5G Next Generation Mobile Wireless Technology with Massive MIMO Continue 4G Revolution, Key Technologies and Challenges

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ABSTRACT

Mobile telecommunication system grown very fast motivating the companies to plan continuously and work from first generation until fourth generation, many companies in this field planned and started their scenarios toward fifth generation (5G) mobile, this is because of the need of higher data rate transmission and wireless system radio network, many challenges expected will be problem during this project, this paper is an attempt to contribute in this field to give more details about these challenges and then toward overcome these problems in order to give continuous working according to the time table planned which is about 2020 and beyond.

Keywords: Mobile System, 4G mobile, 5G mobile, MIMO System

1. INTRODUCTION

One of the fastest growing and most demanding communication industries is mobile telecommunications. The stages of evolution of these systems are known as “generations”, 1G system process began with the designs in the 1970s. the earliest systems were implemented based on analog technology and the basic cellular structure of mobile communications. Global system for mobile communications (GSM) was the second generation (2G) were first used in the early 1990s in Europe, GSM provides voice and limited data services, GSM uses digital modulation Gaussian Minimum Shift Keying (GMSK), in addition, adding the General Packet Radio Service (GPRS) 2G became 2.5G through which the user was able to access to the network but limited access. Universal Mobile Telecommunication System (UMTS) which is third generation mobile system (3G) has been designed with higher data rate transmission and different multiple access code division multiple access (CDMA) system, and Wide-Band CDMA (WCDMA) became 3.5G, because of the demand of more higher data rate and wide access to the internet, fourth generation (4G) starting with Long Term Evolution (LTE) and then advanced LTE has been designed which data rate indoor and outdoor rates were 1Gbps and 100 Mbps respectively. For higher data rate transmission, mobile companies and designers planned for fifth generation (5G) which expected be complemented beyond 2020. Table 1 is the major mobile evolution and standards from 1G to 5G, it is given that all different parameters and access with different technologies, 1G was analog system, from 2G until 4G are digital, 5G also will be digital but with different features.

TABLE 1.

All mobile generation comparison [1]

Technology / Feature	1G	2G	3G	4G	5G
Start/ Deployment	1970 – 1980	1990 – 2004	2004 2010	Now	Soon (probably 2020)
Data Bandwidth		64kbps	2Mbps	1 Gbps	Higher than 1Gbps
Technology	Analog Cellular Technology	Digital Cellular Technology	CDMA 2000 (1xRTT, EVDO) UMTS, EDGE	Wi Max LTE Wi Fi	WWWWIcoming soon!
Service	Mobile Telephony (Voice)	Digital voice, SMS, higher capacity packetized data	Integrated high quality audio, video and data	Dynamic information access, Wearable devices	Dynamic information access, Wearable devices with AI Capabilities
Multiplexing	FDMA	TDMA, CDMA	CDMA	CDMA	CDMA
Switching	Circuit	Circuit, Packet	Packet	All Packet	All Packet
Core Network	PSTN	PSTN	Packet N/W	Internet	Internet

2. 5G MOBILE WIRELESS TECHNOLOGY

The 5G wireless communication system will be a converged system with multiple radio access technologies integrated together. It can support a wide range of applications and services to comprehensively satisfy the requirements of the information society by the year 2020 and beyond. From the technology perspective, 5G will be the continuous enhancement and evolution of the present radio access technologies, and also, the development of novel radio access technologies to meet the increasing demand of future. 5G can be characterized as data, connectivity and user experience [2], as a technical requirements of the 5G, preliminary technical requirements of 5G are given in Figure 1.

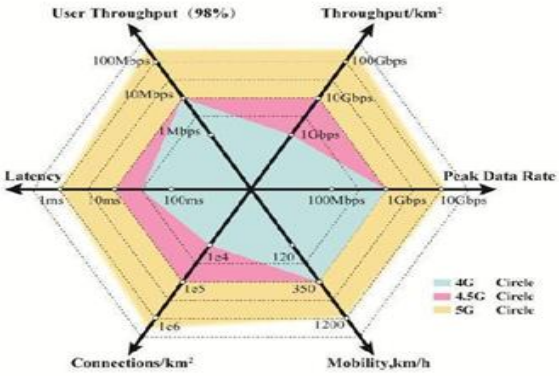

FIGURE 1. Key capabilities of 5G [1]

