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A COMPREHENSIVE SURVEY OF THE WIRELESS GENERATIONS

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Abstract: - The world is undergoing a major technological resolution in wireless communications that will provide ubiquitous communication access to people wherever they are. The exponential evolution of wireless technologies, services and business applications has resulted in a wide-scale deployment and usage of wireless and mobile networks. The development of wireless access technologies is about to achieve its fifth generation (5G). Looking past, wireless access technologies have followed different evolutionary paths aimed at unified target: performance and efficiency in highly mobile environments. The first generation has fulfilled the basic mobile voice, while the second generation introduced capacity and coverage. This was followed by the third generation, which targets for data at higher speeds. The Fourth generation provides access to a wide range of telecommunication services which are supported by mobile and fixed networks. This paper provides an overview of the evolution of Mobile Wireless Communication Networks from 1G to 5G.

1. Introduction

Wireless communication is in its best ever growth period in history, due to the enabling technologies which permit pervasive deployment, miniaturization, digital signal processing, networking, and switching. Historically, development in the mobile communications area came gradually, and in the past was coupled closely to technological improvements which did not come about easily. The ability to provide wireless communications to an whole population was not even thought of until Bell Labs developed the cellular concept in the 1960's and 1970's [6,7,8]. The wireless communications era was born with the invention of highly dependable, small, solid-state radio frequency hardware in the 1970's [2].

The recent exponential growth in the cellular radio and PCS throughout the world is directly attributable to the new technologies of the 1970s, which are mature today. The exceptional development in the number of wireless subscribers in the late 1990s, combined with the Nextel's novel business approach of purchasing private mobile radio licenses for bundling as a nationwide commercial cellular service has increased today's subscriber base for cellular and Personal Communication System [2].

Today the Wireless communication has become the most active areas of technology development. This development is due to the transition of what has been largely a medium for supporting voice telephony into a medium for

supporting other services, such as the transmission of video, images, text, and data [1]. Wireless communications have become the most robust, viable voice and data transport mechanism. This has actually led to the development of newer wireless systems and standards for many other types of telecommunications traffic besides mobile voice telephone calls.

The explosive development of wireless communications continues to drive the development of cellular networks with advanced services. This paper highlights the key developments, technical details and standards of the existing wireless generations and the upcoming ones. The paper is organized as follows: Section 2 discusses the zero generation, Section 3 discusses the developments of the first generation, Section 4 describes the developments of second generation, Section 4 elaborates the third generation, Section 5 describes the fourth generation, section 6 discusses the upcoming fifth generation, section 7 provides a comparison of all the generations and finally section 8 concludes.

2. The Zero Generation (0G-0.5G)

Mobile radio telephone systems referred to as 0G or *pre-cellular mobile telephony technology*, and were introduced in 1970s [4]. In the early 1970s, wireless service offerings were a rare and high-priced way of communication. The first wireless service in the U.S. was *Improved Mobile Telecommunications Service (IMTS)*, which consisted of a 100-watt base station centrally located in a service area. In order to complete a call, either operator assisted or manual selection of an available frequency was needed. The rotary telephone was mounted on the dashboard of the vehicle and contained 12 buttons for manual selection of an available radio frequency [3]. This early service was a party-line service in which to search for an available radio frequency, the user had to listen to an accessible channel before starting a call. Since the spectrum was a restricted resource, early subscriptions to mobile communications needed a customer to be placed on a waiting list for service [5]. The service request was generally granted to those in greatest need of mobile communications. MTS (Mobile Telephone System), IMTS (Improved Telephone Mobile System) and AMTS (Advanced Mobile Telephone System) are headed under 0 G.

This generation was followed by 0.5 G which was a group of technologies with improved features than 0G. HCMTS (High Capacity Mobile Telephone System) and Autotel, or PALM (Public Automated Land Mobile), ARP (Autoradiopuhelin car Radio Phone) come under this generation [4].

Key Features:

3. First Generation (1G)

Also known as the *Analogue Radio Interface Generation*, the 1st generation began in early 1980's. It was analog; circuit switched, and carried only voice traffic.

The core difference between the existing 0G systems and 1G was the discovery of cellular technology therefore also known as *First generation of analog cellular telephone*. In this generation the network consists of many cells and each cell is covered by a radio network with one transceiver and so same frequency can to be reused many times which allowed a large spectrum usage and thus increased the system capacity.

Different standards of 1G which were used worldwide are: Advance Mobile Phone Service (AMPS), Total Access Communication System (TACS) / Extended Total Access Communication System (ETACS), Nordic Mobile Telephone-450 (NMT-450), Nordic Mobile Telephone-900 (NMT-900), Radio Telephone Mobile System (RTMS), Nippon Telephone and Telegraph (NTT), NTACS (Narrowband Total Access Communications System) and JTACS (Japanese Total Access Communication System).

The first generation systems suffered from the limitations of low capacity, unreliable handoff, poor voice links, and no security at all since anybody with an all-band radio receiver can listen to the conversation.

