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5G: Challenges & Research

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Abstract –*By 2020 the future mobile technology 5G is expected to be operational with some prime objectives such as increased capacity, improved data rate, lower latency, and better quality of service.To fulfil these demands, drastic and major improvements need to be made in cellular network architecture and the technology.It is important to understand the direction of research and developments which will be helpful in enabling 5G technology. This paper throws light on the challenges toward5G provides few such developments such as network architecture, massive multiple input multiple output (MIMO) technology, and device-to-device (D2D) communication,millimetre wave solutions, cloud technologies for 5G radio access networks and software defined networks.*

Keywords- 5G, D2D, MIMO, mm – wave, SDN, Cloud, C-RAN.

I-INTRODUCTION

We have seen the continuous and rapid growth in the evolution of the cellular network generations from 1G to 4G.It is expected that this digital world will have more than 50 billion connected devices by the end of the year 2020 [1], which would tremendously increase data traffic.Also there is tremendous demand forbetter quality of experience (QoE) and for high datarate.This encourages the development of future generation 5G mobile communication networks.

5G must address six challenges, not effectively addressed by earlier generation of mobile (4G) namely Ubiquitous connectivity, high capacity, high data rate, low End to End latency, connectivity support for massive device, reduced cost and consistent and better Quality of Experience provisioning [2],[3]. A few more expected features of 5G networks compared to the fourth generation (4G) networks, are as below [4, 5, 6]: (i) 10-100 times morenumber of connected devices, (ii) 1000 timeshigher volume of mobile data per area, (iii) 10-100 *times* higherdata rate, (iv) latency of 1 millisecond (v) 99.99% availability, (vi) 100% coverage, (vii) *1*/10 energy consumption thanthe year 2010, (viii) real-time information processing and transmission, (ix) *5 times less* network management operation expenses, and(x) seamless integration of the current wireless technologies. In this paper, the key challenges encountered by future 5G wireless communication along with some technological directions that can be considered to fulfil these challenges are discussed.

CHALLENGES IN MIGRATION FROM 4G [7]

A. User terminals with multi mode

There is a need to design a mobile terminal that can operate in different wireless networks andovercome the design issues such as size of the device, its cost and power utilization.

B. Selection of appropriate wireless systems.

Every wireless system has itsown distinctive characteristics andspecificroles. Selecting appropriate technology for a specificservice at right place & right time for better QoS (Quality of Service) requirements.

C. Security

Protectionmechanisms for the data &content should be adaptive, easy to maintain & configure and lightweight. Also protection from jamming &snooping is necessary with the increase in mobile devices and cyber crime rate. Encryption must be strong.

D. Network infrastructure

Integration of non-IP and IP-based systems and providing betterQoS assurance .

E. Billing

Handling and storing consumer account information for proper billing is an important and difficult task.

F. Attacks on Application Level

Every now and then Software applications which offer an new feature are been targeted and commence new bugs.

DEVELOPMENTS TOWARD 5G TECHNOLOGIES

Many technologies and schemes, such as modulationtechniques, radio access techniques, or distributed computing, could be reused in 5G. With few alterations in some old technologies together withmany other newly developed and evolved solutions will help to fulfill the goals and overcome the challenges of future 5G communication network.

4.1. Millimeter wave communication& MIMO

Radio waves enables to cellular network communication. 5G use new spectrum above 6GHz so as to achieve very high data rates, low latency, energy efficiency, ultra-high reliability[8].There is a substantial amount of spectrum available at very high frequencies, but the engineering challenges are also intense as this spectrum is vulnerable to shadowing effect.If line-of-sight link between the access point and the user device is not there, then the connectivity becomes zero – unless you have a reflection off a very flat wall nearby.

The current cellular licensed carrieris from the 750 MHz to 2600 MHz this spectrum is saturated now. Hence, the design of the under-utilized physical layers of the mm-wave spectrum is required. In addition, massive MIMO, beam forming, traffic offloading on to unlicensed spectra and cloudification of radio resources will provide faster data transfer and guaranteed availability.[9].

