The Role of 5G Networks in the Field of Medical Sciences Education

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***Abstract*—Over the past decade, rapid developments in computer and communication technologies have emerged for the use of Internet of Things (IoT) in various fields and collection and providing security in terms of privacy and integrity, of big data on a daily basis is a challenge. Researchers are revealed that, it is expected to have 25-50 billions of devices with minimum number of 6 devices per person on a huge amount of IoT based activities by 2020. 5th generation wireless systems (5G) are on the horizon and IoT is expected to form majority of the 5G network paradigm. IoT technologies have started drastically change landscape of various industries. Considering these changes, technological innovations are providing new ways of education and learning materials for educators to help their teaching and communication methods with their learners. New opportunities alter teaching and learning. Especially, in order to increase quality and quantity of learning and teaching in higher education institutions, blended learning approaches have been emerged. This adopts use of virtual learning environments (VLEs) into traditional teaching mechanisms through both instructor and learner generated contents. Findings suggest that Generation Z use e-learning materials more effectively and efficiently revision tools than their textbooks and their own notes respectively. As new opportunities in technologies become more mature, the volume of data published will increase rapidly. This paper investigates and identifies how these emerging technologies of IoT in 5G will be integrated on education sciences like medicine. The paper aims to present how learners will get quality education through improvements in digital imaging, decision on diagnostics, and knowledge to treatment.**

***Index Terms*—Internet of Things, 5G, distance-virtual learning, quality learning, higher education**

I. Introduction

Since past three decades, use of computers and network-based devices have increased rapidly, especially in last decade, growing popularity and developments on portable devices and mobile communications, many large, confidential and interesting collections of materials are available electronically. Therefore reaching information and services electronically are employed in all phases of today's world. According to various forecasts, it is expected to have around 25 to 50 billion devices to be online by 2020 [5]. Within these circumstances, a new era of communication, IoT has risen. It is defined as combination of embedded technologies such as wired and wireless communications, sensors, and the physical objects connected to the Internet [1], [2]. In IoT things talk to other things. People and machines can give inanimate things instructions on what to do. Among the technologies converged we can count wireless sensor networks (WSNs), intelligent sensing, remote sensing, radio frequency identification (RFID), near field communications (NFC), low-energy wireless communications, and cloud computing. The technologies involved have particular applications in public safety as well as other domains such as health monitoring, smart homes and environments, smart cities, smart grid, and various types of pervasive systems [10].

5G is on the horizon and IoT is expected to form majority of the 5G network paradigm [4]. Also further innovations in IoT is expected to happen with emerged cloud computing technology with intelligent 'smart' devices. Researchers, scientists, and engineers face emerging challenges in designing IoT based systems that can efficiently be integrated with the 5G. These developments form a motivation to survey existing work, design new techniques, and identify new applications of IoT. 5G is apprehended to create a "Networked Society", providing an unlimited access to information and data at anytime, anywhere by anyone and anything [5]. In order to provide this opportunity, major improvements and developments are required to create in latency, energy efficiency, accuracy of terminal location, reliability and availability fields, as well as flexibility to accommodate future applications, and creating an impression of "infinite" capacity [4], [5].

Considering the relationship between education and technology is as long and complex interference, tools that assist students in activating and deploying information into knowledge, are at the heart of pedagogic practice. Since 1990s, face of the higher education has improved and number of attending learners to any higher education institute has been increased drastically [6]. Because of this, teaching and learning in higher education have been improved in order to plan effective learning situations as discussed in Brown, 1988 and Rowland, 1996 [6]. In order to create more effective and efficient student learning, practitioners and educators, who are part of any higher education system all around the world need to develop and adopt new learning and teaching practices.

Owning to the new developments for communication technologies, new ways and methods for educators are created to communicate with learners. Especially, in order to increase quality and quantity of learning and teaching in higher education institutions, blended learning approaches have been

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emerged. This adopts use of virtual learning environments (VLEs) into traditional teaching mechanisms through both instructor and learner generated contents [7], [8].

