The next Wireless Generation 5G: Technologies and Applications

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Abstract—In this paper various aspects of 5G communication has been discussed. With the ever increasing demand in the data rate and the increase in population, the number of cell phone users are increasing at an exponential rate. The current communication network may not suffice the burgeoning users and limited spectra available, improvements need to be made. Hence we need 5G which would overcome the drawbacks of previous generation’s network. Here an extensive literature survey of 5G network is presented with prime focus on mm Wave based solution for 5G networks, Massive MIMO, Cloud Ran, and IoT using 5G.

Keywords—Massive MIMO, Cloud RAN, mmWave, IoT, 5G

I. INTRODUCTION

With the limited availability of spectrum and outburst in the mobile users, the current mobile technology may not be able to deal the traffic. Hence a new and more advance technology is needed that is 5G. It is IP based architecture which will create a wireless world where everything is connected together and share their data at seamless speed without any delay. The key features of 5G communication are, it can accommodate large traffic and gives speed up to 1Gbps using high bandwidth. It has high spectral and energy efficiency with reduced latency and diminished cells. [1]IoT will be deployed very easily with the commencement of 5G communications. The application area is huge such as connecting mobile with PC to enjoy high speed data and video access, video calls, device to device communication, internet machine control, virtual reality etc. Unlike 2G, 3G and 4G, it is unlikely that 5G will be a single new Radio Access Technology (RAT) nor will it replace macro cells. It will be a combination of existing RATs in both licensed and unlicensed bands, plus one or more novel RATs optimized for specific deployments, scenarios and use cases. In particular, Nokia has identified the need for a new RAT for ultra-dense deployment. [2]

As the capacity is increased more spectrum is need for better coverage. Hence efficient frequency reuse planning needs to be done in order to get highest efficiency. The key technologies includes device to device communication, extension to higher frequency band and multi antenna transmission.[2] This paper is divided into the following section first a brief introduction about different communication technologies since inception. We later talk about the need of 5G, then we discuss about the technologies that could possibly be used to deploy 5G networks. Then we conclude this paper.

II. OVERVIEW

Let us now look at the communication technologies since inception. In the earlier days the sign languages were used to communicate. In our leisure time we use electronics gadgets which uses a variety of modern communication system. The calls we make to the loved ones, the internet we use on, cell phones to stay connected, the TV we use for entertainment. Here, let’s understand in brief about the historical changes that led to the present day communication system. In Stone Age, first sign language was the mode of communication. Then came pigeons who delivered messages. Then Samuel Poise developed electric telegraph which he demonstrated in 1837. Telephone came in the year 1870 after 33 years which provided services over few miles. [3] Several advancement were seen in telephone. In 1894, coherer was invented by Oliver Lodge which could detect the presence of radio signals used to demonstrate wireless communication. Since then, the development has been phenomenal. They include voice calls, video transmission and data. [3] The first generation of wireless communication system was developed in the USA. Let’s understand this.

1G - This was analog in nature. It was the first commercialized in the USA and introduced in the year 1980. The major technology subscribers were AMPS (Advanced Mobile Phone System), TACS (Total Access Communication System) and NMT(Nordic Mobile Telephone). It uses FDMA(Frequency Division Multiple Access) as the addressing system with circuit switching type with speedup to 2.4 kbps. It scappled voice only feature. The operating frequencies is 800 MHzIt has drawbacks too, the capacity is less, it has security issues and interference in the background. [4],[5]

2G - The major difference between 1G and 2G is the latter uses digital signals, while former used analog radio signals. It was founded in the year 1993. It used CDMA(Code Division Multiple Access)& TDMA (Time Division Multiple Access) systems It is used for both voice and data. GSM (Global Systems for Mobile Communications) was the system for 2nd generation mobile. Other technologies include IS-95. The operating frequency for GSM is 900 MHz, 1800 MHz and for CDMA is 800 MHz[4],[6]

2.5G - It has better data rates. It stands for 2nd and a half generation of mobile communication. It has GPRS merged. The data rate can go up to 144 kbps. It has other technologies like EDGE and use CDMA as access system.[4]

3G - The 3G was established in the year 2001. It has data rate of 3.1 mbps. Hence the speed is like digital broadband. This made mobile internet possible. The QoS(Quality of Service) of voice calls were upgraded. Some technologies
used in this are IMT 2000 where IMT stands for International Mobile Telecommunications, WCDMA. It required more power than 2G and the data plans are more expensive due to high cost of spectrum license. The operating frequency is 2100 MHz. With the advent of 3G, the security was improved and gave rise to international roaming. Video conferencing became possible because of this. [4]

3.5G - It has the technologies such as (HSUPA/ HSDPA) high speed uplink/downlink packet Access and EVDO which stands for Evolution Data Optimized. The data rate is improved with speed up to 5 Mbps. [7]

4G - It is the current generation which has been recently launched in India and already launched in many countries. It is also known as LTE (Long Term Evolution). It uses packet switching. The speed is high as broadband that we can download 1 GB movies in few minutes. It is a IP based network. Hence it becomes easier for video chat, HD movie TV. The drawback is the hardware is complicated and hard to implement. It uses CDMA system and the operating frequency is 800 MHz, 1800 MHz and 2600 MHz[4],[7]

III. MILLIMETRE WAVE COMMUNICATION

As the BW is getting scarce and the need is increasing, the different solution has to be found. It is found that, there is huge BW available in the mmWave band. The BW is from 30 GHz to 300 GHz and this is said to be an crucial part of 5G communication.[8] This will provide high data rates and can accommodate large number of users. This has high carrier frequency and hence it suffers propagation loss. Hence this is mainly preferred for indoor communications. It has small wavelength hence it is inherently directional.

