TEST Engineering & Management

May – June 2020
ISSN: 0193-4120 Page No. 1405 - 1410

Adjusting the LTE structural design to 5G: Prospects and Challenges

MS Alam[1], MM Rahman[2], AA Samy[3], J Afroj[1], SN Prottasha[1], MN Uddin[1], S Ahammed[1], R Roy[4], MM Rashid[4]

[1]Department of Electrical and Electronic Engineering,
Northern University Bangladesh, Banani, Dhaka-1213, Bangladesh
[2]Department of Electrical & Electronic Engineering
Primeasia University, Dhaka, Bangladesh
[3]Department of Electrical & Electronic Engineering
American International University-Bangladesh
[4]Department of Mechatronics Engineering, International Islamic University Malaysia

Article Info
Volume 83
Page Number: 1405 - 1410
Publication Issue:
May - June 2020

Article History
Article Received*: 11August 2019*
Revised*: 18November 2019*
Accepted*: 23January 2020*
Publication*: 10 May2020*

Abstract:

Research directions indicate a behemoth shift will be required from the existing framework to activate 5G in full swing. Current researches are intensively working in this field, however, it will take significant time to reach the ultimate goal. Emphasis has been given on the factors and challenges of 5G, solutions have been proposed accordingly, and some ideas about the architecture have been achieved so far. The work shown in this study is not necessarily a radical one, rather demonstrated the challenges, their possible solutions, and more importantly the proposed solutions are precisely discussed in the context of the architecture. It has been assumed that the whole architecture is closely adjacent to the existing 4G architecture, except that all those elements in the same architecture will be far more capable to enable 5G. Addressing the requirements in a very precise approach, addressing the solutions, and finally locating exactly where they would be applied within the architecture is the main objective.

Keywords: *5G, LTE, adaptation, macrocell, MIMO*

I. INTRODUCTION

Highlight With the advancement of technologies in cellular network, the fifth generation (5G) is not just going to be a gradual evolution from 4G and previous ones, rather a massive shift from the existing system. The eventual goal of 5G is to connect multiple devices under a unified umbrella for any kind of beneficial application. The application can be used to design smart home, safe traffic supervision, automated industry process as well as to transfer bulk media files and to make video calls.

5G networks will not be based on a single specific network topology rather it will be the adaptation of all earlier generations' mobile system with enhanced technologies like WiFi, Internet of Things (IoT) and D2D communications [1]. The specification of 5G will include the development of flexible air interface, high traffic capacity also in terms of latency and reliability. Also development of Narrow-Band IoTis required enabling huge connectivity between devices. As the technology is evolving the use of higher spectrum for subscriber access is required but side by side lower spectrum should exist because the migration of user cannot be done overnight.The write up is a cumulative narration of the requirements of 5G network. The business modification and optimization works could be done further to implement in real time. The total system consists of multiple protocol layers and merger of different transmission and communication systems. Higher end smart devices and higher bandwidth availability are the key factors to support complex user applications for voice and data communication provided by the single service provider.5G is not actually a new idea but the mixer of all user imaginations and capacity in a single frame. The

May – June 2020
ISSN: 0193-4120 Page No. 1405 - 1410

freedom of user is unlimited. The communication between devices should be through different transmission media/ interfaces.

This paper basically focuses on the requirements of 5G and proposes various features of architecture while addressing those requirements within the architecture. Primarily the very basic requirements have been addressed and in the following part different aspects of modifications in the present architecture have been suggested considering the fulfillments of those requirements.

