UNIT 3 Generations OF Mobile CommunicationTechnologies

SYLLABUS: First Generation Wireless Networks, Second Generation (2G) Wireless Cellular Networks,Major 2G standards, 2.5G Wireless Networks, Third Generation 3G Wireless Networks, Fourth Generation 4G wireless networks, Fifth Generation 5G wireless networks

1. Introduction:

The cellular networks are evolving through several generations (figure1). The first generation (1G) wireless mobile communication network was analog system which was used for public voice service with the speed up to 2.4kbps. The second generation (2G) is based on digital technology and network infrastructure. As compared to the first generation, the second generation can support text messaging. Its success and the growth of demand for online information via the internet prompted the development of cellular wireless system with improved data connectivity, which ultimately lead to the third generation systems (3G).

3G systems refer to the developing technology standards for the next generation of mobile communications systems. One of the main goals of the standardization efforts of 3G is to create a universal infrastructure that is able to support existing and future services. This requires that the infrastructure be designed so that it can evolve as technology changes, without compromising the existing services on the existing networks. Separation of access technology, transport technology, service technology and user application from each other make this demanding requirement possible.

The 4th Generation (4G) wireless mobile internet networks are research items in academy, which will integrate current existing 3G cellular networks (i.e., OFDM, CDMA2000, WCDMA and TD_SCDMA) and Wi-Fi (i.e. Wireless LAN) networks with fixed internet to support wireless mobile internet as the same quality of service as fixed internet, which is an evolution not only to move beyond the limitations and problems of 3G, but also to enhance the quality of services, to increase the bandwidth and to reduce the cost of the resource.

The 5th wireless mobile multimedia internet networks can be completed wireless communication without limitation, which bring us perfect real world wireless – World Wide Wireless Web (WWWW). 5G is based on 4G technologies, which is to be revolution to 5G. During this processing, there are two kind of problems need to be solved. The first is wider coverage and the second is freedom of movement from one technology to another. The 6th generation (6G) wireless mobile communication networks shall integrate satellites to get global coverage. The global coverage systems have been developed by four courtiers. The global position system (GPS) is developed by USA. The COMPASS system is developed by China. The Galileo

System is developed by EU, and the GLONASS system is developed by Russia. These in depended systems are difficulty for space roaming. The task of 7th generation (7G) wireless mobile communication networks are going to unite the four systems to get space roaming. But we concentrate here only on 1G to 5G.

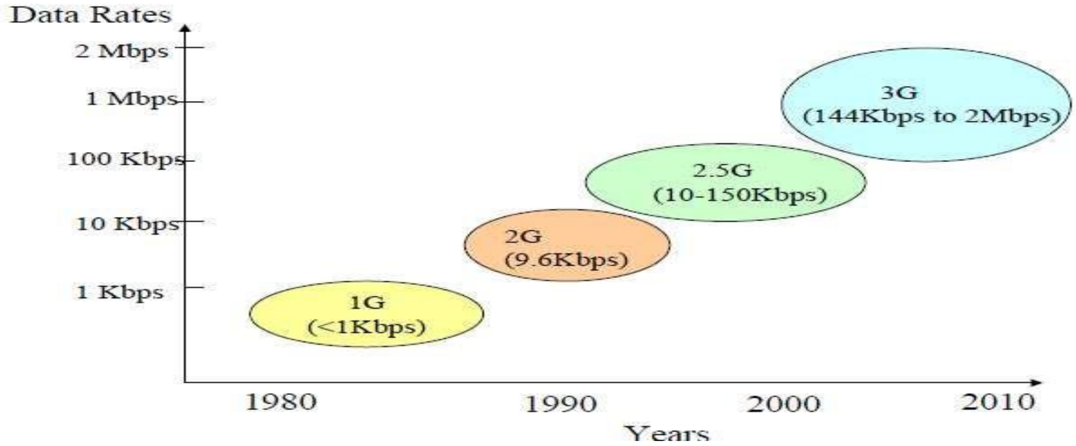

Figure (1): Evolution to 3G – A Technology-Independent View

2. First Generation (1G) – Analog System:

1G refers to the first-generation of wireless telephone technology, mobile telecommunications. These are the analog telecommunications standards that were introduced in the 1980s and continued until being replaced by 2G digital telecommunications. The main difference between two succeeding mobile telephone systems, 1G and 2G, is that the radio signals that 1G networks use are analog, while 2G networks are digital.

Although both systems use digital signaling to connect the radio towers (which listen to the handsets) to the rest of the telephone system, the voice itself during a call is encoded to digital signals in 2G whereas 1G is only modulated to higher frequency,typically 150MHz and up.

Mobile radio telephones were used for military communications in the early 20th century. Car-based telephones were first introduced in the mid-1940s. In fact, the first car-based telephone system was tested in Saint Louis in 1946. This system used a single large transmitter on top of a tall building. A single channel was used for sending and receiving. To talk, the user pushed a button that enabled transmission and disabled reception. Due to this, these became known as “push-to-talk” systems in the 1950s. Although these systems are quite old, taxis and police cars use this technology. To allow users to talk and listen at the same time, **IMTS (Improved Mobile Telephone System)** was introduced in the 1960s. It used two channels (one for sending, one for receiving – thus there was no need for push-to-talk). IMTS used 23 channels from 150 MHz to 450 MHz.

First-generation cellular networks were introduced in the 1980s. This started with the **Advanced Mobile Phone Service (AMPS)** that was invented at Bell Labs and first installed in 1982. AMPS has also been used in England (called TACS) and Japan (called MCS-L1). The key idea of 1G cellular networks is that the geographical area is divided into cells (typically 10-25km), each served by a “base station.” Cells are small so that frequency reuse can be exploited in nearby (but not adjacent) cells. This allows many more users to be supported in a given area. For example, as compared to IMTS, AMPS can support 5 to 10 times more users in the same 100-mile area by dividing the area into 20 smaller cells that reuse the same frequency ranges. In addition, smaller cells also require less powerful and cheaper, smaller devices to transmit and

receive information.

Actually, 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. 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.

The first commercially automated cellular network (the 1G generation) was launched in Japan by NTT (Nippon Telegraph and Telephone) in 1979, initially in the metropolitan area of Tokyo. Within five years, the NTT network had been expanded to cover the whole population of Japan and became the first nationwide 1G network.

In 1981, this was followed by the simultaneous launch of the Nordic Mobile Telephone (NMT) system in Denmark, Finland, Norway and Sweden. NMT was the first mobile phone network featuring international roaming. The first 1G network launched in the USA was Chicago based Ameritech in 1983 using the Motorola DynaTAC mobile phone. Several countries then followed in the early-to-mid 1980s including the UK, Mexico and Canada.

1G cellular networks are based primarily on analog communications. In North America, two 25 MHz bands are allocated to AMPS – one for transmission from base to mobile unit and one for transmission from mobile unit to base. Each phone has a 32-bit serial number and 10-digit phone number in its PROM (Programmable Read-only Memory). When a phone is turned on, it scans for control signals from base stations. It sends this information to the BS with strongest control signal and the BS passes this information to MTS (Master Switching Station) as a packet. The subscriber initiates a call by keying in a phone number and pressing the send key. The MTS verifies the number and authorizes the user. MTS issues a message to the user"s cell phone indicating send and receive traffic channels. MTS sends a ringing signal to the called party. Party answers; MTS establishes the circuit and initiates billing information. Either party hangs up; MTS releases the circuit, frees the channels, and completes billing.

2.1. Security Issues with 1G:

Analog cellular phones are insecure. Anyone with an all-band radio receiver can listen in to the conversation. Many scandals have been reported in this area. There are also thefts of airtime. Basically, a thief uses an all-band radio receiver that is connected to a computer. This computer can record the 32-bit serial numbers and phone numbers of subscribers when calling (recall that this information is sent as a packet). The thieves can collect a large database by driving around and can then go into business by reprogramming stolen phones and reselling them.

