5G-based Smart Health Care System Design Using IoT In Bangladesh

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Abstract

The health care system is society's way of dealing with risk factors for illness. Every culture has its own set of ideas about what influences health, and these ideas don't always line up with what we know to be true. Putting a premium on each individual life is a cornerstone of every healthcare system. As reported by the WHO in 2010, health care in Bangladesh receives just approximately 3% of the country's GDP. Bangladesh lacks a comprehensive health strategy to develop the whole health system, despite the fact that the nation has a rising private sector that predominantly provides tertiary level health care services. Current smart health-care services and apps use 4G and other communication protocols. Advancements in these areas are essential for the development of next-generation intelligent health care services. There will be a huge variety of data types and sizes generated by several applications as the healthcare sector expands. Therefore, 5G networks are being built to meet the various communication requirements of IoT health-care applications (IoT). 5G-enabled, internet-of-things-based smart healthcare networks are already a reality. Telemedicine and the healthcare business as a whole stand to benefit greatly from the 5G technology's low latency, high speed, expanded high-resolution bandwidth, greater dependability, and reduced energy usage. The preventative and curative effects of this cutting-edge wireless networking technology are far-reaching. Wearables equipped with powerful sensors connected to a 5G network may be used to remotely monitor patients. Other uses of 5G technology in the medical field include: remote patient consultation; augmented reality (AR) and virtual reality (VR)-based simulated surgeries; artificial intelligence (AI)-powered robotic surgeries; real-time maintenance of ambulances and other medical devices; and a dynamic huge data repository. The Internet of Things will dramatically alter medical treatment while reducing the price of necessary equipment. When it comes to facilitating broad adoption of the Internet of Things, 5G networks will play a crucial role. One of the most vital uses for 5G networks will be in the field of smart healthcare.

Keywords

5G Technology, IOT, Determinants of Health, Societal Response, Internet of Medical Things, AR, VR, Healthcare, e-Health, Telemedicine and Healthcare Requirements.

1. Introduction

In 5G networks, smart health-care is one of the most important applications. Smart health-care will enable us to use advanced systems to provide advanced treatment for the patients. Furthermore, the smart health-care devices in between will enhance the quality of health-care on a massive scale. The aim of smart health-care is to facilitate the patients through the delivery of information regarding medical issues and providing their solutions. Smart health-care in contrast will form a relation towards patients to take appropriate measures in case of critical circumstances (Ahad et al. 2020). IoT is going to revolutionize health-care and bring down the cost of medical devices. 5G networks are going to play a major role in order to enable widespread adoption of IoT. The 5G technology, with its low latency, high speed, enhanced high-resolution bandwidth, superior reliability, and less energy consumption, is bound to transform telemedicine and the healthcare industry as a whole. This next-generation of wireless networking technology has many massive implications in both grounds on the preventive and therapeutic care for the patients. Remote monitoring of patients will be possible with wearables facilitated by robust sensors coupled to 5G network. Virtual patient consultation; augmented reality (AR) and virtual reality (VR)-based simulated surgeries; artificial intelligence (AI)–powered robotic surgeries; real-time maintenance of ambulances and other medical devices; and dynamic huge data repository are some of the other applications that can be received with the establishment of 5G technology in the health sector (Dananjayan and Raj 2021). The healthcare industry is growing fast as well and with

such establishment the number of remote-end applications, which does require a powerful communication network to effectively connect patients, healthcare professionals, medical equipment amongst all others for information sharing. The 5th Generation (5G) mobile networks, is the next evolution of wireless connectivity, which is bound to advance telemedicine and transform the future of healthcare delivery. By establishing IOT an emergence in the healthcare industry can be formed. 5G is not only about speed; rather, it can change the entire healthcare system bypassing all the limitations that are present with the current generation of wireless networking technology. It can also provide an excellent user experience. The whole healthcare system can be moved towards a decentralized network(Dananjayan and Raj 2021). To keep in sync with the rapid development of networking technologies, there is a necessity to integrate enriched media communications into the current medical practice. For such cases, focus is established on the proposal of smart eHealth systems with 5G network slicing, and consequently, harmonizing heterogeneous patient-related data from wide-ranging wearables—sometimes, even in the realm of the Internet of Things "IOT".

