to play in the management of networks. Knowledge Plane is described as machine learning system within a network which provides services to other elements of the network. More recently, network function virtualization and software defined networking become mainstream and large scale data acquisition has become easier than ever before, making a strong case of machine learning based management and orchestration primitives within 6G, ultimately leads to full network automation. In particular, the domain of network management presents a wide variety of problems that can be broadly categorized into:

1.3.1. Supervised Learning

Supervised learning is typically applied to problems relating to traffic prediction and classification, as well as slice resource prediction. While the former primarily involves preemptively determining the network traffic load, as well as determining the applications, protocols, and Quality of Service classes the traffic belongs to, for ne-grained traffic engineering, the latter involves predicting the resource requirements associated with different network slices based on the anticipated traffic load.

1.3.2. Reinforcement Learning

Reinforcement learning typically finds use in problems associated with resource management. For example, the popular virtual network embedding difficulty wherein the network orchestrator performs optimal placement of virtual network functions onto the underlying physical substrate, is highly amenable to reinforcement learning. Other applications include elastic scaling of network infrastructure, failure prevention, and configuration rollback.

1.4 Unsupervised Learning

While both supervised learning and reinforcement learning have shown significant promise in the network management domain, we note that there exist certain use cases such as those relating to optimizing the end-users' Quality of Experience (QoE) and network security where: labeled data for training is simply not present and the real-time nature of the application makes it impractical to wait for feedback. In such cases, unsupervised learning can prove to be an indispensable tool. For example, intrusion detection systems based on auto encoders have been shown to outperform supervised learning-based systems.

2. OPEN PROBLEMS FOR PERVASIVE AI

In the early years of fifth generation standardization, researchers have discussed potentials of AI in achieving high time and spectrum efficiency once incorporated in 5G. Specially, AI algorithms can help facilitate the following tasks which would yield low efficiency with conventional solutions: identify network anomalies, allocate network resources, and perform network management, among others. However, so far these solutions have not been officially adopted 5G standards worldwide. In June 2020, the ITU has initiated an AI/ML in 5G challenge to motivate researchers to identify and solve real-world problems using AI/ML solutions in relevant 5G directions. As such, it is envisioned that such efforts would be factored in later 5G development but will be materialized in a more concrete and pervasive manner in 6G.

While pervasive artificial intelligence in wireless communication networks will undoubtedly bring a paradigm shift towards data-oriented approaches (Shakeri et al., 2019), there are still open problems to be resolved. First, thus far no agreement has ever been reached on which algorithms work the best to solve a generalized problem in wireless networks like modulation and coding scheme design, channel estimation, and resource allocation, among others. Almost all published works claim significant accuracy or reduced complexity with either analytical theories or practical data sets. Additionally, we note the absence of an effective method to draw a fair comparison among all proposed solutions (Fan et al., 2016), due to variations in selected facts set, assumptions, evaluation criteria and so on. However, when it comes to realistic deployments, a careful gleaning process should be performed in order to identify algorithms without loss of general applicability (Lasi et al., 2014). Second, the limited availability of quality datasets is detrimental to the testing and validation of proposed classification or regression algorithms.

2.1 Terahertz

Terahertz (THz) is measured as major technologies for 6G wireless communications (Letaief et al., 2019; Mohapatra et al., 2019)–(Lasi et al., 2014). 5G defines below 100 GHz as the millimeter-wavebands, whereas 100 GHz - 3 THz is categorized as Terahertz band in 6G (Akyildiz & Jornet, 2016). 90 GHz band is merely used for scientific service, which has not been fully explored. Consequently, it is intended to support the expansion of wireless networks (Akyildiz et al., 2014a). Terahertz makes it possible to create ultra low latency and high bandwidth communication paradigms, which will be advantageous for many emerging applications, including autonomous driving and the Internet of Things. However, when the frequency raises, the path loss also up surges as well, which becomes a challenge for extensive range communications. Thus, the THz is particularly suitable for high bit-rate short-range communications (Abood et al., 2017). SR is a new technique that maintains the advantages and makes up the disadvantages of cognitive radio (CR) and ambient backscattering communications (AmBC). SR is considered as one of the promising solutions to build 6G as a spectrum and energy efficient communication system. In addition, IRS technology can further contribute to improving the performance of the transmission by enhancing the backscattering link signal.

2.2 Cell-Free Massive MIMO

Cellular wireless networks are based on cellular topology. Drawback of the cell based wireless network is that if the device is at the boundary of the cell, its signal is pretty weak. By tackling the low communication ability at the edge of the cell, the cell-free enormous multiple-input-multiple output proposal is anticipated, which removes the cells of the network.

Proposal of cell-free enormous multiple-input-multiple output means, one device is no longer attached to a single base station; instead, all base stations coherently serve the device in a region such as Air, space and Ground Sea Integrated Network. Global coverage can be achieved with 6G wireless communication network that integrates space, air and ground sea network (FCC, 2019), i.e., 6G will construct a space, air and ground sea incorporated network (SAGSIN). As expected in the white paper released in January 2020, the 6G network should cover environments, including sky (10000km) and ground sea (20 nautical miles) (FCC, 2019). By integrating three networks, SAGSIN can cope with various users and services' growing traffic demands.

2.3 Space, Air and Ground Sea Integrated Network.

6G wireless communication network gathers air; space and Ground sea network to accomplish the large scale coverage (FCC, 2019), i.e., 6G will construct a network that integrates space, air and Ground Sea (SAGSIN). As expected in the white paper released in January 2020, the 6G network should cover environments, including sky (10,000km) and sea (20 nautical miles) (Priebe & Kurner, 2013). By integrating three networks, SAGSIN can cope with various users and services growing traffic demands.

3. Block Chain Based Network

Block chain network is distributed databases which are constructed based on the theory of the hash tree, and they are tamper-proof and hard to reverse (Abadal et al., 2020). Block chains have attributes like audit ability, data integrity, and transparency (He et al., 2017). Thus, block chains can be used to manage spectrum resources without using a centralized authority. Besides, block chains are also suitable to protect data's security and privacy or control 6G technologies. They put forward well-organized and secure block chain pedestal privacy and preserving design, in which encryption technologies and access policies to assurance privacy of data. The authors (He et al., 2017) presents a design, that make use of block chain, these block chains are used as decentralized repository to develop the access protocols which is treated as sound spectrum that is shared in mobile cognitive radio network. The authors (Burford & El-Shenawee, 2017) present a trust substantiation structural design based on block chain that uses radio above fiber network.

3.1 Index Modulation

Index modulation conveys the source information bits through classical APM signals and the index selection of resource entities. Therefore, Index modulation can improve the transmission rate and is potentially to be used in 6G. The authors (Jornet & Akyildiz, 2011) suggest that information bits can be transmitted through the index of antennas in MIMO systems. They name such a technique as space shift keying (SSK) and combine the SSK with classical linear modulation, amplitude-phase modulation (APM); for example, space modulation (SM) is proposed based on the same idea in SSK. In SM technology, the source information bits are divided into two parts: the index of antennas that transmit and the other parts for the APM.

Therefore, SM can significantly increase the transmission rate by sending the spare information bits through the traditional APM transceiver's antenna index. Apart from the antennas, other resource entities can also be indexed to transmit the additional information bits. These resource entities include time slots, sub-carriers, and channel state. Also, this modulation class, where the spare information bits are transmitted through the index of resources, is called index modulation. Orthogonal frequency division multiple access (OFDMA) plus Index modulation will be essential technologies to significantly increase the throughput to support more users to access 6G network.

3.2 SWIPT

Wireless 6G is supposed to be a complex network where a large variety of smart devices are accessed to the system and are required to communicate with others at anytime, and the lifetime of the battery-charging modules is also required to fulfill the constraints of ultralow power consumption as occur. To prolong the life span of various devices in the network, SWIPT technology is recommended. SWIPT enables sensors to be charged exploiting wireless power transfer; thereafter, battery-free devices can be supported in 6G, reducing the network's power consumption substantially (Andersson et al., 2017). The authors (He et al., 2017) describe SWIPT technology from the perspective of a scientific hypothesis and engineering practice in detail. Subsequently, in (Jornet & Akyildiz, 2011)–(He et al., 2017), performance on the outage probability, throughput, and sum rate for non-orthogonal multiple access (NOMA) networks with SWIPT are derived. The Authors (Nagatsuma & Carpintero, 2015; Nagatsuma

et al., 2016) presents conduct error probability analysis of the NOMA-based networks with SWIPT. Error probability performance of SWIPT is sternly pretentious by the power splitting factor, which make available a principle for designing the SWIPT system in practical engineering.

3.3 Perceptible Light Communication.

Perceptible light communication (PLC) employs light, between 400 and 800 THz (780–375 nm) to communicate information. It provides ultrahigh bandwidth (THz), zero electromagnetic interference, unlicensed spectrum and very high frequency reclaim (Ishibashi et al., 2014). Therefore, PLC helps to develop the short range communications of 6G networks (Ito & Ishibashi, 2017). Besides, 1G to 5G wireless network make use of microwave interactions above the 6G band, whose resources are almost used up (Lasi et al., 2014). Correspondingly, since more smart devices are integrated into the network, and an explosive growth appear in the area traffic. High capacity becomes an essential requirement of 6G. To fulfill the requirement of capacity or data rate, VLC technologies are potential to be used in 6G.

3.4 Device to Device.

Device to Device (D2D) communication represents the direct communication between devices without going through base stations, and the communication can be done under licensed (i.e., cellular network) or unlicensed spectrum (i.e., WiFi) (Burford & El-Shenawee, 2017; Kloosterman et al., 2013). D2D improves the throughput, energy efficiency, delay, and fairness of the communication (Momeni & Afshari, 2011; Yachmenev et al., 2019). As the number of edge devices is explosively increasing, D to D is gaining more attention and getting more widely implemented (Gamzina et al., 2017).

3.5 Applications

Empowered by 6G, a wide range of AI applications will evolve into “connected intelligence” (Fan et al., 2016), hence facilitating every aspect of our daily life. For example, advanced AI approaches can be employed in network management or autonomy to save manpower (Nagatsuma et al., 2016; Saad et al., 2020). In addition, 6G revitalizes smart healthcare by providing real-time health monitoring, high-precision medical treatment (Mohapatra et al., 2019), and reliable privacy protection (Ishibashi et al., 2014). With the advent of 6G, Industry 4.0 will be fully realized as smart manufacturing will achieve high precision manufacturing.

Intelligent robots connected by ubiquitous 6G network enable manufacturing systems to carry out complex and dangerous tasks without risking people’s life. Moreover, the smart home that equips with intelligent IoT devices will provide a comfortable living environment to people, and 6G allows the smart home to ensure the residents’ security. In terms of traffic and transportation, sophisticated sensing and planning algorithms can be deployed for traffic optimization. Other applications such as smart grid and unmanned aerial vehicle will also be enhanced with the aid of 6G.

With the increasing popularity of AI technologies, 6G enables various applications in communications such as network planning, optimization of network, network operation and maintenance, and autonomous vehicles (Li, 2018; Nagatsuma et al., 2016). AI resides in fog and cloud environment that helps to create new appliance that uses sensors and can be embedded into every corner of our life (Bresson et al., 2017). Deep learning is deemed as very important part of technology related to AI which is used in

wireless based networks. It plays very important role in region, that includes holistic management and semantic communications, control resource areas, computation etc., which may lead to a shift of 6G.

4. INTELLECTUAL SURFACE

Intellectual surface are new and revolutionary technology for significantly improving the performance of the wireless communication networks. Currently there are two types of intellectual surface that attract researcher's mind, which includes large intelligent surface (LIS) and intelligent reflecting surface (IRS). LIS is useful to assemble an intelligent and dynamic environment that holds integrated electronic devices and an external generator that generates signals. IRS makes low outlay passive reflecting elements to reflect the beam forming. Overview of LIS and IRS is presented below along with other similar technologies.

4.1 LIS

LIS is electromagnetically dynamic in physical environment, in which all part of LIS (Vazquez et al., 2017) can receive and send electromagnetic signals. Therefore every building, streets, and every wall are estimated to be active in nature, after decorating LIS. As signal processing units (Akyildiz et al., 2014b) and radio frequency circuits are embedded in the surface, the entire surface of LIS can be used to convey and take delivery of communication signals (Zak et al., 2014).

4.1.1. LIS Has the Following Main Favorable Features

To produce perfect LIS indoor and outdoor propagation environment, a little restriction is fused on the antenna elements. For this reason, antenna correlation and effect of mutual coupling maybe easily cleared off because sub arrays are huge and channels are well in condition for propagation. LIS is very functional for applications with low latency such as wireless virtual/augmented reality and vehicular communications.

4.2 IRS

By modifying incident waves, IRS improves signal quality at receiver end. RFID (Akyildiz & Jornet, 2015) can help to form radio environment that is smart. IRS can increase the power and phase of the reflected signals. In particular, by powering local tune, graph based plasmonic reconfigurable surface (Jornet & Akyildiz, n.d.) can achieve various benefits, which includes beam focusing, beam steering, and control over wave vortices. Passive array architecture is used for reflecting purposes in the IRS (Jornet & Akyildiz, 2011) instead of the LIS.

4.2.1 Large Intelligent MetaSurface (LIM)

LIM uses a special metallic material called meta-atom to form its surface, which is more flexible in manipulating electromagnetic waves. Smart reflect arrays: smart reflect arrays put more emphasis upon the reflection function other than the transmission, reception and wave guiding functions.

4.3 Software-Defined Surface (SDS) / Software-Defined Meta Surface (SDM)

The SDS/SDM introduces the thought of radio into smart surfaces and by controlling smart surface units through units. As mentioned above, technologies have almost similar functions with LIS or IRS and in our survey; it is stressed on the investigation of this intellectual surface, quality of service (QoS) enhancement. Therefore, use of IRS in our following manuscript is only for universal purpose.

Since channel fading of base station, direct link of user equipment is too large to guarantee QoS. IRS of NI units is utilized to facilitate the communication.

Generally used method to solve the problem is to consider phase shift and amplitude attenuation in continuous mode and choose discrete values that are close to solved continuous solutions. The problem with no amplitude attenuation also makes the constraint non-convex, and in such a case the optimization can be done first by neglecting this non-convex constraint and then by normalizing the phase shifts to fulfill the constraint of unit modulus.

The protocol first estimates the channel coefficients between BS and UEs by turning off IRS and then estimates the BS-IRS-UE link by turning on the IRS unit in turn. Finally, MMSE approach is utilized to obtain a comprehensive estimation of all channels. This protocol is complicated and time consuming due to the fact that each IRS should be turned on once a time while the others turned off, especially when the number of IRS elements is large.

He et al. presents three state channel estimation algorithms. The algorithm first obtains the channel matrices of the BS-IRS and IRS-UE links via matrix factorization. By exploiting the IRS state matrix, the ambiguity of the solutions to matrix factorization is eliminated. In the final stage, the properties of channel matrices are utilized to recover the missing entries. The proposed estimation algorithm is also time consuming because IRS units should also be turned on in turns to eliminate the ambiguity in the second stage.

To address such a problem, the authors (Kloosterman et al., 2013) propose a novel method to estimate the channel state information for IRS-enhanced OFDM systems. The authors first design a reflection pattern of the IRS for channel estimation by exploiting pilot signals, and then perform a joint channel estimation and reflection optimization based on the strongest signal path resolved in the first stage. This novel method avoids the requirement of large numbers of pilot signals and operation for each IRS units, therefore, reducing the complexity of the receiver for a large scale. Besides the fundamental application as described above, there exist some other IRS-assisted communication systems or IRS technologies in available references.

For instance, The Author (Abood et al., 2017) discusses the application of the IRS in OFDM systems where multiple paths exist in the wireless communication environment. The authors establish an objective of maximizing the capacity with maximum transmitting power, where the coefficients of IRS and the power allocation for each unknown parameters. By exploiting the idea of alternating optimization, the optimal power allocation and the IRS coefficients can be derived.

The Author (Fan et al., 2016) investigated the capacity performance with hardware impairments that exist in IRS. The authors also give a conclusion that by splitting the IRS into several subgroups with each subgroup consists of a number of the IRS' units, the performance degradation can be mitigated to a certain degree.

In the manuscript, optimal (exhaustive search) and suboptimal (greedy) detectors for the IRS-assisted SM or SSK schemes are formulated in detail, and their theoretical average bit error probabilities are derived as well, to give a benchmark of IRS-IM/SSK wireless communication systems.

Furthermore, Huang proposed the scheme where the IRS is combined together with MIMOS to form the HMIMOS systems. Interference is regarded as resource, for developing holographic communication systems. Multi user interference can be decomposed into constructive and destructive parts using simple geometric relations. Constructive part is considered as beneficial communication resource, which can be used to improve Quality of Service of 6G communication systems. To be more specific, active HMIMOS using IRS are equipped with RF circuits and signal processing units, whereas passive HMIMOS only use IRS for reflecting signals.

5. SIMULTANEOUS WIRELESS INFORMATION AND POWER TRANSFER (SWIPT)

In 6G network, various mobile wireless devices will be accessed to the network. The high transmission rate leads to an increase in power consumption, and thus, requires the long lifetime of battery-powered devices. SWIPT is such a novel technology promisingly used in the 6G network where energy harvesting through RF signals can be made to fulfill it.