2.2. Paging Networks:

Paging networks are one of the oldest wireless technologies. They support one-way and two way alphanumeric messages between callers and pagers (beepers). The callers typically call a beeper company and leave a phone number and possibly a short message. Paging networks are being integrated with PDAs (personal digital assistants) like Palm Pilots. An example of paging networks is the BellSouth Clamshell Pager with keyboard.

2.3. Characteristics of Paging Networks:

Paging networks have been around for a while and were among the first wireless networks used for sending numeric and alphanumeric messages to external devices carried by mobile workers. These are specialized wireless networks for broadcasting a message to a specific pager to call back a specific number. Figure (2) shows a conceptual view of paging networks. The paging network provider (paging operator), such as Skytel, runs a paging control center which receives paging requests from regular phones, cellular phones, or other pagers and routes them to their destination pagers. The paging BTSs (Base Transceiver Stations) are connected to the paging control center through leased lines or wireless links such as satellites or wireless local loops.

The paging networks come in two flavors: one-way paging networks and two-way paging networks. The two-way paging networks allow pre-defined messages to be sent back by the receiver of the message. The commercial paging operators can establish a network that meets subscribers‟ requirements and supports a wide range of paging devices. The paging devices can be equipped with sophisticated features such as priority paging, group paging, voice paging, voice prompts, and remote transmitter control.

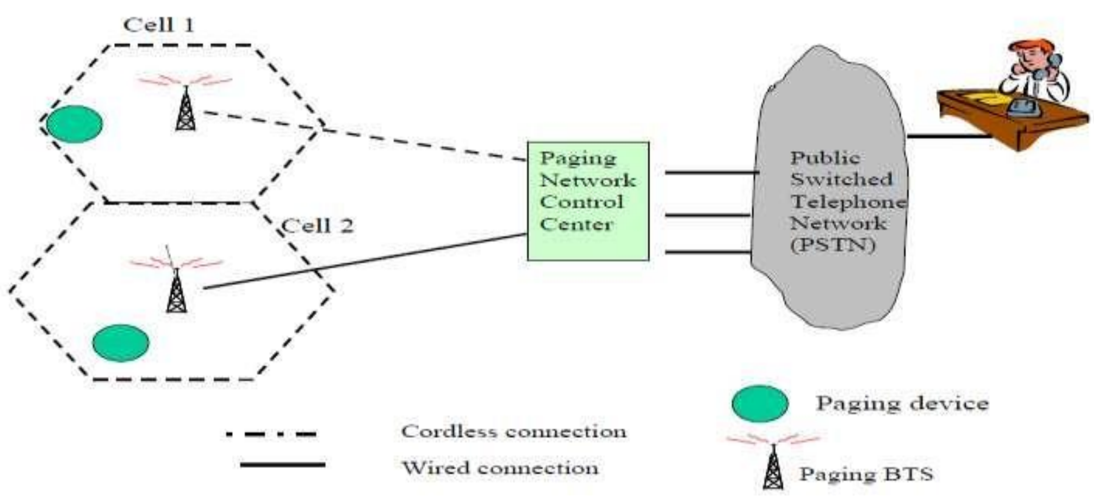

Figure (2): Conceptual View of a Paging Network

A few characteristics of the paging networks are follows:

- Common applications are personal numeric messaging for call-back, alphanumeric messaging (dispatching and service), and two-way messaging (call dispatching with confirmation).

- Capacity and speed includes 1200 bps for older and 6400 bps for newer systems. The paging networks are slower but have different design criteria for delivering the message within specific time periods.
- Frequency bands used include 800 MHz for older paging networks and 901-941 MHz, with gaps, for newer networks.
- Components of a paging network are a personal paging device, a paging computer/server at the paging operator‟s site, and a paging transmitter. These networks may also use satellites for national coverage.
- Coverage is 95% of the US, thanks to many local, regional and national paging network providers.
- Communications protocols supported include FLEX and ReFLEX developed by Motorola for two-way paging.

- Security is low and has not been considered a high priority.

The advantages of paging networks are:

- Very inexpensive
- Easy to operate for sender (from any telephone) and receiver
- Many options for users (numeric, alphanumeric, two-way, message storage)
- Wide coverage at local, regional , national, and international levels
- Good building penetration

The limitations of paging networks are follows:

- Slow data transfer rate (1200 bps)
- No acknowledgment (two-way paging costs extra)
- Some of the available paging networks are overloaded, causing delays.

3. Second Generation (2G) Network – Digital System:

Overview:

Second Generation (2G) cellular networks, introduced in the late 1980s, are based on digital transmission. Digital transmissions offer several benefits over analog. Different approaches to 2G have been developed in the US and Europe. In the US, divergence happened because only one player (AMPS) existed in 1G. Because of this, several players emerged to compete in 2G. Although many players emerged, the following two have survived in the US:

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- IS-54 and IS-135: backward-compatible with AMPS frequency allocation (dual mode– analog and digital)
- IS-95: uses spread spectrum

In Europe, exactly the reverse happened – there was a convergence because there were many (more than 5) incompatible 1G systems with no clear winner. This caused a major problem for the users (you could not use your telephones while traveling from England to France).

2G is short for second-generation wireless telephone technology. Second generation 2G cellular telecom networks were commercially launched on the GSM standard in Finland by Radiolinja (now part of Elisa Oyj) in 1991. Three primary benefits of 2G networks over their predecessors were that phone conversations were digitally encrypted; 2G systems were significantly more efficient on the spectrum allowing for far greater mobile phone penetration levels; and 2G introduced data services for mobile, starting with SMS text messages.

After 2G was launched, the previous mobile telephone systems were retrospectively dubbed 1G. While radio signals on 1G networks are analog, radio signals on 2G networks are digital. Both systems use digital signaling to connect the radio towers (which listen to the handsets) to the rest of the telephone system.

2G has been superseded by newer technologies such as 2.5G, 2.75G, 3G and 4G. however, 2G networks are still used in many parts of the world.
European PTT (Post, Telephone and Telegraphic) sponsored development of the now very popular GSM that uses new frequency ranges and complete digital communication.

The primary differences between first and second generation cellular networks are:

- Digital traffic channels – first-generation systems are almost purely analog; second generation systems are digital.
- Encryption – all second generation systems provide encryption to prevent eavesdropping.
- Error detection and correction – second-generation digital traffic allows for detection and correction, giving clear voice reception.

3.2. Capacity, Advantages and Disadvantages of 2G:

- Channel access – second-generation systems allow channels to be dynamically shared by a number of users.

Capacity:

¬ Digital voice data can be compressed and multiplexed much more effectively than analog voice encodings through the use of various codecs, allowing more calls to be packed into the same amount of radio bandwidth.
¬ The digital systems were designed to emit less radio power from the handsets. This meant that cells had to be smaller, so more cells had to be placed in the same amount of space. This was made possible by cell towers and related equipment getting less expensive.

Advantages:

The lower power emissions helped address health concerns.
¬ Going all-digital allowed for the introduction of digital data services, such as SMS and email.
¬ Greatly reduced fraud: With analog systems it was possible to have two or more "cloned" handsets that had the same phone number.
¬ Enhanced privacy: A key digital advantage not often mentioned is that digital cellular calls are much harder to eavesdrop on by use of radio scanners. While the security algorithms used have

proved not to be as secure as initially advertised, 2G phones are immensely more private than 1G phones, which have no protection against eavesdropping.

