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Review Paper

The 5G Network: Dangers and Challenges of a Worldwide Standard Network

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Abstract: 5G is the fifth generation cellular network technology. The 5G mobile wireless communication networks is the newest revolution in the mobile industry which has the capacity to transform the mobile world within a very high bandwidth and hence projected to be a worldwide standard network. Despite the truly momentous promising projections of 5G, there are a whole lot of dangers and challenges the International Telecommunication Union (ITU) and the 3rd Generation Partnership Project (3GPP) are been silent to. This is the premise of this paper. The paper is on the 5G network: dangers and challenges of a worldwide standard network. The paper first focused on the essence of 5G network being a mobile wireless communication network in the telecommunications industry. From the projections of the network, the paper further made discourses on the benefits and spectrum requirements of 5G network. The role of ITU as a UN agency that coordinates the shared global use of the radio spectrum promotes international cooperation in assigning satellite orbits and works to improve telecommunication infrastructure and development in the globe was not left out. Key elements of the 5G network were also highlighted. The paper finally ended with the discourses on the dangers and challenges of 5G network. Based on the discourses, it was recommended that since the dangers associated with 5G is still under contention from different scientists, 3GPP and ITU should formally make their findings and come up with a common worldwide statement on the dangers of 5G network.

Keywords: 5G, network, dangers, challenges, worldwide, standard, telecommunication, mobile, wireless

INTRODUCTION

Telecommunication is one of the branches of electronics technology or engineering. Telecommunication refers to the transmission of signs, signals, messages, words, writings, images and sounds or information of any nature by wired or wireless means. It occurs when there is an exchange of information between communication participants with the use of technology. It is transmitted through a transmission media like physical media using electrical cable (wired means), or electromagnetic radiation (wireless means) through space. The paths to transmission in telecommunication are usually divided into communication channels that can bring about multiplexing (Huurdeman, 2003). With the innovative dynamism of science and technology, the wired means of telecommunication has gradually been replaced by the wireless means. The wireless means of telecommunication is carried out through electromagnetic radiation which has different levels of frequency range such as audio waves, radio waves, microwaves, infrared radiation, visible light, ultraviolet radiation, X-rays and gamma rays in their order of increasing frequency and decreasing wavelength. However, all these different levels of frequencies in the electromagnetic spectrum can accommodate the operation of different telecommunication systems at a required transmission. For instance, communication through emails, phone calls, text messages, viewing pages on the Internet, downloading files; are communications that make use of telecommunication systems. A telecommunication system is a collection of nodes and links to enable communication between participants. Examples of telecommunications systems

are the telephone network, the radio broadcasting system, computer networks and the Internet. The nodes in the system are the devices we use for the communication such as a telephone or a computer system. In its most fundamental form, a telecommunication system includes a transmitter to take information and convert it to a signal, a transmission medium to carry the signal and a receiver to take the signal and convert it back into usable information. This applies to any telecommunication system, whether it uses computers or not. Telecommunication systems are connected using a number of different types of communication channels. These include both wired and wireless connections. Wired connections consist of an actual physical cable, such as copper wire or fiber optics. Wireless connections do not use a physical cable but transfer data using waves at a particular frequency of the electromagnetic spectrum.

Modern day telecommunication systems are best described in terms of a network. This network makes use of some basic elements (facility or equipment used in the provision of a telecommunications service), infrastructure and controls needed to support the systems. A telecommunications network is a collection of terminal nodes in which links are connected so as to enable communication between the terminals. The transmission links connect the nodes together. The nodes use circuit switching, message switching or packet switching to pass the signal through the correct links and nodes to reach the correct destination terminal. Each terminal in the network usually has a unique address so messages or connections can be routed to the correct recipients. The collection of addresses in the network is called the address space. Examples of telecommunications networks include; Computer networks, Internet, Telephone network, etc.

The telephone network has gradually evolved to become more of a Mobile wireless communication network since its first introduction in Japan in 1979. Since its first introduction, the Mobile Wireless Communication network has been through remarkable innovations and upgrade popularly referred to as Generation (G). The mobile wireless Generation (G) generally refers to a change in the nature of the system, speed, technology, frequency, data capacity, latency etc. of the network. Each generation of network brought with it a significant milestone in the development of mobile communications. In order to give room for innovations, the newer generation is usually an upgraded to the older generation, and the upgrade happens in every ten years by the International Telecommunication Union (ITU). For instance, the First Generation (1G) was launched in 1979; the Second Generation (2G) in 1989; the Third Generation (3G) in 1999; the Fourth Generation (4G) in 2009 and the Fifth Generation (5G) launched this year 2019 (Dave, 2018). Each generation has some standards, different capacities, new techniques and new features which differentiate it from the previous one. The 5G mobile wireless communication networks is the newest revolution in the mobile industry which has the capacity to transform the mobile phone usage within a very high bandwidth and hence projected to be a worldwide default standard network.