II. THE REQUIREMENTS FOR 5G

A. Data Rate:

It is expected that the network will be able to serve data to 10000 or more devices regardless the devices are of low or high rate. A single macro cell may have to handle all those devices with maintaining the required aggregate data rate, edge rate and peak rate consistently. As it is mentioned about a unified umbrella before, this umbrella will take enormous yet compact architecture under it with many nodes. Some of the fundamental requirements are shown in Figure 1. All the requirements or challenges, those will be discussed later, are completely associated with each other and they are themselves the requirements for each other. Some of them are explained below:

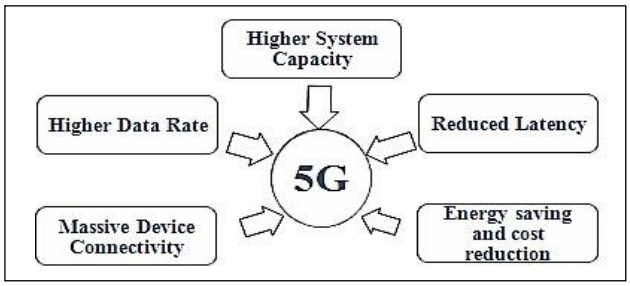

Fig. 1: *Requirements (not limited to) for Enabling 5G.*

B. Latency: Reducing latency is another big challenge, and at present in 4G age 15 ms latency is considered good for many services, however, the targeted latency in 5G is as low as 1 ms or less [5].

C. *Higher* Massive Device Connectivity: Massive number devices enrolled with thousands of different applications may be easily prone to frequent interference, noise and disconnection while reduced size of network will make challenging further. Overcoming this challenge will require some drastic changes in the architecture [6].

D. **UNIT Energy and Cost:** Energy as well as cost, both are role players at the end of the day, and it is evident that approach to 5G refers to individualization of each and every single component and decentralization from where they are attached with now. Leading to smaller cells will require less power and a user device or a WiFi node will not be more expensive than a typical BTS, however, the supportability for extremely high data rate and heterogonous interfaces an appropriate trade-off amongst cost, capacity and energy will be some big challenges.

Table 1: Basic Requirements for Enabling 5G and Their Probable Solutions.

Requirements	Possible Solutions
i) Extreme High Data Rate	1. Boosting modulation technique such as including 256 QAM so that more data transferred per hertz of frequency [7]. 2. Including more layer cells such as macro cell, pico or femto cell in smaller area [8]. 3. Using mmWave interface to deal with scarce microwave spectrum. 4. Including cognitive radio system for sharing spectrum, hence, enhancing spectral efficiency [20].
ii) Low Latency	1. Including a single all-IP backbone cloud to transfer information packets seamlessly and without any delay as per priority.
iii) **Higher System Capacity (this is another way of mentioning enhancing data rate to some extents)**	1. Introducing various functional servers for various types of interactions with enabling local caching [1], and these are shown as application servers connected along with RAT and C-RAN connected between core network and IP cloud. 2. Introducing massive MIMO in layer of macro cell which generally means adding more number of antennas than the number of devices that reduces frequency dependencies [2].

May – June 2020
ISSN: 0193-4120 Page No. 1405 - 1410

iv) Massive Devices Connectivity	1. A device centric architecture would be initiated where devices would be connected by means of IoT or RFID. 2. Smarter devices with variability in applications will reduce the dependency on macro cells while rejecting the interference and enabling local caching [9].
v) Energy and Cost	1. Enabling Dynamic Experience Management (DEM) to ensure increased responsiveness to the continuous changing need of the users which will provide both energy and cost efficient system [10]. 2. The concept of initiating mmWave spectrum may save 10 to 100 times cost [2]. 3. Providing adaptive beam forming algorithm by including smart antenna array system at macrocells coverage efficiency can be significantly improved.

III. POSSIBLE SOLUTIONS: A MULTIFACETED UNIFIED ARCHITECTURE

The approach is not to make solely a novel architecture; rather, it can be referred as the adapting with 4G, which means adding numerous extreme features with the existing framework. The objective is to provide a compact solution for variety of sky high users' demands. As some basic requirements have already been addressed before, the objective of this study is to gather all the possible solutions and precisely address their implications directly in the proposed architecture. At first, all the possible solutions are included in Table 1 listing different requirements or challenges for enabling 5G.The above probable solutions are not necessarily to be confined to some limited considerations, as present studies are bringing up with enormous range of challenges and solutions. Several architectures have been proposed; however, in this study the intention was to represent some clear adaptations of 4G architecture. A noble 5G model is conceptualized and projected in Figure 2. The itemized details showing the possible upgrade to meet the requirements- where applicable- are shown Figure 2.

