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Review article

Emerging Technologies in 5G Networks for IoT-Based Smart Healthcare: A Review

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Abstract
Extensive efforts have been undertaken by governments, research institutes, and telecommunications corporations to expand the availability of fifth-generation (5G) technology. Closely integrated with the Internet of Things (IoT), 5G enables automation and facilitates large-scale data collection aimed at improving quality of life. This paper presents an overview of 5G and IoT technologies, highlighting common architectural designs, typical IoT deployments, and persistent challenges. Particular attention is given to interference in wireless applications, with a focus on issues specific to 5G and IoT, as well as potential strategies for mitigation. The study underscores the importance of managing interference and enhancing network efficiency to ensure reliable communication among IoT devices, which is essential for the effective operation of enterprise systems. For organizations that rely on these technologies to improve customer satisfaction, reduce downtime, and increase productivity, the findings provide valuable insights. Finally, the paper emphasizes the potential of network convergence and advanced services to enhance internet speed and accessibility, thereby fostering new opportunities for innovative businesses and applications.
Keywords. 5G Technology, Internet of Things, Interference, and Wireless Network Optimization.

Introduction

Smart healthcare technologies help to raise the bar for general healthcare standards by displaying patients' vital statistics in real-time and supporting advanced gadgets utilized for patient diagnosis and care. Smart healthcare's main objective is to assist the patient by supplying information mainly about medical problems and their possible fixes, as stated in the case of declaring its aims. When faced with life-threatening situations, smart healthcare enables patients to take the appropriate action. [1]. In a sense, this facilitates remote check-up services, which decreases the cost of therapy and helps the medical facility grow internationally. To guarantee health services for consumers, the growth of smart cities necessitates a robust smart healthcare infrastructure. In addition to improving well-being, one of the most significant benefits of early diagnosis is the reduction in the amount of money needed for treatment. IOT will lower the cost of medical equipment and revolutionize the healthcare industry. As the industry looks to expand the IoT further, 5G networks will be needed to support it [3]. The most significant application for Smart health care is 5G networks [4]. An example 5G-based smart healthcare network design is displayed in (Fig. 1).

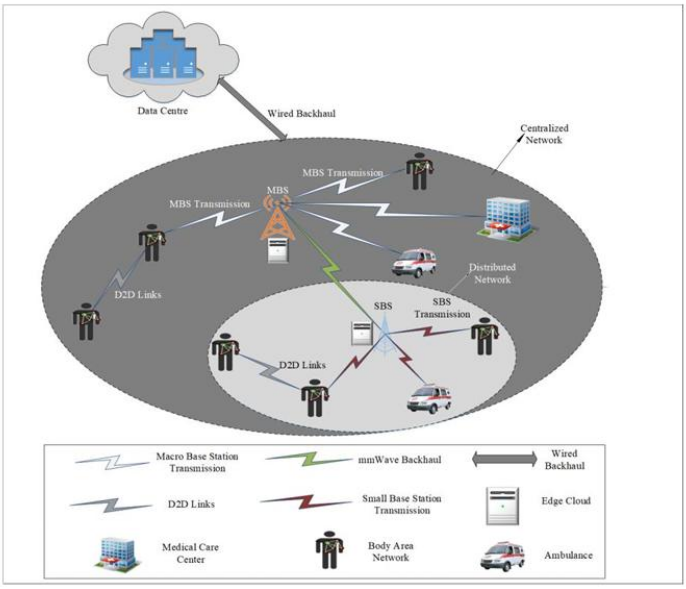

Figure 1. A general 5G-based smart healthcare network design (adapted from [2])

IoT can improve several services in smart healthcare, including behavioral modification, tracking of assets in hospitals, treatment tracking, Telehealth, smarter medication, supported living, and remote care services [5]. These applications will soon be at the forefront of the medical industry's growing demands. Worldwide