5G was formally launched in April, 2019 and its formal release to be completed in a year's time. The technology promises to transmit a high volume of data to mobile and Internet of Things (IoT) devices in a very fast manner, hence becoming the worldwide default standard network. According to Paul (2019), its growth was projected at more than 10 million subscriptions worldwide by the end of 2019, 1.9 billion subscriptions for enhanced mobile broadband by the end of 2024, and this will account for over 20 percent of all mobile subscriptions at that time. The peak of LTE (Long Term Evolution) subscriptions is projected for 2022, at around 5.3 billion subscriptions, with the number declining slowly thereafter. By the end of 2024, 5G networks will carry 35 percent of mobile data traffic globally, can cover up to 65 percent of the world's population in 2024 and can account for close to 45 percent of cellular IoT connections in 2024. By the end of 2024, nearly 35 percent of cellular IoT connections will be Broadband IoT, with 4G connecting the majority, but 5G connections will support more advanced use cases. Besides, its device suppliers are expected to be ready with different band and architecture support in a range of devices during 2019. Concerning spectrum sharing, chipsets are currently in development and are anticipated to be in 5G commercial devices in late 2019 (Deng et al., 2012). Voice over Long Term Evolution (VoLTE) is the foundation for enabling voice and communication services on 5G devices. Subscriptions are expected to reach 2.1 billion by the end of 2019. The number of VoLTE subscriptions is projected to reach 5.9 billion by the end of 2024, accounting for more than 85 percent of combined LTE and 5G subscriptions. No previous generation of mobile technology has had the potential to drive economic growth to the extent that 5G promises. Despite the truly momentous promising projections of 5G, there are a whole lot of dangers and challenges the ITU and 3GPP are being silent to. This is the premise of this paper. The paper intends to reveal some of the hidden dangers and challenges of 5G as an intended worldwide default standard network.

The 5G network and its benefits

Fifth generation (5G) mobile wireless network is the latest iteration of cellular technology of mobile standards being defined by the ITU. IMT-2020 (5G) is the name given to 5G systems, components, and related elements that support enhanced capabilities beyond those offered by IMT-2000 (3G) and IMT-Advanced (4G) systems

(Factcheck, 2019). It is designed to immensely increase the speed and response of wireless networks. It will also help in the fast sharp increase in the size of data transmitted over wireless systems due to more available bandwidth and advanced antenna technology. The connectivity benefits of 5G will make businesses more efficient and give consumers access to more information faster than ever before. Highly-connected automatic cars, communities that think fast, industrial IoT (Internet of Things) and completely involving education will all rely on 5G.

The key purpose of 5G network is to provide faster and higher capacity transmissions of massive amount of data that industries will generate from the Internet of Things (IoT), smart cities, driverless cars, video streaming etc. From the bases of some parameters of 5G, it can offer 1000x times the speed of 4G. In essence, with good coverage, you can stream 4K videos on your phone, or have a bandwidth of 100 Gb per second (Cherry, 2004). With respect to interference, 5G uses frequencies that are not crowded with current devices. The standard of 5G mobile network and it's intended capacity is expected to deliver improved end user experience by offering new applications and services through gigabit speeds, and significantly improved performance and reliability. 5G networks are expected to be enhanced with Artificial Intelligent (AI) in order to make sensitivity of data, manage network resources and to provide intelligence that will connect automatic systems. In its efficient use, 5G will be an opportunity for policy makers to enhance the businesses of citizens. It will also play a key role in supporting governments and policy makers in transforming their cities into smart cities, allowing citizens and communities to realize and participate in the socio-economic benefits delivered by an advanced, data-intensive, digital economy.

5G Technology and spectrum requirements

5G technology will achieve its expected high efficiency when it puts together certain basic technical requirements. Some of the key requirements are seen below.

The frequency range

The boundary across which data passes in the air for 5G was known as New Radio (NR). This definition was given by 3GPP, and the specification is subdivided into two frequency bands with different capabilities; FR1 (below 6 GHz) and FR2 (mmWave, above 24 GHz). The maximum channel bandwidth defined for FR1 is 100 MHz, but the band most widely used for 5G in this range is around 3.5 GHz. The minimum channel bandwidth defined for FR2 is 50 MHz and the maximum is 400 MHz, but it can use frequencies of up to 300 GHz. The higher the frequency, the greater the ability to support high data transfer speeds without interfering with other wireless signals or becoming overcrowded. Under this circumstance, 5G can support approximately 1000 more devices per meter than 4G.

