5G: Super-Fast Mobile Networking

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Abstract—***5G is also referred to as beyond 2020 mobile communications technologies. Mobile technologies have undergone a great evolution from 1G to 4G. Now, 5G technologies is being planned to design the best wireless world that is free from limitations and hindrance of the previous generations. The major difference, from a user point of view, between expected 5G techniques and current generations include low battery consumption, more secure, high speed. This paper represents, a brief evolution of pervious technologies, introduction to 5G technologies, why there is a need for 5G, advantages of 5G networks technology, exceptional applications, Quality of Service (QoS) and comparison of 4G and 5G technologies.***

Keywords-5G; Why 5G?; architecture of 5G component; requirements and challenges.

I. INTRODUCTION

In the last fifteen years mobile and wireless networks have made tremendous growth. We have different mobile and wireless communication technologies, which are mass deployed, such as WiMAX (IEEE 802.16 wireless and mobile networks) , Wi-Fi (IEEE 802.11 wireless networks), LTE (Long Term Evolution), 3G mobile networks (UMTS, cdma2000) and 4G as well as accompanying networks, such as personal area networks (e.g., Bluetooth, ZigBee) or sensor networks. All wireless and mobile networks implements all-IP principle, that means all signalling and data will be transferred via IP (Internet Protocol) on network layer.

Fifth generation is based on 4G technologies with several improvements that would make it more intelligent and beneficial for users. This technology provides facilities like camera, large phone memory, MP3 recording, video player, audio player etc. The fifth generation wireless mobile multimedia internet networks can be completely wireless communication without any limitation, which can make a perfect wireless real world – World Wide Wireless Web (WWWW). The 5th wireless mobile internet networks are real wireless world which shall be supported by LAS-CDMA (Large Area Synchronized Code-Division Multiple Access), OFDM (Orthogonal frequency-division multiplexing), IPv6, MCCDMA (Multi-Carrier Code Division Multiple Access), UWB (Ultra-wideband), and Network-LMDS (Local Multipoint Distribution Service). The development of 5G technologies is a cornerstone for realizing breakthroughs in the transformation of ICT network infrastructure. Ultra-broadband and intelligent-pipe network features that achieve "zero distance" connectivity between people and connected machines – no matter where they are – are just the first step. It is expected to arrive around 2020.

Figure1- Mobile phones of all generations of mobile technology.

II. BRIEF DESCRIPTION OF PREVIOUS TECHNOLOGIES

A. First-Generation Systems (1G)

The first generation was pioneered for voice service in early 1980's, where almost all of them were analog systems using the frequency modulation technique for radio transmission using frequency division multiple access (FDMA) with channel capacity of 30 KHz and frequency band was 824-894 MHz [1], which was based on a technology known as Advance Mobile Phone Service (AMPS).

B. Second Generation Systems (2G)

The 2nd generation was accomplished in later 1990's. The 2G mobile communication system is a digital system; this system is still mostly used in different parts of the world. 2G, mainly used for voice communication also offered additional services such as SMS and e-mail. Two digital modulation schemes are used in this generation; one is time division multiple access (TDMA) and the 2nd is code division multiple access (CDMA) [2] and frequency band is 850-1900 MHz. In this generation, GSM technology uses eight channels per carrier with a gross data rate of 22.8 kbps (a net rate of 13 kbps) in the full rate channel and a frame of 4.6 milliseconds (ms) duration [3].The family of this generation includes of 2G, 2.5G and 2.75G.

C. *Third Generation Systems (3G)*

Third generation (3G) services combine high speed mobile access with Internet Protocol based services. The main features of this generation include wireless web base access, email, multimedia services and video conferencing. The third generation W-CDMA air interface standard had been designed for ―always-on‖ packet-based wireless service; so that computer, telephones and entertainment devices may all share the same wireless network and can be connected internet anytime, anywhere [4]. Third generation systems offer high data rates up to 2 Mbps, over 5 MHz channel carrier width, depending on velocity/ mobility, and high spectrum efficiency. The data rate supported by 3G networks depends also on the environment the call is being made in; 384 kbps in urban outdoor 144 kbps in satellite and rural outdoor and 2Mbps in indoor and low range outdoor [5]. Frequency band is 1.8 - 2.5 GHz.

D. Fourth Generation Systems (4G)

4G usually refers to the successor of the third generation and second generation standards. In fact, the 3GPP is recently standardizing LTE Advanced [6] as future 4G standard. A fourth generation system may upgrade existing communication networks and is expected to provide a comprehensive and secure IP based solution where facilities such as streamed multimedia, voice and data will be provided to users on an "Anytime, Anywhere" basis and at much higher data rates compared to previous generations. One characteristic of the new services to be provided by 4G is their demanding requirements in terms of QoS. Many applications such as wireless broadband access, video chat Multimedia Messaging Service (MMS), mobile TV, HDTV content and Digital Video Broadcasting (DVB) are being developed to use a 4G network.