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sales of 5G network slicing are expected to reach $5.3 billion by 2028, system integrators, manufacturers, and carriers must collaborate to ensure the success of 5G network slicing [6]. There are several examples of how mobile communication technology can be used in conjunction with web services applications and/or e-health. A portable health app called "Health Inspection of Health," which keeps track of pressure sores electronically, is recommended in [7]. This study's list of reviewed papers is as follows: [7] suggested a clever health app for evaluation and nutritional analysis. Therefore, the author of [9] offers a novel strategy for mobile health applications. In [10], wearable technology for enhancing mobility in residential environments is presented. [11] Suggests the mobile gateway, an Internet of Things application that focuses on offering intelligent assistance within the framework of MHealth. This IoT is seen in [12] as a potentially significant component of the medical use platform in e-health. Wearable technology is recommended for healthcare inspection in a wireless sensor network in [13] as part of future research.

Smart antennas are one of the many crucial locations that have been recognized in relation to communication on 5G networks [14,15]. In [16], the focus is primarily on identifying potential applications of 5G in healthcare, such as real-time monitoring, remote diagnostics, and emergency response systems. In [17], the evaluation by Hoque et al. offers a broader technological viewpoint, highlighting recent innovations, enabling technologies like AI and edge computing, and emerging concepts such as smart textiles and cybersecurity challenges. Additionally, Singh [18] offers a comprehensive legal analysis of IoT and 5G integration in systems for tracking health, highlighting the need for robust regulatory frameworks and ethical considerations. Moreover, the integration of 5G with Mobile Edge Computing (MEC) is shown to significantly improve medical services by enabling secure, current data transmission and analysis, although it still faces operational challenges such as scalability and data protection [19]. Technology breakthroughs up to 5G are depicted in (Fig. 2) [28]. The diagram indicates that voice calls have been used as the starting point. These days, you can access the internet with extremely high speeds that are unimaginable.

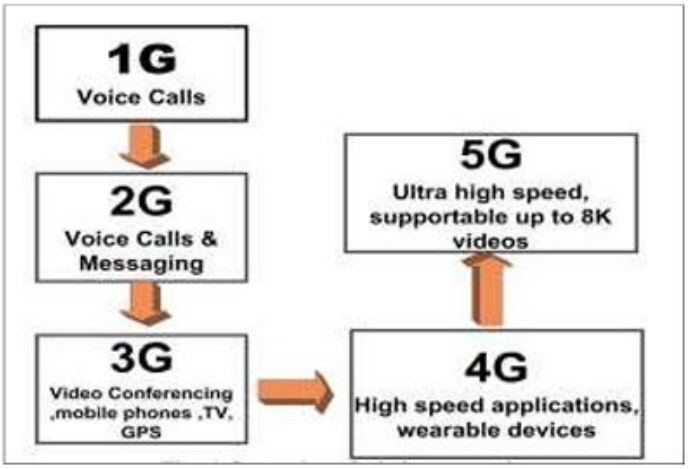

Figure 2. Wireless Network Generation [32]

In order to improve 5G coverage and network capacity, smart antennas use a number of important improvements [20,21]. Beamforming, or beamforming in both vertical and horizontal directions, is one of these innovations where radiofrequency energy is concentrated within a contracted beam to the exact location it is required, instead of emitting identical energy throughout a wide area. [20-23]. Due to its higher frequency, mm Wave RF is more likely to fade over distance and lose authentication when objects like vehicles, buildings, and other objects strike it. Beamforming works very well in 5GNR [24,25]. They are more likely to have a more directed beam, which increases the likelihood of promising Energy from radio frequencies penetration, best signal quality, and transmission capacity [26, 27]. Even if attenuation reduces beamforming sites of interest, it is important to keep in mind that the line of location is still an issue [28, 29]. Regarding 5G networks, the concept of smart healthcare is defined by two primary subfields: Communication between machines (M2M) and the Internet of Things (IoT) [31].

