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The Deployment of the Future Mobile Network

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Abstract

With the explosion of mobile services and the continuouse increase demand for a higher data traffic, a new high speed communication networks are required. Mobile networks are developing to increase the data speed and channels bandwidth inorder to meet the subscriber needs. Many attempts have been carried out to achieve the main demands of faster connectivity and download. 5G technolgy which refers to the 5th Generation Mobile Tecnology is the new mobile network that will provide the users with more features and effeciency at the finest QoS (Quality of Service). This study presents most of the experemints and researches to deploy the new Mobile Network 5G, however it is still in its infancy stage and lacks standardization. Some of the proposed potential architecture for 5G are described in this article.

Keywords: 4G; LTE; 5G; Quality of Service(QoS); OFDM; MIMO

1. Introduction

Mobile Network plays a main role in today life. Sunbscriber becomes more aware of mobile phone technology and services. Mobile data traffic has been expected to grow more than 24-fold between 2010 and 2015 and more than 500-fold between 2010 and 2020 [1].That is why the communications industry is working on a fifth-generation wireless system. Compared with today's 4G and LTE networks, researchers say 5G will achieve 1,000 times the system capacity; 10 times the energy efficiency, data rate, and spectral efficiency; and 25 times the average mobile cell throughput. The aim is to offer seamless and universal communications between any people, anywhere, at any time by just about any wireless device. Standards for 5G are likely to be defined between 2016 and 2018, with 5G-ready products not expected until 2020. Mobile wireless industry has started its technology creation, revolution and evolution since early 1970s. There exists variety of technologies starting from the first generation (1G) through the fourth generation (4G), with typical services and representative technologies for each generation. For example, in 1981 1G was analog system, while the second generation (2G) which was introduced in 1992 was new digital system [2]. Both 1G and 2G use circuit switching. The third generation (3G) appeared in 2001, it was designed for packet switching. Orthogonal Frequency-Division Multiplexing (OFDM) and Multiple Input Multiple Output technology (MIMO) are the key technologies for 4G services that were launched last year. It is still unclear how much time it will take to launch the standards for 5G. Mobile Cellular Network evolution has been categorized in to 'generations' as shown in Figure1.

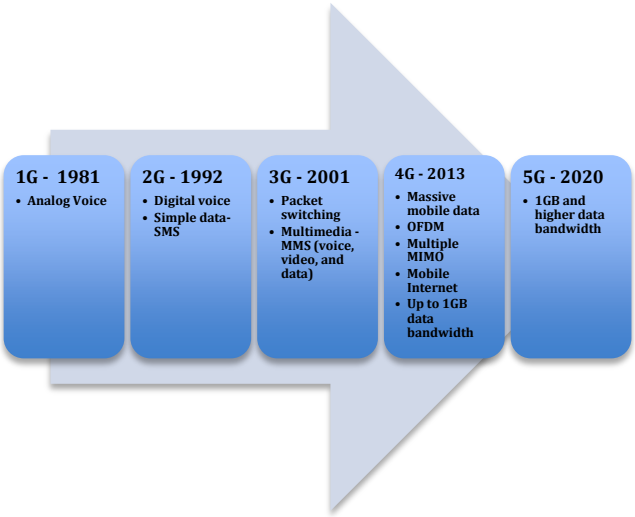

Fig.1 The Evolution of Mobile Network

5G mobile network comprise packet switched wireless systems using OFDM with wide area coverage, high throughput at millimeter-waves (10 mm to 1 mm) covering a frequency range of 30 GHz to 300 GHz, and enabling a 20 Mbps data rate to distances up to 2 km [3]. The millimeter-wave band is the most effective solution to the recent surge in wireless Internet usage. These specifications are capable of providing Wireless World Wide Web (WWW) applications.

This paper addresses the specification and network architecture that meets the 5G requirements and challenges. Furthermore, it shows a comparison between some of the universities and research centers like: European Union, METIS, NTT DOCOMO and others, who are playing role in 5G developments. 5G deployment will begin around 2020, where Asia is the leader in the reseaches. While the future is becoming more and more difficult to predict with each passing year, we should expect an accelerating of technological change. Though there are many obstacles and opportunities in 5G development, with much hanging on the outcome.

