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Case Study on Evolution of Wireless Technologies

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Abstract— Communication between people while moving has been evolved from the ancient time. We can see the evidence from the time of Marconi (1897). New wireless communication methods and services have been adopted by people throughout the world. During the last two decades, the growth in wireless communication has been remarkable. The digital switching techniques, large scale integration and other miniaturization technologies like 3G,4G/5G etc. have been the major contributory factors in this regard.3G has been launched in India in line with other countries of the world. Presently,in India,the number of mobile users are over 950 m which is expected to be about 1b in 2015.Emerging technologies such as 4G and 5G has attracted the attention of industry and media. The 4G and 5G wireless networks remain highly relevant in the area of communication. Currently they are supporting over 80 % of all networking activities. Recent surveys says that the use of 4G and 5G technologies will expand dramatically during the next three to five years as the world's two largest markets, India and China has open their doors wide to these latest technologies. With the advent of Internet, Whatever the new technology is, whether it is a television, cellular phone, or refrigerator, we need a better, faster, efficient and accurate access to information. To fulfill such a powerful requirement, we need efficient pervasive, high-speed wireless connectivity. A number of technologies like Wi-Fi, WI-Max, Bluetooth, 802.11 etc. are currently existing to provide the users with high speed wireless connections. They provide the users with both short-range and long-range communication. The implementation of 4G /5G will be the ultimate goal in the field of communication.

Keywords—Zero Generation, First Generation, Second Generation, Third Generation, Fourth Generation, Fifth Generation

I. INTRODUCTION

During the past two decades we can see that the wireless communication has brought in an unimaginable revolution in the field of communication. The mobile communication industry has exceeded the growth of all other communication fields. The amount of mobile data traffic is doubling each year due to the increase in communication traffic and increase in the usage of smart phones. Transferring data over a distance without using any physical mediums like wires etc. can be referred to as wireless technologies. The coverage distance may be short or long. The term wireless means having no wires. In networking terminology, wireless is a term used to describe any computer network where there is no physical wired connection between the sender and receiver, whereas the network is connected by radio waves or micro waves to maintain communication. They use NICs at routers in place of wires. Wireless technologies have made tremendous growth in the last two decades. In the past few decades, Wireless communication has been experiencing five generations of changes from 0G to 5G.The era of wireless communication has started in early 1970s.Among this; the latest evolved one is the fifth generation technology. It offers large number of advanced features which can improve its demand in future. Nowadays various mobile and wireless technologies like UMTS, LTE, Wi-Fi ,WI Max and also sensor networks or Personal Area Networks like Bluetooth, Zigbee etc. are present. In this advanced world the entire wireless industry is concentrating on standardization of the fourth generation cellular networks[1][2]. The 4G standards will get concluded in next two years. The entry of 5G technology into the mobile market place will introduce a new revolution in the same way as the international cellular market. The two important features of these emerging technologies are better and fast access to information. The currently existing technologies like Bluetooth and 802.11 provide a high speed digital wireless communication. The zero generation technology refers to those technologies existed prior to both cell phone and mobile technology, which included the radio telephone systems etc. The first generation technology which is the cellular technology had made large scale wireless communication possible. The digital communication in the second generation has replaced the older analogy communication, which in turn has improved the quality of wireless communication. The next evolved third generation technology appended the data communication to the voice and as a result of this, a network supporting both data and voice communication has emerged. The 4G technology which is an extension of 3G technology, with higher bandwidth, supports high quality audio/video streaming over an end to end Internet protocols [3]. In this advanced world, a high speed broadband communication technology is required for the efficient utilization of resources. So the next generation, ie, Fifth generation technology concentrates on broadband wireless connectivity. It is an all-IP based model for mobile and wireless network operations capable of fulfilling the increased demands of cellular communication [4][5][6][7]. Presently a lot of research work is going on in the field of wireless technology. Detailed study in the field of 5G nanocore technology is going on and is clearly described in [8]. The rest of the paper is structured

as follows. Section II describes the evolution of wireless technologies. Section III presents an Eyeview on the generations of wireless Technology: 1G-4G.Section IV describes about the Fifth generation technology. The paper is concluded in section V and the references to this case study is mentioned at the last part.

II. EVOLUTION OF WIRELESS TECHNOLOGIES

The number of telecom customers is increasing day by day. As a result the wireless technology has advanced with great speed. With the evolution of new technologies, the capacity and performance of wireless communication system had an exponential improvement. Due to the emergence of wireless technology,the systems can be installed and reconfigured with minimum cost and disruption (adds flexibility). Moreover the users can access information at anytime from anywhere (increases the mobility). The revolution ranges from the PTT, OLT, MTS etc. in the zeroth generation to the wireless wide area networks like GSM mobile phones and 3G mobile phone technologies in the fourth and higher generations.

A. *Zero Generation Technology(0G)*

The mobile telephone services came into existence after the Second World War. Radio telephones were the major attractions of this generation technologies. They were the predecessors of 1G cellular telephones. The main technologies coming under 0G includes PTT, MTS, IMTS, AMTS, OLT and MTD.

1) PTT (Push-To-Talk)

PTT means Push-To-Talk. It is also called Press-To-Transmit.This is a conversation method on half-duplex communication line which uses a button to switch from voice receiving mode to transmit mode. A best example of this method is an air traffic controller. The controller communicates in the same radio frequency to all aircrafts under its supervision. This is done using the procedure words like over or out. The use of such procedure words provides an order during the conversation. This makes the users aware of each other's actions and intentions. PoC is the advanced version of PTT. It is a cellular phone network service option which permits users to use their phone as a compact easily transportable battery operated radio transmitter and receiving set with unlimited range. In this process, a single person can reach an active talk group with a single button press. The problem with this method is that, it requires an operator for controlling the calls.

2) MTS (Mobile Telephone System)

MTS is a VHF (Very High Frequency) radio system used to connect to the external PSTN (Public Switched Telephone Network). It is an operator assisted pre-cellular technique which was introduced in June 17,1946. It is equivalent to land dial phone service. The actual equipment weights about 36 kg. Initially only three channels were available for all the users in the metropolitan area and later 32 channels across 3 bands were added to the existing equipment. This technique was used till 1980s. It used 25 VHF radio channels in USA and Canada.

3) IMTS (Improved Mobile Telephone Service)

IMTS is a VHF/UHF radio system used to connect to the external PSTN. It was introduced in 1964 and the MTS technique and replaced the operator assisted system with direct dial system. The Motorola TLD-1100 series is a common IMTS phone that performs channel scanning and digital decoding process by using two circuit boards of 8 inches square and all logic was being performed with discrete transistors. IMTS system had 25 watts of transmitter power at the mobile station and 100-250 Watts at the terminals. These are full-duplex,that means the user can talk to and hear the other party at the same time. IMTS base station sites requires an area of 40-60 miles in diameter. The major disadvantage is that it constantly limits the number of subscribers. This result in low quantity sales and production of IMTS phones.

