

# Evolution of 5G in Internet of Medical Things

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**Abstract**—3D ultra high resolution videos can be downloaded within seconds by deploying state-of-the art 5G technology. It handles big data with lesser delay and provides more bandwidth. The Internet of things (IoT) is the physical networks which different technologies together Wi-Fi, Bluetooth and Cellular on a one platform. The IoT for medical healthcare which is IoMT requires high data, high speed and long battery life with reliable connectivity. The 5G fulfills these requirements with its superfast capabilities and supports IoMT for human health such as, diagnosis and treatment. This paper present the detailed survey about how 5G has revolutionized the medical healthcare with the help of IoT for enhancing quality and efficiency of the wearable devices. Besides, state-of-the art 5G-based sensor node architecture is proposed for the health monitoring of the patients with ease and comfort.

**Keywords**—5G, internet of medical things, healthcare, sensor.

## I. INTRODUCTION

As the demand for wireless networks increases which requires more bandwidth and more speed to meet the increasing data rates. The technology which supports this is known as 5th generation or (5G). With 5G deal with 40 times faster speed as 4G and download 8K or ultra-3-D movies in just a second. Ericson said that 5G is not about having the tag of super-fast internet capability but it beyond smartphones and tablets. His thinking is that 5G would offer a best choice to transform the world [3]. Now-a-days most challenging problems is to focus on the latency which means how much time a service takes or how much time it responds to request. The 5G technology having capability of increased computing and connectivity will provide a new thing is called internet of things. The Fig: 1 shows the advancements in technologies up to 5G. As it can be observed from diagram that the start has been taken from voice calls. Now you can have the ability to use the internet with ultra-high speed which you can't imagine.

Now imagination will prove to be the real world. The customers will have been given to data rate of 100 megabits per second on just average data transmission. The researchers has decided to commercialize the 5G networks up to 2020.

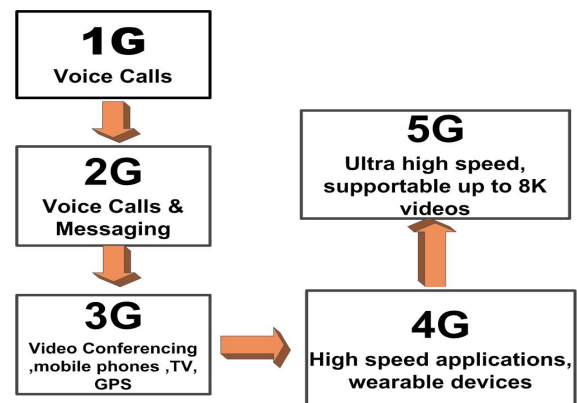


Fig. 1 Generation of wireless network

One of the most significant telecommunication company in South Korea KT Corporation will officially promote the Winter Olympics and will becomes the one to explain what 5G actually is?

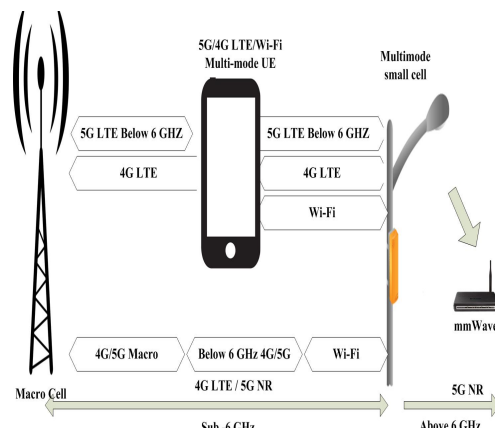


Fig. 2 Vision of 5G Ecosystem [28]



In Fig: 4 it is illustrated that how future network 5G will work. The patient will have to look at their smart phone to check the health results. As a person recent discharge from hospital and is linked to cloud by which doctors can access them for further medication [12]. The backbone for IoMT is 5G which connects different mobile and medical devices together [29]. Now-a-days there many applications that will provide range of benefits to industries that requires reliable connectivity and high bandwidth. These types of things are one of the portion of the upcoming 5G technology.

