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3G COMMUNICATION TECHNOLOGY (ADVANCE COMMUNICATION)

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Abstract: *This research paper aims to be responsible for the upcoming of 3G technology in emerging or developing countries. At the global level 3G technology had reached to the higher level. Hereafter, the study of success factors and the hitches faced is advisable before the launch of this service in developing countries.*

Evolution of wireless access technologies is about to reach its fourth generation (4G). Looking past, wireless access technologies have followed different evolutionary paths aimed at unified target: performance and efficiency in high mobile environment. The first generation (1G) has fulfilled the basic mobile voice, while the second generation (2G) has introduced capacity and coverage. This is followed by the third generation (3G), which has quest for data at higher speeds to open the gates for truly "mobile broadband" experience, which will be further realized by the fourth generation (4G).The Fourth generation (4G) will provide access to wide range of telecommunication services, including advanced mobile services, supported by mobile and fixed networks, which are increasingly packet based, along with a support for low to high mobility applications and wide range of data rates, in accordance with service demands in multiuser environment.

This paper provides a high level overview of the evolution of Mobile Wireless Communication Networks from 1G to 4G. Though 3G has still not been implemented fully, the attention has already turned to the next generation of mobile communications, i.e. 4G. Presently, NTT DoCoMo and Hewlett-Packard are on their agenda to make it available by the year 2006. 4G is being developed to provide data transfer speeds up to 50 times more than of 3G.So topic is named as 3G Technology.

Keywords: *Mobile Wireless Communication Networks, 1G, 2G, 3G, 4G, Mobile Broadband.*

I. INTRODUCTION

First-generation (1G) mobile phones had only voice facility. These were replaced by second-generation (2G) digital phones with added fax, data, and messaging services. The third-generation (3G) technology has added multimedia facilities to 2G phones. And now talks are on for the next-generation mobile technology with more advanced features, i.e. 4G, which is expected to be available in the market by 2010.

Different Standards Used in Different Generations of Mobile Technologies

1G	2G	3G
1. Paging systems 2. Cordless telephone (CTO, CTI) 3. Cordless telephone cell 4. Private mobile radio 5. Cellular systems (NMT, AMPS, etc) 6. Mobile satellite systems (INMARSAT)	1. Paging systems 2. Cordless telephone (DECT, PACS) 3. WLL 4. Private mobile radio (TETRA) 5. Cellular systems (GSM, D-AMPS, PDC, IS-95) 6. Mobile satellite systems (IRIDIUM, ICO, GLOBALSTAR)	1. Single standard under IMT-2000, UMTS, MC-CDMA, TD-SCDMA

The theory of electromagnetic radiation was propounded by Clark Maxwell in 1857 and explained mathematically the behavior of electromagnetic waves. Then G. Marconi invented trans-Atlantic radio transmission using electromagnetic waves in 1901. However, as the bandwidth of these transmission systems was very small, the transmission of information was very slow. Though the electromagnetic waves were first discovered as a communications medium at the end of the 19th century, theses were put in use for the masses very late. [1]

The first systems offering mobile telephone service (car phone) were introduced in the late 1940s in the US and in the early 1950s in Europe. These single cell systems were severely constrained by restricted mobility, low capacity, limited service, and poor speech quality. Also the equipment was heavy, bulky, expensive, and susceptible to interference.

II. THE FIRST GENERATION

1G mobile was based phones on the analogue system. The introduction of cellular systems in the late 1970s was a quantum leap in mobile communication, especially in terms of capacity and mobility. Semiconductor technology and microprocessors made smaller, lighter, and more sophisticated mobile systems a reality. However, these 1G cellular systems still transmitted only analogue voice information. The prominent ones among 1G system were advanced mobile phone system (AMPS), Nordic mobile telephone (NMT), and total access communication system (TACS). With the introduction of 1G phone, the mobile market showed annual growth rate of 30 to 50 per cent, rising to nearly 20 million subscribers by 1990.[3]

III. THE SECOND GENERATION

2G phones using global system for mobile communications (GSM) were first used in the early 1990s in Europe. GSM provides voice and limited data services, and uses digital modulation for improved audio quality.

