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5G and IoMT: Moving Towards Modernization of Healthcare

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***Abstract*— The much-awaited fifth-generation of cellular wireless technology has the ability to revolutionize healthcare with its high speed and massive connection power. Along with its many primary advantages, it will also empower medical innovations via extended reality (augmented/virtual/mixed reality), artificial intelligence, remote medical learning, patientcare, and monitoring, to name a few. The healthcare domain's critical and time-sensitive nature makes it all the more essential to have continuous access to near real-time data to support and derive full use of the advanced technologies today. Currently, healthcare uses the existing 3G/4G network and other communication technologies extensively in smart health care applications, and they are constantly being developed to meet the needs of future smart health applications. As the smart healthcare market expands the number of applications connecting to the network will generate data that will vary in size and formats. This will place complex demands on the network in terms of bandwidth, data rate and latency, among other factors. As this smart healthcare market grows rapidly, the connectivity need for a large number of devices and machines with sensor-based applications in hospitals will increase the need to implement Massive-Machine Type Communication. The future smart healthcare networks are expected to be a combination of 5G and IoT devices which are expected to increase network coverage, network performance and address security related concerns with accuracy and correctness.**

Keywords—5G, IoT, Healthcare, Technology

I. INTRODUCTION

It is the beginning of the high-tech era in the healthcare technology sector. New-age technologies such as artificial intelligence, cloud computing, IoT, and bigdata have become a common topic of discussion amongst healthcare professionals to cater to patients with high-quality services while lowering the costs substantially.

5G and IoMT are the future of current healthcare system where every medical device will be better connected and monitored over internet by healthcare providers with ensuring security of patient data. This offers a faster and low-cost alternative to existing system that we have in all over the world.

Smart healthcare has a significant role in the economy. In Europe, the average spending on smart healthcare is approximately 10% of gross domestic product (GDP), and up to 99 billion Euros of healthcare cost can be saved through smart healthcare by 2020. The global IoT in healthcare market is projected to reach US$ 181.4 Billion in 2022, anticipated to grow at a CAGR of 18.0%, reaching US$ 952.3 Billion by 2032. [1]

II. SMART HEALTHCARE

Smart healthcare provides healthcare services through smart gadgets (e.g., smartphones, smartwatch, wireless smart glucometer, wireless blood pressure monitor) and networks (e.g., Body area network, wireless local area network, extensive area network. The intelligent gadgets process health information gathered from numerous sources, including sensors and biomedical systems (i.e., the application having information about medical science such as diagnosis, treatment, and prevention of disease). In short, smart healthcare allows people from different background and walks of life (e.g., doctors, nurses, patient caretakers, family members, and patients to access the right information and obtain the right solutions, which are mainly to minimize medical errors and improve efficiency, as well as to reduce cost at the right time in the medical field.

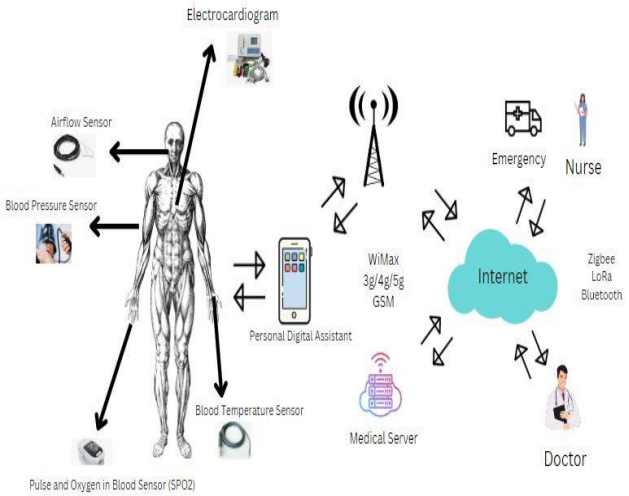

Fig.1 Smart Healthcare Diagram

III. 5G

5G is the fifth generation of wireless network technology. The central theme of 5G, just like the previous fourth-generation, is speed. Every new generation of wireless network is significantly faster and more capable than the last. The first-generation of the cellular network, i.e., 1G, was focusing primarily on improving the voice quality on the phone; second-generation or 2G was launched to enhance the voice quality further and introduced the concept of sending

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and receiving text messages. 3G, in addition to improved call and texting experience, also brought the internet to our cellphones, and fourth-generation or 4G took data sharing to another level with significantly faster wireless internet connectivity. 5G represents another step forward with super-fast connectivity, ultra-low latency, and widespread coverage. The global 5G technology market is expected to reach $667.90 billion by 2026, with a CAGR of 122.3% from 2021 to 2026.[2]

IV. IoT

There are different definitions of IoT, and based on the definition from IoT European Research Cluster (IECR) project, Internet of Things is dynamic network infrastructure which has the capability of self-configuration on the bases of interoperable and standard communication protocols. In other words, IoT is flexible, complex, and dynamic network infrastructure that connects anyone, anything, anytime, anywhere, for any services. The internet of things has numerous applications in healthcare, from remote monitoring to smart sensors and medical device integration. There is now a growing trend in the synthesis of sensors and sensor-based systems with device-to-device (D2D) communications.