4) OLT (Norwegian for Offentlig Landmobil Telefoni, Public Land Mobile telephony)

OLT was the first land mobile telephone network in Norway. It was introduced in 1966 and continued till 1990. OLT operated in the 160 MHz VHZ band with a frequency modulation of 160-162 MHz (mobile unit) and 168-170 MHz (bas station). Some of them were full-duplex and some were semi-duplex.

5) AMTS (Advanced Mobile Telephone System)

AMTS is a zero generation technology for radio communication. AMTS operates at a frequency band of 900MHz. The successor of AMTS is called High Capacity Mobile Telephone System (HCMTS).

6) MTD (Mobile Network)

MTD is a manual mobile phone system having a frequency band of 450 MHz It was introduced in 1971 in Sweden and lasted till 1987. Following are the two early examples of 0G technology:

- In 1971, Finland launched their first commercial mobile phone network, called Autoradiopuhelin.
- In 1972, Germany launched their second commercial mobile phone network called B-Netz.

B. *First Generation Technology (1G)*

In 1980s the analog mobile phone system commonly known as cell phones was emerged. They are the standard first generation technologies.1G uses analog radio signals. Here the voice calls are modulated to about 150MHz while

transmitting between the radio towers. This uses the most predominant technology called FDMA. 1G technology supports a speed of 2.4kbps. Its drawbacks includes low capacity, poor voice links, unreliable handoff and unsecured data transmission. All these makes voice calls susceptible to third party eavesdropping. Compared to the successors, 1G shows the advantage that it survives longer distances as the analog signals have a smooth curve as compared to the jagged angular curve of digital signal. Before going into details about the 1G technology we have to analyze the features of FDMA. FDMA (Frequency Division Multiple Access) is a channel access method used with both analog and digital signals. Here all the users share the frequency channel simultaneously but each of them transmits at single frequency. It requires high performing filters in the radio hardware. They are insensitive to the near-far problem in networks. Even though FDMA allows multiple users to access the transmission system simultaneously, they face the problem of interference in the frequencies due to crosstalk and this in turn leads to disruption in the transmission. The main technologies coming under 1G are AMPS, NMT and TACS.

1)AMPS (Advanced Mobile Phone Service)

AMPS was introduced in 1978 and developed by Bell Lab to replace the radio phone services, especially IMTS. It was one of the modern cellular systems.

2) NMT (Nordic Mobile Telephone)

The first fully automatic cellular system is NMT. Due to the massive increase in network congestion and requirements of manual mobile phone networks, NMT was introduced in 1981. NMT is an analog technology. NMT-450 and NMT-900 are the two variants. The numbers, 450 and 900 defines the bandwidth used. Among this NMT-900 (introduced in 1986) carries more channels. The free and open availability of NMT specifications pushed their price down. The cell size in NMT ranges from 2 km to 30 km. This helped them to serve more simultaneous callers at a time. It supports full duplex transmission. It has automatic switching mechanism (ie, dialing). With the use of FFSK modulation, the signaling transfer speed varies between 600-1200 bits per second. It supports robust data and messaging services. The major drawback in the case of NMT is that voice traffic was not encrypted. Therefore by using scanners, it is possible to listen to calls.

3) TACS (Total Access Communication System)

TACS is an out dated version of AMPS. This was initially developed by two companies named Vodafone and Cellnet. This communication system was introduced in the late 1985. TACS cellular phones was being used in European countries. ETACS is an extended version of TACS and it provides more channels for data transmission.

C. Second Generation Technology (2G)

As demand for voice plus telephony, text messaging and limited circuit switched services increased, the second generation technologies were introduced in 1991. They introduced the first fully digital mobile phones. These were developed on the GSM standards. As the entire conversations were digitally encrypted, only the required or intended receiver can receive and read data. This in turn provided secrecy and safety to the data and voice calls. They introduced SMS text messages and provided greater mobile phone penetration levels. It enabled the services like MMS, picture messages etc. 2G enabled voice transmission with digital signal supported a transmission speed of 64 bps. This generation technology can be based on TDMA or CDMA. Digital coding in 2G improved the voice clarity and reduced the noise in the transmission line.2G used CODEC (Compression-Decompression Algorithm) to compress and multiplex digital voice data. Data like emails or softwares cannot be transmitted in 2G and the only data that it can transmit is the digital voice calls and the supplementary data like date and time. By using the second generation technology, the digital signal consumed less battery power, which in turn provides long life to the batteries.

1) TDMA (Time Division Multiple Access)

TDMA is a shared medium channel access method,which divides the signals into time slots. It allows many users to share same frequency channel by dividing signals into different time slots. It is a type of time division multiplexing with multiple transmitters. TDMA shares single carrier frequency with multiple users. It is a non-continuous type of transmission in which the time slots can be assigned according to the demand especially in Dynamic TDMA. Its major drawback is the frequency and slot allocation complexity.

2) CDMA (Code Division Multiple Access)

CDMA is multiple channel access method where several transmitters can send information simultaneously over a single transmission channel. It allows users to share band of frequencies using spread spectrum multiple access technology and special coding scheme, so that the interference between the users can be avoided. CDMA is applied commonly in GPS application. CDMA provides flexible allocation of resources. The spread spectrum techniques used in CDMA uses a transmission bandwidth of higher magnitude than that of the required signal bandwidth. This increases the security and resistance to jamming. It efficiently reduces the narrow band interference and multi path interference. CDMA supports frequency reuse ie, the same frequency can be reused in multiple cells.

3) GSM (Global system for mobile communication)

The European Telecommunications Standards Institute developed this standard. GSM act as an actual standard for global mobile communication. It is a digital circuit switched network used for full duplex voice telephony. The establishment of

GSM made International Roaming facility more common. The GSM network structure includes a base station subsystem, network and switching subsystem, GPRS core network and an operations support system. GSM is a cellular network. The five basic cell sizes in GSM are macro, micro, pico, femto and umbrella cells. In macro cells the base station antennae is installed on a building above average rooftop level. In micro cells, the antennae height is under average rooftop level. Pico cells supports coverage area of a few dozen meters. The femto cells are designed for small business environment and uses broadband Internet connections. Umbrella cells cover shadowed regions of smaller cells. GSM operates at 900-1800 MHz carrier frequency. Subscriber Identity Module (SIM) is an important feature of GSM. It is a detachable smart card containing the user's subscription information and phone book. GSM offers an affordable level of security and it uses a shared key and challenge response mechanism for authenticating the users. So it offers good confidentiality and authentication. It uses a large number of cryptographic algorithms for the purpose of security in the networks. Even after implementing these mechanisms GSM lacks proper authorization facilities.