Applications for healthcare based on IoT

Based on research that P&S Market Research submitted is projected that the healthcare Internet of Things (IoT) market would expand at a compound annual growth rate (CAGR) of 37.6% from 2015 to 2020. There's no denying that the Internet of Things has revolutionized medical treatment in a variety of ways over the last few years and will continue to do so for many more. The taxonomy of smart healthcare is shown in Fig. 3. Communication technologies, network kinds, services, applications, requirements, and features are the parameters that make up the taxonomy that has been defined.

Implantable Glucose Monitoring Systems

It is possible to implant devices with sensors just beneath the skin in diabetic patients. The devices' sensors will record past data for patients and notify their mobile phones when their blood sugar levels go too low. In

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this manner, patients will also be able to identify the times in the future and present when their blood sugar is most likely to be low.

Activity Monitors for Cancer Therapy

The ideal course of therapy for a patient with cancer is usually determined by more than just their age and weight. What the right treatment plan for them will involve is also much influenced by their lifestyles and levels of fitness. Activity trackers track the movements of a patient, the level of exhaustion, hunger, and other factors. Moreover, the data collected by the tracker before and during the start of therapy will help physicians make any necessary adjustments to the recommended treatment plan.

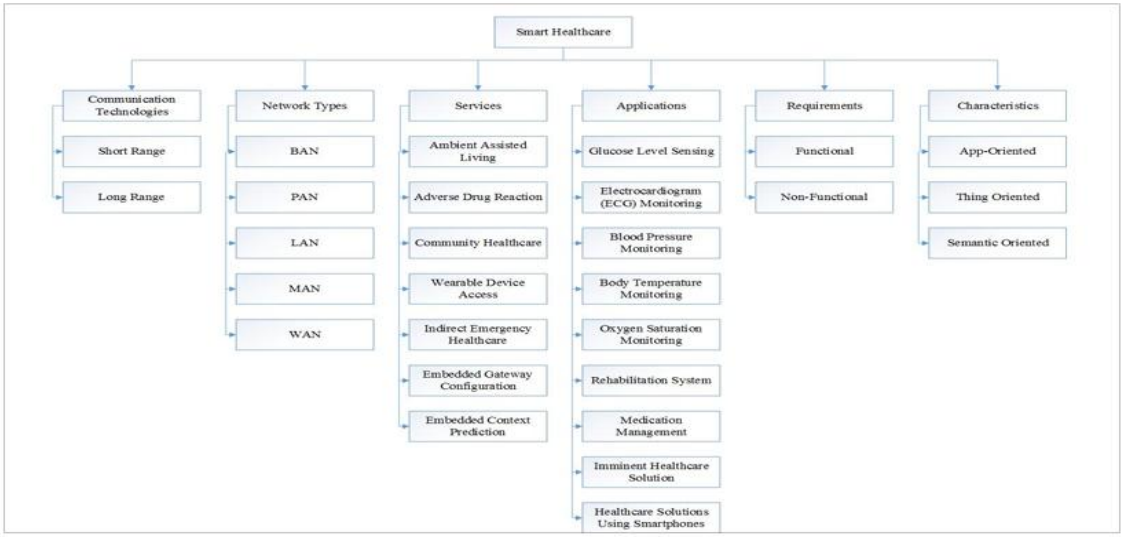

Figure 3. The parameters and taxonomy of smart healthcare (adapted from [2])

Reporting Heart Monitors

To find out if their blood pressure is elevated, patients might put on devices that track their pulse rates. When necessary, pull data from a patient's heart monitor during an examination or checkup. Healthcare providers will be able to access it. Wearable technology could even notify medical personnel when people are having heart attacks, strokes, palpitations, or arrhythmias. At such a point, the timely dispatch of an ambulance could mean the difference between life and death.

Alerting Systems for Medical Conditions

In order to notify loved ones in the event of an emergency, people can wear jewelry-like objects. A medical alert wristband wearer who slips out of bed in the middle of the night, for example, their approved emergency contacts are instantly notified on their smartphones that assistance is required.