3. MAJOR 5G ACTIVITIES BY COMPANIES

Many mobile and wireless companies started their proposals and plans toward 5G, according their plan, about 2020 5G will be ready to final test, for example:

a. Mobile and wireless communications enablers for twenty twenty (2020) information society (METIS) the European group started the project on November 2012.
b. The China IMT 2020 promotion group began the project on February 2013, the 5G – related activities in China are primarily centered on two main for a. these two for a are the IMT-2020 promotion group and Ministry of Science and Technology (MOST) 863-5G project.
c. Korean 5G Forum as an ambitious plan started on June 2013.
d. The Japanese ARIB established new Ad Hoc started their project on October 2013. The association of Radio Industries and Businesses (ARIB) "2020 and beyond" Ad Hoc group was established in September 2013 with the objective to study system concepts, basic functions and distribution/architecture of mobile communication in 2020 and beyond, additionally, the Tokyo Institute of Technology in cooperation with NTT DoCoMo is currently undertaking research for a new 5G network with the intent of reaching 10 Gbps transmission speeds.
e. The other European Union projects like 5GNOW, LTE and LTE-advanced leverage orthogonal wave forms (OFDMA). The 5th Generation Non-Orthogonal waveforms for asynchronous signaling (5GNOW) will investigate non-orthogonal waveform and develop a proof of concept with hardware demonstrator, 5G PPP. The 5G Infrastructure Public Private Partnership (5G PPP) is part of Horizon 2020. 5G PPP is a joint initiative between the European Information and Communications Technology (ICT) industry, small/medium enterprises (SMEs) in the research community and the European Commission to rethink the infrastructure and create the next generation of communication networks and services that will provide ubiquitous super fast connectivity and seamless service delivery in all circumstances, COMBO (Convergence of fixed and Mobile Broadband access/aggregation networks) will propose and investigate new integrated approaches for Fixed/Mobile Converged (FMC) broadband access/aggregation networks for different scenarios. COMBO architecture will be bases on joint optimization of fixed and mobile access / aggregation networks around the innovative concept of next generation point of presence (NG-POP), iJOINT (Internetworking and Joint Design of an open access and backhaul network architecture for small cells based on cloud networks) introduces the novel concept of RAN as a Service (RANAAS), where RAN functionality is flexibility centralized through an open IT platform based upon a cloud infrastructure. Massive MIMO for Efficient Transmission (MAMMOET) is to advance the development of Massive MIMO. Mobile Opportunistic Traffic Offloading (MOTO) proposes a traffic offloading architecture that exploits in a synergistic way a diverse set of offloading schemes. Figure 2 shows the European user equipment program structure.
f. 5G related activities in America like SWARM Lab is a research program at UC Berkeley, Berkeley wireless research center (BWRC), Broadband wireless access and application center (BWAC), center for wireless systems and applications (CWSA), Intel strategic research alliance (ISRA),..etc.