A. Core Network

This level of architecture does not have any significant change from that of previous architectures except increased capacity. In fact this performs the job of mobile service switching with a bigger server to store users' data and other features [18]. The 5G core will be IP cloud-based network with a higher level of network functions virtualization for controlling its size, SDN for flexible networking and dynamic allocation of network resources. The initial requirement for setting up 5G demands full support on NX – described as new access network over 6 GHz spectrums- and evolved LTE, as well as Wi-Fi and other non 3GPP technologies. The new idea is slicing core network [11]; diving the different functionalities in different logical plane as traffic plane, control plane and network management plane. This decentralization of core enables quick expansion and enhances flexibility.

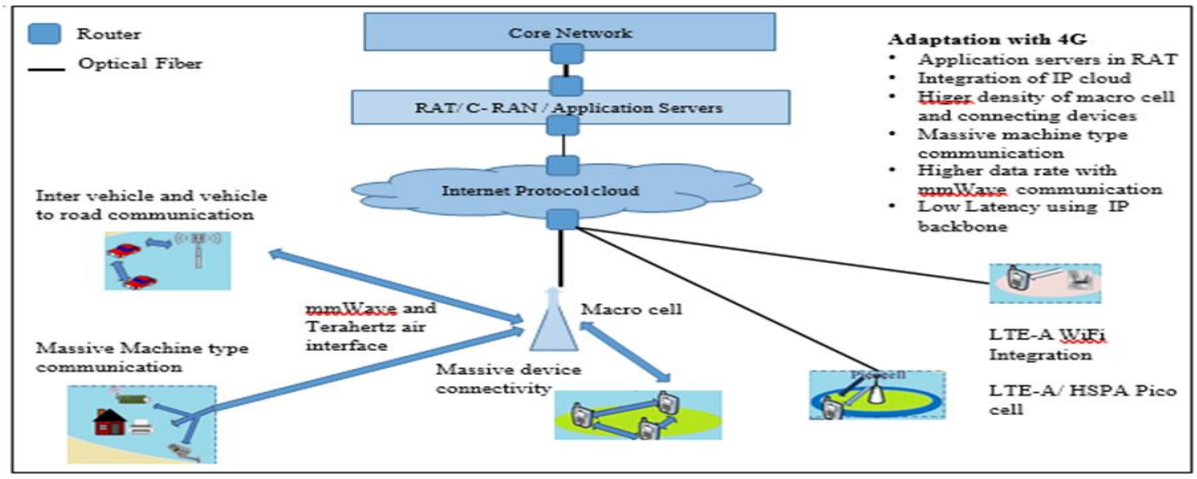

Fig. 2: *Architecture Showing Adaptation with 4G and Addressing the Up-gradations for 5G.*

May – June 2020
ISSN: 0193-4120 Page No. 1405 - 1410

B. RAT/C-RAN/Application Server

These are highest nodes in the radio access networks and perform radio resource switching, access control, control information broadcast for user authentication, traffic handling, and provides the application based services. Additionally the communication through backhaul with the extended capacity core network. The addition in the context of 5G is the application servers with enormous capacity directly supported by the operator [4]. Also 5G will support device to device communication, Vehicle communication aid, softer handovers and many more smart features [19].

C. Internet Protocol (IP) Cloud

The level of enormous IP cloud basically is the largest adaptation or upgrade from the previous architecture of 4G and which acts as the unified umbrella to support all the features underneath it [12]. This level provides seamless data transfer amongst the users without the requirement of some transfer protocols-such as E1 over IP, GB over IP, SDH over IP- which is connected with numerous RATs, macro cells, or pico cells or even with giant Wi-Fi network through optical link [7]. The massive cloud with highly reliable optical link ensures flawless data speed and significantly improved latency in almost all interfaces from top to bottom of the architecture. The IP network is based on seven layer Open System Interconnection model [13]. The up-gradation includes hardware improvement as well protocol stack implementation in rest layers [17]. The network is named as mobile packet backbone network. The implementation of IP backbone boosts network reliability, security and speed ensuring higher level resource management.

