International Journal of Computer Networks and Applications
Volume 2, Issue 2, March – April (2015)

SURVEY ARTICLE

A Study on 5G Evolution and Revolution

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Abstract – As the cellular technology is growing at a rapid pace, users always seek for a set of appropriate packages all together, including all the current features in use. Hence, the search for a new technology is always the main concern of the foremost cell phone companies to out innovate their competitors. The main purpose of the fifth generation wireless technology (5G) is formulated to design the ultimate wireless world that is free from limitations and impediments of the previous technologies. 5G technology will mend the way most users access their mobile networks. So, this paper presents the evolution of 1G (First Generation) to 4G yielding 5G, introduction to 5G technology- its need, advantages and architecture.

***Index Terms* – 5G, BDMA(Beam Division Multiple Access), Nanocore, Cloud Computing , All-IP Network (AIPN).**

1. INTRODUCTION

In this modern world, we cannot think a single day without smart gadgets like mobiles, tabs. Communication makes our life comfortable and simple. The Modern world is being shortened due to the development of the technology. During the past few decades, the world has seen astonishing changes in the telecommunication industry due to advancement in the science and technology. Wireless and mobile communication technologies have been mass deployed, such as Long Term Evolution (LTE), 3G like CDMA2000, 4G, Wi-Fi, WiMax (IEEE 802.16), personal area networks, Bluetooth, ZigBee and sensor networks. The Mobile terminals include various interfaces, such as GSM, the most effective technology that is going into its decade of existence. The cellular technologies differ from each other based on the four main aspects: 1 switching schemes, 2 bandwidth, 3 data rates [3] and 4 radio access. Such differences have been noticed in all the previous wireless generations (1G, 2G etc.). The most advance cellular technology in the coming years might be 5G. Mobile phones in 5Gare configured to use very high bandwidth and are packet switched based wireless system. Area coverage under 5G is very large and throughput of the system is also very high. 5G technology uses CDMA (code division multiple access) and BDMA (beam division multiple access) that enables data rate greater than 100 Mbps at full mobility and higher than 1Gbps at low mobility. 5G includes some advance features like it is the most powerful and high demanding in the near future. By this time following features of the 5G technology have come to existence- High resolution for extreme mobile users, higher data rates and Quality of Service (QoS), bidirectional high bandwidth [4]. Now a day all the wireless and cellular networks are forwarding to all-IP network principle, means all data and signaling will be transferred to network layer via Internet Protocol [5].

2. EVOLUTION OF WIRELESS TECHNOLOGIES

The world has seen lots of changes in the realm of wireless communication network. Landline is becoming obsolete. Cell phones not only keep us connected to the world at large scale but also serve the purpose of entertainment. From 1G to 2.75G and from 3G to 5G the world of telecommunication has seen a number of improvements along with performance and quality of service with every passing day.

2.1. First-Generation (1G):

The 1st generation was launched for the voice services in early 1980‘s. All the systems were analog systems embedded with the frequency modulation technique for radio transmission using frequency division multiple access (FDMA). The channel capacity of the 1G system was approx 30 KHz [6] and frequency band of 824-894 MHz. It was based on the technology known as Advance Mobile Phone Service (AMPS).

2.2. Second Generation Systems (2G):

The 2nd generation was pioneered in 1990‘s and is a digital system. It is mainly used for voice communication with additional features like e-mails and SMSs. Digital modulation schemes used in 2G technology are time division multiple access (TDMA) and code division multiple access (CDMA) [8] with Frequency band of approximately 850-1900 MHz and is a GSM based technology that uses eight channels per carrier with a frame of 4.6 milliseconds (ms) duration and data rate of 22.8 kbps [12]. Family of this generation includes of 2G, 2.5G and 2.75G.

2.3. Third Generation Systems (3G):

3G service includes high speed mobile access along with Internet Protocol (IP) services. The main features of 3G include wireless web base access, multimedia, email, as well as video conferencing. The 3G WCDMA air interface was designed for packet switching-based wireless services, so that

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computer, telephones and other devices may share the same wireless network and Internet anytime [13]. 3G system offers data rates up to 2 Mbps over 5 MHz channel carrier width, depending on the device mobility and spectrum efficiency. The data rate depends on the environment surrounding the device (like 144 kbps in satellite communication [6], 384 kbps in urban areas). Frequency band allotted under 3G is 1.8 - 2.5 GHz.