Multiple digital systems. The development of 2G cellular systems was driven by the need to improve transmission quality, system capacity, and coverage. Further advances in semiconductor technology and microwave devices brought digital transmission to mobile communications. Speech transmission still dominates the airways, but the demand for fax, short message, and data transmission is growing rapidly. Supplementary services such as fraud prevention and encryption of user data have become standard features, comparable to those in fixed networks. 2G cellular systems include GSM, digital AMPS (D-AMPS), code-division multiple access (CDMA), and personal digital communication (PDC). Today, multiple IG and 2G standards are used in worldwide mobile communications.[2] Different standards serve different applications (paging, cordless telephony, wireless local loop, private mobile radio, cellular telephony, and mobile satellite communication) with different levels of mobility, capability, and service area. Many standards are used only in one country or region, and are incompatible.

GSM is the most successful family of cellular standards. It includes GSM900, GSM-railway (GSM-R), GSM1800, GSM1900, and GSM400. GSM supports around 250 million of the world's 450 million cellular subscribers, with international roaming in approximately 140 countries and 400 networks.

The core network.[7] 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 2G architecture.[9] The existing mobile network consists of the radio access network (comprising cells and backhaul communications) and the core network (comprising trunks, switches, and servers). Mobile switching centers (MSCs) are intelligent servers and the whole network is data-driven, using subscription and authentication information held in the home location register (HLR) and authentication centre (AuC). The standard services include circuit-switched voice, fax, and data, as well as voicemail and voicemail notification. Additional services include wireless application protocol (WAP), high-speed circuit-switched data (HSCSD), mobile location services (MLS), and cell broadcast. You can change to a new operator keeping your old phone number.

2.5G:

The mobile technology using general packet radio service (GPRS) standard has been termed as 2.5G. 2.5G systems enhance the data capacity of GSM and mitigate some of its limitations. GPRS adds packet-switched capabilities to existing GSM and TDMA networks. Working on the basis of emails, it sends text and graphics-rich data as packets at very fast speed. The circuit-switched technology has a long and successful history but it is inefficient for short data transactions and always-on service. The packet switched technology has grown in importance with the rise of the Internet and Internet protocol (IP). But as IP too has its own weaknesses, circuit-switched services are not going to disappear.

The GPRS (2.5G) core network and service characteristics.[8] Although GPRS is an extension to the radio access network, it requires whole new packet based IP data links, servers, and gateways in the core network. Thus GPRS adds several new components besides changing the existing GSM or TDMA network.

GPRS is important because it helps operators, vendors, content providers, and users prepare for 3G, as many concepts of GPRS live on in 3G, and we will need these enhancements to 2G networks for ten years or more. At the moment, wireless network technologies are somewhere between 2G and 2.5G. The second generation of mobile communications technology was all about digital PCS. The problem, however, was that much of the digital network was implemented for, or overlaid onto, proprietary networking equipment. Taken together, 2G and 2.5G technologies are far from seamless. These range from spread spectrum code-division multiple access (CDMA) in North America to narrow spectrum time-division multiple access (TDMA) and GSM in Europe and Asia. In addition to these incompatibilities, both systems offer digital voice at a relatively low speed with very little bandwidth left over for data.

IV. THE THIRD GENERATION

The 3G technology adds multimedia facilities to 2G phones by allowing video, audio, and graphics applications. Over 3G phones, you can watch streaming video or have video telephony. The idea behind 3G is to have a single network standard instead of the different types adopted in the US, Europe, and Asia. These phones will have the highest speed of up to 2 Mbps, but only indoors and in stationary mode. With high mobility, the speed will drop to 144 kbps, which is only about three times the speed of today's fixed telecom modems. 3G cellular services, known as Universal Mobile Telecommunications System (UMTS) or IMT-2000 will sustain higher data rates and open the door to many Internet style.