Disadvantages:

¬ In less populous areas, the weaker digital signal may not be sufficient to reach a cell tower. This tends to be a particular problem on 2G systems deployed on higher frequencies, but is mostly not a problem on 2G systems deployed on lower frequencies.National regulations differ greatly among countries which dictate where 2G can be deployed.

¬ Analog has a smooth decay curve, digital a jagged steppy one. This can be both an advantage and a disadvantage. Under good conditions, digital will sound better. Under slightly worse conditions, analog will experience static, while digital has occasional dropouts. As conditions worsen, though, digital will start to completely fail, by dropping calls or being unintelligible, while analog slowly gets worse, generally holding a call longer and allowing at least a few words to get through.

¬ While digital calls tend to be free of static and background noise, the lossy compression used by the codecs takes a toll; the range of sound that they convey is reduced. You will hear less of the tonality of someone's voice talking on a digital cell phone, but you will hear it more clearly.

GSM (Global System for Mobile Communications)–The Popular 2GSystem

Although there are many competing technologies in the 2G cellular network landscape, GSM by far dominates the world today, with over 200 million users in over a hundred countries. GSM is very popular in Europe and is now gaining popularity in the US also. These networks operate at 9.6 Kbps and are based on international standards defined by the European Telecommunications Standards Institute (ETSI). Due to the popularity of GSM, let us look at GSM somewhat closely.

GSM is completely designed from scratch (there is no backward compatibility with 1G systems such as AMPS). It can deliver data rate up to 9.6 Kbps by using 124 channels per cell; each channel can support 8 users through TDMA (maximum 992 users per cell, in practice about 500). Some GSM channels are used for control signals for mobile units to locate the nearest base stations.

In addition to voice, GSM phones provide data services for wireless users; i.e., you connect your GSM phone to your PC and it acts as a modem for email, fax, Internet browsing, etc. GSM also permits roaming between North American countries and European countries. To make it work, because of the frequency differences, you have to remove the user-specific SIM card from inside the American network"s phone and place it into a European network"s phone, or vice-versa.

GSM"s air interface is based on narrowband TDMA technology, where available frequency bands are divided into time slots, with each user having access to one time slot at regular intervals. Narrowband TDMA allows eight simultaneous communications on a single radio multiplexer and is designed to support 16 half-rate channels.

3.3. GSM Network Architecture:

The architecture of GSM network defines several interfaces for multiple suppliers. The key players of this architecture are shown in Figure (3).

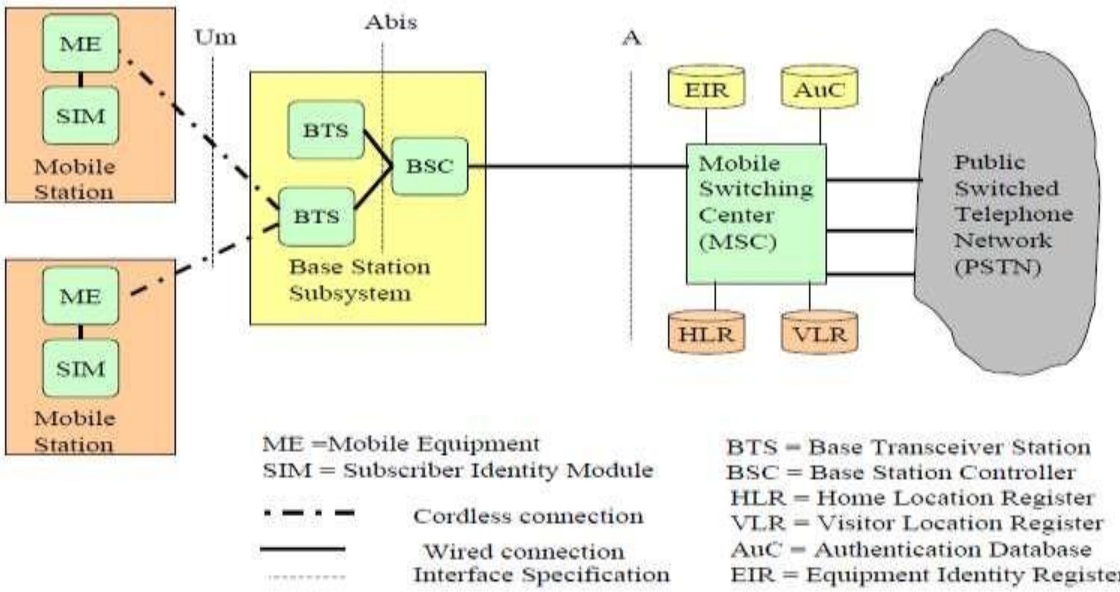

Figure (3): GSM Network Architecture

Mobile station (MS): It represents the mobile user and communicates across the Um interface (air interface) with a base station transceiver in the same cell as the MS. The main part of MS is mobile equipment (ME) that represents physical terminals, such as a telephone or PDA. An ME includes a radio transceiver, a digital signal processor, and a subscriber identity module (SIM). GSM subscriber units are generic until SIM is inserted. SIMs are used to support roaming, as indicated previously.

Base Station Subsystem (BSS): It consists of a base station controller (BSC) and one or more base transceiver stations (BTS). Each BTS defines a single cell and includes radio antenna, radio transceiver and a link to a base station controller (BSC). BSC reserves radio frequencies, manages handoff of mobile units from one cell to another within BSS, and controls paging.

Mobile Switching Center (MSC): It is the nerve center of GSM. It provides links between cellular networks and public switched telecommunications networks. Specifically, an MSC controls handoffs between cells in different BSSs, authenticates users and validates accounts, and enables worldwide roaming of mobile users. To support these features, an MSC consists of the following databases:

- Home location register (HLR) database – stores information about each subscriber that belongs to it.
- Visitor location register (VLR) database – maintains information about subscribers physically in the region currently
- Authentication center database (AuC) – used for authentication activities and holds encryption keys

- Equipment identity register database (EIR) – keeps track of the type of equipment that exists at the mobile station

A number of control messages are exchanged between the key entities in the GSM architecture. These messages are used to support mobility and connection management. Figure (4) shows the GSM Protocol Architecture. The protocols, as can be seen, follow the typical 7-layer model, where the lower layers provide transport over radio links (between the mobile station and BTSs) and wired packet-switching network (between BTSs and MSCs). Protocols above the link layer of the GSM signaling protocol architecture provide specific functions such as the following:

Connection management connects end users (mobile stations) to the MSC or to other end users. These protocols, at layer 6 of the protocol stack, are used when you dial a number, for example, from your phone to another mobile or wired phone.

- Mobility management provides location services and security controls. These protocols are supported at the layer 5 of the protocol stack.
- Mobile application part (MAP) is used between HLR and VLR to provide updates as the users move around. These layer 4 protocols are used between an MSC and a BSC.
- Radio resource management is used to control setup, termination and handoffs of radio channels. For example, all communications between your cellular phone and the base station are managed by using these layer 3 protocols.
- BTS management is used for management of the base transceiver system also at layer 3.