Features

1. The mode of modulation used were Amplitude/ frequency modulation.
2. The type of communication allowed was a full duplex which allows both the persons to communicate at a time.
3. Device was equipped with direct dialing hence operator help was no more required to connect to a call.
4. Channel access method used was Frequency Division Multiple Access or FDMA.
5. The system was able to handle the billing, roaming and call setup functionality.
6. It allowed text messaging with only few of the sophisticated devices.

4. The Second Generation (2G)

In the 1990's the 'second generation' (2G) mobile phone systems such as GSM (Global System for Mobile Communications, IS-136 ("TDMA-Time Division Multiple Access"), iDEN and IS-95 ("CDMA-Code Division Multiple access") was launched. 2G networks employ digital modulation and advanced call processing capabilities. These systems also provided dedicated voice and signaling trunk between MSC's and between each MSC and PSTN. These networks provided services such as paging, facsimile and high data rate network access. This generation systems catered to the needs of all four information types- text, picture, data and voice.
This generation supports data and voice services. Two types of digital modulation schemes are used: Time Division Multiple Access (TDMA) and Code Division Multiple Access (CDMA) [5]. The 2G mobile phone networks provide the services such as text messages, picture messages and MMS (multi media messages). It converts the voice into digital pulses/codes, which gives a clear signal which can be encrypted for security. 2G phone systems were run through digital circuit switched transmission, and a more advanced and fast phone-to-network signaling. The bitrate offered was higher with better error detection.

4.1 2.5G

2.5G is a group of bridging technologies between 2G and 3G wireless communication and is currently being used by the mobile operators of Pakistan. The basic change in it is that the system is upgraded to the data services as well, which means that the share of voice and data are distributed within GSM arch. It is a digital communication allowing e-mail and simple Web browsing, in addition to voice, 2.5 G supports higher data speeds. The term 2.5G also applies to technology such as WAP (Wireless Application Protocol), which uses a version of the web to fit into a mobile phone's slow data rate and small screen. 2.5G networks include EDGE (Enhanced Data Rates) and GPRS (General Packet Radio Service).

4.2 2.75G

2.75 G is used to refer EDGE (Enhanced Data Rates for GSM Evolution) Networks. It supports high speed data. The main advantage of using this particular technology is that it is feasible for enhanced data rates for GSM evolution.

5. The Third Generation (3G)

3G:

The Third generation of wireless communication technologies are used to support broadband data rate, voice, data and multi-media communications over wireless networks. The performance of GSM by adding 3G improved by

adding more functionality, and provides value to the existing GSM network. The 3G technology can also be used to provide high speed, fast data rate capacity and good Quality of service. This system provides various facilities that support muldimedia applications such as full-motion video, video conferencing and internet access. Technologies like Universal Mobile Telecommunication System, wideband CDMA, CDMA 2000 and TD-SCDMA. 3G Technology starts from 2001 with having data capacity 384 KBps. The main feature is that it provides high speed voice, data, video services with 1.6-2.5 GHz frequency.

3.5G:

The 3.5G technologies provides services like mobility with greater speed. The 3G comprises the additional technologies along with 3G wireless/mobile technologies. The 3.5G generation starts from 2003 with data capacity 2MBps. Technology used in this generation is GSM/3GPP.The main feature provided in this generation is its high speed voice,data,video services. Packet switching with frequency 1.6-2.5 GHz is provided having horizontal hand off services. The main networks used in CDMA multiplexing are GSM TDMA. Technologies like EV-DO, HSDPA, HSUPA generally called as HSxPA are involved in this generation. The enhanced version of this HSxPA emerged with the name of HSPA+.

6. The Fourth Generation (4G)

The fourth generation refers to the Next Generation of wireless communication or the Heterogeneous networks. The main aim of 4G is to congregate all the technologies into one another with simplified structure, wherein any user can use his services even on the phone line, and similarly he can use his broadband services on mobile. In order to support roaming across heterogeneous wireless networks and packet-switched wireless communications, there is a growing interest in the design and development of 4G wireless networks [7], which will allow users to move from one type of wireless network to another using multi-network devices or interconnected wireless networks.
The main technologies of 4G are LTE (Long Term Evolution), WiMax (Worldwide Interoperability for Microwave Access), UMB (Ultra Mobile Broadband) and EV-DO (Rev. C).
The factors that distinguish the 4G networks are roaming across networks, IP interoperability, and higher speeds. The 4G systems will encompass all systems from various networks, public to private, operator-driven broadband networks to personal areas, and ad hoc networks. The 4G systems will be interoperable with 2G and 3G systems, as well as with digital (broadband) broadcasting systems. 4G systems will have broader bandwidth, higher data rate, and smoother and quicker handoff and will focus on ensuring seamless service across a multiple of wireless systems and networks.
The 4G technologies will consist of direct channel condition estimations of several users to distribute transmission load, better access methods than 3G, adaptive antenna, adaptive coding and modulation, adaptive channel/code allocation, and scheduling among sectors and users. Applications of 4G will be virtual presence, virtual navigation, tele-medicine, tele-geo-processing applications, and online education.
Fourth generation wireless systems are packet switched wireless systems with wide area coverage and high throughput. They are designed to be cost effective and to provide high spectral efficiency.