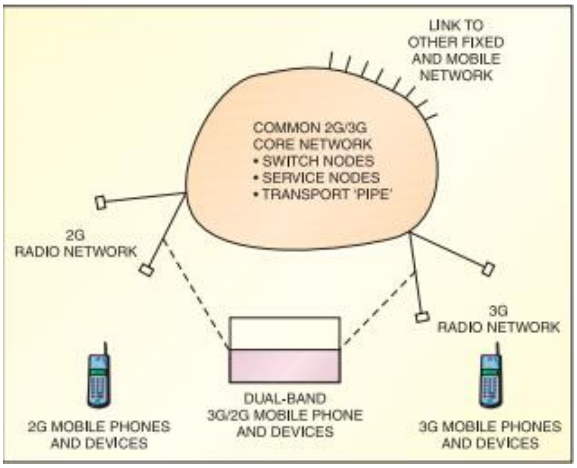

Fig 1. 3G Network [4]

The main characteristics of IMT-2000 3G systems are:
1. A single family of compatible standards that can be used worldwide for all mobile applications.
2. Support for both packet-switched and circuit-switched data transmission.
3. Data rates up to 2 Mbps (depending on mobility).
4. High spectrum efficiency.

IMT-2000 is a set of requirements defined by the International Telecommunications Union (ITU). 'IMT' stands for International Mobile Telecommunications and '2000' represents both the scheduled year for initial trial systems and the frequency range of 2000 MHz. The most important IMT-2000 proposals are the UMTS (W-CDMA) as the successor to GSM, CDMA2000 as the successor to interim-standard '95 (IS-95), and time-division synchronous CDMA (TDSCDMA).[6] UWC-136/EDGE as TDMA based enhancements to D-AMPS/ GSM—all of which are leading previous standards towards the ultimate goal of IMT-2000. UMTS increases transmission speed to 2 Mbps per mobile user and establishes a global roaming standard. Fig. 1 shows the 3G network perspective. UMTS is a so-called 3G, broadband standard for packet-based transmission of text, digitized voice, video, and multimedia at data rates up to and possibly higher than 2 Mbps, offering a consistent set of services to mobile computer and phone users, no matter where they are in the world. Based on the GSM communication standard, UMTS, endorsed by major standards bodies and manufacturers, allows mobile users to have the constant access to the Internet and the same set of capabilities irrespective of their location. Users gain

access through a combination of terrestrial wireless and satellite transmissions. Until UMTS is fully implemented, users can have multi-mode devices that switch to GPRS or EDGE technology where UMTS is not yet available.

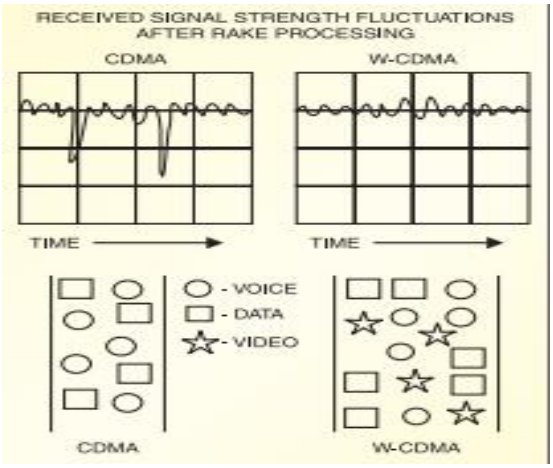

Fig 2. Difference between CDMA & W-CDMA [5]

Today's cellular telephone systems are mainly circuit-switched type, with connections always dependent on the circuit availability. With UMTS, the packet-switched connection using the IP means that a virtual connection is always available to any other end point in the network. This makes it possible to provide new services such as alternative billing methods (pay-per-bit, pay per-session, flat rate, symmetric bandwidth, and others). The higher bandwidth of UMTS also promises video conferencing and the virtual home environment. In virtual home environment, a roaming user can have the same services as at home or in the office, through a combination of transparent terrestrial and satellite connections. Fig. 2 shows the difference between regular CDMA and W-CDMA.
3G promises increased bandwidth, up to 384 kbps when the device holder is walking, 128 kbps in a car, and 2 Mbps in fixed application[10].