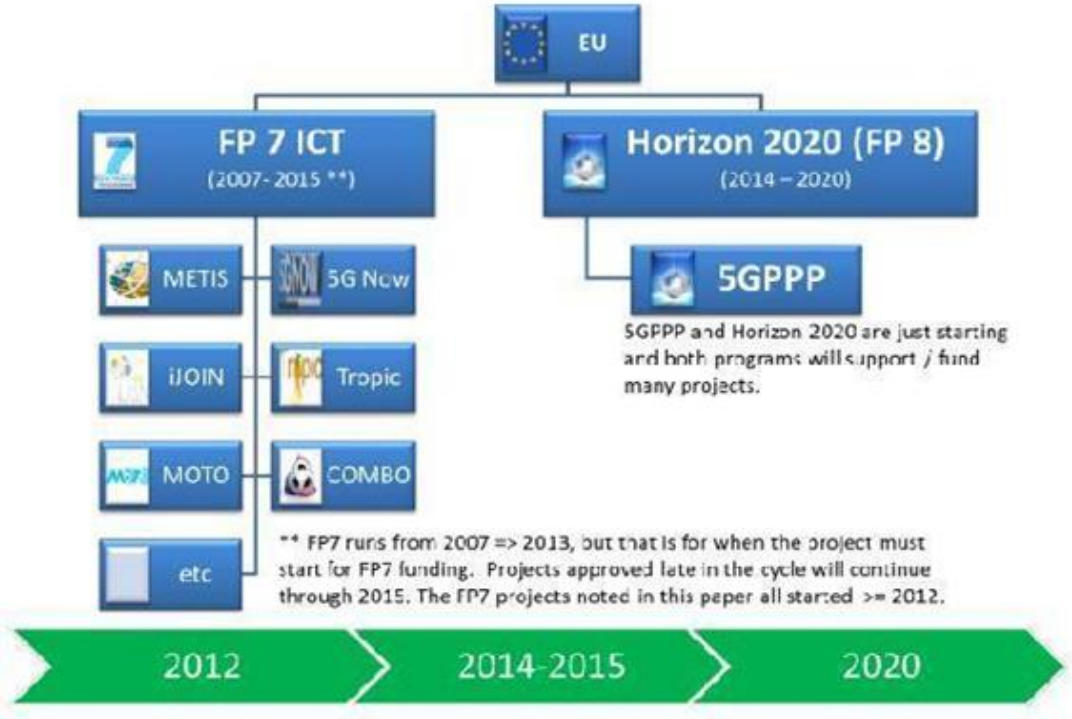

FIGURE 2. User equipment European 5G program structure

4. 5G KEY TECHNOLOGIES

Mobile networks will increasingly become the primary means of network access for person to person and person to machine connectivity, these networks will need to match advances in fixed networking in terms of delivered quality of service, reliability and security, to do so, 5G technologies will need to be capable of delivering fiber like 19Gbps speeds to make possible ultra-high definition visual communications and immersive multimedia interactions. These technologies will depend on ultra-wide bandwidth with sub-millisecond latencies, the main 5G key technologies can be summarized as:

a. The frequency spectrum for 5G system expected will be millimeter wave communication 30-300 GHz bands, therefore, the cell coverage will be smaller than that in 4G and more base stations (C-Node-B), the letter C means cloud, and lower powered radio access nodes and then picocells and femtocells.
b. MIMO system with higher order spatial multiplexing (Massive MIMO system), LTE MIMO is 2x2 , LTE advanced is 4x4, 4G mobile is 8x8 MIMO, for 5G will be 24x24 and higher may be about 64x64 which leads to higher size, a comparison between MIMO for 4G and expected for 5G given in results section in this paper.
c. To the boost spectral and energy efficiency, new concepts will be in 5G because traditional methods for radio resource and interference management (RRIM) in single and two tier networks may not be efficient.
d. Smart cities, 5G will provide the foundational infrastructure for building smart cities, which push mobile network performance and capability requirements to their extremes, low latency and extremely high reliability, however, will also be essential requirements for the likes of mobile industrial automation, vehicular connectivity and other applications. Applications like smart sensors and text based messaging

are examples of extremely high volume applications that will require very low data rates and will not be sensitive to latency.

e. Necessary break through, new break through in multiple access and advanced waveform technologies combined with advances in coding and modulation algorithms are essential for realizing continuing improvements in spectral efficiency, this will accommodate the necessary scalability for massive connectivity and drastic reductions in access latency multi-Carrier CDMA (MC-CDMA) expected the most efficient multiple access for 5G.

5. 5G EXPECTED CHALLENGES

The main five expected challenges for 5G system are: great service in crowd, very high data rate, ubiquitous things communicating (very low energy, cost, massive number of devices), mobility and very low latency, these five challenges are summarized in Figure 3.

FIGURE 3. The five challenges and scenarios for 5G system [2]

6. RESULTS FOR SOME EXPECTED 5G FEAATURES

This paper is an attempt to contribute in 5G mobile design and plan which expected will be completed about 2020, many conferences and papers has been done and published in related to this field, as mentioned in this paper, the main key technologies for 5G are massive MIMO, higher data rate (amazingly fast), lower latency compared to other mobile systems specially 4G, about MIMO system, Figure 4 shows the ergodic capacity (in

bits/transmission) for 4G system 8x8 versus signal to noise ratio (in dB), Figure 5 shoes the same relation as in Figure 4 but for 5G MIMO system 64x64, as shown ergodic capacity in bits per transmission for 5G will be about eight times that for 4G, this is because the higher number of channels usin higher number of transmitting and receiving antennas.