1.1 Objectives

The objectives of this research are:

- To introduce 5G network technology to revolutionize the healthcare sector.
- To improve the current scenario of the health sector on a larger scale establishing a 5G-based architecture for smart healthcare.
- To find out the probable best scope of application research and innovation using 5G in terms of healthcare and its other predecessor sectors as well.

2. Literature Review

Healthcare is being dramatically transformed from a conventional fixed physician-focused method to a dynamic and distributed patient-oriented strategy. The establishment of several emerging technologies, for instance, IoT and 5G, is driving this rapid revolution of healthcare verticals by providing very personalized and remote medical services very efficiently and accurately at present (Sodhro et al. 2022). Besides, most traditional medical platforms are connected to a 4G network. But in case of it such networks communication processes are static, computationally complex, and less secure in contrast. So, to cope with the emerging healthcare trends, conventional networks must face strict requirements in terms of data rate, speed, and latency. 5G is introduced in such a broader concept.

Now as the healthcare market matures, the connectivity requirements for numerous IoT devices in hospitals will promote the deployment of such massive machine type communication (mMTC). Besides, other critical applications, for instance, remote surgery, will need ultra-reliable including low-latency communications (URLLC) or critical machine type communication which are possible through the help of 5G. Wearable IoT-5G devices as such require lightweight security while high-speed and critical applications and services need strong security and proper authentication. The traditional network-enabled hop-by-hop security method is inappropriate for protecting different devices in healthcare applications (Sodhro et al. 2022).

Machine to machine communication has a significant role to play in the emerging internet of things paradigm in years and decades to come. The emerging IoT-5G scenario extends sensor based IoT capabilities to robots, actuators and drones for distributed coordination and low-latency reliable execution of tasks at hand (Ejaz et al. 2016).

2.1 5G for the Internet of Things (IoT)

IOT which is also known as Internet of Things is a dynamic, adaptive, computationally complex, and ad hoc framework for connecting and integrating anything, anyone, and any service at anytime and anywhere. The use of the IoT in healthcare is also growing day by day. 5G networks are going to play a major role in order to enable widespread adoption of IoT (Sodhro et al. 2022).

Now there has been on-going research on the severe requirements in healthcare applications to provide services that are reliable and cost-effective. 5G promises to offer advancement in the healthcare sector by providing service to various domains of healthcare such as health care providers, caretakers and patients. According to researchers, the health care market is a flourishing area since its overall share in national GDPs is significant with values ranging between 6% in China, 10% in Europe and 18.5% in the United States. E-Health has been going through a typical hype curve starting in early 2000 fueling high hopes of quick enhancement of quality of care, quality of experience and a reduction in health care costs (Padmashree and Nayak 2020). The World Health Organization (WHO) concludes in their most recent report on e-Health that there "is the need for stronger political commitment for e-Health, backed by

sustainable funding and for effective implementation of the policy" speeds much greater than 4G LTE networks. It promises speeds of more than 100 megabits per second. This can be accomplished by making use of concepts of millimeter waves, small cell, beamforming, full-duplex, etc.

5G has brought three new aspects- higher speed, lower latency, and connection of multiple devices both as sensor and IOT devices. As an enabling technology for IOT, 5G will pave the way for a smart healthcare system (Mester n.d. 2020). By using the 5G network, more users could continuously send more information without fear of overcrowding the network, leading to delays in the past. The 5G connectivity would allow everyone to realize the IoT technology's strength. Now, IoT potential is vast, but the potential connectivity will come to fruition with 5G technology. (Khuntia, Singh, and Sahoo 2021). IOT can help revolutionize and adopt a major role in the healthcare system.