As stated earlier, 5G will be transform economy and connected societies of both developed and developing countries. These two concepts will strongly rely on the technology's hardware and software infrastructures and contribute to the digitalisation of vertical markets such as education, automotive, banking and finance, city management, food and agriculture, media, government, healthcare, manufacturing, transportation, and retail and real estate. Many educational institutions have seen this shift and are including courses on IoT and other technologies as part of their curriculum. However, it is still a small list and further developments are required to consider in terms of infrastructure for both hardware and software basis.

Recent developments in mobile communication technologies have provided many rich digital resources more available to the learners beyond the physical limits of the classroom. Approaches in mobile technology, and IoT changed education perspectives [9]. Augmented Reality (AR) and Virtual Reality (VR) are already used in many applications such as gaming. A number of institutions have already been using this technology to create immersive, simulated training and education platforms for learners and educators.

Description of future learning model is stated as an environment that is international, immediate, virtual, and interactive. This new model will be considered as learner-centric, skill-centric, on-demand and personalised [3], [9]. This paper aims to highlight the role of 5G in enhancing efficient education in medical sciences that requires big data analysis in terms of convergence, connectivity, and energy consumption.

II. Related Works

With the modernisation of the communication networks, significant advancements have converged for the Internet. Since the emerging technologies grow and become more mature, Internet-connected devices technology named as IoT, continues to extend by providing connectivity and interaction between the physical and virtual worlds [3].

As stated earlier, IoT is defined as set of connected devices that can transfer data among themselves in order to optimise their performance where no input or human interaction occurs [3]. According some existing literature, it includes four main components named as sensors, processing networks, analysing data, and monitoring the system [1]–[3].

5G is categorised as a transformative system, includes a heterogeneous network that integrates 4G, Wi-Fi, and other wireless access technologies. Cloud infrastructure, a virtualised network, intelligent edge services, and a distributed computing model (data generated by billions of devices) will be combined for it [11]. It is an end-to-end system that senses data from billions of devices and moves those communication packets seamlessly, using the appropriate processing platform with fast and intelligent networks, back-end services, and extremely low latency. These qualities enable enhanced mobile broadband, machine-to-machine communications, artificial intelligence, and advanced digital services [11]. Following figure, Fig. 1 is adopted from [5] that shows heterogenous network concept of 5G.

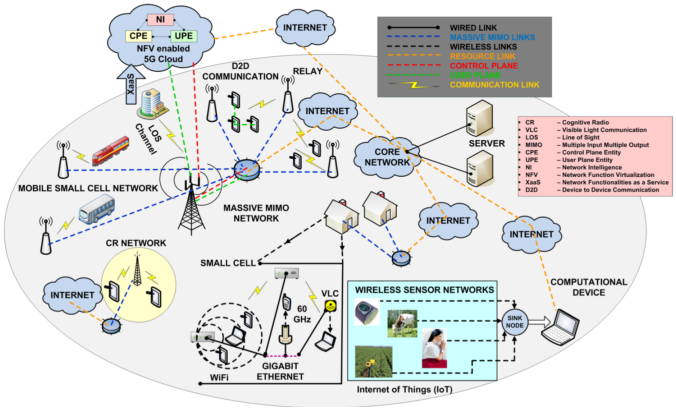

Fig. 1. Heterogenous network concept of 5G.

As literature analysed critically it is found out that, the use cases for future 5G are so diverse, and each one has different set of requirements and parameters and could occupy its own network slice in the network [4], [5]. A network slice is defined as providing only the traffic treatment that is necessary, and avoid all other unnecessary functionalities [5]. Therefore, each market can adopt the technology more rapidly and efficiently. Detailed comparison between existing wireless communication technologies and 5G is stated in [12]. Comparison of todays wireless communication technology, 4G, and 5G is provided given below Table I.