2.4. Fourth Generation Systems (4G):

4G is an advance version of 3G and 2G standards. The 3GPP is recently standardized LTE Advanced [14] as future 4G standard. 4G frameworks are expected to provide a secure IP based network with facilities such as voice, streamed multimedia and data at much higher rates as compared to previously existing technologies. One common characteristic of the new services facilitated by 4G is their demanding requirements in terms of QoS Wireless broadband access, Multimedia Messaging Service (MMS), video chat, mobile TV, HDTV and Digital Video Broad-casting (DVB) are being developed in the 4G network.

3. FIFTH GENERATION (5G)

5G is the further step in the evolution of mobile communication. It is not deployed yet. But it will change the manner in which cellular plans are offered worldwide. Main challenge for the deployment of 5G wireless system will be to increase system capacity and quality of service within the limited frequency spectrum, whose frequency band will be 3-300GHz and the Bandwidth of 1Gbps or higher. Comparison among various wireless technologies can be seen in table 1.

Technology	**1G**	**2G**	**3G**	**4G**	**5G**
Evolution	1970-1980	1990-2004	2004-2010	2010	2015
Frequency Band	824-894MHz	850-1900MHz	1.8-2.5GHz	2-8GHz	3-300GHz
Speed	2.4Kbps	64Kbps	144kbps- 2Mbps	100Mbps- 1Gbps	Higher than 1Gbps
Signal	Analog	Digital	Digital	Digital	Digital
IEEE Standards	802.11	802.11b	802.11g/a	802.11n	802.11ac
Standards	AMPS,TACS	GSM based, GPRS (50Kbps), EDGE (1Mbps)	UMTS/HSPA	LTE/LTE Advance, WiMax, Wi-Fi	WWWW
Switching	Circuit	Circuit, Packet	Packet except for air interface	All Packet	All Packet
Core Network	PSTN	PSTN	Packet N/W	Internet	Internet

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Handoff Type	Horizontal	Horizontal	Horizontal	Horizontal & Vertical	Horizontal & Vertical
Services	Voice Telephony	Digital voice, SMS, Higher capacity packetized data	Integrated high quality audio, video and data	Dynamic data access, wearable devices	Dynamic information access, wearable devices with AI capabilities.

Table 1: Basic comparison among 1G, 2G, 3G, 4G and 5G Technology

5G will be a technology that will provide all the possible applications, by using any one universal device and interconnecting most of the pre-existing communication infrastructures devices. The 5G radio terminals will be an upgradable cognitive radio- enabled terminals and will be appropriate in multimode phase. All the upgradable software should be able to be downloaded from the Internet on the run, hence it will be easily approachable. The 5G mobile networks will have to concentrate on the development of the user terminals where the terminals will be having the access to the different wireless technologies at the same time and will unite various flows from various technologies. Besides, the terminal will make the ultimate choice among various different wireless access network providers for a given service.

As a user point of view, the major difference between previous generation technologies and expected 5G techniques must be something else than increased maximum throughput; other requirements include [3]:

- It could make better interoperability and will be more feasible.
- Improved data coding and modulation techniques.
- Lower battery consumption.
- Lower outage probability.
- Better coverage and high data rates.
- Many concurrent data transfer paths.
- Evolving the radio access and allows applications with lower tolerance.
- Feasible to1Gbps and higher data rate in mobility.
- More secure better cognitive radio/SDR Security.
- More system level spectral efficiency.
- World Wide Wireless Web (WWWW), wireless-based web applications.
- Full multimedia accessibility.
- Applications cumulative with Artificial Intelligent (AI).
- Not harmful to human health.
- Less traffic fees due to low infrastructure deployment costs.
- Smart beam antenna systems.

