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An Overview of Generation Enhancement in Wireless Communication Systems

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Abstract:
Enhancement in wireless and mobile communication has a remarkable history of generation advancement adopted by more than four billion people today. In the near future, wireless data traffic will be increased exponentially, and the present wireless cellular network system is not capable to match technically this increasing trend. In this paper, generation with technical advancement is portrait as wireless technology progress from "Connected things" to "connected intelligence". Wireless communication system commence with first generation as voice calls unlock system. Progression of wireless communication system is prolonged with second generation and third generation by introducing new concept of digital modulation. Presently 4G offers new services as "anytime anywhere". With the increasing demand, drastic improvement is needed in the current technology. The prime objective of next generation (5G) to match dense traffic requirement is increased capacity, fast data rate transmission, smaller latency which will be launched very early. 5G will not be capable to fulfill the increasing user demands and artificial intelligence requirement of society till 2030, the new paradigm as sixth generation in wireless communication system is expected to commercialize the market in 2030. In this paper, the future vision of 6G technologies and roadmap to achieve 6G is portrait.

Keywords: 4G, 5G, 6G, Artificial intelligence, Ultra massive MIMO.

I. INTRODUCTION

Advancement in the wireless communication industry is growing in a fast rate with the features advancement from the number of decades. Presently 4G long term Evolution (LTE) is reaching to saturation and deploying day by day. As the improvement can be expected to be a minimal and new spectrum of small value is unused. For the present scenario, Scientists and researchers must contemplate as "what to do next"? [1]Due to increase in the wireless data traffic due to the regular usage of video and increasing number of subscriber per year, the wireless communication industry moved to 5G cellular technology [2].

The 5G technology is based onto the use of mm wave where frequency spectrum is subjugated above 6 GHz of frequency. 5G offers great flexibility which supports multitude of internet protocol based devices, smaller frequency reuse cell structure and intense region for coverage of subscribers. 5G expansion provides application advancement as device to device communication, tactile internet, device to infrastructure communication, machine to vehicle communication and their application requires tremendously lower network latency and lower energy consumption, low cost and immense number of devices for data communication as shown in figure 1.

As shown in figure 1, 5G is capable in working different environment and traffic data rate must be as

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10000x more traffic along with 10x high speed to each and every individual user. Network latency will be decreased with lower value as 1ms and efficiency in energy will be increased by 90% as compared with 2010.The advancement requirement from 5G in terms of performance is to provide high data rate as 10x Gigabits (Gbps) peak data rate so that offering services will be extended in a wider range by using sensor network which will provide Vehicle-to-vehicle (V2V), Mobile-to-mobile (M2M), Vehicle-to-Mobile (V2M) communication using satellite coverage. 5G is unlicensed band, must be available at very small cost and the system should be highly consistent. Also 5G should offer 10x better battery lifetime and the wider coverage for all subscribers. 5G should support 100x numbers of devices which increases indoor and outdoor communication. The data transmission delay in 5G is reduced to less than 1ms. 5G should offer the similar speed to the indoor and outdoor users, V2V, M2M and V2M communication. [3] While 5G is at the first stage of implementation, to manage the advancement trend and the increasing subscriber demand in the competition world of wireless communication system, it's the time for scientist, industrialist and academics to think about the next generation as 6G and its performance requirement needed for success. [4]

In preceding years, researches have been done from various countries and described roadmap and its architecture reaching towards 6G. For example, European Union started a research project of 3years onto the basic technologies of 6G.

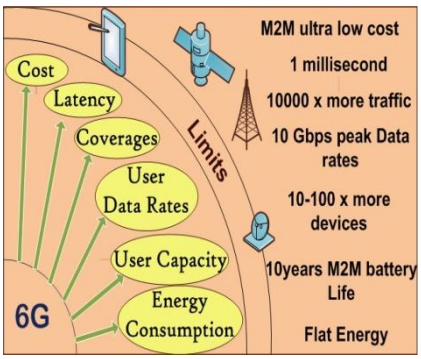

Figure 1: Performance requirements of 5G

The main objective of the research project is to study forward error correction code which can be used for next generation, the channel coding advancement methods and newer channel modulation techniques for terabits wireless network. China also started its research in 6G in 2017 for meeting increasing demand of communication as smart city development in the upcoming years. China research is focused on Medical Image, augmented reality and sensing.

"6 Genesis" project of 8 years for research and development is also launched by Academy of Finland and University of Oulu and Nokia in April 2018. [5] Based on the above research speculation and past wireless communication commercialization familiarity, the researchers may start 6G commercialization with 10 years as till 2030. With the advancement as smart city, the wireless connectivity requirement will be unlimited and as a result, the expectation from 6G is advancement in technologies which will enhance the wireless connectivity performance. The basic performance requirement from 6G as wider coverage area, ultra low latency for communicating larger number of devices, disaster management prediction intelligently, surreal virtual reality (VR). So the future vision of 6G as to provide higher frequency spectrum to obtain 100 to 1000 times faster data rate with current generation, flexible connectivity with mobile to mobile, vehicle to vehicle, machine to machine communication and latency must be less than 1ms.