### III. PROPER TREATMENT AND DIAGNOSIS

The main issue of new innovation digital medical is distant access to imaging and capability that how fast these images share information across region with low delay and distance. Taking an example if a doctor is in one city of any region he needs any advice from another doctor the he has to transfer the medical images or results to that doctor and get its feedback at the medical condition. These advices will help doctors to gain access to most experienced persons and enables the healthcare system more efficiency by improving difficulties based on geography and income. This is the condition especially in rural areas or suburban populations [1]. In rural areas patients do not have the facility to contact with the modern medical specialists. When it comes to the digital world how these patients can access the specialists who are far away from them. This reduces the issues in health and it will help to connect the urban/rural people together which exists in some countries as separate. The patients will not have to travel for high quality medical services. Now they will not limited to just their local doctors but they will have access an international network of professional doctors.

Darrell M. West gives an example of Michael J. Fox Foundation who developed and worked on those devices which tracks the movements related with Parkinson’s disease. The transmission of videos to track the health of patients and battery technologies of sensors are important issues in WBSN [31]. There are different techniques introduced for energy efficient transmission in wireless body area networks [32]. If the diagnosis is not complicated then they can get health care at their home through conferencing and digital medical care. The doctors and nurses have ability to scans vital symbols, movements, levels of speech bleeding in order to provide the facility of diagnosis in real time to patient’s health care issues [6]. The “Citizen Tele-care Service System” (CTSS) organization aim is to completely implement those technologies that can be able to provide continuous scanning, alerting of earlier warnings and biometric monitoring, that are related to health issues [7]. The respiratory sensor having clothing that display the infant and parents can watch this all information in an Android application. It also help parents to keep track of baby conditions and warns the parent when there is need of change of diaper [8]. The capsule endoscopy with battery friendly can increase the efficiency of images because it requires less power consumption and long battery life [9].

The actual use of these advances is relates to cancer genes. As most cases of cancers are complicated and are related to patient’s genetic composition. It requires complete information

of how genes are affecting cancer growth is more valuable knowledge for doctors and patients [10]. There are a lot of medical equipment and devices developed for the 5G network to mark this thing possible but desktop computers cannot store this detailed data so the cloud has been used for storing the data which is visible to doctors who requires this access. The cloud is one of the latest growth in the network which has wide-range of storing data that doctors requires.

### IV. FUTURE RESEARCH CHALLENGES IN MEDICAL HEALTHCARE

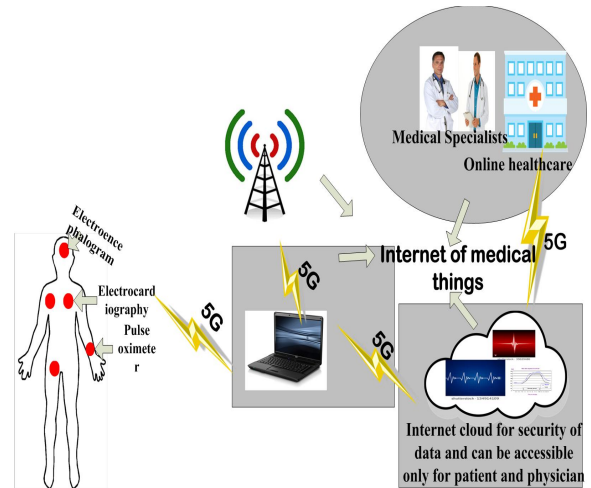


Fig. 5 IoMT in Healthcare system [12]

This section discusses the future innovation in IoMT for health care. There are three layers. The work of first layer is at home for a patient who use personal computer, cell phones or sensors to connect with the cloud for storing data. The patient must have secure RFID for securing purposes. The second is the connectivity provided by 5G network in the whole process. At the hospital the doctors will have access to patient data for diagnosis and treatment. In the hospital there will be increases in the number of medical devices like tablets, laptops to connect with patient. The Internet of things is gradually giving its benefits to human healthcare on doctors and patients. The IoMT also helps patient to take care at homes. As some

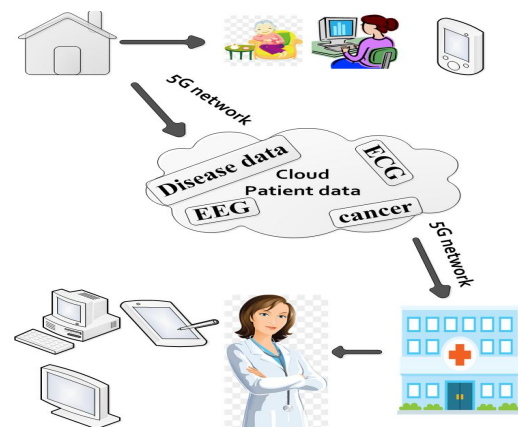


Fig. 6 Future IoMT

patients do not take care of themselves and also do to take medicines at appropriate time. So smart IoMT in the home automatically upload this information to cloud and send alert to doctors for patients not taking their medicine. In broader sense it also helps doctors to know the critical conditions of patients [14]. In simple word more connectivity means more data and better healthcare for patients. This is illustrated in Fig. 6. The new technology IoMT will allow patient and doctors to monitor the heath in real time and through health records all the doctors will have access to the that information. These things will enhance the improvement in patient health, treatment services in an affordable rates.