TABLE I
Comparison of 4G and 5G Technologies

Specification	4G	5G
Full form	Fourth Generation	Fifth Generation
Data Bandwidth	2Mbps to 1Gbps	1Gbps and higher
Frequency Band	2 to 8 GHz	3 to 300 GHz
Standards	OFDMA,MC-CDMA network-LMPS	CDMA and BDMA
Technologies	Unified IP seamless broadband LAN/WAN/PAN and WLAN	Unified IP seamless broadband LAN/WAN/PAN/WLAN advanced tech. on OFDM
Service	Dynamic info. access, wearable devices, HD streaming, global roaming	Dynamic info. access, wearable devices, HD streaming, any demand of users
Multiple Access	CDMA	CDMA,BDMA
Core network	All IP network	Flatter IP network, 5G network interfacing (5G-NI)
Handoff	Horizontal and vertical	Horizontal and vertical

Lately, academics, researchers and industrial experts have involved with requirements gathering of vertical markets and

their needs and requirements into 5G specification and architecture. However, it seems one of the most important ones, education, has not yet been included in details [5].

As stated earlier, starting from early 1990s, face of the higher education has changed and number of learners attending to any higher education institute has been increased drastically [6]. Because of this, teaching and learning in higher education have been improved in order to plan effective learning [6]. In particular, last two decades increasing in globalisation has affected and diverted many traditional ways of lives. Within this context, diversity of the students has changed and increased. This affected styles of teaching and learning of students. Depending on this, many researches are done, critically evaluated and discussed for identifying the needs of diverse learners and ways of engaging them in learning environments. Different learning theories for different practises and subject areas are presented, critically evaluated, as well as both physical and online supporting learning materials are provided [6]. It is emphasised that since, number of diverse learners on both undergraduate and postgraduate levels are increased, structuring teaching sessions, learning materials and engaging students within the learning environments are crucial.

The exploitation of advances in mobile technologies, IoT and Tactile Internet (where at Industry Conference & Exhibition 2015, The Next Generation Mobile Networks (NGMN), released its 5G White Paper (the first version), the Tactile Internet was described as "the capability for people to wirelessly control both real and virtual objects, thus requiring tactile-based control signal and feedback of images and sounds".) will increase the effectiveness of any education while lowering its cost, meeting the needs of both learners and educators significantly [9]. The learners will be able to easily access learning materials at anytime, anywhere so that they will use all their available time, and will improve their critical-thinking and collaborative learning.

Advances in information technologies bring many different applications such as VR and AR available to the market. For instance, these kind of applications will play a big role in quality education and understanding-based learning as well as by combining tactile Internet will create new definitions to distance teaching, virtual university, virtual classroom, etc. New mobile communication technologies and network connected devices will give students the opportunity to learn mostly through exploration, discovery and peers, rather than intervention from teachers. Internationally, medical schools are trialling teaching methods using computer-simulated cadavers.

As authors discussed in [9] educators believe that in order to achieve educational goals faster, reaching their learners at anytime, anywhere is an important aspect. Additionally, they emphasised that apart from teaching, developing customised learning curriculum and materials, and even reutilising existing ones electronically, will accelerate their work loads. Also, they critically evaluated that another time consuming task is traditional ways of assessments of the learners, and they believe that, with the guidance of automated assessment technologies, educators will have the understanding of personalisation of the learning experience and learner's behaviour (exploiting sensing devices and data fusion) [9].

Additionally, in the same study, authors drove attention to the fact that today's learners of all age groups are familiar with mobile technologies and these technologies based applications including cloud-based ones. These applications enable the seamless communication among the learners, and between learners and educator/practitioner. Furthermore, over a decade available, emerged technologies provide large cloud infrastructures for big data and complex processing.

Nowadays, advances for smart mobile devices, and applications for these devices are able to use for detecting and personalising the learning experiences feasible. These developments use the sensors available on them. Such smart educational solutions are expected to increase the effectiveness of education at all levels and reduce the relevant cost through the sharing of learning resources [9].

III. 5G and Internet of Medical Things for Education

As discussed in [11], IoT communications are enabled by cellular, Wi-Fi and similar technologies and 5G is the network that will connect IoT. It is expected that 5G will support IoT devices with different capabilities (long battery life, fast speed and reliable connectivity) and data usage.

