Unlocking the Potential of 5G in Healthcare Sector

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ABSTRACT

The global increase in healthcare expenditure for the aging and rising population is not viable – the healthcare sector therefore needs a way to improve efficiency in the healthcare sector, whilst also improving access to good quality universal health care for patients. 5G will help a variety of industries by designing plans for telecommunications operators and other sectors to facilitate the delivery of services. 5G can be characterized as a dynamically linked community with developments in artificial intelligence, intelligent IoT (Internet of Things), big data analytics, high-speed, stable networking and a multitude of other things. The introduction of new or upgraded technology such as 5G will serve to reinforce collaboration around the health sector. 5G supports the healthcare sector with its limited resources adequately (monetarily and also in terms of infrastructure) and helps to support, at the appropriate point, with the required competence, equipment and data as set out in this paper. This paper will also ascertain 5G's capability, potential healthcare applications and requirements in adapting to technologies like 5G.

Keywords

5G, Smart Healthcare, Augmented and Virtual Reality, Wireless sensor network, Low Latency, High Reliability, Enhanced Mobile Broadband (EMB), Millimetre-Wave communications, Wireless Regional Area Networks (WRAN) and Cognitive Radio.
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Introduction

5G is more than just an incremental transition to a new technological generation; it is a radical shift in the role of mobile technology advances. 5G is a platform to develop a versatile, targeted network that is personalized for various needs of the community and the economy as demand for perpetual connectivity soars. Implementing 5G gives operators the potential to expand beyond connectivities and work together for new rich services for communities and enterprises in sectors like automobile, agriculture, banking and healthcare. With 5G a trigger for disruption it is an incentive for business, economy and people to support their technological aspirations. 5G would of course grow from established 4G networks, but it will be a pivotal moment in digital communications, introducing trillions of devices with seamless high-powered networking. It is explicitly targeted at consumers and offers a foundation for creating latest technological services and business concepts. It empowers machines to interact in an Internet of Things (IoT) which can drive a pretty close-endless array of services without human interference.

Healthcare is increasingly leveraging operating 4G as well as other infrastructure technology to deliver intelligent health care solutions and is adapting quickly to take advantage of the new intelligent healthcare applications. As the need for intelligent smart healthcare increases, a number of network systems will generate data from multiple levels and conditions. In terms of bandwidth, data rate and latency, this location of complex networks requires other considerations [4]. If this advance medical industry progresses, networking can play a crucial role, with massive-machine style communication for a variety of sensor-based devices and other equipment infrastructures across the hospitals and clinics. Other examples, such as virtual and Tactile Internet procedures, will often promote the need for highly effective and efficient communications sort of infrastructure. The diverse and evolving need of the communications networks of various smart healthcare applications cannot be met in current communication technologies. Intelligent medical applications that meet certain criteria such as incredibly low latency, high dependability, huge band width and energy efficiency will also benefit the next 5G network. In future smart healthcare networks, a combination of 5G, Artificial Intelligence and Internet of things will strengthen wireless connectivity and resolve network safety problems. [4]

5G's distinctive capabilities

The safety and reliability enhancements are critical to protecting privacy of patient data and the consistency of operation for mission-critical applications. Although healthcare sector may not

be highly reliant on 5g networks capabilities altogether as other industries like gaming where low-latency applications evaluate below 15ms latency, these technologies, combined, can enhance the end-user experience of new devices considerably. For instance, lag and jitter would offer customers a more personalized experience. This is because patients are more familiar with their own sicknesses and possible treatments through the growth and development of the digital world. As a result, they become more proactive customers – their therapies and the approaches they want to follow and use can be selective. 5G would have a huge effect on the use of use cases on a magnitude in contrast with LTE and other communications technologies. 5G is not only faster than 4G but also it has been adapted to satisfy the needs of different applications [2].

