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5G Evolution: Differences between Basic 4G/LTE with 5G Network

Nurul Syahira Binti Nordin, Woo Ying Yee, Md Saeed Hasan Joarder, Badrul Hisham Bin Ahmad

Abstract: ***Wireless ccommunication is one of the fastest growing area today. Wireless devices are growing exponentially day by day. The need for massive data transmission is growing and growing every year. Some of the prime goals or demands that need to be addressed in the near future, i.e. beyond 4G, are increased efficiency, higher data speeds, decreased latency and better service quality. To meet these demands, there needs to be dramatic changes in the design of the cellular network. Some of the main 2020+ timeline services include smart city applications that require smart grid, smart infrastructure, smart medicine with connected vehicles, connected houses, moving robots and sensors that build the Internet of Things environment. 5G is the fundamental IoT connectivity infrastructure that can handle extremely high power, high bandwidth, robust integrity and low latency. This represents a number of innovative and disruptive advancements in technology. This paper comprises of basic comparison between 4G and 5G characteristics. It covers how 5Gs architectures differs from 4G architecture and what are the advantages and characteristics of 5G. First, 4G and 5G network architecture are pointed out. Second, overview of technological advancement of 5G over 4G is discussed.***

Keywords: ***Wireless communication, wireless devices, data transmission, 5Gs architecture.***

I. INTRODUCTION

Today, 4G is popular technology for high speed data transmission, video streaming and many other interactive communication but it has lot of limitations also. To challenge those limitations now 5G seems to be much more convenient with more data speed, less latency and less power loss. 5G communication expected to cater unprecedented challenges like massive deployment of IoT, M2M etc which is the future of automation. Over 50 billion devices are expected to be connected to the Internet by 2020. IoT devices represent more than 75% of traffic. 90% cars are to be connected to the Internet. Biometrics, sensors and integrated Geo-positioning capabilities will be involved in the access devices [8]. 5G is targeting at a much broader range of communication patterns with applications in various vertical domains like industrial production, automotive, transportation, agriculture, and health care. In particular, 5G offers an excellent support for machine-to-machine communications and Internet of Thing (IoT) connectivity, which have the potential to change many aspects of our economies and societies. 5G is not only a new high speed network but its revolution in terms of its different characteristic for different services.

This paper deals with the differences between basic 4G/LTE with 5G network. Section II summarizes the methodology, 4G and 5G network is introduced in Section III followed by overview of technological advancement of 5G over 4G in Section IV.

II. METHODOLOGY

As an anchor for an academic thesis or dissertation, the literature review is necessary to synthesize the understanding of researcher on their particular project, to test the rigorous research dedication of the researcher, justify future research, and act as the scholarly tradition and etiquette. Generally, the review was conducted by only 4 stages, which are planning, selection, extraction and execution. However, a standardize methodology which consisted of 8 steps as “Figure 1” are essential during conducting a systematic review for a review to be scientifically rigorous.

First, every researcher must know the purpose of the literature review. In this step, the purpose and the anticipated goal of the review must be clearly identified in order to explicit to its readers. As in all empirical work, the first step of a project should be to consider whether the methodology to be employed is the most appropriate one. Therefore, determining the purpose of the literature review would resolve the concern.

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* Correspondence Author
Nurul Syahira Binti Nordin*, Department of Electronic and Computer Engineering, University Teknikal Malaysia Melaka, Melaka, Malaysia. E-mail: M021920001@student.utem.edu.my.
Woo Ying Yee*, Department of Electronic and Computer Engineering, University Teknikal Malaysia Melaka, Melaka, Malaysia. E-mail: M021910013@student.utem.edu.my.
Md Saeed Hasan Joarder*, Department of Electronic and Computer Engineering, University Teknikal Malaysia Melaka, Melaka, Malaysia. E-mail: M021920008@student.utem.edu.my.
Badrul Hisham Bin Ahmad*, Department of Electronic and Computer Engineering, University Teknikal Malaysia Melaka, Melaka, Malaysia. E-mail: badrulhisham@utem.edu.my