MIMO is a scalable technology i.e. any number of BS antenna's can be employed. Massive MIMO can have arrays with dozens or 100 antennas. Simultaneouslylarge number of users are served. It gives high spectral efficiency, high reliability and high energy efficiency. Directivity of massive MIMO helps to reduce mm- wave attenuation, multipath and multiuser interface. In turn mm waves helps toreduces the size of antenna array for MIMO. Due to size and weight they would be more likely, on the side of a building than on a cell tower.

4.2. Modulation technique better than OFDM

Spectral efficiency depends mainly on the multiple accesstechnique and modulation scheme used. Orthogonal frequencydivision multiplexing (OFDM) and orthogonal frequencydivision multiple access (OFDMA) are used as the modulationscheme and multiple access strategy in LTE-Advanced (4G). OFDM'sapplicability on wide band mm-wave with the requiredhardware setup is not certain. FBMC is robust to intrinsic asynchronicitybetween a transmitter and a receiver. The currently four waveforms, for 5G provide an efficient air-interface that is no longer dependent on stringent like orthogonality and synchronization requirements are GFDM,UFMC, FBMC, and BFDM.

4.3. Architecture

The 5G wireless cellular network architecture consists of two logical layers: a radio network and a network cloud. Radio network consist of different types

of components which perform different functions ..5G is expected to have a well-connected core network and RAN. The backbone network may shift from optic fiber to mm-wave wireless connectivity, and the interconnected base stations. 5G should have an increase in the capacity of RAN, and should also an evolved core network, which is scalable, intelligent, easy to install and maintain, and low in cost. Recent development in cloud-based networking has opened new horizon of possibilities for virtualized core networks.[9]Hence a totally new application of cloud services, namely RAN deployment is the important element of 5G communication network which has sustainability and energy efficiency.

The main concept of thecloud-based RAN is to keep the RAN capacity in a centralized server and making it available on demandto the customer. In short,Cloud-RAN implement radio access network function in software and deploy them in the cloud.To achieve this, the base stations needs to be segregated into two parts, a radio access unit and baseband unit. There is a need to create a reserve pool of thebaseband unit which will satisfy any cell that experiences high traffic. To reduce energy consumption, low power small cells should be deployedand the reserved capacity is made available to the cell that needs it in case ofa sudden surge intraffic. The computational power requirementand energy efficiency will be further optimized with the availability of new cloud computing platforms and the development in data-centerservers. Not only the RAN but also the core and backbone network may be virtualized

Along with C-RAN , two more concepts are thought to be part of 5G communication network development and they are SDN (Software Define Network) and NFV (Network Function Virtualization) SDNSeparates the network's control plane and forwarding planes and provides a centralized view of the distributed network so as to achieve more efficient orchestration and automation of network services. But this intelligence centralization technique has few drawbacks in terms of security, scalability and elasticity and these are the main issue of SDN which needs to be considered. Whereas,NFV has more focus on optimizing the network services.It decouples the network functions, such as DNS, router, firewall, caching, etc., from usual hardware appliances, so that these functions can run in software. These software packages can be then deployed and connected to cloud and accelerate the service innovation and provisioning, particularly within service provider environments.The network function virtualization (NFV) cloud consists of a User plane entity (UPE) and a Control plane entity (CPE) that perform functionalities those related to the User and Control plane, respectively.

4.4. Energy efficiency

Energy consumption is one of the major concernin the deployment of new networks in large scale. Currently, more than 0.5% of the world's total energy isbeen consumed by the mobile networks. Therefore, one of the major aspects of 5G development is reduction in energy requirements for the environmental needs and also from the network maintenance perspective.

Tombaz and Sung [10] had made it clear that a networkwhich is dense due to reduction in the size of cell has unavoidable network energy requirements. As the network will have a greater number ofsmaller cells, the major energy consumption component will be the idling and backhauling power. A 5G communication network framework with software defined MAC and network functional virtualization can be deployed. By integrating these solutions, a low latency and energy efficient5G network can be deployed. In their research, they agreed that the logical separation of the control and data planes is a potential solution toward an energy efficient and flexible 5Garchitecture.