There are 3 aspects where network has been enhanced hugely:

High Security and reliability: 5G is not only secure and safe but also as suggested by experts it is consistent and dependable to the network by 99,999%4. This is accomplished via new features such as network slicing technology, data encryption and self-assured transfer between the modules of network. 5G's shift to virtualized networks and infrastructure specified by technology will minimize service disruption and interruption considerably. This is a big asset for 5G relative to other networking options [2].

Performance: 5G will make huge improvements to network performance as dictated in the 3GPP release 16 standards. It requires 90% latency reductions relative to 4G / LTE5. The increased bandwidth also involves the fact that data will pass at peak speeds of up to 25 Gb/s in average 100 -110 Mb/s [2].

Capability and Capacity: The global connectivity of the devices is expected to rise by about 30 billion by 2022, with various estimates. Connectivity solutions cannot cope with this device-density surge — particularly when cases begin to rely on hundreds of parameters instead of one or two variables. 5G guarantees up to 1 million wired devices per km2 [2].

Literature Review

All studies on the 5 G architecture of smart medical care are conducted, taking into account different core technologies activated (i.e. Small cells, D2D connectivity, mmWaves, SDN, 5 G smarts, virtualization of Network (NFV) functions. A device to a D2D system are defined where direct communication takes place between the two network devices without the intervention of the base station (BS) or the core network. In several applications, SDN is characterized as an efficient, scalable, flexible and economic framework to give high-bandwidth ranges. To build a network to handle a modern computing infrastructure, application server and more versatile options, SDN provides variety of network technologies. NFV is an emerging network solution that allows expensive devoted hardware equipment, such as the firewalls, to be substituted with software-based network resources that operate on standard servers as virtual machines. Edge computation is viewed as a technology design where data is processed close to the originating source, on the edge of the network. 5 G Smart Healthcare taxonomy is presented touching communication technologies, demands, goals and performance measures. Application for IoT-based 5 G smart health care and future research potential, including planning, routing and congestion regulation [4].

Research on the intellect of Internet tools has elevated both the business and the user group's expectations. An IoT health system does, however, have many challenges including stability, authorization and information sharing. The IoT health system turns actual artifacts and medical facilities every day into a smart health system that is rooted in us. In view of the population and the rapid rise in medical expenses, great attention has been paid to public health. It is widely accepted that an appropriate health surveillance device can identify health anomalies on a timely basis and render diagnosis based on sensing data [1].

With the healthcare industry in mind, there are many numerous applications available such as Efficient AI-based Decision-Support, Intelligent Wearables, Sensor Network, Rapid First Aid, Ultrasound Scanners, Real-Time Remote Monitoring, Telemedicine, Emergence Service and Tele-Surgery. Flexible communication between patients, doctors, hospital departments,

IoT, wearable sensors and big health statistics will allow smart healthcare reform to be promoted.

Four ways 5G can change Healthcare

Home health services

Currently, there is a significant difference between the care of the patients at a hospital and home. More and more patients choose to be seen or treated at home instead of trying to contend with lengthy wait times and high hospital costs. In several cases, patients are only released from the hospital to come back weeks, or even days later. In recent years, there are still ways to get home treatment, so this becomes a reasonably viable second choice for hospital care. 5 G will make home healthcare more accessible. 5 G is contributing to enhancing the development of home health services such as video chats with providers via a secure 5 G mobile network. In order to make home health a principal healing and treatment option, 5 G will also facilitate a plethora of remote monitoring and recovery devices. 5 G services with a low latency enable nurses and physicians to monitor the patient in real time. Furthermore, abnormalities or emergencies will be reported in no time, and 5 G networks can provide instant care and high-quality medical care ties, reducing the risk of potential injury or abnormalities. The host of monitoring, rehabilitation and therapeutic services in the homes is actually unleashed with 5 G, which further improves patient experience and reduces increasing costs for healthcare [5].