D. 2.5 Generation Technology (2.5G)

2.5G technology was those cellular wireless techniques developed in between 2G and 3G technology. It is implemented at packet switched domain along with the existing circuit switched domain. The major technologies coming under 2.5G are GPRS, MMS, WAP and SMS.

1) GPRS (General Packet Radio Service)

GPRS is a packet oriented data service. It was standardized by ETSI. Now GPRS is maintained by 3GPP. The volume of data transmitted describes its charges especially billed per minute of connection time. It has variable throughput and latency which depends on number of users sharing the service concurrently. With the use of time division multiple accesses (TDMA) channel, GPRS provides moderate speed of data transfer. A GPRS connection is established using the access point name as a reference. GPRS offers SMS and MMS messaging, broadcasting, push to talk over cellular network service, instant messaging services, point-to-point and point to multipoint services and it supports the protocols like IP, PPP and X.25.

2) WAP(Wireless Application Protocol)

WAP is used over a mobile wireless network for accessing information. Before the existence of WAP,the mobile service providers had very less opportunities for interactive data services. The interoperability of WAP equipment is allowed by a protocol suite described by the WAP standard. The actual WAP model provided a simple platform for access to WML (Wireless markup language) services and email using mobile phones.The initial design of WAP aimed at protocol independence across different protocols. The WAP browser is a browser for mobile devices that uses the protocol.

3) MMS (Multimedia Messaging Service)

MMS is one of the standard way to send messages which has multimedia content, through mobile phones. It is an extended version of Short message service (SMS) which allows only length of 160 characters. MMS can also be used to send photos, videos etc. from camera equipped mobile phones. Open Mobile Alliance (OMA) developed this standard. In order to distribute multimedia content, MMS does not utilize data plan
maintained by the operator.

4) SMS(Short Message Service)

The SMS concept was developed on 1984.The main idea of SMS is to transport messages on the signaling path to control telephone traffic. The first SMS message was send through Vodafone GSM network in United Kingdom on December 3,1992. SMS is a service component used in phone, web or mobile telecommunication systems for text message service. SMS uses standardized communications protocols for exchanging short text messages. The SMS gateway providers allow SMS traffic between business and mobile subscribers. Threaded SMS which is a visual styling orientation of SMS message allows us to send messages to and from a contact in chronological order on a single screen. SMS messages were send to SMS center which provides a store and forward mechanism, from were it is send to the recipient. This transmission is done using the Mobile Application Part (MAP) of the SS7 protocol. Messages are sending with MAP MO and MT- forward SM operations and its payload length is 140 octets.

E. 2.75 Generation Technology (2.75G-Enhanced Data Rates For GSM Evolution)

In this technically advanced world, the mobile devices are used to watch streaming videos and download mp3 files with high speed, this is what EDGE provides. EDGE provides a speed of 180 Kbytes per second. This technology works in GSM networks and can work on any network deployed with GPRS. It is also known as IMT-SC or single carrier technology with high speed data transmission. It is flexible to carry both packet switched and circuit switched data. EDGE supports black berry and N series mobile phones. The demand for EDGE increased because there was no need of any additional hardware, software etc. for using this.

F. Third Generation Technology (3G)

The Telecommunication System based on the International Telecommunication standards under the IMT-2000 came to be known as 3G. It provides advanced network capacity through improved spectral efficiency (the amount of data transmitted over a bandwidth in a specific digital communication system).This supports video calls, broadband networks

and wide area wireless voice telephony. They provides advanced technologies like HSPA with a downlink speed of 14.4Mbit per second and uplink speed of 5.8 Mbits per second. It supports high speed technologies like WI-Max, UMTS, CDMA2000, 3GPP etc.. It is a complete packet switched network technology. It makes use of both TDMA and CDMA. 3G provides enhanced audio and video streaming, higher data speed and supports video conferencing, WAP browsing, IPTV etc.

1) CDPD (Cellular Digital Packet Data)

CDPD is a wide area mobile data service which operated on the unused bandwidth between 800 and 900 MHz It supports a data transmission speed of 19.2 Kbits/sec. This technology was developed in the early 1990s. They had very less consumer products. The basic elements of CDPD includes end systems (mobile end system and fixed end system), intermediate systems (generic intermediate system and mobile data intermediate system).End systems refer to those physical and logical systems that exchange data. Intermediate systems are those systems that store, forward and route the information. CDPD is designed in such a way that it is independent of the location, and service providers. This increased coverage area and provided interoperability between products from different vendors.

2) CDMA 2000:

CDMA 2000 is also known as C2K or IMT Multi-Carrier. For the purpose of sending data, voice and signaling between different mobile phones, CDMA 2000 uses CDMA channels. One of the major highlight in the case of CDMA2000 is that it is backward compatible. They are the registered trademarks of the telecommunication industry association in countries like USA. The successor of CDMA 2000 under fourth generation technology is called Ultra Mobile Broadband.

3) 3GPP (3rd Generation Partnership Project)

The 3GPP is a joint venture by a group of telecommunication association known as Organizational Partners. This technology was started on December 1998, which encloses radio, core network and service architecture .The four technical specification groups of 3GPP includes GERAN(GSM-EDGE Radio Access Network),RAN(Radio Access Network),SA(Service and System Aspects) and CT(Core Network and Terminals). The highest decision making body in 3GPP is the Project Coordination Group. It manages the overall time frame and progress in work. 3GPP2 is a standard technology coming under 3G standards CDMA-2000.

4) Wi-Max (Worldwide Interoperability for microwave Access)

Wi-Max is a technology standard for long range wireless networking. Its equipment exist in two basic forms- Base stations, installed by Service providers to deploy the technology in a particular coverage area and receivers, installed at clients. They support a networking model like fixed wireless broad band Internet access and LTE technology. It provides a data rate of 30-40 M bit/sec. The 2011 updation increased this to 1Gbit/sec for fixed station. The Wi-Max forum describes Wi-Max as a standard based technology which enable the delivery of last mile wireless broadband access and act as an alternative to cable and DSL. Wi-Max provides mobile broadband connectivity across countries through a number of devices. They support VoIP and IPTV services to a great extent. A large number of examples can be shown for the deployment of Wi-Max. After the Tsunami in 2004, Wi-Max was used for communication purpose in Aceh, Indonesia. Moreover Wi-Max helped FCC and FEMA in their communication efforts in the areas affected by Hurrical Katrina. Both indoor and outdoor versions of Wi-Max gateway devices are available from different vendors. Wi-Max is based on IEEE 802.16ee-2005 standard approved in December 2005. There is no uniform global licensed spectrum for Wi-Max but Wi-Max Forum has specified three licensed spectrum named 2.3GHz,2.5GHz and 3.5GHzin order to decrease the cost. The most important advantage of WI-Max over other technology is its spectral efficiency. They use unlicensed spectrum to provide access to local networks. The major competitors for Wi-Max are UMTS and CDMA 2000.