2.2 Key features of 5G networks

Unlike previous network technologies, 5G operates on three different spectrum bands namely low-band spectrum, mid-band spectrum and high-band spectrum. This not only increases the capacity of the network but it also allows the smallest devices to perform high-level computations and connect quickly to the processing power that is diffused throughout the system. The factors which make 5G stand out from its predecessors are the number of connected devices it supports, network speed and extremely low latency (Padmashree and Nayak 2020). The importance of 5G does not stem from its potential to support billions of devices or its bandwidth speeds, but rather because of its potentiality to transform the lives of people around the world. Experts believe 5G will usher in the fourth industrial revolution and change the economy on a massive scale.

5G communication technology is complementary to the characteristics and requirements of the IOT. The key technologies of 5G communication are utilized to develop the IOT. As a result, the IOT can get more and more vitality (Xu et al. n.d. 2020)**.** With the 5G worldwide deployment, the scale of vertical applications is innovated. The benefit from 5G technologies includes MEC (Multi-access Edge Computing), IoT, network slicing, etc. 5G networks are being designed and are being developed to tackle the diverse communication needs of health-care applications in Internet of Things (IoT) and also it is going to play a major role in order to enable widespread adoption of IoT.

2.3 5G for the healthcare industry

The applications of IoT in the healthcare industry are limitless and the concept is referred to as the Internet of Medical Things or "IoMT" (Dananjayan and Raj 2021). It is the collection of medical devices equipped with Wi-Fi and applications connected to healthcare IT systems through online computer networks. As our hospitals struggle towards lower operating costs and to remain competitive, IoMT has the required potential to reduce such costs and improve a patient's journey through a medical facility. The idea of telemedicine or the ability of a doctor with a webcam to diagnose a patient's problems without an office visit is becoming popular nowadays. This is a very useful method for patients who live in remote areas as they easily receive such specialized care.

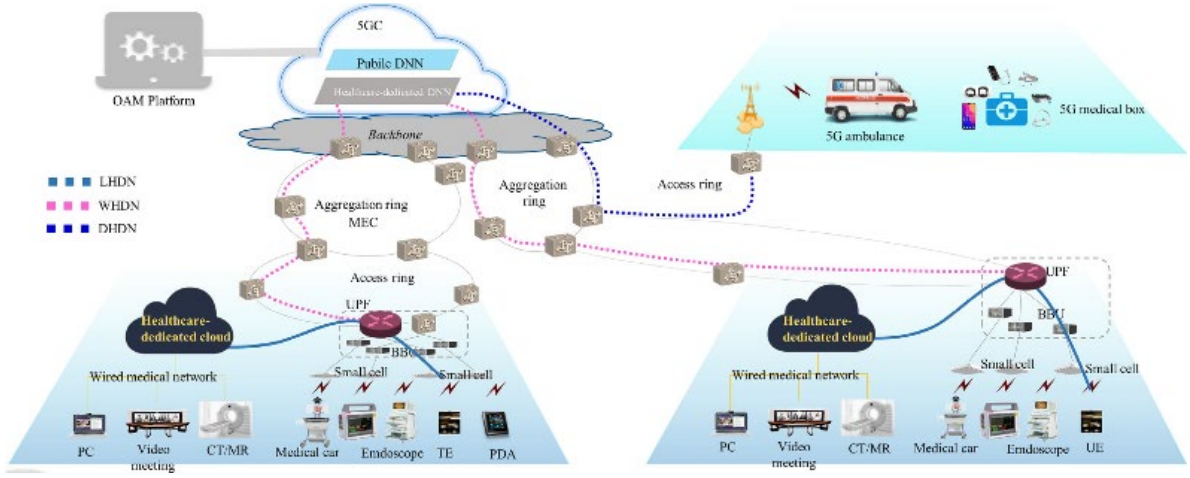

Figure 1. The smart healthcare scenario (Tang et al 2022)

From Figure 1, we see that mobile health can help the healthcare industry improve efficiency and reduce costs in the areas of disease prevention, counseling, treatment, and rehabilitation. Besides, from the figure we also see 5G assisted smart health-care networks which are an amalgamation of IoT devices that require improved network performance and enhanced cellular coverage.