Hand-in-hand with telemedicine is remote monitoring of patients, including prescribing and modifying medications based on near-real-time data collection and analysis. With the use of IoT tools, healthcare professionals can control vitalities remotely, track medications and move existing data to help staff make quicker, more intelligent choices. 5 G will allow better connectivity on mobile devices, boost data transmission ability using wider bandwidth, promote huge data transmission blocks and allow medical professionals to provide better live and fairly close-real-time remote care [3].

Remote treatment and Emergency Care

Delivering prompt and appropriate triage treatment in emergency situations is crucial-take patients with cardiac arrest where brain damage will start at four minutes. Historically, the treatment model was a patient-to-hospital approach, but 5G technology might carry the hospital to the patient in an attempt to expedite care. For example, current medical technology providers have built applications that allow paramedics to notify the emergency department to their arrival with incredible precision by using the ambulance GPS coordinates as well as by transmitting data on ECG, personal details etc which would help the emergency team in equipping themselves with proper personnel and equipment in advance. Moreover, 5G networks could support 4K body cameras that have a live link with ER health professionals or specialists to help steer the EMT through a field operation or to accurately evaluate, treat and prepare the travel of the injured patient [5].

In addition, the 5G-enabled ambulance or mobile clinics in rural areas would allow AR-assisted operations to improve the capabilities of EMTs or primary care physicians through directed actions to administer emergency care in the community. A generalist now has a valuable tool for diagnosing and treating or performing such necessary procedures using AI-assisted Augmented Reality applications.

Augmented and Virtual Reality

5 G would potentially open a window of opportunity to use augmented reality (AR) and virtual reality (VR) to help patients and train clinicians. For illustration, AT&T is partnering with VITAS Healthcare to research the impact of 5G-enabled AR / VR on hospice patients. The purpose of this study is to alleviate pain and/or anxiety in certain hospice patients by delivering relaxed, stimulating content through 5G-enabled AR / VR. In the meantime, 5G-powered AR / VR has the ability to help allow doctors, nurses, interns and staff to better envision procedures in an interactive, trying to learn-by-doing environment that will improve their learning.

Virtual reality is usually related to the gaming world, but VR has also changed numerous facets of the healthcare industry. Through vr technology, hospitals are able to indulge patients and physicians in the world of their imagination. Virtual Reality therapy has been a ground breaking way for hospitals to use VR to support patients to help them heal from severe pain or

accidents. VR has been shown to relieve pain by 25%, which not only promotes patient well-being, but also saves them money by decreasing the amount of time they need to invest in a hospital. At present, hospitals and rehabilitation centers are limited in their VR capability due to costs, operating support and accessibility. Today, genuinely effective VR-based medical training system needs a wired VR system to deliver the realism required to be an effective tool. A 'wired' VR set-up can be a costly PC with specialized audio and networking – requiring hospital IT and security assistance, culminating in thousands of dollars in costs.

Data Analysis and Large file transfers

5 G would help to facilitate the sharing of highly protected data required for better research. Health data has the potential to be exploited reducing operating costs and boosting performance. Predictive analytics, prescriptive analytics, and AI technology are also being used to perform core functions such as diagnosing and assessing care plans for patients. In all of these, data rates play a significant role and 5G promises to have ultra-low latency. This will allow multi-access edge computing to analyse data faster at the edge of the network. 5 G can enable the linking of smartphones and mobile applications, cloud services, computers, sensors, machines and systems that can be used to power Big data analysis. The data can be allocated at multiple points of care with the help of 5G. It would lead to advances in successful remote diagnosis, remote surgery, smart hospitalization management, operation planning, increased transparency and enhanced patient participation [3].

5 G can help improve the hospital's capacity to exchange large image files. Unless the network is low on bandwidth, it can take a long time to send or not to pass through effectively at all. The network can stop, the patient will wait even longer for diagnosis, and the doctors will only be able to see a few patients at the same time. 5 G has the potential to deliver faster delivery of vast medical images, with outstanding network efficiency.

