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5G Technology: Future of Mobile Communication Outlook

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ABSTRACT

In the future outlook of mobile communication technology, the various requirements are to be fulfilled as the main objective which are high data rate, low latency, increased capacity and better Quality of Service (QoS). This paper presents a brief survey of 5th Generation (5G) network architecture and arising technologies to enhance the overall improvement in existing mobile communication technology. The backhaul concept is introduced to make the connection of dense small cells with the core network.

Keywords: *5G, mMIMO, QoS, MWT, SDN, MTC, CR, SCD, mRATs, SON.*

1. INTRODUCTION

In the mobile-communication field, a large number of researches have been carried out to improve the Quality of Services (QoS). The increased traffic of cellular data has forced to increase the existing frequency spectrum. At present time, 5G researches are based to provide the features such as Wireless Broadband Access (WBA), Multimedia Messaging Services (MMS), mobile TV, HDTV and Digital Video Broadcasting (DVB) with minimal services like voice and data. Therefore, 5G networks were introduced to increase the capacity, higher data rate, lower peer-to-peer latency, adequate RF coverage, consistent Quality of Experiences (QoE) concepts and interconnection of all wireless heterogonous networks and energy efficiency. [1][2]

2. THEORY

5G would emerge as a real wireless world with the new term www i.e. world-wide wireless web. This new technique promises to access the service with no limitation and no zone boundary with one unified global standard. Overall, future life would be based on a networked society with unlimited access to information and sharing of it that can be accessible at the instant of time and anywhere.

With the increasing numbers of users, 4G is going to be replaced by 5G with additional technologies of Beam Division Multiple Access (BDMA) and Filter Bank Multi Carrier (FBMC) [2]. In BDMA, each mobile station is allocated with orthogonal beam that would be divided by this BDMA technique to the other mobile stations resulting in the increased network capacity.

3. 5G PROTOCOLS

<table>
<tr><td>Application Layer</td><td rowspan="2">Application (Services)</td></tr>
<tr><td>Presentation Layer</td></tr>
<tr><td>Session Layer</td><td rowspan="2">Open Transport Protocol
(OTP)</td></tr>
<tr><td>Transport Layer</td></tr>
<tr><td rowspan="2">Network Layer</td><td>Upper Network Layer</td></tr>
<tr><td>Lower Network Layer</td></tr>
<tr><td>Data Link Layer
(MAC)</td><td rowspan="2">Open Wireless Architecture
(OWA)</td></tr>
<tr><td>Physical Layer</td></tr>
</table>

As we know that wireless network protocols defined by the physical layer i.e. OSI layer – 1 and Data link layer (Medium Access Control – MAC) i.e. OSI layer – 2. Based on these two layers, the 5G network would be defined by Open Wireless Architecture (OWA).

The network layer is dedicated to Internet Protocol (IP). Previously, the IPv4 was used to spread worldwide. But it was not capable to provide adequate QoS and had very limited space for the address. Later, these issues were solved in IPv6. In this, there would be a mobile IP standard and various micro-mobility solutions. The network layer would be divided into two layers: lower network layer (for each interface) and upper network layer (for mobile terminal).

The Wireless networks are differed from wired networks by the transport layer. In all Transmission Control Protocol (TCP) versions, segments are lost due to the network congestion. This is why TCP improvements are introduced by which lost TCP segments can be retransmitted to complete the devoted transmission session. 5G phones shall have the benefits to download TCP version that would be with the aim to install a particular wireless technology at the respective base station. This technique would be termed as Open Transport Protocol (OTP).

In 5G phones, there is a possibility to Quality of Service (QoS) which include the specific parameters like delay, losses, jitter, bandwidth etc. Theses QoS parameters would be stored in 5G phones and run in background by particular algorithms as phone system is processed. Hence best wireless network can be connected based on QoS parameter and cost [3] [4].

4. CHALLENGES IN MIGRATION TO 4G

1) Multimode User Terminals

There would be an additional requirement of designing single user terminal to operate in various wireless networks. Design parameters should be considered with the facts about size boundary, cost, and consumption of power.

2) Selection

The selection of appropriate technology to provide service at specific time and location is a difficult task for a heterogeneous system of the wireless network. The best selection can be made based on QoS.

3) Security

Security is a big challenge in today's wireless network. Many solutions like adaptive and dynamic re-configurability are introduced to overcome the insecurity issue.

4) Network Infrastructure

There is a big challenge to integrate the IP based and non-IP based systems and maintaining the QoS for peer-to-peer services.

