A Comparative Study of Mobile Wireless Communication Networks and Technologies

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Abstract— *Mobile and wireless networks have made tremendous growth in the last fifteen years. The rapid improvement of the mobile generations was for the purpose of supporting as many mobile devices as possible that could benefit the users at anytime and anywhere in terms of common practical applications such as internet access, video-on-demand, video conferencing system and many more applications. In this paper, a survey for the mobile generations in the wireless communications is presented in order to highlight and compare the issues and challenges that are involved in each generation and also in order to understand how solutions and improvements were successfully performed to these issues starting from the earlier generations along to the following generations and finally till the current available generation..*

Keyword: 1G, 2G, 2.5 G, 3G, 4G, FDMA, TDMA, UMTS.

I. INTRODUCTION

Wireless mobile communication networks have been experienced four generations of change. In this research work, we present the detail survey of the different generations of the mobile communication networks. First Generation (1G) [1] mobile phone networks were the earliest cellular systems to develop, and they relied on a network of distributed transceivers to communicate with the mobile phones. Second Generation (2G) mobile telephone networks were the logical next stage in the development of wireless systems after 1G, and they introduced for the first time a mobile phone system that used purely digital technology. Third Generation (3G) mobile telephone networks are the latest stage in the development of wireless communications technology. Significant features of 3G systems are that they support much higher data transmission rates and offer increased capacity, which makes them suitable for high-speed data applications as well as for the traditional voice calls. Fourth Generation (4G) is known as beyond 3G, stands as an acronym for Fourth-Generation Communications System. It is used to describe the next step in wireless communications. A 4G system will be able to provide a comprehensive IP solution where voice, data and streamed multimedia can be given to users on an anytime, anywhere" basis, and at higher data rates than previous generations.

II. 1G - FIRST GENERATION NETWORKS

1G - First Generation mobile phone networks were the earliest cellular systems to develop, and they relied on a network of distributed transceivers to communicate with the mobile phones. First Generation phones were also analogue, used for voice calls only, and their signals were transmitted by the method of frequency modulation. These systems typically allocated one 25 MHz frequency band for the signals to be sent from the cell base station to the handset, and a second different 25 MHz band for signals being returned from the handset to the base station.

The first generation wireless mobile communication system is not digital technology, but analog cellular telephone system which was used for voice service only during the early 1980s [2]. This Advanced Mobile Phone System (AMPS) was a frequency modulated analog mobile radio system using Frequency Division Multiple Access (FDMA) with 30kHz channels occupying the 824MHz − 894MHz frequency band and a first commercial cellular system deployed until the early 1990's [3].

There are such limitations in the 1G mobile communications. First of all, it has no data service that can convert the voice into digital numbers. Secondly, the global roaming service was not available. Fourthly, it contains an analog system in such a way only voice is carried by these systems. In the matter of fact, the main problem that was held in the 1G is that there was only one channel which carries the data from one caller (source) to another (destination). More clearly, the available radio spectrum was not efficient for the space of channels. In other words, the first caller (source) will have to wait for a response from the other caller once the voice is received. This means that the two callers are not able to hear each other simultaneously since the number of calls was limited by this effect. Consequently, such calls can be only performed once. This process refers to which is called "Frequency Division Multiple Access" FDMA [4]. This problem could be solved by having more than one channel (two channels or more) where one channel will have to be involved in carrying the voice and the other channel will have to be involved in carrying the data of the voice. Consequently, a

digital system is required for such tasks. More specifically, the frequency modulation method was used to transmit the signals of these voice calls.

III. 2G - SECOND GENERATION NETWORKS

2G - Second Generation mobile telephone networks were the logical next stage in the development of wireless systems after 1G, and they introduced for the first time a mobile phone system that used purely digital technology. The demands placed on the networks, particularly in the densely populated areas within cities, meant that increasingly sophisticated methods had to be employed to handle the large number of calls, and so avoid the risks of interference and dropped calls at handoffs. Although many of the principle involved in a 1G system also apply to 2G - they both use the same cell structure - there are also differences in the way that the signals are handled, and the 1G network are not capable of providing the more advanced features of the 2G systems, such as caller identity and text messaging.

2.5G: In term "2.5G" usually describes a 2G cellular system combined with General Packet Radio Services (GPRS), or other services not generally found in 2G or 1G networks. A 2.5G system may make use of 2G system infrastructure, but it implements a packet-switched network domain in addition to a circuit-switched domain. It can support data rate up to 144kbps.GPRS, EDGE, & CDMA 2000 were the focal 2.5G technologies. This does not necessarily give 2.5G an advantage over 2G in terms of network speed, because bundling of timeslots is also used for circuit-switched data services (HSCSD).

