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Evolutionary steps from 1G to 4.5G

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Abstract: The journey from analog based first generation service (1G) to today's truly broadband-ready LTE advanced networks (now accepted as 4.5G), the wireless industry is on a path that promises some great innovation in our future. Technology from manufacturers is advancing at a stunning rate and the wireless networking is tying our gadgets together with the services we demand. Manufacturers are advancing technologies at a stunning rate and also evolution in wireless technology all impossible things possible as market requirement.

Keywords: Mobile Wireless Communication Networks, 1G, 2G, 3G, 4G,4.5G

I. INTRODUCTION

With rapid development of information and communication technologies (ICT), particularly the wireless communication technology it is becoming very necessary to analyse the performance of different generations of wireless technologies. In just the past 10 years, we have seen a great evolution of wireless services which we use every day. With the exponential evolution, there has been equally exponential growth in use of the services, taking advantage of the recently available bandwidth around the world. As per market survey data usage around the world exceed 1EB in a month. 1EB is the same as 1 billion gigabytes, 1,000,000,000GB. It should surprise no one that the smartphone revolution is fuelling this growth, and by 2017, half of all mobile devices in the world will be smartphones. The key to keeping users happy is network performance and good value for the money. From the looks of it, we are on track to seeing continued network performance improvements and increasingly easier access to smartphones as developing markets hop on the bandwagon.

II. 1G

A. Features

Since the introduction of 1G around 1980's the mobile communication have undergone significant changes and experienced enormous growth rate of around 35-50% rising to nearly 20million subscribers. It was based on Analogous techniques. However the different applications of 1G were Paging system, cordless telephone, cordless telephone cells,Private mobile radio.

B.Technology

The prominent systems used in 1G were Advanced Mobile Phone system (AMPS), Nordic Mobile Telephone(NMT),Total Access communication system(TACS). AMPS was introduced in 1982 providing bandwidth of 40MHz,offering 832 channels for subscribers with data rate of 10Kbps.initially Omni directional antennas were used and are replaced by directional antennas having a 7cell reuse pattern.

III. 2G

A. *Features*

Aiming improvement in 1G services the concept of 2G was introduced in late 1980's. In this Analogus technology was replaced by Digital Access techniques such as TDMA (Time division multiple access), CDMA (code division multiple access) having enhanced Spectrum efficiency, better data services and special feature as Roaming was introduced.

B.Technology

2G cellular systems includes GSM, digital AMPS, code division multiple access(CDMA),personal digital communication(PDC). Out of these the most widely used technology in 2G was Global system for mobile communication (GSM).GSM includes GSM 900, GSM railway,GSM 1900,GSM 400. This network links together all the cells into a single network, coordinates resources to hand over your call from one cell to another as you move, discovers where you are so that you can receive incoming calls, links to the fixed network so that you can reach fixed-line phones, and communicates with roaming partners. You can use your phone on other network links to the Internet, so you can reach Web servers and corporate systems worldwide to control and deliver services depending on your subscription profile. The standard services provided includes circuit switched Voice,fax,wireless application Protocol(WAP),high speed circuit switched data,(HSCSD),Mobile location service(MLS).

IV. 3G

A. *Features*

3G has made revolutionary change in the world of mobile technology and many more industries in telecommunication. Apart from increasing the speed of communication, the objective of this technology is to provide various value added services like video calling, live streaming, mobile internet access, IPTV, etc on the mobile phones. These services are possible because the 3G spectrum provides the necessary bandwidth.

B. Technology

3G is a network protocol which refers to the generations of mobile phones and telecommunication equipments which are compatible with the International Mobile Telecommunications-2000 (IMT-2000) standards stated by International Telecommunication Union (ITU). The