The carrier aggregation

Carrier aggregation is a technique used in LTE, advanced to better the system efficiency. In carrier aggregation, two or more carrier signals are collected together to form a whole in order to support wider bandwidth which allows even up to 100 MHz. Carrier aggregation uses three techniques for aggregation: Intra-band contiguous (two carriers are transmitted at neighboring channels), Intra-band non contiguous (two carriers are transmitted with channel spacing), Inter-band (in this technique different LTE bands are used for transmission simultaneously).

The concept of small cell

For the sake of continual network efficiency, the cell (the geographical area covered by a cellular telephone transmitter) is sub-divided into micro and pico cells. Spectrum reusability allows to adding more users in a small geographical area and handle network more efficiently.

The concept of MIMO

The technology of MIMO (Multiple Input Multiple Output) is expected to be used, which involves the use of multiple antennas for transmission and reception. In that respect, simultaneous data transfer is possible using this technology thus offering efficient data rate. The more the number of antennas, the more transmission and reception can be done.

Wi-Fi offloading

Offloading of Wi-Fi is one of the main features of the future network. It allows the user to connect using Wi-Fi network and the cellular network can be allocated for other users. It would be suitable for some places where cellular network quality is poor and users still have the option to connect to the network without cellular reception.

Device to device communication

Device-To-Device **(**D2D) communication is one of the key techniques that proffer solutions to 5G network.

It is a technique that allows direct communication between two mobile users without being assisted from the Base Station (BS) or infrastructure base networks. The network will usually have control over the devices and allows an operator to determine the traffic routing between direct and network path. During the absence of network, one device can connect to another device.

Cloud – Radio network access

C-RAN is a network technology used for efficient communication using a centralized information process, carried out at a distance within the cloud system. The signal will be processed at a far location and the base stations will be connected with most efficient fiber optic connections. It gives lot of advantages in system implementation and maintenance.

The role of ITU

ITU is known as the International Telecommunication Union. Its French interpretation is known as: Union Internationale des Télécommunications (UIT). It was initially known as the International Telegraph Union (ITU) with its French interpretation as: Union Télégraphique Internationale (ITU). ITU is one of the oldest international organization, and a specialized body of the United Nations that is responsible for issues that concern information and communication technologies. The ITU coordinates the shared global use of the radio spectrum, promotes international cooperation in assigning satellite orbits, works to improve telecommunication infrastructure in the developing world, and assists in the development and coordination of worldwide technical standards. It plays a prominent role in the areas of broadband Internet, wireless technologies, aeronautical and maritime navigation, radio astronomy, satellite-based meteorology, convergence in fixed-mobile phone, Internet access, data, voice, TV broadcasting, and next-generation networks. Therefore, ITU is responsible for all the set standards (old and review) for the 5G Mobile Wireless Communication network, though in consonant with the industry standards group 3GPP (3rd Generation Partnership Project); a global consortium of telecom groups (Teral, 2019). The ITU has defined three main uses for 5G network. They are, Enhanced Mobile Broadband (eMBB); Ultra Reliable Low Latency Communications (URLLC) and Massive Machine Type Communications (mMTC). Enhanced Mobile Broadband (eMBB) make use of 5G as a progression from 4G LTE mobile broadband services, but with faster connections, higher volume of data and more capacity. Ultra-Reliable Low-Latency Communications (URLLC) is expected to use the network for mission critical applications that requires uninterrupted and robust data exchange. Massive Machine-Type Communications (mMTC) would be used to connect to a large number of low powers, low cost devices, which have high scalability and increased battery lifetime, in a wide area. Neither URLLC nor mMTC are expected to be deployed widely before 2021 (Dave, 2018).

Key elements of 5G network

In telecommunication, a network element is a manageable logical entity uniting one or more physical devices. This enables distributed devices to be managed in a unified manner using one management system. According to the Telecommunications Act of 1996, the term network element means a facility or equipment used in the provision of a telecommunication services. It encompasses features, functions and capabilities that are provided by means of such facility or equipment; including subscriber numbers, databases, signaling systems, and information sufficient for billing and collection or used in the transmission, routing, or other provision of a telecommunication services. Every Generation of mobile wireless communication network has its peculiarity which is embedded in the elements specifications. With the promise to usher in a new era of digital transformation, 5G network has two key elements that are quite outstanding, which are speed and latency.

Speed

5G wireless network could deliver data at nearly 10 gigabits per second, several orders of magnitude faster than current 4G networks which peak at about 100 megabits per second (Figure 1). 5G speed in the less common millimeter wave spectrum has much more abundant bandwidth and shorter range, hence greater frequency reusability can be substantially higher (Saracco, 2019).

