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The Development of Wireless Communication Systems from Zero Generation to Fifth Generation - A survey

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Abstract
Wireless communication is the process to send information over a short distance or long distance without using wires. The recent researches in mobile wireless technology focused on implementation of fourth generation (4G) technology and fifth generation (5G) technology where the fifth generation provide affordable broadband wireless connectivity (very high speed). In this study we will present the evolution and development of all generations of mobile wireless systems and their significance and compare between these generations. Also we will study the concept of 5G and its architecture and the services that 5G provides.

Keywords: Generations, 1G, 2G, 3G, 4G, 5G Architecture, wireless communication.

Introduction

Wireless communication has begun in early 1970s. After 40 years a mobile wireless technology evolved from the zero generation (0G) to 5G.The fifth generation technology offers very high bandwidth and various new advanced features and services which make it most powerful and effective.

The Wireless is a technique used to send data or voice by using electromagnetic waves for short or long distances. The wireless communication systems started with the Zero-Generation in the United States. The phones of this generation use radio waves, which were very limited for many reasons such like a jamming sound, overlapping calls, weakness and loss of signal (coverage), this caused a breakdown in communication in case the caller moved from one place to another.

The First Generation (1G) networks spread in Japan in 1973. These networks depend on the allocation of channels with different frequencies for each person, so each of the transmission stations contains 832channels, which will provide a wider coverage that covers all users. The 1G is characterized by a high quality voice transmission and provides the caller with the possibility to move during a call, unlike the previous generation, which not allowed the user to move during a call.

The Second Generation (2G) networks transfer the voice and data in a digital way, where votes and statements are transferred to a stream of bits that contain 0 and 1, and then they are sent wirelessly unlike the previously mentioned generations. The second generations networks provide the user with the possibility to send text

messages, surf the Internet, and send and receive fax. Also, this generation of wireless networks is fully encrypted, and among the techniques that are currently used in this generation Global System for Mobile communications (GSM) and Code Division Multiple Access (CDMA) techniques [3].

The Third Generation (3G) networks are considered as the fastest generation where the speed of transferring data in the network is up to more than 2 Mbps, unlike previous generations, which did not exceed kilobytes per second. Networks of the third generation offer the possibility of using the internet at high speeds and provide making calls, conference video and audio, in addition to the possibility of the direct satellite receiving and the possibility of positioning.

The Fourth Generation networks are distinguished by being a set of techniques that provide the possibility of using more than one technology in one device, it is also distinguished by the high speed networks with wide geographical coverage, and the most important techniques of these networks is the technology of WiMax [5].

Each new generation provide new techniques and additional services different from the previous generations to accommodate with the incremental requirements of work. In this study we will review the evolution of wireless and cellular systems from the zero generation to fifth generation, and compare between these generations through different criteria to show the advantages and disadvantages of these generations. On the other hand, we will study the 5G according to more than one researcher and show the importance of this generation, and the expected services for this generation.

In this paper we will present a survey and comparison between all generations of communication systems and its architecture. After that we will explore the services of the 5G and illustrates why there is a need for 5G.

ZERO GENERATION

0G refers to pre-cell phone mobile telephony technology in 1970s, such as radio telephones that some had in cars. Where there was a mobile operator to set up the calls and there were only a handful of channels available .In this generation the technologies used included PTT (Push to Talk), MTS (Mobile Telephone System), IMTS (Improved Mobile Telephone Service), AMTS (Advanced Mobile Telephone System), OLT (Norwegian for Offentlig Landmobil Telefoni, Public Land Mobile Telephony) and MTD (Swedish abbreviation for Mobilelefonisystem D, or Mobile telephony system D) [3].

FIRST GENERATION

The first generation appeared in 1973. This generation depends on analog system which is defined as cell phones. This generation contributed in developing the mobile technologies such as Mobile Telephone System (MTS), Advanced Mobile Telephone System (AMTS), Improved Mobile Telephone Service (IMTS), and Push to Talk (PTT), this generation uses analog radio signal with frequency 150 MHz and Frequency-Division Multiple Access (FDMA) in voice call modulation [1].

The main analogue systems are:

1) Nordic Mobile Telephone (NMT), it is used in Nordic countries, Eastern Europe and Russia.
2) Advanced Mobile Phone System (AMPS), it is used in the United States.
3) Total Access Communications System (TACS) where it is used in the United Kingdom.