Generation→ Features↓	1G	2G	3G	4G	5G
Deployment	1970 – 1980	1990 - 2001	2001-2010	2011	2015-20 onwards
Data Rates	2kbps	14.4-64kbps	2Mbps	200 Mbps to 1 Gbps	1Gbps and higher
Technology	Analog Cellular Technology	Digital Cellular Technology: Digital narrow band circuit data Packet data	Digital Broadband Packet data: CDMA 2000 EVDO UMTS EDGE	Digital Broadband Packet data: WiMax LTE Wi-Fi	wwww Unified IP seamless combination of broadband LAN PAN MAN WLAN
Service	Analog voice service No data service	Digital voice with higher clarity SMS, MMS Higher capacity packetized data	Enhanced audio video streaming video conferencing support Web browsing at higher speeds IPTV support	Enhanced audio, video streaming IP telephony HD mobile TV	Dynamic Information access, Wearable devices with AI Capabilities
Multiplexing Switching	FDMA	TDMA, CDMA	CDMA	CDMA	CDMA
Core Network	PSTN	PSTN	Packet N/W	Internet	Internet
Standards	MTS AMTS IMTS	2G:GSM 2.5:GPRS 2.75:EDGE	IMT-2000 3.5G-HSDPA 3.75G:HSUPA	Single unified standard LTE, WiMAX	Single unified standard
WEB Standard		www	www(IPv4)	www (IPv4)	wwww (IPv6)
Handoff	Horizontal only	Horizontal only	Horizontal & Vertical	Horizontal & Vertical	Horizontal & Vertical
Shortfalls	Low capacity, Unreliable handoff, Poor voice links, Less secure	Digital signals were reliant on location & proximity, required strong digital signals to help mobile phones	Need to accommodate higher network capacity	Being deployed	Yet to be implemented

Figure 2 Comparison of All Generations of Mobile Technologies

III. WHY 5G?

- 5G technology can provide large broadcasting of data in Gigabit which supporting almost 65,000 connections.
- 5G technology can offer high resolution for crazy cell phone user and bi- directional large bandwidth shaping.
- 5G technology can offer transporter class gateway with unparalleled consistency.

- 5G technology is more attractive and effective due to its advanced billing interfaces.
- 5G technology can also provide subscriber supervision tools for fast action.
- High quality services of 5G technology based on Policy to avoid error.
- Remote diagnostics also a great feature of 5G technology.
- Traffic statistics by 5G technology makes it more accurate.
- 5G technology will take all delivery service out of business prospect
- The downloading and uploading speed of 5G technology touching the peak.
- Remote management offered by 5G technology helps in getting better and fast solution.
- The 5G technology can providing up to 10Gbps speed.
- The 5G technology can also support virtual private network.
- This technology is cheaper than previous generations.