Methodology

5G's Requirements

For the implementation of 5G based healthcare network, the following specifications and technological trends are to be followed:

Enhanced Mobile Broadband (EMB)

The deployment of enhanced mobile broadband to the user market would be a central proposal in early 5G implementations, with large IoT and ultra-reliable, low-latency communications gaining steam at a later point. The catalyst of 5G market adoption could play an important role by innovative and segmented consumer initiatives targeted at improved smartphone and video customer service. The key aim of the scenario is to boost the performance and data rate of network traffic [12]

Massive Machine-Type Communications (MMTC)

The situation applies to the wireless sensor network, M2M communication and IoT communication. The key goal relevant to this situation is energy efficiency and connection density. The key problem in MMTC is flexible and effective networking for a wide number of devices transmitting very small packets, which is not carried out properly in cellular networks configured for human-type communications. In addition, MMTC solutions need to allow wide area reach and deep interior infiltration while still being low-cost and energy efficient [12]

High Reliability and Low Latency and Communications

The situation is associated to ultra-reliable connectivity and Tactile Internet applications, such as remote surgery and vehicle-to-vehicle (i.e. ambulance) communications for driverless vehicles. High reliability and low latency are the key criteria for this situation. Low latency describes a network that is designed to handle vast volumes of data packets with a relatively low delay tolerance (latency). Most advanced medical devices need very low latency. For instance, during communications latency the operation of robotic tools has an impact. For possible Remote surgery, less than 250 ms of latency is ideal. Accuracy is attributed to the network's capabilities to deliver desired operation at incredibly low error rates. Various biomedical devices with IoT capacities generate more details that can overpower the network's capacity. The modern

network system must therefore accommodate a vast number of connections and a huge storage bandwidth [12]

Wireless Regional Area Networks (WRAN)

WRAN is a communication network used to provide Internet connectivity for communities or businesses, particularly in rural areas through underused radio frequency spectrum sections. WRAN also integrates intelligent radio capabilities to allow base stations to communicate better than existing Wireless technologies in order to avoid interruption. WRAN is highly suitable for rural applications where wireless and interference radio frequencies are less common. WRAN would stress the use of more expensive and less efficient Internet connectivity options such as cellular and satellite internet.

Technology trends to fulfil the requirement of the 5G network

From the above requirements and situations, the critical criteria for future cellular network generation (5G) are ultra-fast connection density, traffic capacity and high data rate, super reliability, low latency and exceptional energy efficiency. In order to satisfy these criteria, a range of technical developments should be established.

Massive Multiple Input Multiple Output (MIMO)

Massive Multiple Input Multiple Output — expands beyond legacy networks by adding a much larger number of antennas to the base station. The "massive" amount of antennas allows to concentrate on electricity, which brings rapid increase in throughput and quality. In addition to the increased number of antennas, both the network and cellular devices deploy more complex architectures for controlling MIMO operations.

According to the Shannon Network Capacity Theorem, the upper bound for the communication channel capacity in bps is constant, and this concept may be used to examine the achievement of higher data rates [4].

Millimetre-Wave Communications

Millimeter-wave (mmWave) cellular networks running in the 30-300 GHz range tend to be an extraordinary prospect for the next generation 5G cellular infrastructure, which is supposed to accommodate several Gb/s data speeds. However, using mmWave involves grappling with the transmission attributes and channel abnormalities of high-frequency bands. Significant impediments to the distribution of mmWave are higher path losses due to higher carrier frequency, restricted scattering, which in turn decreases the diversity available, and increased blocking effects due to weaker non-linear pathways [9]

Device-To-Device (D2D) Communications

Direct Device to Device (D2D) communications, which corresponds directly to device connectivity minus network traffic across any connectivity node, are normally planned to function in the future fifth generation system (5G) as a vital cornerstone to improve system reliability and enable new infrastructure after 2020. The advantages of D2D service typically include, but are not limited to, enhanced spectral performance, enhanced typical user data rate and area capacity, expanded reach, reduced latency and increased cost and power efficiency. Direct communication in D2D requires multiple D2D connections to use the same bandwidth at the same time, which contributes to an improvement in mobile traffic capacity. In addition, the SNR can be accomplished by addition of a direct communication approach (as opposed to communication through a base station) which minimizes transmission power to save energy or maximizes linkage capability [6]

