This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2023.3317174

IEEE Access
Multidisciplinary ⋮ Rapid Review ⋮ Open Access Journal

Digital Object Identifier

An AI-Assisted Smart Healthcare System Using 5G Communication

BUDDHADEB PRADHAN[1], SHIPLU DAS[2],DIPTENDU SINHA ROY.[3], SIDHESWAR ROUTRAY[4],FRANCESCO BENEDETTO.[5],RUTVIJ H. JHAVERI[6]

[1]Department of Computer Science and Engineering, University of Engineering and Management, West Bengal, India, (Email:buddhadebpradhan@gmail.com)
[2]Department of Computer Science and Engineering, Adamas University, West Bengal India, (Email:shiplud63@gmail.com)
[3]Department of Computer Science and Engineering, National Institute of Technology Meghalaya, Shillong, India (Email:diptendu.sr@nitm.ac.in)
[4]Department of Computer Science and Engineering, School of Engineering, Indrashil University, Rajpur, Mehsana, Gujarat (Co-correspondence Email:sidheswar.routray@indrashiluniversity.edu.in)
[5]Signal Processing for Telecommunications and Economics, Department of Economics, Roma Tre University, Rome Italy (Correspondence Email:francesco.benedetto@uniroma3.it)
[6]Rutvij H. Jhaveri is with the Department of Computer Science and Engineering, School of Technology, Pandit Deendayal Energy University, India (E-mail:rutvij.jhaveri@sot.pdpu.ac.in)

Corresponding author: Francesco Benedetto and Sidheswar Routray (e-mail: francesco.benedetto@uniroma3.it and sidheswar.routray@indrashiluniversity.edu.in)

ABSTRACT Technology's fast growth has profoundly impacted myriad areas, including healthcare. Implementing 5G networks offering high-speed and low-latency communication capabilities is one of the most promising technical developments. Parallel to this, artificial intelligence (AI) has become a robust data analysis and decision-making tool. This paper examines how 5G and AI are combined in the context of intelligent healthcare systems. T5G green communication systems must overcome several challenges to satisfy the need for more user capacity, faster network speeds, cheaper pricing, and less resource use. By applying 5G standards, data rates, and device dependability for Industry 4.0 applications may be significantly increased. Advanced security and decreased unauthenticated assaults from various platforms are also covered in the paper. An outline of prospective new technologies and security improvements was provided to safeguard 5G-based intelligent healthcare networks. This paper identifies several research issues and potential future directions for secure 5G-based smart healthcare. This article discusses Industry 4.0, 5G standards, and new research in future wireless communications to explore current research concerns related to 5G technology. A brand-new architecture is also suggested in the paper for Industry 4.0 and 5G-enabled intelligent healthcare systems.

INDEX TERMS Artificial intelligence, healthcare system, Internet of Things,Network Simulator, Smart healthcare system, 5G communication system.

I. INTRODUCTION

THE way we communicate, engage, and use technology is about to change because of the combination of Artificial Intelligence (AI) technology and the fifth-generation (5G) wireless networks. The power of super-fast, low-latency connectivity is combined with sophisticated algorithms and decision-making abilities when 5G and AI are used together. This introduction will address this convergence's advantages, uses, and difficulties while exploring the possibilities of 5G using artificial intelligence. The huge amounts of data produced by AI applications require an infrastructure that can handle them, and 5G networks deliver previously unheard-of speeds, capacity, and dependability. 5G allows real-time communication and seamless connectivity thanks to its high data transfer rates and low latency. It provides the groundwork for a wide range of AI-powered services and applications. Several opportunities exist across numerous domains when AI is integrated with 5G networks. Healthcare is one industry where real-time AI analysis of massive amounts of medical data enables telemedicine, individualized healthcare, and remote patient monitoring. In the transportation industry, AI algorithms with 5G connectivity can improve the security and effectiveness of autonomous cars by allowing object detection, real-time decision-making, and vehicle-to-vehicle communication. Through intelligent systems and real-time data analysis, smart cities can use 5G and AI to optimize traffic management, increase energy efficiency, and improve urban planning. Predictive maintenance, robotics, and real-time monitoring are three ways industries can use AI-driven 5G networks to boost efficiency, productivity, and safety. Using AI and 5G together is crucial for public safety and emergency response. AI systems may analyze video feeds, spot anomalies, and provide real-time situational awareness to enable quicker and more efficient response times. A more secure and effective user experience can be delivered by AI-powered 5G networks, which can also improve financial services by enabling fraud detection, individualized suggestions, and quick financial transactions. However, there are several difficulties with the combination of AI with 5G. Due to the vast volume of data being produced and analyzed, privacy and security issues about data are raised. Gaining confidence and comprehending AI system decisions require algorithm openness and explainability. Additionally, a significant amount of processing power, infrastructure investment, and legal considerations are needed to deploy and administer AI models in 5G networks. Combining artificial intelligence (AI) and fifth-generation (5G) networks opens up a wide range of creative applications in many industries. In this part, we give a table detailing the various 5G AI applications, emphasizing their benefits. The first is Smart Healthcare, where AI-powered 5G networks enable telemedicine, real-time analysis of medical data, and remote patient monitoring, leading to better diagnosis and individualized healthcare. Another use for AI algorithms in 5G networks is autonomous vehicles, where they improve real-time decision-making, object detection, and vehicle-to-vehicle communication for safer and more effective autonomous driving. For sustainable and habitable cities, the 5G and AI combination offers intelligent traffic control, energy optimization, environmental monitoring, and effective urban planning. Industrial Automation uses AI-enabled 5G networks to enable robotics, real-time monitoring, and predictive maintenance, increasing industrial processes' effectiveness, productivity, and safety. Through enhanced video analytics, facial recognition, and real-time situational awareness made possible by AI algorithms in 5G networks, public safety, and emergency response are improved. 5G networks powered by AI are advantageous for smart grids because they improve power distribution monitoring, control, and optimization, resulting in effective energy management and grid stability. 5G networks and AI enable high-bandwidth, low-latency connections for immersive gaming, remote collaboration, and virtual training, enhancing augmented and virtual reality experiences. Precision agriculture increases crop yields, resource efficiency, and sustainability by utilizing AI-powered 5G networks for real-time monitoring, agricultural data processing, and autonomous machinery. By enabling fraud detection, individualized suggestions, risk assessment, and quick financial transactions, AI algorithms in 5G networks assist the financial services industry and improve consumer experiences. To meet the enormous connectivity and management needs of Internet of Things (IoT) devices, connectivity, and management employ AI-driven 5G networks, ensuring effective data processing and wise decision-making. We emphasize the various fields where these technologies intersect to produce game-changing solutions by organizing the applications of 5G employing AI in table format. We will examine each application in depth in the following parts, going through its advantages, practical considerations, and future research objectives. Through this investigation, we hope to demonstrate the enormous potential of 5G and AI integration for fostering innovation and progress in various industries.

- **Smart Healthcare** AI-powered 5G networks enable remote patient monitoring, telemedicine, and real-time medical data analysis for improved diagnosis and personalized healthcare.
- **Autonomous Vehicles** AI algorithms in 5G networks enhance real-time decision-making, object recognition, and vehicle communication, leading to safer and more efficient autonomous driving.
- **Smart Cities** 5G with AI enables intelligent traffic management, energy optimization, environmental monitoring, and efficient urban planning for sustainable and livable cities.
- **Industrial Automation** AI-powered 5G networks facilitate predictive maintenance, robotics, and real-time monitoring, enhancing industrial efficiency, productivity, and safety.
- **Enhanced Public Safety** AI algorithms in 5G networks enable advanced video analytics, facial recognition, and real-time situational awareness, improving public safety and emergency response.
- **Smart Grids** AI-driven 5G networks enhance the monitoring, control, and optimization of power distribution, enabling efficient energy management and grid stability.
- **Augmented and Virtual Reality** 5G networks combined with AI enable high-bandwidth, low-latency connections for immersive experiences, gaming, remote collaboration, and virtual training.
- **Precision Agriculture** AI-powered 5G networks enable real-time monitoring, analysis of agricultural data, and autonomous machinery, enhancing crop yields, resource utilization, and sustainability.
- **Financial Services** AI algorithms in 5G networks enable fraud detection, personalized recommendations, risk assessment, and efficient financial transactions for enhanced customer experiences.
- **Internet of Things (IoT) Connectivity and Management** AI-driven 5G networks handle the massive connectivity and management requirements of IoT devices, ensuring efficient data processing and intelligent decision-making.

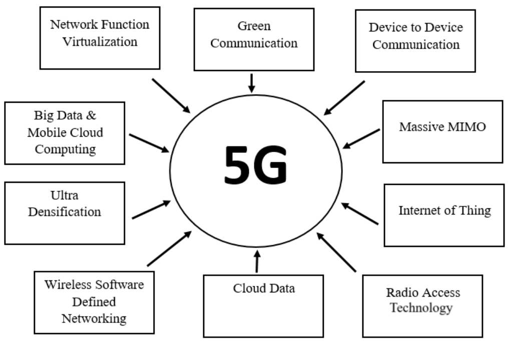


Fig 1.Enabling technologies connected with 5G

One of the cornerstones of 5G's success is beamforming, a sophisticated transmission technique that tailors the direction of wireless signals with unprecedented precision. Unlike traditional omnidirectional broadcasting, where signals spread indiscriminately in all directions, beamforming empowers 5G networks to concentrate energy in specific directions. This is achieved through the manipulation of signal phase and amplitude from multiple antennas, resulting in stronger and more reliable connections, reduced interference, and enhanced spectral efficiency.