3.1. 5G ARCHITECHTURE

NANOCORE: Globalization is the latest offering of the innovatory technology. Convergence in the technology is the main focus of network systems for making it possible in the case of performing homogenous tasks. The digitization is the transformation of atoms into bits, the digitization of all media content. The sounds, images, words etc. will get transformed into digital form of information and we will be able to elaborate the potential relationship between them and thereby enabling them to flow across the available and newly introduced platforms. The 5G Nanocore is a confluence of below mentioned technologies. These technologies have their own effects on exiting wireless network which makes them in to 5G [6].

- Nanotechnology.
- Cloud Computing.
- All IP Platform.

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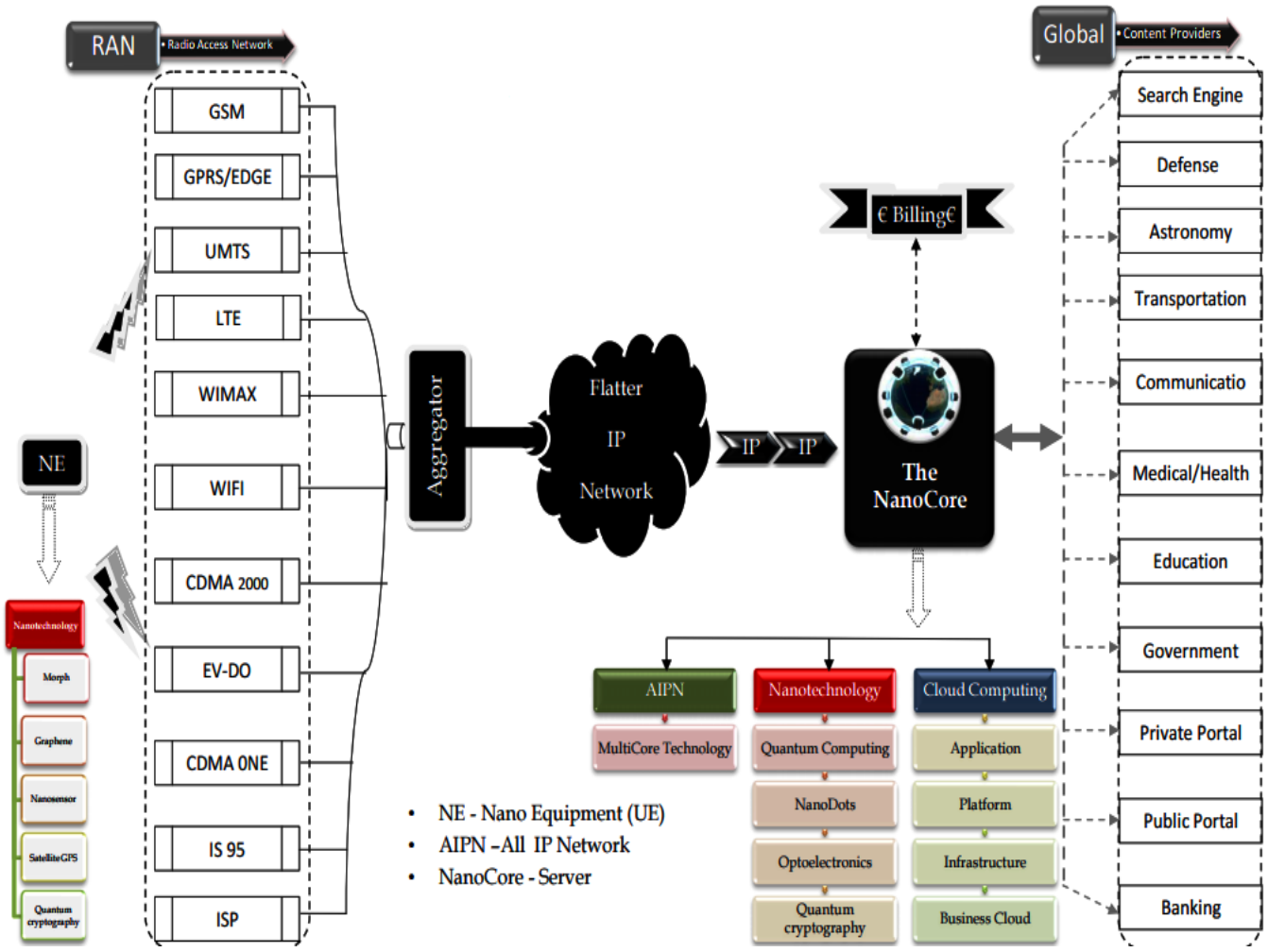

