NEAR EAST UNIVERSITY

Faculty of Engineering

Department of Electrical and Electronic Engineering

Third Generation Mobile Communication System

Graduation Project
EE-400

Student: Bilal Qarquor (990731)

Supervisor: Prof. Dr. Fakhreddine Mamedove

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TABLE OF CONTENTS

DEDICATIONS

TO THE MEMORY OF MY PARENTS WHOM GAVE ME
ALL THE SUPPORT AND LOVE

I LOVE AND RESPECT YOU BOTH

DAD & MOM

THANK YOU

ACKNOWLEDGMENT

I must thank my god who gave me the spirit and power to write this project and fulfill my ambitions as it has been a challenging task to run my study through the years and produce such a project.

A very special note of an appreciation goes to Prof. Dr. FAKHRDDIN MAMEDOV who supervised my work step-by-step; helping me with his great experience and knowledge; and played an important role in my personal development, I consider my self lucky for that.

How sad, I would never thought of my self writing my graduation project acknowledgment dedicated to the memory of my father and my mother, whom I have a deep, heart felt gratitude, may they rest in peace.

My appreciation and deep respect goes to my brothers who supported me through the years, and never saved anything on me to complete my study and to be the man who I am today.

Finally a very special thanks to my friends who stood beside me through my study years, home mates Mohammed Darabie and Tarek Ahmad, and close friends Mohammed Qunj and Manaf El-Oqlah and others with my wishes for a good future to all, Thank you.

ABSTRACT

Mobile communication technology has evolved along a logical path, from the simple first-generation analogue products designed for business use to second generation digital wireless telecommunication systems for residential and business environments. It was with higher capacity and lower cost service, describes the standards and digital wireless and UMTS to next generation.

Discusses the motivations and characteristics for the next generation of mobile Communication systems, known as third generation mobile communication systems (3G systems). Evolution of mobile communication systems to the present time is first described the architecture, application and the satellite systems are then explored.

We then provide an insight into future technology for the implementation of mobile communication systems; in particular the role of software radio and impulse transmission the potential health hazard of using mobile phones is also discussed.

INTRODUCTION

Since the first second generation mobile telephones were introduced into the marketplace in 1991, the demand for digital mobile telephones and service continues to grow at over 40% per year. At the end of 2000, there were more than 680 million mobile subscribers throughout the world. Third generation systems will rapidly replace second generation systems as second generation digital mobile telephone systems have rapidly replaced first generation analog systems.

Third generation (3G) wireless systems are an evolution of second generation wireless technologies, and they will use much of the existing second generation infrastructure and radio systems. 3G systems will become the leading communication technology because they provide more cost effective solutions and new broadband multimedia services. In comparison to second generation systems, 3G systems available in 2001 allow for a 70%o increase in network capacity while reducing the cell sites needed by over 30%.

The main issues for both users and operators will be capacity and security. Revenue from radio airtime usage is declining. To increase the value of a customer to a wireless operator, new services can be offered that will increase airtime usage, and content delivery and advertising revenues will supplement basic service revenues. Creative mobile operators offer thousands of services through Internet hypermarketing that will prompt greater wireless usage.

Third generation systems were designed for secure, efficient interconnection with the Internet. By designing the network to take advantage of Internet Protocol (IP), third generation networks provide cost savings for system operators and end users. Third generation systems are less complex networks with fewer nodes, with a single core network that allows standard Internet-based software applications such as email and web browsing. The twenty-first century will see new lifestyles that are enabled by the advanced capabilities of digital wireless communication. Third generation systems offer the potential for many new content-based services to take advantage of efficient high-speed data services that can reach up to 2 Mbps. The key applications can be classified as person-to-person communications, mobile entertainment, wireless advertising, mobile transactions, location-based services, mobile information, and business solutions. By focusing on these key applications and establishing partnerships with content providers, operators will be able to increase profits and customers will improve their lifestyle.

Chapter one describes the history of the first generation system and the develop for analog wireless; also this chapter described the cellular system in analog system and roaming analog.

Chapter two which describes architecture of second generation, and PCS of 2G, TDMA and CDMA as digital system, with described to Communication and Control Channels, digital wireless. As I also described the Universal Mobile Telecommunication System (UMTS) as development to the third generation.