SECOND GENERATION

The second generation depends on digital signals for voice transmission and has speed of 64 kbps and the bandwidth of 30 to 200 KHz. The second generation cellular telecom networks were issued on the GSM standard in Finland by Radiolinja in 1991,

The 2G technologies depends on two standard technologies the Time Division Multiple Access (TDMA) based and Code Division Multiple Access (CDMA), and uses the Compression- Decompression Algorithm (CODEC) to compress digital voice data.

The researchers developed the 2G and introduced the 2.5G and 2.75G systems which have data rate up to 144 kbps. This generation was applied in General Packet Radio Service (GPRS), Short Message Service (SMS), CDMA and Enhanced Data rates for GSM Evolution (EDGE) [3].

THIRD GENERATION

The Third Generation depends on the packet switching technology to send data through the network. This generation provided the systems with some services such as access to television/video, global roaming, internet service, video chatting, broadband wireless data and High-Speed Packet Access (HSPA) data transmission capabilities with speed up to 14.4Mbit/s on the downlink and 5.8Mbit/s on the uplink. These services use the frequency 2100MHz and a bandwidth of 15-20MHz and use wide band voice channel [4].

There are different 3G technologies as Universal Mobile Telecommunications System (UMTS), Wideband CDMA (WCDMA), Digital Enhanced Cordless Telecommunications (DECT) and CDMA 2000. The 3G has advantages over 2.5G and previous generations, it enhanced audio and video streaming and increased the data rate, it also provides the video-conferencing service and TV through the Internet (IPTV). After this stage the researcher developed the 3G and introduced new generations derived from it:

Universal Mobile Telecommunications System (UMTS)

A.(3.5)G :High-Speed Downlink Packet Access (HSDPA)

HSDPA is a mobile telephony protocol which allows for higher data rates for downloading .it is applied in WCDMA with bandwidth of between 5MHz and 10 MHz

B.(3.75)G: High-Speed Uplink Packet Access (HSUPA)

HSUPA provides faster upload speed (up to 5.76 Mbps) in order enhance advanced person-to-person data applications with higher and symmetric data rates and allow full-duplex packet services.

FOURTH GENERATION

The Fourth Generation represents a revolution in communication systems where this generation provides a downloading speed starts at 100Mbps (higher data rate than 3 G) and reaches 1G.The 4G provides same feature as 3G with additional services like multi-media newspapers to watch T.V programs. This generation is applied in deferent applications such as in wireless broadband access, Multimedia Messaging Service (MMS), video chat, mobile TV, High-Definition Television (HDTV) content and Digital Video Broadcasting (DVB). The 4G applications will be available across various wireless technologies like Long Term Evolution (LTE), Wi-Fi and also in devices like cell phones, laptops, e-readers, digital cameras, printers [6].

There are several features which are sufficient to adopt 4G technology:

1) High performance

The 4G generation provides a downloading speed reaching 100Mbps.

2) Interoperability and easy roaming

The 4G provides global mobility across different heterogeneous wireless access networks.

3) Fully converged services

The user can able to access the networks from different terminals as cell phones, laptops, PDAs. So the 4G supports the user everywhere with voice over internet

protocol (VoIP) telephony, e-mail, Web browsing, e-commerce and streaming video, and allow everyone to access the internet from everywhere using almost any wireless device[7].

4) Low cost

Since the 4G uses the existing networks and it does not need extra requirements, it is more cost efficient than previous generations.

5) more user friendly interface

The devices of 4G are visual and intuitive and easy to use.

6) Scalability

The 4G can handle the incremental number of users and services in the network.

7) Crisis-Management applications

It is easy to reconstruct a wireless communication system if the current system has crashed.

FIFTH GENERATION (5G)

5G represents the fifth generation of cellular wireless communication networks and so-called 5th generation mobile networks or 5th generation wireless systems, The 5G network must serve our growing needs from 2020, which is why work on 5G has already begun , so It may be nothing more than a concept today. The most important improvements for this generation are to increase the frequency range of bandwidth channels used 1 G up to 30 kHz, 2 G up to 200 kHz, 3 G up to 5 MHz, 4 G up to 40 MHz .

The 5G network is suggested to be the perfect level of wireless communication in mobile technology to be a complete wireless communication without limitation, which brings us a perfect real world wireless web (WWWW).at present, 5G is not a term officially used for any particular specification. The 5G network is expected to improve the services and applications offered by it[1].