5) UMTS (Universal Mobile Telecommunication System)

UMTS is a GSM based 3G mobile cellular network systems. This is developed and maintained by 3GPP. They use WCDMA radio access technology and provide higher bandwidth and spectral efficiency for mobile network operators. UMTS is a broadband, packet-based transmission of text, video, multimedia data and digital voice with a transmission rate of 2 megabits per second. UMTS includes the radio access network (UMTS terrestrial radio access network), the core network (Mobile application part), and the authentication of users using SIM (Subscriber identity module) cards. UMTS provides a theoretical data transmission rate of 42 Mbits/s when HSPA+ is implemented in the network. UMTS uses a combination of terrestrial wireless and satellite transmission. Once UMTS is fully implemented, irrespective of the location, the users can be connected to the Internet. The higher bandwidth of the UMTS supports video conferencing and provides enhanced billing services like pay-per-bit, pay-per-session, flat rate etc.. The electromagnetic radiation spectrum for UMTS is 1885- 2025 MHz for IMT-2000 and 1980-2010 MHz and 2170-2200 MHz for satellite systems. UMTS provides three different air interfaces W-CDMA, TC-CDMA, W-SCDMA.

- W-CDMA (Wideband Code Division Multiple Access) is a radio technology used in UMTS and is a part of ITU IMT-2000 family of 3G standards. It supports both FDD and TDD. This is a spread spectrum modulation technique using a channel whose bandwidth is higher than that of the required data transmission rate. W-CDMA uses DS-CDMA (Direct sequence code division multiple access) channel access method with a 5MHz channel. The most widely discussed drawback of W-CDMA was the large spectrum usage.

- TD-CDMA (Time Division-CDMA) channel access technique is standardized as UTRA-TDD HCR. It uses an increment of 5MHz spectrum and each time slot is divided into 10 ms frames containing 15 time slots of 1500 per second. Fixed time slots are allocated for both uplink and downlink. They are used in multiplex streams to and from multiple transceivers. They do not need any separate frequency bands for uplinking and downlinking data. TD-CDMA can be used freely for low mobility scenarios in micro and Pico cells.

- TD-SCDMA (Time Division Synchronous CDMA) uses adaptive synchronous CDMA along with TDMA channel access method. When compared to other air interfaces TD-SCDMA is not part of UMTS but later it has been added to Release 4 specification. TDSCDMA is also known as IMT-CDMA TDD . They make use of TDD scheme in contrast to W-CDMA which uses FDD.It can reduce number of users in each time slot which in turn reduce the implementation complexity of multi user detection in the networks.

6) DECT(Digital Enhanced Cordless Telecommunications)

DECT was originated in Europe and is used for developing cordless phone systems. They were developed by ETSI (European Telecommunications Standards Institute) in different phases. They can also be used for various purposes other than cordless phones. DECT is a digital wireless telephone technology which uses TDMA to transmit radio signals to phones. They are mainly used in home and small office systems. It is a portable unit for accessing fixed telecom networks via radios without specifying any internal aspects of the fixed networks. The gateway and a base station plays an important role in establishing connectivity. In most cases the gateway connection is made with the external PSTN. The major applications include Domestic cordless telephony, wireless LANs, wireless local loop, cordless terminal mobility, home cordless phones and GSM/DECT inter networking. It is possible to deploy GSM and DECT together in a telephone and can work seamlessly.

G. 3.5 Generation Technology(3.5G)

3.5 G technologies are about six times faster than the UMTS based 3G technology. The basic technology in 3.5G is the HSDPA (High-Speed Downlink Packet Access). HSDPA is a mobile telephony protocol that performs high speed data transfer and belongs to the High-Speed Packet Access family. This is a packet based data service with a speed of 8-10 Mbit/sec. Later in 2013, it was calculated that HSDPA can support a data transmission speed of 42.3 Mbit/sec and HSPA+ offers a speed of 337.5 Mbit/sec. A new transport layer channel called High-Speed Downlink Shared Channel is added to UMTS release 5 for the HSDPA. This is done with the following three physical layer channels:

- HS-SSCH (High speed shared control channel) informs the user that data will be sent two slot ahead on HS-DSCH.

- HS-DPCCH (High speed dedicated physical control channel) carries acknowledgement information and data about current channel quality indicator.

- HS-PDSCH (High speed physical downlink shared channel) is mapped to this HS-PDSCH. Data is transmitted with error correction bits. So there is no need of retransmission in the case of minor errors. But when the retransmission is required, the device saves the packet and then combines it with the retransmitted packet to recover the error free data packets.