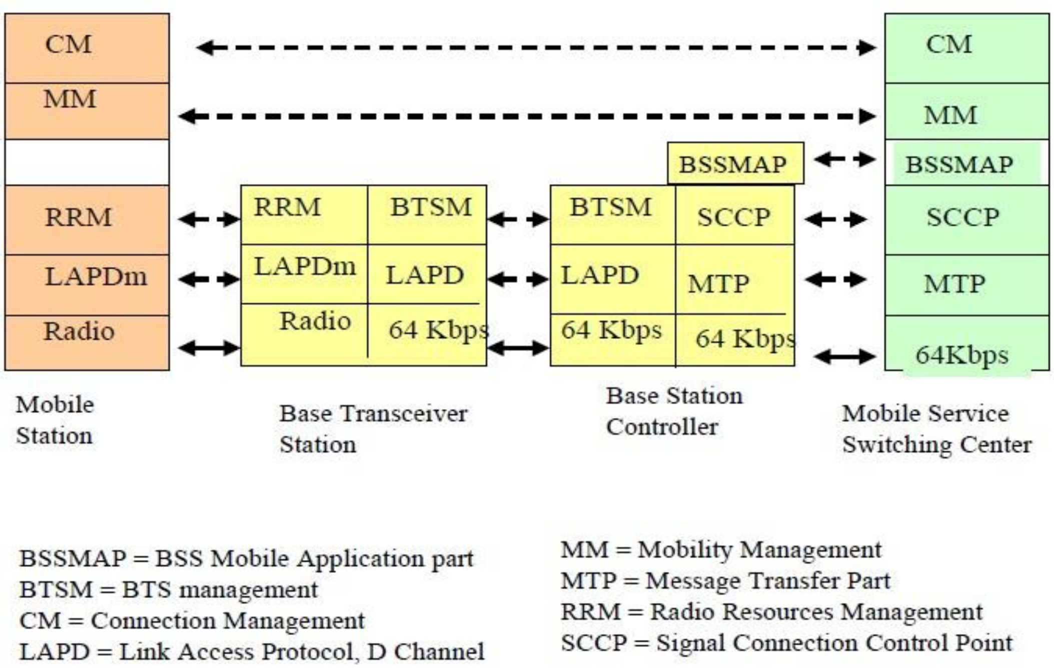

Figure (4): GSM Protocol Architecture

3.5. 2G CDMA (IS-95):

GSM uses TDMA, but who uses CDMA in 2G? While some systems have appeared, IS-95 is the best-known example of 2G with CDMA. Recall that in the case of CDMA, each user is

assigned a unique code that differentiates one user from others. This is in contrast to TDMA where each user is assigned a time slot. Why use CDMA for cellular? Although the debate between CDMA versus TDMA has been raging for a while (see Section 8.5.5), there are several advantages of CDMA for cellular networks. The main advantage of CDMA is that many more users (up to 10 times more) can be supported as compared to TDMA. Although this leads to some complications, the advantage of supporting more users far outweighs the disadvantage of added complexity.

The IS-95 cellular system has different structures for its forward (base station to mobile station) and backward links. The forward link consists of up to 64 logical CDMA channels, each occupying the same 1228 kHz bandwidth. The forward channel supports different types of channels:

- Traffic channels (channels 8 to 31 and 33 to 63) – these 55 channels are used to carry the user traffic (originally at 9.6 Kbps, revised at 14.4 Kbps).
- Pilot (Channel 0) – used for signal strength comparison, among other things, to determine handoffs
- Synchronization (Channel 32) – a 1200 bps channel used to identify the cellular system (system time, protocol revision, etc.).
- Paging (channels 1 to 7) – messages for mobile stations

All these channels use the same frequency band – the chipping code (a 64-bit code) is used to distinguish between users. Thus 64 users can theoretically use the same band by using different codes. This is in contrast to TDMA where the band has to be divided into slots – one slot per user. The voice and data traffic is encoded, assigned a chipping code, modulated and sent to its destination. The data in the reverse travels on the IS-95 reverse links. The reverse links consist of up to 94 logical CDMA channels, each occupying the 1228 kHz bandwidth. The reverse link supports up to 32 access channels and up to 62 traffic channels. The reverse links support many mobile unit-specific features to initiate calls, and to update location during handoffs.

The overall architecture of 2G CDMA-based systems are similar to the TDMA-based GSM systems (see Figure 4). The main difference is that the radio communication between the Base Station Subsystem and Mobile System uses CDMA instead of TDMA. Of course, the MSC now has to worry about handling soft handoffs, but the overall structure stays the same.

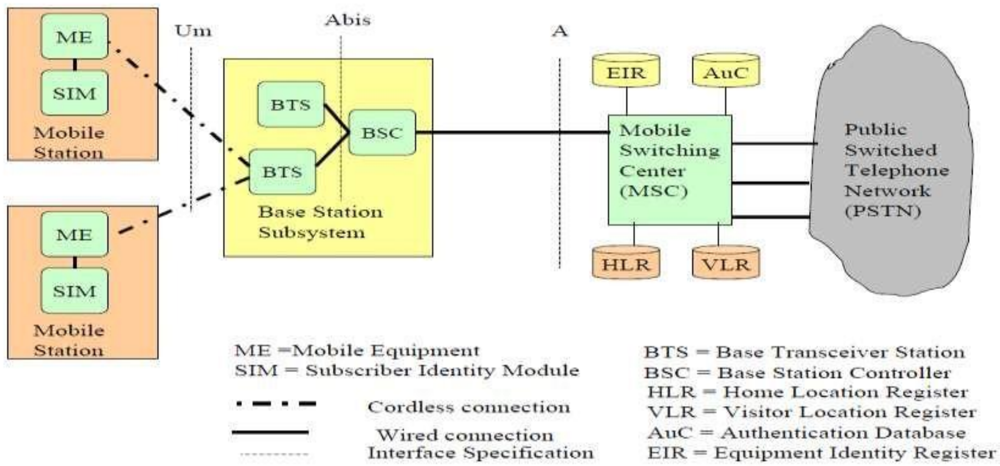

Figure: 2G CDMA (IS-95) Network Architecture

3.6. CDMA Versus TDMA:

There are conflicting performance claims for CDMA and TDMA. The debate is raging because hardware vendors have chosen sides and consequently the standardizing bodies have been lobbied hard. The primary motivation for this level of debate is that vendors want their selection to become the industry standard. Since both TDMA and CDMA have become TIA (Telecom Industry Association) standards – IS-54 and IS-95, respectively – the debate goes on to determine which standard is better. Technically speaking, CDMA has the following advantages over TDMA.

Network capacity: In CDMA, the same frequency can be reused in adjacent cells because the user signals differentiate from each other by a code. Thus frequency reuse can be very high and many more users (up to 10 times more) can be supported as compared to TDMA.

Privacy: Privacy is inherent in CDMA since spread spectrum modulates data to signals randomly (you cannot understand the signal unless you know the randomizing code).

Reliability and graceful degradation: CDMA-based networks only gradually degrade as more users access the system. This is in contrast to the sudden degradation of TDMA based systems. For example, if the channel is divided between ten users, then the eleventh user can get a busy signal in a TDMA system. This is not the case with CDMA because there is no hard division of channel capacity – CDMA can handle users as long as it can differentiate between them. In case of CDMA, the noise and interference increases gradually as more users are added because it becomes harder to differentiate between various codes.

Frequency diversity: CDMA uses spread spectrum, thus transmissions are spread over a larger frequency bandwidth. Consequently, frequency-dependent transmission impairments that occur in certain frequency ranges have less effect on the signal.

Environmental: Since existing cells can be upgraded to handle more users, the need for new cell towers decreases.

But, there are some drawbacks of CDMA cellular also:

Relatively immature: As compared to TDMA, CDMA is a relatively new technology but it is catching up fast.

Self-jamming: CDMA works better if all mobile users are perfectly aligned on chip (code) boundaries. If this is not the case, then some interference can happen. This situation is better with TDMA and FDMA because time and frequency guard bands can be used to avoid the overlap.

Soft handoff: An advantage of CDMA is that it uses soft handoff (i.e., two cells can own a mobile user for a while before the handoff is complete). However, this requires that the mobile user acquires the new cell before it relinquishes the old – a more complex process than hard handoff used in FDMA and TDMA schemes.

The main advantage of CDMA is that the frequency reuse can be very high and many more users can be supported in a cell as compared to TDMA. Although this leads to a soft handoff that is more complicated than the hard handoff used in TDMA, the advantage of supporting more users far outweighs the disadvantage of added complexity.

