

Next generation 5G Wireless Technologies in Healthcare

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Abstract

With vastly developing technology regime, healthcare sector is witnessing next generation upgrades that are showing a lot of promises with impetus on assistance to healthcare infrastructure. Coincidentally telecommunication advancements like 5G will emphatically revolutionise the due course in this domain with super low latency and highly precise information transfer. With IoT devices available to retrieve personal medical data (MIoT) the paradigm shift towards personalised medicine is leveling itself. This paper in detail covers each aspect of 5G technology and how it could act as a pathbreaker in recovering from present challenges in healthcare. Critical evaluation of present applications is also being made to contrast the past practices with hypothesised futuristic advantages. Quantitative data transfer at broad scale is a next generation requirement to facilitate efficient transfer of information and healthcare sector pan globe with integrated and well devised policies could be the real beholder of these beneficiaries.

Keywords : 5G; Remote surgery; Telemedicine; Latency; IoT; MIoT.

Introduction

In 2016, the United Nations (UN) underwent serious deliberations for the establishment of world order in the spirit of sustainable development and the umbrella organization came with the policy of sustainable development goals (SDGs). These are a series of issue-specific propositions intended to guide people and the planet towards a better future in a comprehensively devised integrated manner. Under this very directive goal, 3 for better health and well being of every citizen is proposed. But since the advent of these measures primarily devised under the continuation of millennium development goals the progress has been very little. Despite bilateral and multilateral policies centered towards healthcare and large sums of budgets involved, the beneficiaries are very less thus making the rest of the people devoid of basic healthcare facilities resulting in increased mortality rates. The deaths due to non-communicable diseases are considerably high which otherwise could be less as compared to present trends. Inaccessibility to immediate healthcare response in case of emergency is one of the major contributors to such soaring numbers. Inaccessibility

here means both in terms of distance from patient to the nearest center (as a large part of the rural population lives in remote areas) and the potential of nearest primary health care center to consult specialists in case of exceptional situations. In the classical context, to solve such problems infrastructure-centric policies would be the best solution but it requires larger capital investments which become difficult for developing countries at times. Is there any alternative? Present biotechnologists and healthcare researchers answer this question with a big yes. Wide-Scale developments in the field of machine learning and artificial intelligence clubbed with technological achievements in the Internet of Things in the form of biosensors and signaling devices could provide us with an affordable and less time exhaustive solution. The major setback that these tools had in the field of healthcare was that as compared to any other domain with their applications healthcare has more risk involved thus high accuracy is required with the fastest mode of transmission of information to prevent any fatal delays. Thus, the recent innovation of 5G can prove its mettle. So, we will analyze a broader dimension of 5G and its throughputs in detail in this paper.

Defining 5g

The 5G is an acronym for fifth generation which is an upgrade in wireless data transmission technology. It is upgraded from 4G which is used in major parts of the world with better network speeds, capacity, and scalability. As concluded in a recently conducted project by ITU (International Telecommunication Union) this advanced networking technology has some key features[1].

It is more efficient both in terms of energy and spectrum efficiency with 100x and 3x efficiency respectively. Up to 500 km/h mobility can be achieved. Peak data should reach 10 Gbps but with better logistical implementations and technological feedback analysis with comprehensive implementations, it can go to 20 Gbps. Large machine type communication systems can work more efficiently due to its support to high connection density. Services (less than or equal to 1ms) that require very low latency will be largely benefitted.

Unlike 4G and 3G, 5G is an integration of 4G with Wi-Fi and millimeter-wave technology with various other technical wireless communication methods resulting in formation of a transformative ecosystem. This comprises of cloud based network architecture, virtualized network core, smart edge

services with state-of-the-art attributes, and dispersed computing model that derives insights from the data generated by billions of devices which includes biosensors, system-to-system communications (applications in telesurgery) and advanced digital services (in diagnostics).

Algorithms and machine design that enables 5G confers end-to-end encrypted communication on a cloud platform.

This is an evolved version of point-to-point channel in which it gathers data from millions of sources simultaneously and relays that bunch of user specific information to the directed device with utmost precision over a suitable cloud enabled operational platform [3].

As subjected to many international projects the main area of brainstorming lies in the factors that did not enable 4G technology to be used as a wireless communication technology especially in healthcare despite being the main reason behind the sudden rise in data transmission speed and applications.