In theory, 3G would work over North American as well as European and Asian wireless air interfaces. EDGE is a faster version of GSM wireless service. But the outlook for 3G is neither clear nor certain. Part of the problem is that network providers in Europe and North America currently maintain separate standards bodies. In addition to technical challenges, there are financial issues that cast a shadow over 3G's desirability.
FOMA:

Launched in October 2001, DoCoMo's Freedom of Multimedia Access (FOMA) service provides fast, high-quality voice and image transmission through packet based networks. FOMA's secure access can be used for mobile banking and e-commerce, e-mail, and i-mode compatible Websites. Its high-speed packet transmission network allows the i-mode structure to handle more multimedia content for 3G and 4G wireless Internet services. FOMA handsets use user identity module (UIM) SIM cards. These will be available in three types, namely, Standard (FOMA N2001), Visual (FOMA P2101), and Data Card (FOMA P2401). The FOMA N2001 by Nokia has an improved colour screen and no external antenna. The P2101V by Panasonic takes image stills, so it can function as a TV phone with compatible equipment. Panasonic's P2401 has a PCMCI card for high-volume data transmissions.

A group of cellular phone makers, carriers, and software developers had announced the so-called 'open mobile architecture' that would support two basic air-interface standards, namely, GSM/GPRS and W-CDMA.[13] But some companies didn't agree with the proposal However, mobile phone designs adopting a common architecture are gaining momentum. The main reason for this trend is microcontrollers executing application software for processing moving pictures, music, and other data. Microcontroller manufacturers like Texas Instruments and Intel Corp. are collaborating with handset manufacturers in Taiwan and China. Such handsets, when produced in large volumes, will cost lower than the existing handsets. Thus, Texas Instruments and Intel Corp. are expected to become the main players in the global mobile industry.
The fourth generation:

4G mobile communications will have transmission rates up to 20 Mbps— higher than of 3G. The technology is expected to be available by the year 2010. Presently, NTT DoCoMo and Hewlett-Packard are on their agenda to make it available by the year 2006.

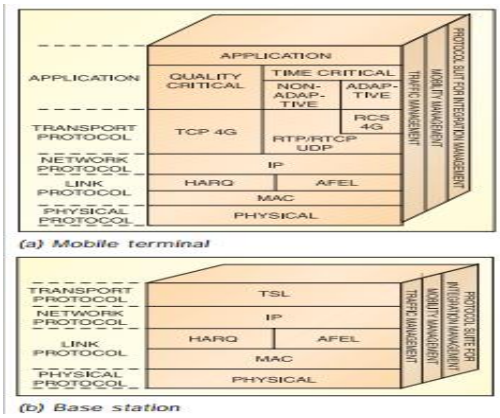

Fig 3. Protocol suite for 4G mobile terminal and base station [11]

4G is being developed with the following objectives:

1. Speeds up to 50 times higher than of 3G. However, the actual available bandwidth of 4G is expected to be about 10 Mbps.
2. Three-dimensional virtual reality—imagine personal video avatars and realistic holograms, and the ability to feel as if you are present at an event even if you are not. People, places, and products will be able to interact as the cyber and real worlds merge.

4G will solve problems like limited bandwidth in 3G when people are moving and uncertainty about the availability of bandwidth for streaming to all users at all times. One of the key requirements is to realize a wireless 4G IP-based access system.

The ultimate objective is to create a protocol suite and radio communication schemes to achieve broadband mobile communication in 4G wireless systems. A new protocol suite for 4G wireless systems supported by Department of Defense (DoD) contains:

1. Transport-layer protocols
2. Error-control protocols
3. Medium-access protocol
4. Mobility management
5. Simulation tested
6. Physical tested
7. Protocol suite in the mobile terminal (Fig. 3(a))
8. Protocol suite in the base station(Fig. 3(b))

V. 4G TECHNOLOGY CONCERNS

One of the main concerns about 4G is that due to high speed of the frequency, it will experience severe interference from multipath secondary signals reflecting off other objects. To counter this problem, a number of solutions have been proposed, including use of a variable spreading factor and orthogonal frequency code-division multiplexing.

Next comes the problem of non-compatibility of various applications. For example, FOMA-enabled videophones cannot be used for i-motion music and video links; and the N2002 handset erases parts of the phone's memory if certain Websites are accessed.