The Fig. 5 has been shown that 5G will fulfill the requirements of connectivity between patients and doctors. The IoMT will support the medical devices and mixed them together in a combined system in order to get the more efficient system and facilitate the patient. There are some security problems and real hurdles with data sharing, privacy to be taking concerns so the 5G technology could be compensated with this issue. The 5G technology bring the evolutionary steps that will give benefit to everyone. Though there is still issue to be overcome future of IoMT would be improved [18]. The Price Waterhouse Coopers suggests that the market will grow to \$61 billion by 2020 for IoMT healthcare. By 2020 the medical healthcare devices would grow up to \$14 billion. The provided services are estimated to be increased by \$45 billion on this same period. The yearly growth rates from recent levels will be 37% and 31% [15]. The deployment of IoT would mostly concern with security and privacy of data. There are some methods for securing of data in the cloud but still there are some intellectual hackers which can steal only the data [17]. A survey of 12,000 people among eight nations showed that 70% of them are eagerly to see a doctor via video conference for usual appointments and 70% are willing to using toilet sensors and health monitors [19]. Instead of going to hospital for medical services, patients would have benefit of medical health care technologies, digital technologies and remote tracking devices. It is approximated that POCT market would increases up to \$27.5 billion by 2018[20]. The Veterans Administration (VA) researcher's studies on over 17,000 VA patients showed that there would be 25% reduction in number of bed of care, 19% reduction in numbers of admissions in hospitals and means result for satisfaction score rating of 86% after enrollment into the program [21]. University of Virginia Health System had taken a study and found that there would be 37% improvement in hospital readmission after home visits and post-acute care assistance [22]. The optimal smoothing algorithm can be used to optimize the quality of service of telemedicine [37]. The 3% of patients could be readmitted if they were monitored daily and they have video conference with health providers weekly while 15% are those who are not able to get these types of services [23]. The diabetes disease is the important problem in many societies. The state of Mississippi found that 13% of the people have diabetes disease and 54% are those patients which are in rural areas having limited access to this quality of care. After producing Diabetes Telehealth network with monitoring

care management, health providers could cost upto \$339,184 for almost 100 patients having diabetes and it can save the money \$189 million annually [24]. The Fig. 7 illustrated the increases number of devices in the future years [14]. The IoMT in healthcare has ability to provide the as services of hospitals at home at low costs without any avoiding any quality.

The voice recordation software could restricts the administrative operations but some studies shows that it help health providers to give proper care without being any interruption of data and querying tasks [25]. The capability of tracking the usage and status of devices facilities for ensuring the safety of patient [26]. According to the industry point of view Paul Buss Communications reported that the saving the money through e-health can be expected between 10% and 20% of total healthcare costs [27]. The patients will have

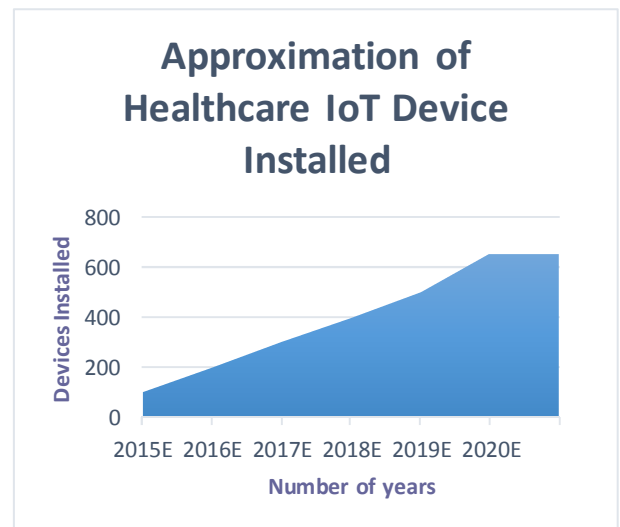


Fig. 7 Growth in IoMT devices [14]

ability to go online for medical data and use this data to improve their previous questions to doctors. In simple words it can be say that 5G technology can be helpful in connectivity of these devices for smart and proper treatment of patients.