3.7. 2.5G Networks (GPRS):

2.5 G wireless cellular networks have been developed as a transition path to 3G. Examples of these networks are GPRS and EDGE. These systems build packet-switching systems on top of existing 2G systems to improve data rates significantly.

GPRS (General Packet Radio Service):

GSM networks offer circuit-switched data services at 9.6 Kbps. Most GSM carriers are developing a service called **General Packet Radio Service (GPRS),** a 2.5G technology. GPRS can theoretically provide IP-based packet data speeds up to a maximum of 160 Kbps. However, typical GPRS networks operate at lower data rates. One proposed configuration is 80 Kbps maximum (56 Kbps typical) for the downlink and 20 Kbps maximum (14.4 Kbps typical) for the uplink. GPRS supports both IP and X.25 networking.

GPRS can be added to GSM infrastructures quite readily. It takes advantage of existing 200 kHz radio channels and does not require new radio spectrum. GPRS basically overlays a packet switching network on the existing circuit switched GSM network. This gives the user an option to use a packet-based data service. An architectural view of GPRS is presented in Figure(5). The main component of a GPRS network is the GSN (GPRS Support Node) that receives the packet data and transfers it to the Internet or other GPRS networks. To provide GPRS services on top of GSM, the network operators need to add a few GSNs and make a software upgrade to BSCs and few other network elements. This quick upgrade capability has fueled the popularityof GPRS.

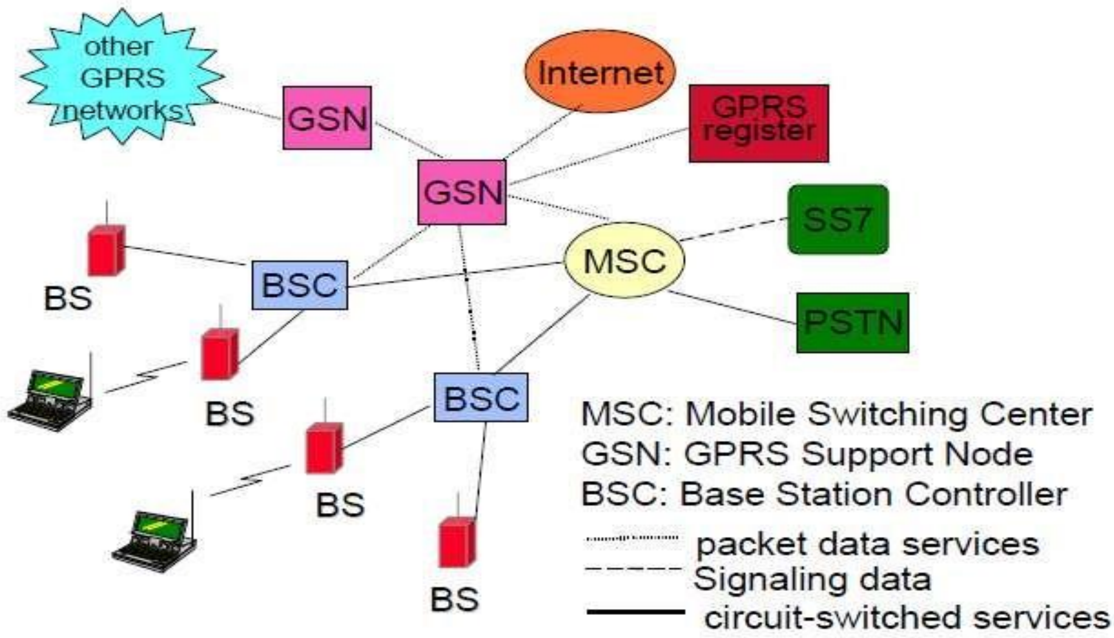

Figure (5): GPRS Network Architecture

GPRS capability has been added to cell phones, and is also available in data-only devices such as PC card modems. Pricing is either flat rate or based on the volume of information communicated. GPRS is appealing because it offers higher data rates and also allows, because of packet services, constant "virtual" connections without the need to constantly "dial" into the network. The „always-on‟, higher capacity, GPRS networks are very suitable for Internet based content and packet-based data services. You can do Web browsing, email, and file transfer over a GPRS enabled phone. To use GPRS, users specifically need a mobile phone or terminal that supports GPRS (existing GSM phones do not support GPRS necessarily) and a subscription to a mobile telephone network that supports GPRS.

3.8. 2.75G Networks (EDGE):

The phase after GPRS is called **Enhanced Data Rates for GSM Evolution (EDGE).** EDGE, generally considered a 3G technology, introduces new methods at the physical layer, including a new form of modulation (8 PSK) and different ways of encoding data to protect against errors. But the higher layer protocols stay the same. Thus EDGE can deliver maximum data rates up to 500 Kbps using the same GPRS infrastructure (practical throughputs may be only half the maximum rate).

EDGE has been designed to address some of the limitations of GPRS. For example, GPRS impacts a network‟s existing cell capacity because voice and GPRS calls both use the same network resources. The extent of the impact depends upon the number of timeslots, if any, that are reserved for exclusive use of GPRS. In addition, GPRS actual data rates are much lower than advertised. Specifically, achieving the theoretical maximum GPRS data transmission speed of 172.2 Kbps would require a single user taking over all eight timeslots without any error protection. Finally, GPRS is based on a modulation technique known as Gaussian minimum-shift keying (GMSK). EDGE is based on the eight-phase-shift keying (8 PSK) modulation that allows a much higher bit rate across the air interface. Since 8 PSK is also used in 3G, network operators need to incorporate it at some stage to make the transition to third generation mobile phone systems.

4. Third Generation Network (3G) – Internet System:

4.1. Overview:

3G or **3rd generation mobile telecommunications** is a generation of standards for mobile phones and mobile telecommunication services fulfilling the **International Mobile Telecommunications-2000 (IMT-2000)** specifications 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.

The first pre-commercial 3G network was launched by NTT DoCoMo in Japan on 1998, branded as FOMA. It was first available in May 2001 as a pre-release (test) of W-CDMA technology. The first commercial launch of 3G was also by NTT DoCoMo in Japan on 1 October 2001, although it was initially somewhat limited in scope and broader availability of the system was delayed by apparent concerns over its reliability.

11 December 2008, India entered the 3G arena with the launch of 3G enabled Mobile and Data services by Government owned Mahanagar Telephone Nigam Ltd MTNL in Delhi and later in Mumbai. MTNL becomes the first 3G Mobile service provider in India. After MTNL, another state operator Bharat Sanchar Nigam Ltd. (BSNL) launched 3G services on 22 Feb 2009 in Chennai and later launched 3G as Nationwide. The auction of 3G wireless spectrum was announced in April 2010 and 3G Spectrum allocated to all private operators on 1 September 2010.

The first Private-sector service provider that launched 3G services is Tata DoCoMo, on November 5, 2010. And the second is by Reliance Communications, December 13, 2010. Vodafone Launched their 3G by mid of March, 2011. Then, Bharti Airtel launched their 3G services on 24 January 2011 in Bangalore and also launched in Delhi & Jaipur on March 4, 2011 (not GSM but only USB estick). Aircel also launched 3G in Kolkata in the month of February. Idea also launched its 3G services in mid April. Other providers like Virgin are expected to launch 3G services by Q1 2011.

All the operators provide 3G services on the 2100 MHz band. As of now, the Government owned BSNL is the most successful company with the subscribers of 3G service. It has more than 3 million subscribers of its 3G service. It also has the widest coverage with around 826 cities across the country. The private operators like IDEA and Reliance are increasing their 3G coverage as well as the number of subscribers.