Sensitive Ingestion

Patients can now consume sensory devices that look like tablets. After consumption, the sensors send details taken from a patient's smartphone application, which assists them in adhering to prescription dosage instructions. The majority of drugs are not taken as directed because of human carelessness or mistake. Making sure patients are taking the appropriate drugs in the right amounts at the right times is the goal of this ingestible sensor. Furthermore, ingestible sensors are being used to improve the accuracy of diagnoses for conditions like colon cancer and irritable bowel syndrome.

Drug Receptacles

Nowadays, implanted devices that administer regular medication dosages throughout the day are available to patients. When it's time to renew their prescriptions, patients will be informed. During routine appointments, missing prescriptions can also be reported to doctors.

Sensors with wireless capabilities

Hospital refrigerators and labs utilize wireless sensors to make sure that biological materials, including blood samples and cold drugs, are always stored at the appropriate temperatures.

Trackable Inhalers

Through the transmission of data to their smartphones or tablets, IoT inhalers are informing patients about their actions or experiences that may trigger asthma attacks. They can also provide their doctors access to that information. Additionally, the linked inhalers notify patients of the timing for taking their prescriptions.

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Wearable Technology to Combat Depression

For the Apple Watch, Apple has created an app that helps people with manic-depressive mania manage their sadness. The app helps to monitor mood and cognitive skills and records episodes a patient has when they are not at their planned appointments.

Lenses with Connectivity

Diabetes patients' blood glucose levels are currently being read through contact lenses that are connected. But ultimately, they'll be able to help with improving vision and refocusing the eye.

5G's applications

The elements of the future world include mobile robots, medical devices, smart transportation technology, and health, all of which contribute to the IoMT environment. Simply said, 5G technology offers low latency and high data throughput, but it also lays the groundwork for IoMT applications. It integrates numerous unique and cutting-edge technological features. Biomedical equipment and sensors are among the IoMT devices; all of these include GPS systems, and the majority have increased M2M traffic, necessitating numerous radio access protocols, better capacity, and high bandwidth [31]. Data on many human body characteristics, including blood oxygen, EEG, ECG, and EMG, are collected by the wearable sensors. The IoMT must incorporate standards and technology, including wearables, biosensors, memory, protocols, variable data, and video transmission. Therefore, a technique that extends the sensor's lifetime is suggested to enhance the energy management algorithm's performance for video transmission [33]. Every system, from the house to the hospital, requires big data and constant connectivity [30]. The following is a highly accurate list of the advantages that IoMT offers. It ought to be the QoS (adaptive quality of service). The network and spectrum efficiency will be greatly increased. The system can handle large devices with connectivity to many traffic types and has a high capacity. A spectrum switching from low to high bandwidth will exist regarding the available communication channel and its application. It is well known that networks are energy efficient and have low latency [38–42].

Intelligent Clothes

By combining several micro physiological signal data, Data from multi-modal physiological signals is delivered by smart clothes [38]. The most crucial prerequisite for the purpose of diagnosis is the human body's bioelectricity. One of the primary issues with signal bio signal capture technology is electrode use. The textile construction of this electrode has been devised in recent years to track and gather a human bioelectric signal environment. This construction is long-lasting, supple, and cleanable. The human body has the ability to gather various bioelectric signals.[39]. The ability in order to monitor the ECG signal and use it for diagnostics is one advantage of smart clothes. By positioning an electrode in a particular area of the human body, the ECG can be measured. EEG signals and blood oxygen levels can also be measured using it. To put it briefly, wearable technology can be replaced by smart clothing. It is useful for diagnosing a broad variety of illnesses and monitoring long-term circumstances.

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Rural Diagnosis Services

Developing countries' rural areas have limited access to healthcare resources; hence, it is critical to integrate these resources and create IoMT services. These diagnostic services are available to farmers whenever they want, and they can obtain the appropriate health-related data. At any time, a rural area clinic can give healthcare monitoring regarding the health status of its patients. All rural clinics are connected to urban hospitals, and new, cutting-edge medical monitoring equipment and systems are used for treatment in rural areas. The farmers will be able to get cutting-edge medical services in their hometowns, thanks to this. In addition to helping patients with chronic illnesses, this will increase the standard of healthcare services for farmers. The management group estimated the risk of diseases using a professional monitoring system, which may assist patients in receiving prevention before an illness is discovered, and also lowers the incidence of diseases.