V. INTERNET OF MEDICAL THINGS (IOMT)

The IoMT is a connected infrastructure of medical devices, software applications, and health systems and services.
Internet of Medical Things (IoMT) systems are increasingly diverse and prevalent and are excellent candidates for preventing, predicting, and monitoring emerging infectious diseases like COVID-19. The use of IoMT as a health monitoring system provides real-time surveillance through the use of wearable health-monitoring devices, Wireless Body Area Networks (WBAN), artificial intelligence (AI), and cloud-based remote health testing.

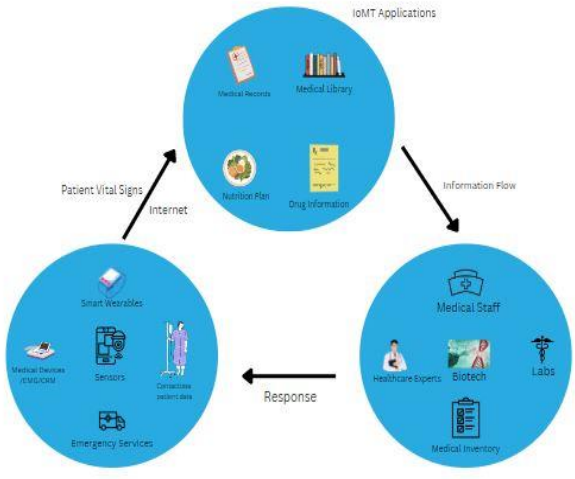

Fig. 2 IoMT Diagram

VI. HEALTHCARE INDUSTRY TRENDS DRIVING THE ADOPTION OF 5G AND IOMT

A. Shift in demographics

The 2019 revision of the United Nation's World Population Prospects estimated the global population of 7.7billion. It is expected to rise to 8.5 billion by 2030 and 9.7 billion by 2050. As life expectancy is increasing year on year, the world population is bound to grow older. For the first time in history, in2018, persons aged 65 and above outnumbered children under 5years of age. The rise in the aging population and the prevalence of chronic or lifestyle diseases boost RPM systems' demand for homecare.

B. Big data analytics

Big data has made a remarkable impact on the healthcare industry in oncology, neurology, cardiology, and other specialties. The extensive use of wearable devices and smartphones has helped to accumulate a large volume of patient-specific data.
Big data enables healthcare professionals to utilize population data for new research and personalized treatment opportunities.[3]

C. Remote monitoring systems in hospitals and eHealth

Many Hospitals have an electronic patient data management system to manage admitted patients' data, including prescriptions, diagnostics, analytical test results, medical reports, etc. A well-equipped hospital also has modern PDMS, which helps collect data in real-time such as cardiac monitors, pulse oximetry, blood pressure, etc. This allows doctors to fully optimize patient care, eventually leading to a significant amount of time-saving and reduced unnecessary re-admissions.

VII. OBJECTIVES OF SMART HEALTHCARE

A. Resource optimization

Resource optimization in one of the key objectives for smart healthcare. Resource optimization techniques are used to minimize energy consummation while maximizing network lifetime. Resource optimization techniques play an important role in 5G based smart healthcare network. A huge number of IoT devices enable smart healthcare, which can produce a massive amount of data and consume more bandwidth of the network. Improper resource optimization can lead to several issues in network.

B. Quality of service (QoS)

Quality of service (QoS) refers to the ability of the network to achieve high bandwidth and handle other network performance such as error rate, latency and uptime. QoS also includes managing and controlling network resources on priority basis for a different type of data (audio, video, files) in the network. The main goal of QoS is to provide priority to networks, including low latency, dedicated bandwidth, controlled jitter, and enhanced loss characteristics.[4]

C. Energy efficiency

Energy efficiency has become the main criterion for designing smart healthcare network, not just due to the environmental concerns, but also because of the nature of IoT devices participating in the network. Due to the density of access point in the network increases the energy consumption of the network. Therefore, energy efficient schemes are required to increase the lifetime of the devices deployed in the network.

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VIII. IOMT FOR SMART HEALTHCARE

The medical ecosystem has evolved significantly with the rapid advancements in science, technology, and medicine, and the proliferation of smart medical devices. In addition, the advancement of communication technologies has turned various medical services into accessible virtual systems and remote distance applications.[6]

Implementations of the IoT into medical systems have had a tremendous impact on public life and in the healthcare industry. Researchers and industries are moving towards IoMT applications in order to provide better, cheaper, and accessible healthcare. In addition to these, IoMT medical ecosystem includes cloud data, applications (online, mobile, real-time, and non-real-time), Wearable sensor devices, and security. Below figure compares a traditional medical ecosystem with a more advanced IoMT-based ecosystem.[8]