D. Macro cell, PicoCells and Wi-Fi Integration

These act as the base station (BS)that was in 4G and before, however, the adaptation is multiple number of macro will replace BS. The density of these cells will be massive and the cell will be capable of allocating control and traffic resources dynamically [14]. The handover will be very smooth as there will be sufficient number of cells and the handover will be based on capacity rather than quality of service. The macro cell will have direct optical link with the all-IP backbone, however, there will be air interface between them and devices up to the user end. This feature will be built more densely with smaller space, and hence in more numbers [15]. They will be well equipped with smart antenna systems such as massive MIMO, smart adaptive antenna systems and smart handover systems [1]. Similar will be applied for other cases such as Pico cell and Wi-Fi. Pico cell is already a part of 4G LTE and Wi-Fi integration is still an ongoing process in the same platform. However, in 5G they may each act as a BS and create more cells with different ways for connectivity [8].

E. Machine Type Communication

This can be referred as user end communication, where devices, massive machines, vehicles and other allied devices are connected through the air interface. A mmWave wave and tera Hertz interface and smart devices will ensure high data rate and lowest possible latency [2]. This will be the most revolutionary improvement which can contribute a lot in urban lifestyle like safe traffic system and to construct smart homes. Unlike the devices in previous generations, there will be communication directly between devices of different kinds and that can take place without the controlling of BS equivalent macro or pico or any Wi-Fi zone [16]. Internet of Things, or improved RFID or even Bluetooth may be studied further to enhance their connectivity.

I. CONCLUSION

Gathering wide range of applications under the same umbrella or platform is the target of implementing 5G. Nevertheless, this is not a task to be accomplished within a short time, and that is why a projection of 2020 is importantly considered and many projects are racing with the same objective. Building a framework with such enormous features and capability will be one of the greatest achievements. This paper has attempted to focus on the architecture while addressing requirements and their possible solutions directly into it.

The study shows not modification rather accumulation of the resources under the same umbrella with enhancing capacity to very high level creates the architecture for 5G. As 5G is something

May – June 2020
ISSN: 0193-4120 Page No. 1405 - 1410

beyond the capacity of present mobile communication system, and the dimensions of applications, users, demands- will be huge variations, a large number of technology will be required to implement. Therefore, scope of works on it is literally limitless.

REFERENCES

[1] Boccardi F, Heath Jr, R, AL. Five Disruptive Technology Directions for 5G.IEEE Communications Magazine. Feb 2014; 74–80p.

[2] Jeffrey G, Stefano A, Wan B, Stephen CV, Angel HL, Anthony CKS, Jianzhong Z. What Will 5G Be? IEEE Journal on Selected Areas in Communications. Jun 2014; 32(6): 1065–1082p.

[3] ICT-317669 METIS project, Updated scenarios, requirements and KPIs for 5G mobile and wireless system with recommendations for future investigations, Deliverable D1.5, Apr 2015, available at: https://www.metis2020.com/wp-content/uploads/deliverables/METIS_D1.5_v1.pdf'

[4] Ericsson, Ericsson Mobility Report, Nov 2015. Available at: http://www.ericsson.com/res/docs/2015/mobility-report/ericsson-mobility-report-nov-2015.pdf

[5] Fettweis GP. The tactile Internet: Applications and challenges. IEEE Veh. Technol. Mag. Mar 2014; 9(1): 64–70p.

[6] Laneman N, Tse D, Wornell G. Cooperative diversity in wireless networks: Efficient protocols and outage behavior. IEEE Trans. Inf. Theory. Dec 2004; 50(12): 3062–3080p.

[7] Andrews JG, Claussen H, Dohler M, Rangan S, Reed MC. Femtocells: Past, Present, Future. *IEEE J. Sel. Areas Commun.* Apr 2012; 30(3): 497–508p.

[8] Chandrasekhar V, Andrews JG, Gatherer A. Femtocell Networks: A Survey. *IEEE Commun. Mag.* Sep 2008; 46(9): 59–67p.