The system for hospital management

The diagrams illustrate the services that hospitals are able to provide. This is further illustrated in (Fig. 4).

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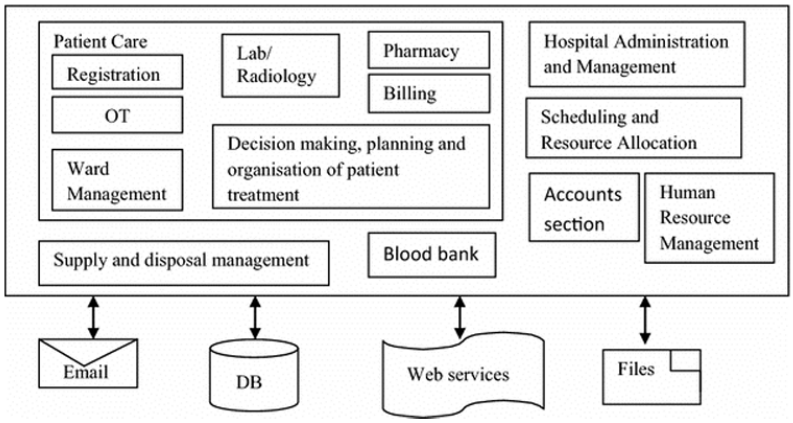

Figure 4. Hospital management system [43]

Robotic Use

The employment of robots to precisely send and receive medical data makes possible the application of 5G technology in medical fields, greatly improving patient care. 5G-enabled robots can provide remote surgeries, real-time health monitoring, and accurate and prompt medical interventions. Healthcare professionals can provide patients with precise and effective medical care, even in remote areas, thanks to this cutting-edge communication network, which guarantees data transmission with minimal latency and great reliability [44-47].

Developments in Technology for 5G Network Needs

A number of technological trends have been recognized in order to address the fundamental needs of future 5G networks, including high rates of data and traffic capability, ultra-high connection densities, long-distance connectivity, extremely low latency, good energy efficiency, and ultra-high reliability. As listed in (Table 1), for a variety of intelligent healthcare scenarios to work, several trends are necessary, each with unique communication requirements.

Table 1. Summary of 5G Network Requirements [48-51]

Situation	Operators	Technologies of Communication	The necessary latency	The necessary rate of data
Wearable M2M devices	establishing connections for data	Bluetooth (D2D sensors), Zigbee (data gathering), LoRa (sensor applications), and NB-IoT (interconnected devices)	10-700 ms	A few Kbps to Mbps
Medical Digital	Building interaction within	Wi-Fi	10-100 ms	Few Mbps
Medical Emergency Services	Communication in an emergency and quick response	LTE, LTE-A, LTE-A Pro	20-100 ms	From 100 Mbps to 3 Gbps
Remote Procedures	URLLC service across numerous sites	5G	20-30 ms	Few Gbps
Communication Through Touch	Improved eMBB Mobile Broadband, also known as URLLC (communications with low latency and high reliability)	5G, 4G, Wi-Fi, Bluetooth	sub-ms	Few Gbps
A mix of every situation	Latency, bandwidth, applications, and communication	Bluetooth, Wi-Fi, 4G, and 5G	up to several ms	From a few Mbps to three Gbps

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3D MIMO and Massive MIMO (Multiple-Input Multiple-Output)
Through the utilization of several antennas on both the receiver and the transmitter ends to increase the channel capacity, MIMO technology enables faster data rates [52, 53].

Communications using Millimeter Waves
Makes use of higher frequency bands (30–300 GHz) to offer faster data rates and wider bandwidths, which are necessary for applications needing incredibly fast data transport.