Chapter Three describes the development of third generation which have rapidly replaced second generation, and digital wireless to the 3G, application of 3G and where we can use it, with the health and safety to the system, described satellite system and architecture to 3G software radio, and some advantages and disadvantages involved with.

The aim of the this project to get more information about evolution of mobile communications system for the next generation (3G) and development to this system.

1. FIRST GENERATION MOBILE COMMUNICATION SYSTEM

1.1 Introduction

The first-generation of cellular wireless communication system was analogue and progressively became available during early 1980s [1]. It was popular for business users due to the convenient mobile nature of the service. Several countries (US, Sweden, Japan) started developing their own standard of mobile analogue networks. Different frequency bandwidth usage and different protocols in different countries make roaming impossible. The most successful analogue systems are NMT (Nordic Mobile Telephone – Sweden, Norway, Finland), AMPS (Advance Mobile Phone Service – Asia, North America), ETACS (Extended Total Access Communication System – UK), and JDC (Japan Digital Cellular). All of these are still in some demand As the popularity of wireless communication escalated in the 1980s, the cellular industry faced practical limitations. For a fixed allocation of spectrum, a large increase in capacity implies corresponding increase in difficulties enlarging the networks. In addition to the capacity bottleneck, the utility of first-generation analogue systems was diminished by the proliferation of incompatible standards in Europe. The same mobile telephone frequencies cannot be used in different European countries. The limitations of first-generation analogue systems provided motivations to the development of second-generation systems.

1.2 History of First Generation

In 1979, the first commercial cellular telephone system began operation in Tokyo In 1981 Motorola and American Radio telephone started 1982, the slow moving FCC finally authorized commercial cellular service for the USA. A year later, the first American commercial for analog cellular service or AMPS (Advanced Mobile Phone Service). In 1970 the Federal Communications Commission (FCC) allocated spectrum in the 800 MHz band for cellular communications, and advanced mobile phone service (AMPS) was born. AMPS, a high-capacity analog standard introduced by AT&T, was the first widely deployed cellular technology. The first systems using this technology began operations 1983 and are still used today. Each AMPS provider is given half of the band of spectrum from 824849 MHz and half of the band from 869-894 MHz. These bands are broken up into 30-kHz sub-bands, called channels, with each provider receiving half of all available channels. All of the channels in the 824-849 MHz band are called reverse channels because they carry transmissions from the mobile cellular phone to the cell site. The channels in the 869-894 MHz range are called the forward channels because they carry transmissions from the cell sites to the cell phones. The practice of dividing the larger bands into sub-bands is referred to as frequency division multiple access (FDMA) and is widely used in cellular communications.

AMPS do not try to cover one large area with one transmitter. Instead, an area is divided into smaller section called cells. Each of these cells has its own low power transmitter, which uses a subset of the available channel pairs to communicate to mobile phones within the cell boundaries. Adjacent cells use a different subset of channels so that they do not interfere with the first set. When the mobile unit begins to leave a cell, the network controller commands the first transmitter to hand off the call to another cell and simultaneously commands the transmitter in the second cell to use a new channel pair to take over the call.

1.3 The Future

With second-generation systems still in their childhood, third-generation systems are on the drawing board. There are two competing air interfaces proposed by separate coalitions of equipment manufacturers. One camp is proposing a wide band code division multiple accesses (W-CDMA) which is incompatible with IS-95. This standard uses 5 to 10 MHz bands and promises data transmission rates of around 384 Kbps. The competing standard is a hybrid W-CDMA/TDMA air interface that promises similar data rates, but provides more backward compatibility to TDMA and GSM service providers. With these higher data rates, third-generation systems providers will offer high-speed multimedia applications in addition to the abundance of features offered with voice communications. As wireless communications evolved from a one-tower analog system to multi-cell analog systems and then to TDMA and CDMA digital systems, service providers faced many challenging decisions about that technology they would implement. One technology, GSM, has come very close to capturing their hearts-or at least their wallets-in its pursuit to dominate mobile communications. It gained distinct advantage through legislation that made it illegal to deploy any other digital air interface in Europe. As the more mature and earliest available technology for PCS at 1900 MHz, GSM has also fared well in North America, with more than 1.5 million subscribers to date. TDMA has also done well, notably with AT&T Wireless Services and Southwestern Bell Wireless in the U.S. Now, with third-generation systems on the horizon, Japan's largest wireless provider, NTT Docomo, has adopted WCDMA for its future wireless technology. Europe is to decide very shortly if it will follow suit and essentially make W-CDMA a de facto standard. Either way North America cellular providers are not likely to standardize on a single third-generation technology. As with the earlier digital technologies, the marketplace will probably be given a choice, and the buyers, not the legislators, will decide on the winner.