Requirement of high power efficiency, initiative of energy harvesting would be back to 1969, when he conducted a series of experiments and demonstrate that a helicopter at a height of 50 feet operating on 2.45GHz can provide a direct current power supply of about 270W. The energy is harvested either from the ambient wireless signals or from a specific controlled power source. In 2008, Varshney, first propose the concept of SWIPT, which deliver information and energy concurrently from a theoretical perspective. Generally used structures for resource allocation are time switching structure, power splitting structure, and antenna switching structure. In Time switching structure, a frame consisting of several time slots are classified into information transfer slots and power transfer slots, and a switcher is used at the receiver to decide which state is at work .The receiver splits the received signal into two streams with power ratio where the two parts are used for harvesting energy and decoding the information, respectively.

In Power splitting structure, a power splitting factor is utilized to decide how much signal flows to the decoder circuit for signal processing or the battery circuit for energy harvesting. And subsequently, the two power streams can function separately but simultaneously through the overall frame duration. At the receiver, the ratio of the power used for harvesting energy and decoding information can be set as a constant α , leading to the element of the splitting vector be $\alpha_k = \alpha$; ($k = 1; \dots; N_f$). In addition, the power splitting factor can be designed to balance according to different system requirements

.In antenna switching architecture, the RXs is divided into two subsets for energy harvesting and information decoding separately. Compared to Time and Power switching structures, Antenna switching is easier to implement and thus appealing for practical SWIPT deployment, on the other hand, the performance will degrade significantly in case of hardware impairments. In one frame duration, all splitting factors remain unchanged for a given received antenna, $\alpha_k = \alpha$; ($k = 1; \dots; N_f$) for energy harvesting RXs and $\alpha_k = 1 - \alpha$; ($k = 1; \dots; N_f$) for information decoding RXs.

Overall performance can be increased by optimizing the combination of signal power and Antenna Switching ratio factor, to balance the tradeoff between transmission rate and energy harvesting. In most application scenarios, research works focus on different resource allocation schemes considering data rate, harvested energy power, transmit power, and received SNR.

By performing a joint optimization of resource allocation with power control and resource scheduling, both the capacity of the system and harvested energy can be promoted considerably. A lot of references

have discussed the energy efficiency of SWIPT-based technologies. Then here the investigation of the energy efficiency performance of a SWIPT-enabled cooperative relay network with interfering exists in systems.

In two different scenarios the relay can be gathered only from the source and that harvest energy from both the source and the interference are considered. A suboptimal PS factor is derived and a new energy-saving power splitting relaying protocol is investigated, which provides PS based relaying protocol for the future relay networks. Then consider SWIPT scheme with pre-coder MIMO system. By optimizing the pre-coder to maximize the harvested energy with the power constraint, high power efficiency is achieved, which is feasible for both separated and co-located receivers. Authors conclude that HAP has adverse effects on both energy harvesting and information decoding.

To address this problem, it gives a frequency splitting SWIPT, which separates the power and transmitted signals in frequency domain. The proposed scheme can reduce the harmonic distortion of the high power amplifier, thus decreasing the effect of amplifiers' non-linearity. Frequency splitting SWIPT outperforms its PS counterpart in terms of the harvested power, and is more beneficial to the 6G network where a lot of low-power wearable devices are accessed to the network

Then the study of an IRS assisted SWIPT technology for MISO systems is introducing an energy efficiency indicator to trade off between transmission rate and harvested energy, a joint optimization is performed to obtain the beam forming vector, the PS ratio of each user, and the phase shifts of IRS. The optimization problem is divided into two sub problems and a suboptimal solution is achieved for the system. The proposed scheme has the advantages of both low power consumption and high BER performance, which is attractive for the 6G network.

The Author (Akyildiz et al., 2014a) also considers an IRS-assisted SWIPT technology, where the security issue is emphasized since broadcast nature makes the system be vulnerable to eavesdropping. In order to optimize the secrecy rate, the beam shaping vector at the BS and reflective beam shaping at the IRS are jointly designed, considering transmit power constraints and energy harvesting constraints. The proposed scheme is useful for future network because both low power consumption and high security are guaranteed, which can satisfy the requirements of 6G network. Additionally, investigate the security issues of SWIPT networks.

Jamming is provided to improve security, where full duplex energy limited receiver is used to generate jamming signals. By optimizing the PS factor, the security throughput is maximized. Minimum harvest energy among users is maximized, with the constraints of secrecy rate and transmits power.

It will investigate the security performance of SWIPT scheme for cognitive radio network. Intercept and secrecy outage probability is derived with imperfect CSI and with the influence of power splitting factor. The secrecy performance is also studied in detail. The entire SWIPT based scheme mentioned above consider security as one of the main problems in system design, and is beneficial for 6G network where high security is required to protect the individual data of each UE.

6. CHALLENGES OF SWIPT

The SWIPT-based systems motioned above exemplify the general usage of SWIPT technology in wireless communication networks. It can degrade the power consumption and takes advantage of scenarios where it is difficult to charge the battery such as volcanoes and marine areas. However, still there are some challenges of SWIPT technology that exist.

Existing studies mainly focus on low-power relays and sensors because; the level of harvested energy is too low to satisfy the requirements of large wireless devices. In 6G network, dense deployment of wireless devices leads to complex electromagnetic interference, which is desirable to power transfer while averse to information decoding. Intense RF radiation has adverse impact on human health. However, to achieve high QoS of SWIPT based system, denser sensors or relays should be deployed for energy harvesting, which causes more intense RF exposure.

7. AIR, SPACE AND GROUND SEA INTEGRATED NETWORK

In the 5G network, users only have access to a single wireless communication system, for example, the terrestrial wireless communication system, which is experiencing explosive growth both in the number of users and services available. To overcome 5G's bottleneck, 6G integrates communication network, satellite communication network, worldly communication network, and marine network to build air, space and Ground Sea integrated network. SAGSIN shore up the large-scale coverage and ubiquitous connection, as network may work independently or collaboratively.

Specifically, SAGIN is essential to support applications like IoT, big data, and cloud computing. It will summarize the inter-satellite communication from viewpoints of the physical and network layer. Besides, here analyze the QoS provision in satellite and worldly network. They emphasize the technical challenges related to the convergence of satellite and terrestrial networks in detail, where the satellite networks act as a complement to the existing terrestrial infrastructures.

The study of satellite's based hybrid sensor network is mentioned in the perspective of detection and tracking in a mobile scenario. However, they only consider two networks, space, Ground Sea or air ground integrated networks. Coverage is different for space, air and Ground Sea integrated networks in 5G, similarly SAGSIN of 6G also provides different coverage for underwater and deep sea communications. Satellite Communication Network in 5G communication network focuses on the terrestrial coverage, which leave some areas uncovered.

Satellite communication in 6G is envisioned to integrate with terrestrial communication to provide full coverage and high throughput for the regions where terrestrial wireless communication cannot reach, such as rural areas. Communication with satellite can be categorized into Geosynchronous Earth Orbit (GEO) and non-GEO, based on the satellites' altitude. Let's conclude that a GEO satellite is at an altitude of about 35,800 km. GEO satellite communication uses high frequencies, which aggravates the path loss. Low Earth Orbit is an altitude of 500 to 2000 km, and MEO is an altitude of 8000 to 12000 km.

Non-GEO satellites have lower end-to-end delay compared to GEO satellites. Different orbits decide that satellites are suitable for different scenarios. GEO is stationary to Earth, while LEO is moving with the Earth. Therefore, GEO can provide a designated region with continuous service. However, due to the long distance, it suffers a relatively high signal delay. Compared with GEO, LEO has a shorter delay because its orbit is much lower than GEO, which is more convenient for communicating with ground terminals, such as GPS communication and satellite phones.

8. UAV COMMUNICATION NETWORK

An unmanned aerial vehicle (UAV) is an unmanned aircraft, which means it works automatically. Each UAV can be viewed as a node. Different UAVs construct UAV network. Since the UAV communication network is distributed and federated learning is an emerging distributed learning framework, some studies leverage federated learning to assist UAV communication (Akyildiz et al., 2014a; FCC, 2019). In (Akyildiz et al., 2014a), according to the Author, a collaborative learning scheme is proposed based on federated learning and involves UAVs for implementation in the IoV paradigm. Our work extends federated learning algorithms to swarms of unmanned aerial vehicles and introduces a joint power allocation and scheduling design, which increases the rate of convergence of federated learning algorithms

9. MARITIME COMMUNICATION NETWORK

Underwater links will support communication among ships, submarines, and sensors. In marine time communication network, it involves ashore stations and satellites. There are self-organized ad hoc networks which consist vessels. This network function is to accelerate the communication between mobile stations and aid navigation and also to switch the routes. Maritime communication also has several challenges to be overcome.

Here, concluded eight existing challenges. They are ubiquitous connectivity & service continuity, capacity & scalability, simplicity & reliability, device heterogeneity, traffic non-uniformity, service-centricity, interoperability, and radio spectrum internationality.

10. VLC

VLC is envisioned to be utilized in various applications in 6G. By integrating with SAGSIN, short range network and cellular communication, VLC can be used to provide a better coverage (Abood et al., 2017). Furthermore, Vehicle-to-vehicle communication relies on vehicles' headlights and taillights for communication (Bresson et al., 2017; Mohapatra et al., 2019). However, VLC is still facing many challenges. For example, the light source's bandwidth restricts the speed of VLC, so new materials and mechanisms should be developed to increase the light source's bandwidth. Besides, Si-based detectors used by VLC systems are more sensitive to infrared waves than visible light. Moreover, there are no application specific integrated circuits for VLC baseband processing. Furthermore, the data processing for future systems will be a much more complex to process.

11. DEVICE-TO-DEVICE COMMUNICATION

As the Internet of Everything (IoE) will be introduced in 6G, the number of edge devices' booming increase imposes unpredictable pressure on the communication between centralized servers and edge devices.

Device to Device (D2D) communication enables device, to communicate directly without making use of infrastructures like base station or access points, which guarantees ultralow latency, speeds up the transmission, improves communication quality, and offloads traffic from the conventional cellular

network in end-to-end communication. Thus, D2D communication will gain much more attention in increasing data transmission speed, decreasing end-to-end latency, and reducing the cost of communication. Specifically, D2D communication can operate in licensed bands and unlicensed bands (i.e., Bluetooth and Wi-Fi). Because of the decentralized features that D2D possesses, D2D obtains its advantages in multiple areas, such as mobile edge computing, IoT, IoE, etc., which also share decentralized features. With the aid of D2D communication, coordination between the centralized server and user's devices has significantly changed. Users who are close to each other exchange data without forwarding through the BS in the node. Hence, D2D communication can reduce energy consumption and upgrade its quality of service (QoS) demands. D2D is encountering challenges, including severe interference, prohibitively high cost, a vast amount of signaling, complex resource management, and energy consumption.

To facilitate D2D communication, more advanced and state-of-the-art technologies such as AI and IRS can utilize. To be more specific, D2D communication will become AI Driven and intelligent in 6G network. One application is to leverage AI to manage resources intelligently. AI driven D2D communication enable three kinds of application that includes NOMA based D2D cognitive networking, intelligent D2D intelligent network, and D2D mobile edge computing slicing. Network slicing (NS) helps to manage and share resources in 5G network.

D2D clusters can extend network flexibility, which enables services available according to user needs. In 6G, large number of D2D clusters may provide both physical and virtual resources, which are critical to building NS. AI will be employed to support and manage D2D clusters. Resources may be intelligent and automatic, which means AI will monitor the underlying resource and network slices to intelligently achieve resource mapping. Combined with NOMA, D2D will support the cognitive network. Delta orthogonal multiple access (D-OMA) technique is proposed to obtain large scale synchronized access. D-OMA which serves as the new multiple access schemes for 6G is leveraged to tackle terminal devices, including the high complexity and increased energy consumption at terminal devices.

12. NETWORK IN BOX

In future, additional new kinds of technologies will be entrenched in 6G network. Examples are factory automation and self-directed vehicles etc. To satisfy real time and reliable feature of network, NIB techniques attracted towards industrial automation. NIB offers devices that provide seamless connectivity between different services. On the other hand, NIB covers up wireless environment which includes air, ground and marine integrated region. They fulfill the vision of IoE in 6G environment.

13. CONCLUSION

Communication systems evolve with every generation, bringing new features and benefits. Compared to 4G, 5G will launch globally in 2020 with remarkable features. Five-generation 5G communications systems feature new and electrifying features that lead to a new generation of networks. As 5G communications begin to take off worldwide in 2020, they will feature innovative and impressive features. The mounting demand for wireless communication in 2030 will, however, be beyond the capacity of 5G. As a result, 6G must be introduced. Researchers are still studying and researching 6G technology. In this paper, we envision what 6G communication could be and how it might be achieved. Several promising

technologies in 6G networks communications are envisioned in this paper along with an explanation of their usage, including artificial intelligence, SWIFT, intelligent reflecting surfaces, THz communications, block chains, and combined air, space, and marine networks. Furthermore, it is explained how these technologies might be applied to the creation of 6G networks to advance the eminence of services. This paper explains not only the vision and goals of 6G communications, but also describes the various technologies that can be used for 6G communications in the future.

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Chapter 19

A Federated Learning– Based Light–Weight Privacy– Preserving Framework for Smart Healthcare Systems

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ABSTRACT

Smart healthcare systems have been widely applied in the fields of intelligent healthcare, self-monitoring, diagnosis, and emergency. In recent years, there have been growing concerns regarding the privacy of the data collected from the users of the smart healthcare systems. This chapter proposes a light-weight federated learning framework based on multi-key homomorphic encryption for deploying predictive models trained on patient data distributed across multiple healthcare institutions without exchanging them. Two predictive models based on the proposed framework are deployed for in-house mortality prediction from patient data and COVID-19 detection from chest x-ray images. Performance evaluation of these models with standard datasets and comparative analyses show that the proposed models are superior to state-of-the-art approaches. The proposed framework and the models are potential solutions to improve the quality of healthcare across multiple healthcare institutions, protecting the sensitive patient data and ensuring personalization of healthcare.

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INTRODUCTION

According to Piran and Suh (2019), the novel 6G wireless networks feature a throughput at least three to five times higher, as well as a 10 to 100 times lower latency than that of 5G. It is a new technology whose development and deployment is underway to benefit from the rapid development of Internet of Things (IoT) technology. Such improvements in performance allow for faster data transfers for ubiquitous use of Internet-connected devices. In addition, the scope of 6G networks is expected to be expanded to support emerging technologies such as augmented reality and virtual reality, and various services, including mobility and network access for vehicle-to-vehicle and vehicle-to-infrastructure communications, enhanced mobile broadband, ultra-reliable and low-latency communications, next-generation machine-type communications, and enhanced mobile IoT for machine-to-machine (M2M) communications (Amodu and Othman, 2018).

Smart healthcare applications can be realized with 6G technology because it supports a considerably higher volume of data communication, shorter latency, and higher reliability than those of the existing mobile communication networks. The 6G technologies are required to support not only infrequent and delay-tolerant but also frequent and delay-sensitive operations. For example, healthcare data collection, analysis, and reporting may be delayed when a patient is in hospital. 6G-based healthcare applications may also support M2M communications in order to improve efficiency of the healthcare process and reduce medical costs. In addition, M2M communications can offer telemedicine service, remote healthcare, emergency detection, patient monitoring, etc., and the healthcare industry is focusing on M2M communication technologies for in-hospital medical device network applications to improve the quality of healthcare services. These technologies can be used to obtain patient information and manage medical devices remotely, detect problems in emergency situations, and monitor patient conditions, thereby improving the quality of healthcare services provided to patients.

A review of requirements of data-driven models in 6G-based healthcare systems by Ray et al. (2021) show that they are able to combine many kinds of patient's health data (e.g., biometric signals, images, and continuous health parameters) urgently needed to avoid costly reactive data inflow and support health-aware decision-making. Scarpato et al. (2017) show that intelligent healthcare focuses not only on in-hospital, but also on healthcare data communication (Health IoT), personal healthcare of individual (personal health technology), and service-to-service communications. Various statistical classification techniques, and Natural Language Processing (NLP) are important enablers for 6G-based healthcare.

With the increasing number of patients and demand for novel personalized healthcare services, there is a need to transfer healthcare data for analysis to cloud-based environments. Further, stringent regulations such as the Health Insurance Portability and Accountability Act of 1996 (HIPAA) and other data protection directives have identified patient privacy as a major concern in healthcare data sharing and management ("Act", 1996). Need for privacy-preserving schemes for sharing patient data is highly pronounced in smart healthcare systems as discussed in the work of Son et al. (2017). Light-weight privacy preserving schemes incurring low data cost and computational overheads, and few communication round trips are highly preferred to improve the quality of care.

Adhering to these requirements, this chapter proposes a novel privacy preserving approach for smart healthcare environments, leveraging Federated Learning (FL) paradigm, the application of which in wireless communications is investigated by Tran et al. (2019) in predictive modelling (Henriksen and Bechmann, 2020). FL aims to reduce the storage of the sensitive data, and processes the model with low communication and computation costs by harnessing the central computing power of the data owners.

FL continuously updates the global learning model with the latest data on the local instance for each client, while the global model is not stored on a local instance.

In addition to the security and privacy of the sensitive data, security of the model when transmitting the model parameters through the network must also be considered. Security of these models is realized with Homomorphic Encryption (HE) algorithms proposed by Yi et al. (2014) which permit mathematical operations directly on encrypted data guaranteeing data privacy and usability. This research proposes a secure FL framework for deploying predictive models for patient mortality prediction from clinical parameters and COVID19 detection from Chest XRay images (CXR). The contributions of this research are as below.