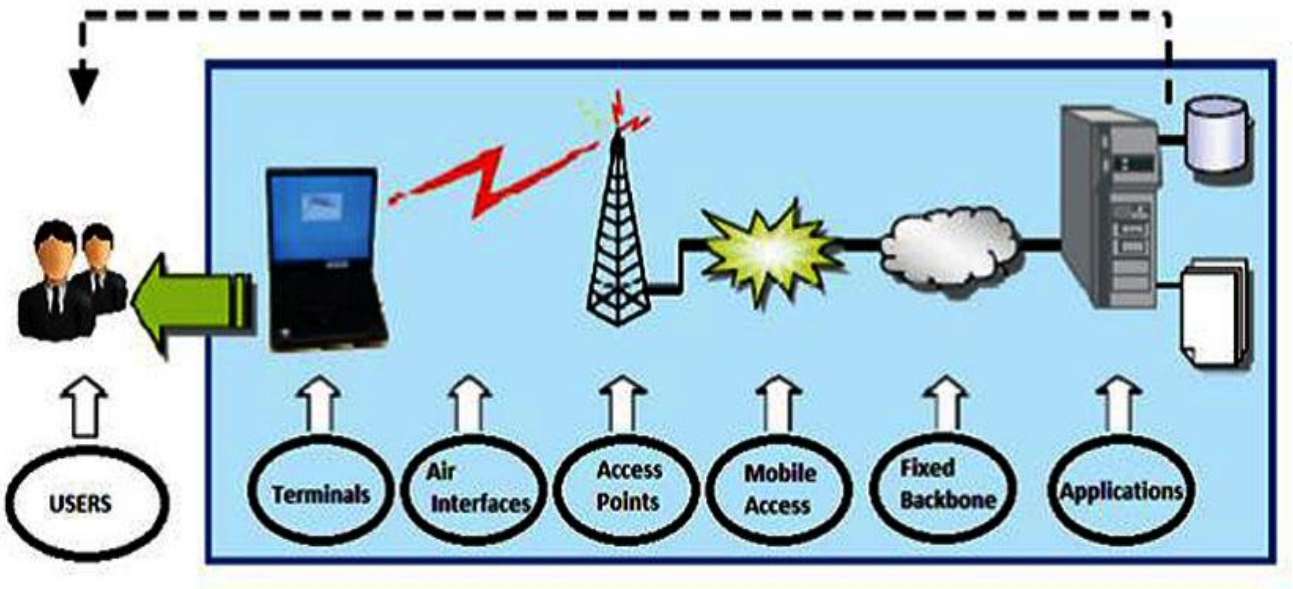

Fig. 1. 4G Mobile communication vision

H. 3.75 Generation Technology (3.7G)

The technology that is beyond the well-defined 3G system is called 3.75G technology. HSUPA (High Speed Uplink Packet Access) is the major evolution technology of 3.75G.HSUPA and HSDPA are complementary to each other. It has an uplink speed of 5.75 Mbit/sec. Official name for HSUPA is enhanced uplink (EUL). Its major goal is to improve the performance of uplink dedicated transport channel, which means to increase the capacity and throughput of the channel and to reduce the channel delay. It encloses the link adaptation methods like shorter transmission time interval enabling faster link adaptation and hybrid ARQ with incremental redundancy. It operates on a request-grant principle basis where the user equipment requests for a permission to send data packets and the packet scheduler decides when and how the user equipment can do so.

I. Fourth Generation Technology (4G)

In telecommunication, 4G is the fourth generation of cellular wireless standards. 4G provides a comprehensive and secure all-IP based wireless networks. The facilities like ultra-broadband Internet access, IP telephony, gaming services and streamed multimedia are the major highlights of 4G technology. Fig1. clearly explains the vast vision of 4G technology. The 4G encompass almost all the networks ranging from
public to private, operator-driven broadband networks to personal area and Ad-hoc networks. They provide digital broadcasting systems and provide better interoperability between 2G and 3G. The 4G system is also a fully IP based wireless network system. This integrated system shows the wide range of systems that the 4G wants to integrate with. It includes satellite broadband to cellular 3G, 3G to WLL (Wireless Local Loop), FWA (Fixed Wireless Access) to WLAN (Wireless Local Area Networks) and PAN (Personal Area Networks) which are integrated with IP. With this fourth generation , the mobile communication has gained higher bandwidth and data rate, smoother and fast handoff and other seamless services across the wireless networks. The major technology coming under fourth generation technology includes MIMO, OFDMA, and LTE. 4G is described as MAGIC which means Mobile Multimedia, Any time Anywhere, Global Mobility, Integrated Wireless Solution and Customized Personal Service.

1) MIMO (Multiple Input Multiple Output)

The Multiple Input and Multiple Output is the use of number of antennas at transmitter and receiver side for improving the performance of communication. It is a smart antenna technology for carrying the signals through radio channels. This technology has increased the throughput and communication range without any additional bandwidth or transmission power. This is achieved by spreading the transmission power along the antennas. As a result of all these properties MIMO has become an important part of various communication standards like Wi-Fi, 4G, Wi-Max etc.. The important functions of MIMO are precoding (multi-stream beam forming), spatial multiplexing (a powerful technique for increasing channel capacity at higher signal to noise ratio) and diversity coding (used when there is no channel knowledge available at transmitter). MIMO can be used in 3GPP and 3GPP2 Mobile radio telephone standards. It can also be used in non-wireless technologies like the home networking standard ITU-T G.9963 which uses this MIMO technique to transmit multiple signals over multiple AC wires.

2) OFDMA (Orthogonal Frequency Division Multiple Access)

OFDMA is an extended version of OFDM developed mainly for the multi-user environment. They achieve multiple access capacity by assigning subsets of subcarriers to individual users. It can be considered as an alternative to the combination of OFDM and TDMA. OFDMA can be considered as a combination of frequency domain and time domain multiple access in which the resources are distributed in the time-frequency space. They are highly suitable for broadband wireless network. They can be used to fill the free radio frequency bands adaptively. OFDMA can handle multipath interference with less complexity and provides better MIMO spectral efficiency. They can be deployed across various frequency bands with less modification to the air interface. They enable the single frequency network coverage, which gives excellent coverage. They offer frequency diversity by spreading the carriers all over in the used spectrum. The major problems associated with OFDMA includes higher sensitivity to frequency offset and phase noise. Methods used for dealing with co-channel interference by OFDMA are very complex. The fast channel feedback information and adaptive sub-carrier assignment is also very complex in OFDMA. They can be applied in the mobility mode of the IEEE802.16 Wireless MAN standard (Wi Max) and IEEE 802.20 mobile wireless MAN standard (MBWA). OFDMA is also considered in the case of IEEE 802.22 wireless regional area network (WRAN).

3) LTE (Long Term Evolution)

The Long Term Evolution commonly known as 4G LTE is a truly global mobile standard for high speed communication in mobile phones and other data terminals. It is an evolution of GSM/UMTS standards. LTE uses OFDMA and provides higher data rates. This technology can improve the speed and capacity of data transmission using a radio interface with core network improvements. The world's first LTE service was developed by Telia Sonera in Stockholm and Oslo on December 14, 2009. Even though LTE is marked as 4G wireless service, it does not satisfy the technical requirements of 3GPP. The aim of LTE is to increase the speed and capacity of wireless data using digital signal processing (DSP) techniques. Since LTE wireless interface is not compatible with 2G and 3G, it must be separately operated on wireless spectrum. This technology provides an uplink rate of 75 Mbits/sec and downlink rate of 300 Mbits/sec. It can manage fast moving mobiles and can support multicast and broadcast streams. LTE has carrier bandwidth of 1.4 MHz to 20 MHz and it supports FDD (Frequency Division Multiplexing) and TDD (Time Division Multiplexing). Initially LTE devices were not having software support. This led to a new solution called carrier promoting VoLGA (Voice over Generic

Access). The LTE standard supports only Packet switching with all-IP networks. It can also support at least 200 active data clients in every 5 MHz cell.

III AN EYEVIEW ON THE GENERATIONS OF WIRELESS TECHNOLOGY: 1G-4G.