While beamforming is a standout feature of 5G's physical layer, it is complemented by a constellation of auxiliary technologies that collectively amplify the network's capabilities. Multiple-Input Multiple-Output (MIMO) configurations enable the use of multiple antennas for simultaneous transmission and reception, boosting data rates and signal reliability. Massive MIMO, an extension of MIMO, leverages an abundance of antennas to serve numerous users concurrently, fostering efficient resource allocation. Non-Orthogonal Multiple Access (NOMA) optimizes spectrum utilization by allowing multiple users to share the same time and frequency resources, enabling better connectivity in crowded environments. Full-duplex communication empowers devices to transmit and receive data simultaneously, increasing efficiency and reducing latency

These tables comprehensively overview the key aspects of integrating 5G Industry norms and artificial Intelligence (AI) in an IoT system. They cover connectivity, edge computing, data analytics, decision-making, security, privacy, resource optimization, and industry-specific applications.The state-of-the-art in the areas of artificial intelligence (AI), industry 4.0, and 5G will be covered in this paper [5] .the integration of 5G and AI in healthcare also poses challenges and considerations. The security and privacy of patient data become crucial concerns as the volume and sensitivity of medical information being transmitted and analyzed increase. Robust security measures and compliance with data protection regulations are essential to ensure the confidentiality and integrity of patient data. Furthermore, ethical considerations surrounding AI algorithms and decision-making processes must be addressed to ensure healthcare practices' transparency, fairness, and accountability. In summary, the convergence of 5G industry norms and artificial intelligence presents a paradigm shift in

TABLE 1. Connectivity and Edge Computing

Aspect	Description
5G Networks	High-speed, low-latency connectivity for IoT devices, enabling seamless communication.
Edge Computing	Deploying AI algorithms at the edge for real-time data processing, reducing latency.
Multi-access Edge Computing (MEC)	Bringing computing capabilities closer to the edge, enhancing response time and efficiency.
Satellite-Terrestrial Architecture	A hybrid architecture that combines terrestrial (ground-based) and satellite-based components to extend the coverage and capabilities of the 5G network.
Satellite Gateway	Acts as an intermediary between the terrestrial network and the satellite communication system, handling communication routing and translation.
IoT Connectivity	Enabling smart IoT devices to connect seamlessly to the network, facilitating data exchange and control over the satellite-terrestrial architecture.
Network Management	Monitoring and managing the entire satellite-terrestrial architecture, including network performance, security, and troubleshooting.
Telemedicine Services	Services provided over the satellite-terrestrial architecture, enabling remote medical diagnosis, patient monitoring, and healthcare delivery.

TABLE 2. Data Analytics and Decision-making

Aspect	Description
AI Data Analytics	Leveraging AI algorithms to extract valuable insights from IoT data, enabling better decisions
Predictive Modeling	Using AI techniques to predict future trends and behaviors based on historical IoT data.
Real-time Decision-making	Making intelligent decisions in real-time using AI algorithms and real-time data analysis.

healthcare. The high-speed and low-latency capabilities of 5G networks, coupled with the analytical power of AI algorithms, enable the development of smart healthcare systems that can significantly improve patient care, enhance clinical decision-making, and drive preventive healthcare strategies. However, careful attention must be given to security, privacy, and ethical considerations to ensure these technologies' responsible and beneficial implementation in healthcare settings.

The convergence of 5G, Massive MIMO (Multiple-Input Multiple-Output), and artificial Intelligence (AI) has the potential to revolutionize the performance and capabilities of the Internet of Things (IoT). As IoT expands and connects an ever-growing number of devices, the need for advanced technologies to address its challenges becomes crucial. This detailed analysis explores how the combination of 5G, Massive MIMO, and AI can work together synergistically to enhance IoT performance. 5G, the next generation of wireless communication technology, introduces a range of capabilities that are specifically designed to meet the requirements of IoT applications. With its high-speed, low-latency, and high device density support, 5G provides the foundation for seamless connectivity and efficient data transfer among IoT devices.

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and
content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2023.3317174

TABLE 3. Security and Privacy

Aspect	Description
AI-driven Security	Employing AI to detect and prevent cyber threats, ensuring the integrity and privacy of data.
Secure Data Transfer	Ensuring secure transmission of IoT data over 5G networks, safeguarding against unauthorized access.

TABLE 4. Resource Optimization and Efficiency

Aspect	Description
AI Resource Optimization	Optimizing network resources, bandwidth allocation, and energy consumption for efficient operations.
Energy-efficient IoT	Utilizing AI techniques to optimize energy usage in IoT devices, prolonging battery life.

Moreover, Massive MIMO, a key technology in 5G networks, leverages many antennas to improve spectral efficiency and increase network capacity. This enables simultaneous communication with numerous IoT devices, enhancing overall network performance. In parallel, Artificial Intelligence plays a pivotal role in optimizing IoT performance. AI algorithms can process massive amounts of data from IoT devices and extract valuable insights, patterns, and trends. This enables data-driven decision-making, predictive analytics, and real-time optimizations for various IoT applications. AI also contributes to IoT security by identifying anomalies, analyzing behaviors, and predicting potential threats, thereby enhancing IoT ecosystems' overall resilience and robustness. IoT performance can be significantly enhanced by combining the strengths of 5G, Massive MIMO, and AI. The increased bandwidth, reduced latency, and improved network capacity of 5G networks enable seamless connectivity and efficient data transmission. Massive MIMO complements 5G by optimizing spectral efficiency and accommodating the massive number of connected IoT devices. Meanwhile, AI-driven data analytics and intelligent network management enhance IoT performance by extracting insights, optimizing resources, and ensuring secure and reliable operation.

Section 1 presents the enormous potential of 5G and AI integration for fostering innovation and progress in various industries. Section 2 presents the related work on Enabling technologies connected with 5G in IoT applications. Section 3 examines the methodology with experimental result. Section 4 presents the simulation result of different network configuration parameters and 5G Multi-tier network configurations. Section 5 discusses the research gap, and next section presents the conclusion of the paper.

A. CONTRIBUTION OF RESEARCH WORK

Our research study makes the following significant contributions:

- The main focus is to provide a general understanding of the recent research and help newcomers to understand the essential modules and trends.
- The Paper presents a 5G-based smart healthcare architecture with advanced MIMO.
- Discuss advanced security and reduced unauthenticated attacks from different platforms.
- An overview of existing security issues' fixes and potential new technologies and fixes for the security of 5G-based smart healthcare networks were presented.
- Finally, the paper highlights a number of research concerns as well as possible future research areas for 5G-based smart healthcare security.

TABLE 5. Industry-specific Applications

Aspect	Description
Smart Cities	Utilizing 5G and AI for intelligent infrastructure, traffic management, and energy efficiency.
Healthcare	Enhancing remote monitoring, personalized healthcare, and efficient patient management.
Industrial Automation	Optimizing industrial processes, predictive maintenance, and automation for improved productivity.

B. INTRODUCTION TO IOT AND ITS CHALLENGES

Introduction to IoT and its Challenges Provide an overview of the Internet of Things (IoT) and its challenges in terms of connectivity, scalability, and data processing. The paper discuss the need for advanced technologies like 5G, Massive MIMO, and AI to address these challenges and unlock the full potential of IoT.

C. UNDERSTANDING 5G TECHNOLOGY

Explain the key features and capabilities of 5G technology, such as high data rates, ultra-low latency, and massive device connectivity. The paper discuss how 5G networks are designed to support the requirements of IoT applications and enable seamless communication between IoT devices.

D. EXPLORING MASSIVE MIMO

Describe the concept of Massive Multiple-Input Multiple-Output (MIMO) technology and its role in 5G networks. The paper discuss how Massive MIMO utilizes a large number of antennas to improve spectral efficiency, increase capacity, and enhance overall network performance, thereby benefiting IoT applications.

E. LEVERAGING 5G FOR ENHANCED IOT CONNECTIVITY

Analyze how 5G networks provide enhanced connectivity for IoT devices. The paper discuss the use of 5G's increased bandwidth and reduced latency to support a massive number of connected devices, enable real-time communication, and facilitate seamless data transfer in IoT ecosystems.

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2023.3317174

F. AI-DRIVEN IOT DATA ANALYTICS

Explain how Artificial Intelligence (AI) techniques can be applied to IoT data analytics. The paper discuss the use of AI algorithms for real-time data processing, pattern recognition, and predictive analytics, enabling actionable insights and improved decision-making for IoT applications.

G. AI-ENABLED NETWORK MANAGEMENT

Explore the role of AI in managing and optimizing IoT networks. The paper discuss how AI algorithms can be used for intelligent resource allocation, dynamic network optimization, and predictive maintenance, resulting in improved network performance and efficient utilization of IoT resources.

H. ENHANCING IOT SECURITY WITH AI AND 5G

Address the critical aspect of IoT security and the role of AI and 5G in enhancing it. The paper discuss how AI can be leveraged for anomaly detection, behavior analysis, and threat prediction to identify and mitigate security risks in IoT networks. Explain how 5G's advanced security features can complement AI-driven security measures for robust IoT security.

I. EDGE COMPUTING AND 5G-ENABLED AI

The paper discuss the synergy between edge computing, 5G, and AI in enhancing IoT performance. Explain how edge computing, empowered by 5G connectivity and AI capabilities, enables real-time data processing at the network edge, reducing latency, enhancing reliability, and supporting time-sensitive IoT applications.

II. RELATED WORK

The paper [29] presents the application of Artificial Intelligence (AI) has changed H-IoT systems at nearly every level. The fog/edge concept brings processing power closer to the deployed network, hence minimising several issues. While big data provides for the management of massive amounts of data. Furthermore, Software Defined Networks (SDNs) add flexibility to the system, while blockchains discover the most unique use cases in H-IoT systems. The Internet of Nano Things (IoNT) and Tactile Internet (TI) are driving H-IoT application innovation. This article investigates how these technologies are reshaping H-IoT systems, as well as the future path for increasing Quality of Service (QoS) using these new technologies.