The third-generation (3G) vision is to create a unified global set of standards requirements that could lead to the commercial deployment of advanced multimedia wireless communications. The goal of 3G systems is to enable wireless service providers to offer services found on today’s wireline networks.

3G is not one standard; it is a family of standards which can all work together. This is the main reason why there are too many terms and standards in the 3G space. The International Telecommunications Union (ITU) is coordinating this international harmonization of 3G standards under the overall umbrella of International Mobile Telecommunication 2000 (IMT 2000). See the sidebar "ITU"s View of 3G" for the requirements that are driving 3G developments.

The goal of 3G wireless systems was to provide wireless data service with data rates of 144kbps to 384kbps in wide coverage areas, and 2Mbps in local coverage areas. Possible applications included wireless web-based access, E-mail, as well as video teleconferencing and multimedia services consisting of mixed voice and data streams. After ten years of development,

IMT-2000 (International Mobile Telecommunications-2000) has accepted a new 3G standard from China, i.e TD-SCDMA. Thus, there are new three 3G cellular network standards. They areCDMA2000 from America, WCDMA from Europe and TD-SCDMA from China.

The best known example of 3G is the **UMTS (Universal Mobile Telecommunications System)** – an acronym used to describe a 3G system that originated in Europe and is being used elsewhere. In fact, several analysts claim that UMTS-3G. The overall idea is that UMTS users will be able to use 3G technology all over the world under different banners. This roaming ability to use devices on different networks will be made possible by satellite and land based networks. UMTS provides a consistent service environment even when roaming via "Virtual Home Environment" (VHE). A person roaming from his network to other UMTS operators experiences a consistent set of services, independent of the location or access mode (satellite or terrestrial).

Whatever the name**,** 3G is designed to raise the data rate to 2 megabits per second (2 Mbps) – a much higher rate than 2G and 2.5G. Specifically, 3G systems offer between 144 Kbps to 384 Kbps for high-mobility and high coverage, and 2 Mbps for low-mobility and low coverage applications. In other words, 3G systems mandate data rates of 144 Kbps at driving speeds, 384 Kbps for outside stationary use or walking speeds, and 2 Mbps indoors. However, the indoor rate of 2 Mbps from 3G competes with high-speed 802.11 wireless LANs that offer data rates of 11 to 54 Mbps. The main attraction of 3G is the 384 Kbps data rate for outdoor use as an IP-based packet-switching service over wide areas. This service can support wireless Internet access over very wide geographical areas.

3G systems are based on packet switching instead of the older circuit-switching systems used in 2G. What does this mean? In 2G cellular networks, most data communication, apart from the Short Message Service (SMS), requires a circuit-switched connection in which a user must connect to a server to check email, for example. The main limitation of this approach is that the users have to be online even when they are not sending data, so they pay higher costs and network capacity is wasted.

3G networks use a connectionless (packet-switched) communications mechanism. Data are split into packets to which an address uniquely identifying the destination is appended. This mode of transmission, in which communication is broken into packets, allows the same data path to be shared among many users in the network. By breaking data into smaller packets that travel in parallel on different channels, the data rate can be increased significantly. For example, splitting a message into 6 packets can theoretically increase data rate six times (e.g. from 9.6 Kbps to 56 Kbps, roughly). In addition, users can stay online throughout and yet not be charged for the time spent online. Rather, they only pay for the amount of data that they retrieve. This is in contrast to a circuit-switched network like the regular voice telephone network where the communication path is dedicated to the callers, thus blocking that path to other users for that period of time. This means that although a 3G handset is, in effect, permanently connected to the network, it only uses bandwidth when needed.

3G has evolved from 2G and is built on the success of GSM (GSM, GSM1800 and GSM1900). Dual-mode terminals ease migration from 2G to 3G. Although many options for 3G exist, the radio technology in 3G will likely be Wideband CDMA (Collision detect multiple access). This is similar to local area network technologies such as Ethernet. In the US, CDMA2000 will be used (this is similar to Wideband CDMA but backward compatible with IS-95).

4.2. MMS - The Main Driver for 3G:

While different applications are being envisioned for 3G, MMS (Multimedia Message Service) is getting the most attention. From an end-user point of view, MMS is the same as SMS (Short Message Service) but with pictures. Let us examine the possible role of MMS in 3G cellular networks.

Several 3G cellular providers, such as Ericsson, are counting on MMS to drive the 3G developments because it is difficult to satisfy MMS requirements with 2G networks. Ericsson has an estimated 40% market share and more than 50% of the global subscriber base of MMS. Delivery of MMS services over 3G requires developments in handsets, infrastructure, content, and systems integration. Examples of the MMS applications include push messaging, automated data-generated graphics, picture messaging, cartoon delivery, and enhanced dating service including photos. Some operators such as the Telecom Italia Mobile are offering access to information on Italian football matches, TV program vignettes and Disney animated cards as part of its mobile multimedia services. Another MMS application uses the latest traffic-status information and knowledge of location to generate a map of the quickest route to a destination.

4.3 IEEE 802.11 versus 3G Cellular:

Although 3G cellular networks are getting a great deal of attention, the 802.11 WLANs are proving to be a tough competitor to 3G.

In the very best case, 3G networks are supposed to deliver around 2 Mbps in an office environment. This is in no way competition for 802.11 networks that can deliver from 11 Mbps to 54 Mbps. For data applications such as Web browsing, remote database access and software downloads, 802.11 is far superior to 3G. In addition to slower data rates, Web browsing on cellular phones requires use of special protocols such as Wireless Application Protocol (WAP) and markup languages such as Wireless Markup Language (WML). In short, viewing Web pages with 3G is inherently inferior to doing so with 802.11 LANs.

But 3G cellular networks are well suited for applications like instant messaging (IM), Short Messaging Service (SMS),or Multimedia Messaging Service (MMS). However, IM is not straightforward – you cannot send messages from IM to someone using MMS or SMS on a digital phone without a special gateway between the SMS/MMS servers and IM clients.

A very attractive alternative to 3G are the 802.11 hotspots that connect 802.11 LANs to wired networks at airports, Internet cafes, shopping malls and Starbucks coffee shops. While 802.11 hotspots have far less range than 3G, they are much cheaper to set up – a business class hotspot can be deployed for about $1500, while most 3G base stations start around $100,000. In addition, anyone can set up a hotspot but only a telephone carrier or corporation can afford 3G base station.

In short, 802.11 WLANs are easier to install and cost far less than setting up a 3G network. In addition, 3G‟s fastest data rate of 2 Mbps is slow compared to the slowest data rate of 802.11‟s 11 Mbps. As 802.11 WLANs move toward 54 Mbps, it is apparent that 3G cannot compete with the data rate of WLAN. Another difficulty is that the WLAN industry is growing at a stellar rate while 3G deployments have been slowed down considerably due to infrastructure costs. In some sense, the growth of WLANs is coming at 3G‟s expense. In reality, many of the 3G providers including T-Mobile, AT&T, and Verizon have made announcements about deploying WLAN services as their 3G plans are delayed. In particular, British Telecom is planning to deploy more than 4,000 WLAN hotspots based on 802.11 by the summer of 2005.

But the limitations of 802.11 should be also noted. 3G cellular phone network cells can transmit from 5 to 6 miles in diameter. Compare this to 802.11 access points which range only between 300 to 900 feet. Thus you will need millions of 802.11 based access points to cover a metropolitan area. Due to this, "hybrid wireless networks" that support hot spots and are connected through 3G or other networks make more sense.

The success of 802.11 versus 3G is also leading to interesting new developments. For example, Cisco has announced an 802.11 telephone that supports Voice Over IP (VOIP) over WLANs. This not good news for 3G (see the sidebar, "Voice Over 802.11 – Competition to 3G").