1. A novel privacy preserving framework for deploying predictive models, securing sensitive patient data from unauthorized access
2. A secure in-hospital mortality prediction model trained on local instances trained with private clinical parameters
3. A COVID19 detection model from CXR images held privately in the local datasets of model instances

Performance evaluation of the models with objective metrics, comparative analyses and security analysis show that the proposed federated models are superior to state-of-the-art models. Rest of this chapter is organized as below. Section 2 provides a background of the FL models and security mechanisms. A comprehensive review of the existing FL models and their applications are presented in section 3. The datasets employed in this research and underlying methodologies employed in this research are described in section 4. Section 5 presents the mathematical formulation of the proposed framework and the models and their architecture. Extensive experimental results and their interpretations are given in section 6 and the chapter is concluded in section 7 with directions for future research.

BACKGROUND

FL is a new paradigm of distributed learning by which a machine learning model can continue to learn with an immense amount of data collected from a variety of sensors and distributed networks, and disseminate the learned knowledge and the parameters of the algorithms among the individual instances to facilitate the scalability and distributed system. The schematic of a federated learning framework is shown in Figure 1.

The mathematical representation of a federated learning model is described as below for N clients in a distributed environment. N clients share parameters θ and iterate the following steps for local model updation.

Step 1: $t=0$

Step 2: $l_i^0 = 0$ for $i = 1, 2, \dots, N$

Step 3: while $t \leq T$

Step 4: $l_i^{t+1} = \sum_{i=1}^N l_i^t$

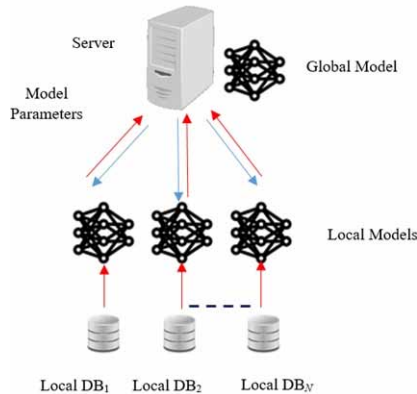
Step 5: $\theta^{t+1} = \theta^t - \alpha l^{t+1}$

Step 6: $t=t+1$

where l_i is the label of the i -th client, θ is the parameters of the model, α is the learning rate, t is the current iteration and T is the number of iterations. The clients transmit their l_i^t to the server for aggregation and update the server and θ^{t+1} is used to calculate the loss $L(\theta^{t+1}, y)$ of the server, and then the server model is updated as in equation (1), where β is the learning rate of the server model.

$$\theta^{t+1} = \theta^t - \beta L(\theta^{t+1}, y) \quad (1)$$

Figure 1. Federated learning architecture



Generally, the number of clients in FL is very large, potentially thousands or even millions of instances. With the larger size of data, it is more difficult to train models with high accuracy in the centralized training. If the model is shared among the clients, the privacy of the individual clients can be protected. FL provides a way to achieve a high accuracy model with small clients (i.e., mobile devices or sensors) with privacy protection. In FL, the data used to train the model is distributed to clients. The clients send the data to the server, and the server aggregates the data from all clients to train the model. The model will be updated to the server with the server learning rate. The clients do not need to upload the sensitive data to the server, and the clients will not share their sensitive data with other clients. The data from the clients can be encrypted and sent to the server, which makes it more difficult for adversaries to intercept the data or maliciously interpret the data. If the server learns the model too quickly, there will be too much information about the sensitive data. To solve this problem, FL proposes a double learning rate algorithm. The model can be updated in two stages: the first stage is to update the model by the learning rate of the server, and the second stage is to update the model by the learning rate of the client. In the first stage, the model can be well trained, while in the second stage, the accuracy of the model can be further improved. It is still a challenge to make sure the privacy of the data collected from the clients and the stability of the training process, in order to obtain a well-trained model. The commonly employed security mechanisms in FL are Differential Privacy (DP) discussed by Dwork et al. (2006),

Secured Multi-party Communications (SMC) proposed by Ishai et al. (2009) and HE, described in the following subsections.

Differential Privacy

DP is a theoretical approach to privacy which establishes a privacy guarantee for a given data collection process by introducing a privacy budget which limits the amount of information that can be gleaned from the process. Mathematically, a process is private if the amount of information gained from observing the output of the process is bounded by a privacy budget. The privacy budget can be set according to the needs of the data collector. For example, if data is collected from a healthcare system, the privacy budget for each individual who participates in the data collection process would be the number of entries that the database can contain, which depends on the number of patients that the system can handle.

In a data collection protocol with the output of a function $f(\bullet)$ where the input is $O(n)$ and its output is a m -dimensional vector $\hat{X}R^m$. We assume that there is an untrusted curator who collects the data. Each element in X is generated independently and identically from a probability distribution μ . A ϵ -differentially private algorithm has the following two properties.

1. The Local Lipschitz Condition: For any two neighboring databases D_1, D_2 that differ by one row, and for any $j \in [m]$, the change in the j^{th} element in the output is upper bounded by a function L_j
2. Lossy Privacy: For any two neighboring databases D_1, D_2 , that differ by one row, the difference in the j^{th} element of the output is upper bounded by a function L_j such that $0 \leq L_j \leq 1$

A DP algorithm that satisfies the ϵ -differential privacy guarantee can be constructed as below with a private sampler Π which satisfies following two properties:

1. For any $x, x' \in R^m$, $\|\Pi(x) - \Pi(x')\|_2 \leq \epsilon \|x - x'\|_2$
2. For any $x, x' \in R^m$ with $x' \neq x$, $\Pi(x) = \Pi(x')$ with probability at least $1 - \delta$, It follows directly from the ϵ -differentially private algorithm that such that Equation (2) is true

$$\Pr(\Pi(x) = \Pi(x')) = \Pr(f(x) = f(x')) = \Pr(\|f(x) - f(x')\| \leq \epsilon \|x - x'\|_2) \geq 1 - \delta \quad (2)$$

where δ is a small additional density of probability on which the upper bound ϵ does not hold. It is seen that ϵ -differentially private algorithms have worst case guarantees that grow at a rate of $1/\epsilon$. For instance, a value of $\epsilon = 0.01$ means that an algorithm produces answers that are within 99.99% of the truth. For smaller values of ϵ , the accuracy of answers gets closer to the truth, but the algorithm is less accurate for larger values of ϵ .

Secured Multi-Party Communication

SMC is a technique where multiple parties can securely compute a function over their inputs while keeping them private. Because the parties are not communicating with each other, this method of computation is less vulnerable to side-channel attacks and other forms of security analysis. Mathematically, SMC

is the composition of a verifier function and a computation function . The first is to convince multiple parties that a value they compute is correct, while the second is to verify that the parties are computing the correct function.

The verifier V is some random function and the inputs to V are the N values that are to be submitted to the computation function E by the N parties. The verifier V chooses random values $r_1, \dots, r_N \in \mathbb{R}$, and tells each of the N parties that $(r_1, \dots, r_N) = (V(x_1), \dots, V(x_N))$. Each party can then compute $E(x_1, \dots, x_N)$ using their own input x_i to obtain an output $E(x_1, \dots, x_N)$. The verifier V checks whether the output is correct: $E(x_1, \dots, x_N) = V(x_1, \dots, x_N)$. If all parties are honest, this will be the case with probability 1; if any of the parties are malicious, they can cheat by outputting an incorrect value, so $E(x_1, \dots, x_N) \neq V(x_1, \dots, x_N)$ with probability 1. The computation function E is usually chosen to be the point-wise product of all the N parties' inputs. In this case, the value $E(x_1, \dots, x_N)$ represents the value of the output function f that the parties would compute, if they had access to all the N inputs.

In SMC, as V is random, the parties' individual verification is not secure, and the security of the whole protocol depends on the security of the individual party computation. For a given set of parties $P = \{p_1, \dots, p_N\}$, the security of the whole protocol is determined by the security of the individual party verification and the individual party computation.

Homomorphic Encryption

Though FL features distributed learning without transferring local data, vertical and horizontal FL models are susceptible to poisoning, Byzantine and misbehaving participant attacks, compromising the model or the training dataset, thereby compromising the entire system. An adversary can alter the learning parameters of the local models when they are transferred to the server for aggregation. Further, training data can be predicted from statistical analysis of the model parameters. Recently, several works are proposed exclusively on privacy preserving mechanism for FL models based on HE techniques such as the approaches introduced by Hardy et al. (2017) and Zhang et al. (2020). This section presents the classic HE algorithm based on modular arithmetic, proposed by Paillier (1999). It has 3 steps as described below.

1. Key Generation

Step 1: Choose two large prime numbers p and q such that $\gcd(pq, (p-1)(q-1))=1$

Step 2: Compute $n=pq$ and $\lambda=lcm(p-1, q-1)$

Step 3: Select a random integer $g \in \mathbb{Z}_{n^2}^*$

Step 4: Ensure that n divides the order of g

Step 5: The public key is $\{n, g\}$ and the private key is $\{p, q, \lambda\}$

2. Encryption

Step 1: Let m be the plaintext to be encrypted such that $0 \leq m < n$

Step 2: Select a random integer r where $0 < r < n$ and $r \in \mathbb{Z}_{n^2}^*$ and $\gcd(r, n)=1$

Step 3: Compute the ciphertext $C = g^m r^n \mod n^2$

3. Decryption

Step 1: Compute the plaintext message $m = L(c^\lambda \mod n^2) \cdot \mu \mod n$ where

$$\mu = (L(g^\lambda \mod n^2))^{-1} \mod n \text{ and } L(x) = \frac{x-1}{n}$$

The security of this cryptosystem depends upon integer factoring and the values of p and q must be very large to evade intentional attacks. This approach is employed in FL to protect training data and model parameters from attacks.

A thorough analysis of the security mechanisms shows that SMC and DP have certain limitations which do not exist with HE. Though SMC guarantees that the participating clients do not share anything among them or with any third party, it cannot prevent an adversary from learning some personal data influencing the decision boundary of a classifier. Further, SMC protocols require computationally expensive encryption and decryption operations, and communications between clients for trivial problems.

Similarly, DP due to its lossy nature, prevents data leakage to a certain extent and it is the property of the query but not of the dataset. Further, the utility of the output degrades with the noise added to obscure the input. Lastly, DP and SMC suffer from the scalability issue whereas HE does not, as it is based on the simple rule that if all the data is encrypted then the query can be resolved with the encrypted data only.

RELATED WORK

This section presents an overview of representative works on FL in healthcare domain. Several tasks have been studied in FL setting in healthcare, such as patient phenotyping, similarity learning and predictive modelling. Xu et al. (2021) present an extensive review of FL approaches for biomedical applications. Patient similarity learning finds similar patients across healthcare institutions without sharing Electronic Healthcare Records (EHR) explicitly. A federated hashing framework proposed in b Lee et al. (2018) learns context sensitive hash codes from patient data. Similar patients are identified by comparing the hash codes. It also employs HE to prevent reverse engineering the model. In this context, the approach proposed in Xu et al. (2020) finds patient similarity querying heterogeneous patient data distributed across healthcare institutions, employing two losses namely similarity preserving and heterogeneity digging losses.

Deriving phenotypes from massive EHRs is a challenging task which requires diverse voluminous samples. A federated tensor factorization approach for phenotyping from distributed sensitive patient data is proposed by Kim et al. (2017). This approach performs phenotype computations by secured harmonization of patient data employing Alternating Direction Method of Multipliers (ADMM) for federated optimization. Similarly, a two-stage federated model for phenotyping obesity and comorbidities from clinical notes is presented by Liu et al. (2019). A federated representation learning approach proposed by Silva et al. (2019) explores the structural relationships between brain images to comprehend the genetic backgrounds of brain diseases. Tested with real clinical and synthetic data, this approach demonstrates potentials for distributed analysis of large-scale imaging data. A DP approach based on object perturbation proposed by Choudhury et al., (2019a) is integrated with FL in realizing a framework for prediction of Adverse Drug Reactions (ADR) and mortality rate prediction. The same authors (Choudhury et al., 2019b) have proposed a similar approach exclusively for learning a global model for ADR. The model is realized as a binary classifier and two aggregation methods are proposed for aggregating the local models. The first approach is designed to train imbalanced classes, estimating the class ratio, assigning weights to training samples. The second approach assigns weights to local models based on the training data size and convergence rate, and the global model is constructed by aggregation of these weighted models.

A FL framework for patient activity recognition, securely aggregating data collected from wearable healthcare devices distributed across multiple healthcare organizations is proposed by Chen et al. (2020).

This model exclusively focuses on building personalized local models by transfer learning, aligning the coarse and fine learnings of the global and local models. In addition to the above, FL finds applications in deploying a wide array of predictive models described below.

A federated model to predict future hospitalization of patients with heart diseases from distributed EHRs proposed is realized as a binary classifier by Brisimi et al. (2018). This decentralized model is built as a sparse Support Vector Machine (SVM) classifier, employing the cluster Primal Dual Splitting (cPDS) algorithm which improves the convergence rate.

The Federated Uncertainty-Aware Learning Algorithm (FUALA) proposed by Boughorbel (2019) for the task of preterm-birth prediction using perinatal data from multiple hospitals has two components: 1) a strong aggregated model based on FedAvg where hospitals are trained together, and 2) an ensembling mechanism where the last layers of each hospital model are assigned to learn the overall generalization of a model based on the training data of that hospital only. It reduces the influence of models with high uncertainty through a weighted update of the model and uses the generalization prediction of the assigned model for model selection.

An investigation by Pfohl et al. (2019) evaluates the utility of FL, across a network of hospitals to implement clinical models for prediction of prolonged length of stay and in-hospital mortality. Experimental results show that as compared to a centralized learning setting, it is more difficult to structure a federated training process to maintain patient privacy with a differentially private Stochastic Gradient Descent (SGD) algorithm. Similarly, a federated predictive model based on DP, for in-hospital mortality prediction proposed by Sharma et al. (2019) demonstrates superior privacy compared to state-of-the-art models. This model is implemented as a binary classifier with a global model and a set of local models and the global model is updated with the weighted means of the local models.

An advanced FL framework for training deep learning networks proposed by Yuan et al. (2020) partitions allocates the network to IoT devices and a server, such that most of the computations pertaining to training are performed in the server. This framework for arrhythmia prediction from electrocardiograms demonstrates a low accuracy loss and requires only 0.2% of the synchronization traffic of vanilla federated learning.

The Community Based Federated Learning (CBFL) algorithm proposed by Huang et al. (2019) takes advantage of Non-Identically Independently Distributed (non-IID) patient data of each local hospital to cluster patients into meaningful communities. The algorithm leaves the computations to the local silos creating a local model for each hospital for forecasting mortality and in-hospital stay of critical patients in Intensive Care Units (ICU). Compared to baseline FL models which learn from dissimilar patients, the community based model based on Auto Encoder (AE) which learns from patient communities demonstrates superior Receiver Operating Characteristic (RoC) Curves.

Distributed Noise Contrastive Estimation (DNCE), a neural network based approach to build predictive models for patient diagnoses from multiple distributed patient data is proposed by Li et al. (2019). Information from multiple datasets are incorporated into the global model for prediction of seventy common diseases. This approach trains an empty network with terminologies obtained from multiple local sites and each instance of this network is trained locally in a sequential order, imbibing DP.

A privacy preserving predictive model called ADDetector, proposed by Li et al. (2021) employs FL and DP to predict Alzheimer's Disease from the audio samples of the subjects, collected from IoT devices. It is realized as a classifier model built on a three layered architecture and an asynchronous aggregation framework. The KETOS platform proposed by Gruendner et al. (2019), based on Docker virtualization and Health Level 7 (HL7) standard facilitates deployment of predictive models in healthcare settings. It

supports an end-end research lifecycle spanning data analysis, retrieval and deployment in a real clinical setting. Due to the widespread adaptation of FL models in healthcare domain, model aggregation approaches have received research attention recently. Three robust aggregation methods are evaluated on predictive models run on two clinical datasets for diabetes and heart failure detection by Grama et al. (2020). Experimental results reveal that privacy preserving mechanisms can be integrated with robust aggregation approaches in detecting bad clients, and Adaptive Federated Averaging (AFA) is superior to other aggregation approaches in detection and blocking of malicious clients.

The outbreak of COVID19 pandemic has resulted in a surge of research in automated deep learning models for infection screening, detection, diagnosis and prognosis. Training these models for prediction of infections is very challenging due to the heterogeneity of clinical manifestations and also demands for large datasets from diverse populations. While the pioneering COVID19 prediction models are based on Convolutional Neural Network (CNN) architectures, recently several FL based models are proposed, with security and privacy considerations in sharing clinical images.

Vaid et al. (2020) have presented two FL models called the L1 regularization and Multi Layer Perceptron (MLP) models for mortality prediction in COVID19 patients. Evaluation of these models with EHRs collected from five hospitals show that they are superior to the local baseline models. Further, federated MLP model demonstrates superior performance metrics compared to the federated L1 regularization model.

A FL based predictive model for COVID19 detection from Chest X-Ray images proposed by Liu et al. (2020) demonstrates superior detection performance compared to classifier models such as ResNet18, ResNeXt, MobileNet and COVIDNet. Performance evaluation of the FL based and baseline models show that ResNet18 exhibits superior performance as an individual classifier and as a local classifier under FL. In this work, the global model is constructed by aggregation of the local models' parameters without any additional security mechanisms.