II. Evolution of Wireless Technology

Wireless communication is proven to be an important part of our present day society as its growth is unprecedented and other technologies as television and radio transmission, internet usage is not capable to attract billions of users in such small duration. In 1980, the first analog communication system is introduced and after nearly 10 years, a new advancement technology is launched. In this article, we provide an overview of the advancement

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technologies in terms of growth, data rate, latency, capacity, power consumption and efficiency. [6]

1G: The First Generation

In 1980, the first generation in telecommunication was launched where the spectrum was free of cost. The cost of data transmission of the telephone was very high as that of today's mobile tariff, so below 10% of users were able to afford the services. 1G provided the data rate of 2.4Kbps and used circuit switching technology. The fundamental service offered from 1G was voice calling. Quality of voice call was good and the network coverage was moderate. 1G service providers were Advanced Mobile Phone system (AMPS) in United States, C-network in Germany to Netherland, Nordic Mobile Radio System, Total Access communication System (TACS). Nordic Mobile Radio System has provided light weighing mobile terminals. Also C-Network was a digital system and launched Subscriber Identity Module (SIM). 1G was initial phase of telecommunication so there were many drawbacks like below par capacity, inattentive handoff, and no secure communication. [6][7]

2G: The First Generation

IN 1990's, the 2nd generation of telecommunication was launched. Although some industries were existing like IS-95 in United States, Global System for Mobile Communication (GSM) and Code Division Multiple Access (CDMA) in Europe. GSM was the most dominant telecommunication system standard came in existence. GSM was first started in Europe and then captured 90% of market in the world. GSM was using digital and circuit switching technology and firstly it provided only voice calls with improved quality as per 1G. The data rate was of 64 Kbps and provided longer battery life as radio signal consumes less power. The great achievement GSM provided to the society was short messaging services (SMS) and email which increased the popularity of GSM.

The Trend of enhancement continued and General Packet Radio Service (GPRS) and Enhanced data rates for GSM evolutions (EDGE) was sprang in 2nd generation, called as 2.5G in late 1990's. 2.5G was using the same framework as 2G but introduced a new concept of packet switching along with circuit switching. 2.5G offers a data rate of 144 Kbps. Many improvement achieved in 2G like lighter weight mobile handset, clamshell and slider, mobile set with cameras. Nokia and Motorola were the leaders of market in 2G. Canada's research in motion innovated blackberry cell phones for email as well as for personal usage which was very effective for business purpose.

3G: The Third Generation

The 3rd generation was introduced in late 2000. The first technology after granting license was Universal Mobile Telecommunication System (UMTS), which introduced first cell phone in 3G. The maximum data rate offered by UMTS was 364 kbps. In 2G, GSM air interface was based on to the Time Division Multiple Access (TDMA), Frequency Division Multiple Access technology (FDMA), whereas UMTS used Code Division Multiple Access scheme (CDMA), which was presumed to provide larger bandwidth but there was not a success. The capacity of UMTS could not increase compared with 2G, GSM and service providers start operating 2G, GSM again as UMTS was not technically victorious. Also the charges of the data services was too high, the technology did not reward with the success. Up gradation in UMTS is done with achievement of new technology as High Speed Uplink Packet Access and High Speed Downlink packet Access. This latest version of 3G was reinforced with several megabits per second on uplink and several tens of megabits per second on downlink with reformed latency. High Speed Packet Access (HSPA) was available for the users for low data rates and they could ingress email and company database via wireless cellular network. [6][7]

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4G: The Fourth Generation- LTE WIMAX

4G is the fourth generation of broad band cellular network. The first release of 4G is Long Term Evolution (LTE) and WIMAX standard commercially launched in 2009 in Oslo, Norway and Sweden and since then extended to other part of the world. LTE is an improved version of WLAN used for high speed wireless communication network. LTE used the orthogonal Frequency Division Multiplexing (OFDM) Technology, which reduces the delay in the data transmission and does not support traditional circuit switching. LTE commercialized with minute data tariff increment and nullify roaming charges, not only for voice calls but also for SMS which invites enormous number of users to make use of 4G LTE technology.

LTE is making headway rapidly in advancement as it is providing high downlink speed as up to 300 Mbps and high downlink speed as up to 50 Mbps.LTE is also under development switching to newer technology from voice service to Voice over Internet Protocol (VoIP), also called as Voice over LTE (VoLTE) which will provide the use of wide band speech codes to result improvement in voice quality. The other LTE technical advancement called as LTE advanced uses Multiple Input and Multiple Output (MIMO) and massive MIMO technology which reduce latency to a minute value and provide increased data rate. Device to device (D2D) communication using LTE technology is under research. 4G applications are Multimedia Messaging Service (MMS), Digital Video Broadcasting (DVB), video conferencing, Whatsapp, High Definition Television (HD TV).