But, limited by the hospital's traditional information infrastructures, those 5G-based healthcare applications are hard to be deployed and mostly present only for demonstration, isolating it from the existing medical systems. Even though the standardized 5G MEC framework has been widely used in many vertical scenarios, it is also hard to satisfy hospital-specific requirements such as hospital-dedicated deployment, medical data security, and various network connections etc (Tang et al. 2022).

2.4 5G and its application for the healthcare industry

The medical applications target is to build out a full scenario smart medical service ecosystem for smart hospitals, telemedicine, and emergency rescue applications, under various medical scenarios, including in-hospital, inter-hospital, and out-of-hospital. Benefit from the proposed new 5G-based medical information infrastructure that is constituted by the dedicated network and cloud, where various applications can be deployed and can also be managed in the 5G healthcare cloud. In this case two category applications can be presented here, including the 5G basic application and the medical application, where the 5G basic application intuitively demonstrates 5G's intuitive experience on improving the hospital production efficiency and 5G transmission capabilities.5G promises to transform the medical field by redefining the aspects to form a full smart layout of a medical service ecosystem.

A recent study by Ericsson identified different ways the healthcare industry can derive value out of 5G networking technology (Ericsson 2018).
They are summarized below:

- Effective capture of the vast amount of patient data.
- Real-time mobile delivery of rich medical data.
- Improved availability of suitable infrastructure.
- Improved security of patient data and superior data storage.
- Ability to accurately control remote medical equipment without delay.
- Ability to incorporate augmented and virtual reality for enhanced training of interns.
- Facilitate the connectivity and operations of smart medical objects and instruments such as syringes, beds, and cabinets.

Thus, proposal of a 5G-based architecture for smart healthcare information infrastructure, a new network element **iGW** (industry gateway) is defined, and the smart healthcare dedicated cloud platform **iMEP** (industry multi-access edge platform) is also introduced here, making it possible to satisfy both the hospital-specific requirements and the long-term evolution (Tang et al. 2022).

Meanwhile, the implementation methodology and the corresponding test results are presented as well which show the significant network performance gain achieved by the proposed new system structure in contrast from a traditional structure.

3. Methodology

Proposed IoT-5G framework for healthcare: It is based on the device layer, network layer and application layer, there is a strong interlink between three layers for efficient and sustainable connectivity.

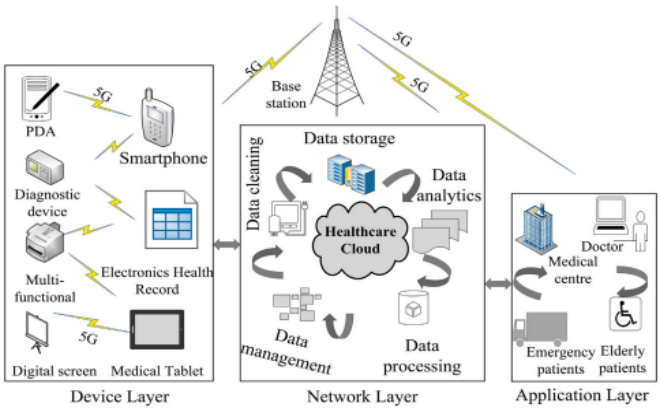

Figure 2. IoT-5G framework for healthcare

From Figure 2, limited by the hospital's traditional information infrastructures, those 5G-based healthcare applications are hard to be deployed and mostly present only for demonstration, isolating it from the existing medical systems. Even though the standardized 5G MEC framework has been widely used in many vertical scenarios, it is also hard to satisfy hospital-specific requirements such as hospital-dedicated deployment, medical data security, and various network connections, etc. (Tang et al. 2022). But we formed an IoT-5G framework for healthcare for efficient and sustainable development in healthcare.