So, to make 5G assist the healthcare sector in every technical and computational manner following features are either developed or are in the phase of development:

- It is an intelligent network with fast implementations that work on data traffic prioritization. It can differentiate between the information that has to be transferred simultaneously or can be transmitted during off-peak hours in split seconds. This is required as not all the information directed towards the cloud platform has to be sent immediately.
- It will enable real-time aggregation and analysis of medical data which will enable healthcare practitioners to deliver more personalized and prompt treatment to the patient. Critical/Intensive care can also be facilitated with better disposal of resources in hand or in remote areas primary treatment can also be provided.
- The best advantage of having 5G is low latency. Latency is the time lapse between the time at which the demand for the execution of a command is made to the time at which that command appeared.
- It supports larger bandwidth thus supporting higher frequency information transmission rates with broader spectrum utilization. This mainly enables distant healthcare providers to see high-resolution images for diagnosis and exchange of ultra high definition medical content.
- It allows multiple connections at the same time which enables all the biosensors to function at the same time with very little delay in relay information transmission. Scalability has to be given additional attention in m-health (mobile-health) enabled technologies because better scalability execution can accommodate node fluctuations without any impact on network processing [2].

Fig. 1: Features of 5G communication Technology.

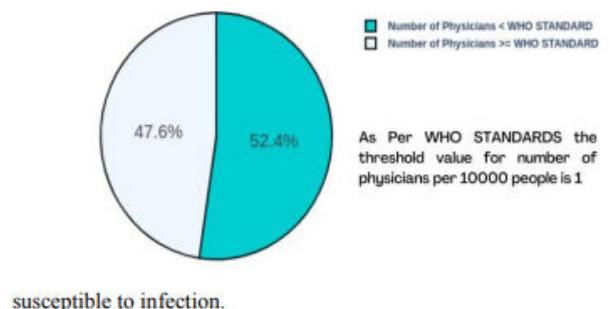


Present Shortcomings in the healthcare sector

Logistical and Manpower

As per the global standard set by WHO, the minimum threshold required of health workers required in India to facilitate optimum delivery of healthcare services is 22.8 per 10,000 people but the present estimates are much lower than the desired ones banked at only 16 per 10,000 people [4]. Also at ground level, this decline becomes more profound and concern due to urban-rural disparity with some later regions having a workforce as low as 4 to 5. Out of the top 5 reasons for mortality in India preterm birth complications (first), ischaemic heart disease (third), and chronic pulmonary infections (fifth) are non-communicable and their mortality tally can be reduced by the immediate availability of emergency medical services. But this can be done by more health care centric recruitments in remote rural areas which further requires fiscal investments and comprehensive policymaking which is a time-taking process. A better alternative is to make utilization of innovations made under 5G wireless communication technology which are efficient, require less man-power, and can provide an immediate response that too from a specialist from urban areas. The same process will not only reduce the fiscal deficit burden from the government but also assist the logistics sector present at ground level as better networking will lead to faster production in supply chains and delivery more swiftly. Thus making use of proposed innovations will not only assist stakeholders in disseminating technology in rural areas but also make them bypass what otherwise would be a mountainous task especially in developing countries like India with a lot of decision-making units before the implementation of welfare services. On a side note, this will technological advancement will be a real boon while dealing with global pandemics like

Fig. 2: Number of physicians as per WHO standards.



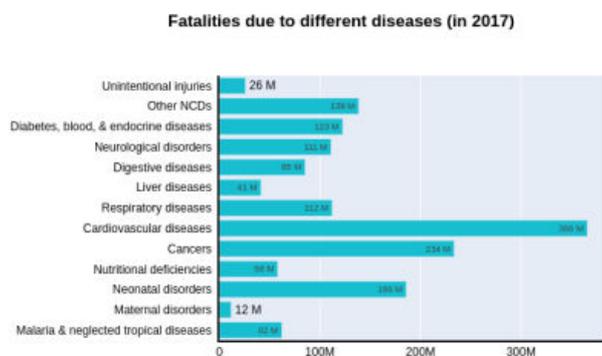
COVID (Coronavirus infectious disease) in future due to big data availability over the cloud with universal access and

telemedicine services which will reduce the exposure to primary healthcare workers who otherwise are at the frontline thus more susceptible to infection.