![Image of mmWave spectrum for 5G](image)

Fig. 1. The proposed mmWave spectrum for 5G

Hence smaller antennas can be created it will have highly directional beam forming antennas. This mmWave will help the network to switch from copper wire/ optical fibre cable to mm wireless connection which will help in rapid deployment. The operators those days reduces the cell size to exploit spatial reuse and implement new architectures but with the advent of mmWave, the cost of per base stations would drop. [9] Currently 28 GHz and 38GHz bands are available with a bandwidth of over 1GHz. [8]It is said that the mmWave antennas will face propagation losses due to rain and atmosphere absorption. But as we know the cell sizes are decreasing, the atmosphere absorption does not create significant path loss so on 28GHz and 38GHz bands. Moreover due to lower wavelength, It is possible to get away of hundreds of smaller antennas placed which will overcome attenuation due to rain. In overpopulated cities understanding of radio channel is a must. We ever need to analyse the penetration percentage in outdoor and indoor environment. Outage studies conduct in paper [9] at 28GHz and 38GHz showed consistent coverage can be achieved by having BS (Base Station) with cell radius of 200m.Path loss is larger in urban environment and hence penetration loss is more for outdoors. Since the propagation of signals from outdoor environment to indoor is less easy, we need repeaters and access points for full functions of mm Wave and to allow hand off.[9]

IV. MASSIVE MIMO

MIMO stands for Multiple Input Multiple Output. How to maximize the capacity without maximizing the spectrum use? Massive MIMO uses large number of antennas and serves many terminus in the same time frequency resource[7]. It can improve the capacity 10 times and the energy efficiency by 100 times. The number of users in indoor are more than outdoor users. So when the user is accessing the network from indoors that is need to communicate with outside propagation loss occur with decrease data ratio and spectral efficiency as the penetration through walls occur. To overcome this we use the massive MIMO architecture. In this it will have distinct antennas away outdoors as well as indoor. Present MIMO systems use of 3 or 4 antennas but the 5G networks. Massive MIMO will use thousands of antennas away. These array will be placed in dispersed geographical locations and will communicate with each other through Access point. They will give huge capacity increment which will help accommodate the large numbers of users. We need to understand how we will form the architecture.[10] Small cells are one more option as they are energy efficient, the propagation losses are drastically reduced and it provides high data rate. Using more number of antennas creates more degree of freedom which helps in increasing SNR (Signal to Noise Ratio). It can concentrate the energy of all antennas to a smaller area. [7]

![Image of Massive MIMO](image)

Fig. 2. Massive MIMO

Let’s understand the architecture of Massive MIMO, the outside BU will be equipped with antenna arrays and some antenna arrays will be situated at other places of a hexagonal cell which would be linked to the BU using optical fibre cables. λ/2 spacing is mandatory for almost no correlation between antenna and the gain of the system will be better. For outside users, certain antenna are fixed. But for building the antennas arrays are placed and they communicate with BU (Base Unit) arrays using LOS(Line of Sight). The outside antennas will communicate with Access points placed inside the buildings which are connected using optical fibre so the users inside will just communicate with Access Point. [11] Massive MIMO is an emerging field and there are many issues which need to be addressed. Among these are interference mitigation and
management, resource allocation. The amount of feedback information for coordinates. Implementation and energy consumption issue, scalability and coordination between access ports strategies [12]

V. C-RAN (Centralised RAN)

It stands for centralised RAN or cloud RAN which uses cloud computing technique. It is said that the new architecture should support existing network also and 5G network also. Hence more heterogeneous architecture is needed for seamless experience. This process is cost effective as it cuts down the use of upgrading architecture. We know that the 5G will be IP based and the speed of downlink would be 1-10 Gbps. So, the need would be to bring up more infrastructure. RU (Radio Unit) consists of antenna & RF circuits & digital units.

In distributed RAN the interface between the core networks is located at radio site. [13] In centralised RAN, all baseband proxy is located at a central location that serves multiple distributed radio sites. The transmission link between BBU (base band unit) & RU uses CPRI frontal over dedicated fibre or microwave links. [13] The Remote Radio unit communicate with the centralized baseband using advance signal processing technologies.

VI. INTERNET OF THINGS

Here people could transfer data without human intervention. With the commencement of 5G, the device to device communication could be possible. The augment reality would be the next big thing. With that high data rate and continuous connection machine could communicate with each other. The appliances in our homes would become ‘smart’ and do their work intelligently. The cars could communicate with each other leading to lesser road accidents. With high speed bullet trains sending seamless data to the control room could be reality. Every device will have an IP and all devices could communicate provided 5G seamless connectivity. In machine 2 machine communication which involves sensors, huge connection are required which possible 4G cannot handle. 5G will meet real time communication which is reliable and can connect many devices at a time. This will lead to advancement in IoT such as wearable devices, smart houses, smart grids, Traffic management system etc. This will also open gates for device to device communication such as in intelligent cars and home automation.

VII. CONCLUSION

In this paper a detailed literature survey has been done about the requirements of 5G, the go green incentive, the ubiquitous wireless connectivity, higher data rates, IP based connectivity, use of powerful cloud computing resources, decreased latency, low cost equipments, together shape the vision of 5G, All the benefits and advancement in applications make us more than happy to shift to new wireless technology, the 5G. To meet all the demands the 5G will need to have many face problems and challenges. It is fascinating to know how massive MIMO can be implemented in mm Wave frequency band using CRAN technology to shape the coming wireless generation which provides promising improvements in QoS. Currently research is going on and in many parts of the world along with the testing of 5G. It is said it will be deployed by 2020.

VIII. REFERENCES


[8] Professor Robert W. Heath Jr., The University of Texas at Austin, “MillimeterWave for 5G Features and Implications”