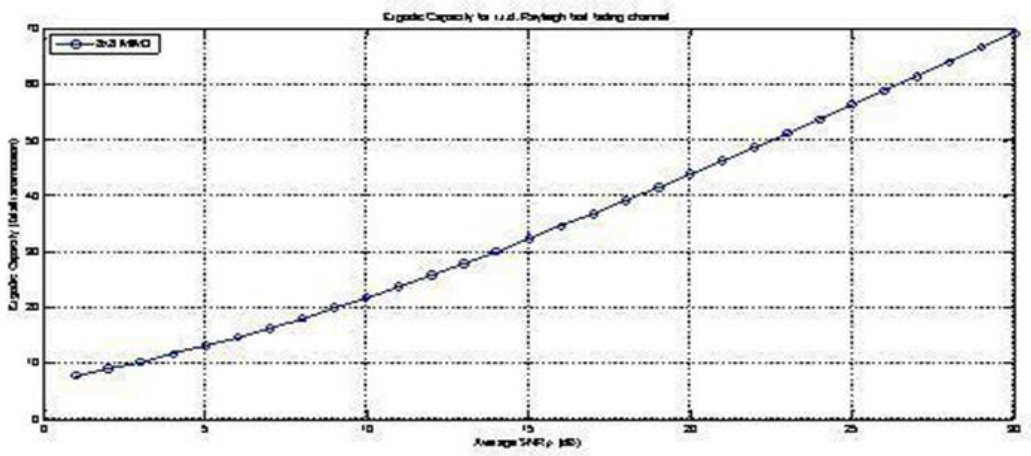

FIGURE 4. Ergodic capacity vs average signal to noise ratio (SNR) for 8x8 MIMO 4G system

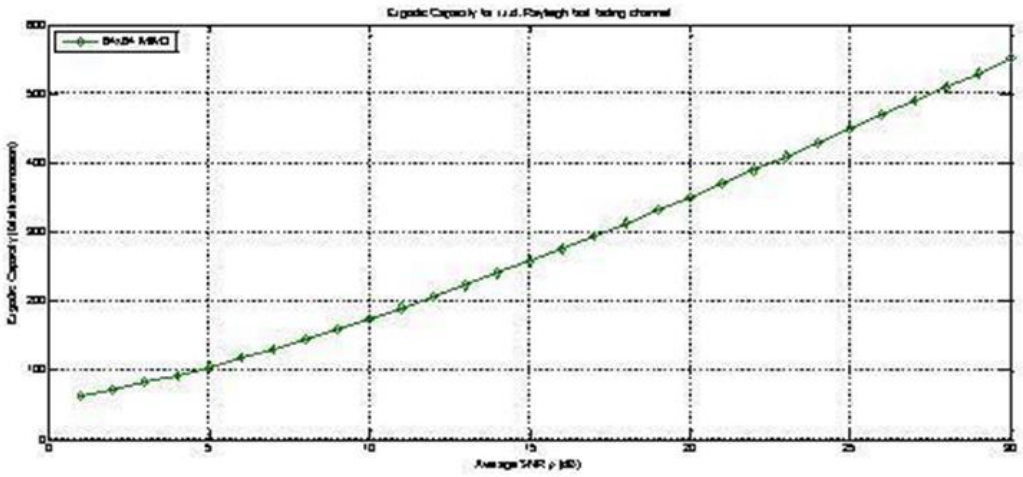

FIGURE 5. Ergodic capacity vs average signal to noise ratio (SNR) for 64x64 MIMO 5G system

Another key technology is the amazing fast (higher data rate) for 5G, Figure 6 shows the comparison between 4G and 5G expected data rates which is relation between data rate in Mbps and signal to noise ratio (SNR), it is shown that 5G expected data rate will be about six times that for 4G system, this is because the massive MIMO system and higher bandwidth with smarter radio networks.