Diagnostic

Diagnosis of medical conditions plays a very crucial role in the initiation of treatment. Higher precision rates can guarantee the prompt treatment of infirmity thus reducing the chances of fatality. Since the basic nature of medicinal diagnosis is based on trial and error approach the time delays become more evident resulting thus contributing as a risk factor which could be reduced by better availability of data(both personal and community) and efficient machine learning algorithms which have trained on a lot of data related to fixed medical conditions. 5G wireless technology thus can serve as a medium to propagate and analyze data available to the cloud with highly rated computational efficiency. Not only this, but it will also deliver the required specialist consultations with high definition image resolution features in a very crucial narrow duration of time. One marginal advantage could be that better diagnostics reduce the time required for treatment thus reducing the burden on health care providers and infrastructure. Since 5G allows better outreach of connectivity, it could facilitate virtual (visual and tactile) training opportunities in remote communication systems.

Fig. 3: Fatalities due to different diseases.



As per latest data (2017) rendered by Institute for health metrics and evaluation a major number of deaths reported in non-communicable and allied diseases section direct us to deduce that had timely primary-aid and accurate diagnosis services being provided the number of reported deaths would have been reduced especially in cases of cardiovascular diseases, neonatal ailments and diabetes.

Therapeutic

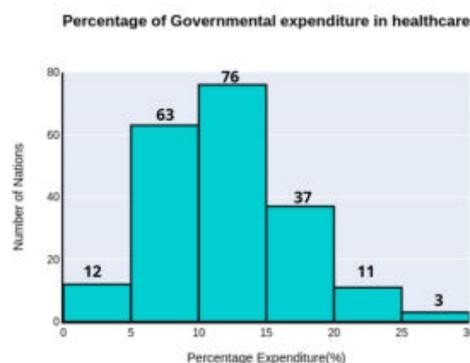
Antibiotic resistance is a major upcoming challenge that might lead to another international health emergency soon. Antibiotics that came as a blessing to the medical sector during the 20th century have become a disguise. Susceptive microbes have either evolved or mutated themselves against the anti-life substance. Although when we deal with natural entities their relapse to bypass the resisting factors is a scientifically established phenomenon but our hit and trial/assumption based medicinal practices with one size fits all strategy has made this surge more rapid. If we do not consider it a need of an hour it

might become too late and the existing line of treatment of some fatal chronic infections will become ineffective. Development and propagation of 5G enabled internet of medical things will help us in delineating this rapid surge as a better personalized data-driven dosage. It will reduce the chances of consumption of unrequired medicines. Thus reducing the probability of antibiotic impairment within a cohort. Not only antibiotic resistance but several other hindrances that arise in the treatment of especially chronic infections will be reduced by the advent of it.

Economical

As per 2019 public health expenditure report the at present Indian government invests at an average 1.3% of its GDP in healthcare which as per CAG report under national health program it has to be 2.5%[5] thus a double amount of GDP spending per capita is required to provide equal and efficient medical service to every citizen with rapid fluctuations in demand in case of health emergencies like COVID. Jeopardy arises when this high demand for investment comes with a relative rise in population growth rate thus enhancing the burden on the existing healthcare structure. With immediate investments required, the task has become unbearable but phasing out secure digital policies can qualitatively rescue us. With very less investment(especially when compared with the grade of development of physical infrastructure) major challenges can be resolved promptly. Also as stated in the above three points this innovation has overlapping benefits, reduced costs, better treatment, and patient-specific are some of the key features. With a far reach of technology in rural areas, the accessibility of city-based healthcare centers will also increase thus reducing the amount of logistical and transportation costs therefore higher benefit-cost ratio with all shortcomings handled via a single set-up.

Fig. 4: Percentage of Governmental Expenditure in healthcare.



Fringe Benefits

Apart from providing economical and optimum benefits to bypass existing shortcomings in healthcare, integrated development in AI and ML in healthcare and the Internet of Medical Things(IoMT) with efficient transmission technology like wireless 5G will enable certain hypothetical domains to become reality. These are research-intensive works but if we were able to develop them as per our ideas and assumptions they could revolutionize our way of handling healthcare machinery.