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basic requirement for compiling to IMT-2000 standards is that the technology should provide peak data rates of atleast 200 kbit/s. It's worth mentioning that speed isn't the only criteria for deciding whether the network protocol is 3G or not. 3G isn't just any high speed network but a protocol which has its own standards defined under IMT-2000 by ITU. According to ITU it is expected that IMT-2000 will provide higher transmission rates: a minimum speed of 2Mbit/s for stationary or walking users, and 348kbit/s in a moving vehicle. CDMA2000 is not constrained to only the IMT-2000 band, but operators can also overlay a CDMA2000 1x system, which supports 144 kbps now and data rates up to 307 kbps in the future, on top of their existing CDMAOne network. Time Division Synchronous CDMA (TD-SCDMA) was proposed by China Wireless Telecommunication Standards group (CWTS) and after approval by the ITU in 1999, this technology is being developed by the Chinese Academy of Telecommunications Technology and Siemens. TD-SCDMA uses the Time Division Duplex (TDD) mode, i.e., traffic from the mobile terminal to the base station (uplink) and vice versa (downlink) are transferred in the same frame in different time slots. The uplink and downlink spectrum is assigned flexibly, depending on the type of information to be transmitted. When services like telephony are used a symmetrical split in the uplink and downlink takes place whereas when asymmetrical data like e-mail and internet are transmitted from the base station, more time slots are used for downlink than for uplink. Wideband Code-Division Multiple-Access (W-CDMA) is one of the main technologies for the implementation of third-generation (3G) cellular systems. It is also known as IMT-2000 direct spread. It is developed by 3GPP (Third Generation Partnership Project). 3GPP is the joint standardization project of the standardization bodies from Europe, Korea, Japan, the USA and China. Within 3GPP, WCDMA is called UTRA (Universal Terrestrial Radio Access) FDD (Frequency Division Duplex) and TDD (Time Division Duplex), the name WCDMA being used to cover both FDD and TDD operation.

WCDMA is a wideband Direct-Sequence Code Division Multiple Access (DS-CDMA) System. WCDMA supports two basic modes of operation: Frequency Division Duplex (FDD) and Time Division Duplex (TDD). In the FDD mode, separate 5 MHz carrier frequencies are used for the uplink and downlink respectively, whereas in TDD only one 5 MHz is timeshared between the uplink and downlink. Uplink is the connection from the mobile to the base station, and downlink is that from the base station to the mobile.

The implementation of W-CDMA will be a technical challenge because of its complexity and versatility. The complexity of W-CDMA systems can be viewed from different angles: the complexity of each single algorithm, the complexity of the overall system and the computational complexity of a receiver. W-CDMA link-level simulations are over 10 times more compute-intensive than current second-generation simulations. In W-CDMA interface different users can simultaneously transmit at different data rates and data rates can even vary in time. UMTS networks need to support all current second generation services and numerous new applications and services.

3G telecommunications, is a generation of standards for mobile phones and mobile telecommunication services fulfilling the International Mobile Telecommunications-2000 (IMT-2000) specified by the International Telecommunication Union.] Application services include wide-area wireless voice telephone, mobile Internet access, video calls and mobile TV, all in a mobile environment. To meet the IMT-2000 standards, a system is required to provide peak data rates of at least 200 kbit/s. Recent 3G releases, often denoted 3.5G and 3.75G, also provide mobile broadband access of several Mbit/s to smart phones and mobile modems in laptop computers.

V. 4G

A. *Features*

4G wireless technology is also referred to by "MAGIC" which stands for *Mobile multimedia, Any-where, Global mobility solutions over, integrated wireless and Customized services.*4G is all about convergence; convergence of wired and wireless networks, wireless technologies including GSM, wireless LAN, and Bluetooth as well as computers, consumer electronics, communication technology and several others. 4G is a Mobile multimedia, anytime anywhere, Global mobility support, integrated wireless solution, and customized personal service network system 4G is an all IP-based integrated system will be capable to provide 100 Mbps for high mobility and 1 Gbps for low mobility , with end-to-end QoS and high security, and will offering various services at any time as per user requirements, anywhere with seamless interoperability, at affordable cost. The user services include IP telephony, ultra-broadband Internet access, gaming services and High Definition Television (HDTV) streamed multimedia. ITU has specified IMT-A (IMT-Advanced) for 4G standards.

B. *Technology*

Long Term Evolution (LTE) technology is sometimes called 3.9G or Super 3G and has been developed by the Third Generation Partnership Project (3GPP) as an improvement to the current Universal Mobile Telecommunications System (UMTS). By using Orthogonal Frequency Division Multiple Access (OFDMA), LTE will be able to provide download rates of 150 Mbps for multi-antenna (2x2) multiple-input multiple output (MIMO) for the highest category terminals. For these terminals upload rates in the 50 Mbps range will allow an efficient transfer of data. LTE makes very efficient use of the available spectrum with channel bandwidths from 1.25 Megahertz (MHz) to 20 MHz The flexible "slice" will allow LTE to be more easily implemented in countries where 5 MHz is a commonly allocated amount of spectrum. LTE will also co-exist with legacy systems already rolled out around the world.

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VI. 5G

LTE Advanced is the next wireless upgrade, beyond LTE/4G – essentially 4.5G which is faster better in user experience and highly efficient in spectrum use.Average user download speeds should be 2x-3x that of vanilla LTE. This suggests real (typical / average) download speeds on LTE Advanced could be 14-21Mbps (vs. 7-12 Mbps over early LTE/4G). LTE -A to its higher speeds, far greater spectrum efficiency and use of Heterogeneous network, can boost network capacity by 3x-5x (vs 4G). LTE Advanced will enhance customer experience via much lower latency. Delays between click & download will be cut by >50% (4G: 12ms vs 4.5G: 5ms). LTE Advanced is a spectrum-efficient technology.