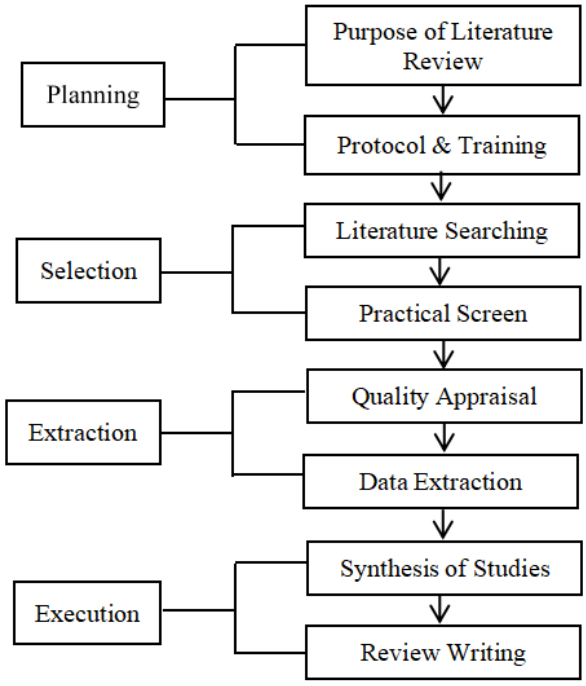

Fig. 1 Flow Chart of Systematic Literature Review Development.

Second, protocol and training is critical if the review was prepared by a group of researchers. All of the researchers must be completely clear and share the common consciousness about the detailed procedure to be followed. This requires both a written, detailed protocol document, and training for all reviewers to ensure consistency in the execution of the review.

Third, searching for the literature begins the selection stage, which involved of searching for and the studies that will be include in the study, and eliminating several studies that do not meet the requirements. Hence, this step require researcher to be explicit in describing the details of the literature search, and needs to explain and justify how the comprehensiveness of the search was assured.

Forth, practical screen which also known as screening for inclusion must be undergone by researcher to eliminate the studies without further examination and keep those that considered for review. The studies that been eliminated must with practical reasons for non-consideration, and justification of comprehensive result that would provide the practical exclusion criteria.

Fifth, quality appraisal is the step after practical screening which used for exclusion screening. Quality of all studies will be focus in this step by explicitly spell out the criteria for judging which articles are of insufficient quality to be included in the review synthesis. The appraisal was divided into two groups, which are quantitative that used to test or confirm theories and assumptions while qualitative used to understand concepts, thoughts or experiences.

Sixth, data extraction of all literature will be performed through systematically extract the applicable information from each study for synthesis step.

Seventh, synthesis of studies to combine all studies by using appropriate techniques, whether quantitative, qualitative, or both in order to make comprehensive sense out of a large number of studies is carry out. At the end of this stage, a completely and polished synthesis of information will be generated to ease the review writing step.

The final step of the literature review is writing the review. The most important thing in the review writing is the process of the review development to be documented in sufficient detail.

III. 4G AND 5G NETWORK

4G LTE is a wireless communication with high speed (around 100MBPS) with increased efficiency from its predecessor 3G. The overall architecture of the LTE network is similar with the GSM and UMTS (Universal Mobile Telecommunications System) networks. In principle, the network is divided in radio network part and the central network part. E-UTRAN is the radio network used for communication with UE and the Evolved packet core network. The E-UTRAN consists of eNodeBs, which are base stations. eNodesBs functions are Radio resource management between cells, handoff, Radio bearer control, ensure QoS for certain services, Dynamic resource allocation, ciphering and integrating protection of NAS signaling [1].

5G support two types of network architecture SA (Stand alone) and NSA (Non stand alone). NSA is also called E-UTRA dual connectivity (EN-DC) because it can use radio part and core part of a 4G network with the 5G radio access part. Due to dual connectivity here an UE can connect both eNodeB as a master and gNB as secondary (gNB is the radio part of 5G) [2]. 5G NSA has a major issue which is delay due to dual connectivity and which can be problematic for Low latency feature such as IIoT, M2M. Whereas in 5G SA consists of NR and 5G CN (Core network). Here all the functionality of 5G can be obtained. The main advantage of 5G is service based architecture. If we want to incorporate a new element in the network then we can define it as network function via a common network framework. This architecture increases the modularity, reusability by taking advantage of virtualization and cloud infrastructure.

The 5G solution is based on a flat architecture called the Cloud-Radio Access Network (C-RAN), with a combined base station and base station controller. The Enhanced Virtual Packet Core (vEPC) is basically a software Packet core 4G Long Term Evolution (LTE) upgrade based. Creating software and operation is based on cloud-based platform. There is no core circuit as opposed to 3G wireless [8].

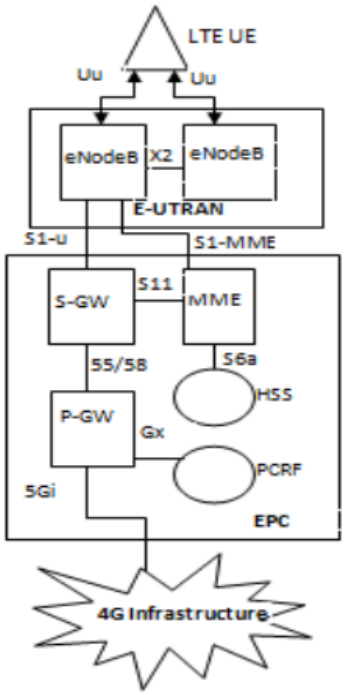

Fig. 2 LTE Architecture.