An automated framework for multi-modal COVID19 diagnosis based on clustered federated learning (CFL) is built as an integral model by Qayyum et al. (2021), combining local models pertaining to different modalities such as X-Ray and Ultrasound. Experimental results show that CFL is superior to conventional FL based models in COVID19 prediction, under wide divergence in medical imaging data. However, this approach requires well-trained customized models for individual modalities at the local sites and optimization methods for defining the stopping criteria of the global model.

A large scale study by Flores et al. (2021) comprising 20 healthcare institutions and 16000 cases, to predict oxygen requirement of COVID19 infected patients proposes a FL model which generalizes well with heterogeneous and highly diverse data. This study called the EXAM (EMR CXR AI Mode) predicts oxygen need from vital signs, CXR images and laboratory data and reports an Area Under the Curve (AUC) of over 0.92 for the FL model which is an average improvement of 16% compared to local models.

A FL model featuring fast response times for elementary prognosis of symptoms, preserving patient privacy under pandemic outbreak is proposed by Priyanshu and Naidu (2021). This model is trained with statistical data derived from COVID19 symptoms collected across five countries. Privacy of patient data is ensured incorporating differential privacy with the model.

A dynamic fusion based FL approach for COVID19 detection from diagnostic images, proposed by Zhang et al. (2021) constructs the global model in two steps. Initially, the fusion architecture is designed and the participating clients are chosen dynamically, evaluating their classification performance with local data. Evaluation of performance metrics shows that incorporation of dynamism yields better robustness, accuracy and communication efficiency.

A Keras based FL model for COVID19 detection from CXR images, proposed by Abdul Salam et al. (2021) is reported to achieve better classification performance compared with a Tensor Flow based traditional classifier. Exercising the FL model with different learning rates, dataset sizes, optimization and activation functions reveals that the model performs well under softmax activation function and SGD optimization.

Two FL based COVID19 prediction models proposed by Feki et al. (2021), employing ResNet50 and VGG16 backbones are built with and without data augmentation. These models are compared with conventional classifiers based on the same backbones. Evaluation of these models show that the FL model based on ResNet, trained with augmented datasets demonstrates superior performance with an accuracy of 97.0% compared to other models.

Finally, the significance of FL in predictive modelling under non-COVID19, COVID19 and post-COVID19 scenarios is summarized by Qian et al. (2021) and several limitations and challenges in the application of FL in healthcare are highlighted. The prominent limitations are identified to be divergence in data distribution, verification of security, optimization of training and aggregation, communication and computational overheads.

Detailed review of FL models and their applications reveals that protection of patient data and model parameters are challenging in distributed computing environments. The significance of FL model in pandemic and non-pandemic environments is established by several use-cases. Extensive experiments with real and synthetic data reveal that, FL models integrated with security mechanisms are ideal for healthcare domain in deploying robust predictive models trained on large volumes of patient data, adhering to ethical guidelines. An in-depth analysis of these models shows that most of the models are based on DP. However, these models are susceptible to reverse engineering of data. Similarly, secure multi-party communications suffer from high communication costs between the participants. Further, this review reveals that HE based FL frameworks for COVID19 detection have not been proposed so far.

MATERIALS AND METHODS

This section describes the datasets employed in this research and the underlying methods of the proposed model.

Datasets and Details of Implementation

The proposed FL model is trained and tested with two publicly available datasets. The first is the Medical Information Mart for Intensive Care (MIMIC-III) dataset constructed by Johnson et al. (2016), the largest single dataset containing data of patients admitted to ICUs. It includes various structured and unstructured data such as demographic information, vital signs, laboratory tests, diagnoses, medications, notes, procedures, length of stay, survival rate etc. For a fair comparison, the proposed model is tested on 21,138 admissions and the variables captured in the first 48-hour window, similar to the model proposed by Sharma et al. (2019). Further, for three vital signs including respiration rates, oxygen saturation rated (SpO2) and systolic blood pressure, six statistical features viz. minimum, maximum, mean, standard deviation, skewness and number of measures are computed for seven time-series and normalized in the range [-1 1].

The second dataset used in this research is the Kaggle Chest X-Ray public image dataset for COVID19 detection, constructed by Chowdhury et al. (2020). This dataset includes images pertaining to 1341 normal, 1143 COVID19 positive, 1345 Viral Pneumonia (VP) cases of dimension 1024x1024 in PNG format. This dataset is divided into training and testing subsets, and the training subset is augmented with images by affine transformation. The CXR dataset employed in this research is described in Table 1.

Table 1. Dataset description

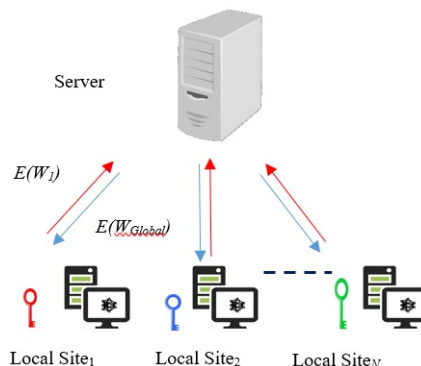
Dataset	Infection	No. of Images in Database	No. of Training Images	No. of Training Images After Image Augmentation	No. of Testing Images	
					Binary Classification	Multiclass classification
Kaggle CXR	COVID19	1143	443	2215	700	700
	Viral Pneumonia	1345	645	3225	1400	700
	Normal	1341	641	3205		700

The proposed model is implemented in PyTorch and run on a i7-7700K processor with 32GB DDR4 RAM equipped with a NVIDIA GeForce GTX1060 3GB Graphics card.

Multi-Key Homomorphic Encryption

Multi-Key Homomorphic Encryption (MKHE) conceptualized by López-Alt et al. (2021) is a cryptosystem in which a message is encrypted under multiple keys and the result of this encryption is decrypted under all of the keys used. This property leads to the possibility of allowing a message to be sent from a sender to a number of recipients, the message being encrypted under different keys for each recipient. This is particularly useful in situations where a message is confidential and it is not required that the full contents of the message be known to all recipients. In addition to allowing a message to be sent, MKHE is also capable of performing operations on encrypted messages such as addition or multiplication. The schematic of the MKHE is shown in Figure 2.

Figure 2. Multi-key homomorphic encryption



In the FL model proposed in this research, the MKHE scheme is used in sharing the updated parameters of the global model. Particularly, employing multiple keys for sharing the parameters from the global model to the local sites improves the security of the framework against attacks. The MKHE mechanism employed in this chapter is described as below.

The MKHE mechanism consists of five algorithms: *Setup*, *KeyGen*, *Enc*, *Dec*, *Eval*) as described below. In a MKHE system with n participants, each participant has an index i to the public and private key pair (p_{ki}, s_{ki})

Setup: $p \leftarrow \text{MHKE\_Setup}(\lambda)$ Takes the security parameter λ as an input and returns the public parameter p

Key Generation: $(pk, sk) \leftarrow \text{MHKE\_Key}(p)$ generates the public-private key pair

Encryption: $C_i \leftarrow \text{MHKE\_Enc}(M, p_{ki})$ Encrypts the plain text M with the public key p_{ki} to generate the cipher text

Decryption: $M \leftarrow \text{MHKE\_Dec}(C_i, s_{ki})$

Evaluation: $CT \leftarrow \text{MHKE\_Eval}(C, C_1, C_2, \dots, C_n), \{p_{ki}\} \forall i=1 \dots n$. Given an arithmetic circuit C and a sequence of cipher texts, the evaluation process generates the cipher text CT . The correctness of the encryption process is verified as below.

$M \leftarrow \text{MHKE\_Dec}(CT, \{s_{ki}\} \forall i=1 \dots n)$

Semantic security is a very strong property of cryptographic schemes. In a semantically secure cryptographic system, it is not possible for an adversary to have any advantage in guessing the plain text or the cipher text from the secret and public keys. In the above MKHE, message M or the ciphertext C_i cannot be guessed based on the observation of the keys as each client is associated with the a public-private key pair $\{p_{ki}, s_{ki}\}$ and the difficulty increases with the number of parties.

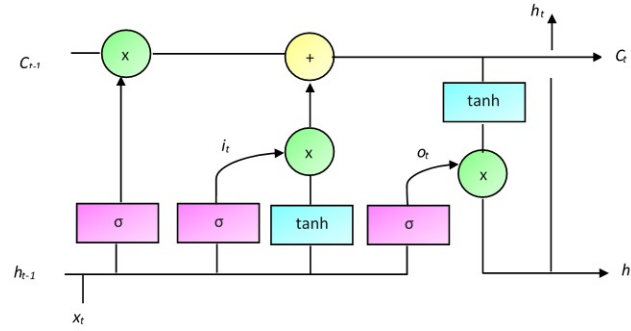
Attention Based Long Short Term Memory

LSTM (Long Short-Term Memory) employed in phoneme classification by Graves and Schmidhuber (2005) is a Recurrent Neural Network (RNN) variant, which is widely used for time-series prediction. The underlying idea is to use memory to remember the past so that the next step can be predicted. RNN, just like any neural network, uses a series of layers to convert the input to the output. Each layer contains a subset of neurons, which are connected to one or more neurons in the next layer. The output is computed by multiplying the inputs to the layer with the activation of the neuron. This process is repeated until the output is reached. If the output is required at a time t , then the input for that time step is called the target. LSTM is just an RNN with added memory. The way memory is implemented in LSTM is by defining a cell state.

The LSTM network can be used to perform classification and regression tasks. The structure of the LSTM unit is shown in Figure 3. LSTM retains a cell state C_t to store information about the sequence. The memory cell consists of a cell state C_t , an input gate i_t , an output gate o_t and a forget gate f_t . The cell state c_t is a vector, which holds the information about the network's memory. The vector's dimension is same as the number of inputs. The input gate i_t controls how much of the input is stored in the cell state C_t . The output gate o_t decides how much of the output is stored in the cell state C_t and the forget gate f_t

determines which part of the cell state C_t to overwrite. In each time interval, LSTM considers C_{t-1} , h_{t-1} and x_t to predict C_t .

Figure 3. Structure of LSTM unit



To implement memory, LSTM uses a set of multiplications between the input x_t and the weight matrices W_i , W_o and W_f of the input, output and forget gates. The cell state C_t and its components can be represented with equations (3) to (7).

$$C_t = \tanh(W_i x_t + W_o h_{t-1} + W_f C_{t-1}) \quad (3)$$

$$i_t = \sigma(W_i x_t + b_i) \quad (4)$$

$$o_t = \sigma(W_o h_{t-1} + b_o) \quad (5)$$

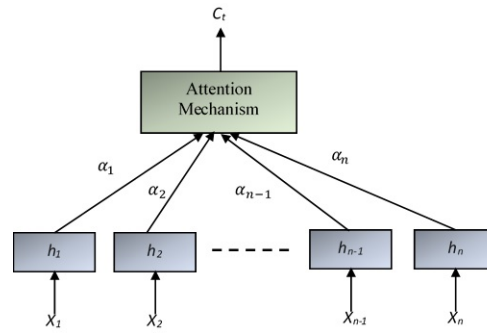
$$f_t = \sigma(W_f C_{t-1} + b_f) \quad (6)$$

$$\sigma(x) = \frac{1}{1 + e^{-x}} \quad (7)$$

The input of LSTM is a sequence of inputs $X = \{x_1, x_2, \dots, x_t\}$. Each input is a vector of dimension n , which is the number of inputs in the cell. The inputs are mapped to a hidden state $H = \{h_1, h_2, \dots, h_t\}$, which are the states of the cell at time t . The hidden state is passed through the cell state C_t , which has a vector of dimension of n which is the same as the number of inputs in the cell. At time t , each input x_t is multiplied with the input gate i_t , which decides how much of the input is stored in the cell state C_t . This results in a new hidden state h_t and it is then passed through the output gate o_t which decides how much of the hidden state is passed to the output. The forget gate f_t is multiplied with the cell state C_{t-1} . This multiplication is done by a *sigmoid* activation function and finally, the total result is passed through the *tanh* activation function.

Introducing attention mechanism into the LSTM network simplifies the selection of the neurons of the hidden state. Instead of concentrating on all the hidden neurons, attention concentrates only on the relevant neurons. Attention mechanism is a mechanism for adjusting the importance of the information to be encoded by the network. It is done by weighting the relevant neurons according to their importance. Attention is a bimodal mechanism. One mode concentrates on the relevant neurons and the other concentrates on the irrelevant ones. The schematic of the attention mechanism in LSTM is shown in Figure 4.

Figure 4. LSTM attention mechanism



The underlying hypothesis is that relevant neurons are more important than the irrelevant ones. Attention mechanism does this by learning a set of weights for each neuron. The attention weight for a neuron i at time t is represented by α_t^i . Attention mechanism can be used to improve the performance of LSTM by adding an attention layer to the LSTM network. The attention mechanism is applied at the output layer, which is a linear layer such that it concentrates only on the important neurons in the output layer. Attention mechanism is implemented by equations (8)-(12), where y_t is the output of the output layer and α_i is the output of attention layer for neuron i .

$$\alpha_t^i = \text{softmax}(W_a \tanh(W_h h_{t-1} + b_h)) \quad (8)$$

$$h_t = \tanh(W_i x_t + W_o h_{t-1} + W_f C_{t-1}) \quad (9)$$

$$y_t = W_y \tanh(W_h h_{t-1} + b_h) \quad (10)$$

$$\alpha_i = \frac{\exp(y_t^i)}{\sum_i \exp(y_t^i)} \quad (11)$$

$$C_t = \alpha_i C_{t-1} + (1 - \alpha_i) h_t \quad (12)$$

Residual SqueezeNet Architecture

The basic squeezeNet introduced by Iandola (2016), follows a CNN architecture characterized by fewer hyper parameters and it is considerably smaller and highly accurate than other CNNs. The basic building blocks of this model are called fire modules, which consist of a squeeze layer with 1x1 filters and an expansion layer with 1x1 and 3x3 filters. A classifier can be constructed by chaining the fire modules and an activation layer. In this research, the residual SqueezeNet, a variant of the basic squeezeNet is modeled with bypass connections. With the bypass or skip connections around the fire modules, these modules learn the residual connection between the inputs and outputs. The skip connections pass the features learnt by the top layers to lower layers, enabling the classifier to discern the fined details for accurate classification. The schematic of the residual squeezeNet employed in this research is given in Figure 5.

Figure 5. Residual SqueezeNet architecture

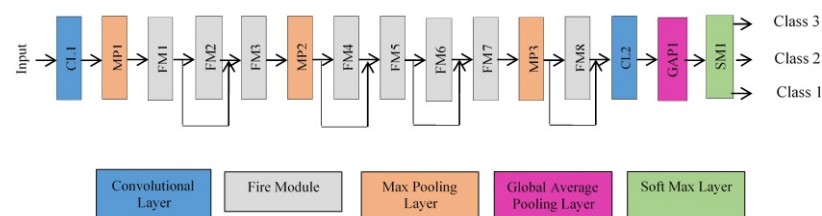
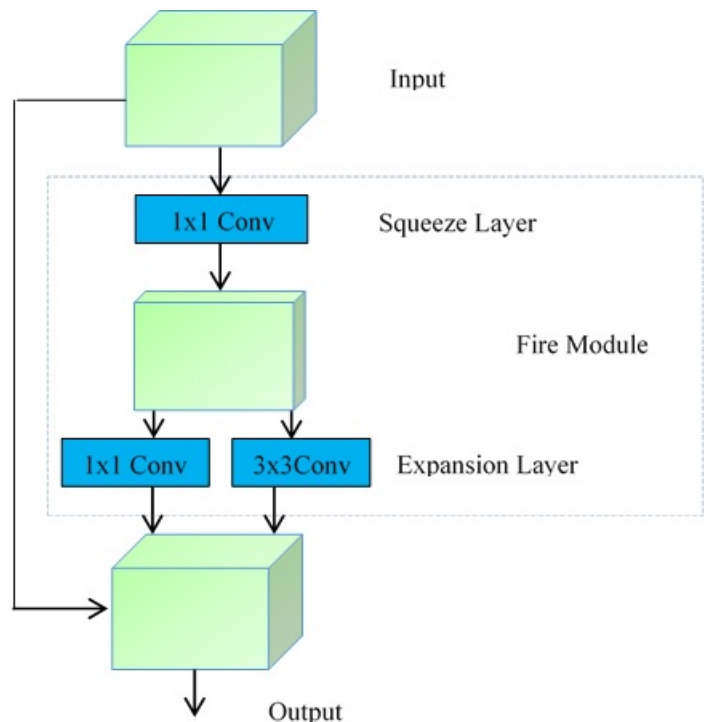


Figure 6. Residual fire module structure



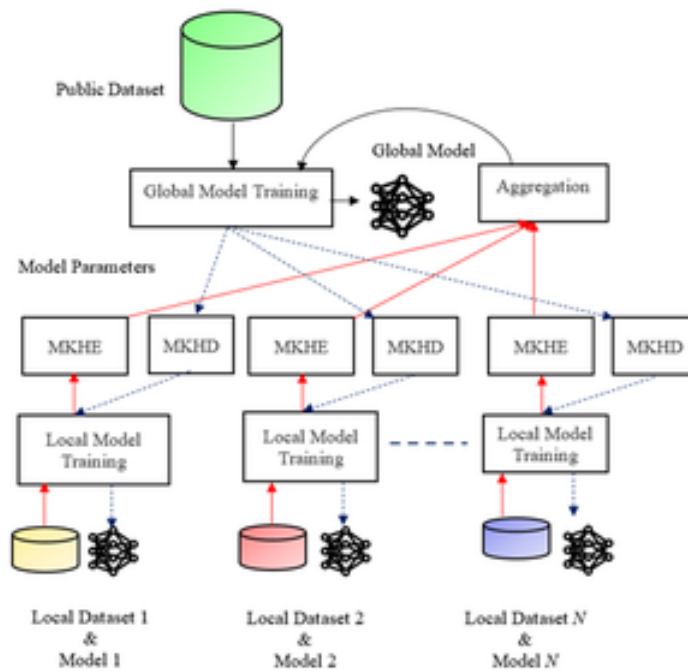
PROPOSED FEDERATED LEARNING FRAMEWORK AND PREDICTIVE MODELS

This research proposes a generic FL learning framework called F_{Fed} based on MKHE. Two predictive models, one for mortality prediction and the other for COVID19 detection are deployed with F_{Fed} as the underlying architecture. The attention based LSTM and squeezeNet described in sections 4.3 and 4.4 are employed as the baseline models for mortality prediction and COVID19 detection models respectively.