In the same study the author stated that developed and emerged facilities including super-fast connectivity, and intelligent management, of the 5G will be enable new horizons for health care including digital imaging, decision on diagnostics, data analytics, and learning new treatments [11]. It is called Internet of Medical Things (IoMT) and it includes many devices such as clinical wearables and remote sensors that monitor and electronically transmit data such as vital signs, results of physical activities, and personal values for safety. These devices will provide diagnosis and treatment services while delivering high quality health care at reasonable and affordable prices. It is believed that 5G will bring consistent, reliable user experiences to improve medical care for developing countries and populations. Today, there are a number of health applications that require high bandwidth and reliable connectivity, and these applications are part of the emerging different 5G test cases and industries. However, these test cases have not been yet considered for medical education field.

As stated earlier, researchers have been involved with requirements gathering of various vertical markets in 5G specification and architecture, but one of the most important ones, education, has not yet been included in details [5]. Therefore, role of 5G in enhancing medicine education, extending traditional and digital learning and teaching techniques far beyond the last two decades.

Considering these developments, in this section, emerging applications in health care, and medicine through improvements in imaging, diagnostics, and treatment will be discussed and demonstrated for both students and educators in medical eduction as well.

A. Digital Imaging

As suggested in [4], [5], with advances in computing speed and networking, low latency, and high-frequency bands are offered in 5G communications. Considering today's mobile communications such as 4G, latency interval is recorded as 50 to 80 milliseconds (ms). This is accepted as sufficient for audio, video communications as well as the Internet usage. However in 5G, it is aimed to reduce latency to a few milliseconds (ms). Addition to this, currently most commercial mobile communications occur within the range of 3.5 MHz [5]. Until today, these low-frequency bands are good and enough to facilitate mobile and wireless communications. Nevertheless, they have started to be not sufficient as demand for use of mobile devices increased. Because of this reason, in 5G communication technologies, higher frequency bands (around 60,000 MHz) are considered to be implemented [4]. Even though, milli-meter wave (mmWave) frequency spectrum which is between 30 Ghz and 300 Ghz are planned to implement in 5G.

With regard to these developments, the underlying idea is to explore real-life scenarios with products and industrial standards, as a new knowledge for learners. High definition, even 3D images will be accessed remotely and rapidly in order to share information across globe, without any time delay and long distances. For instance, a physician who seeks a second professional opinion in one part of the country (or world), he or she will be able to transmit medical image or test result and get information about patient's situation from other doctor. These changes and developments will provide accessibility to an intellectual global network of medical professionals. Additionally, considering enhancements in biomedical and bioengineering fields, taken digital images such as X-rays or CT scans are in high definition. High-speed transmission of these images will be enabled patients and consultants to obtain second or third opinions quickly, as well as the learners will be able to easily access these as learning materials at anytime, anywhere for strengthen user engagement and improve the learning experience [9].

This helps both learners and educators gain access to learning materials and experiments, as well as enables learning outcomes on expertise fields. Also, it will improve the health care system for people who live in different geographical landscapes, and have different incomes.This will guide patients, learners and educators in order to get access to high quality medical assistance, continuous refinement of research areas, and respective curriculum respectively.

B. Decision on Diagnostics

As stated above, WSNs are one of the emerging technologies of IoT developments. Especially, body sensor networks (BSNs) technology is gaining popularity in healthcare systems [10]. In this technology, patients can be monitored and diagnosed using a collection of tiny-powered and light weight wireless sensor nodes. Therefore, the use of these wearable medical devices will be an important advancement in diagnostics.

With today's existing 4G networks, devices, and mobile technologies, patients suffering from serious or chronic health issues those need to have careful, continuous and critical attention such as cardiovascular disease, diabetes or cancer, are remotely monitored, their vital signs are tracked, and transmit this information to electronic health care systems, and to the learners for continuous refinement of knowledge. If 5G facilitates this kind of communication, it will be a unique capability for providing real-time analytics.

Similarly in the research [11] author emphasised that, emerged technologies in 5G and the advances could particularly be relevant for the field of cancer genomics (Genetic therapy is used to cancer diagnoses and treatment that is customised according to patients' individual circumstances). Considering the fact that most cancer types are complex and people's genetic compositions play a vital role in it, it is important to develop learning schemes for knowledge of how genes affect cancerous growth. In these circumstances, personalised treatments are crucial and apart from the physicians, healthcare educators need to obtain detailed information about patients' genetic composition, family health records, and social environment and lifestyle. These information are huge and big data access are required. To gather this kind of information, billions of sensors, and mobile devices will be deployed with 5G. Since most of these sensors and mobile devices do not have any sufficient storage for that kind of big data, storing that data on a cloud (that provides the extensive storage capabilities) makes it available to consultants, doctors, researchers, learners and educators who need access.