5G Cognitive systems

Unlike the prospects of availability of basic healthcare facilities via long-range low latency, transmission 5G can also be used for treating psychological conditions[6]. The

5G - Cognitive system is a way ahead. It consists of a data cognitive engine and resource cognitive engine. The latter covers the architectural and technical aspects including learning of data networks, very-low latency, and very-high reliability whereas Former deals with analytics of big data over cloud therefore in the diagnosis and treatment. It perceives the user's emotions via environmental, emotional, and behavioral data. To attain medical cognitive intelligence with algorithms that can process the available data from three categories to achieve real-time emotion communications. It further will be used in rendering drug recommendations for patients. To achieve low data latency within core network functionalities like network fusion and content delivery are developed. This technology is in the developmental phase with major feedback implementations required to be developed and tested. The major emphasis is on forming less time complex algorithms to process the computation than the initial ones for less time-bound output of the data cognitive engine.

Wireless tele-surgery

As the name suggests this is innovation is subjected to facilitate surgical/operational services in a remote area from a specialist distant apart via robots. With ultra-low latency levels, this task seems achievable. The specialist can either be appointed to conduct the surgery or be consulted any time in between from a well-equipped decentralized medical center. Low latency should come with stable haptic feedback and improvised data rates for high accuracy and efficient visual communication. Cyber-sickness(a condition in which there is a time delay in perception of movement by our vestibular system and observation made by eyes) of surgeons should be taken care of[7]. A reaction time less than or equal to 100ms(auditory), 10ms(visual), and 1ms(manual)[8].Robots will be in control of haptic gloves, they will thus enable transferring of tactile data back and forth to the specialist. Since it is logistically intensive with high data connectivity demands with the simultaneous requirement of several connections on the cloud which is required for high reliability of tactile applications, some applications like Network slicing are very helpful in this context as the operator develops customized relay networks for enhanced solutions. Mobile edge computing (MEC) is another domain that guarantees faster relay and low-latency to hosted softwares in processor trusted domain in proximity of retrieval point for robot[9].

Wireless service robots

It is based on creating an AI-enabled edge cloud platform to command robots in far away from healthcare centers. These robots hence can be used to help patients, especially older ones in hospitals, hospices, homes, and nearby areas. IoT enabled sensors will keep a track of their circadian rhythms with special emphasis on the blood-sugar level, blood pressure, and oxygen level. If any of these deviates from the expected physiological range, robots linked via 5G enabled wireless transmissions can

assist based on data retrieved from cloud storage thus reducing the chances of fatal complications in case of absence of human assistance. So these wireless robots can provide monitoring based and logistic assistance. The target with 5G wireless is to meet the required latency and throughput, with ultra-high reliability, between wireless robots and mobile edge computing centers (reasoning systems), where most of the intelligence is located. Also, for fully autonomous robots to meet the required performance, it is very important to decide where and what to compute, and how to transmit data and signals, at a given bandwidth [10].

Advent Of 5g Wireless Technology

The onset of 5G technology specifically in healthcare will transform the architecture and features of modern day with major advancements in cloud data analytics and haptic feedback.

Tactile internet

An integral part associated with this upgrade in modern-day internet is its potential to transfer real-time point to point touch feedback back and forth from users. Therefore its development is inevitable for further enhancements in technologies like telesurgery. Suitable robotics and haptics equipment are required along with a swift and stable communication network.

Simultaneous relay of physical tactile experiences over the web will shift the role of the internet from content delivery to skill-set delivery. For deployment of telemedical technologies at basic level tactile internet-based servers and resource centers have to be developed as high fidelity and extreme precision are the prerequisites. Additional benefits will come with telediagnosis services which can become available anywhere anytime without physicians' actual presence[11]. The latency of not more than 1ms is required to prevent fitful oscillatory movements of multi-connected robots and to ensure real-time synchronous and visual-haptic feedback.

Big Data analytics over cloud

As mentioned in the diagnosis section, larger availability of aggregated data with faster applications to transfer the concluded information will help healthcare facilitators in precision medicine unlike prescriptions based on average populations while also considering an individual's medical and genetic history. But to make it a reality primarily we require Electronic Health Records(EHRs). It is a repository that stores patient's digital data[12] in case of IoT sensors utilized by the patient for regular tracking of several physiological variables(blood pressure, pulse rate, heartbeat, etc.) it will store those values as well. Thus, an established reliable channel for error-proof transfer of data is required which 5G is capable of providing. In case the availability of such large data related to a cohort is studied, community medicinal approaches can be devised and population-based health patterns can be developed which become crucial while dealing with epidemics and pandemics. Big data provide the necessary support for developing a patient-centric personalized healthcare system in which the right health intervention for a given person and the health problem can be identified in an evidence-based manner.