Cognitive Radio

For the next-generation 5G network, this is another key technology to remember. Cognitive radio technology could be an effective way to activate the WRAN scenario. In the cognitive radio network, users would be split into two groups. The first is the main customer and the second is the secondary. There are two modes for a cognitive device to function. Spectrum overlay is the first and underlay is the second. The first approach allows secondary users and primary users to concurrently transmit while the transmitting capacity for the secondary user is reduced to less than a defined threshold. Second solution requires secondary users to use white lengths, which are delegated in the spectrum to the

main network with complex connections to the spectrum [4]

Conclusion

In this study, an overview of recent work along with study prospects on the 5G connectivity facet for smart healthcare have been discussed. First we incorporated distinctive capabilities of 5G where we looked at how 5G promises a very reliable and safe connectivity by utilizing features such as network slicing technology, data encryption and self-assured transfer between radio and network nodes. We have also seen how performance is enhanced by increasing the bandwidth so as to increase the data transfer. Secondly, we introduced how 5G can be utilized in healthcare sector and its potential use cases. Thirdly, we incorporated taxonomy for 5G smart health care and examined current criteria including EMB, Massive Machine Communications (MMTC) and latency aspects for Smart 5G Networking. Finally, we addressed an in-depth analysis of the numerous technical developments, such as the Massive MIMO, Millimetre-wave networking and D2D communications required to satisfy the 5G specifications.

References

[1] Farah Nasri and Mtibaa Abdellatif, “Smart mobile healthcare systems based on WBSN and 5G”

[2] Darius Singh and Chris Barraclough, “5G’s Healthcare Impact: 1 billion patients with improved access in 2030”

[3] AT&T, “5G and Healthcare, the dawn of 5G technology is here”

[4] Mohammad Tahir and Kok-Lim Alvin Yau, “5G-based Smart Healthcare Network: Architecture, Taxonomy, Challenges and Future Research Directions”

[5] Samsung, “How 5G will support the healthcare industry”

[6] F. Jameel, Z. Hamid, F. Jabeen, S. Zeadally, and M. A. Javed, "A survey of device-to-device communications: Research issues and challenges," IEEE Commun. Surv. Tutorials, vol. 20, no. 3, pp. 2133-2168, 2018.

[7] G. Kilic and T. Girici, "Joint channel and power allocation for device-todevice underlay," Ad Hoc Networks, vol. 83, no. September, pp. 158-167, 2019.

[8] D. Fang, F. Ye, Y. Qian, and H. Sharif, "Small Base Station Management - Improving Energy Efficiency in Heterogeneous Networks," 2018 14th Int. Wirel. Commun. Mob. Comput. Conf. IWCMC 2018, pp. 1191-1196, 2018.

[9] N. Al-Falahy and O. Y. K. Alani, "Millimetre wave frequency band as a candidate spectrum for 5G network architecture: A survey," Phys. Commun., vol. 32, no. December, pp. 120-144, 2019.

[10] E. Jovanov and A. Milenkovic, "Body area networks for ubiquitous healthcare applications: Opportunities and challenges," J. Med. Syst., vol. 35, no. 5, pp. 1245-1254, 2011.

[11] H. Shariatmadari et al., "Machine-type communications: Current status and future perspectives toward 5G systems," IEEE Commun. Mag., vol. 53, no. 9, pp. 10-17, 2015.

[12] Abdul Ahad, Mohammad Tahir, Muhammad Aman Sheikh, Kazi Istiaque Ahmed, Amna Mughees and Abdullah Numani, “ Technologies Trend towards 5G Network for Smart Health-Care Using IoT: A Review