The study presented [12] a smart-healthcare system based on Edge-Cognitive-Computing (ECC). Using cognitive computing, this system can monitor and analyse individuals' physical health. It also modifies the computing resource allocation of the whole edge computing network holistically based on each user's health-risk grade. The trials reveal that the ECC-based healthcare system gives a better user experience and adequately optimises computer resources, while also dramatically boosting patient survival rates in a sudden emergency.

This article [23] discusses people's contributions to IOT in the healthcare sector, as well as the application and future problems of IOT in terms of medical services in healthcare. We expect that our research will be valuable to scholars and practitioners in the field, assisting them in understanding the enormous potential of IoT in the medical sector and identifying important problems in IOMT. This approach will also aid scholars in their understanding of IOT applications in the healthcare arena. This work will assist scholars in comprehending the historical contribution of IOT in the healthcare business.

The proposed [10] outcome of the paper is to build a system to provide world-class medical aid to patients even in the most remote areas where there are no hospitals by connecting over the internet and gaining information about their health status via the wearable devices provided in the kit that use a raspberry pi microcontroller to record the patient's heart rate and blood pressure. In the event of a medical emergency, the system should notify the patient's family members and doctor of the patient's current health state and complete medical information. Using data mining, the obtained information may be utilised to analyse and forecast chronic ailments or other diseases such as heart attacks in the early stages.

The proposed architecture [18]incorporates the following core technologies: a 5G-IPv6 communication network, a context-aware health situation identification-based similarity measure, and a secure data exchange mechanism based on blockchain. Finally, a prototype system for monitoring hypertensive heart disease has been built, showing its usefulness in a real-world setting. When combined with the data of 45 patients, the prototype system can identify health problems with 96.34% accuracy, 92.46% sensitivity, and 93.62% specificity, while considerably lowering latency and enhancing data sharing security.

In this research, the paper presents [1] a clustering technique based on game theory (i.e., mixed strategy) to pick optimum cluster heads (CHs) and transmit data from a cluster head (CH) to a base station (BS). The simulation reveal that our suggested method outperforms the LEACH protocol in terms of network lifespan and energy usage. We utilised the MATLAB environment to simulate our suggested system and compare it to the LEACH technique.

Utilizing computer-based intelligence tactics has gained the attention of many experts in the last ten years due to their variety of benefits. Future communications will benefit in a few ways from the use of artificial intelligence in 5G and, by extension, IoT. Based on an understanding of the key advances in 5G, [19] has reviewed several interesting research topics in simulated intelligence for 5G developments. In addition, they focused on establishing plan standards for the improvement of the 5G network [15], optimum resource designation, speed increases for the 5G actual layer brought together, joint enhancement of the start and finish of the actual layer, etc. The resource management solutions for 5G and IoT networks based on machine learning and deep learning have been reviewed in-depth and from top to bottom by [19] and [21]. [3] examined how IoT-produced data is managed for machine learning research and highlighted the existing challenges in helping wise decisions in the IoT environment. IoT apps can take advantage of other IoT applications in an adaptive way according to the proposed framework.

To manage the IoT gateway bottleneck and improve control performance, [31] presented a two-level control system with master and slave levels. The control delay of significant nodes could be decreased by the authors by 30.56%. For SDN-based cloud IoT networks,suggested architecture for an intelligent intrusion detection system achieves a potential improvement in anomaly detection and handling bottleneck problem. Although latency was not taken into account as a performance metric, the authors were able to reduce the load imbalance between SDN controllers. In their suggested energy-efficient SDN controller architecture, [37] achieved high throughput, low energy consumption, and low delay in an IoT environment.

In order to improve the security and energy optimisation of IoT devices, [24] presented an architecture for IoT networks that combines BC technology with SDN controller.62 Although the authors were able to achieve high security, low latency, and low energy usage, the SDN controller becomes overworked trying to stop selfish nodes.

To reduce network latency and boost reliability, [34] suggested an action and reward-based algorithm for SDN-assisted wireless power distribution in the IoT environment. In order to tackle COVID-19 utilising a drone application and established an edge intelligence architecture with 6G-enabled services. Although the architecture was well suited for 6G features, communication overhead remained a concern. An SDN-based IoT architecture was presented by [4] to address COVID-19 scenarios. Throughput, reaction time, and packet failure rate were used as the basis for the result analysis; latency was not taken into account. The authors used the 5G network for highly mobile UAV equipment to accomplish security, trust, and effective network connectivity, but energy efficiency remained a problem. In a heterogeneous IoT context, prediction-based strategy to manage the load on the SDN control plane and distribute traffic efficiently.

The paper [17] presented strong zero-watermarking technique based on federated learning to address the teledermatology healthcare framework's privacy and security concerns. Federated learning is used to train the sparse autoencoder network in this technique. To extract image characteristics from a dermatological medical picture, a trained sparse autoencoder network is used. Two-dimensional Discrete Cosine Transform (2D-DCT) is applied to image characteristics in order to determine low-frequency transform coefficients for zero-watermarking. When compared to alternative zero-watermarking systems, experimental findings reveal that the suggested scheme is more resilient to conventional and geometric attacks and provides greater performance.

The paper [6] presented the Software Defined Networking (SDN) technology, which is used to realise mobility management for NDN, is one of the plausible options. The separation of the network control plane and the data plane is important to SDN. The data plane is responsible for data transmission, whereas the control plane is in charge of network control. The network control plane and data plane are detached, resulting in a more programmable environment and the opportunity for external applications to determine network behaviour. The key characteristics of the SDN, such as programmability, flexibility, and centralised control, make it a simple and scalable network. To address the issue of NDN mobility, we suggest the development of a software-defined mobility architecture for NDN, in which the SDN plays a role.

The paper [13] proposed a complete assessment of the Metaverse for healthcare, focusing on the current state of the art, the enabling technologies for implementing the Metaverse for healthcare, prospective applications, and associated initiatives. The problems in adapting the Metaverse for healthcare applications are also noted, and some solutions are presented as future research paths.

The paper [30] described The federated learning-based system collects model updates from two clients and trains the Deep Neural Network (DNN) model on the dataset separately. Each customer checks the findings three times to reduce the over-fitting issue. Experiments demonstrate that the DNN model has an accuracy of 80.09%, indicating that the proposed framework has the capability of detecting side-channel assaults.

The paper [33] presented the Modular Encryption Standard (MES) and layered modelling of security mechanisms. The performance study demonstrates that the suggested work outperforms other frequently used algorithms for health information security in the MCC environment in terms of higher performance and supplementary qualitative security assuring features.

The paper [22] describes a generalised collaborative framework called the collaborative shared healthcare plan (CSHCP) for assessing people's cognitive health and fitness utilising ambient intelligence applications and machine learning techniques. CSHCP supports daily physical activity recognition, monitoring, and evaluation, as well as the development of a shared healthcare plan through cooperation among many stakeholders, including doctors, patient guardians, and close community circles.

Future Portability Management (MM) arrangements in the cell network will be examined in a new study by [11]. The suggested method includes reducing delays during handoff and testing versatile management in both low-speed and high-speed scenarios in order to reduce delays and enhance QoS performance.

Lean radio resource management engineering has been provided by [32] that combines cutting-edge advances in machine learning with a lot of data that is already present in the network from estimates and framework perceptions.

In [2] handle the network aspects with a smaller scope, such as erroneous expectations and unexpected network conditions. For the purpose of assisting RAN in making resource planning decisions, RSS can expertly switch the weighting of the expectation and online choice modules depending on the amount of authentic traffic data that is readily available. By taking into account the emerging 5G models and administration kinds (eMBB, mMTC, URLLC), has provided a brief overview of the patterns in versatile management. The author focused on the advancements in portability management that were made in fagging as a result of unique design elements, taking into account the requirements of various vertical use cases that would lead to the required throughput, inactivity, and adaptability.

In order to investigate their complexities for 5G correspondences, [31] have provided updated estimates for bunching towers dependent on location and for pressing base band unit groups based on the projection of adaptability and traffic designs.

In-depth research on the most recent cutting-edge resource management ideas for this engineering has been published by [8]. Radio resource management (RRM) and computational resource management (CRM) strategies were used to categorise the resource management techniques. Then, based on the investigative methodologies used, both of the operations were additionally categorised and assessed.

[39] have presented a review investigation of various advancement strategies that were being looked at for addressing resource challenges in 5G and IoT. The classes discussed these arrangements and their advantages and disadvantages while looking at fresh and exciting exploration directions. One of the areas under consideration specifically noted how range accessibility had a tendency to.

A summary of the justifications for combining massive MIMO, NOMA, and interleave division multiple entrances (IDMA) in a connected system has been provided by [40]. The authors emphasize multiple client acquisition, which alludes to the benefits of allowing multiple user transmission in massive MIMO. Such addition can result in rate increases on tens or even several occasions. The existing designs' reliance on exact channel state data (CSI) presents the main challenge in achieving multi-client acquisition.