A.The need for 5G

The need for 5G according to different researchers is summarized in the following requirements:

- Increasing the maximum throughput by using cell phones within very high bandwidth.
- Reducing the battery consumption.
- Minimizing the outage probability through achieving better coverage and high data rates available at cell.
- Providing concurrent data transfer paths.
- Enhancing the data rates in mobility to become around 1Gbps.
- More secure.
- Worldwide wireless web (WWWW), wireless based web applications that include full multimedia capability.
- Not harmful to human health.
- To support interactive multimedia, voice, video, Internet, and broadband services, more effective and more attractive, and have Bi- directional, accurate traffic statistics.
- To offer global access and service portability.
- High quality services with high error tolerance.
- Providing large broadcasting capacity up to Gigabit.
- Combining the applications with artificial intelligent (AI) as human life will be surrounded by artificial sensors which could be communicating with mobile phones.
- 5G technology use remote management that user can get better and fast solution.
- The uploading and downloading speed of 5G technology is very high.
- Providing High Altitude Stratospheric Platform Station (HASP System).
- To make use of Beam Division Multiple Access (BDMA) where Korean researchers has suggested BDMA as a radio interface for 5G instead of TDMA or FDMA , which is not depended on frequency or time resources as shown in figure 1.

- To ensure user could be simultaneously connected to several technologies and seamlessly move between them.

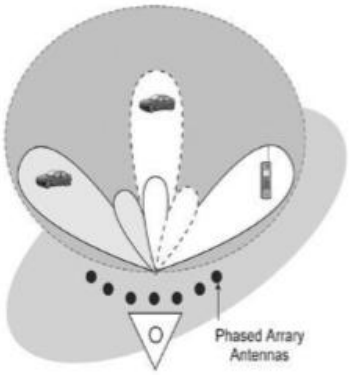

Fig.1: Beam Division Multiple Access [9].

The new generation will suppose to support the following characteristics [5]:

- Using cell phones within very high bandwidth.
- The 5G technologies include all types of advanced features which makes 5G technology most powerful and in demand in the future.
- 5G technology which is on hand held phone will provide more power and features.
- A user can get broadband internet access.
- 5G technology including camera, MP3 recording, video player, large phone memory, dialing speed, audio player and much more.

A.The concept of 5G

Toni Janevski in [1] proposed a concept for the new generation and put a proposed architecture for the 5G. The concept of 5G includes:

- The 5G terminals will have software defined radios (SDR) and modulation schemes.
- New error-control schemes.
- The development will be towards the user terminals
- The user can access to different wireless technologies at same time.
- The terminal Combine different flows from different technologies.
- Each network will handle user-mobility and the terminal will select the service among different wireless mobile access by using intelligent middleware in the mobile phone.

In the next section we will study the architecture of 5G supposed by Toni Janevski.

While the Kavita Sogale and D.J.Pete in [8] proposed a different concept for the 5G, the concept of 5G includes:

- Cognitive radio (CR)-new ways of using spectrum through dedicating new frequency bands and wider spectral bandwidth per frequency channel to permit different radio technologies to share the same spectrum.
- Software defined radio (SDR) – reconfigurability enabler : Software defined radio (SDR) benefits from today's high processing power to develop multiband , multistandard base stations and terminals .for example ,to increase network capacity at a specific time (e.g. During festivals or events),an operator will reconfigure its network adding several modems at a given base transceiver station(BTS). In the context of the expected 5G systems, SDR will become an enabler for terminal and network reconfigurability through software download.
- Reconfigurable – interoperability between several types of wireless access network by developing IEEE 802.21standard to achieve the interoperability with heterogeneous networks where the IEEE 802.21 standard is responsible for communication with different terminals.

So the reconfigurable interoperability allows selecting the appropriate wireless access with minimal investments.

- Network energy efficiency: the terminals have low power consumption.
- Nanotechnology: by using the nanotechnology the mobile phones can access to different applications such as in industries, transportation, communications, medicine and safety. Furthermore the nanotechnology increases the speed and capacity of the network.
- All IP network: to allow for different access systems with lower cost, universal access and less latency as shown in figure 2.

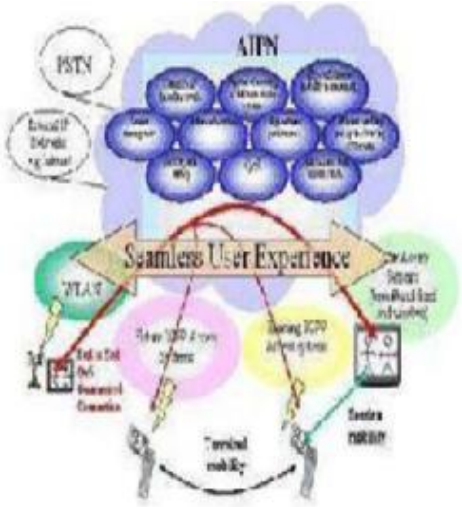

Fig.2: All IP Network [8].