The first generation technologies existed in 1980s. It is based on analog signaling system. It supports data transmission in the kbps band width range. They exhibit poor carrier capacity. They didn't support MIMO technology. Its cell size was very large and ranges from 2-20 kms. It supported a maximum speed of 1.9 kbps. They lack network security and was very time consuming. The major drawbacks of 1G are poor voice quality, poor battery life, large phone size, low security, limited capacity and poor handoff reliability. Second generation technologies were present in 1990s. They were wireless telephone technology based on GSM standards. They depend on digital voice and were based on CODEC. They were mainly used for mobile communication. They support a maximum speed of 14.4 kbps. Its core network act as PSTN.2G supports TDMA and CDMA. They support a carrier bit rate of 270.8 kbps and a speech coding bit rate is 13 kbps. They support text messaging in handsets and was safe for consumers to use. They can operate at a channel bandwidth of 200 KHz in GSM. They cannot support multiple users simultaneously. The major drawback of 2G technology includes requirement for strong digital signals to help mobile phones work. Digital signals will become weak in the absence of network coverage. These systems are unable to handle complex data such as videos. Third generation mobile technologies are called 3G. They are the successors of 2G. The different release versions of 3G include 3.5G and 3.75G. CDMA 2000, UMTS, EDGE etc. comes under 3G technologies. With a data bandwidth of 2 Mbps, they support high sped broadband networks. Its spectral efficiency ranges between 1-5 MHz They are very expensive to implement. They provide a throughput of 3.1 Mbps. They are packet switched network technologies. They use turbo codes for error correction and their network architecture is wide area cell based architecture. Its frequency band exists between 1.8 and 2.5 GHz. They also support video access also. The drawback of 3G technology includes expensive fees for 3G licenses services. It was a big challenge to build the infrastructure to 3G.They requires higher bandwidth. The fourth generation technologies are called 4G technology developed in the late 1990s. They are based on IP based wireless communication. They provide multiple carrier aggregation and support a data band width in Mbps range. They exhibit a high speed of 150 Mbps and uses MIMO technology. They provide better data security and fast internet connectivity. 4G is based on IP protocol. They support both mobile and wireless communication. They support a data transmission speed of 150 Mbps. Wi-Max, LTE technologies are part of 4G. They provide a flexible channel band width. Here the handsets are provided with Wi-Fi and Bluetooth technologies. They provide high quality of service. They support multi-user interface. They are less expensive than 3G. They have a maximum upload rate of 500 Mbps and 1 Gbps download rate. Both packet switching and message switching are supported by 4G. They provide high definition video access to the users. They support virtual navigation capabilities. They exhibit a spectral efficiency of 20 MHz The drawbacks of 4G technology are very high battery use, hard to implement, require complicated hardware. Now the entire world is concentrating on 5G technology. Table I shows the comparison of 1G-4G technologies.

TABLE I: COMPARISON OF 1G-4G TECHNOLOGIES

First Generation	Second Generation	Third Generation	Fourth Generation
Existed in 1980's (1980-1990)	Existed in 1990's (1990-2000)	Existed in 2004 (2004-2010)	The idea of 4G emerged on 2008 (2010-Present)
Designed for Basic Voice Services	Designed for Voice	Designed for Voice with some data consideration	Designed Primarily for Data
Used Analog based Protocols	Fist Digital Standards	First Mobile broadband	Uses IP-based Protocols and True Mobile Broadband
Data Transmission rate is 2.4 Kbps	Data Transmission rate is 64 Kbps	Data Transmission rate is 2000 Kbps	Data Transmission rate is 100,000 Kbps
Provides Basic Mobility	Provides Advanced Mobility(Roaming)	Provides seamless Roaming	Supports IP-based Mobility
World's first Cellular System was launched	Digital Cellular Standard GSM Service launched	UMTS Service launched	Advanced MIMO technology was launched
Peak Speed up to 1.9 Kbps	Peak Speed up to 14.4 Kbps	Peak Upload rate of 5 Mbps and Download rate of 100 Mbps	Peak Speed up to 150 Mbps
Mobile Satellite Systems(INMARSAT)	Mobile Satellite Systems(IRIDIUM,ICO,GLOBALSTAR)	Single Standard under IMT2000,UMTS	Mobile WiMax,IEEE802.16e
Throughput up to 14.4 Kbps	Throughput up to 9.5 to 14.6 Kbps	Throughput up to 3..1 Mbps(peak)	Throughput up to 100 to 300 Mbps(peak)

IV. FIFTH GENERATION TECHNOLOGY (5G)

5G technology refers to the fifth generation technology started from late 2010s. It is also referred to as the beyond 2020 mobile communication. They provide complete wireless communication with no limitations. It is highly supportable to WWWW (Wireless World Wide Web). They provide high speed and capacity.5G supports a data transmission in the range of Gbps. Faster data transmission, large mobile phone memory, dialing speed and clarity in Audio/Video are the major highlights of 5G technology.5G is a packet switched wireless system with wide area coverage and high throughput. They use OFDM and millimeter wireless which enables data rate of 20 mbps in a frequency band of 2-8 GHz. They are packet based network. 5G offers a new revolution to the mobile market. 5G terminals have software defined radios. They provide advanced error-control schemes. 5G technology is based on Open Wireless Architecture. While considering the network layer, all mobile networks will use Mobile IP and each mobile terminal will be a foreign agent. Here a mobile can be attached to several mobiles or wireless networks at the same time and the fixed IPV6 is implemented in all the mobiles. The network layer is divided into lower network layer and upper network layer. The middleware between the upper and lower network layers maintains the address translation from upper network address to different lower network IP addresses and vice versa. The mobile terminals are suitable to have transport layer that can be downloaded and installed. They support Open Transport Protocol. In 5G the application layer provides intelligent QoS management over variety of networks. Various intelligent algorithms run in the mobile terminal as system processor provides the best wireless connections. 5G is a complete packet based network. The attractive billing interface makes 5G more attractive and effective. They supports Virtual private networks.5G provides a flexible bandwidth between 5 and 20 MHz optionally up to 40MHz.They increases the system spectral efficiency up to 3 bit/s/Hz/cell in the downlink and 2.25bit/s/Hz/cell for indoor usage. By the support of IPV6 the network address size is increased from 32 bit to 128 bit and this in turn support more levels of addressing hierarchy and much greater number of addressable node. They extend the IP address space for offering a unique IP address to any device and to support IP mobility. In the evolutionary view of 5G, they will be able to support wwww for highly flexible networks like DAWN (Dynamic Adhoc Network). In a revolutionary view of 5G, there should be extra intelligent technology providing unlimited interconnection between the networks. They will support artificial intelligence to a greater extend. Table II shows a brief comparison between fourth and fifth generation technologies.