Generic Federated Learning Framework F_{Fed}

The generic framework F_{Fed} defines an architecture to build a set of N local models $\{L_1, L_2, \dots, L_n\}$ and a global model M_{Global} , sharing the model parameters and updating the models. Each local site is associated with a local dataset D_i . The schematic of this framework is shown in Figure 6.

Figure 7. F_{Fed} federated learning framework



Initially, the global model M_{Global} is constructed by training it with public datasets and it is distributed to N local sites. Subsequently, each local model L_i is constructed from M_{Global} and trained with the local dataset D_i . In this research deep learning networks are used to build the global and local models as classifiers.

The learning objective of the global model M_{Global} is given in equation (13) where $l(\bullet, \bullet)$ is the cross entropy loss function which is characteristic of the classifiers, where $\{(x_i, y_i) \forall i=1 \dots N\}$ is the set of input sample and target label pair and θ is the model parameter.

$$\arg \min_{\theta} Loss_{Global} = \sum_{i=1}^N l(y_i, M_{Global}(x_i)) \quad (13)$$

Mortality Prediction

The predictive model for mortality prediction called the $P_{Mortality}$ is realized as a binary classifier with the global model GM and a set of local models, $\{(LM_i) \forall i=1 \dots N\}$. To train this model, GM is initially trained with the public dataset and the model parameters are shared with the local sites for training the local models. The model parameters are exchanged between the server and the local sites through MKHE. The learning objective of this model is given in equation (14).

$$\arg \min_{\theta} Loss_{Mortality} = \sum_{i=1}^N l(y_i, GM(x_i)) \quad (14)$$

COVID19 Detection

The predictive model for mortality prediction called the P_{COVID} is realized as a multi-class classifier with the global model GC and a set of local models, $\{(LC_i) \forall i=1 \dots N\}$. It is trained to detect normal, COVID19 and VP cases. To train this model, GC is initially trained with the public dataset and the model parameters are shared with the local sites for training the local models. The model parameters are exchanged between the server and the local sites through MKHE. This classifier can also be tweaked as a binary classifier combining the normal and VP cases as Non-COVID19. The learning objective of the P_{COVID} model is given in equation (15).

$$\arg \min_{\theta} Loss_{COVID} = \sum_{i=1}^N l(y_i, GC(x_i)) \quad (15)$$

EXPERIMENTAL RESULTS AND DISCUSSIONS

This section presents the experimental setup for deploying the models, classification results of the mortality prediction and COVID19 detection models, performance evaluations, and quantitative and security analyses in the following subsections.

Experimental Setup

The FL environment for running the proposed predictive models is established with the Python based IBM federated learning framework. It is implemented on existing container engines and it supports data collection, directed queries, communication scheduling and automating workflow, annotation key values, required workloads, and algorithm transfer.

Initially, a mathematical computable workflow is constructed for a specific data processing task, which can be directed to scale to multiple worker nodes and servers. In this research, two separate workflows are created for the two prediction models as they are trained on numeric and image datasets. Many of the parameters to control computation are automated according to a scripted workflow including computation scheduling and data redistribution.

The FL parameters for the proposed predictive model are listed as below.

1. Time frame for updating (3 hours, 6 hours, or 24 hours)
2. Size of the cluster (5 to 15 worker nodes)
3. Frequency of query updates (30 minutes, 1 hour or 6 hour)
4. Lag time between the completion of predictive model training and the launching of the predictor (30 seconds to 3 hours)
5. Aggregation metrics (mean error)

In deploying the mortality prediction model, JavaScript Object Notation (JSON) is used in distributed data capture and the query, updating and model launching processes are automated. Summary statistics are retrieved to create a more robust prediction model at the end of updates. The hyper parameters of the attention LSTM and squeezeNet backbones are listed in Table 2. These parameters are uniform for both models and chosen arbitrarily to control the learning process.

The maximum number of epochs which defines the number of iterations on the dataset is chosen as a large value to ensure that model training stops at a preset training accuracy which is assumed to be 99% for both the models. Three batch sizes are chosen as the size of the datasets vary at the local sites. The Stochastic Gradient Descent with Momentum (SDGM) is employed as the optimizer which uses the moving average of gradients called the momentum to update the weights of the network. The momentum is assumed to be 0.9 to maximize the contribution of previous updates in the learning process. A moderate learning rate of 0.001 is chosen to ensure that the model learns steadily. L2 regularization which generally minimizes the mean cost to keep the overall error small.

Table 2. Hyper parameters of predictive models

Parameter	Value
Maximum Epochs	100
Mini Batch Size	32,64,128
Momentum	0.9
Learning Rate	0.001
L2 Regularization	0.0001
Optimization	SGDM

Performance Metrics

The objective metrics employed in this research to evaluate the performance of the predictive models are defined in this subsection. The accuracy, sensitivity, specificity, precision, F1-score, Area Under the Receiver Operating Characteristics (AUROC) and Area Under the Precision Recall Curve (AUPRC) are computed with the equations (16)-(23).

$$Accuracy = \frac{(TP + TN)}{(TP + TN + FP + FN)} \quad (16)$$

$$Sensitivity = \frac{TP}{(TP + FN)} \quad (17)$$

$$Specificity = \frac{TN}{(TN + FP)} \quad (18)$$

$$Precision = \frac{TP}{(TP + FP)} \quad (19)$$

$$F1 = 2 * \frac{Precision * Recall}{(Precision + Recall)} \quad (20)$$

$$MCC = \frac{TP \times TN - FP \times FN}{\sqrt{(TP + FP)(TP + FN)(TN + FP)(TN + FN)}} \quad (21)$$

$$AUROC = \sum_{i=1}^N AUC_i = \sum_{i=1}^I \frac{[1 + \exp(y_i)]^2}{1 + \exp(y_i)} \quad (22)$$

$$AUPRC = \frac{1}{TP + FP} \sum_{i=1}^N AUC_i \quad (23)$$

where, N -size of the dataset, TP- True Positive, TN- True Negative, FP- False Positive, FN- False Negative

Accuracy is the ratio of the number of correctly identified values and the total number of values. Sensitivity and specificity are measures of the predictive power of the model, which are defined as the rate of correctly identified positive and negative samples, respectively. Precision is a measure of the confidence that the model generates positive predictions. The balanced measures F1 and MCC are used

to evaluate classification and regression models under imbalanced data. F1 is the weighted average of recall and precision values of a model and ranges from 0 to 1 and evaluates to 1 under ideal classification. MCC ranges from -1 to +1 and evaluates closer to +1 when the balanced ratio of the TP, FP, TN and FN values is high. When the classification of a model is perfect, MCC approaches the ideal value 1. AUC and AUPRC are the performance measures of the ROC curve and PR curve, respectively. ROC curve is a graphical display of the true positive rate (TPR) versus false positive rate (FPR) for all threshold settings. TPR is the fraction of positive samples that are correctly identified and FPR is the fraction of negative samples that are incorrectly identified. The Area Under the ROC curve (AUC) is a single number that summarizes the performance of the ROC curve. The higher AUC indicates the better prediction power. AUPRC is calculated as the area under the precision –Recall curve which shows the trade-off between the precision and recall values.

Mortality Prediction

The performance of the proposed mortality prediction model $P_{Mortality}$, is evaluated with the MIMIC-III dataset with F1 score, AUROC and AUPRC measures and compared with state-of-the-art approaches in Table 3. It is seen that $P_{Mortality}$ demonstrates superior performance compared to MLP and Logistic Regression (LR) models proposed by Sharma et al. (2019). LR which models the relationship between a dependent variable and one or more independent variables is used to realize a binary classifier for mortality detection the same authors. It finds the probability of mortality from the vital signs of the MIMIC-III dataset. It is seen that the proposed model exhibits superior performance to this model which is attributed to the attention mechanism employed with the LSTM which learns the dependency between the vital signs and mortality with cognitive attention.

The MLP model is constructed with a single hidden layer of 50 nodes between the input and output layers and trained in 100 epochs with a cross entropy loss. Generally, MLPs cannot easily be generalized to work on new tasks or with new features. Performance metrics of this model show that the learning ability of $P_{Mortality}$ is better than that of MLP. Similarly, $P_{Mortality}$ also demonstrates improved performance compared to three mortality prediction models based on LSTM and, FL and imbalanced FL models based on LSTM proposed by Lee and Shin (2020). In the basic FL, each client is trained on three subsets of data of the same size without duplication. For the imbalanced FL, three clients are trained with 50%, 30%, and 20% of data without duplication.

It is evident from the results that $P_{Mortality}$ is superior to probabilistic and naïve LSTM based predictive models.

COVID19 Detection

The performance metrics of the proposed mortality prediction model P_{COVID} , evaluated for multi-class and binary classifications are given in Table 4. It is observed that the model performs well under binary classification compared to the three class classification. Illustrations of the performance of P_{COVID} is shown with the confusion matrices in Figure 7. It is seen that the proposed model demonstrates better performance for binary classification compared to three class classification. This result reveals that the model is capable of discerning COVID and Non-COVID cases well, than distinguishing among Non COVID cases.

Table 3. Performance evaluation for mortality prediction

Method	F1	AUROC	AUPRC	Precision	Recall
MLP-FL Sharma et al. (2019)	-	0.7769	0.3504	-	-
LR-FL Sharma et al. (2019)	-	0.7890	0.3659	-	-
LSTM Harutyunyan et al. (2019)	0.944	0.857	0.505	0.973	0.773
Basic FL Lee and Shin (2020)	0.944	0.850	0.483	0.975	0.797
Imbalanced FL Lee and Shin (2020)	0.943	0.850	0.481	0.981	0.714
$P_{Mortality}$ Proposed	0.9569	0.8705	0.6539	0.9905	0.843

Table 4. Performance metrics for COVID detection

Dataset	Classifier Type	Metrics						
		Accuracy	Sensitivity	Specificity	Precision	FPR	F1-Score	MCC
Kaggle CXR	Binary	0.9981	0.9986	0.9979	0.9957	0.0021	0.9971	0.9957
	Three Class	0.9938	0.9938	0.9969	0.9938	0.0031	0.9938	0.9907

Figure 8. Confusion matrix –binary classification

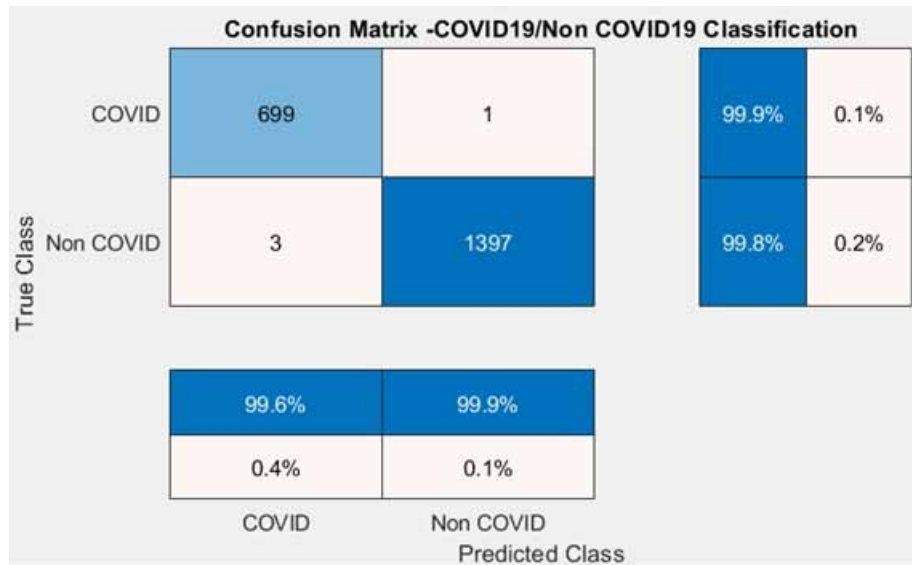


Figure 9. Confusion matrix–three–class classification

Confusion Matrix-COVID19/Normal/Pneumonia Classification						
True Class	COVID	697	1	2	99.6%	0.4%
	Normal	3	694	3	99.1%	0.9%
	VP	2	2	696	99.4%	0.6%
		99.3%	99.6%	99.3%		
		0.7%	0.4%	0.7%		
		COVID	Normal	VP		
		Predicted Class				

Further, the proposed model is compared with other classifier models for COVID19 detection from CXR images as shown in Table 5.

Table 5. Performance comparison with state-of-the-art FL models for COVID detection

Model	Dataset	Classifier Type	Metrics				
			Accuracy	Sensitivity	Specificity	Precision	F1-Score
P_{Covid} squeezeNet (Proposed)	Kaggle CXR	Binary	0.9981	0.9986	0.9979	0.9957	0.9971
		Three Class	0.9938	0.9938	0.9969	0.9938	0.9938
ResNet18 Liu et al. (2020)	COVIDx	Three Class	0.9126	0.9126	-	-	-
Clustered FL VGG16 Qayyum et al. (2021)	covid-chestxray-dataset	-	-	0.82	-	0.71	0.76
Fed-SGD Abdul Salam et al. (2021)	chest-xraycovid19-pneumonia.	-	0.9872	-	-	-	-
FL-ResNet50 with data augmentation Feki et al. (2021)	-	-	0.9700	0.9811	0.9589	-	-
- Not Specified							

Comparative results in Table 5 show that most of the metrics are not evaluated in the representative works. It is observed that each work evaluates a different dataset due to lack of benchmark datasets. Further, some of the recent works proposed by Flores et al. (2021), Priyanshu and Naidu (2021) and Zhang et al. (2021) do not explicitly report quantitative metrics for comparison.

It is seen that the proposed model is evaluated with conventional performance metrics and the balanced scores for binary and multi-class classifications, demonstrating its uniqueness and superiority over the most recent approaches. The federated models proposed by Liu et al. (2020) and Feki et al. (2021) based on ResNet are highly sensitive compared to the VGG16 based model proposed by Qayyum et al. (2021). Though ResNet solves the vanishing gradient problem with short-cut connections, the computations are dense demanding high-end computing facilities even for less complex machine vision applications. Similarly, VGG networks take a long time to train due to their heavy weights. Generally, squeezeNet architecture is better than VGG and ResNet in terms of training speed and inference time. The decrease in weights and learnable parameters in squeezeNet makes training of the model quicker. Further, the residual squeezeNet employed in the proposed P_{COVID} increases the ability of the model to learn the relationships between the image features and the target classes.

Ablation Study

Ablation experiments show how the deep learning models behave in the presence and absence of certain components of the model. In this research, this study is performed on the predictive models $P_{Mortality}$ and P_{COVID} , exercising them with different numbers of local models running in the local sites. The ablation study results are given in Table 6 and 7 to understand the performance of the models under varying number of local models. Graphical illustrations of the metrics under ablation study in Figure 8 shows that there is a degradation of around 10% in performance of the $P_{Mortality}$ model, as the number of models is reduced. Similarly, P_{COVID} also demonstrates around 5% of degradation in performances when constructed with lesser number of local models.