2. What Is 5G Technology?

5th generation mobile network is a packet switched wireless system. It is an upgraded version of the existing and establishment network 4G. It is more scientific experiment than reality, since there are no standards have been formalized yet. 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 [4]. 5G will provide the services people need at the appropriate QoS (Quality of Service) [5].
The International Telecommunications Union (ITU) has recently start reaseraches on defining requirements for International Mobile Telecommunications (IMT)-2020, similar to how ITU has previously defined requirements for IMT-2000 and IMT-Advanced [6]. However, there is no clear definition of or detailed requirements of 5G. The best way to understand the requirements for 5G is to understand the requirements of mobile communication, from end-user and service provider points-of-view, in the 2020 and beyond [6]. The identification on these requirements and corresponding technology components will address to the key ideas for the 5G architecture design activities and reasearches around the world.

3. 5G Requirements And Challenges

The 4G wireless systems were designed to use IP for all services and meet all the requirements of IMT-A [7]. However, there is still a huge increase in the number of mobile users who need faster Internet access every where. 5G Requirements can be subdivided into two categories:

- User requirements: such as users satisfaction, reliability, battery life, safety, ease of use and connection speed.
- Network requirements: such as network capacity, scalability, cost, coverage, security and efficiency.

The requirements needed include support of a large number of connected devices and flexible air interfaces, always online capabilities and energy efficiency; all which may not be acquired by a simple upgrade of current systems, but will require new protocols and access technologies altogether. [6]. The European Mobile Observatory (EMO) pointed out that there has been a 92 percent growth in mobile broadband per year since 2006 [8]. As more and more devices go wireless, many researches challenge need to be considered. The further expansion of mobile broadband users and the additional traffic according to communication machines (1000x in next ten years) required an Ultra-Dense Networks (UDN) [9] [10]. The massive growth in connected devices (50 billion devices in 2020) requires an Ultra Reliable Communication (URC) [11]. The large density of use cases Device-to-Device (D-to-D) needs new requirements and characteristics needs Massive machines [11]. Mobile and wireless communications Enablers for the Twenty-twenty Information Society (METIS) is the European Union (EU) flagship 5G project having the objective to lay the foundation for 5G systems and to build consensus prior to standardization. The technical objective of METIS, that reflects the 5G requirements, is to develop technical solutions towards a system concept that supports :

Table1 : 5G Requirements

1	Data rates	1-10 Gbps / 100s of Mbps
2	Capacity	36TB / 500 GB /month/user
3	Spectrum	Higher frequencies & flexibility
4	Energy	90% reduction of system energy usuage
5	Latency reduction	~ 1ms end-to-end round trip delay
6	D2D capabilities	NSPS, ITS, resilience, ...
7	Reliability	99.999% within time budget
8	Coverage	> 20 dB of LTE
9	Battery	Low battery consumption ~ 10 years
10	#devices per area	300.000 per access node

This means that 5G networks should be able to support communications for some special scenarios not supported by 4G networks. All these requirements shall be fulfilled at similar cost and energy dissipation as today. 5G technologies use CDMA and BDMA and millimeter wireless that enable a higher data rate with less power consumption. 4G focused on speed, while 5G is expected to address latency and capacity

limitation. A simple comparesion between 4G and the new 5G mobile networks is presented in table.2 .

Table2 : Comparesion between 4G and 5G mobile networks

		4G	*5G*
1	Data rate	2 Mbps to 1Gbps	1 Gbps & higher
2	Frequency	2-8 GHz	3-300 GHz
3	Standards	OFDMA, MC-CDMA Network - LMPS	CDMA & BDMA
4	Multiple Access	CDMA	CDMA & BDMA
5	Core Network	All IP Network	Flatter IP Network & 5G Network Interfacing (5G-IN)
6	Start from	2010	2015

4. 5G Wireless Cellular Architecture

To meet the 5G system requirements, a big change in the current network design is needed. One of the keys is to separate outdoor and indoor scenarios to avoid the signal loss through the obstacle and building walls. Using Distributed Antenna System (DAS) and massive Multiple-Input and Multiple-Output (MIMO) technology will assist in avoiding the penetration loss [12]. Outdoor base stations (BSs) will be equipped with large antenna arrays. Some of the antenna will be distributed arround the cell and connected to BSs by fiber optics from DAS and massive MIMO. Outdoor users are equipped with limited number of antenna , but they can coorporate with each other to form a virtual large antenna array and construct a masive MIMO link [9]. Using the same architecture, the indoor users need only to communicate with indooe access point with large antenna outside the building [9]. The 5G cellular architecture should be a heterogeneous and reduce the size of the cell, it may consists of different types of infrastructure BSs (macro- , micro- , pico- , and femto-BSs) [13]. By reducing the size of the cell, area spectral efficiency will increase, while transmit power will be reduced, such that the power lost through propagation will be lower. Heterogeneous networks offer multiple options to satisfay different applications requiremnets [13].