Finally, as i-mode mobile phones cost very high, the technology will be limited to corporate use. Nevertheless, following the Moore's law and Metcalfe's law, no one can predict the future. The Moore's law predicts that the speed and capacity of semiconductor double every 18 months, whereas Metcalfe's law predicts that the network utility increases with the number of nodes and users. 4G will provide better-than-TV quality images and video-links. The communications model has new developed versions of HTML, Java, GIF, HTTP, and many more. New standards will need to be developed for use in 4G. IMT-Advanced 4G standards will usher in a new era of mobile broadband communications, according to the ITU-R. IMT Advanced provides a global platform on which to build next generations of interactive mobile services that will provide faster data access, enhanced roaming capabilities, unified messaging and broadband multimedia.

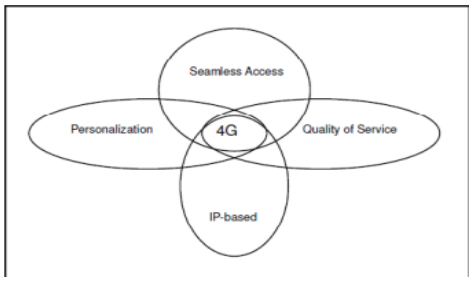

Fig 4. The next Generation Mobile Communication Systems

According to ITU, "ICTs and broadband networks have become vital national infrastructure — similar to transport, energy and water networks — but with an impact that promises to be even more powerful and far-reaching. These key enhancements in wireless broadband can drive social and economic development, and accelerate progress towards achieving the United Nations' Millennium Development Goals, or MDGs." [12].

the current agreements on the requirements for IMT-Advanced are:

• Peak data rate of 1 Gbps for downlink (DL) and 500 Mbps for uplink (UL).

• Mobility up to 350 km/h in IMT-Advanced. An antenna configuration of 4 × 4 or less in DL and 2 × 4 or less in UL.

• link peak spectral efficiency up to 6.75 – 15bps/Hz

Table 1 summarizes the generations of wireless technology.

• The average user spectral efficiency in DL (with inter-site distance of 500m and pedestrian users) must be 2.2 bps/ Hz/cell with MIMO 4× 2, whereas in UL the target average spectral efficiency is 1.4 bps/Hz/cell with MIMO 2 × 4.

• In the same scenario with 10 users, cell edge user spectral efficiency will be 0.06 in DL 4 × 2. In the UL, this cell edge user spectral efficiency must be 0.03 with MIMO 2 × 4.

Generation	Requirements	Comments
1G	No official requirements. Analog technology.	Deployed in the 1980s.
2G	No official requirements. Digital Technology.	First digital systems. Deployed in the 1990s. New services such as SMS and low-rate data. Primary technologies include IS-95 CDMA and GSM.
3G	ITU's IMT-2000 required 144 kbps mobile, 384 kbps pedestrian, 2 Mbps indoors	Primary technologies include CDMA2000 1X/ EVDO and UMTS-HSPA. WiMAX now an official 3G technology.
4G	ITU's IMT-Advanced requirements include ability to operate in up to 40 MHz radio channels and with very high spectral efficiency.	No technology meets requirements today. IEEE 802.16m and LTE-Advanced being designed to meet requirements.

• Regarding latency, in the Control plane the transition time from Idle to Connected should be lower than 100ms. In the active state, a dormant user should take less than 10ms to get synchronized and the scheduler should reduce the User plane latency at maximum.
• Backward compatibility and inter-working with legacy systems.
• IMT-Advanced system will support scalable bandwidth and spectrum aggregation with transmission bandwidths more than 40MHz in DL and UL.

After completion of its Release-8 specifications, Third Generation Partnership Project (3GPP) has already planned for a work item called LTE-Advanced to meet the IMT-Advanced requirements for 4G.

VI. CONCLUSION

This article offers a qualitative comparison of wireless technologies that can be viewed simultaneously as substitute and / or complimentary paths for evolving to broad band wireless access. The technologies are 3G, which is the preferred upgrade path for mobile providers. The goal of the analysis is to explore divergent world views for the future of wireless access and to speculate on the likely success and possible interactions between the technologies in the future. First, technologies are likely to succeed in the market place.

The 4G network 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 interoperate with 2G and 3G systems, as well as with digital (broadband) broadcasting systems. In addition, 4G systems will be fully IP-based wireless Internet which will provide access to wide range of telecommunication services, including advanced mobile services, supported by mobile and fixed networks, which are increasingly packet based, along with a support for low to high mobility applications and wide range of data rates

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