TABLE 6. 5G with AI for IoT application

Research Study	Objective
"AI-Enabled Resource Management in 5G Networks" [14]	Investigates AI-based resource management techniques in 5G networks, including resource allocation, scheduling, and optimization.
"Integrating AI and 5G for Autonomous Vehicles" [16]	Explores the integration of AI algorithms and 5G networks to enhance autonomous driving capabilities, including decision-making, object recognition, and real-time communication.
"AI-Driven Smart Healthcare in 5G Networks" [35]	Examines the use of AI in 5G networks for remote patient monitoring, telemedicine, and real-time analysis of medical data, providing personalized healthcare solutions.
"Security and Privacy in AI-Enabled 5G Networks [36]"	Discusses the security and privacy challenges associated with AI integration in 5G networks, proposing solutions for data protection, encryption, and access control
"AI-Based Traffic Management in 5G-Enabled Smart Cities" [38]	Explores AI-driven traffic management systems in 5G-enabled smart cities, optimizing traffic flow, reducing congestion, and improving urban mobility.
"AI-Enhanced Public Safety using 5G Networks" [26]	Investigates the use of AI algorithms and 5G networks for real-time video analytics, facial recognition, and situational awareness in public safety and emergency response scenarios.
"Machine Learning for Energy Optimization in 5G-Enabled Smart Grids" [20]	Examines the application of machine learning techniques in 5G-enabled smart grids for energy optimization, demand response, and efficient power distribution.
"AI-Driven Augmented and Virtual Reality in 5G Networks" [28]	Explores the combination of AI and 5G networks for delivering immersive augmented and virtual reality experiences, enabling real-time rendering, content delivery, and interactive applications.
"Precision Agriculture using AI and 5G Networks" [7]	Discusses the application of AI and 5G networks in precision agriculture, including real-time monitoring, analysis of agricultural data, and autonomous machinery for improved crop management.
"AI-Powered Financial Services in 5G Networks" [27]	Investigates the use of AI algorithms in 5G networks for fraud detection, risk assessment, personalized recommendations, and efficient financial transactions in the financial services sector.

TABLE 7. IoT use cases and/or applications relative to the relevant sector-based quantitative performance metrics

Different Sectors	Depiction of IoT use cases
buildings & constructions	IoT devices are used for building automation, monitoring structural integrity, and managing energy usage. QoS is crucial for real-time monitoring of equipment and systems, as well as ensuring the safety and security of occupants. Low latency is essential for immediate response to critical events such as fire alarms or equipment malfunctions
energy sector	IoT devices in the energy sector are used for smart metering, grid optimization, and renewable energy management. QoS is important for accurate meter readings and efficient energy distribution. Low latency is needed for real-time grid monitoring and control to prevent power outages and balance energy supply and demand.
consumer & home	IoT devices in homes include smart appliances, security cameras, and home automation systems. QoS is essential for seamless user experience, and low latency is critical for real-time interaction with devices. Security and data privacy are also paramount in this sector.
health& life science	In healthcare, IoT devices include remote patient monitoring, medical wearables, and telemedicine tools. QoS is vital for ensuring patient health data is transmitted accurately and reliably. Extremely low latency is crucial for real-time monitoring and diagnosis in critical healthcare scenarios.
industrial; transport & logistics	Industrial IoT (IIoT) devices are used for process automation, predictive maintenance, and supply chain management. QoS is essential for maintaining production efficiency, and low latency is required for real-time insights into machinery performance and process optimization. IoT devices in the transport and logistic sector includes vehicle tracking, fleet management, and cargo monitoring.
retail	IoT devices are used in retail for inventory management, customer analytics, and personalized shopping experiences. QoS ensures accurate inventory tracking and data-driven insights.
security & public safety	IoT devices in this sector include surveillance cameras, access control systems, and emergency response systems. QoS ensures reliable transmission of security data, and low latency is vital for real-time threat detection and emergency response.
ICT	In the ICT sector, IoT devices may include networking equipment, data center management systems, and network monitoring tools. QoS is important for stable network operation and data transmission.

According to [9], huge MIMO has advantages in terms of limit and energy effectiveness. Regarding phantom efficiency and energy productivity, execution evaluations of large MIMO were provided. The significant challenges for the practical implementation of massive MIMO were discussed in detail.

By taking into account the emerging 5G models and administration kinds (eMBB, mMTC, URLLC), [25] have provided a brief overview of the patterns in versatile management. The author focused on the advancements in portability management that were made in fagging as a result of unique design elements, taking into account the requirements of various vertical use cases that would lead to the required throughput, inactivity, and adaptability. In order to investigate their complexities for 5G correspondences, [31] have offered new estimates for pressing baseband unit groups based on the forecast of versatility and traffic designs and for bunching towers reliant on the place.

In-depth research on the most recent cutting-edge resource management ideas for this engineering has been published by [8]. Radio resource management (RRM) and computational resource management (CRM) strategies were used to categorize the resource management techniques. Then, based on the investigative methodologies used, both of the operations were additionally categorized and assessed. Form the above survey, it is evident that Quality of Service (QoS) and latency requirements for IoT devices can vary significantly based on the specific industry or sector they are deployed in. Different industries have distinct use cases, operational needs, and regulatory considerations that impact their QoS and latency requirements. Brief details of the different sectors for the IOT needs are depicted in Table 7.

III. METHODOLOGY AND RESULT ANALYSIS

It starts with identifying the needs and requirements, followed by system design, data collection, processing, communication, integration, testing, deployment, evaluation, and continuous improvement. Following this methodology can help ensure a systematic and effective integration process, leading to a successful implementation of the smart health care system utilizing 5G and AI technologies.

IoT systems with WSN support are useful for many different things. Each SHS application shares a necessity for energy efficiency, or the on-field sensor nodes' decreased energy consumption. In addition, SHS applications must meet critical standards for communication latency, security, and QoS performance. The suggested design for a smart healthcare system, represented in Figure 2, includes many levels of Industry 4.0 (IoT) standards, including edge, fog, and storage layers. The amount of nodes that periodically gather patient data from various body sensors make up the edge layer. Patients who have body sensors installed are identified by the red nodes. The fog nodes at the fog layer received the medical data wirelessly provided from the edge layer. The edge devices send the locally gathered data to the fog node. Routers, access points, gateways, and base stations may all

TABLE 8. Methodological Step on 5G Industry norms Artificial Intelligence-enabled communication systems

Step	Description
Step 1: Identify Needs	Identify the specific needs and challenges in the smart health care system that can be addressed through the integration of 5G and AI.
Step 2: Requirements	Define the requirements for the integration, considering factors such as data security, real-time communication, and scalability.
Step 3: System Design	Design the overall system architecture, incorporating 5G infrastructure, AI algorithms, and IoT devices for data collection and analysis.
Step 4: Data Collection	Implement mechanisms for collecting health data from IoT devices, ensuring privacy, security, and interoperability.
Step 5: Data Processing	Develop AI algorithms for data processing, analysis, and predictive modeling, considering the specific health care needs and objectives.
Step 6: Communication	Establish 5G-enabled communication channels for seamless and reliable data transmission between IoT devices, healthcare professionals, etc.
Step 7: Integration	ntegrate the AI algorithms, data analytics, and communication infrastructure into the smart health care system using 5G industry norms.
Step 8: Testing	Conduct rigorous testing to ensure the system's functionality, performance, and compliance with healthcare regulations and standards.
Step 9: Deployment	Deploy the integrated system in real-world healthcare settings, considering factors such as user training, scalability, and resource management.
Step 10: Evaluation	Evaluate the performance and effectiveness of the integrated system, using metrics such as patient outcomes, cost-efficiency, and user satisfaction.
Step 11: Continuous Improvement	Continuously monitor and improve the system, incorporating user feedback, technological advancements, and emerging industry standards.

function as fog nodes. Data from the fog nodes is finally received by the storage layer for storage and analysis. Many programmes access, analyse, and make decisions using cloud storage services.

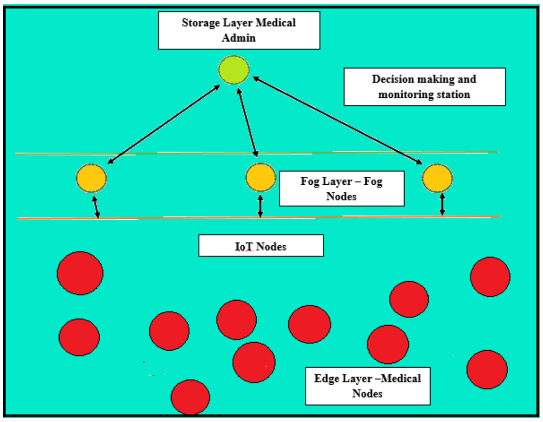


Fig 2. System design for smart healthcare system using 5G and IoT

Since the 5G standard is necessary for network communications, we develop the 5G communication lines using the parameters listed below for performance evaluation and simulation. This paper's goal is to analyse the performance

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2023.3317174

of current 5G resource management methods for networks that support the Internet of Things. We've used techniques like the Multi-Traffic Internet of Things [8]. The approaches are used in accordance with the methodology described. In macrocells, parameters of Base Station (bs) operating power are configured as:
A_{macro} = 28.76 and B_{macro}=396.67W, respectively. In small cells, parameters of bs operating power are confgured as A_{macro}=8.98 and B_{macro}=84.80 W, respectively. The lifetime of Macro BS (mbs) Tmacro lifetime and Small BS (sbs). Tsmall lifetime are assumed as 12 and 7 years, respectively. Other parameters are listed in Table 1.