Heterogeneous Networks, Networks with extreme density, and Small Cells
A greater quantity of devices linked may be supported, and the overall performance of the network is improved by deploying numerous tiny cells in congested regions, which also increases coverage and capacity.

Communications from Device to Device (D2D)
Reduces latency, increases dependability, and boosts energy efficiency by enabling direct connection without the need for a base station between devices.

Radio Cognitive
Permits devices to recognize and use available frequency bands intelligently, maximizing spectrum usage and enabling dynamic spectrum management.

AI and ML stand for artificial intelligence and machine learning
By way of analysis in actual time of massive abundance of data, AI, and ML algorithms can improve security, anticipate and manage traffic, optimize network operations, and deliver tailored services. These technological developments are essential to meeting the sophisticated needs of 5G networks and guaranteeing dependable and effective communication for a range of uses, including smart healthcare. In order to serve a range of smart healthcare applications and guarantee dependable, effective, and robust communication systems, 5G networks must satisfy a number of complex and demanding requirements, as these scenarios demonstrate.

Obstacles and Unresolved Research Questions
The integration of 5G technology into intelligent medical treatment systems presents numerous challenges and open research problems that must be addressed to enable seamless, secure, and efficient deployment. The following subsections highlight the key issues [54-66]:

Interoperability among Heterogeneous Devices
One of the major challenges lies in enabling communication between a wide range of IoT devices that operate using different protocols and standards. Research Challenges include ensuring smooth integration of devices and services across heterogeneous platforms and developing secure mechanisms for device authentication and data exchange. Key Requirements include the adoption of flexible and unified communication models such as CoAP and IP-based protocols, and the creation of standardized interfaces to facilitate interoperability and scalability.

Big Data Analytics in Healthcare IoT
The huge volume of information generated by wearables, sensors, and medical devices requires efficient tools for processing and analysis to support real-time healthcare. Research Challenges include the limited availability of effective analytical tools to handle massive data streams and insufficient centralized and distributed infrastructure for big data processing. Key Requirements include the establishment of centralized or hybrid big data centers tailored for healthcare applications and enhancing public and institutional understanding of secure and ethical data usage.

Reliable IoT Connectivity in Dense Networks
Ensuring seamless connectivity across a multitude of IoT devices deployed in dynamic healthcare environments is critical for effective service delivery. Research Challenges include maintaining stable connectivity in highly mobile and dense network environments, and resource optimization and energy management under high-load conditions. Key Requirements include efficient spectrum utilization techniques for IoT communications and implementation of intelligent connectivity algorithms and clustering strategies to increase availability and accommodate a variety of workloads.

Security and Privacy Protection
Protecting sensitive health information from cyber threats is a top priority in smart healthcare systems. Research Challenges include protecting edge-based and cloud-based services on the network and device level, and early identification and mitigation of internal and external cyber-attacks. Key Requirements include the development of comprehensive vulnerability assessment frameworks and the integration of clever security measures to preserve information confidentiality, honesty, and availability.

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Conclusion

It is commonly acknowledged that the upcoming generation will greatly support IoT applications and smart healthcare. The network of the fifth generation. Healthcare and IoT are important from a functional and financial standpoint. The 5G network. This report alluded to several applications that are both short- and long-range and have different perspectives. For the smart healthcare zone, communication technologies were compared according to their power, frequency, range, and data rate. Furthermore, four distinct scenarios are examined, contingent on the varying demands for the 5G community (i.e, enhanced cellular connection, M2M communications, Internet access for WRAN, and low latency and high reliability communications), and are provided with distinct technological trends to accomplish the These needs are carefully considered for 5G networks. Lastly, we talked about the unresolved problems and possible directions for future research for smart healthcare within the framework of the 5G network. This offers researchers the chance to begin researching Smart healthcare powered by 5G through several techniques, such as machine learning and scheduling.

Conflict of Interest

The writers affirm that their interests are not conflicting.

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