4.5. Protocol stack

Table 1: 5G Protocol stack [11]

Application Layer	Application (Services)
Presentation Layer	
Session Layer	Open Transport Protocol (OTP)
Transport Layer	
Network Layer	Upper network layer
	Lower network Layer
Data Link Layer	Open Wireless Architecture (OWA)
Physical Layer	

Any communication system toperforms well needs basis of a layered protocol stack. Gohil et al. [11],presented the general protocol stack for 5G end-toend mobile communication.The stack has provision for compatibility with other open source protocols. The physical layer & data link layer are combined and called as Open Wireless Architecture. While the Session and Transport layers are combined to the Open Transport protocol (OTP), which canbe downloaded by any user equipment when required. Userequipment may be connected to more than one base station (infact, base stations may belong to different networks).The Network layer is divided into two where the Upper Network layer is for mobile terminal and the Lower Network Layer is for each interface. Also the Application and Presentation layer are included in one single Application Layer.

4.6. *D2D Communication*proximity services

Peer to Peer or direct device to device communication (D2D) eliminates IP based or Base station oriented connectivity.For increasing the cell capacity and for offering various proximity services D2D connectivity is essential in any cellular system. 3GPP itself has standardized LTE-Direct (LTE-D) which allows the discoveryof "always-on" devices in a proximity of 500 m in an energy efficient and secured manner by using a licensed spectrum. Wi-Fi or Bluetooth technologiesare the P2P proximity communication protocols which are widely used, but the energy consumption is an issue for them.

D2D communication in mm-wave is needed for 5G to reduce the traffic burden. Mm-wave D2D communication was presented in [12] where capable mobile devices wereequippedwith electronically steerable antennae and beam-forming technology. By virtue of highly directive antennae and beam formingtechnology, concurrent transmission among D2D users and the base station will not create much interference.

An overview of challenges, facilitators, and corresponding designfundamentals for 5G is shown below

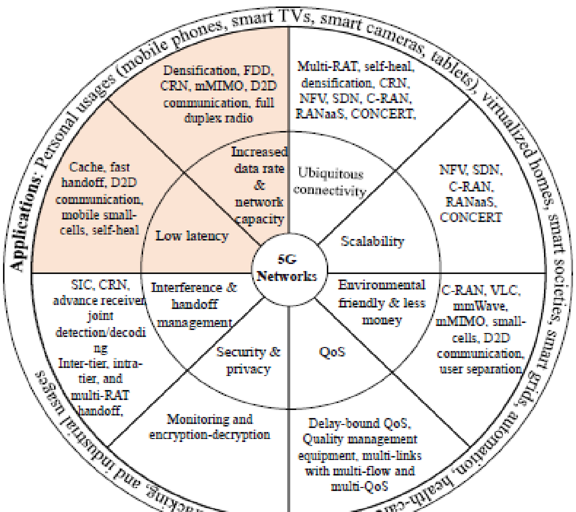

Figure 1: Requirements and proposed solutions for the development of 5G networks [13].

From the above figure we can see that the inner, middle, and outermost layers present requirements, solutions, and applications of 5G networks, respectively. Primaryfeatures of 5G networksis highlighted with two colored wedges [8].

CONCLUSION

This paper surveyed future5G technology formobile communication. The salient features (high speed, data transfer and ubiquitousconnectivity, reliability), requirements, applications, and challenges involved in the development of 5G cellular mobile communication are discussed. 5G network technology willstart a novel age in mobile communication. Device-to-Device (D2D) communication, and cloud-based radio access networks are been discussed. Along with the development of new architectures, other issues like interference , handoff management, QoS guarantee, channelaccessing, and load balancing also needs to be focused on .

The design of 5G infrastructure is still under progress. The mostprominent issues are enlisted below, which if resolved would contribute in early deployment and long run growth of 5G networks.

1. Huge number of deviceswill demand for better encryption, security and privacy of devices, infrastructures, communication, and data transfer.
2.The algorithms must be self-healing, self-configuring, andself-optimizing to preform dynamic operations such as dynamic load balancing, QoS guarantee,traffic management, and pooling of residual resources.
3. With C-RANs virtualization, backhaul data transfer, inter-cloud communication, ubiquitous service guarantee, security and real-time performance guarantee with zero-latency are big question
4. The design, development, and usage of user devices, service-application models, and, especially, the network devices mustbe affordable to cater the needs of overwhelming users, service providers, and network providers.

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