Table 6. Ablation experimental results for mortality prediction

No. of Local Models	Metrics				
	F1	AUROC	AUPRC	Precision	Recall
15	0.9569	0.8705	0.6539	0.9905	0.843
10	0.851641	0.774745	0.581971	0.881545	0.75027
5	0.755951	0.687695	0.516581	0.782495	0.66597

Table 7. Ablation experimental results for COVID19 detection

No. of Local Models	Metrics					
	Accuracy	Sensitivity	Specificity	Precision	F1-Score	MCC
15	0.9981	0.9986	0.9979	0.9957	0.9971	0.9957
10	0.948195	0.94867	0.948005	0.945915	0.947245	0.945915
5	0.89829	0.89874	0.89811	0.89613	0.89739	0.89613

Figure 10. Performance metrics of $P_{Mortality}$ under ablation

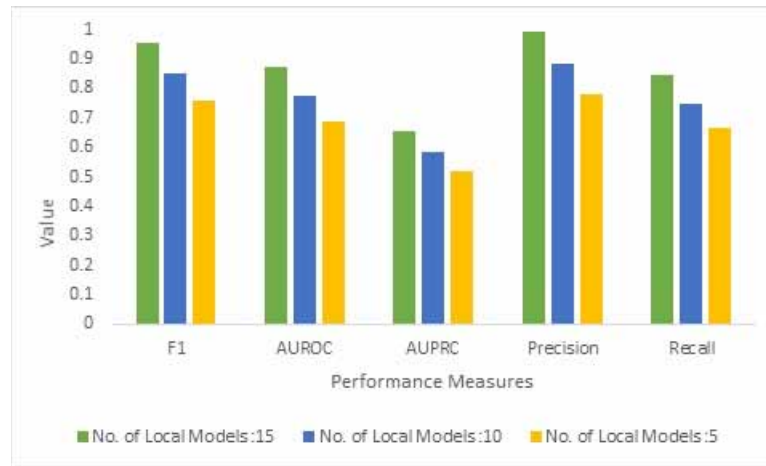
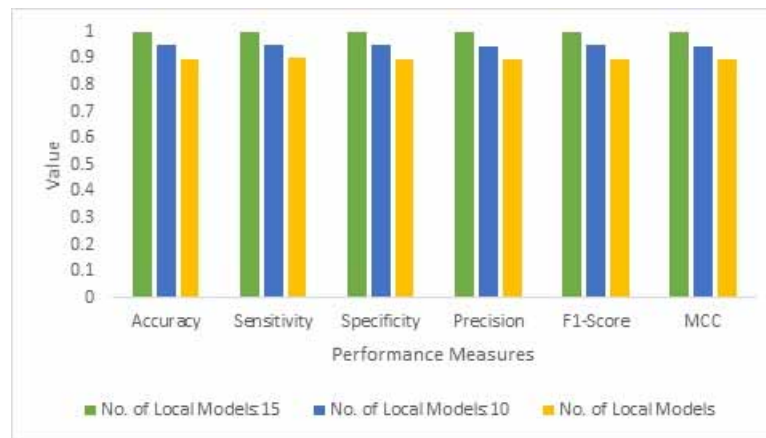


Figure 11. Performance metrics of P_{COVID} under ablation



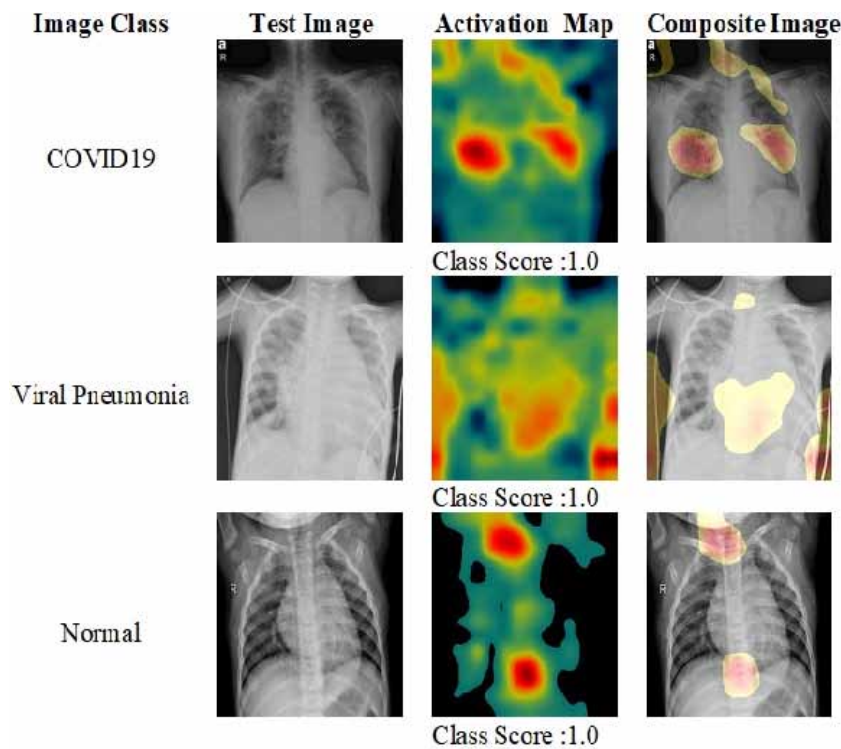
Explainable Artificial Intelligence Analysis

Explainable Artificial Intelligence (XAI) is an approach to building artificial intelligence systems that explicitly account for the rationales, reasoning, and other human-like characteristics of those systems. It is gaining popularity as a way to help people understand and trust artificial intelligence systems, particularly in the areas of health and safety. XAI is performed to understand the P_{COVID} model visualizing the image features influencing the decision of the model. Class Activation Mapping (CAM) is an implementation of explainable artificial intelligence on the model in question. It identifies the feature that has impacted the decision of the model. CAM generates heatmaps from feature maps to visualize what the model learns.

In this research, Gradient-weighted Class Activation Mapping (Grad-CAM) introduced by Selvaraju et al. (2017) which generates localization maps from image feature maps and gradients of target classes is employed in analyzing the P_{COVID} model. Grad-CAM generates heatmaps from the image features extracted

by final learnable layer of the model and a class score which determine the probability of a target class is computed. The XAI analysis of the proposed model is presented in Figure 9 for visual interpretation of the results. It is seen that the heatmaps localize the significant image features influencing the model output. It is seen that the target classes are predicted with an accuracy of 1.0. The composite images are constructed to localize the regions of images with infections. Further, these regions can be subjected to morphological analysis to define the shape and location of the affected region during the progression of the infections for clinical monitoring.

Figure 12. XAI analysis of P_{COVID}



Security Analysis

Generally, healthcare systems are vulnerable to security attacks, compromising patient privacy and data security when the work-flow pipelines are designed without security concerns. Experimental results with the secured FL framework proposed in this research show that it is leveraged in two potential predictive models to expedite care in healthcare domain. Security of the proposed FL framework against attacks is evaluated with intentional attacks on the models. This is illustrated with an attack to guess the global model parameters with an adversarial node in COVID19 prediction with P_{COVID} . While this model is realized with one global model and N local models, an adversarial local site $N+1$ is introduced. It is assumed that the adversary knows that a deep learning model is employed as baseline of the global model but has no know knowledge on the architecture of the model. Assuming the adversary at $N+1$

gets the encrypted version of the parameters of the global model i.e., $E(\theta)$ and a local model L_i by eavesdropping an arbitrary local site i , it cannot create a local model L_{N+1} from L_i as it has to be updated with the parameters of the global model decrypting $E(\theta)$ with the secret key of i . In a MKHE system, the secret key sk_i is not a separate entity; it is paired with the public key pk_i . It is unrealistic for the local sites to have the same key-pair and the corresponding encrypted data. This work demonstrates that the proposed models are secure in the sense that an adversary cannot generate an accurate local model from the encrypted global model parameters.

Limitations of the Research

From the experimental results, security analysis and XAI analysis, it is observed that the proposed FL framework can be employed in realizing promising predictive models for solving the most intriguing problems in the current healthcare scenario. However, there are two limitations of this research worth discussion which can be alleviated by further research. The first limitation is concerned with the choice of base learning models. While attention based LSTM and residual squeezeNet are employed as the learning models in mortality prediction and COVID19 detection respectively, they are not evaluated under ablation studies with large number of local sites due to the computing requirements. Further, it is seen from Table X that most of the COVID detection models reported in literature are not evaluated with all the performance metrics. Further, there is a lack of benchmarked models for a fair performance comparison. This drawback can be addressed by benchmarking FL models and datasets for validation of new predictive models.

Beyond these limitations, this research delivers promising baselines for deploying diverse healthcare solutions, based on predictive modelling trained on voluminous patient data ensuring adherence to patient privacy laws. The light-weight nature of the framework and the models are demonstrated from the fact they can learn from locally trained models without exchanging patient datasets.

FUTURE RESEARCH DIRECTIONS AND CONCLUSION

This chapter proposes a secure FL based framework for predictive models and presents two prospective light-weight models for in-hospitality mortality prediction and COVID19 detection. These models are constructed from local models which are trained with proprietary datasets without exchanging them with the central server. The MKHE employed in this research enhances the security of the model assuring patient privacy and data protection. The predictive models are trained and tested with standard datasets demonstrating superior performance compared to state-of-the art models. Experimental results including quantitative metrics, visual illustrations and XAI analysis, and security analysis signify that the proposed framework and the predictive models are promising for deploying work-flow pipelines integrating healthcare institutions irrespective of their locations. This research provides an extensible framework which can be tailored to construct several automated clinical applications which need to be trained on large volumes of data. The mortality prediction model can be customized for several time-series based clinical applications such as prediction of length-of-stay, design of timeframe based treatment protocols etc. The COVID19 prediction model can be extended to a multi-modal model for COVID19 detection from multiple imaging modalities. This research has resulted in significant deliverables for realizing

potential healthcare solutions with the 6G networks in extending quality of healthcare across the globe beyond geographical barriers.

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Chapter 20

Planar Metamaterial-Inspired Circular Ring Antenna With Neutralization Lines for Dual-Band Applications

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ABSTRACT

This chapter presents a simple, metamaterial-loaded planar ring antenna for WLAN/WiMAX applications. The proposed antenna is equipped with two neutralization lines to improve performance in the desired operating bands. The use of neutralization lines as conducting strip allows the antenna to function at the upper resonance-3.5GHz and the incorporation of complementary split ring resonator at the rear of the substrate benefits in the antenna's compact size. Due to the incorporation of a quarter wave transformer with a semicircular ring construction, the ring antenna produces better dual-band response. The upper resonance 3.5GHz is obtained due to the combination of tuned semicircular ring and circular ring along with the conducting strip in the structure. The fabricated antenna is printed on FR4 substrate with dimensions 10×10×1.6 mm³. The simulated results are verified by experimenting the fabricated antenna. It offered 14.6% bandwidth in the lower resonance 2.4 GHz and 8.5% bandwidth at upper resonant frequency 3.5GHz with radiation characteristics suitable for the WLAN/WiMAX applications.

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INTRODUCTION

With the growing popularity of sophisticated wireless communication systems, there seems to be a growing interest in lightweight, simple, and cost-effective broadband antennas. (Zaker, R. and A. Abdipour, 2010). For a variety of wireless applications, circularly polarised (CP) antennas have recently received much interest than linearly polarised (LP) aerials. particularly WLAN, WiMAX, Wi-Fi, and Bluetooth (Rocca, P., M. Donelli, G. Oliveri, F. Viani, and A. Massa, 2013). In terms of maximum intensity toward power reception, the reflectivity of transmitting and receiving signals in all planes, ease of installation, resistance to adverse weather conditions, and reduced multipath losses, CP antennas outperform LP antennas (Shin, Y. S., S. O. Park, and M. Lee, 2005). Monopole antennas have become increasingly popular in recent years due to their low profile, low cost, wide bandwidths, and simple structure. The main disadvantage of CP antennas is their narrow bandwidth and large size. To compensate for these drawbacks, researchers must develop a small-scale, broadband CP antenna with a wide axial ratio bandwidth (Foudazi, A., H. R. Hassani, and S. M. A. Nezhad, 2012). Because of its ease of setup, integration, and multiband operation capabilities, planar geometry monopole antennas have received a lot of attention in recent years.

Various planar broadband antennas have been presented in (Midya, M., S. Bhattacharjee, and M. Mitra, 2019 to Donelli, M., T. Moriyama, and M. Manekiya, 2018) to improve AR bandwidth for various applications such as GSM and WLAN while keeping the size as small as possible. A triple-band G-shaped fed antenna has an ARBW of 53.92% and an impedance BW of 62.94% (Midya, M., S. Bhattacharjee, and M. Mitra, 2019). However, the axial ratio of this antenna is lower than its bandwidth. For wireless standards, (Wang, C.-J., M.-H. Shih, and L.-T. Chen, 2015), provide a bent-shaped feed with three slots, one T-shaped and two inverted-L slots etched in the ground plane, but with a lower BW. The antenna in (Ellis, M. S., 2016) is composed of a rectangular slot and a microstrip feed line. This antenna has an IBW of 90.2% and a 40% axial ratio of 3 dB.

For CP operation, (Li, Q, 2017) proposes an inverted-L strip and a modified ground plane. The Wi-Fi, Bluetooth, and WLAN bands, as well as a portion of the WLAN spectrum, are covered by the 10 dB reflection coefficient bandwidths. An L-shaped radiator with two opposing strips at ground plane corners covers 44% (2.35–3.66 GHz) and 70% (4.55–9.55 GHz) IBW with AR of 35.9% (2.40–3.45 GHz), 44.0% (4.65–7.27 GHz), and 6.3% (8.13–8.66 GHz) in (Xu, R, 2017). (Gyasi, K. O, 2018) demonstrates a planar antenna with an IBW of 9.7% in the lower band, 11.3% in the middle band, and 60.2% in the upper band. The axial ratio bandwidths in the lower band are 4.9% and 58.6% in the upper band, respectively.

Gyasi, K. O (2018) illustrates an inverted F-shaped slotted radiating patch antenna with a large ARBW. The IBW is 3.12 GHz (56% of 2.25–4.0GHz) with a 63.61% axial ratio (2.38–4.60 GHz). Another feed with antipodal Y-stripes and slots. (Nosrati, M., and N. Tavassolian, 2016) present a ground plane to improve BW, which covers impedance BW of 84% and ARBW of 41%. In their paper, Yeung et al. presented a circularly polarised antenna with an axial ratio BW of 83.5% (4.3 GHz, 3–7.3 GHz) and an S11 bandwidth of 92.6% (Yeung, S. H., K. F. Man, and W. S. Chan, 2011). (Samsuzzaman, Md., M. T. Islam, and M. J. Singh, 2018) demonstrate a microstrip antenna with an IBW of 66.66%. The authors of (Mousavi, P., B. Miners, and O. Basir, 2010) presented an L-shaped monopole slot antenna fed by a C-shaped microstrip line. It has a 23% ARBW. The inclusion of two embedded stubs in the microstrip feed-line, which excites a two-linked elliptical slot, resulted in a 40% ARBW (Rezaeieh, S. A., A. Abbosh, and M. Antoniadis, 2013). (Chen, X., L. Wang, D. Wu, J. Lei, and G. Fu, 2017) describes a small, wideband directional CP antenna with a large IBW, whereas (Liang, W. L., Y. C. Jiao, Y. C. Luan, 2015)

describes an antenna loaded with modified stubs that achieves CP in dual bands but with a limited axial ratio (AR) bandwidth in the lower band.

A circular SRR with an IBW of 2.7 GHz and reduced AR is shown in (Verma, A., 2020). An I-shaped patch with an IBW of 115% and an AR of 56% is shown in (Jaiverdhan, M. M. Sharma, R. P. Yadav, and R. Dhara, 2020), but it is still unsuitable for multiband applications, whereas a U-shaped patch with a lower IBW and an ARBW of 18.91% is presented in (Jaiverdhan, M. M. Sharma, R. P. Yadav (Sankhla, V. and A. Kumar, 2020). The hook-shaped antenna (Robol, F., and M. Donelli, 2018) has a substantial return loss and an excellent axial ratio, however, it is only suitable for ISM-band applications. Similarly, an array antenna and planar antenna with higher IBW are given in (Donelli, M. and P. Febvre, 2012 and Donelli, M., T. Moriyama, 2018), although they are confined to Wi-Fi applications. According to the literature review, the mentioned antennas feature a complicated construction or a narrow BW.

The current mobile devices can run multiple applications at the same time, and its main requirement is compactness. The amount of space available for antenna installation in these mobile devices is extremely limited. The search for a multiband antenna with a small footprint is necessitated by the aforementioned need. The multiband antenna has drawn the attention of academics because of its importance in mobile devices. The main benefit of using a multiband antenna is that it reduces the number of antennas required for each application while also eliminating the filter used in the multiband system, reducing manufacture, deployment, and cost. The inclusion of slots (Baudha, S. and D. K. Vishwakarma, 2019) in the radiating element and ground plane (Al-Tumah, W. A. G., R. M. Shaaban, and A. Tahir, 2020 & Shan, K., C. L. Ruan, and L. Peng, 2011) is one of the broadest techniques for realizing the multiband response, and another method is the use of various current courses created by the inclusion of strips (Iqbal, A., A. Bouazizi, O. A. Saraereh, A. Basir, and R. K. Gangwar, 2018). In addition, to implement the multiband capabilities, various approaches such as Defected Ground Structures (DGS) (Liu, G., M. Fang, R. Zhi, J. Bai, and Z. Zeng, 2017), fractal (Ran, X., Z. Yu, T. Xie, Y. Li, X. Wang, and P. Huang, 2020), active devices, and passive devices (Promwong, S. and A. Pinsakulhave, 2020) been employed.

Although the methods described above can perform multi-band operations, they influence design complexity, gain, and radiation pattern. Because of their unique electromagnetic characteristics, which are not explained by science, metamaterials (MTM) assist to overcome the aforementioned disadvantage. In recent years, metamaterial constructions have effectively addressed the limitations described above. Various metamaterial structures have been described in the literature, with characteristics like refractive index, permittivity, and permeability being negative at the intended frequency of operation. They are used in the absorber, cloaking, filter, coupler, and antenna applications (Liu, C. Y., T. Jiang, and Y. S. Li, 2011). The use of metamaterial in a metamaterial-inspired antenna can increase antenna characteristics like gain, directivity, and the number of operational bands. (Ouedraogo, R. O., E. J. Rothwell, A. R. Diaz, K. Fuchi, and A. Temme, 2012) presents a compact size multiband antenna utilising MTM; the MTM is integrated into the substrate to decrease the size of the radiating element. MTM substrates are utilized to provide better impedance matching and multiband performance (Weng, Z. B., Y. C. Jiao, F. S. Zhang, Y. Song, and G. Zhao, 2008). The addition of the MTM boosts the directivity and gain in various operating frequencies (Arora, C., S. S. Pattnaik, and R. N. Baral, 2017 & Al-Bawri, S. S., S. Islam, H. Y. Wong, and M. F. Jamlos, 2020). In (Patel, S. K., C. Argyropoulos, and Y. P. Kosta, 2016), metamaterial superstrates are employed to improve gain. In all of the aforementioned arrangements, adding MTM as a separate layer increases the total size.