One of the recent such advancements in this field is Apple Smart Watch. It has various features as compared to other devices. But what makes it a technological marvel is that it has certain features like Crass/Fall detection, ECG, Spo2, Period tracker and many more. Crass/Fall detection has helped numerous people when they have faced with some kind of accident or fall, it has contacted the emergency services and informed the emergency contacts as well. Similarly, its other features like Period cycle tracker has helped women keep track of their menstrual cycle and personal well-being, Spo2 has helped many people in keeping track of their blood-oxygen levels during the recent covid-19 pandemic and ECG has helped many people from heart related ailments by notifying them proactively about their irregular heart rhythms and possible heart attacks and other medical complications.[8]

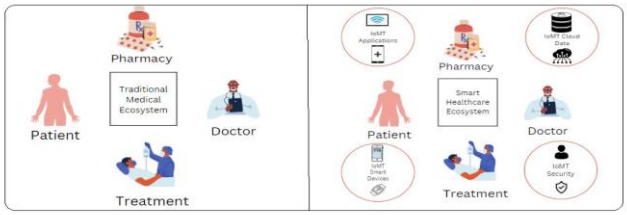

Fig. 3 Traditional vs Smart Healthcare System

IX. 5G FOR SMART HEALTHCARE

Smart healthcare depends on various short range and long-range communication technologies to transport data between devices and servers. Most of the short-range wireless technologies are Wi-Fi, Zig-Bee, Bluetooth, and Wireless Metropolitan Area Network (WiMAX) which are primarily used for short communication in smart healthcare such as BAN (Body Area Network).

The 5G is already capable enough to fulfill some of the requirements of smart healthcare and it is going to further enhance its capabilities to strengthen the smart healthcare infrastructure.

The 5G network can minimize latency up to 1 ms, which can lead to new telesurgery applications with strict latency requirements. In future, modern solutions might be possible in the healthcare environment. For example, surgeons can perform operations with robots virtually from anywhere in the world.

A key feature of the 5G network is to support higher frequencies (including above than 10 GHz frequencies). More spectrum is available by using these frequencies, which leads to very high transmission rates (on the order of Gbps). Physicians can see high-resolution pictures remotely and deployed healthcare solution with ultrahigh definition (UHD) content through the high-speed 5G network.

To connect large numbers of sensors and biomedical equipment's, low-cost devices with high battery life is important. For continuous remote monitoring, the aim is to connect self-sustainable devices in the network for the full duration of medical operation. In 5G, low-power sensors are intended to work on the same battery for 10 years. Therefore, the network lifetime must be improved.[8]

X. OPEN ISSUES AND CHALLENGES

Along with numerous benefits of these technologies, there are numerous challenges and open research issues in adopting 5G and IoMT for smart healthcare.

A smart healthcare network consists of billions of devices. Smart healthcare concept can succeed only if it can provide connectivity to every device present in the network with the capabilities of sensing to produce important information. However, guaranteeing connectivity in smart healthcare postures many challenges, such as:

- Guaranteeing connectivity to huge devices deployed in the network in wide range.
- Providing connectivity to high mobility (i.e., high-speed ambulance, carrying patients) devices in the network.

Big data analytics is a key research direction in smart healthcare. In smart healthcare, billions of devices are connected, which can produce a huge amount of data and information for analysis. This data can consist of information about user private data (i.e., Patient Data) and from the surrounding environment (i.e., ECG, Heart Rate monitoring). For example, data produced by locally connected devices can be analyzed efficiently by adopting deep learning algorithms. The key issues that must be addressed are:

- During data analysis, user privacy must be protected.
- Data secrecy must be provided for sensitive data.
- Infrastructure must be provided to collect, analyze, and store a massive amount of data.[3][9]

Implementing security on IoMT devices is a challenging task due to the constrained-device criteria and distributed architecture of IoMT ecosystem. Additionally, these devices are located at the edge of a network and, in some cases, are remote or located within the body, etc. and not easily accessible. Moreover, data protection and safe communication that adhere to security requirements are required to make IoMT systems secure. Many IoT systems suffer from lack or weak authentication as a result of

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constraints in hardware, energy consumption, and other computing resources. Unfortunately, this has presented opportunities for cyberattacks.[9]

XI. CONCLUSION

This paper presents an overview of recent advancements and use cases along with existing and future opportunities on the aspect of 5G and IoMT for smart healthcare solutions.

Health systems currently face challenges related to shortages of critical medical professionals, long waiting times, rising demand for services, and financial constraints. 5G and IoMT could help in easing some constraints by shortening the time healthcare experts invest in repetitive activities (using AI methods and IoT devices), thus allowing them to focus on other activities, such as seeing more patients and indulging in more R&D for new methods and techniques in healthcare. [13]

Moreover, these recent trends show that people are taking their health more seriously and taking proactive steps to prevent them from getting sick or facing any critical conditions by actively focusing on mental health, physical health and safeguarding themselves from any unknown diseases by investing in sound healthcare practices. And this trend will certainly grow in terms of growing population, changing demographic and rapid growth of economy of the entire world post these pandemic times.

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