TABLE 9. 5G multi-tier network confguration parameter

Wireless backhaul frequencies	5.8 GHz	28 Hz	60 GHz
A_{macro}	21.45	21.45	21.45
B_{macro}	354W	354W	354W
A_{small}	7.84	7.84	7.84
B_{small}	71W	71W	71W
Energy consumption	25%	25%	25%
Time Period	7Years	7Years	7Years

TABLE 10. Network confguration parameters

Number of small cells	35, 60, 85, 110, 135, 160
Trafc patterns	CBR (constant bit rate)
Network size (X×y)	1400×1400
Max SPEED	12 m/s
Simulation time	600
Transmission packet rate time	20 m/s
Pause time	2.0 s
Routing protocol	Shortest path tree
MAC protocol	902.3

IV. SIMULATION RESULT

Simulation outcomes By creating networks of various tiny cells in accordance with the other simulation parameters listed in Table VIII, we put the techniques into practise in NS2. Modern methods are assessed using crucial performance parameters like:

A. AVERAGE DELAY

The average delay in a 5G Industry norms Artificial Intelligence (AI) enabled smart health care system refers to the average time it takes for data packets to travel from the source to the destination. This delay can vary depending on various factors such as network congestion, data processing time, and the distance between the source and destination.The average delay can be calculated by collecting data on packet transmission times and then calculating the average over a certain period or across multiple test scenarios. This value provides insights into the overall efficiency and responsiveness of the smart health care system, with lower values indicating faster data transmission and reduced latency, which are desirable for real-time health care applications. It is important to note that the specific average delay values will vary depending on the system design, network conditions, and the workload placed on the system. Thus, conducting performance evaluations and simulations specific to the targeted smart health care system is necessary to obtain accurate and relevant average delay measurements.

Typical delay This statistic figures out how long it typically takes for a packet to travel from its origin at all sources to its destination nodes. It's calculated as:

$$D = \sum_{i=1}^{N}(d_t + d_p + d_c + d_q)/N \tag{1}$$

where N is number of total transmission links, d_t is transmission delay of i^{th} link, d_p is propagation delay of i^{th} link, d_c is processing delay of i^{th} link, and d_q is transmission delay of i^{th} link.

B. AVERAGE ENERGY CONSUMPTION:

To determine the specific average energy consumption in a smart health care system, a comprehensive assessment or measurement of energy usage needs to be conducted. This can involve monitoring power consumption of individual components, such as IoT devices and network infrastructure, as well as estimating the energy consumption associated with AI algorithms and data processing.

The energy consumption can be quantified in terms of power consumption (in watts) or energy consumption (in joules) over a defined period. By collecting data on energy usage from different components of the system and calculating the average energy consumption, insights can be gained regarding the overall energy efficiency of the smart health care system.

It computes the average energy consumption by entire network after the end of simulation by measuring the remaining consumed energy of all nodes. The total energy consumed E^{tot} is computed as:

$$E^{tot} = \sum_{i=1}^{N} E^{initia} - E^{consumed} \tag{2}$$

where E^{initia} and $E^{consumed}$ are initial and consumed energy of ith node, respectively. N is total number of nodes in network. The average consumed energy is computed as:

$$E^{avg} = E^{tot}/N \tag{3}$$

C. PACKET DELIVERY RATIO (PDR):

It is important to note that the specific packet delivery ratio values will depend on factors such as network conditions, data volume, system configuration, and the efficiency of the communication infrastructure and AI algorithms employed. Therefore, conducting performance evaluations and simulations specific to the targeted smart health care system is necessary to obtain accurate and relevant packet delivery ratio measurements. The percentage of packets transmitted

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2023.3317174

by the various sources of the various traffic patterns and received by the destinations is calculated.

$$P = (p_r/p_g) \tag{4}$$

where, P_r is number of received packets and P_g number of generated packets.

D. AVERAGE THROUGHPUT:

A higher average throughput indicates a system that can handle a larger volume of data and transmit it more efficiently. In the context of a smart health care system, a higher average throughput is desirable as it allows for timely and reliable communication of health-related data, such as patient records, imaging data, or real-time monitoring information. The total number of packets sent per second—or the total number of messages delivered per second—is calculated using this statistic. In Kbps, the typical throughput is:

$$P = (R/(T_2 - T_1)) \times (8/1000) \tag{5}$$

where R is complete received packets at all destination nodes, T_2 is simulation stop time and T_1 simulation start time. The table below shows the result of average throughput, average communication latency, average energy consumption, and average PDR.

In an era of unprecedented technological advancement, the convergence of cutting-edge technologies is reshaping industries across the spectrum, and healthcare is no exception. The intersection of 5G network standards and artificial intelligence (AI) has given rise to a new paradigm in healthcare: the Smart Healthcare System. This transformative synergy holds the promise of revolutionizing medical services, patient care, and healthcare management in ways previously thought unimaginable. The marriage of 5G network norms and AI capabilities to create smart healthcare systems represents a monumental step forward for the healthcare industry. By fostering real-time connectivity, data-driven insights, and personalized care, this fusion addresses critical healthcare challenges and sets the stage for a future where timely and efficient healthcare is accessible to all. As 5G networks continue to expand and AI technologies mature, the synergy between the two has the potential to reshape the healthcare landscape, ultimately leading to better patient outcomes and improved quality of life. The integration of AI and 5G in smart health care systems also enhances the efficiency and effectiveness of resource management. AI algorithms can optimize the allocation and utilization of network resources, such as bandwidth and computing power, based on real-time demands and priorities. This ensures that critical health data is prioritized, network congestion is minimized, and resources are utilized in the most efficient manner. Moreover, AI-driven energy optimization techniques can help reduce energy consumption in IoT devices and networks, prolonging battery life and promoting sustainability.

TABLE 11. Outcome of average throughput, average communication delay, average energy consumption, and PDR(%)

Method	Throughput	Small Cells	Delays	Small Cells	Energy Cells	Small Cells	PDR
MT-IoT	110Mbps	25	20s	25	0.7	25	72%
IRS-5G	120Mbps	25	20s	25	0.9	25	77%
RO-5G	135Mbps	25	20s	25	1.1	25	80%
MT-IoT	160bps	50	34s	50	1.2	50	78%
IRS-5G	175Mbps	50	30s	50	1.4	50	80%
RO-5G	185Mbps	50	32s	50	1.5	50	82%
MT-IoT	190Mbps	75	45s	75	1.8	75	80%
IRS-5G	210Mbps	75	42s	75	1.9	75	84%
RO-5G	220Mbps	75	43s	75	2.1	75	85%
MT-IoT	230Mbps	100	54s	100	2.2	100	82%
IRS-5G	240Mbps	100	50s	100	2.3	100	86%
RO-5G	260Mbps	100	52s	100	2.4	100	90%
MT-IoT	250Mbps	125	58s	125	3.5	125	85%
IRS-5G	255Mbps	125	55s	125	3.6	125	88%
RO-5G	285Mbps	125	57s	125	3.7	125	92%
MT-IoT	230Mbps	150	75s	150	5.0	150	88%
IRS-5G	260Mbps	150	70s	150	5.2	150	90%
RO-5G	370Mbps	150	72s	150	5.3	150	94%

TABLE 12. Application Requirement and Proposed System in 5G

Application	Latency	Link Reliability	Energy	Privacy
Smart Buildings	Median	Median	Low	High
Smart Devices	Median	Median	Low	High
Smart Farming	Tolerant	Median	Low	Median
Smart Energy	Median	High	Median	High
Smart Mobility	Median	High	Median	Median
AR and VR Service	Critical	Median	High	Median
Autonomous Driving	Critical	High	High	Critical
Urbun Monitoring	Tolerant	Median	Low	Median
Smart Healthcare System	Median	Median	Low	High

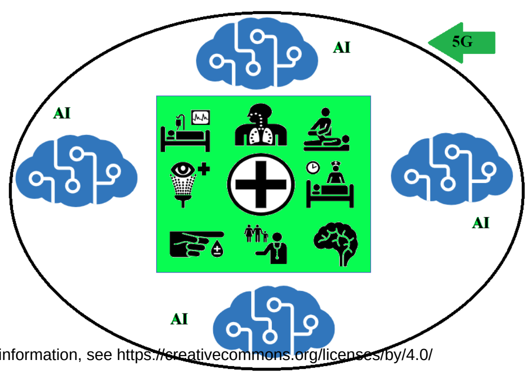


TABLE 13. Requirement of 5G norms AI for Smart Healthcare System

Characteristics	Model
Pervasive AI	Yes
Realtime Buffering	No
Cell Free Networks	Conceivable
Data Rate UPLINK	12Gbps
Data Rate DOWNLINK	22Gbps
Latency Rate	1.34ms
Satellite Integration	No
Intelligent Reflecting Surfaces	Conceivable
Uniform User Experience	60Mbps
Visible Light Communication	No
Spectral Efficiency	32Pps
THz Communication	No

Fig 3. 5G Industry norms Artificial Intelligence for Smart Healthcare System

However, adopting 5G Industry norms and AI in the smart healthcare system also brings challenges and considerations. Data privacy, security, interoperability, and ethical use of AI must be carefully addressed to maintain patient confidentiality and build trust in these advanced healthcare systems. Furthermore, collaborations between healthcare providers, technology vendors, and regulatory bodies are essential to establish standardized protocols, ensure interoperability among devices and systems, and overcome potential barriers to the widespread implementation of 5G and AI in healthcare.

The integration of AI and 5G in healthcare promises remarkable benefits, it also raises critical considerations, such as data privacy, security, and the need for robust infrastructure. Addressing these challenges is paramount to ensure the responsible and ethical implementation of Smart Healthcare Systems. By harnessing the potential of AI and 5G, healthcare stakeholders can embark on a journey towards a future where patient care is more personalized, accessible, and efficient than ever before.