## V. PROPOSED 5G BASED SENSOR NODE ARCHITECTURE FOR IoMT

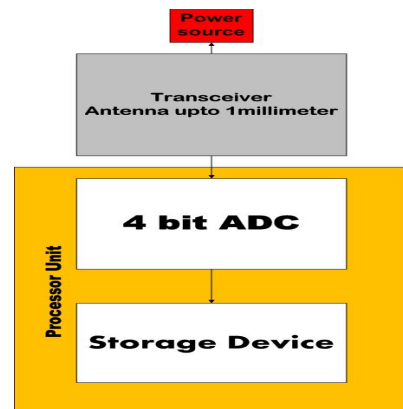


Fig. 8 Architecture of sensor node [39]



The recent 5G technology has introduced the IoT to help the patients and doctors at home and hospitals. In this regard, wireless body sensors need is to give a device which monitor the health of patients. Many different BSN (body sensor node) introduced to offer the medical care facility to patients. The main requirement in the architecture of sensor node is the power consumption and size of the sensor. The size of the sensor should not be too long that people can't handle it. The architecture consists of a transceiver, storage device, and processor. The transceiver includes antennas. The size depends on antenna size. This size is an inverse relation to frequency and direct link to wavelength. The frequency ranges for 5G is in gigahertz. The higher frequencies decrease the wavelength and antenna size also decreases. The antenna size reduced, the sensor size will also decreased. There is a benefit of small sensor node which is easy to carry out and handle. It also requires low power consumption due to the smaller size.

$$f \propto \frac{c}{\lambda} \quad (1)$$

$\lambda \propto \text{size of antenna} \propto \text{size of sensor}$ .

Where by,  $\lambda$ ,  $c$  and  $f$  represents the wavelength, speed of light and frequency, respectively.

Moreover, in our proposed architecture of sensor node in 5G technology, the transceiver antenna size reduced to 1mm and 12-bit ADC is minimized upto 4 bit ADC.

## VI. APPLICATIONS OF 5G

The key technologies for future world involves smart technology in transportation, medicine, mobile robots and medical devices which makes the environment of the IoMT. 5G is just high data rates and low latency technology but it provides the base to IoMT applications. It integrates variety of different and innovative advances in technologies. The IoMT devices includes biomedical, sensors and these devices have built-in GPS system and it provides efficient and dominant machine to machine traffic which needs higher capacity, high bandwidth and multi radio access techniques [31]. The wearable sensors gather information about different human body parameters like EEG, ECG, blood oxygen and EMG etc. The IoMT needs to converge the technologies and standards like biosensors, wearable devices, protocols, memory and variable data and video transmission. To improve the performance of the video transmission energy management algorithm is presented which increases the lifetime of the sensor [33]. Big data and continuous connectivity is required to integrate every system from home to hospital [30]. The benefits which IoMT provides are precise below.

- The system should be the adaptive quality of service (QoS).
- There will significant increment in the network and spectral efficiencies.
- The system has high capacity, device connectivity, and also handles the large devices having varied traffic features.

- There will be a range of low to high bandwidth for communications.
- The system provides low latency and energy efficient network.

It is obvious that sometimes data from one sensor would not be useful for tracking high areas and complicate activities so a variety of sensor nodes are integrated with wirelessly each other. The wireless sensor network (WSN) comprises of thousands of sensor nodes connected. They gather the data and transfer it to gateway devices that communicate this information through cloud by internet [36]. The WSNs are many properties like they are combination of sensors having processing and small storage elements, which work on constant energy and memory [38].

### a) Smart Clothing

The smart clothing provides multi-modal physiological signal data by incorporating multiple micro physiological signal data [34]. The most essential requirement for diagnosis is the bioelectric signal of the human body. The usage of electrode is one of the main concern to get signal bio signal acquisitions technology. In recent days, the textile structure of this electrode is designed in such a way that it collect and tracks the bioelectric signal of the human body. This structure is soft and washable and long life usage. It can collect range of bioelectric signals of the human body [35]. The benefit of smart clothing is to track the ECG signal and it can be used for diagnosis purposes. The ECG can measured by placing electrode in specific part of human body surface. It can also measure blood oxygen and EEG signals. In short description the smart clothing can overcome the usage of wearable devices. It can be used in variety of diseases diagnosis and tracking of chronic health diseases.