- Cloud computing: in 5G the cloud computing permits the clients to use applications without installation and access their personal files at any computer with internet access, it works like content provider.

ARCHITECTURE OF 5G

In this section we will introduce the architecture of the 5G proposed by Toni Janevski in [1] where architecture contains four layers as shown in table 1, figure 3 shows the design of 5G mobile phone.

Table 1: OSI Layers in the 5G ARCHITECTURE[1].

OSI model	Layers of 5G architecture
Application Layer	Application (Services)
Presentation Layer	
Session layer	Open Transport Protocol
Transport Layer	
Network layer	Upper network layer
	Lower network Layer
Data link Layer	Open Wireless Architecture
Physical Layer	

Fig. 3: 5G mobile phone design[1]

A.Physical/ Medium Access Control **(***MAC) layers :*

The Physical and Medium Access Control layers provide the wireless technology for the 5G mobile networks.

B. *Network Layer :*

- All mobile networks will use Mobile IP.
- Each mobile terminal will be Foreign Agent.
- A mobile can be attached to several mobile or wireless networks at the same time.
- The fixed IPv6 will be implemented in the mobile phone .
- Separation of network layer into two sub-layers
  The lower network layer (for each interface) and the upper network layer (for the mobile terminal) .
- The middleware between the Upper and Lower network layers as shown in figure (4) maintains address translation from

upper network address (IPv6) to different Lower network IP addresses (IPv4 or IPv6), and vice versa.

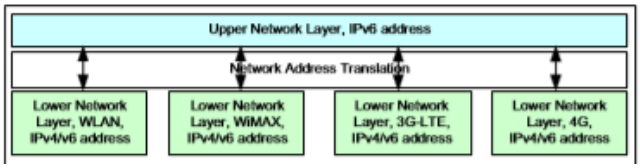

Fig.4: 5G Mobile Terminal Network Layer [1]

C.Open Transport Protocol (OTA) layer:

- In wireless, the loss is due to higher bit error ratio in the radio interface
- 5G mobile terminals can download the transport protocol which is targeted to a specific wireless technology to retransmit any loss of data during the transmission.

D. Application layer : it aims to

- Provide intelligent Quality of Service (QoS) management over variety of networks
- Provide possibility for service quality testing and storage of measurement information database in the mobile terminal
- Select the best wireless connection for given services
- QoS parameters, such as, delay, losses, BW, reliability, will be stored in DB of 5G mobile

Comparison between all generations

The table 2 shows the main differences between all generations of wireless communication systems.

Table 2: comparison between all generations.

Generation feature	1G	2G	3G	4G	5G
Start/Deployment	1970-1980	1990-2004	2004-2010	Now	Soon (2020)
Data Bandwidth	2 Kbps	64 Kbps	2 Mbps	1 Gbps	Higher than 1 Gbps
Technology	Analog cellular	Digital Cellular	CDMA 2000 UMTS, EDGE	WiMax LTE Wi-Fi	wwww (coming soon)
Service	Mobile Telephony (Voice)	Digital voice, SMS, Higher Capacity	high quality audio, video and data	Dynamic Information access, wearable devices	Services of G4 and Wearable devices with AI Capability
Multiplexing	FDMA	TDMA CDMA	CDMA	CDMA	BDMA
Switching	Circuit	Circuit, Packet	Packet	All Packet	All Packet
Core Network	PSTN	PSTN	Packet	Internet	Internet

Discussion and analysis

After studying various papers and comparing their components of them.

It was clear that each paper has a relative perspective towards the first four generations in the techniques and protocols. But in the fifth generation every papers tackles it differently where each paper introduce different concept and different proposed architecture for the fifth generation.

we found out the description for the fifth generation and the layers used in the paper "5G Mobile Phone Concept " is more realistic than other papers and the proposed architecture may apply in the near future because it uses reliable references .

Conclusion

The wireless communication system has become very essential part of our life. Their current development is the outcome of various generations. In this paper we reviewed the various generations of mobile wireless technology and make comparison between them.

The goal of developing the mobile and wireless networks is to get higher data rates

and all-IP principle. Mobile terminals are obtaining each year more processing power, more memory on board, and longer battery life for the same applications. 5g include latest technologies such as cognitive radio, SDR, nanotechnology, cloud computing and based on All IP Platform. It is expected that the 5G will introduce the solution for all challenges that may appear in the future.

In this survey we introduced the concepts of 5G according to more than one researcher and the expected services to 5G and what the need for 5G and explained one architecture among the existing architectures for the 5G.

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