IV. 3G - THIRD GENERATION NETWORKS

3G - Third Generation mobile telephone networks are the latest stage in the development of wireless communications technology. Significant features of 3G systems are that they support much higher data transmission rates and offer increased capacity, which makes them suitable for high-speed data applications as well as for the traditional voice calls. In fact, 3G systems are designed to process data, and since voice signals are converted to digital data, these results in speech being dealt with in much the same way as any other form of data. Third Generation systems use packet-switching technology, which is more efficient and faster than the traditional circuit-switched systems, but they do require a somewhat different infrastructure to the 2G systems.

The benefits of higher data rates and greater bandwidth mean that 3G mobile phones can offer subscribers a wide range of data services, such as mobile Internet access and multimedia applications. Compared to earlier mobile phones a 3G handset provides many new features, and the possibilities for new services are almost limitless, including many popular applications such as TV streaming, multimedia, videoconferencing, Web browsing, e-mail, paging, fax, and navigational maps.

3G technologies make use of TDMA and CDMA.3G (Third Generation Technology) technologies make use of value added services like mobile television, GPS (global positioning system) and video conferencing. The basic feature of 3G Technology is fast data transfer rates. 3G technology is much flexible, because it is able to support the 5 major radio technologies. These radio technologies operate under CDMA, TDMA and FDMA.CDMA holds for IMT-DS (direct spread), IMT-MC (multi carrier). TDMA accounts for IMTTC (time code), IMT-SC (single carrier). FDMA has only one radio interface known as IMT-FC or frequency code. Third generation technology is really affordable due to the agreement of industry. This agreement took pace in order to increase its adoption by the users. 3G system is compatible to work with the 2G technologies. The aim of the 3G is to allow for more coverage and growth with minimum investment. There are many 3G technologies as W-CDMA, GSM EDGE, UMTS, DECT, WiMax and CDMA 2000.Enhanced data rates for GSM evolution or EDGE is termed to as a backward digital technology, because it can operate with older devices.

3G has the following enhancements over 2.5G and previous networks: Enhanced audio and video streaming;

- Several Times higher data speed.
- Video-conferencing support.
- Web and WAP browsing at higher speeds.
- IPTV (TV through the Internet) support.

V. 4G - FOURTH GENERATION NETWORKS

A fourth generation (4G) network is the name given to an IP-based mobile system that provides access through a collection of radio interfaces [5]. A 4G network promises seamless roaming/handover and best connected service, combining multiple radio access interfaces into a single network that subscribers may use. With this feature, users will have access to different services, increased coverage, the convenience of a single device, one bill with reduced total access cost, and more reliable wireless access even with the failure or loss of one or more networks. At the moment, 4G is simply an initiative by R&D labs to move beyond the limitations, and deal with the problems of 3G (which is having trouble meeting its promised performance and throughput).

At the most general level, 4G architecture will include three basic areas of connectivity: Personal Area Networking (such as Bluetooth), local high-speed access points on the network including wireless LAN technologies and cellular connectivity. Under this umbrella, 4G calls for a wide range of mobile devices that support global roaming. Each device will be able to interact with Internet-based information that will be modified on the fly for the network being used by the device at that moment. In short, the roots of 4G networks lie in the idea of pervasive computing [6].

4G is being developed to accommodate the QoS and rate requirements set by forthcoming applications like wireless broadband access, Multimedia Messaging Service (MMS), video chat, mobile TV, HDTV content, Digital Video Broadcasting (DVB), minimal services like voice and data, and

other services that utilize bandwidth. The definition of 4G is to provide adequate RF coverage, more bits/Hz and to interconnect all wireless heterogonous networks to provide seamless, consistent telecom experience to user.

Mobile networks have been designed up to this point — for circuit- switched voice. Wireless networks were designed in a hierarchal fashion to aggregate, authenticate, manage and direct calls. A BSC aggregates calls from multiple base stations, allocates radio channels, enables handoffs between base stations and passes on calls to an even more centralized mobile switching center. As packet data networks emerged, they were overlaid on the existing voice-centric architecture, using the BSC for the same mobility management functions and adding the SGSN and GGSN in the case of GSM/UMTS and a PDSN in the case of CDMA to route and manage data sessions, as well as to connect to the Internet or appropriate IP network. As data traffic is increasing rapidly, this voice centric architecture has become cumbersome and harder to manage with too many network entities. Flat network architecture removes that voice-centric hierarchy from the network. Instead of overlaying a packet data core on the voice network, separate and much-simplified data architecture can be implemented that removes the multiple elements from the network chain. BSC functions are divided between Base station and media gateway router. Base station will communicate directly via 3GDT (3G direct tunnel) with media gateway over WAN (Carrier Ethernet, MW, DWDM etc.). Some of the functions of BSC/RNC such as Radio resource management, Radio Bearer Control, and Dynamic allocations of resources will be handled by base stations, while functions such as Distribution of paging messages, Security will be function by mobility manager, located in Gateway router.