The use of MTM in the radiating element and ground has surged in the recent decade to improve antenna performance. For addressing the drawback of larger volume, the Split Ring Resonator (SRR)

and Complementary Split Ring Resonator (CSRR) are the two most commonly utilized MTM designs. Various forms of MTM CSRR arrays (Liu, T., X. Y. Cao, J. Gao, Q. Yang, and W. Q. Li, 2011) are utilized to enhance bandwidth (Dattatreya, G. and K. K. Naik, 2019) and impedance matching (Arya, A. K., S. J. Kim, and S. Kim, 2020). In (Naoui, S., L. Latrach, and A. Gharsallah, 2015), several CSRR rings are used to create the directional antenna; as the number of CSRR rings increases, the structure's resonant frequency drops. For size reduction, gain, and bandwidth increment, MTM structures such as single ring CSRR (Pandeewari, R., 2018 & Naik, K. K., 2018), SRR (Geetharamani, G. and T. Aathmanesan, 2020, & Boopathi Rani, R. and S. Pandey 2017), Open Complementary Split Ring Resonators (OCSRR) (Herraiz-Martínez, F. J., G. Zamora, F. Paredes, F. Martín, and J. Bonache, 2011), and Electric Inductive-Capacitive (ELC) resonator (Sam, P. J. C. and N. Gunavathi, 2020) are etched on the patch. However, only a little amount of work has been done on the MTM to realize multiband functionality, circular polarization, and minimization.

In the paper (Prasad Jones Christydass, S. and N. Gunavathi, 2021), a CSRR-loaded rectangular monopole is proposed for dual-band operation. The GSM operating spectrum is between 1.78 and 1.90 GHz, whereas the WiMAX, WLAN, and 5G sub-6 GHz new radio ranges are between 3.45 and 6.58 GHz (n77, n78, and n79 bands). Impedance bandwidth is increased by reducing the ground structure. To span the 1.83 GHz range, the 1.8 GHz CSRR is carved on the radiating element. A metamaterial loaded patch antenna for WiFi applications is described in (Geetharamani, G., Aathmanesan, T. A. 2020), along with the mathematical design equations for the split ring resonator. (Nornikman, H., Ahmad, B. H., Aziz, M. A., & Othman A. R. 2012) discusses the impact of different forms of complementary split-ring resonators (CSRR) on patch antenna performance. As a kind of metamaterial antenna, the dipole is incorporated in a planar form with capacitively loaded loops (CLLs) as its nearfield resonant parasitic (NFRP) elements in (Dakhli, S., Rmili, H., Floc'h, J.-M., Sheikh, M., Dobaie, A., Mahdjoubi, K., et al. 2016).

(Ali, T., Khaleeq, M. M., Pathan, S., & Biradar, R. C., 2017) describes the impact of triangular complementary split-ring resonators (CSRR) in a Wi-Fi patch antenna. (Rosaline, S. I., & Raghavan, S., 2016) presents two metamaterial-inspired split ring radiating components for WLAN and WiMAX applications. (Zhang, H., Li, Y.-Q., Chen, Xi, Yun-Qi, Fu, & Yuan, N.-C. 2009, Baena, J. D., Bonache, J., Martín, F., Sillero, R. M., Falcone, F., Lopetegi, T., et al. 2005, Zhou, L., Liu, S., Wei, Y., Chen, Y., & Gao, N., 2010, Satish, K. 2015) describe the fundamental ideas of metamaterial-inspired patch antennas. Recent advances in WLAN antennas are addressed in (Sahoo, A. K., Gupta, R. D., & Parihar, M. S. 2018, Rajkumar, R., & Kommuri, U. K. 2018, Bhatia, S. S., Sivia, J. S., & Sharma, N. 2018, Kumar, A., Gupta, N., & Gautam, P. C. 2018, Torabi, Y., & Omid, R., 2018). A metamaterial antenna based on SRR is designed in (Geetharamani, G., Aathmanesan, T. A. 2020) for Wi-Fi (2.4GHz) application. The broader area antenna covered an area of 40x30 mm, with an impedance bandwidth of 200MHz.

The most common antenna designs for wireless local area network (WLAN) and worldwide interoperability for microwave access (WiMAX) applications have been described (Kuo, Y. L. and K. L. Wong, 2003, Eleftheriades, G. V., A. Grbic, and M. Antoniadis, 2004, Erentok, A. and R. W. Ziolkowski 2008, Malik, J. and M. V. Kartikeyan, 2011). The problem is building a WiMAX system is to create antennas that are tiny, low-cost, and low-profile. The planar microstrip antenna is a promising option for WiMAX applications since it has a low profile, is etched on a single substrate, and can operate in many bands. The typical technique to achieving multi-band functioning is to utilize multi-resonator components (Ge, Y., K. Esselle, and T. Bird, 2006) which generally results in a large volume (Dahele, J. S., K. F. Lee, and D. P. Wond, 1987, Long, S. A. and M. D. Walton, 1979, & Sappan, A. 1984) or needs a big ground-plane (Tan, Y. M., Y. K. Chan, V. C. Koo, and M. T. Islam, 2010). Kuo et al. presented a dual-band double

T-monopole antenna with a certain downsizing factor but a restricted bandwidth at the upper WLAN band (Kuo, Y. L. and K. L. Wong, 2003). Metamaterials (MTM), on the other hand, offer a conceptual pathway for constructing tiny resonant antennas (Eleftheriades, G. V., A. Grbic, and M. Antoniadis, 2004; Erentok, A. and R. W. Ziolkowski 2008). In (J. Malik and M. V. Kartikeyan, 2012), a compact antenna with (40×25) mm², L-shaped slot is proposed for WiMAX (3.5 GHz) and WLAN (5.8 GHz).

New systems are designed with the growth of wireless devices such as mobile phones, portable laptops, and smartphones. WLAN frequencies are covered by the IEEE 802.11a, IEEE 802.11bg, and HyperLAN/2 specifications. The IEEE 802.11 standard specifies three frequency bands: 2.4 GHz (2.4842.4), 5.2 GHz (5.355.15), and 5.8 GHz (5.8255.725), with 3.33.8 GHz reserved for wireless personal area networks (WPAN) and WiMAX (Song, X, 2009 & Liu, J.-C., B.-H. Zeng, C. Y. Liu, H. C. Wu, and C.-C. Chang, 2010). Modern communication systems demand microwave components with excellent performance and small size, which necessitates the use of tiny antennas. Because of their ideal size, weight, affordability, performance, and ease of installation, microstrip antennas are employed in aviation, space exploration, satellite, missile, and different government and commercial applications (Ramli, N. H., M. R. Kamarudin, N. A. Samsuri, E. N. Ahyat, A. Y. Abdulrahman, and M. F. B. Jamlos, 2013 & Hu, Y., Y. J. Zhang, and J. Fan, 2012).

In comparison to previous generations, the 5G wireless network marks the beginning of a fully digitized society and achieves significant progress in terms of latency, high data rate, agility, and the number of available devices. Because 5G is still in its early stages of commercialization, the time is ripe to begin research on 5G's replacement. The rapid development of new applications results in an exponential increase in mobile data traffic (T.Huang, et.al, 2019). As 5G enters the commercial deployment phase, research institutions around the world have begun to focus on 6G, which is expected to be deployed by 2030. Sustainable 6G is expected to improve information transmission performance, with peak data rates of up to 1 Tbps and ultra-low latency in microseconds. One of the goals of 6G is to provide global coverage by integrating satellite communication networks and underwater communications (A. Yastrebova, et.al, 2018).

Antennas for multi-band applications must be compact, readily fed, and inexpensive. A slot antenna is a well-known antenna for wireless applications, with all of the characteristics that WLAN communication systems require. Multi-band antennas are designed using techniques such as the notch approach, metamaterial, slot, and fractal methods (Alam, M. S., M. T. Islam, and N. Misran, 2012; Yu, A., F. Yang, and A. Z. Elsherbeni, 2008; Sayem, A. T. M. and M. Ali, 2006).

EBG structures (electromagnetic band-gap structures) can be utilized to miniaturize and build high gain patch antennas. Frequency selective structures (FSS) are characterized as a periodic array of holes on a substrate patch (Majid, H. A., M. K. Abd Rahim, and T. Masri, 2009; Zhao, L., D. Yang, H. Tian, Y. Ji, and K. Xu, 2013). These artificial magnetic materials have been employed on the substrate to enhance effective permeability, resulting in a smaller antenna (Ouedraogo, R. O., E. J. Rothwell, A. R. Diaz, K. Fuchi, and A. Temme, 2012).

The approach of composite right/left-handed transmission line (CRLH-TL) is based on the usage of artificial electromagnetic materials (metamaterial). These materials are periodic structures that do not exist in nature and have been studied due to their unique properties and wide range of uses. The real component of epsilon, mu, or both are negative in metamaterials (Li, M., H.-L. Yang, X.-W. Hou, Y. Tian, and D.-Y. Hou, 2010; Buell, K., H. Mosallaei, and K. Sarabandi, 2006; Bilotti, F., A. Allu, and L. Vegni, 2008; Gurel, L., A. Unal, and T. Malas, 2009). Metamaterials, such as metamaterial structure in the substrate (Buell, K., H. Mosallaei, and K. Sarabandi, 2006) and metamaterial load for miniaturization

(Bilotti, F., A. Allu, and L. Vegni, 2008), are extensively employed in antenna and microwave circuits to enhance the antenna's miniaturization factor.

In this article, a simple lightweight, low cost, miniaturized circularly polarized planar antenna is proposed. It is fabricated on a low-cost dielectric material FR-4 (Flame Retardant 4). The presented antenna covers a bandwidth of 14.6% in the lower band (WLAN) coverage 2.2 GHz – 2.6 GHz and 8.5% bandwidth at the upper band of 3.3 GHz – 3.6 GHz (Wi-Max) coverage. The incorporation of CSRR and consecutive ring-shaped structure in the radiating patch helps in improving the bandwidth and reducing the physical dimensions of the antenna. Also, it had a greater advantage of providing negative permittivity which helped in achieving the lower resonance band 2.4 GHz and the introduction of neutralization lines provided the upper resonance band 3.5 GHz. Further sections discuss the theory behind metamaterial, design methodology and parametric study of the proposed ring antenna for WLAN and Wi-MAX applications.

THEORY OF HOMOGENEOUS METAMATERIAL TRANSMISSION LINE

A metamaterial transmission line (MTL) is a TL construction that consists of unit cells with a series capacitor and a shunt inductor. These components are incorporated into the traditional transmission line model (Antoniades, M. A. and G. V. Eleftheriades, 2009). These additional components allow for left-handed (LH) propagation and reverse wave support. Although gap and interdigital capacitors are both employed as series capacitors, interdigital capacitors have a greater capacitance. Shunt inductors are made of vias, but their inductance may be enhanced by combining them with other types of inductors, such as spiral or meander architectures (Niu, J.-X, 2010; Zhu, J. and G. V. Eleftheriades, 2009).

By superimposing additional ground to spiral or meander structures, we may use them as shunt inductors (G. V. Eleftheriades, 2009). ZORs (zeroth-order resonators) have become essential structures in the construction of tiny antennas. They are significantly smaller than typical microstrip rectangular patch antennas. CRLH is a structure that possesses both RH and LH properties (Azimi Fashi, A., M. Kamyab, and M. Barati, 2010; Rafael Booket, M., M. Veysi, Z. Atlasbaf, and A. Jafargholi, 2012). It is very hard to create a superstructure with entirely left-handed characteristics. The transmission line theory states that the propagation constants in a lossless construction are $\gamma = j\beta$, where $\beta = \sqrt{ZY}$ where Z and Y are per unit length impedance, and admittance, respectively (Park, J.-H., Y.-H. Ryu, J.-G. Lee, and J.-H. Lee, 2007). The frequency-dependent effective permeability and permittivity can be calculated using (1) & (2),

$$\mu(\omega) = \mu_{eff} = L_R - \frac{1}{\omega^2 C_L} = \frac{Z}{j\omega} \quad (1)$$

$$\varepsilon(\omega) = \varepsilon_{eff} = C_R - \frac{1}{\omega^2 L_L} = \frac{Y}{j\omega} \quad (2)$$

$$Z = j \left(\omega L_R - \frac{1}{\omega C_L} \right) \Omega / m \quad (3)$$

$$Y = j \left(\omega C_R - \frac{1}{\omega L_L} \right) S / m \quad (4)$$

$$\omega_L = 1 / \sqrt{L_L C_L} \quad (5)$$

$$\omega_R = 1 / \sqrt{L_R C_R} \quad (6)$$

$$\omega_{se} = 1 / \sqrt{L_R C_L} \quad (7)$$

$$\omega_{sh} = 1 / \sqrt{L_L C_R} \quad (8)$$

$$\omega_0 = \sqrt{\omega_R \omega_L} = 1 / \sqrt[4]{L_R C_R L_L C_L} \quad (9)$$

Here ω_L , ω_R , ω_{se} , ω_{sh} , ω_0 are left-handed, right-handed, series, shunt resonant frequency and transmission frequency, respectively. This transmission frequency is a parameter that differentiates series and shunts resonant frequency (Park, J.-H., Y.-H. Ryu, J.-G. Lee, and J.-H. Lee, 2007).

DESIGN OF METAMATERIAL CIRCULAR RING PATCH ANTENNA

By arranging several concentric slots on the ground plane, it is possible to keep the resonant frequency constant of a complementary structure by reducing the structure's dimensions. This method allows for high degrees of miniaturization. The maximum level of miniaturization is determined by the total number of slots that can be placed on the antenna structure. Alternatively, the frequency of resonance can be kept constant while the size of the loaded antenna is lowered to the desired level of downsizing by loading CSRR shapes that couple well with the antenna to provide the appropriate output parameters.

The conventional ring antenna dimensions can be calculated using the formula given in (Dileepan Dhanasekaran, Natarajan Somasundaram, and Rajkumar Rengasamy 2021),

$$F = \frac{c}{\lambda} = \frac{c}{\pi(r_1 + r_2)\sqrt{\epsilon_{eff}}} \quad (10)$$

Here, r_1 and r_2 represent the inner and outer radius of the ring antenna. The fundamental ring patch antenna is optimized and its evolution in step by step process is shown in figure 1. The proposed an-

tenna had dimensions of 4 mm as outer radius and 3.5mm as inner radius which is optimized to obtain the desired results. The other dimensions of the structure as shown in figure 2 are tabulated in table 1.

An optimized semi-circular ring-shaped patch of radius 4.8mm is taken as a fundamental radiating element and the analysis was carried over with consecutive ring-shaped structures without loading the neutralization lines and complementary split-ring resonators (CSRRs), in the antenna. The simulated results for different iterations are plotted in figure 3.(a), which shows the frequency variation of the antenna. The desired frequency response is attained in iteration#5. Initially in iteration #1, where a semicircular patch was considered, and it was found to resonate at 6 GHz. The resonances obtained from iteration #2 to iteration #3 were able to achieve 2.4 GHz with more reflections due to a mismatch at the resonance. In iteration#4, 2.4 GHz was achievable only after loading the CSRR structure in the ground plane, which can be seen from figure 2. Even though WLAN (2.4GHz) was achievable at the dominant mode, the higher resonance 3.5 GHz, compatible for future generation application 3.5 GHz, was not achieved.

In order to achieve the 3.5GHz resonance by maintaining the lower order resonance at 2.4 GHz, neutralization lines were introduced in the structure with length 0.1mm and width 0.205mm, as shown in figure 2. The optimization done with and without neutralization line is shown in figure 3.(b). The incorporation of NL's in the structure supported in holding the $f_{r1} = 2.4$ GHz by reducing the coupling between ring 1 and ring 2, and since the NL's also behaved as a conducting strip $f_{r2} = 3.5$ GHz is achieved, additionally. This can be inferred from the current distribution on the patch, where the first NL was neutralized to maintain f_{r1} and f_{r2} due to the second NL, which behaves as a conducting strip. The voltage standing wave ratio (VSWR), is an important parameter which stands as a supporting feature for justifying the performance of the proposed antenna was found to be less than 2. This VSWR plot for different iterations is plotted in figure 4. With the incorporation of CSRR and neutralization lines, the fractional bandwidth of 18.3% has not changed in the lower order resonance and due to the effect of introduction of NL, the new upper resonance 3.5 GHz is obtained with 8.3% bandwidth. The attained bandwidth level with the decreased dimensions is comparatively better than the other literatures considered. The overall footprint of the proposed antenna is $(10 \times 10 \times 1.6) \text{ mm}^3$. It can be seen that, the impedance bandwidth is widened for lower band 2.2-2.6 GHz, due to the presence of CSRR and the upper band 3.3-3.6GHz had a narrow bandwidth due to the presence of NLs. The presented circular ring shaped antenna had a dual band operation with TM_{01} mode. This can be seen from the current distribution of the antenna which is plotted in figure 5. It can be seen that better impedance matching was achieved due to the incorporation of quarter wave transformer (QWT) in the structure. This QWT helped in maximum current transfer in order to enhance the radiation effects.