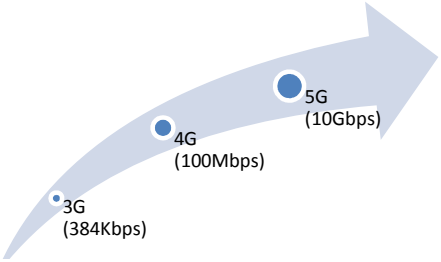

Figure 1: Speed for each generation.

Latency

Latency is how long it takes the network to respond to a request. For instance, it is like somebody trying to play a

song, video or load a website in the internet. Since every input has a new response time; inputs have to respond before the loading starts. This can lead to minor but obvious lag and is more challenging for online games. Concerning 3G, those response times are typically around 120 milliseconds and for 4G, they are less than half that which is likely between 15 to 60 milliseconds. The theory is that for 5G, response times will ultimately drop to just 1 millisecond, which will be very imperceptible (Figure 2). This latency of 5G is more suitable to high technologies such as self-driving cars, which need to respond to inputs and changes in situation immediately.

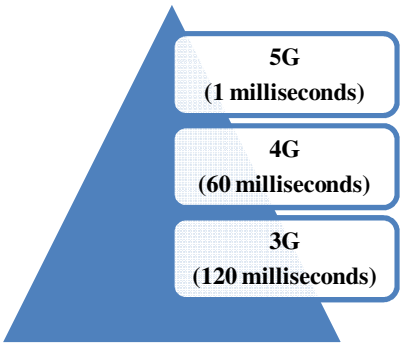

Figure 2: Newer generation.

Lower latency

Dangers of 5G network

Interference issues

Some findings have revealed that various 5G proposals will encounter disturbing interferences using remote sensing, which in turn will affect weather and the earth observation satellites, particularly for water vapor monitoring. Interference will occur and will potentially be significant without effective controls. According to Samenow, (2019) 5G out-of-band emissions could produce a 30% reduction in weather forecast accuracy. Interference to satellite operations impairs numerical weather prediction performance with substantially deleterious economic and public safety impacts. Besides, increases in interference already exist with some other initial proximate band usages.

Human health issues

Health issues related to radiation from cell phone towers and cell phones are not new. The unseen enormous power of effects such as headaches and neurasthenia has been claimed from 4G and Wi-Fi. 5G technology presents a couple of new issues which depart from 4G technology like higher microwave frequencies from 2.6 GHz to 28 GHz, compared to 700–2500 MHz typically used by 4G. Because the higher millimeter wave used in 5G does not easily penetrate objects, this requires the installation of antennas every few hundred meters, which has sparked concern among the public.

The speed of 5G technology has been creating the fear that 5G radiations could have adverse health effects on humans. There are also a lot of fears that the technology could cause cancer, infertility, autism, Alzheimer's, and mysterious bird deaths. This is because the millimeter wave frequencies used by 5G have not been extensively been tested on the general public. In April 2019, the city of Brussels in Belgium blocked a 5G trial because of an observation of its adverse effects. In Geneva, Switzerland, a planned upgrade to 5G was also stopped for the same reason; though the Swiss Telecommunications Association (ASUT) has not been able to show studies of health implication of 5G frequencies.

Security threats

It has been revealed that 5G technologies could open ground for a new era of security threats (Basin et al., 2018). The findings described the technology as immature and insufficiently tested. A technology that allows the movement and access of higher volume of data can definitely give room for enormous and indiscriminate threats to many nations security sites and archives. Besides, many network security companies have advised on personalized and mixed security deployments against massive Distributed Denial of Service (DDoS) attacks foreseen after 5G deployment. In addition, IoT Analyst has revealed that an increase in the number of IoT devices enabled by 5G technology from 7 billion in 2018 to 21.5 billion by 2025 will also raise more security dangers. It will definitely raise the attack surface for these devices to a substantial rate, and the capacity for DDoS attacks, cryptojacking, and other cyberattacks could boost proportionally.

Increase in heat

Increase in heat is another unseen danger the public will be exposed to over 5G radiations. There is often a misunderstanding between ionizing and non-ionizing radiations because the term radiation is used for both cases. Every light is seen as a radiation because it is simply energy moving through space. Ionizing radiations are short wavelength radiations which have enough energy to knock out electrons from their atoms and can break chemical bonds. However, non-ionizing radiations

are millimeter waves' radiations (5G), which has an established hazard of generating too much heat. Too much of heat can cause several thermal damages, which is very dangerous to every segment of the society.