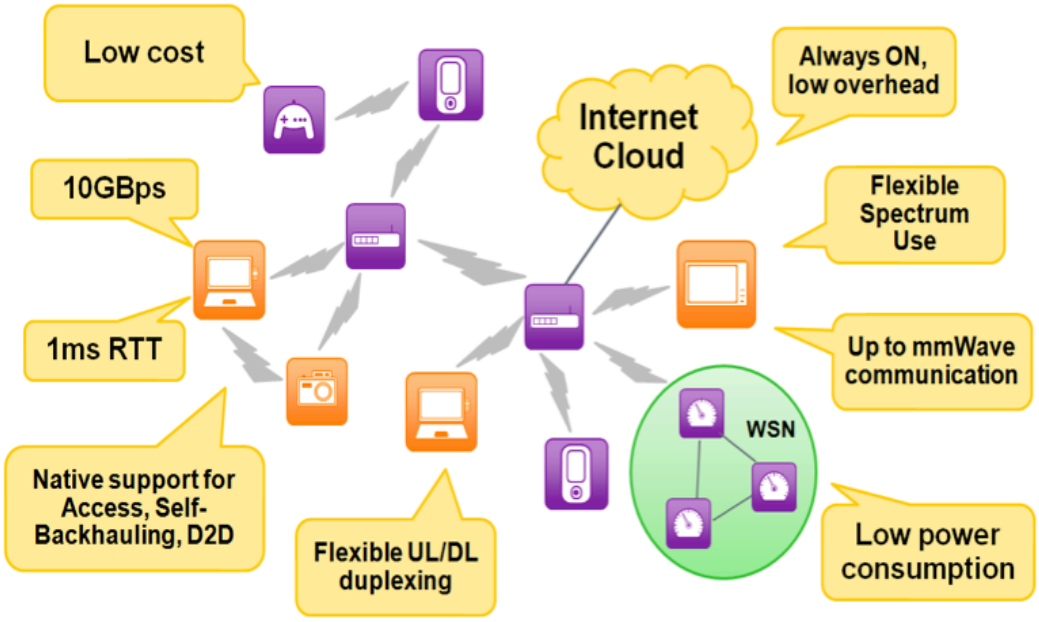

Figure 3- Advantages of 5G Technology

IV. ARCHITECTURE OF 5G

Figure 4 shows the system model that proposes design of network architecture for a 5G mobile system, which is all IP based model for wireless and mobile networks interoperability. The system consists of a user terminal (having a crucial role in the new architecture) and a number of autonomous and independent radio access technologies. Within each of the terminal, each of the radio access technologies is seen as the IP link to the outside Internet world. There should be different radio interface for each Radio Access Technology (RAT) in the mobile terminal. For example, if we want to access four different RATs, we should have four different accesses - specific interfaces in the mobile terminal, and have to make all of them active at the same time, with the aim to have this architecture to be functional. The first two OSI levels (data-link and physical levels) are defining the radio access technologies through which is provided access to the Internet with less or more QoS support mechanisms which is further dependent upon the access technology (e.g., WiMAX and 3G have explicit QoS support, while WLAN has not this). Then, over the OSI-1 and OSI-2 layers is the network layer and this layer is IP (Internet Protocol either IPv4 or IPv6) in today's communication world. The function of IP is to ensure enough control data (in IP header) for proper routing of IP packets belonging to a certain application connections - sessions between client applications and servers somewhere on the Internet. Packet's routing should be carried out in accordance with established policies of the user.