5G: The Fifth Generation-Massive MIMO, C-RAN

With exponential usage of Smartphone in video (multimedia) application, 4G should be replaced with the next advancement as 5G, so that an average user of mobile can able to download the data with speed of 1 terabyte approximately by 2020. Capacity, cell size, physical layer all reaches to its saturation limit and cannot be explained further in 4G. The key principle of 5G wireless network is analyzing system bandwidth and explores this high frequency millimeter wave band, ranging from 3 to 300 GHz used by radar for collision avoidance to obtain outrageous capacity and data rate. Unlicensed wireless spectrum started by Federal Communication Commission (FCC), US is 59-64 GHz and 81-86 GHz which is using by radars, airport communication, radio astronomy. The appropriate mmwave spectrum for communication is 57-64 GHz and 164-200 GHz only. The minute accessible mmwave spectrum can provide services to hundred of users and so, this concept open up a new horizon for improvement of future wireless network communication.

The merging consequences of mmwave spectrum access, hyper- connected vision and application oriented requirements are going to provide major advancement as 5G in wireless communication system. The primary objectives of 5G wireless communication is increased data rates, bandwidth, coverage and connectivity with tremendous reduction in latency(less than 1ms) and power consumption. Group special Mobile

Market Player	**Key Vision**
Ericssson	• Networked Society • Affordable and sustainable
Qualcomm	• Enabling Novel Services • Connecting industries and devices • Improved user experience
Huawei	• Massive capacity and connectivity • Diverse services, applications, users • Network deployment scenarios
Docomo 5G	• Extensive and enriched content • Everything connected wirelessly
Nokia	• Heterogeneous deployments

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Solution Networks	• Augmented reality and tactile Internet
Samsung Electronics	• Internet of Things(IOT) • Enhanced multimedia experience • Extensive Cloud Computing
5GPP, METIS(EU)	• Software Driven 5G • Multi-tenancy • Scalable and sustainable
5G Training	• Disruptive technology directions • Architecture and key technologies • Personal mobile internet, D2D
5G Forum	• Commercialization of 5G by 2020 • Intertwining heterogeneous networks
5GNOW	• Abandon synchronism & orthogonality • Unified frame structure concept • Universal Filtered Multi-Carrier

Table 1: Research and Industries 5G vision

Association (GSMA) is jointly researching with its collaborator and shaping 5G roadmap to commercialize 5G wireless technology which is expected to float in market by 2020.

The expected application of 5G as smart city, smart house, smart buildings, 3D videos, cloud gaming and working remote connected medical services, massive vehicle to vehicle communication, massive machine to machine communication.[9] As the 5G is going to approach market in 2020, wireless industries and research organization started working in partnership with its own vision. This is shown in table 1. [8]

6G: The Sixth Generation- Ultra Massive MIMO

5G is yet to commercialized, the projection and evolution of 6G mobile wireless communication excited a great deal of attention. Our society will have unlimited wireless data driven connectivity around 2030, so researchers initiated to provide the roadmap to proceed towards 6G. Wireless communication to obtain enhanced system performance. In distinct to preceding generations, 6G vision is to provide "connected things" to "connected intelligence". The 6G first future vision is to provide faster data rate as 100 to 1000 times faster then that of previous generation by using higher frequency spectrum then previous generations. To precise 6G wireless communication, multi-band high spread spectrum band can be used to allow data rate as hundred gigabits per second to terabits per second. The band combination can be used as 1-3