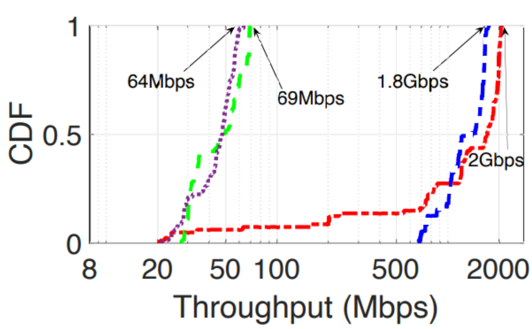


Fig 4.(a) Throughput measurements on mmWave 5G networks of a Smart Healthcare System

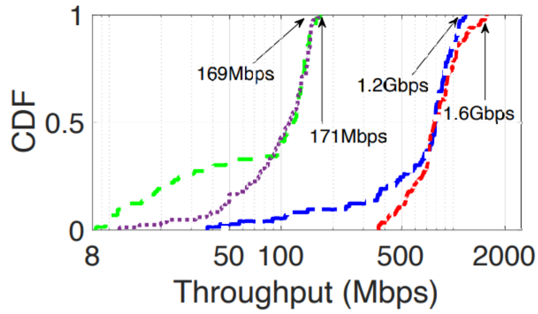


Fig 4.(b) Throughput measurements by sub-6GHz 5G networks of a Smart Healthcare System

Fig 4.(a) and Fig 4.(b) shows the different 5G network in Helathcare system.Those are CDF and sub-6GHz 5G networks.The Cumulative Distribution Function (CDF) can be used to analyze the throughput performance in a 5G network. Throughput refers to the rate at which data can be transmitted over a network and is typically measured in bits per second (bps) or megabits per second (Mbps). To analyze the throughput using CDF, you would gather data on the achieved throughput values for a set of users or locations within the 5G network. Then, you can calculate the CDF to understand the distribution of throughput values and the probability of achieving certain throughput levels.In the context of sub-6GHz 5G networks, sub-6GHz refers to the frequency range below 6 gigahertz (GHz) in which 5G networks can operate. These lower-frequency bands are known for their wider coverage and better penetration through obstacles compared to higher-frequency bands. Sub-6GHz signals can propagate over longer distances and provide wider coverage compared to higher-frequency bands. This makes them suitable for providing connectivity in suburban and rural areas.CDF stands for Cumulative Distribution Function. It is a mathematical function commonly used in probability theory and statistics to describe the distribution of a random variable. The CDF gives the probability that a random variable is less than or equal to a certain value.

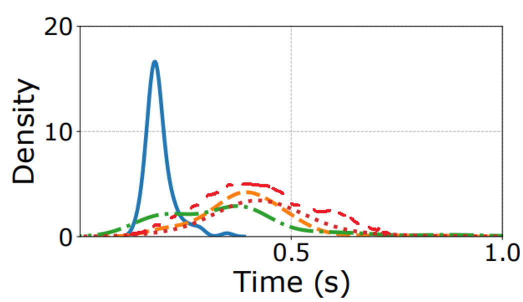
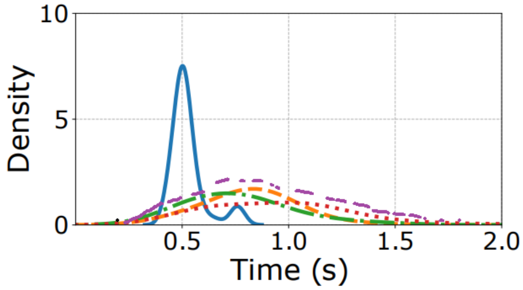


Fig 5.(a) Density measurements of Edge Server,10MB in 5G networks of a Smart Healthcare System



(b)

Fig 5.(b)Density measurements of Edge Server,100MB in 5G networks of a Smart Healthcare System

Fig 5.(a) and (b) define the Edge Server 10MB and Edge Server 100MB. These configurations refer to the processing capacity or throughput capabilities of the edge servers. However, it is important to note that specific configurations and measurements can vary depending on the network architecture and deployment strategy.it is challenging to provide specific density measurements for Edge Server 10 and Edge Server 100MB in 5G networks. The density of edge servers can vary significantly depending on the specific network requirements, deployment strategies, and the characteristics of the target area

In a detailed analysis of how 5G, Massive MIMO, and AI work together to enhance IoT performance, mathematical formulas can be used to model and quantify the effects of these technologies on various performance metrics. Here are some examples of mathematical formulas that can be employed in such an analysis:

Channel Capacity Calculation: The channel capacity (C) of a wireless communication system can be determined using the Shannon Capacity formula:

$$C = B * log2(1 + (SINR)) \tag{6}$$

where:

C is the channel capacity in bits per second (bps) B is the bandwidth available for communication in hertz (Hz) SINR is the Signal-to-Interference-plus-Noise Ratio, representing the ratio of the desired signal power to the combined interference and noise power. This formula can be used to analyze how the implementation of Massive MIMO and advanced 5G features impact the achievable channel capacity in an IoT network.

The paper explores the multifaceted ways in which AI-powered Smart Healthcare Systems, bolstered by the high-performance features of 5G networks, are poised to reshape healthcare delivery. We will delve into the key advantages and potential applications of this transformative synergy, including faster and more reliable data transfer, remote patient monitoring, telemedicine and virtual consultations, AI-driven diagnostics, predictive analytics, surgical assistance, efficient resource management, and improved emergency response. Latency Analysis: The latency (L) of an IoT system, including the communication delay and processing time, can be estimated using the following formula:

$$L = T_{trans} + T_{prop} + T_{proc} \tag{7}$$

where:

T_{trans} is the transmission time, calculated as the ratio of the data size (D) to the data transmission rate (R):

$$T_{trans} = D/R \tag{8}$$

T_{prop} is the propagation time, which is the time taken for the signal to travel from the source to the destination T_{proc} is the processing time, representing the time required for data processing at the source and destination nodes. This formula can be utilized to assess how the integration of AI algorithms and optimizations in 5G and Massive MIMO systems affects the overall latency of IoT communications.

Energy Efficiency Evaluation: The energy efficiency (EE) of an IoT system can be quantified using the following formula:

$$EE = Data_{throughput}/Power_{consumption} \tag{9}$$

where:

Data throughput $(Data_{throughput})$ represents the amount of data transmitted or processed per unit time Power consumption $(Power_{consumption})$ denotes the energy consumed by the system during the same time period. This formula can be utilized to evaluate how the integration of AI techniques, 5G network enhancements, and Massive MIMO technology impacts the energy efficiency of IoT devices and networks. These are just a few examples of mathematical formulas that can be employed in the detailed analysis of how 5G, Massive MIMO, and AI work together to enhance IoT performance. The specific formulas used will depend on the performance metrics under consideration and the objectives of the analysis.

Smart Healthcare Systems leverage the capabilities of AI to analyze vast amounts of medical data, facilitate real-time communication, and enable seamless integration of various healthcare processes. With the advent of 5G communication, the possibilities for healthcare optimization have expanded exponentially, offering high-speed data transfer, low latency, and the ability to connect a multitude of devices and systems with unparalleled reliability.

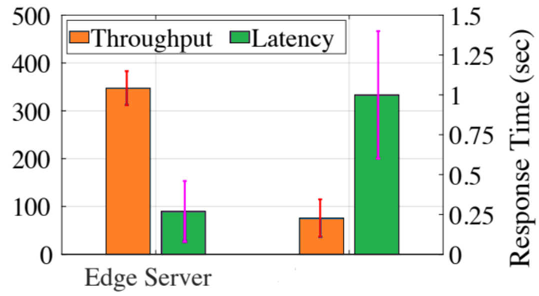


Fig 6.Performance of Throughput and Latency

In conclusion, the integration of 5G Industry norms and Artificial Intelligence in the smart health care system holds immense potential for transforming healthcare delivery. The combination of high-speed connectivity, real-time data analysis, and intelligent decision-making enables improved patient care, enhanced remote monitoring, personalized medicine, and optimized resource utilization. However, careful consideration must be given to ethical, privacy, and security aspects to ensure the responsible and effective implementation of these technologies. With proper planning, collaboration, and innovation, 5G Industry norms and AI have the power to revolutionize healthcare and provide a new era of connected and intelligent health care systems.

V. RESEARCH GAPS DISCUSSION

Analysis of research gaps in 5G standards for IoT applications involves identifying areas where further research is needed to address challenges and limitations. Here are some key research gaps in this domain:

A. INTEROPERABILITY AND STANDARDIZATION:

There is a need for standardized protocols and interfaces to ensure seamless interoperability between IoT devices and 5G networks. Research is required to develop and optimize protocols that facilitate the integration of diverse IoT devices, platforms, and technologies with 5G networks, enabling efficient communication and data exchange.

B. SCALABILITY AND NETWORK CAPACITY:

As the number of IoT devices connected to 5G networks continues to grow exponentially, research is needed to address scalability challenges. This includes investigating techniques for efficient device management, network resource allocation, and traffic management to accommodate the increasing IoT device density and data traffic demands.

C. ENERGY EFFICIENCY:

IoT devices often operate on limited power sources and require energy-efficient solutions to prolong battery life. Research gaps exist in developing energy-efficient communication protocols, power management techniques, and resource optimization strategies for IoT devices operating within the 5G network environment. When evaluating the quantitative performance metrics of energy efficiency, several metrics can be considered.

- Energy Consumption: Measure the total energy consumed by the 5G network infrastructure, including base stations, core network components, and data centers. This metric can be expressed in kilowatt-hours (kWh) or joules (J).
- Energy Efficiency Ratio: Calculate the energy efficiency ratio, which is the ratio of the data transmitted/received to the energy consumed. It can be expressed in bits per joule (bps/J) or megabits per watt (Mbps/W). A higher energy efficiency ratio indicates a more efficient use of energy for data transmission.
- Traffic Energy Efficiency: Assess energy efficiency based on the amount of energy consumed per unit of data traffic handled by the network. It is calculated by dividing the total energy consumed by the network over a given period by the total amount of data traffic transmitted/received during that period.

D. SECURITY AND PRIVACY:

Security is a critical concern in IoT applications, and the integration of 5G introduces additional security challenges. Research is needed to develop robust security mechanisms and privacy-preserving techniques that protect IoT devices, networks, and sensitive data from emerging threats such as unauthorized access, data breaches, and malicious attacks.