Challenges of rolling out 5G as a standard network

5G networks are gradually making its way into the cities of many developed nations, but expectations are high all over the globe in order to make it the worldwide default standard network. While 5G will certainly reach most major cities around the globe, as well as smaller communities in between, it won't happen all at once due to some challenges seen below.

5G networks are limited in range

5G networks are operating on high radio frequencies called millimeter waves, which have the benefit of being able to carry lots of data but are limited in range. Data transferred through these types of 5G networks is more easily blocked by common objects like trees and buildings. Because of 5G's limited scope, fewer users can access 5G from a single cell tower. This means that many small antennae have to be erected to serve more customers, and if not, only a small group of very local devices can get on the network. However, deploying hundreds of thousands of small cells across the nation isn't a quick task, and providers are running into other related issues like local community regulations.

Regulatory policies

Many nations of the world especially developing nations are yet to regularize with ITU policies on 4G and now 5G. Hence, most nations' regulatory bodies have the challenge of not been ambitious enough to invest with telecom providers to install 5G equipment or their procedures in approving a rollout of 5G. Before a telecom provider can pay for a section of the spectrum, international authorities have to agree on which parts of the spectrum can be used for mobile communications. Every aspect of regulatory policies might be one of the biggest barriers to a speedy 5G rollout. Some examples include zoning policies, lengthy permitting processes, unreasonable fees, and even aesthetic concerns due to 5G hardware being installed on street lamps and utility poles. Without proper acceptance from relevant authorities, rolling out 5G in a timely manner is difficult.

Delay in 5G devices

Another challenge with 5G that will affect it of becoming the worldwide default network is that most manufacturers have not yet released 5G-compatible devices like phones, tablets, and other devices. This could be considered a serious matter since phones don't need to be released until 5G networks are available. However, the two have to synchronize with each other to make 5G useful, and many of the phones that work on a 5G network aren't set to come out until the year 2010 or later year. Besides, like all developing technologies, rigorous testing must be completed before an actual 5G rollout can take place. A company releasing a new phone, for example, won't provide it for customers until they are confident that it will work as advertised and provide the best experience for customers. Regardless of what's being tested in relation to 5G in releasing a commercial product, thorough testing has to take place and it isn't a quick process.

5G is expensive to roll out

Another major challenge in making 5G a worldwide default network is that, it is very expensive to roll out. Indeed, deployment a brand new mobile network like 5G isn't cheap. There's a lot that goes into starting up a 5G network. Despite the potential benefits, there is concern that 5G is still growing, and notes of caution are being given regularly. Operators are skeptical about the commercial dimension considering the high levels of investment needed to deploy 5G networks. It has been collectively reported that the estimated cost to deploy a small cell-ready 5G network can range from USD 6.8 million for a small city to USD 55.5 million for a large dense city. This amount is not easy to come by in deploying it in several cities. A mobile network operator has to pay for spectrum licensing, the physical hardware used in the 5G deployment, hiring technicians to install the necessary hardware, testing and retesting of the network, deployment fees demanded by regulators, and many more during a 5G rollout before it can even reach customers. In estimate, the price of spectrum acquisition alone can be over $380 million in a 3.6 GHz spectrum auction to nearly $8 billion worth of low-band spectrum.

Conclusion

Expectations of 5G are high, with many assuming it will deliver a transformative promised land; an improved end-user experience, new applications, new business models and new services riding swiftly on the back of gigabit speeds, improved network performance and reliability. 5G networks and services, standing as they do on the shoulders of successful 2G, 3G and 4G mobile networks, are forecast by independent economic studies to deliver very significant economic gains. But there are unseen factors like dangers and challenges that virtually every stakeholder is not given mush considerations to. However, a complete overall merits and demerits over

the promising 5G network deployment will be an added value globally.

Recommendations

Based on the issues raised, the following recommendations were made:

(i) For the proponents of 5G, many believed that the benefits 5G can provide to society far outweigh the unknowns, it is therefore recommended that, the operators should be ready to accept and bear any consequent that will arise to human lives globally.
(ii) Since the dangers associated with 5G is still under contention from different scientists; 3GPP and ITU should formally make their findings and come up with a common worldwide statement on the dangers of 5G network.
(iii) Since there are not enough toxicology studies with this technology, it is recommended that more collective research should be carried out in order to find out more unknown dangerous.
(iv) With the transformational promises projected by 5G network globally, the world leaders should work in synergy and be ready to collectively bear all the financial implications.
(v) Since delay in the deployment of 5G network is a major challenge, ITU should assist developing nations to enhance its release and deployment, in order to make it a worldwide default standard network.

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