VI. EVOLUTION OF GENERATION OF CELLUAR TECHONOLOGIES

1G, 2G, 3G & 4G ("G" stands for "Generation") are the generations of wireless telecom connectivity. 1G (Time Division Multiple Access and Frequency Division Multiple Access) was the initial wireless telecom network system. It's outdated now. The analog ―brick phones and ―bag phones are under 1G technology. Cell phones era began with 1G.The next era, 2G has taken its place of 1G. Cell phones received their first major upgrade when they went from 1G to 2G. This leap effectively took cell phones from analog to digital. 2G and 2.5G were versions of the GSM and CDMA connections. And GSM is still the most popular technology, but with no internet. Fortunately, GPRS, an additional service, is provided over GSM for the purpose of internet access. GPRS has been developed and thus, EGPRS was created. It's more secure and faster than GPRS.

Then 3G came, the new Wireless CDMA technology. It is the first wireless telecom technology that provides broadband-speed internet connection on mobile phones. Further development led to the creation of 3.5G, which provides blazing fast internet connection on phones, up to the speed of 7.2 MBPS. A smart phone can be connected to a PC to share its internet connection and 3G and 3.5G are ideal for this.4G, which is also known as ―beyond 3G or ―fourth-generation cell phone technology, refers to the entirely new evolution. Developers are now going for 4G (OFDMA), which will provide internet up to the speed of 1 GBPS, It is said to be able to overcome the problems of weak network strength and should provide a much wider network, making sure that the users get high-speed connectivity anytime anywhere. No doubt, 4G will open new doors of revolutionary internet technologies, but for now, 3G and 3.5G are the best. 4G will allow for speeds of up to 100Mbps. 4G promises voice, data and high-quality multimedia in real-time form all the time and anywhere.

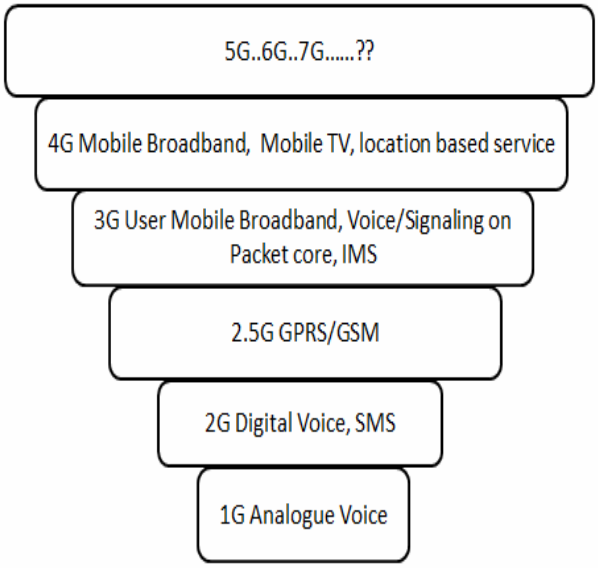

Figure 1: Evolution of Generations of Cellular Technologies

Table 1: Comparative study on various Generations

Generation	Years	Mobile Technology/ Switching Method	Data Bandwidth Offered (Upper Bound)	Services Offered
1G	Early 1980s	Analog Cellular /Circuit Switched	9.6 Kbps	Voice
2G	Early 1990s	Digital Cellular /Circuit Switched	14.4 Kbps	Voice (main), SMS

2.5G	1996	Digital Cellular /Circuit Switched-Packet Enabled	144 Kbps	Voice and packet data introduced
3G	2000	Digital Cellular /Circuit Switched voice (later VoIP) and Packet Switched Data	Up to 14Mbps	Packet data on high-speed, voice, IMS-enabled multimedia applications
4G	2012	Digital Cellular / Packet Data Enable Packet-based Voice	20 to 100 Mbps	Mobile broadband, mobile TV, VoD, location-based services, High speed data and security

Table1: Generations of Cellular Technologies

CONCLUSION

The demand for new high-speed, reliable, wireless services is growing fast. Future wireless networks will provide added value by allowing a large variety of services. Real-life networks require the performance to be compliant with certain quality of service targets in forms of delay, error probability or fidelity in the reconstruction of the data. Depending on the applications, different measures of performance may be more critical than others. For example data-transmission (web browsing, data transfer, email) is not strictly delay sensitive but require a virtually error free link. Multimedia content (video streaming) can be more delay sensitive but tolerate some losses, or it can relax the conditions on the delay and accept some losses as in the case of image transmission.

This paper has compared 1G to 4G Mobile network architecture and technologies which will help to build the high speed mobile network architecture and technologies.

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