E. QUALITY OF SERVICE (QOS) AND LATENCY:

Different IoT applications have varying QoS requirements, and meeting these requirements is crucial for reliable and real-time data transmission. Research is needed to optimize QoS provisioning in 5G networks for IoT applications, considering factors such as latency reduction, traffic prioritization, and network optimization to ensure seamless and high-performance connectivity.

F. COST AND ECONOMIC CONSIDERATIONS:

The deployment of 5G networks for IoT applications involves significant costs, including infrastructure investments, device deployment, and maintenance. Research is needed to analyze the cost-effectiveness of 5G-enabled IoT deployments, develop economic models, and explore innovative business models that consider the diverse requirements and constraints of different IoT applications. From these results, We discovered that none of the protocols in use managed to accomplish the full performance trade-off. Analysis of research gaps Applying the 5G standards to IoT applications raises issues about managing radio resource optimisation and interference, according to the current state of 5G as analysed in this study and the simulation findings produced.

- In this situation, the conventional approaches to managing radio resource and interference in single-level networks may not be effective, necessitating further research into the interference management problem.
- Massive MIMO and 5G technologies now in use are unable to handle the heterogeneity and scalability issues of the Internet of Things.
- When employing 5G for multi-traffic data transfer in the IoT, it is a difficult task to take into account the resource-constrained IoT devices.
- The simulation findings demonstrated that there are no performance trade-offs amongst techniques, i.e., no particular approach stands out as superior than the others.

VI. CONCLUSION AND FUTURE WORK

This research analyzes how 5G, Massive MIMO, and AI work together to enhance IoT performance. This paper reviews current studies and discusses the research needs for a

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2023.3317174

future roadmap based on those findings. We have also used 5G and IoT techniques to create a unique paradigm for smart healthcare monitoring. The approach was implemented and tested utilizing the most modern 5G interference and resource management techniques. The process was implemented and used the most current 5G interference and resource management techniques. The simulation findings highlight the areas for more investigation. The findings will guide the optimization of IoT systems, ensuring improved connectivity, reduced latency, enhanced energy efficiency, and efficient data processing in the evolving landscape of advanced wireless technologies. In the context of future work for an AI-Assisted Smart Healthcare System using 5G communication, several areas can be explored to further enhance the system's capabilities and address potential challenges. Here are some potential avenues for future research which aims to examine the synergistic effects of 5G, Massive MIMO, Real-time Monitoring and Intervention and Enhanced AI Algorithms on bolstering the performance of IoT. By exploring these areas in future work, the AI-Assisted Smart Healthcare System can continue to evolve and make significant contributions in improving healthcare delivery, patient outcomes, and overall healthcare ecosystem.

REFERENCES

[1] AHAD, A., TAHIR, M., SHEIKH, M. A. S., HASSAN, N., AHMED, K. I., AND MUGHEES, A. A game theory based clustering scheme (gcs) for 5g-based smart healthcare. In 2020 IEEE 5th International Symposium on Telecommunication Technologies (ISTT) (2020), IEEE, pp. 157–161.

[2] AKKARI, N., AND DIMITRIOU, N. Mobility management solutions for 5g networks: Architecture and services. Computer Networks 169 (2020), 107082.

[3] AL-HAYANI, B., AND ILHAN, H. Efficient cooperative image transmission in one-way multi-hop sensor network. The International Journal of Electrical Engineering & Education 57, 4 (2020), 321–339.

[4] ALDIABAT, K., KWEKHA RASHID, A., TALAFHA, H., AND KARAJEH, A. The extent of smartphones users to adopt the use of cloud storage. J Comput Sci 14, 12 (2018), 1588–1598.

[5] ALHAYANI, B., ABBAS, S. T., MOHAMMED, H. J., AND MAHAJAN, H. B. Intelligent secured two-way image transmission using corvus corone module over wsn. Wireless Personal Communications 120 (2021), 665–700.

[6] ALI, J., ADNAN, M., GADEKALLU, T. R., JHAVERI, R. H., AND ROH, B.-H. A qos-aware software defined mobility architecture for named data networking. In 2022 IEEE Globecom Workshops (GC Wkshps) (2022), IEEE, pp. 444–449.

[7] ARRUBLA-HOYOS, W., OJEDA-BELTRÁN, A., SOLANO-BARLIZA, A., RAMBAUTH-IBARRA, G., BARRIOS-ULLOA, A., CAMA-PINTO, D., ARRABAL-CAMPOS, F. M., MARTÍNEZ-LAO, J. A., CAMA-PINTO, A., AND MANZANO-AGUGLIARO, F. Precision agriculture and sensor systems applications in colombia through 5g networks. Sensors 22, 19 (2022), 7295.

[8] AWOYEMI, B. S., ALFA, A. S., AND MAHARAJ, B. T. Resource optimisation in 5g and internet-of-things networking. Wireless personal communications 111 (2020), 2671–2702.

[9] AZEEM, H., DU, L., ULLAH, A., MUGHAL, M. A., ASLAM, M. M., AND IKRAM, M. Sub-array based antenna selection scheme for massive mimo in 5g. In Cyberspace Data and Intelligence, and Cyber-Living, Syndrome, and Health: International 2019 Cyberspace Congress, CyberDI and CyberLife, Beijing, China, December 16–18, 2019, Proceedings, Part II 3 (2019), Springer, pp. 38–50.

[10] BANKA, S., MADAN, I., AND SARANYA, S. Smart healthcare monitoring using iot. International Journal of Applied Engineering Research 13, 15 (2018), 11984–11989.

[11] CALABRESE, F. D., WANG, L., GHADIMI, E., PETERS, G., HANZO, L., AND SOLDATI, P. Learning radio resource management in rans: Framework, opportunities, and challenges. IEEE Communications Magazine 56, 9 (2018), 138–145.

[12] CHEN, M., LI, W., HAO, Y., QIAN, Y., AND HUMAR, I. Edge cognitive computing based smart healthcare system. Future Generation Computer Systems 86 (2018), 403–411.

[13] CHENGODEN, R., VICTOR, N., HUYNH-THE, T., YENDURI, G., JHAVERI, R. H., ALAZAB, M., BHATTACHARYA, S., HEGDE, P., MADDIKUNTA, P. K. R., AND GADEKALLU, T. R. Metaverse for healthcare: A survey on potential applications, challenges and future directions. IEEE Access (2023).

[14] ELFATIH, N. M., HASAN, M. K., KAMAL, Z., GUPTA, D., SAEED, R. A., ALI, E. S., AND HOSAIN, M. S. Internet of vehicle's resource management in 5g networks using ai technologies: Current status and trends. IET Communications 16, 5 (2022), 400–420.

[15] ESENOGHO, E., DJOUANI, K., AND KURIEN, A. M. Integrating artificial intelligence internet of things and 5g for next-generation smartgrid: A survey of trends challenges and prospect. IEEE Access 10 (2022), 4794–4831.

[16] HAKAK, S., GADEKALLU, T. R., MADDIKUNTA, P. K. R., RAMU, S. P., PARIMALA, M., DE ALWIS, C., AND LIYANAGE, M. Autonomous vehicles in 5g and beyond: A survey. Vehicular Communications (2022), 100551.

[17] HAN, B., JHAVERI, R., WANG, H., QIAO, D., AND DU, J. Application of robust zero-watermarking scheme based on federated learning for securing the healthcare data. IEEE journal of biomedical and health informatics (2021).

[18] HU, J., LIANG, W., HOSAM, O., HSIEH, M.-Y., AND SU, X. 5gss: a framework for 5g-secure-smart healthcare monitoring. Connection Science 34, 1 (2022), 139–161.

[19] HUSSAIN, F., HASSAN, S. A., HUSSAIN, R., AND HOSSAIN, E. Machine learning for resource management in cellular and iot networks: Potentials, current solutions, and open challenges. IEEE communications surveys & tutorials 22, 2 (2020), 1251–1275.

[20] IBRAHIM, M. S., DONG, W., AND YANG, Q. Machine learning driven smart electric power systems: Current trends and new perspectives. Applied Energy 272 (2020), 115237.

[21] JAVAID, N., SHER, A., NASIR, H., AND GUIZANI, N. Intelligence in iot-based 5g networks: Opportunities and challenges. IEEE Communications Magazine 56, 10 (2018), 94–100.

[22] JAVED, A. R., SARWAR, M. U., BEG, M. O., ASIM, M., BAKER, T., AND TAWFIK, H. A collaborative healthcare framework for shared healthcare plan with ambient intelligence. Human-centric Computing and Information Sciences 10 (2020), 1–21.

[23] JOYIA, G. J., LIAQAT, R. M., FAROOQ, A., AND REHMAN, S. Internet of medical things (iomt): Applications, benefits and future challenges in healthcare domain. J. Commun. 12, 4 (2017), 240–247.

[24] KANG, X., HO, C. K., AND SUN, S. Full-duplex wireless-powered communication network with energy causality. IEEE Transactions on Wireless Communications 14, 10 (2015), 5539–5551.

[25] KARNEYENKA, U., MOHTA, K., AND MOH, M. Location and mobility aware resource management for 5g cloud radio access networks. In 2017 International Conference on High Performance Computing & Simulation (HPCS) (2017), IEEE, pp. 168–175.

[26] LAMBERT, G., FONTAINE, B., MONNERET, M., AND MADANI, R. M. How to build an innovative c2 system supporting individual-centric emergency needs? In ISCRAM (2019).

[27] NAGATY, K. A. Iot commercial and industrial applications and ai-powered iot. In Frontiers of Quality Electronic Design (QED) AI, IoT and Hardware Security. Springer, 2023, pp. 465–500.