Features:

1. High usability: anytime, anywhere, and with any technology.
2. Support for multimedia services at low transmission cost
3. Personalization
4. Integrated services
5. Ubiquitous Mobile Access

5G – The Fifth Generation

The fifth generation of wireless mobile communication refers to WWWW- World Wide Wireless Web. It is the wireless internet network thet will be supported by the technologies like by OFDM, MC-CDMA, LAS-CDMA, UWB, Network-LMDS and IPv6. IPv6 will be the basic protocol for running 5G systems.
The layered model that will be utilized by the 5G systems will be somewhat similar to the one shown in figure below. The physical and Datalink layer will define the wireless technology. This wireless technology is like an open wireless architecture.

<table>
<tr><td>Application Layer</td><td rowspan="2">Application(Service)</td></tr>
<tr><td>Presentation Layer</td></tr>
<tr><td>Session Layer</td><td rowspan="2">Open Transport Protocol</td></tr>
<tr><td>Transport Layer</td></tr>
<tr><td rowspan="2">Network Layer</td><td>Upper Network Layer</td></tr>
<tr><td>Lower Network Layer</td></tr>
<tr><td>Datalink Layer</td><td rowspan="2">Open wireless Architeture</td></tr>
<tr><td>Physical Layer</td></tr>
</table>

The 5G systems shall maintain virtual multi-wireless network. Therefore, the network layer is divided into two sub layers. The upper network layer for the mobile node and the lower network layer for the interface. This is the preliminary framework for the internet, where all the routing will be based on IP addresses which will be different in each IP network world wide [9]. In the existing wireless radio interface a higher bit rate is a big loss; to control this loss the 5G systems will use *Open Transport Protocol* (OTP). The application layer is for quality of service management over different type of networks.

Features:

1. Bidirectional larger bandwidth,
2. less traffic,
3. Equal availability of network across the world,
4. 25Mbps connectivity speed,
5. Data bandwidth higher than 1GB and
6. Low-cost.

	0G	1G	2G	2.5G	2.75G	3G	3.5G	3.75G	4G	5G
Starts from	1970	1980	1991	1997	1999	2003	2003	2003	2010	2015
Standards	MTS, IMTS, AMTS	AMPS, NTT, ETACS, RTMS, NMT-450, NMT-900, NTACS, JTACS	GSM,PDC, CdmaOne, TDMA	GPRS	EDGE	UMTS, WCDMA, HSPA 3.6, HSPA 7.2	HSDPAevolved HSPA,3 GPP LTE	HSPA	Mobile WIMAX, LTE, LTE Advanced	IP broadband LAN/WAN/PAN & WWWW
Services	Voice	Analog Voice	Digital Voice, data	MMS, internet		High speed voice/data/ video wireless voice telephony, mobile internet access, video calls, mobile TV	High speed voice/ data/ video	High speed internet/multi media	Mobile ultra-broadband internet access, IP telephony, gaming services, video conferencing, 3D television, cloud computing, Global roaming across multiple wireless networks, 10Mbps-100Mbps, IP interoperability for seamless mobile Internet	Dynamic-information access, wearable devices with AI feature,
Bandwidth						5-20 MHz			100 MHz or more	
Speed		2kbps	10kbps	64-115 kbps	115-384 kbps	0.384-2 Mbps	2Mbps	30mbps	200Mbps -1 Gbps	>1gps
Multiplexing (Access Technologies)		FDMA	TDMA,CDMA			CDMA	CDMA	CDMA	MC-CDMA, OFDMA,SC-FDMA,Interleaved FDMA	CDMA,OFDM and multicarrier (MC)-CDMA
Switching		Circuit	Circuit/Packet	Packet	Packet	Packet/Circuit	Packet	Packet	All digital with packetized voice	Packet
Main network		PSTN	PSTN	GSM,TDMA	WCDMA	Packet network??	GSM TDMA		Internet	Internet
Handoff Type		Horizontal	Horizontal			Horizontal	Horizontal	Horizontal	Horizontal & Vertical	Horizontal & Vertical
Frequency		800-900 MHz	850-1900MHz (GSM) 825-849MHz (CDMA)	850-1900 MHz	850-1900 MHz	1.6-2.5 GHz	1.6-2.5 GHz	1.6-2.5 GHz	2-8 GHz	

Conclusion

Mobile and wireless networks are rapidly evolving all around the world. Every generation comprises of some special features which make it important in terms of technology. In Future scope we suggest, new work can be done on these technologies by introducing new features to them. Some amendments can be done. Also combination of two or more technologies can be used to get better results. This field of research area is growing very fast so a lot of work can be done.

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