3.1 Data Collection

Comparison of 3G, 4G & 5G Technology:

Features	3G	4G	5G
Start from	2002	2010	2015
Standards	WCDMA, CD MA2000	OFDMA, MC-CDMA	CDMA, BDMA
Network architecture	IP technology and Broadband width CDMA	combined IP and combination of board band standards like LAN, WAN, WLAN, PAN	combined IP and combination of board band standards like LAN, WAN, PANW LAN and WWWW
Data rate	2 Mbps	2 Mbps to 1 Mbps	1Gbps & higher
Frequency	1.8 to 2.5 GHZ	2-8 GHZ	3-300 GHZ
Core type network	Packet network	All IP network	Flatter IP network & 5G network Interfacing (5G-NI)
hand over off	Horizontal	Vertical, Horizontal	Vertical, Horizontal

From the following table we can see a comparison and data collection of the 3G, 4G and 5G technology. Wireless networks provide efficiency, scalability, and reliable services. The 3G, 4G and 5G consist of every form of advanced characteristics which makes mobile technology as more powerful; especially 5G have a huge demand in close to the upcoming era. 5G networks allow the users to access the big repository of data and services (Arasan and Ezhilarasan 2017).

4. Results & Discussions

From Figure 3, we get an aspect of the 5G-enabled healthcare in contrast to a taxonomy of IoT-5G driven Healthcare which includes a breakdown on key indicators such as communication technologies, requirements, objectives, QoS analysis, challenges, and solutions. In addition, from top to bottom, objectives and challenges columns are classified with respective solutions in the solutions column.

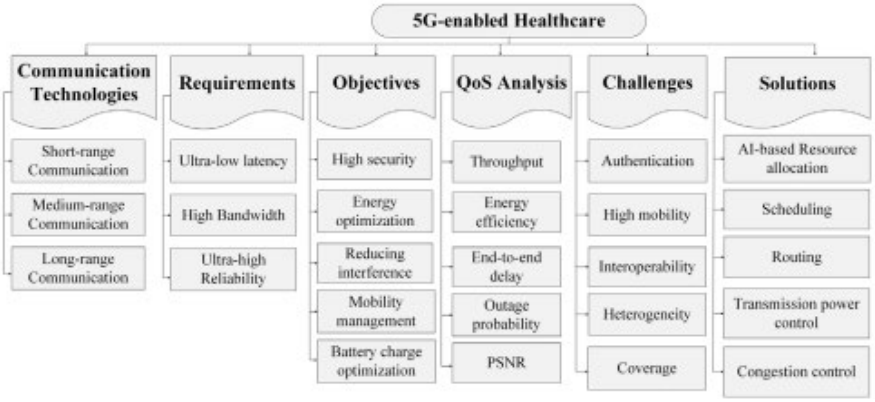

Figure 3. Taxonomy of IoT-5G driven Healthcare

We carried out three typical test scenarios and use cases, including intra-hospital, inter-hospital, and out-of-hospital. Accordingly, only basically key performances are tested at the current stage, including upload data rate, download data rate latency, the corresponding performance requirements of smart healthcare under the perspective of our country.

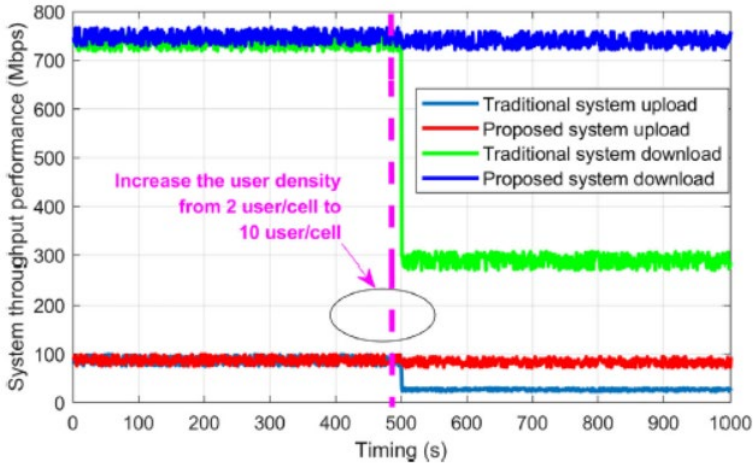

Figure 4. The system data rate performance

From Figure 4, it shows the data performance of traditional and proposed systems which increase the user density from 2 user/cell to 10 user/cell.