[28] PENG, M., QUEK, T. Q., MAO, G., DING, Z., AND WANG, C. Artificial-intelligence-driven fog radio access networks: recent advances and future trends. IEEE Wireless Communications 27, 2 (2020), 12–13.

[29] QADRI, Y. A., NAUMAN, A., ZIKRIA, Y. B., VASILAKOS, A. V., AND KIM, S. W. The future of healthcare internet of things: a survey of emerging technologies. IEEE Communications Surveys & Tutorials 22, 2 (2020), 1121–1167.

[30] REHMAN, A., RAZZAK, I., AND XU, G. Federated learning for privacy preservation of healthcare data from smartphone-based side-channel attacks. IEEE Journal of Biomedical and Health Informatics (2022).

[31] RIGGIO, R., AND SICARI, S. Secure aggregation in hybrid mesh/sensor networks. In 2009 International Conference on Ultra Modern Telecommunications & Workshops (2009), IEEE, pp. 1–6.

[32] SADREDDINI, Z., MASEK, P., CAVDAR, T., OMETOV, A., HOSEK, J., GUDKOVA, I., AND ANDREEV, S. Dynamic resource sharing in 5g with

lsa: Criteria-based management framework. Wireless Communications and Mobile Computing 2018 (2018).

[33] Shabbir, M., Shabbir, A., Iwendi, C., Javed, A. R., Rizwan, M., Herencsar, N., and Lin, J. C.-W. Enhancing security of health information using modular encryption standard in mobile cloud computing. IEEE Access 9 (2021), 8820–8834.

[34] Shin, W., Vaezi, M., Lee, B., Love, D. J., Lee, J., and Poor, H. V. Coordinated beamforming for multi-cell mimo-noma. IEEE Communications Letters 21, 1 (2016), 84–87.

[35] Sodhro, A. H., Awad, A. I., van de Beek, J., and Nikolakopoulos, G. Intelligent authentication of 5g healthcare devices: A survey. Internet of Things (2022), 100610.

[36] Wang, M., Zhu, T., Zhang, T., Zhang, J., Yu, S., and Zhou, W. Security and privacy in 6g networks: New areas and new challenges. Digital Communications and Networks 6, 3 (2020), 281–291.

[37] Yan, M., Feng, G., Zhou, J., Sun, Y., and Liang, Y.-C. Intelligent resource scheduling for 5g radio access network slicing. IEEE Transactions on Vehicular Technology 68, 8 (2019), 7691–7703.

[38] Yaqoob, I., Khan, L. U., Kazmi, S. A., Imran, M., Guizani, N., and Hong, C. S. Autonomous driving cars in smart cities: Recent advances, requirements, and challenges. IEEE Network 34, 1 (2019), 174–181.

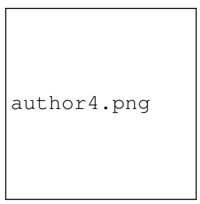
[39] You, X., Zhang, C., Tan, X., Jin, S., and Wu, H. Ai for 5g: research directions and paradigms. Science China Information Sciences 62 (2019), 1–13.

[40] Zeng, M., Yadav, A., Dobre, O. A., Tsiropoulos, G. I., and Poor, H. V. Capacity comparison between mimo-noma and mimo-oma with multiple users in a cluster. IEEE Journal on Selected Areas in Communications 35, 10 (2017), 2413–2424.

BUDDHADEB PRADHAN was born in India. He received the B. Tech. and M.Tech degrees in computer science and engineering from the West Bengal University of Technology (Presently Maulana Abul Kalam Azad University of Technology), Kolkata, India, and Biju Patnaik University of Technology, Rourkela, India, in 2009 and 2011, respectively. He has obtained his PhD degree from National Institute of Durgapur in the year 2020 on the research topic of Robotics. He is currently associated with Department of Computer Science and Engineering, University of Engineering and Management, Kolkata, India. He has authored or coauthored around 12 journal papers and few conference papers. His research interests include multiagent systems, soft computing, big data and others. He is a member of ACM, ASME, and other professional bodies. He is also an additional governing body member of The Robotics Society.

SHIPLU DAS was born in India. He received the B. Tech. degrees in Computer Science and Engineering from the West Bengal University of Technology (Presently Maulana Abul Kalam Azad University of Technology) in 2013 and and M.Tech degree in Computer Science and Engineering from the Jadavpur University in 2019 respectively. He is pursuing his PhD degree from Indian Institute of Information Technology,Kalyani on the research topic of Artificial Intelligence and Computer Vision. He is currently associated with Department of Computer Science and Engineering, Adamas University, Kolkata, India. He has authored or coauthored around different journal papers and few conference papers. His research interests include machine learning,Deep learning, Internet of Things and others.

DIPTENDU SINHA ROY received his Ph.D. degree in Engineering from Birla Institute of Technology, Mesra, India in 2010. In 2016, he joined the Department of Computer Science and Engineering, National Institute of Technology (NIT) Meghalaya, India as an Associate Professor, where he has been serving as the Chair of the Department of Computer Science and Engineering since January 2017. Prior to his stint at NIT Meghalaya, he had served in the Department of Computer science and Engineering, National Institute of Science and Technology, Berhampur, India. His current research interests include software reliability, Distributed and Cloud Computing, and IoT, specifically applications of artificial intelligence/ Machine Learning for smart integrated systems. Dr. Sinha Roy is a Senior Member of the IEEE Computer Society.



SIDHESWAR ROUTRAY Sidheswar Routray received the B.Tech and M.Tech degrees from Biju Patnaik University of Technology, Rourkela, India. He received his Ph.D. degree from KIIT University (Institute of Eminence), Bhubaneswar, India. He was a Post-doctoral Research Fellow with the School of Computer Science and Communication Engineering, Jiangsu University, Zhenjiang, China. He is currently working as an Associate Professor, Department of Computer Science and Engineering Dean-School of Engineering at Indrashil University, Rajpur, Mehsana, Gujarat, India. He has 13 years of teaching and research experience in top-ranked educational institutions. He has worked as a remote researcher at Zhejiang Lab, Zhejiang University, China. He has published over 44 research papers in SCI and Scopus indexed journals and conferences. He has published two German patents to his credit. He is an active member of technical program committees of leading International conferences such as CCGRID 2023, SPIN-2023, ICIICC-2022. He has also served as a reviewer for various top-ranked journals such as IEEE IoT, IEEE Transaction on Industrial Technology, IEEE Access, IEEE Transaction on Consumer Electronics, Signal Image and Video Processing, Optik, Sustainability, Sensors, Electronics. He is currently serving as Lead guest editor for the IEEE Journal of Biomedical and Health Informatics. His research interests include Image Processing, Natural Language Processing, Artificial Intelligence, Machine Learning, and IoT.

This article has been accepted for publication in IEEE Access. This is the author's version which has not been fully edited and content may change prior to final publication. Citation information: DOI 10.1109/ACCESS.2023.3317174

FRANCESCO BENEDETTO (S'04–A'08–M'10–SM'15) has been the Chair of the IEEE 1900.1 standard "Definitions and Concepts for Dynamic Spectrum Access: Terminology Relating to Emerging Wireless Networks, System Functionality, and Spectrum Management," since 2016. He has been the Leader of the WP 3.5 on "Development of Advanced GPR Data Processing Technique" of the European COST Action TU1208—Civil Engineering Applications of Ground Penetrating Radar. He is an Associate Editor of the IEEE Access Journal, an Editor of the IEEE SDN Newsletter, Associate Editor of the AEÜ - International Journal of Electronics and Communications (Elsevier), Editor in Chief of the international journal Recent Advances on Computer Science and Communications (Bentham), the General co-Chair of the IEEE 43rd International Conference on Telecommunications and Signal Processing (TSP 2020), the General Chair of the Series of International Workshops on Signal Processing for Secure Communications (SP4SC 2014, 2015, and 2016), and the Lead Guest Editor of the Special Issue on "Advanced Ground Penetrating Radar Signal Processing Techniques" for the Signal Processing Journal (Elsevier). He also served as a reviewer for several IEEE Transactions, IET Proceedings, EURASIP, and Elsevier journals, and a TPC Member for several IEEE international conferences and symposia in the same fields

DR. RUTVIJ H. JHAVERI (Senior Member, IEEE) is an experienced educator and researcher working in the Department of Computer Science Engineering, Pandit Deendayal Energy University, Gandhinagar, India. He conducted his Postdoctoral Research at Delta-NTU Corporate Lab for Cyber-Physical Systems, Nanyang Technological University, Singapore. He completed his PhD in Computer Engineerng in 2016. In 2017, he was awarded with prestigious Pedagogical Innovation Award by Gujarat Technological University. Currently, he is co-investigating a funded project from GUJCOST. He was ranked among top 2% scientists around the world in 2022 and 2021. He has 2700+ Google Scholar citations with h-index 28. He is an editorial board member in various journals of repute including IEEE Transactions on Industrial Informatics and Scientifc Reports.He also serves as a reviewer in several international journals and also as an advisory/TPC member in renowned international conferences. Heauthored 145+ articles including the IEEE/ACM Transactions and flagship IEEE/ACM conferences. Moreover, he has several national and international patents and, copyrights to his name. He also possesses memberships of various technical bodies such as ACM, CSI, ISTE and others. He is a member of the Advisory Board in Symbiosis Institute of Digital and Telecom Management, and other reputed universities since 2022. He is an editorial board member in several Springer and Hindawi journals. He also served as a committee member in "Smart Village Project" - Government of Gujarat, at the district level during the year 2017. His research interests are Cyber Security, IoT systems, SDN and Smart Healthcare.

• • •