5. 5G Technology Key Drivers

To meet the 5G requirements and address the challenges, 5G architectures need a change in the design.

- Massive MIMO: use a large array of antenna elements, more than the number in use today, spatially multiplex data and provide diversity and compensate for path loss [10].
- UDN: address the high traffic demands by infrastructure densification. It will increase the capacity, and the energy efficiency of radio links, and enable a better exploitation of spectrum.
- Moving Networks (MN): enhance and extend coverage foe potentially large populations of moving devices.
- D-2-D Communications: refers to direct communication between devices, without user-plan traffic going through any network infrastructure. Data packets are exchange between devices locally; this will increase spectrum utilization and capacity per area.
- URC: will enable a higher degree of availability and reliability.
- Massive Machine Communications (MMC): provides up-and down-scalable connectivity solutions for ten billions of network-enabled devices.

A Brief outline for 5G key drivers is shown in the Figure 2 below:

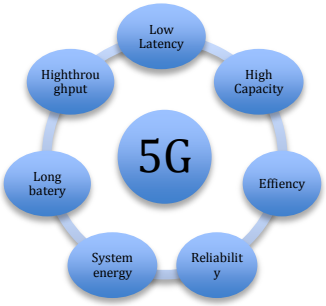

Fig.2 5G Key drivers

6. 5G Researches And Developer

The first whispering of 5G began during the Mobile World Congress in 2012, when executives from Telefonica, Alcatel-Lucent and Bell Labs discussed the nascent technology. The first question posed was: what exactly 5G, and who needs it?
The official process of 5G standardization should be launched in 2015-2016 time frames. The International Telecommunication Union holds an international conference every four years, known as the World Radio-communication Conference (WRC), to sort out international radio frequency issues, including standards for mobile networks. The next WRC is scheduled to be held in Geneva in 2015. The 5G standard is expected to be one of the topics of discussion for international delegates. The Next

Generation Mobile Network Alliance (NGMN) has announced that Apple is the latest organization to join its ranks, as the association aims to catalyze the development of research and standards for 5G.
Specifically, South Korea is seen as the most advanced market in terms of 5G developments, while the Europe research is just behind. On the mean time there are more other companies and industries that are working on the 5G standardizations. Some of these companies' developments are described below:

6.1 Wireless@MIT

Wireless@MIT boasts a strong industrial partnership with Microsoft, Cisco, Intel, Telefonica, Amazon, Goggle, STMicroelectronics, and MediaTek. Research is currently focused on four areas: spectrum and connectivity, mobile applications, security and privacy, and low-power systems [6].

6.2 European Union (EU)

EU has already launched eight projects to begin exploring the technological options available leading to the future generation of "wired" (optical) and "wireless" communications, adding up to over €50m for research on 5G technologies deployable by 2020. Horizon 2020 is the 8th Framework Program (FP8), the programme runs from 2014–2020 and provides an estimated €80 billion of funding [6] [14].

6.3 METIS – Mobile and Wireless Communications Enablers for the Twenty-twenty (2020) Information Society

METIS is an EU-funded, Ericsson-led, consortium of 29 organizations with a €27m budget and more coming from the European Commission is aimed at replicating Europe's worldwide success with GSM and subsequent technologies [15]. It will demonstrate through hardware test-beds key technology components developed in the project [16]. METIS has outlined the following 5G scenarios that reflect the future challenges and will serve as guidance for further work: a wide range of data rate, Great service in crowded area, efficient handling of higher number of connected devices, efficient user experience, longer battery life, reliability and low latency.

6.4 Centre for Communication Systems Research (CCSR), University of Surrey, UK

The researches of CCSR & University of Surrey focus is on: lowering network costs, anticipating user data needs to pre-allocate resources, dense small cells, device-to-device communication and spectrum sensing (for unlicensed spectrum). It's claimed that the new network will be spectrum-efficient and energy-efficient. It will also be faster, with cell speeds bumped up to a capacity of 10Gbps.