A. Basic Concepts in 5G

5G provides a real wireless world with no limitations in the data accessing. They support artificial intelligence to a greater extent. They support IPV6 technology. They prefer one unified global standard and supports pervasive computing. The users can be simultaneously connected to multiple wireless technologies. 5G extends its support to the areas of cognitive radios or smart radios allowing different radio technologies to share the same spectrum in an efficient adaptive manner. They use high altitude stratospheric platform station. They provide high resolution and large bandwidth support for faster data transmission. Strong and faster error-correction mechanism will be provided by 5G. They are providing a network connectivity speed of 25 Mbps. 5G technologies can be applied in medical fields also. They can be used for sensing various natural disasters. Key concepts include Dynamic Adhoc network (includes smart antennas and flexible modulation) and IPV6. The major services provided by 5G includes dynamic information access and wearable devices with AL capabilities. They prefer CDMA multiplexing. The entire network is packet switched.

B. 5G Mobile Network Architecture

Fifth generation mobile systems are all-IP based technology. Here all-IP based mobile applications and services such as mobile portals, mobile health care, mobile commerce, mobile banking, mobile government etc. are offered through Cloud

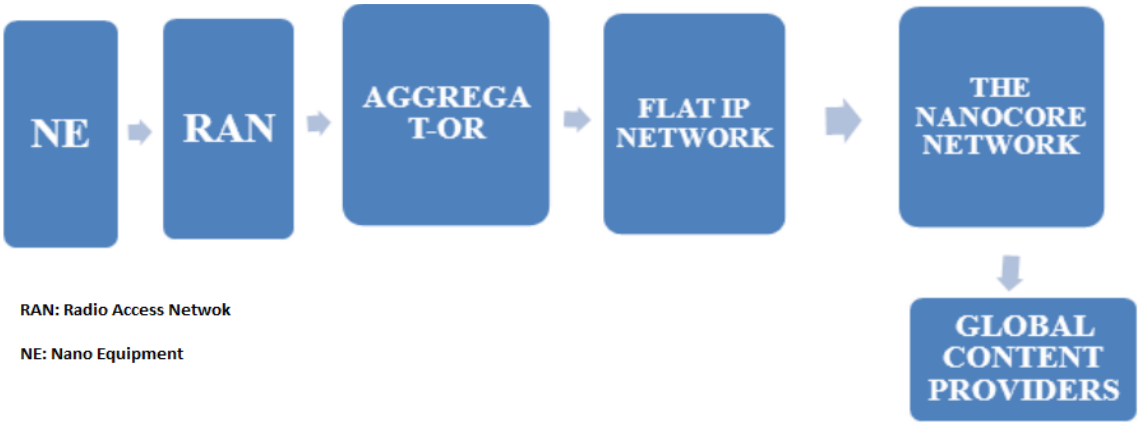

Fig. 2. 5G Architecture [8]

Computing Resources. It is possible to configure on demand network access through computing resources. This allows the consumers to use applications without installation and can access their personal data anywhere at any time. 5G is based on the concept of super core, where all the network operators are connected to a single core and have single infrastructure irrespective of their access technologies. It brings the concept of MVNOs (Mobile Virtual Network

Operators) a reality.Fig2. Shows the architecture of 5g technology. The fifth generation technology is going to be a new revolution in the mobile market as it can handle best technologies and offer priceless handset to the customers. They have extraordinary data access capabilities. Maybe in the coming years the 5G technology may take over the entire market. 5G can provide high data connectivity using its routers and switches. The 5G technology has a glowing future. They provide low cost per bit. They support interactive multimedia, voice, streaming video and other broad band services. They are expected to support virtual private network. The traffic strategies by 5G technology makes it more accurate. Beyond 5G the future enhancement of Nano-core will be extraordinary as it includes artificial intelligence also. The key challenges in 5G include the integration of various standards like 3GPP, 3GPP2, ITU etc. Moreover there is no common platform or architecture for interconnecting different standards. Research is going on to connect users simultaneously to multiple wireless technologies. The main component of fifth generation technology is the 5G nanocore. It is a combination of technologies like nanotechnology, cloud computing and All- IP network. All these technologies have their own impact on the existing wireless communication networks which in turn lead to the concept of 5G. Fig3. Shows the basic architecture of Nanocore components.

1) Nanotechnology

Nanotechnology also known as Molecular Nanotechnology (MNT). It is a technology that uses Nano science for controlling various processes on a nanometer scale ie, between 0.1 and 100nm. It will lead to a next great industrial revolution. They are considered as one of the most significant technology in the wireless communication network. It has a direct impact on the mobile and sensor networks as well as on the core network.

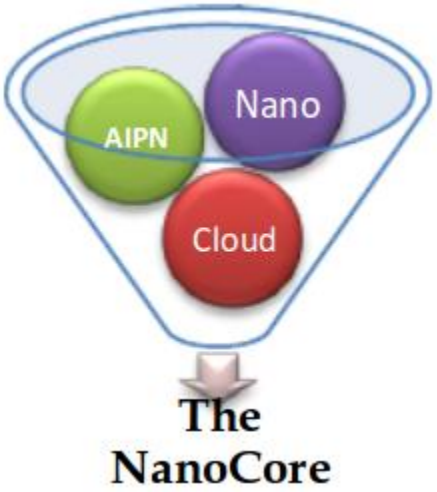

Fig.3. 5G Nanocore

2) Nano Equipment (NE)

In this advanced world, mobile phone becomes an identity of each individual. The fifth generation called these mobiles as Nano Equipment. The main goal of this is to facilitate communication as well as computation for the users in an intelligent manner. These Nano Equipment should exhibit the features like flexibility, transparency, environment sensibility, self-powering (getting charged from resources like sun, air, water etc..) and also they should clean by themself. The Nano Equipment consists of devices like Morph, Graphene's Transistor, Liquid lens, intelligent batteries and Nano Sensors. Nanocore requires reliable capacity and high speed to maintain equilibrium to security aspects. But the most recent standards like Wimax and LTE can achieve this requirement. To fulfill this need, the Nanocore along with Nanotechnology is combined. For creating such a platform, nanocore requires high performance, flexibility and extensibility in the hardware and software infrastructure.

3) Quantum Computing

Quantum computing is the computation intelligence based on the concept of quantum theory in which the behavior of energy and matter is explained at the atomic and subatomic level. Information is in the form of electrons is transmitted in today's digital systems. According to quantum computing, the upcoming technology would be based on the principles of quantum mechanism in which small particles of light and matter can be considered. Here a quantum bit can be expressed as both 0 and 1. They will support a higher speed which is 8 times faster than that of normal computing. They provide improved storage capacity, improved speed and improved security. They can use the
concept of Quantum cryptography for the purpose of improved security.