Table 1. Parameters of the antenna

S.no	Parameters	Value (mm)	S.no	Parameters	Value (mm)
1	r_1	4	8	$L_s = W_s$	10
2	r_2	3.5	9	w_L	0.2
3	r_3	3.3	10	w_f	0.2
4	r_4	2.8	11	w_q	1
5	r_5	2.3			
6	w_1	0.5			
7	w_2	0.2			

Figure 1. Various iterations showing the design evolution

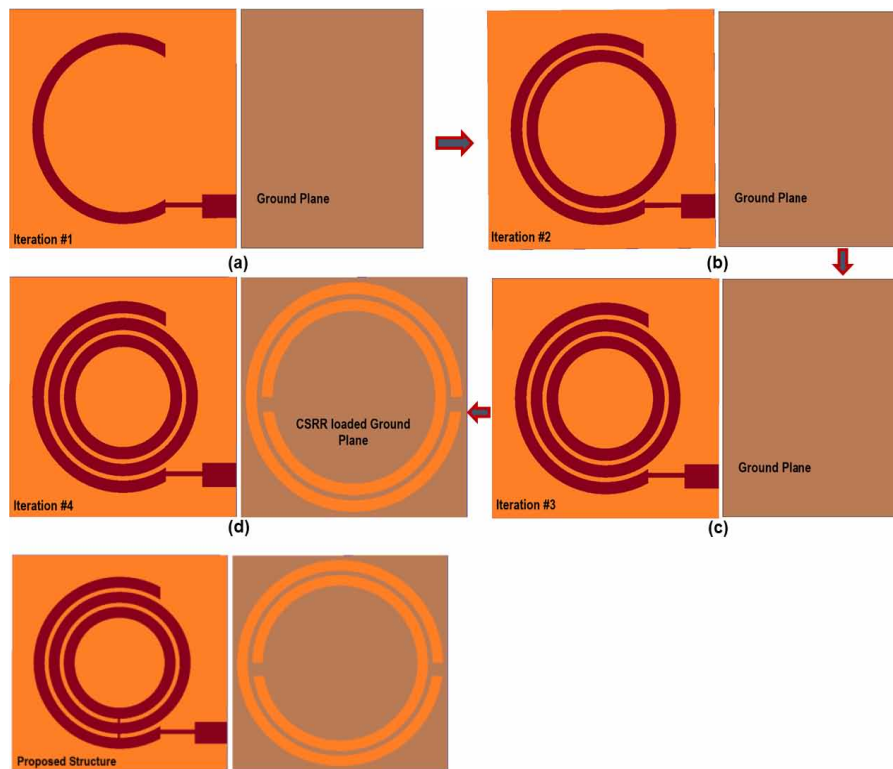


Figure 2. Dimension notation of the proposed structure

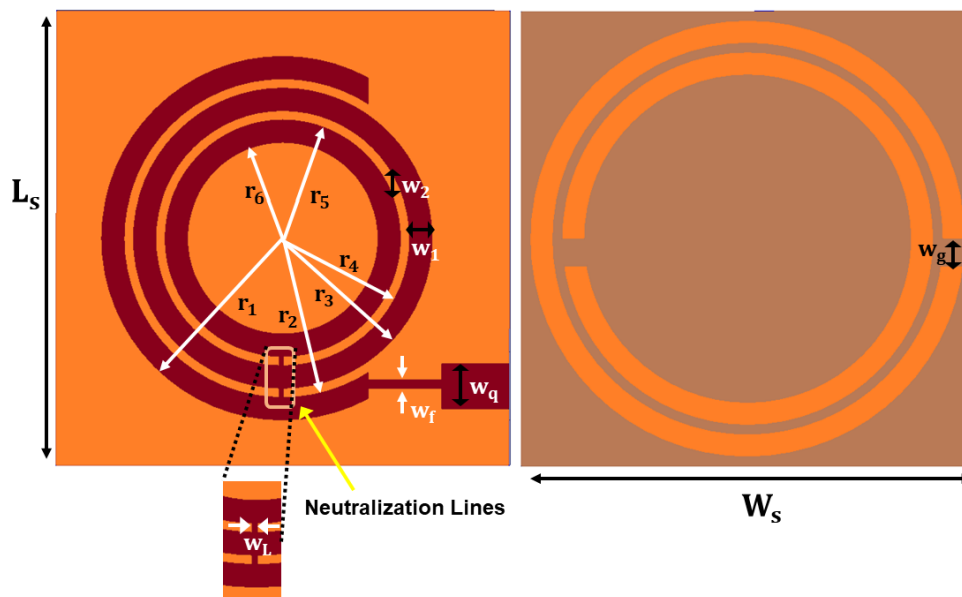


Figure 3. (a) Comparison plot for resonance for different iterations, and (b) comparison plot for resonance with and without neutralization lines (NL).

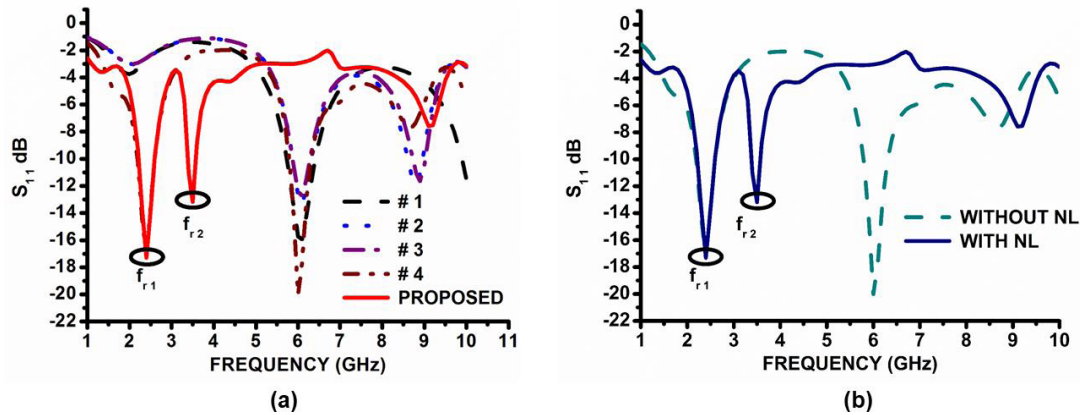
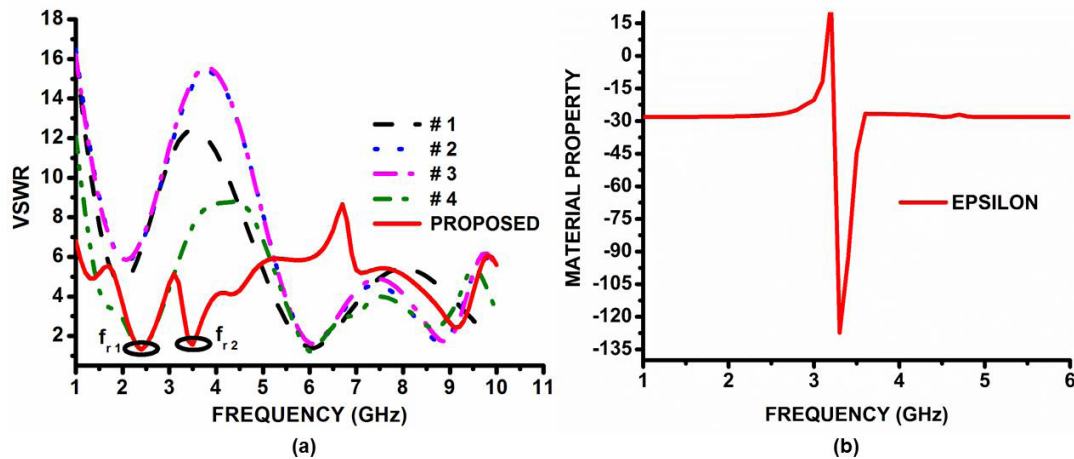


Figure 4. (a). VSWR comparison plot for different iterations, (b) Material property-negative permittivity



From figure 4.(b), it is evident that the ring-shaped patch antenna concentrated its current in the rings and due to CSRR in the ground plane, the surface waves at the ground plane is drastically reduced and the undesired frequency response beyond 3.5GHz is attenuated. As can be seen, the dominant mode of operation is TM_{01} for the presented antenna. Due to the incorporation of CSRR in the antenna, a novel effect called the metamaterial effect is introduced in the antenna, to achieve a higher degree of miniaturization. This can lead to achieving negative permittivity in the structure which cannot be found in the natural materials. This negative effect can be justified using the formulas given in (R. Marqués, F. Martín, and M. Sorolla, 2013).

The negative permittivity due to CSRR is shown in figure 4.(b). Due to the uniform configuration of CSRR, the Lorentzian-Drude model curve is achieved for plotting the negative permittivity. The fabricated prototype is shown in figure 6.(a). The experimental results are compared with the simulation results and were found to be in better agreement with the simulation results. These results are plotted in figure 7.(b) & (c). In the comparison plot, due to the cable losses and fabrication errors, little devia-

tions and noise can be seen. The proposed structure is compared with the existing models presented in the literature and was found to be a better candidate for modelling compact devices suitable for WLAN and Wi-MAX applications.

Circular polarized (CP) antennas (R. E. Fisk and J. A. Donovan, 1976; M. R. Johns and M. A. Ralston, 1981; H. An, B. Nauwelaers, and A. Van den Capelle, 1993; J. S. Row, 2004; K. L. Lau, K. M. Luk, and K. F. Lee, 2006) emit electromagnetic waves that are circularly polarized. They are helpful in communication satellites and global positioning systems (GPS) because the linearly polarized wave may be turned as it passes through the ionosphere, but the circularly polarized wave is unaffected (Y. Qin, S. Gao, and A. Sambell, 2006), (Y. Qin, S. Gao, and A. Sambell, 2006). Furthermore, communication systems using CP antennas offer greater flexibility in terms of the orientation angle between the transmitter and receiver (K.W. Khoo, Y.X Guo, and L. C. Ong, 2007). Multipath reflections and other interferences can also be reduced by using CP antennas (K.W. Khoo, Y.X Guo, and L. C. Ong, 2007). Several types of CP antennas have been created, where two orthogonal modes with identical amplitude but in phase, quadrature should be stimulated to operate CP antennas. As can be seen from fig.5.(c), the axial ratio is lesser than 2 dB, satisfying the condition of circular polarization (Sai Ho Yeung, Kim Fung Man, and Wing Shing Chan, 2011). The 3-dB axial ratio fractional bandwidth is estimated to be 40% (2.4 GHz – 3.6 GHz). The dominant mode of the proposed antenna is found to be TM_{11} mode from the maximum current distribution seen from X- and Y-variation of the current distribution shown in figure 5.(a).

Figure 5. (a) & (b) Surface current distribution in the proposed antenna, (c) Axial Ratio.

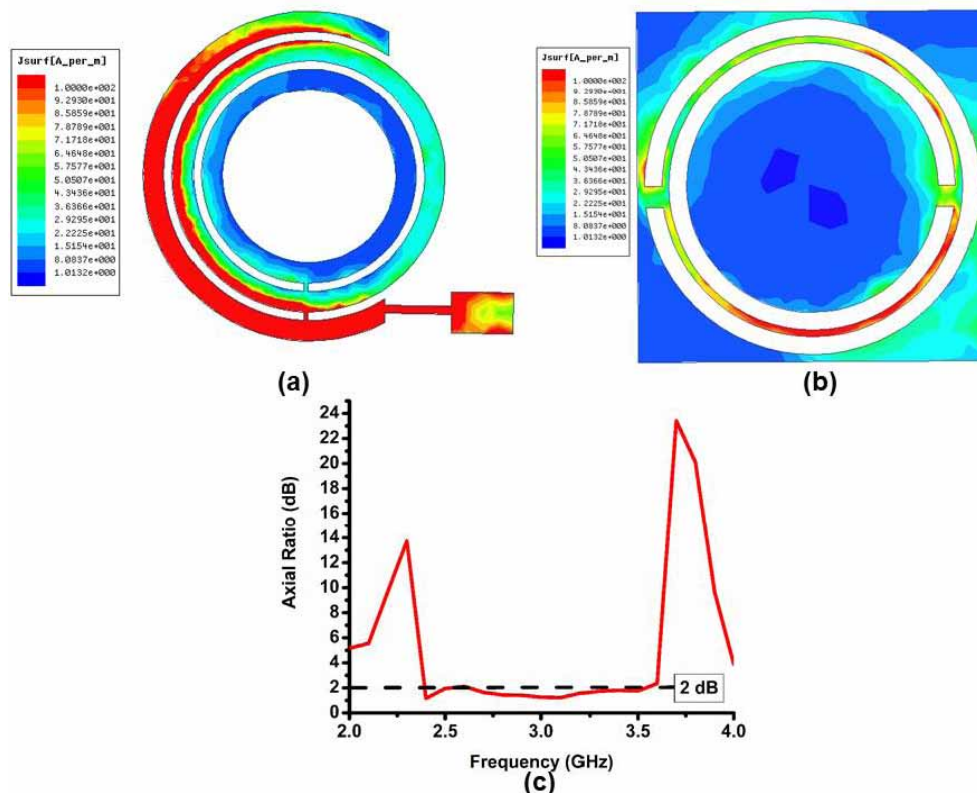


Figure 6.(a) Fabricated prototype, (b) Comparison Plot S_{11} & (c) Comparison Plot for VSWR.

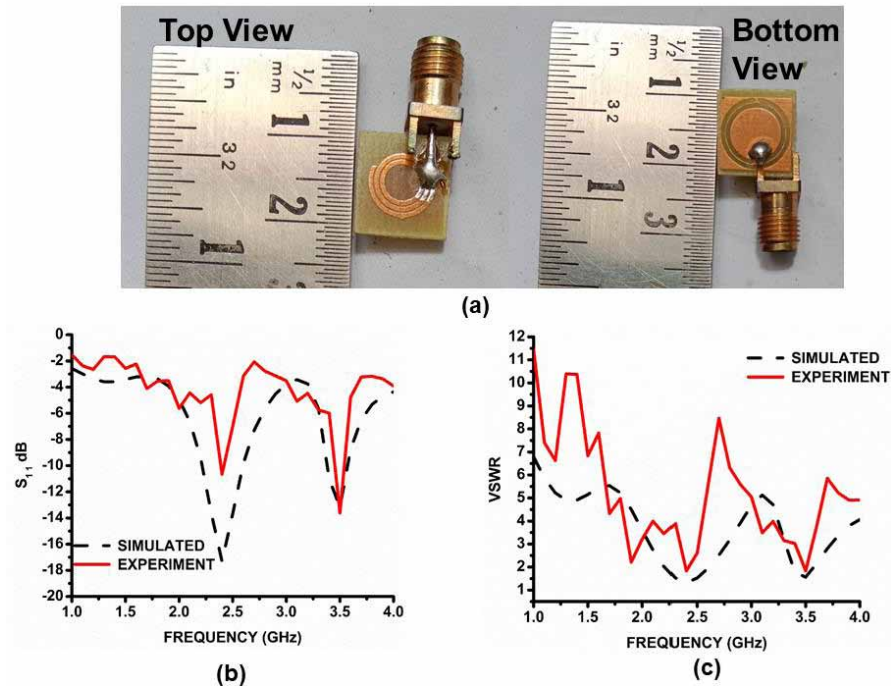


Table 2. Comparison of existing designs and proposed work

Ref	Dimension(mm)	Bandwidth	Technique
Li, Q., et al	42 × 48.4 × 1.6	2.38 GHz to 2.75 GHz – 14.8%	Inverted L-Strip
Xu, R., et al	60 × 60 × 1	2.34 GHz to 3.66 GHz – 44%	Rectangular Strip
Gyasi, K. O., et al, IET	25 × 35 × 1.6	3.41 GHz to 3.82 GHz – 11.3%	Slitted Ground Plane
Gyasi, K. O., et al, IEEE	30 × 30 × 1.6	3.3 GHz to 3.8 GHz – 14.2%	Rectangular Slot
Yeung, S. H, et., al	96 × 108.4 × 1.6	2.08 GHz to 4.01 GHz – 63.4%	Multiple Circular Slots
Izzat Fatima,et.,al,	25 × 25 × 1	2.4 GHz to 2.58 GHz – 8.9% & 3.2 GHz to 3.9 GHz – 33%	Rectangular Strip
Geetharamani, G., Aathmanesan, T. A	40 × 30	2.4 GHz, 200 MHz – 83%	SRR
J. Malik and M. V. Kartikeyan	40 × 25 × 1.6	3.5 GHz, 200 MHz - 57%	Inverted L-slot and CSRR
Proposed	10 × 10 × 1.6	2.2 to 2.6 GHz – 18.3% & 3.2 to 3.6 GHz - 8.3%	Neutralization lines and CSRR

CONCLUSION

A compact negative indexed metamaterial circular ring patch antenna with wide IBW is proposed with smaller dimensions of 10×10×1.6 mm³. The semicircular ring patch with two consecutive rings loaded with CSRR and neutralization lines has a larger impact on the bandwidth and achievement of lower-order frequency band 2.2 to 2.6 GHz with 18.3% bandwidth and upper band from 3.2 to 3.6 GHz with

8.3% bandwidth is achieved with this smaller dimension. Further, the neutralization lines were inferred to behave in their ideal nature while maintaining the resonance at 2.4 GHz and as a conducting strip to obtain resonance at 3.5GHz. The 3-dB axial ratio bandwidth is calculated to be 40% and achieved a value of 1.8dB over the bandwidth, which resulted in circular polarization. The circularly polarized antenna was found to have better VSWR and achieved negative permittivity at one of the resonant frequencies 3.45 GHz. The TM_{11} mode antenna is found to operate at 2.4 GHz suitable for WLAN and 3.5 GHz suitable for Wi-Max application.

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