Many MMS applications for 3G are being built on top of existing popular services by adding images and audio to basic text services. As 3G makes higher bandwidth applications possible, more applications will be developed.

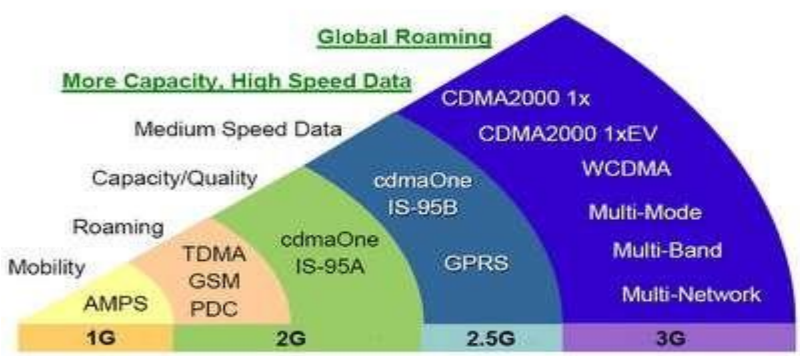

Figure (6): A Journey from 1G to 3G

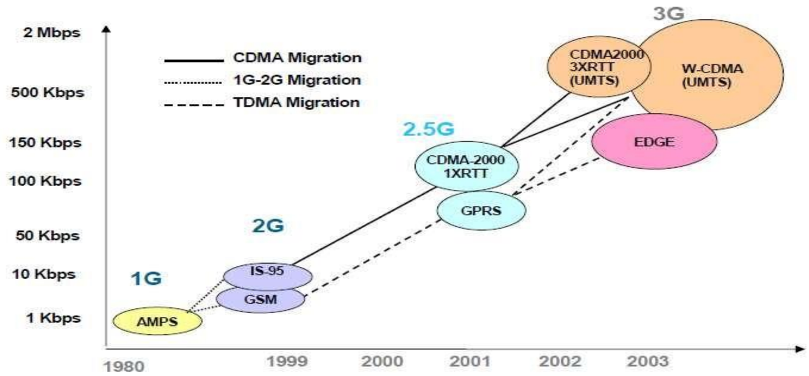

Figure (7): Evolution to 3G

5. 4G Networks – Integration System:

In telecommunications, **4G** is the fourth generation of cellular wireless standards. It is a successor to the 3G and 2G families of standards. In 2009, the ITU-R organization specified the IMT-Advanced(International Mobile Telecommunications Advanced) requirements for 4G standards, setting peak speed requirements for 4G service at 100 Mbit/sec for high mobility communication (such as from trains and cars) and 1 Gbit/sec for low mobility communication (such as pedestrians and stationary users).

The world's first publicly available LTE service was opened in the two Scandinavian capitals Stockholm (Ericsson and Nokia Siemens Networks systems) and Oslo (a Huawei system) on 14 December 2009.

One of the key technologies for 4G and beyond is called Open Wireless Architecture (OWA), supporting multiple wireless air interfaces in an open architecture platform.

A 4G system is expected to provide a comprehensive and secure all-IP based mobile broadband solution to laptop computer wireless modems, smartphones, and other mobile devices. Facilities such as ultra-broadband Internet access, IP telephony, gaming services, and streamed multimedia may be provided to users.

In mid 1990s, the ITU-R organization specified the IMT-2000 specifications for what standards that should be considered 3G systems. However, the cell phone market brands only some of the IMT-2000 standards as 3G (e.g. WCDMA and CDMA2000), not all (3GPP EDGE, DECT and mobile-WiMAX all fulfil the IMT-2000 requirements and are formally accepted as 3G standards, but are typically not branded as 3G). In 2008, ITU-R specified the IMT-Advanced (International Mobile Telecommunications Advanced) requirements for 4G systems.

IMT-Advanced compliant versions of LTE and WiMAX are under development and called "LTE Advanced" and "WirelessMAN-Advanced" respectively. ITU has decided that LTE Advanced and WirelessMAN-Advanced should be accorded the official designation of IMT-Advanced. On December 6, 2010, ITU recognized that current versions of LTE, WiMax and other evolved 3G technologies that do not fulfill "IMT-Advanced" requirements could nevertheless be considered "4G", provided they represent forerunners to IMT-Advanced and "a substantial level of improvement in performance and capabilities with respect to the initial third generation systems now deployed."

As seen below, in all suggestions for 4G, the CDMA spread spectrum radio technology used in 3G systems and IS-95 is abandoned and replaced by OFDMA and other frequency-domain equalization schemes. This is combined with MIMO (Multiple In Multiple Out), e.g., multiple antennas, dynamic channel allocation and channel-dependent scheduling.

The 4G mobile system is an all IP-based network system. The features of 4G may be summarized with one word- integration. 4G technology should integrate different current existing and future wireless network technologies (e.g. OFDM, MC-CDMA, LAS-CDMA and Network-LMDS) to ensure freedom of movement and seamless roaming from one technology to another. These will provide multimedia applications to mobile users by accessing different technologies in a continuous and always best connection possible.

4G networks can integrate several radio access networks with fixed internet networks as the backbone. A core interface sits in between core network and radio access networks, and a collection of radio interfaces is used for communication between the radio access networks and mobile users. This kind of integration combines multiple radio access interfaces into a single network to provide seamless roaming/handoff and the best connected services.

Items	3G	4G
Speed	Up to 2Mbps	Full-mobility: up to 100Mbps Low-mobility: up to 1Gbps
Services	Difficulty of global roaming	Roaming smoothly
Core Network	Wide-area concept Circuit and packet switching	Broadband, Entirely IP-based packet switching
Technologies	WCDM, CDMA2000, TD-SCDMA	All access convergence including: OFDM, MC-CDMA, LAS-CDMA, Network-LMPS

Figure (8): Comparison of 3G and 4G

The wireless telecommunications industry as a whole has early assumed the term 4G as a shorthand way to describe those advanced cellular technologies that, among other things, are based on or employ wide channel OFDMA and SC-FDE technologies, MIMO transmission and an all-IP based architecture. Mobile-WiMAX, first release LTE, IEEE 802.20 as well as Flash-OFDM meets these early assumptions, and have been considered as 4G candidate systems, but do not yet meet the more recent ITU-R IMT-Advanced requirements.

6. 5G Networks - Real Wireless World System:

5G (**5th generation mobile networks** or **5th generation wireless systems**) is a name used in some research papers and projects to denote the next major phase of mobile telecommunications standards beyond the 4G/IMT-Advanced standards effective since 2011. At present, 5G is not a term officially used for any particular specification or in any official document yet made public by telecommunication companies or standardization bodies such as 3GPP, WiMAX Forum, or ITU-R. New standard releases beyond 4G are in progress by standardization bodies, but are at this time not considered as new mobile generations but under the 4G umbrella.

The 5th wireless mobile internet networks are real wireless world which shall be supported by LAS-CDMA, OFDM, MC-CDMA, UWB, Network-LMDS and IPv6. IPv6 is a basic protocol for running on both 4G and 5G.

The problem is that 5G is designed for World Wide Wireless Web (WWWW) to mobile users based on network access management, but IPv6 assigns any IP address to any mobile node based on location management. This will cause 5G wireless networks resources waste and the IPv6 is difficulty working on the World Wide Wireless Web (WWWW). In order to solve this problem, we have proposed the bandwidth optimization control protocol and the mix-bandwidth data path for future 5G real wireless world. The bandwidth optimization control protocol (BOCP) is implemented in between MAC layer and TCP/IP layer, which is used to establish the mix-bandwidth.