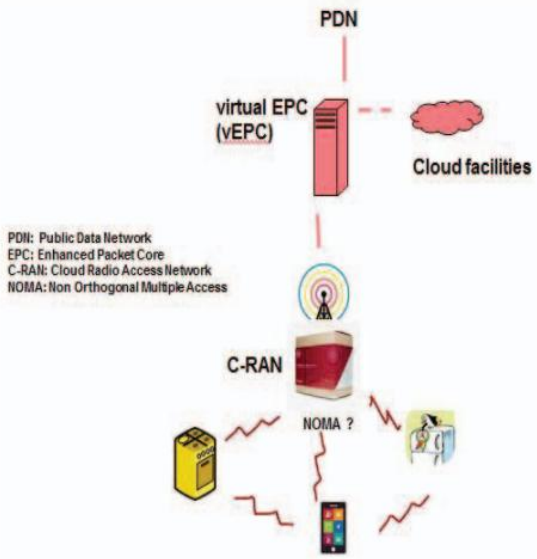

Fig. 3 5G Architecture [8].

IV. OVERVIEW OF TECHNOLOGICAL ADVANCEMENT OF 5G OVER 4G

5G is a technology which can provide highly flexible and highly scalable network to which we can connect any network with any number of devices. Some of the major features and advantages of 5G network is discussed below:

a) Enhanced mobile broadband (eMBB):

eMBB is an extension of LTE and was used in 5G network. In 5G, eMBB has more faster data rate and therefore a much more better user experience than LTE. It ensures high speed broadband data in densely populated area. It will enable broadband service in moving vehicle also. It can give up to 1Gbps data rate, latency about 1ms and high mobility around 500Km/hour in high speed train [3].

b) Ultra reliable low latency communication (URLLC):

The URLLC in NR enhanced the IIOT integration in 5G. It support ultra low latency for time sensitive communication for IIOT. In 5G, a deterministic communication with very low latency and high availability provided by TSN which provide very hard guarantees for QoS and synchronization down to nanosecond. It also support NPN which enhance network deployment for IIOT and can be isolated from the public subscriber to private subscriber in the network. For NPN new authentication scheme also introduced where with specific network slice authentication in addition to the primary authentication, they will get increased access control. There is another feature sidelink communication also enhanced in 5G release 16 C-V2X which can be very useful for driverless car as it can be used to communicate between vehicle to vehicle, vehicle to pedestrian and vehicle to roadside unit communication with lower latency, larger payload and higher data rate. This communication can be made successfully by URLLC of NR with MEC. Like LTE sidelink, it can also make device to device communication without base station [4].

c) Massive machine type communication (mMTC):

mMTC is one of the key feature of 5G and it is use for massive machine type communication to massive user. Very large kind of devices can be connected here. When there is a low latency with high bandwidth is required, then mMTC 5G is required. Though mMTC is primarily designed in LTE but LTE is not actually designed for specific characteristics for specific data where as 5G mMTC is very good for this. It can handle up to 10Gbps data [4].

d) 5G spectrum and frequency:

5G NR use large frequency spectrum from 400Mhz to 90 GHz. The lower the frequency band, the higher the coverage with different obstacle. Higher the frequency lower the coverage and higher data capacity. The main problem of the higher frequency (mm wave) is it cannot penetrate the wall or even leaf but it can give very high data rate in line of sight communication. Whereas in lower frequency like 700MHz or 800MHz it has very good coverage area as it can penetrate the wall much better compared to millimeter wave. In LTE advanced, maximum (5X20)MHz bandwidth can be obtained by carrier aggregation where in 5G NR on 6.4 GHz, the maximum bandwidth(16x400) MHz. Each channel capacity increases 20 time in 5G NR compared to LTE [2].

e) Programmability and softwarization:

5G relied heavily depend on softwarization and virtualization. It has adopted new networking re-architecture by changing network softwarization end to end connect and compute infrastructure which is very flexible and highly programmable. Now its changes to network function from previous monotholic network entity. Network softwarization has eliminate the dependency of hardware by using programmable software like NFV,SDN, network slicing, network function etc. According to 5G PPP “The network slice is a composition of adequately configured network functions, network applications, and the underlying cloud infrastructure (physical, virtual or even emulated resources,