6.5 Polytechnic Institute of New York University (NYU-Poly)

NYU-Poly Professor Theodore Rappaport direct two projects [17] :

- NYU-Wireless : The 5G project will be smarter and less expensive wireless infrastructure with the use of smaller, lighter antennas with directional beamforming that is capable of bouncing signals off buildings using the uncrowded millimeter-wave spectrum.
- Wireless INTERNET CENTER for ADVANCED TECHNOLOGY (WICAT) : Their thrust areas of the reaserach are : increasing network capacity and battery life of terminals, enhancing network security, and raising applications to run efficiently over wireless networks.

6.6 Tokyo Institute of Technology and DOCOMO

Tokyo Institute is mobile solution provider for smart living, begins trials of 5G technology with many suppliers. The operator continues to expand its LTE networks and is already preparing for the 5G evolution of the user experience and new M2M applications .

- NTT DOCOMO & Ericsson: The reasearch plans to achieve ultra-high bit rates of more than 10Gbps, delivering radio network capability of more than 1,000 times today's LTE networks. Ericsson has developed advanced antenna technologies with wider bandwidths, higher frequencies and shorter transmission time intervals, as well as radio base stations built with baseband units and radio units developed specifically for the 5G trial.The trial covers technology areas related to macro/small cell architecture based on the heterogeneous network, broadband communication using frequency bands at 15GHz and high-speed, high-capacity transmission. 5G system will not be a single technology but rather a combination of integrated Radio Access Technologies (RATs) , including evolved versions of LTE and High-Speed Packet Access (HSPA) , as well as specialized RATs for specific use cases [18]. Ericsson will work with NTT DOCOMO on outdoor trials that will take place in Yokosuka, Japan. [18] [19]

- NTT DOCOMO &Nokia: Both companies agreed to cooperate on research of 5G technologies and work jointly on a 5G proof of concept (PoC) system. This move builds on the Memorandum of Understanding (MoU) signed by the two companies in January 2014 to research future radio access experimental systems. The two companies will continue to cooperate on the research of future radio access systems, with an initial focus on exploring the potential of the millimeter wave technology at the 70GHz spectrum band. The experimental 5G PoC system will be implemented using National Instrument's (NI) baseband modules which make up the state-of-the-art system for rapid prototyping of 5G air interfaces today. [20]
  - NTT DOCOMO & NEC: Aim to verify enhanced time-domain beam forming technologies with a very large number of antennas for small cells. This will improve MIMO technology that supports mobile coverage for multiple users simultaneously while reducing interference and enabling 5G advancements that include accelerated communication speeds, improved communication quality and greater capacity. [20]
  - NTT DOCOMO & Tokyo Institute of Technology : They work on a joint outdoor experiment conducted recently, succeeded in a packet transmission uplink rate of approximately 10 Gbps, and 1,000 times the capacity of today's LTE. In the experiment, a 400 MHz bandwidth in the 11 GHz spectrum was transmitted from a mobile station moving at approximately 9 km/h. MIMO technology was used to spatially multiplex different data streams using eight transmitting antennas and 16 receiving antennas on the same frequency [15].
  - NTT DOCOMO & Alcatel-Lucent: Thier vision is that 5G systems will adapt to the user's needs to create the 'network of you' and a new flexible air interface will be a key element. This air interface will couple to a flexible network infrastructure that takes full benefit from network virtualization and software-defined networking. [20]
    - Fujitsu & DOCOMO : Build a cooperative partnership toward the realization of 5G. Through experimental trials with DOCOMO, they intend to verify 5G and, going forward, contribute further to society by driving the development of Internet of Thing (IoT) and Big Data.
    - Samsung & DOCOMO : successfully developed the world's first adaptive array transceiver technology operating in the millimetre-wave Ka bands at a frequency of 28 GHz at a speed of up to 1.056 Gbps to a distance of up to 2 kilometers. Samsung said its adaptive array transceiver technology, using 64 antenna elements to concentrate radio energy in a narrow, directional beam will be a solution for overcoming the weaker propagation characteristics of millimeter-wave bands, which are much higher in frequency than conventional wireless spectrum. [20] [21].