5) Billing

It is a difficult task to manage the customer's account information from multiple service providers.

6) Data Encryption

Data encryption is much required to avoid the breaking of the communication link.

7) Jamming

If there is matching among sent signals, then the jamming problem occurs.

8) Spoofing

Spoofing is effectively falsifying a piece of identifying information.

5. 5G ENABLING TECHNOLOGY

In this section, important technologies for 5G have been discussed in brief [5].

1) Multiple Radio Access Technologies (mRATs)

Basically, the 5G network consists of multiple RATs to increase the network capacity of thousand times as compared to 4G. The improved version of WLAN and Wi-Fi are the key technologies of this mRATs to boost the coverage area.

2) Small Cell Deployment (SCD)

The 5G small cells network consists of micro-cells, pico-cells or femto-cells those are termed as Heterogeneous Network (HetNet).This HetNet may be designed by similar technologies (Multi-Tier HetNet) or of various other technologies (Multi-RAT HetNet).

3) Self Organizing Network (SON)

The Self Organising Network (SON) is the basic building block to design a highly dense SCD. Further, it improves the small cell's capability to be in synchronization in the network and setting the radio coverage. Overall, Inter Cell Interference (ICI) can be minimized.

4) Machine Type Communication (MTC)

The Machine Type Communication (MTC) is defined by the total data generation, exchange, processing, and actuation among intelligent machines with or without the intervention of users. It needs quite low latency and remote controlling of mobile devices.

5) Millimetre Wave Technology (MWT)

The band from 30 to 300 GHz has been considered for Millimetre Wave Technology (MWT) applications. In this band, omni-directional path loss is increased that can be adjusted through proper beam-forming schemes.

6) Cognitive Radio (CR)

This is defined as a radio that can adjust its all transmission parameters based on environment specification in which it operates. Overall, it works as a technology enabler to increase the use of licensed frequency band in an efficient manner.

6. 5G DESIGN OBJECTIVE

The various improvements have been discussed during the development from 1G to 4G till now. Additionally, there would be few challenges to be solved to excite the users for 5G networks. Therefore, a big change is required for designing 5G network architecture. In the present scenario, during the communication between inside user and outside base station, EM waves will travel through the walls of indoors resulting very high penetration loss and reduced spectral efficiency.

To solve this problem, a design technique is used to separate inside and outside set-ups for 5G network architecture. The penetration loss has been decreased at justifying scale. This technique can be reinforced with the concept of massive MIMO system. Actually, massive MIMO system is made with an installed dispersed antenna array of approximate hundreds of antenna units.

A large massive MIMO system can be designed by deploying the large antenna arrays at outside base stations. A few numbers of antennas of this array are scattered around the hexagonal cell and connected to the base station through an optical fiber. Some of the antenna units are designed with large virtual antenna arrays for the outside users associated with antenna arrays of base station form virtual massive MIMO system [6].

To make the communication by the help of a line of sight concept, between every building and outdoor base station, large antenna arrays are deployed at outside of the building. For indoor users, a communication is established of large antenna arrays with wireless access points through cables. In this connection, while large antenna arrays remained deployed at outside area of the building, there is the only requirement of a connection between inside users and inside wireless access points. By this, there would be a substantial improvement in energy efficiency, data rate, spectral efficiency and cell throughput of the mobile network system.

In such architecture, indoor users would be in communication with indoor wireless access points but outside area of the building would have large antenna arrays. A few wireless technologies such as Wi-Fi, ultra wide-band, millimetre wave communication and visible light communication are beneficial for indoor wireless communication with high data rates. However, these two technologies – millimetre wave technology and visible light communication need higher frequency which is not feasible for existing mobile communication system. Since, in outdoor communication with high frequency would be affected to travel through dense obstacles like rain droplets, gases or trees. Although, these millimetre wave technology and visible light communication techniques are useful in the indoor wireless network to increase data rate as they have high bandwidth.

To solve the problem of spectrum lacking, an idea has been developed to increase the use of recent radio spectrum by Cognitive Radio (CR) networks [7]. The 5G mobile network is consisting of small mobile cell as an integral part and remaining part is considered of mobile relay. Since it has been a challenge to connect the user with high mobility inside the high-speed car. Therefore, such car is designed to containing mobile small cell to communicate the user sitting in the car. The outside mobile base station is connected with massive MIMO unit made of large antenna arrays fixed at outside area of the car. There would be high data rate of data services of mobile small cell users with decreased overhead signaling.