Figure 1 The 5G Nanocore Architecture [16]

4. NANOTECHNOLOGY

Nanotechnology is an application of nanoscience to control process on nanometer scale (0.1 to 100nm).The term 'nanotechnology' was introduced by Nori Taniguchi in 1974 at the Tokyo international conference on production engineering Nanotechnology has shown its impact on both mobile as well as the core network. Powerful computation and communication are ready to serve the users in an intelligent way. With nanotechnology, mobile phones can act as an intelligent sensors that have applications in many industries like in transportation, medicine, safety and communications.

NanoEquipment (NE): In 5G Nanocore, the mobiles are known as NanoEquipment as they are stimulated with nanotechnology. Mobile devices along with intelligence, lodged in the human environment, create a new platform that enables ubiquitary sensing, and communication. The main tasks of the NanoEquipments are:

- Self-Cleaning – the phone cleans by itself.
- Self-powered – the phone derives its energy/power from the sun, water, or air.
- Sense the environment – A phone will tell you about the weather, the amount of air pollution present, etc.
- Flexible – bend but not break.
- Transparent – "see through" phones.

Morph: The concept of Morph was developed by Nokia together with the University of Cambridge (UK).

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Figure 2 Morph of 5G [16]

Morph is an idea that demonstrates the flexibility, stretchability and ability of the future mobiles to get transform into different redical shapes. It indicates the extreme functionalities that nanotechnology might be capable of delivering.

5. CLOUD COMPUTING

Cloud computing is a unique and an innovative technique to access various documents, videos and music files etc from any place without carrying any data storage devices. Best example is Gmail. By uploading the data on the cloud, user can access it anytime and anywhere in the whole world. It is a technology that uses internet and central remote server to maintain its applications and data.

In Nanocore, users try to access their private account form a global content provider in form of a cloud. Cloud computing shows the significance of networks and promotes network development. It requires reliable and secure service providers and capabilities that operators have deep expertise in. This could make users to obtain much more real-time applications to utilize 5G network efficiently.

Three main segments of Cloud computing are:

- Applications
- Platform
- Infrastructure

Figure 3 Pros and Cons of Cloud Computing

6. ALL IP NETWORK

The All-IP Network (AIPN) is introduced by 3GPP system to meet the highly increasing demands of the mobile telecommunications market. For the real-time data applications delivered over mobile broadband, televisions, landlines, internet and related services etc, wireless operators are turning to flat IP network architectures (common language), that reduces the number of technologies used and make easier to develop new services.

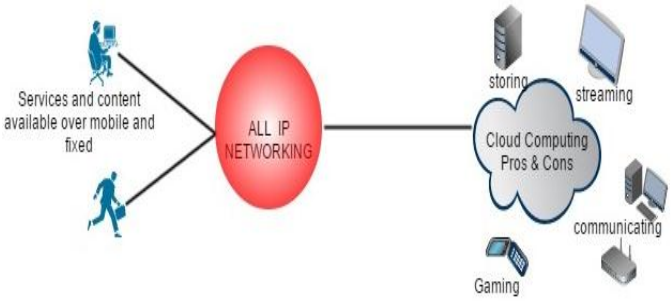

Figure 4ALL IP Network

AIPN is primarily focused upon enhancements of packet switched technology to provide a competitive edge in terms of both cost and performance.

The benefits of the flat IP architectures are- universal seamless access, decoupled radio access, lower costs, core network evolution, and reduced system latency delay. There is highly growing demand for advanced telecommunication services on wired and wireless Next Generation Network

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(NGN) infrastructures and fast growing demands for the same in the enterprise too. After few years, more than 10 billion fixed and mobile devices will be connected via Internet to add to more than one billion already connected. All of the upcoming services are going to be deployed over full IP-based architectures.