6.7 Huawei

Huawei announced last year that it will deliver a peak of 30 Gbps, which is 20 times faster than the top speeds of commercial LTE networks [5]. Huawei will cooperate with the industry to enhance the Mobile Network of Things (MOT) [17]. Huawei's technology relies on advanced antenna arrays, frequency management and MIMO to improve spectrum utilization and achieve greater efficiency [5].

6.8 Agilent Technologies

Agilent announced an agreement to cooperate with China Mobile Research Institute (CMRI), to test-and-measure the simulation and measurement solutions for large-scale antenna systems (LSAS), full-duplex radio, energy efficiency and spectral effeciency co-design , and new signaling/control mechanism to achieve this higher spectral effeciency with lower energy consumption.

7. 5G Timeline

5G is presently in its early research stages. New IMT spectrum is expected to be agreed upon for the WRC in 2015. ITU is currently at work on IMT spectrum requirements for 2020 and beyond to release a global scale for frequemcy spectrum [22]. Many intrenational meetings are held every four years inorder to define the new spectrum distribution [22]. After WRC-15, 4G network will have additional frequency spectrum [22], ITU will have a clearer path for determining 5G network system and technology requirements [23]. By the date of WRC-19 the 5G spectrum requiermnet will be defined [22]. WRC-23 will start after WRC-19 had taken place and the initial technology submission for IMT 2020 are done [23].
The European path from exploring 5G Infrastructured Public Private Partnership (5G PPP) to the deplpyment is described in table3 [24].
Figure 3. present the possible roadmap for 5G (Source Huawei) [22][23].

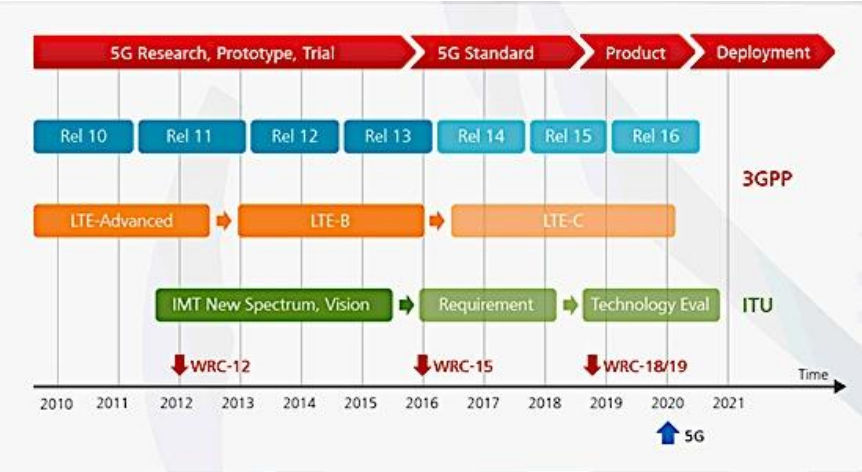

Fig.3 5G roadmap and timeline

Table 3: 5G PPP deployments path

2014-2015	Understand the requiremnets of 5G future system and define the technology architecture and functions based on previous researches
2015-2017	Detailed researches for network core, backbone and acess mean
2016-2018	Effective system design with concern with all requirements and WRC-15 results Enhanced preparation for WRC-19
2017-2018	Examination, network demo, setting prototype …
2018-2020	Emonstrations and trails on prepared standard and componetn availability
2020	New frequency band available for initil commercial use
2020-2025	Explorartory phase to understand detailed requiremnts on 55G future . The best technoogy option had already started since 2014

8. Conclusion

This paper provided an overview for the 5G mobile network challenges, and the enhanced preperation towards its design. 5G network is very fast and reliable. A new revolution of 5G technology is about to begin since 5G is a contuinouse development of the mobile network series. The new coming 5G technology is available in the market in reasonable rates, with unlimited access to information and sharing of data available anywhere and anytime to anyone. In this paper we have presented the roles played by different universities and industries to set the 5G standardizations. Many corporations have been done in order to accelerate the process of launching this standard.

While the future is becoming more and more difficult to predict with each passing year, we should expect an accelerating pace of technological change. Though there are many barriers and opportunities in 5G development, with much hanging on the outcome. But the concept also involves the challenges on which engineers succees.

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