The Collaborative Cancer Cloud is an analytics platform that integrates patient information from a variety of organizations. It allows participating institutions to “securely share patient genomic, imaging, and clinical data for potentially lifesaving discoveries. It will enable large amounts of data from sites all around the world to be analyzed in a distributed way while preserving the privacy and security of patient data at each site.” [13]. Thus cloud computing enabled big data analytics could support every aspect of 5G enabled healthcare by rendering accuracy.

In addition to these benefits, this technology could safeguard the quality of treatment as well. Some examples of this are:

- Undermined communities will get better access to state-driven healthcare facilities as people living in remote/isolated locations could get better medical services.
- For older/physically-disabled people it becomes painful to travel distant medical centers even within cities but with the advent of 5G communications home-health therapies will come into play which could transfer vital medical data regularly thus enabling distant physicians/specialists in therapeutic prescriptions and diagnosis.
- In a study conducted in Indiana, USA on patients of congestive heart ailments it was deduced that remote assistance reduced hospital readmissions. There was a contrast of 12% , in the number of patients that did not render with remote services(15%) readmitted to the ones that rendered the service(3%) [15].

Related Studies

The advent of 5G communication technology has come with several promising advancements in the healthcare sector. Governments and private stakeholders are investing capitals in research and development of state of the art tools and applications based on 5G transmissions. The thrust area of research includes algorithm design and analysis for better data aggregation and estimation with minimum time complexity and achieving low latency rates via architectural and systematic computational amendments. Here are some projects and their outcomes, they could enable a headstart for future developments.

To develop 5G enabled healthcare they need a resilient architecture system. This system utilises Transparent Interconnection of Lots of Links (TRILL) which is a protocol used for delivery of data packages and management of mobile applications. Moreover, it renders bridge routing functions to every eNB. Unlike 4G which has limited bandwidth and does not allow multiple IoT devices connected over the same network. For stable multimedia services, a high-speed network is a prerequisite. Users can access critical medical information as it provides pragmatic roaming services. To make 5G more efficient some technical aspects of 4G are also used in this system for better mobility control. Link layers in the routing bridge incorporated in system architecture also helped in minimizing overhead tunneling [17].

Under the domain of M-health solutions with 5G enabled machine to machine(M2M) communication[2] an M2M

healthcare gateway is considered. These mechanized instruments enable bidirectional communication between healthcare sensors and back-end servers which have enabled better screening facilities. In the case of chronic infections and age-related complications, it can provide better monitoring applications with immediate treatment in case of an emergency. Linked with EHR reports and prescriptions can be directly sent to the patient’s guardians via M2M gateway by the doctor on duty without any restriction and time delay.

Conclusion

After a comprehensive analysis of 5G wireless technology with a briefing about economical, social, logistical, and technical advantages which it can provide one thing becomes natural to understand that if not today, this is the innovation for tomorrow. It has the potential to modify existing medicinal regimes with far-reaching benefits and more accurate and swift disposal of medical service. We are living in an era wherein a time-span of 20 years the world has faced regional epidemics in the form of SARS(2003) and MERS(2013) and the global epidemic of COVID-19 with continental outbreaks in the form of zika virus and ebola. Global antibiotic resistance is also a much-awaited phenomenon that will check our technological advancements in medical science. Despite being breakthroughs in medicine we still lag in the dissemination of universal healthcare guarantees and with the count of community transmittable diseases increasing fourfold with sidelining existing personal ailments the burden on modern-day services is more than ever. The situation worsens in case of highly transmissible infections like COVID, thus making those with regular exposure more susceptible like our healthcare practitioners, for the first time concepts like social distancing came into play just to mitigate the flow of virus and break the chain but still a large number of medical service providers got infected due to direct exposure. Such instances should make governments realize the need for alternative mechanisms that can replace humans thus reducing the chances of exposure. The above-mentioned technology with better policy applications could also prevent us from the future surge in zoonotic viral attacks.

Not only in case of community spread but also in case of regular manifestations as well they could save us precious moments which would reduce the chances of fatality. The reduced financial burden on stakeholders is an additional factor with ubiquitous servicing. In remote areas it will serve twin benefits on one hand urban healthcare facilities will reach in no time on the other hand better employment opportunities open up with technically skilled workforce. Several international organizations like ITU and private players have determined the potential and states are undergoing deliberations to remodel them for better results so that after proper standardization process they can become a part of national healthcare mainstream.

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