RAN resources etc.), that are bundled together to meet the requirements of a specific use case, e.g., bandwidth, latency, processing, and resiliency, coupled with a business purpose". Due to network slicing we can define multiple logical network and can be customized easily according to different service requirement whereas in 4G LTE, the network part is dependent on the hardware with software and functionality for different service like MBB, Voice. Whenever a new policy or service need to incorporate in 4G LTE, then there always will be challenge as it service or policy depend on the available hardware but in 5G softwarization it can be achieved by different technique like SDN, NFV etc .The key benefit of network slicing is that a network can be provided as a service and multiple network and network related function can be served from a single hardware resource. Different logical network can be used according to requirement of a service such as eMBB, V2X, URLLC and mMTC which yielding better QoE for subscriber and better network operability for the telco operator. Its implementation helped to completely decoupled with the underlying hardware resource which is really very cost effective [3].

f) Beamforming:

Day by day demand of higher data rate is increasing. To support high data rate LTE uses Multiple Input Multiple Output (MIMO) antenna which is basically array of antenna. More antenna get strong reception and higher data rate and 5G support massive MIMO (mMIMO) where the array of antenna much larger compared to MIMO and which is very helpful for coverage and capacity enhancement. mMIMO is possible because of higher frequency (24-52.6GHz) spectrum uses in 5G. As higher the carrier frequency lowers the wavelength and we can put a large array of antenna within the same physical location available before. In 2G, 3G or 4G antenna dissipate power in all direction whereas in 5G an improved S/N ratio beamforming is used which involved directing the antenna beam [2]. Effectiveness of this forming depending on the size of antenna array. The 5G NR can be beam formed properly if the user is in line of sight. But as the frequency increases penetration loss increases which depend on the material. So if the user is not in line of sight (within the concrete wall) then there will be significant degradation of services [2].

g) NPNs (Non public network):

According to 3GPP 5G network can be categorize into two types: Public Land Mobile Network(PLMN) and Non Public Network(NPN) [5]. PLMN will provide different network services for general public whereas NPN will provide network service to industries. NPN will provide all the services to the factories and its coverage area will be factories premises. In a factory it can be connected to different types of devices such as different sensors, robots, driverless vehicle etc. With the help of NPN 5G network will collect the information of each of the machine condition by the sensor, which helps easier and accurate maintenance of machine for factories. Robots and automated vehicle also can be instructed through the network and this all can be done by TSN to make everything accurate and reliable. NPN restricted only to the industry/factory premises due to several desirable reason given below:

a) Quality-Of-Service requirement for mission critical requirement with very low latency and high reliability.

b) Very high security credential to restrict the NPN from PLMN to stop malicious attack from PLMN.

c) NPN for a given industry must have a independent network to track their subscription data for accounting and auditing.

3GPP proposed two types of NPN:

a) Stand alone NPN: Which does not rely on network functions provided by a MNO.

b) Public Network integrated NPN: This NPN deployed on support of a PLMN [8].

V. CONCLUSION

In this paper, a detailed overview has been done on the difference between basic 4G/LTE with 5G network. A major feature and advantages of a 5G wireless network has been explained in this paper. The next generation 5G communication will bring significant changes in communication as well as its architecture. It can be concluded that 5G is an important IoT enabler because of the disruptive improvements in radio and antenna systems, architecture of the spectrum, and network.We can get very high bandwidth of data with very low latency. It is capable to process very large amount of data and at the same time it is very scalable. Its data continuity is very high even in very high speed vehicle. It will change the future of automation industries.

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AUTHORS PROFILE

Nurul Syahira Binti Nordin, completed Bachelor Degree of Electronic and Computer Engineering in 2018 for a thesis on the Design of Multiband Matched Band-stop Filter using T-Shape Resonator Network System. Now, she is a student and a graduate research assistant of Master of Electronic and Computer Engineering at Universiti Teknikal Malaysia Melaka (UTeM). She has published paper in Journal of Theoretical and Applied Information Technology (JATIT) title Design of Multiband Matched Band-stop Filter using T-Shape Resonator Network System.

Woo Ying Yee, student of Master of Electronic and Computer Engineering at Universiti Teknikal Malaysia Melaka (UTeM).

Md Saeed Hasan Joarder, student of Master of Electronic and Computer Engineering at Universiti Teknikal Malaysia Melaka (UTeM).

Badrul Hisham Bin Ahmad, completed M.Sc. degree from University Kebangsaan Malaysia (2003) and Ph.D. degree from Leeds University, United Kingdom for a thesis on the Design and Development of SIW Filters (2008). He is an active researcher with a good track record with a number of research projects in RF and Microwave Engineering.