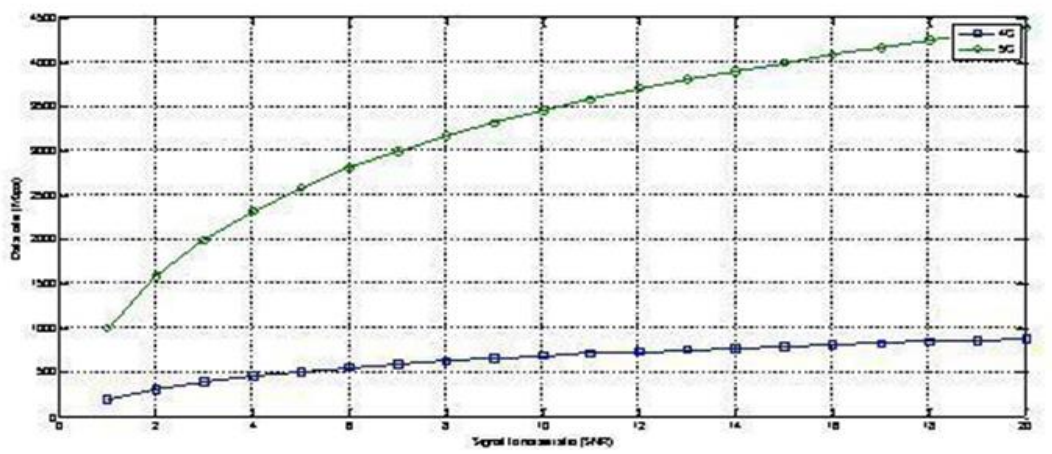

FIGURE 6. Data rate vs SNR for 4G and 5G systems comparison

Because of higher frequency bandwidth for 5G system, path loss will be higher and the cell coverage will be less compared to that in 2G, 3G and 4G. Figure 7 shows the relation between path loss in dB and frequency, it is shown that 5G received power will be decreased because of higher path loss, C-Node-B base stations coverage are smaller causes the use of higher number of base stations (C-Node-B) which leads more difficult cell planning and higher interferences (co-channel and adjacent channel interferences).

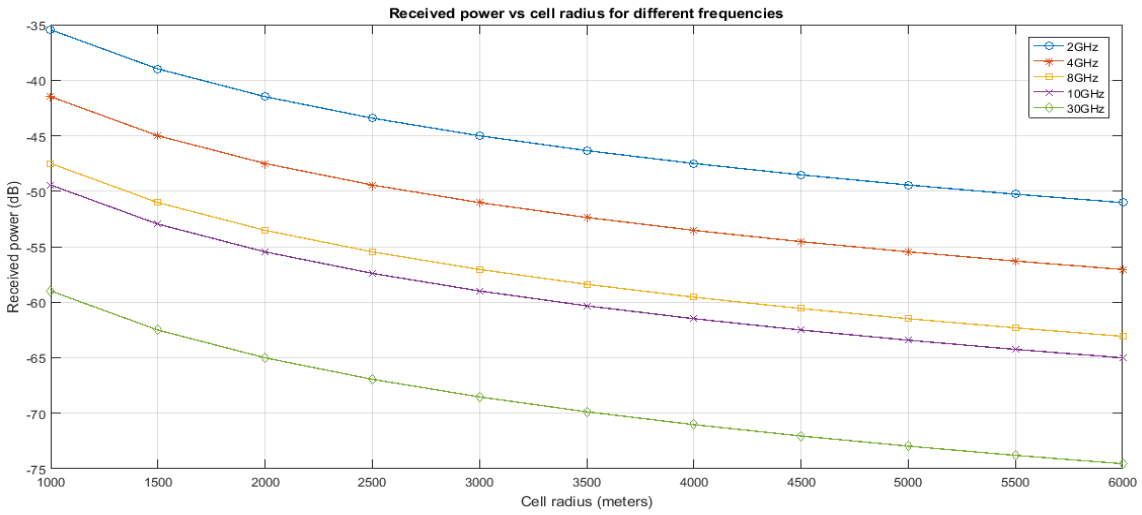

FIGURE 7. Received power vs cell radius for different frequencies

7. CONCLUSION

Next generation mobile system (5G) will be the integration for other mobile systems, there will be some challenges should be solved during the projects toward this system, this paper is an attempt to contribute in this field to give more details will be needed 5G, as shown in the results, ergodic capacity for 5G will be about eight times greater then that for 4G systems because of the use of massive MIMO system, in addition, the data rate for 5G will be greater about six times than that for 4, but the cell radius will be smaller in 5G, therefore, higher number of base stations this is because of higher frequency bandwidth for 5G system.

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