[9] Ying D, Vook FW, Thomas TA and Love DJ. Hybrid structure in massive MIMO: Achieving large sum rate with fewer RF chains. *Communications (ICC). 2015 IEEE International Conference on Communication*, 2015; 2344–2349p.

[10] Network architecture for the 5G era. 2015; Retrieved June, 2016, from http://resources.alcatel-lucent.com/asset/ 200004

[11] A Vison of the 5G Core: Flexibility for new business opportunities [Review of *Ericsson Technology Review* by L. Frid, H. Basilier, M. Stuempert, & G. Hall]. (2016, February). *CHARTING THE FUTURE OF INNOVATION*, 39; 1–16p. Retrieved July, 2016, from https://www.ericsson.com/res/thecompany/docs/publications/ericsson_review/2016/etr-5G-core-vision.pdf

[12] Pachauri A, & Singh O. 5G Technology – Redefining wireless Communication in upcoming years. *International Journal of Computer Science and Management Research.* 2012 Aug; 1(1): 12–19p.

[13] Gohil, Asvin, Modi H, Patel SK. 5G Technology of Mobile Communication: A Survey. *Proc. of 2013 International Conference on Intelligent Systems and Signal Processing (ISSP)*, India, Gujarat. N.p.: n.p., n.d. 288–92p.

[14] Estimated spectrumbandwidth requirements for the future development of IMT-2000 and IMT-Advanced, ITU-R, Geneva, Switzerland. Rep.M.2078. 2006.

[15] Health RW, Peters SW, Wang Y, Zhang J. A current perspective on distributed antenna systems for the downlink of cellular systems. *IEEE Commun. Mag.* Apr 2013; 51(4): 161–167p.

[16] 5G: A Technology Vision. (n.d.). Retrieved August 23, 2016, from www.huawei.com/ilink/en/download/HW_314849

[17] Patil S, Bhat P. A Review on 5G Technology. International Journal of Engineering and Innovative Technology (IJEIT). Jan 2012; 1(1): 26–30p.

[18] Meenal G, K, & Ajay P, T. 5G Technology-Evolution and Revolution. *International Journal of Computer Science and Mobile Computing A Monthly.* 2014; 3(3): 1080–1087p.

[19] Khan J, Abbas A, Khan K. Cellular Handover approaches in 2.5G to 5G Technology. *International Journal of Computer Applications*,2011; 21(2): 28– 37p. doi:10.5120/2482-2984

[20] Badoi C, Prasad N, Croitoru V, Prasad R. 5G Based on Cognitive Radio. *Wireless Personal Communications.* 2010; 57(3): 441–464p. doi:10.1007/s11277-010-0082- 9

AUTHORS PROFILE

Mohammad Shafiul Alam
Senior Lecturer, Department of Electrical & Electronic Engineering
Northern University Bangladesh,
Email: gmshafiul@gmail.com

Md Mirazur Rahman
Assistant Professor
Department of Electrical & Electronic Engineering
Primeasia University, Dhaka, Bangladesh
Email: mrzmist@gmail.com

May – June 2020
ISSN: 0193-4120 Page No. 1405 - 1410

Md Arif Abdulla Samy
Assistant Professor
Department of Electrical & Electronic Engineering
American International University-Bangladesh
Email: arifsamy63@gmail.com

Jinia Afroj
Lecturer, Department of Electrical & Electronic Engineering
Northern University Bangladesh,
Email: jinia470@gmail.com

Soheli Noshin Prottasha
Lecturer, Department of Electrical & Electronic Engineering
Northern University Bangladesh,
Email: prottashaeee@gmail.com

MN Uddin (Md Nasir Uddin) is an Assistant Professor in Northern University Bangladesh. He is from Gazipur, Dhaka, Bangladesh.
Email- engnasirbd@gmail.com.

Shakil Ahammed is a Teaching Assistant in Northern University Bangladesh. He is from Cumilla, Bangladesh.
Coordinator & member of NUB IEEE Student Branch**.**
Email: ahammedshakilbd@gmail.com