Considering the software-defined networks [11] combined with intelligent systems providing clinical decision support, learners can access to the latest and newest information on diagnosis and treatment in the literature. Educators and practitioners can enter basic, main symptoms and vital signs and share information on any kind of medical issues by using these systems. Rather than relying on traditional ways of information provided in the literature, these systems supply gigantic sources of information to provide up-to-date resource, therefore helping learners be more accurate and precise on learning experiences and exploitation of the information.

C. Knowledge on Treatment

As mentioned and discussed above sections, remotely monitored, tracked and recorded data of the patients are enormous and in digital medicine in order to analyse the data, trusted data analytics are used. Since big health data, and data mining will grow rapidly as mobile network infrastructure becomes more powerful, healthcare learners will get the learning needed. Another way for enabling rapid learning is assessing data in real time. Therefore learners can combine and resolve available information in new and original ways. Therefore, learners will have chance of learning in real time, to use the collected knowledge to come to a decision on the most effective treatments.

In the study [9], authors emphasised that, educators believe in order to achieve educational goals faster, reaching their

learners at anytime, anywhere is an important aspect. Additionally, they emphasised that apart from teaching, developing customised learning curriculum and materials, and even reutilising existing ones electronically, will accelerate their work loads.

In these two circumstances, an analytics platform named as the Collaborative Cancer Cloud (CCC) is a good example that combines patient information from a variety of organisations/institutions by sharing patient genomic, digital images and clinical data securely for highly available lifesaving discoveries [11]. It will enable enormous amounts of data to be analysed in a distributed way from all around the world. Although sensitive information and personal data are shared privacy and integrity of the patients' data will be preserved.

The CCC platform allows researchers/educators or practitioners/consultants to make distinguished queries about particular cancers and get detailed combined information on these individual types. In terms of information security aspects such as integrity and privacy, organisations hold secure control of their own medical data. Although this can be considered as a good strategy, in 5G with low latency and high frequency band, the established connection speed will be fast enough to attack authentication mechanism of the system.

With regard to emerged mobile technologies, it is stated that WSNs are key enablers of IoT because of their great sensing ability and ability to generate and process big data. Using machine learning to handle big data in a WSN is a valuable and critical portion of the emerging infrastructure, since it can analyse structured data such as heart rates, and blood pressure readings with unstructured data such as record history of patient's present illness.

Wearable devices such as BSNs are another way for initiation of the personalisation of the learners' learning experiences since they send out real-time data and records for observation of the patients and different learning structures will be developed among the learners.

Since low latency and higher frequency bands are suggested in 5G, remote surgery will be possible. Surgeons (as educators) will be able to use emerged developed virtual tools for certain kinds of procedures, and learners will have a chance of distance learning and distance team-working in hands on experience with expensive equipments and facilities. For example, experienced practitioners/doctors as mentors to young physicians/learners from a distance on proper techniques, and operating robots that assist in minor procedures.

IV. Conclusions

In this paper, emerging technologies of IoT in 5G on education, especially medicine are investigated and identified. As stated in order to provide better and higher quality education, higher education institutes have started to follow new and popular advances in information technologies, and use of blended learning approaches, for advancing learning and teaching. Findings suggest that Generation Z use e-learning materials more effectively and efficiently revision tools than their textbooks and their own notes respectively. Considering technological innovations, practitioners and educators, develop and adopt new learning and teaching practices for altering the nature and delivery of teaching.

As the technologies become more mature, number of information and data published electronically are increased and will continue to increase rapidly by without time and location dependancy. Additionally, it is found out that 5G technologies will anticipate especially to mobile learning as it efficiently providing the educators with efficient learning scenarios and satisfies high priority learner requirements. However, since emerging 5G technologies currently under design, testing and validation, it is important to find out the security and privacy aspects as well as the authentication mechanisms for efficient performance degradation as future research aspects.

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