4) Cloud Computing

Cloud computing is a technology used by a group of computers, connected using Internet for the purpose of data management and maintenance. It consists of a central remote server. This allows the users to access data at any time, anywhere without any additional installations. This concept is the basis for nanocore technology. The users obtain more

real-time applications and thus they can utilize the 5G services to a great extent. Security and reliability is provided using quantum cryptography. The three important segments in cloud computing includes applications, platform and infrastructure. Each segment acts differently in different situations. Fig4. shows a basic structure of cloud computing.

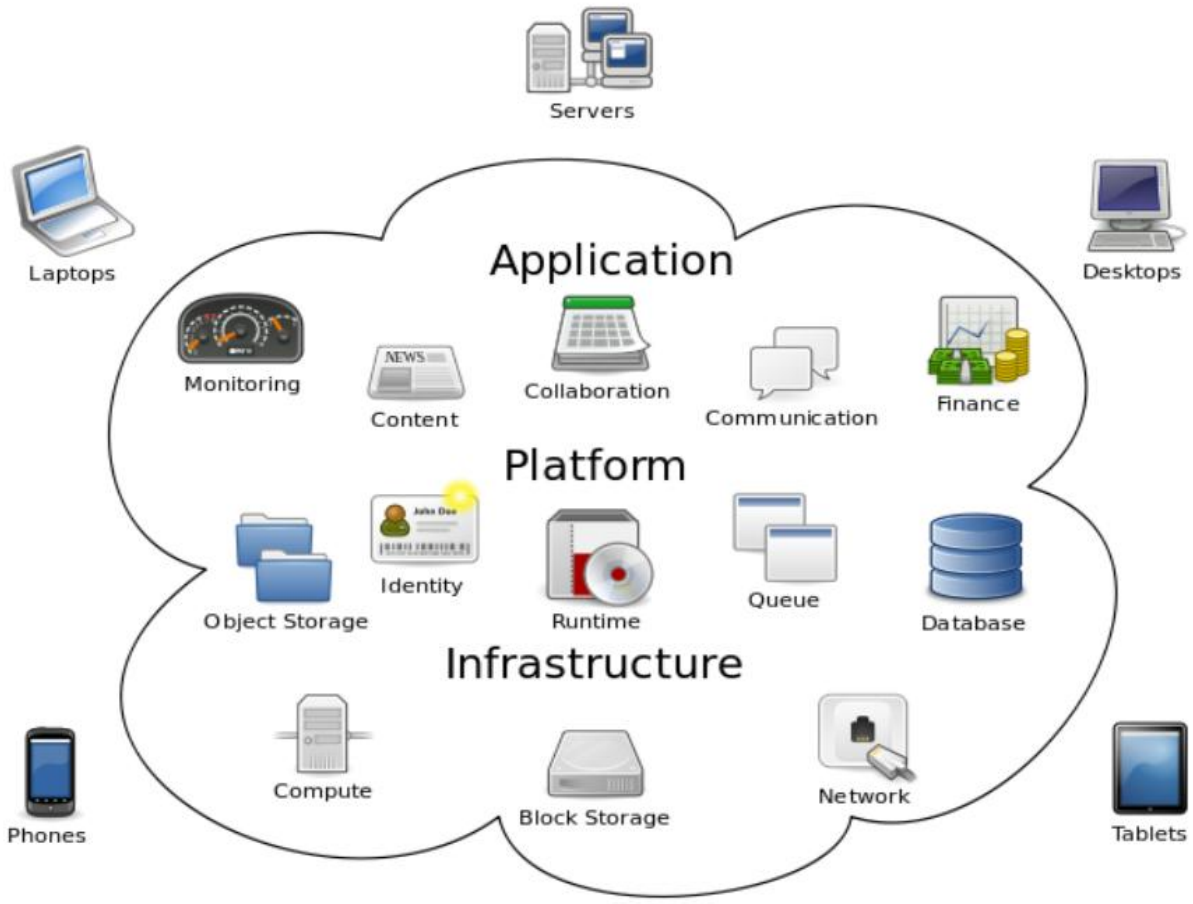

Fig. 4. Cloud Computing

5) Applications:

5G provides higher on-demand services. These on-demand services differ widely in their pricing schemes and other factors like mode of delivery etc. the products used for the deployment of internet come under the platform segment. For example, Google, Amazon etc. developed their platforms to allow users to access data and other applications from centralized servers. The third segment called infrastructure act as the backbone of cloud computing. The cloud computing concepts reduces the CAPEX of 5G network and also provides less billing service to the end user.

6) All-IP network

The All-Ip which is an extended version of 3GPP can increase the demands of mobile telecommunication market. The wireless network operators turning to flat IP network architecture to meet the various needs of customers. APIN is providing a complete edge in terms of performance and cost. The important benefits of IP architecture are reduced system latency and universal seamless access. The increasing demand of IP-based services can improve the performance demand of various IP-based equipments and devices. This can result in increasing demand for multicore technology. Data in a flat mobile IP network model flows freely. The All-IP has the ability to adapt and move sessions from one terminal to another based on certain criteria. It has a provision for advanced application services as well as other ubiquitous services. There exist some methods inside All-IP for ensuring quality of service (QOS).

7) Multi Core Technology

As 5G provides all-IP based technology, it is necessary to incorporate multicore technology. This supports powerful data processing in the telecommunication system.

C. Challenges in 5G

5G technology also have a lot of challenges. One important problem is that there is always a chance for deception. Another main problem is in the area of security. The interoperability between the technologies is required for the Nanocore concept. The entire concept of nanocore is highly expensive. Moreover proper care should be taken to provide enough security for the consumer's health as technology can adversely affect the human health.

TABLE II:
COMPARISON OF 4G AND 5G TECHNOLOGY

Fourth Generation	**Fifth Generation**
Emerged around 2008	Expected to be finalized by 2013-2015
Supports Circuit/Packet Switching	Supports Circuit/Packet Switching
Data rate up to 20 Mbps	Data rate up to 1 Gbps
Provides combination of broadband LAN/WAN/PAN	Provides combination of broadband LAN/WAN/PAN
4G is used in Backhauling Networks as well as User access networks	5G is expected to be Backhauling Backbone Networks
4G networks are almost here	5G networks are roughly 10 years from reality
Rely on Terrestrial Base Stations	Rely on High Altitude Stratospheric Platform Stations

V. CONCLUSIONS

The wireless mobile technology is advancing day by day. The technical advancement is clear from the path of evolution from 1G to 5G. Migration to 5G technologies ensures convergence of networks, technologies, applications and various services. 5G can serve as a flexible platform. While with each passing year, the future is becoming more difficult to predict, we should expect a new enhanced phase of technological change. We conclude that nanotechnology, Cloud computing, All-IP etc all together will become the next generation technology.

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