Broadly, there are two layers of 5G network architecture – Radio Network (RN) contributing for minimal functions of L1 & L2 and Network Cloud (NC) that supports functions of the totally higher layer. The NC provides further two features Software Defined Networking (SDN) and Network Functions Virtualization (NFV) for effective setup and function mapping. The Lean Protocol Stack (LPS) is established by abolishing the redundant working and combination of AS and NAS. In RN, individual arrangements are set for coverage and capacity in terms of bandwidth through rupture architecture of Control Plane and User Plane (C/U planes) [8]. The network cloud is designed to get different objectives. The occurrences of U Plane Entity (UPE) and C Plane Entity (CPE) are existed near to base station and Remote Radio Unit (RRU) to solve the latency critical services.

This network architecture provides a solution for fast processing and flexible arrangement. By the concept of such network, base station working becomes easier and decreased functionalities make it to less energy consuming.

In 5G networks, spectrum availability is the key objective of to maintain the massive mobile congestion. To make the today's mobile communication more efficient, it has been needed to pick the higher frequency of operation and using broad frequency bands with few suitable techniques for sharing of spectrums. There would be a requirement to maintain the multiple instances of various parameterized network functions. Basically, the explicit parameterization is based communication link design and dedicated topology. However, the current mobile market shows that 5G networks should be designed to implement the competent transmission and data processing. The Mobile Edge Computing (MEC) has been considered as a vital role to achieve a number of decisive requirements.

To fulfill these requirements, new epitomes like Software Defined Networks (SDN) and Network Functions Virtualization (NFV) are needed to be implemented [9]. There would be additional requirement to separate the users and control planes i.e. maintain the boundary between the network domains. However, to increase the flexibility of future networks is a most important objective of 5G networks. The other factors like various interfaces, security, edge, access, services have to be precisely evaluated. The very crucial factor is the variance of different air interface has to be maintained in an efficient way [10].

Furthermore, 5G networks must be capable to provide the networking between 5G and Long Term Evolution (LTE). When massive MIMO systems are considered, there would be a concern of complexity of latest communication paradigms and various antennas with individual beam forming patterns. In urban areas, 5G peak downlink frequency is targeted to get 10 Gbps to satisfy the QoS [11].

Multi-connectivity is a principal technology to get the features of 5G networks like data rate, latency, reliability, and availability. The network controlled Device-to-Device (D2D) communication including peer-to-peer, multi-cast and broadcast communication must be supported by 5G networks [12]. The tremendous beneficial technique of virtualization of communication infrastructure must be used to avoid the vast investment in deploying hardware.

According to the current scenario, it is much required that prime challenges still existing in Long Term Evolution Advanced (LTE-A) networks which are higher data rate, increased capacity, massive device connectivity, low peer to peer latency, reduced capital & operations cost and consistent QoE [13].

In future, mobile networks are required to be supported by thousand times of existing traffic and hundred times of available data rates. Indirectly, it demands to be increased Radio Access Networks (RAN) with higher spectrum efficiency. Such circumstances introduce the use of Millimetre Wave Technology (MWT) [14]. The benefit of using high frequency is supporting the massive MIMO system with antenna arrays of fewer form factors. This allows the system capacity to improve by ten times.

On the other hand, this system with high frequency faces the problem of path attenuation and is constrained to Line of Sight (LOS). If there is an effort to make communication without LOS, then the range would be very less. Higher rank modulation (QAM) and coding schemes can be used to make better spectral efficiency and added with massive MIMO system to get the system capacity more [15].

Network densification is termed for dense deployment of various small cells which use the high frequencies. In such system of high frequency, that reduces the attenuation but raises the challenge to alleviate the interference between small cells of this dense system. To making the system with excellent capacity at a particular location, it would be required to refer the coverage and capacity individually. It can be made by the split architecture of Control (C) and User (U) data planes in which macro cells facilitates the coverage (C+U) and small cells would be having the capacity of (U).

To improve the overall throughput, massive MIMO and MCS technology can be used in small cells. However, massive MIMO has an issue of communication failure by narrow beam-forming.

7. CONCLUSION

In this paper, important challenges for 5G networks have been discussed which counts the higher data rate, higher capacity, decreased installation & operation cost, better energy efficiency & spectral efficiency and consistent QoS. The 5G network architecture combines various enablers like small cells, massive MIMO, C/U plane shift, SDN, NFV and peer-to-peer communication.

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