An important challenge in the telecommunication field is that the network should be flexible and improved to provide larger number of connections to multiple users without losing the quality within the limited frequency spectrum available with the increased system capacity. if Communication is made possible within limited frequency spectrum, then time is the biggest challenge to be tackled properly without any loop holes. So this is achieved by the implementation of multiple access techniques like OFDMA (Orthogonal Frequency Division Multiplexing), CDMA, TDMA, FDMA.

OFDMA (Orthogonal Frequency Division Multiple Access) technique divides and allocates the available frequency resources to maximize the resource utility efficiency [11]. In OFDMA,the multi user capability is achieved by assigning each user a sub set of OFDM subcarriers. OFDM is a digital transmission technique that uses a large number of carriers spaced apart at slightly different frequencies.

FDMA (Frequency Division Multiple Access) is a technology in which the total available bandwidth is divided into frequencies [14]. But, CDMA (Code Division Multiple Access) separates calls by codes. Time Division Multiple Access (TDMA) divides of calls on time basis.

Beam Division Multiple Access (BDMA) is the latest allocation technique in which an orthogonal beam is allocated to each mobile station. According to BDMA concept, the antenna beam is divided and allocated to the locations of the mobile stations to provide multiple access in order to increase the capacity of the system. As mobile stations and the base stations are in Line of Sight, both can transmit beams that directed to each other's position for proper communication, and reducing interference. But When the mobile stations are positioned at different angles compared to the base station, the base station will transmit beams at different angles.

The working is like one mobile station does not use one beam exclusively, still the mobile stations are positioned at similar angles and will keep on sharing the beam to communicate with the base station. The MS's that are sharing the same beam will divide the frequency or time resources and will use the orthogonal resources. According to the cellular communication environment, a base station can change the number, widths and direction of the beams adaptively with ease.

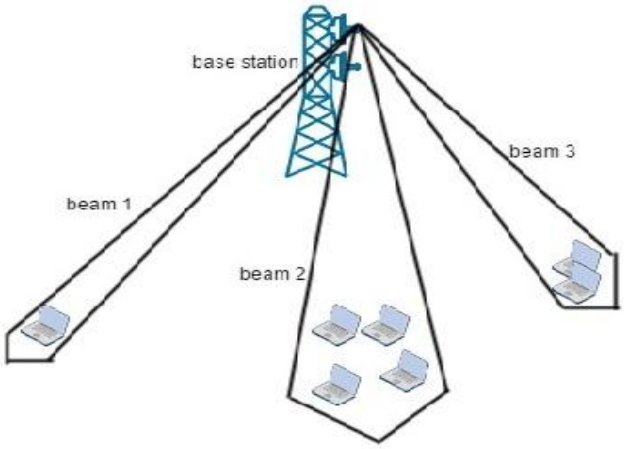

Figure 6 BDMA

3D mode of division will happen in the case of beams and a spatial reuse of frequency or time resources can be maximized. First slot of communication is that the base station and the mobile station do not know each other's position. MS will detect their positions and moving speeds to transmit the entire information to the BS. The second stage is taken care by the base station (BS). Based on information received from the mobile station, Base station will calculate the direction and width of a downlink beam. After that, the base station will transmit the downlink beam to the mobile station with all the calculations regarding the direction and width.

7. FUTURE SCOPE

Nanocore combines with Artificial intelligent (AI) will be able to control an intelligent Robot using a mobile phone. Human life surrounded by artificial sensors could be able to communicating with mobile phones such that Mobile can automatically type the message what one's brain thinks. Communication with people on other planets might be possible using 5G mobile phones.

8. CONCLUSION

In this paper we have surveyed 5G wireless technology. 5G technology is modeled as an open platform that offers the best Operating System and lowest cost for a specific service using one or more than one wireless technology at the same time. There are lots of improvements from 1G to 5G wireless technology. 5G include latest technologies such as SDR, cognitive radio, cloud computing, nanotechnology based on All IP Platforms along with high security, high data rate. 5G is successful to grab the attention of almost all of us in field of communication. Hopefully the idea of keeping the network simple and giving more functionalities to the terminals (end

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nodes) will become reality in future wireless generation of networks, referred as 5G and it will include such features that will make it most dominant technology in near future.

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