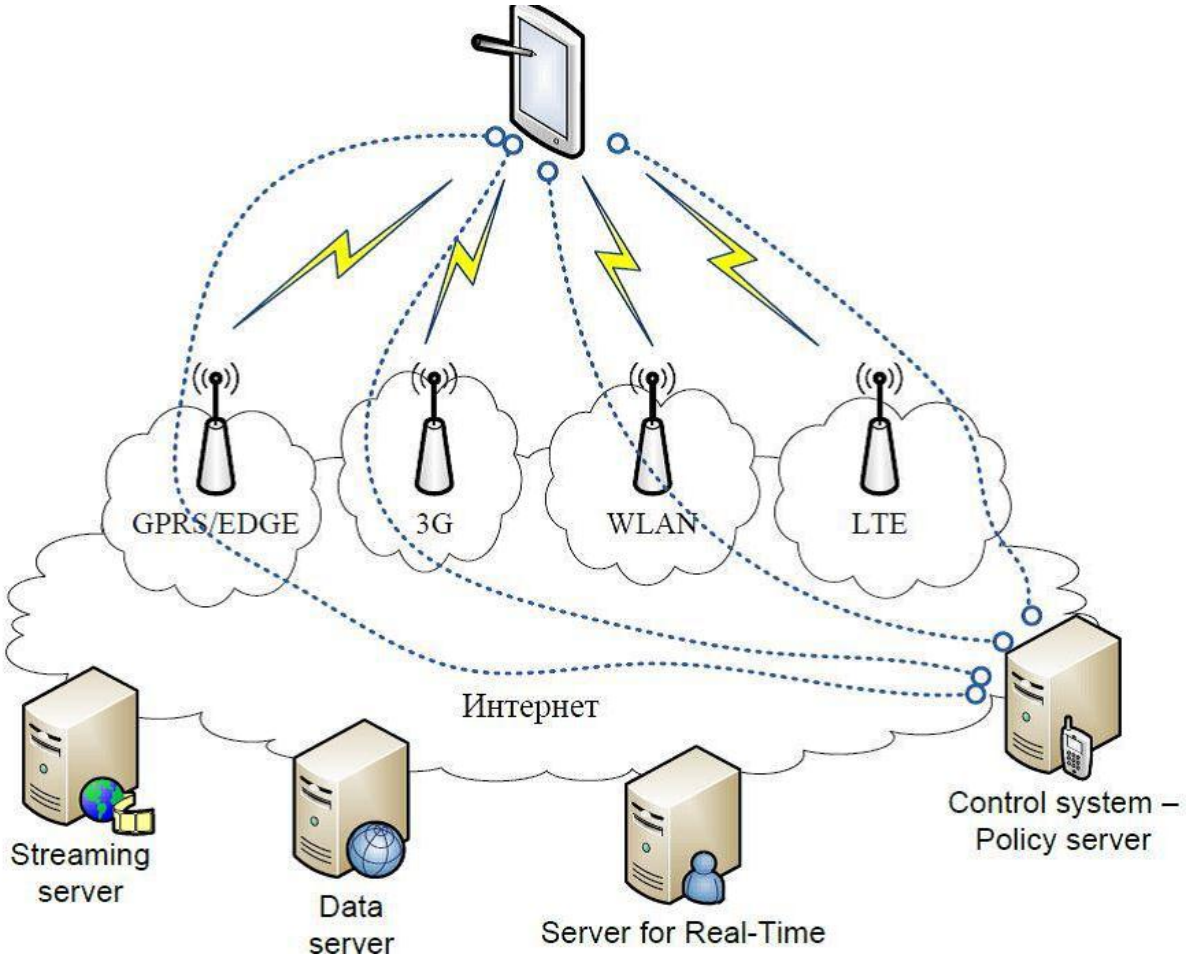

Figure 4- 5G Network Architecture

V. CHALLENGES AND REQUIREMENTS

The three fundamental requirements for building fifth generation wireless networks are:

- Massive capacity and massive connectivity supportive.
- Support for an increasingly diverse set of services, application and users – all with extremely diverging requirements for work and life
- Efficient and flexible use of all available non-contiguous spectrum for wildly different network deployment scenarios

Mobile networks will increasingly become the primary means of network access for connectivity of person-to-person and person-to-machine. The networks will need to match advances in fixed networking in terms of delivered quality of reliability, service and security. For doing so, 5G technologies will need to be capable of delivering fiber-like 10 Gb/s speeds to make possible immersive multimedia interactions and ultra-high definition visual communications. These technologies will depend on ultra-wide bandwidth with sub-millisecond latencies.

VI. CURRENT RESEARCH

There are several key areas that are being investigated by research organizations. These areas include:

- *Millimetre-Wave technologies:* Using frequencies much higher in the frequency spectrum opens up more spectrums and also provides the possibility of having much wide channel bandwidth (nearly 1 - 2 GHz). However this poses new challenges for handset development where maximum frequencies of around 2 GHz and bandwidths of 10 - 20 MHz are currently in use. Frequencies of above 50GHz are being considered for fifth generation and this will present some real challenges in terms of the technology, the circuit design and also the way the system is used as these frequencies do not travel as far and are absorbed almost completely by obstacles.

- *Future PHY / MAC:* This area presents many possibilities from the use of new modulation formats including Generalized Frequency Division Multiplexing (GFDM), as well as Filter Bank Multi-Carrier (FBMC), Universal Filtered MultiCarrier (UFMC) and other schemes to the management of the multiple access schemes. The processing of higher level that will be available by the time 5G is launched mean that multicarrier systems will not require to be orthogonal. This will provide considerably more flexibility.
- *Massive MIMO:* Although MIMO is being used in many applications from LTE to Wi-Fi etc, the numbers of antennas is fairly limited. Using microwave frequencies opens up the possibility of using many tens of antennas on single equipment becomes a real possibility because of the antenna sizes and spacing in terms of a wavelength.
- *Dense networks:* Reducing the size of cells provides a much more overall effective use of the available spectrum. Techniques developed to ensure that small cells in the macro-network and deployed as femtocells can operate satisfactorily are required.

VII. 5G TECHNOLOGY TIMELINE

No dates have been set yet for the development of 5G, but a number of organizations have set their own 5G timelines so they can plan ahead. One major enabler for fifth generation will be the release of spectrum, and it is also anticipated that the new spectrum will be agreed at the World Radio Communication Conference (WRC) to be held in 2015. The International Telecommunications Union (ITU) is currently at work on the International Mobile telecommunications (IMT) spectrum requirements for 2020 and beyond. After WRC15, ITU will have a clearer path for determining network system and technology requirements. Estimations of the development of 5G technology estimate that the basic research phase will take place until around 2016 and then the standards will be developed between 2016 and 2019. The product development will then be a major activity between about 2018 and 2020 and early deployment will occur around 2020.

VIII. CONCLUSION

Fifth generation technologies offers tremendous data capabilities and unrestricted call volumes and infinite data broadcast together within latest mobile operating system. It is user centric and offers ubiquitous terabit wireless connectivity. Cost reduction is the major benefit of 5G technology. It seamlessly bridges the physical and virtual world. So, this generation will change people's lives. Thus, 5g should make an important difference and add more services and features to the world over 4g.

IX. FUTURE SCOPE

5G technologies will enhance more if combined with Artificial Intelligence (AI). One can use his mobile phone to control his intelligent robot. Your Mobile will be able to automatically type the message what your brain thinks. 5G network technology will reveal a new era in mobile communication technology. Further evolution to 6G network can provide more benefits to user. The 5G mobile phones will have access to different wireless technologies at the same time and the terminal should be able to combine different flows from different technologies.

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