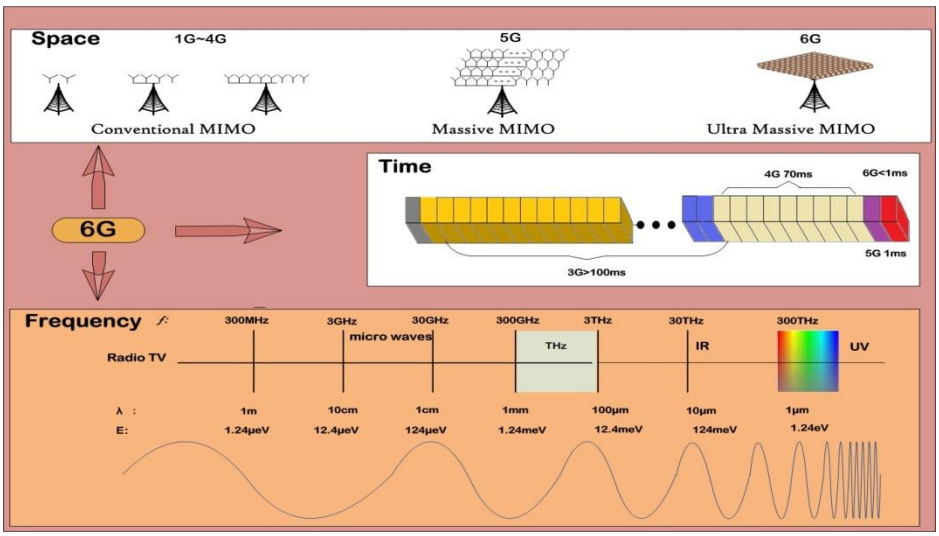

Figure 2: Time-Frequency-Space Resource utilization in 6G

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GHz band, mmwave band as 30-300 GHz and terahertz band as 0.06 – 10 THz. The 6G second future vision is capacity. 6G will be flexible enough to connect upper trillion-level objects in an efficient manner. This allow 6G network tremendously dense and network capacity may be increased from 10 to 1000 times higher than that of previous generations. The 6G third future vision is reduction in latency. Latency refers response time of human as audible response time as 100 ms, th e visual response time as 10 ms and the perceptual response time as 1ms approximately. For autonomous vehicle applications, the minimum latency time response needed is less than 1 ms for decreasing collision rates enhance safety in autonomous vehicles. While 6G is an emerging technology, the preliminary sketch is as shown in figure 2.

In order to produce enhance services for industry, virtual presence and other challenging applications, 6G will be super-flexible by using time-frequency-space resources to obtain fastest speed, larger capacity and ultra low latency, Specifically as illustrated in figure 2, the time-frequency-space resources will be utilized in 6G. In terms of frequency resource utilization, 6G is using higher frequency spectrum to achieve higher data rates and obtain fastest speed. At preliminary stage, 6G will be utilizing higher frequency bands as millimeter wave, terahertz band, visible light frequency band to obtain data transmission rate as 100Gb/sec. While the future 6G vision is to integrate mobile network with satellite system and to create space-air-ground integrated networks which will enhance the frequency limits for personal mobile communication. In terms of space resource utilization by taking multipath concept, the number of installed antenna will be increased in the transmitter and receiver side in wireless communication network which increases the capacity. This can be achieved using post Massive MIMO (PM-MIMO) technology such as Ultra-massive MIMO (UM-MIMO) for terahertz communication as shown in figure 2. In terms of time time resource utilization, 6G will provide ultralow latency.
Low latency is achieved by compressing time slot zone. Some promising technology for future 6G network is as shown in figure 2.

III. Conclusion

In this paper, review on evolution and emerging wireless communication network technology of 1G to 6G is studied.

Advancement technologies, merits and demerits, applications and future technical enhancement in terms of performance of each generation are portrait. 1G was solely circuit switching technology used only for voice and uses cost free frequency spectrum. 2G and 3G wireless technology improved the performance of 1G and provided higher data rate transmission.

Even though 3G was not very successful commercially, but extended the progress trends as 4G. 4G is victorious commercially by using latest technology as LTE and WIMAX. 1G and 2G networks was designed for voice, 3G networks for data and voice, where as 4G is framed for broadband internet experienced. While 4G has been driven by device conception and information access dynamically, 5G will operate for Internet of Equipment (IOE) applications. 5G will be using massive MIMO, C-RAN technologies to satisfy increasing demands of users. 5G provides broadcasting data at Gbps of speed.

5G uses full duplex communication and multicarrier modulation scheme. Future 6G prospective is identified in this paper which follows enhanced 5G technology as ultra massive MIMO. This paper provides the road map to reach towards the objective of 6G communication. In this paper we have also stated as how 6G is helpful to make “connected things” to “connected intelligence”.

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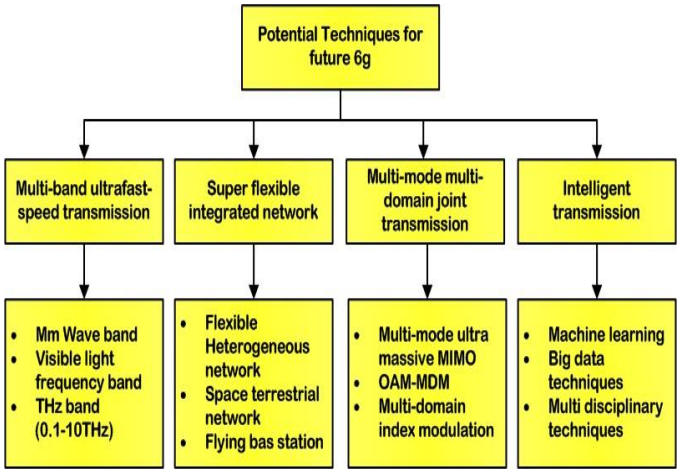

Figure 3: Future 6G Network Techniques

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