Were a 5G family of standards to be implemented, it would likely be around the year 2020, according to some sources. A new mobile generation has appeared every 10th year since the first 1G system (NMT) was introduced in 1981, including the 2G (GSM) system that started to roll out in 1992, 3G (W-CDMA/FOMA), which appeared in 2001, and "real" 4G standards fulfilling the IMT-Advanced requirements, that were ratified in 2011 and products expected in 2012-2013. Predecessor technologies have occurred on the market a few years before the new mobile generation, for example the pre-3G system CdmaOne/IS95 in 1995, and the pre-4G systems Mobile WiMAX and LTE in 2005 and 2009 respectively.

The development of the 2G (GSM) and 3G (IMT-2000 and UMTS) standards took about 10 years from the official start of the R&D projects, and development of 4G systems started in 2001 or 2002. However, still no transnational 5G development projects have officially been launched, and industry representatives have expressed scepticism towards 5G.

New mobile generations are typically assigned new frequency bands and wider spectral bandwidth per frequency channel (1G up to 30 kHz, 2G up to 200 kHz, 3G up to 5 MHz, and 4G up to 40 MHz), but sceptics argue that there is little room for new frequency bands or larger channel bandwidths. From users point of view, previous mobile generations have implied substantial increase in peak bitrate (i.e. physical layer net bitrates for short-distance communication). However, no source suggests 5G peak download and upload rates of more than the 1 Gbps to be offered by ITU-R's definition of 4G systems. If 5G appears, and reflects these prognoses, the major difference from a user point of view between 4G and 5G techniques must be something else than increased maximum throughput. For example lower battery consumption, lower outage probability (better coverage), high bit rates in larger portions of the coverage area, cheaper or no traffic fees due to low infrastructure deployment costs, or higher aggregate capacity for many simultaneous users (i.e. higher system level spectral efficiency).

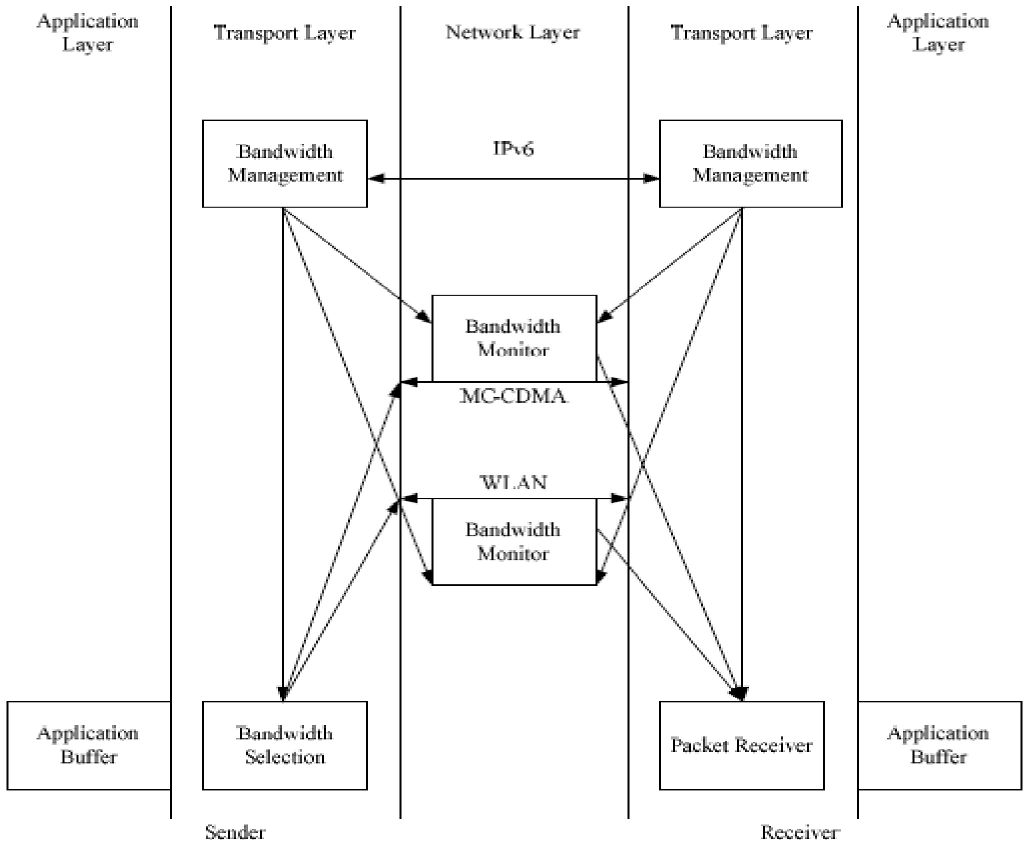

Figure (9): Mix-Bandwidth Data Path

7. The Journey of "G" from 1 to 5th Generation:

Until the controversial spectrum scams were brought up in the lime light many were ignorant of what 1G, 2G or 3G stood for and all of a sudden a hike was found out amongst laymen so as to be knowledgeable about it. Still a number of people are unaware of 1G or 2G when the world has moved on to 4G.

The telecommunication service in World had a great leap within a last few year. 6 billion people own mobile phones so we are going to analyze the various generations of cellular systems as studied in the evolution of mobile communications from 1st generation to 5th generation .Now almost all the service providers as well as the customers seek for availing these 3G and 4G services.

We can analyze that this could be due to increase in the telecoms customers day by day. In the present time, there are four generations in the mobile industry. These are respectively 1G the first generation, 2G the second generation, 3G the third generation, and then the 4G the fourth generation. Ericson a Swedish company is launching this high tech featured mobile into the market. It is being first introduced in the Swedish Capital city, Stockholm.

Generation (1G,2G,3G, 4G,5G)	**Definition**	**Through put/ Speed**	**Technology**	**Time period**	**Features**
1G	Analog	14.4 Kbps (peak)	AMPS,NMT,TACS	1970-1980	During 1G Wireless phones ar used for **voice only.**
2G	Digital Narrow band circuit data	9.6/14.4 Kbps	TDMA,CDMA	1990-2000	2G capabilities are achieved by allowing **multiple users on a single channel via multiplexing**. During 2G Cellular phones are used for **data also along with voice**.
2.5G	Packet Data	171.2 Kbps(peak) 20-40 Kbps	GPRS	2001-2004	In 2.5G the **internet** becomes popular and data becomes more relevant.2.5G **Multimedia services** and streaming starts to show growth. **Phones start supporting web browsing** though limited and very few phones have that.
3G	Digital Broadband Packet Data	3.1 Mbps (peak) 500-700 Kbps	CDMA 2000 (1xRTT, EVDO) UMTS, EDGE	2004-2005	3G has **Multimedia services support** along with streaming are more popular.In 3G, **Universal access** and **portability** across different device types are made possible. (Telephones, PDA"s,

					etc.)
3.5G	Packet Data	14.4 Mbps (peak) 1-3 Mbps	HSPA	2006-2010	3.5G supports **higher throughput and speeds** to support higher data needs of the consumers.
4G	Digital Broadband Packet All IP Very high throughput	100-300 Mbps (peak) 3-5 Mbps 100 Mbps (Wi-Fi)	WiMax LTE Wi-Fi	Now (Transitioning to 4G)	Speeds for 4G are further increased to keep up with data access demand used by various services.High definition streaming is now supported in 4G. New phones with HD capabilities surface. It gets pretty cool.In 4G, Portability is increased further.World-wide roaming is not a distant dream.
5G	Not Yet	Probably gigabits	Not Yet	Soon (probably 2020)	Currently there is no 5G technology deployed. When this becomes available it will provide very high speeds to the consumers. It would also provide efficient use of available bandwidth as has been seen through development of each new technology.

Figure: A Journey From 1G to 5G.