### b) Diagnosis Services in Rural Areas

The rural areas of developing countries having of health resources so it is important and necessary to incorporate these health care resources and develop IoMT services. The farmers can have availability to get these diagnosis services at any time and can get the health care information accordingly. The monitoring of healthcare can be provided at rural area clinic at any time concerning patient health condition. The urban cities hospitals connected to all rural areas clinic, the new advanced medical monitoring devices and system would use at rural side for treatment. This will give the farmers to get facilitate of advanced health care services at their hometown. This will enhance healthcare services quality of farmers and helps to improve the condition of a patient having chronic diseases. The management team used professional monitoring system to estimates the risk of diseases, it may help patient to get prevention before the illness found, and it also reduce the occurrence of diseases.

### c) Management in Hospitals

The diagrams shows that which services can be perform in hospitals. This is further illustrated in Fig. 9.

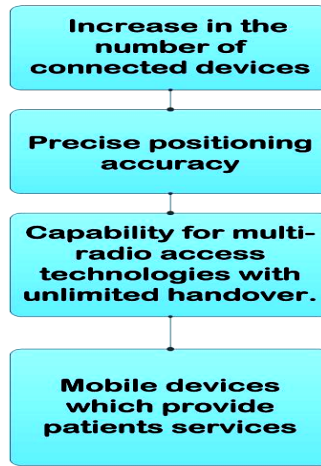


Fig. 9 Hospitals Management system [11]

#### d) Use of Robots

The use of robots to transmit and receive data in order to provide patients accurate medical care. This is explained in Fig. 10.

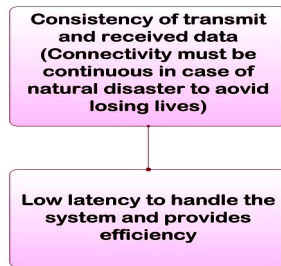


Fig. 10 Usage of robots [11]

#### e) Monitoring of healthcare data

In this how data is monitored at back end means at cloud. The rural areas are main issue because they do not have any facilities and hospitals are far away from them. The requirements for medical care is discussed in Fig. 11.

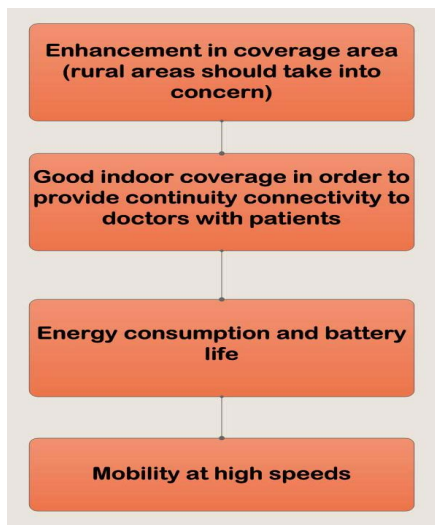


Fig. 11 Monitoring of health record [11]

The smart medical care means omni-presence of the health facilities with less power consumption and longer lifetime, and better coverage. Also there is a large need for increasingly connected devices. The medical care need a secure network due to its nature. The 5G network must provide a reliable and secure system in a way that sensors should authenticate by the network. So that patients will feel free from any theft of data to other parties [11].

## VII. CONCLUSION

With the rapid proliferation of the usage of smartphones and miniaturized wearable sensors there is an advancement in the patient's treatment methods such as, diagnosis, imaging, homecare delivery, etc. So, keeping these benefits and increased demand of the aging society in mind, we carried out this research. This survey paper presents the detailed review of the joint state-of-the art IoT and 5G technologies for monitoring the health status of the patients with ease and comfort. Besides, a novel 5G based sensor node architecture is proposed for IoMT. It is investigated and concluded that 5G is not just beneficial to the wireless network but the friend of the healthcare industries with the notion, 'healthcare for anyone, anywhere and anytime'. Moreover, 5G offers long-term connectivity between devices effectively and efficiently diagnosis the critical conditioned patients. The main purpose of this survey is to investigate state-of-the art and economical ways of service provision to poor and aging society in the rural areas by reducing their resources and frequent visits to hospitals. In the near future we will focus on the energy, battery charge optimization and lifetime extension of the resource-constrained IoT-based wearable devices during patient's vital sign signals or video image transmission over 5G networks.

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