Moreover, operators can use different spectrum bands on the same network service. Previously-segregated spectrum is grouped together in to broader bands. Carrier aggregation is key – up to five carriers can be used on 4.5G. Wider spectrum bands will boost speeds. LTE Advanced signals a shift to Intelligent Networks. 4.5G technology should be able to adapt to changing network environments - uneven loads, switch between macro & pico cells, power-down during low traffic periods etc.

LTE Advanced will offer better signal / range for base stations, while the use of heterogeneous networks(combination of Pico, Micro and Femto) and MIMO will boost 4.5G performance much further.We expect vanilla LTE/4G lead markets to be the first to roll out LTE Advanced – these operators include Verizon W, AT&T, Sprint, DoCoMo, SK, KT, LG, Telia, Telenor. Roll-outs could start in 2013.

VII. 2G vs 3G

Here are some generalizations that may help: •Leaving your phone registered/idle on either 2G or 3G should produce similar battery usage. Voice-only mode without much data should produce very similar battery drain.

• If the 3G signal is poor, or coverage fluctuates, 3G will use much more power while actively transfering data. • 2G has better, more consistent power drain when the 3G coverage is spotty or fluctuating. Use 2G-only mode if the signal is bad, and/or you do not need heavy data usage to increase battery life.

• 3G has a higher battery drain, however, it actually uses less Watts per downloaded Kilobyte compared to 2G. 3G is much better for heavy data usage, and will not use much more battery if the 3G signal is strong. If the signal is poor or fluctuating, however, it may drain your battery as much as twice as fast compared to 2G. Talk time is considerably less than 2G, however, standby drain is about the same. Overall, under typical conditions in suburban areas, you should expect about 2/3 of the 2G battery life.

A Comparison between 1G to 5G is shown in table. Also for more clarification and understanding purpose plot years vs multimedia technologies is shown below.

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Generation / Features	1G	2G/2.5G	3G	4G	5G
Evolution Year	1970-1984	1980-1999	1990-2002	2000-2010	2010-onwords
Data Bandwidth	2Kbps	14.4-64kbps	2Mbps	200Mbps-1Gbps	1Gbps and higher
Standards	AMPS/NMT/TACS	TDMA/CDMA/GSM	WCDMA/CDMA-2000	Single unified Standard	Single unified Standard
Multiplexing Techniques	FDMA	TDMA/CDMA	WCDMA	CDMA	CDMA
Switching Techniques	Circuit	Circuit	Packet except circuit for air interface	Packet	Packet
Handoff Techniques	Horizontal	Horizontal	Horizontal	Horizontal and Vertical	Horizontal and Vertical

Table. 1 Comparison of different Generation technologies

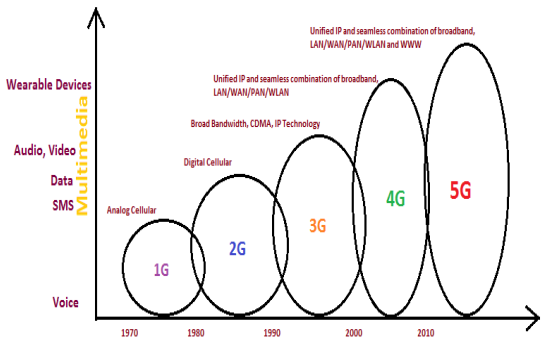

Fig. 1 Evolutionary changes from 1G to 5G.

VIII. CONCLUSION

The advent of 4G is sure to revolutionize the field of telecommunication domain bringing the wireless experience to a completely new level. It would provide wealth of features and services making the world a smaller place to live. Thus, 4G seems to have the capability to realize the scenario discussed in Section 2. But 4G shouldalso take lesson from the 3G's failure to capture the imagination of the end-users. Technology should not be

developed for technology's sake rather it should target the end user. Thus, user-centric approach towards 4G's development is the key to its success. Common consensus on the standards and the technologies for 4G needs to be reached to fasten 4G's deployment which would be a gradual process. Lot of research work is required to investigate the open issues like design for SDR, QoS parameters and so forth. The threat analysis model provided by ITU is very apt for the complete analysis and planning for security of 4G. It can be used as a reference framework for future research. But still comprehensive research work is required in the field of network security to tackle potential security threats because a ubiquitous "secured" heterogeneous network will appeal more to the today's consumers.

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