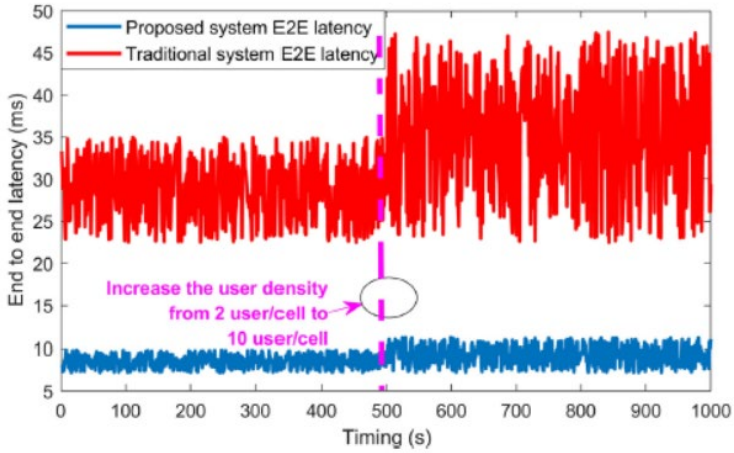

Figure 5. The system end-to-end latency performance

From Figure 5, it shows the system end to end latency (E2E latency) of traditional and proposed systems which increase the user density from 2 user/cell to 10 user/cell.

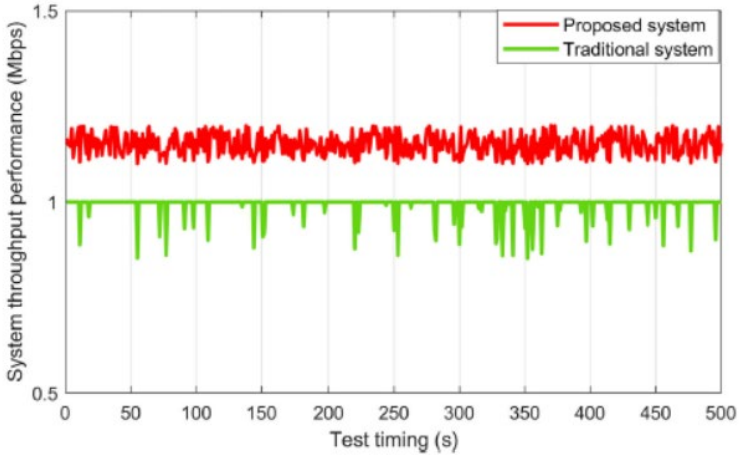

Figure 6. The system data rate performance

From Figure 6, it shows the system data rate performance of traditional and proposed systems.

In the other countries, In April 2019, a Chinese neurosurgeon successfully operated on a patient suffering from Parkinson's disease. The doctor used a pacemaker-like implant on a patient that was about 1864 miles away during the surgery. This surgery was only possible because of the lightning-fast connection of 5G networks that allows surgeons such as the one in China to control an off-site surgical robot and operate in real- time. 5G is driving the rapid revolution of healthcare as a whole.

5. Conclusion

Healthcare is being dramatically transformed from a conventional fixed physician-focused method to a dynamic and distributed patient-oriented strategy. The proliferation of several emerging technologies, for instance, IoT and 5G, is driving this rapid revolution of healthcare verticals by providing personalized and remote medical services efficiently and accurately. Most traditional medical platforms are connected to a 4G network. However, the communication processes are static, computationally complex, and less secure. To cope with the emerging healthcare trends, conventional networks will face stricter requirements in terms of data rate, speed, and latency. As the healthcare market matures, the connectivity requirements for numerous IoT devices in hospitals will promote the deployment of massive machine type communication (mMTC). Besides, other critical applications, for instance, remote surgery, will need ultra- reliable low-latency communications (URLLC) or critical machine type communication, which are possible through 5G. The IoT is a major evolutionary change, as it accommodates the needs of current medical trends and practices. From the security perspective, this review presents comprehensive details on the core and enabling technologies used to build device authentication systems for IoT-5G healthcare applications. Additionally, this paper provides details of related standards of core IoT-5G technologies published by different standardization bodies as well as a brief overview of intelligent authentication of devices by healthcare applications.

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Biographies

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