Easy wireless access to Internet is set to become a major e-commerce driving force. With vastly increased wireless data rates, the full power of the Internet-IP revolution will be available to most of the mobile world by 2005. The significance for business will be the rapid deployment of mobile Internet and Intranets, which are set to comprise 54% of total mobile usage by 2005. Mobile Intranets will accommodate business applications such as e-mail, sales and other support systems, workflow applications, content and voice over IP. The core enabling technology and catalyst for mobile intranets and Internet is GPRS, the 100 kilobits per second packet radio platform available later this year to replace the standard 9.6kbps GSM. In the 1980s, voice went from fixed networks to wireless. The same will happen for the Internet, through two routes: cellular; and fixed IF networking. A combination of 100kbps packet radio and the wireless applications protocol (Wap) which creates World-Wide Web for linking mobile devices will enable full, efficient access to Net services from mobile devices.

1.4 Personal Communication Service

Analog cellular technology is not included as a PCS technology. PCS only refers to digital technologies specifically designed to provide improvements over analog. While analog cellular can be used for data computing, it is inherently less optimal than digital. Therefore, analog cellular data computing should be viewed as a backup solution to PCS technologies. The analog cellular system has the widest coverage of any system, with service available in almost any city or town, and on most major highways in the US. For this reason, analog cellular will remain the only wireless data option in rural areas for quite some time to come.

Technologically, the principles of each are similar; however, PCS has several advantages over the analog or even digital cellular. These advantages include better service quality through use of 100% digital technology, enhanced service features, and anticipated lower service cost to the user.

The combination of advanced digital technology and encryption capacity creates a more secure network for wireless communications. In addition, the cell sites are smaller and closer together providing for a stronger signal and lower power requirements, better in-building reception and fewer dropped calls. Additionally, benefits of broadband PCS over cellular include smaller, lighter handsets, and longer battery life.

Table 1.1 Compare between PCS and cellular

PCS	Cellular
Digital Technology	Analog Technology
Higher Capacity	Limited Capacity
Increased Privacy	Eavesdropping
Increased Security	Fraud Possible
Long Battery Life	Shorter Battery Life
Extended Services	Services Limited

1.5 Wireless Connectivity

1.5.1 Data over Cellular links

The analog cellular telephone system uses FM (Frequency Modulation) radio waves to transmit voice grade signals. To accommodate mobility, this cellular system switches radio connection from one cell to another as the mobile user moves from one cell to another (roaming). Every cell within the network has a transmission tower that links mobile callers to a Mobile Telephone Switching Office (MTSO). The MTSO, which is owned and operated by the cellular carrier in each area, provides a connection to the public switched telephone network. The public telephone networks acts also as gateways to the Internet.

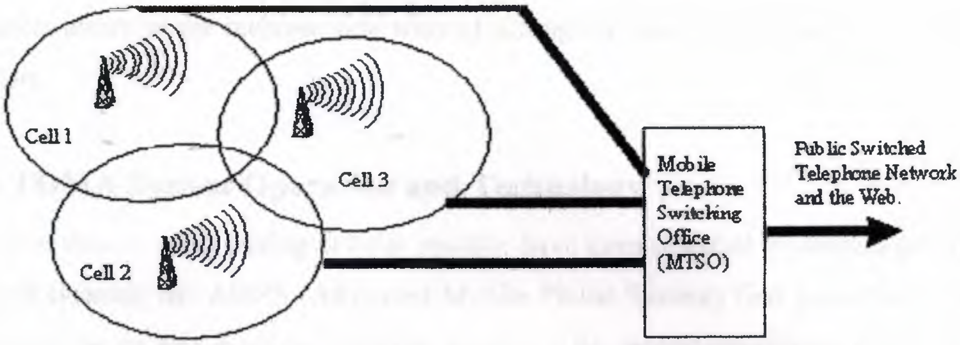


Figure 1.1 General Circuit switched cellular telephone system

Most modems that operate over wire line telephone services will also interface and interoperate with cellular phones; however, modem software optimized to work with cellular phones minimizes battery usage. There are problems with modem communication over cellular links. The first problems occurring were the hand-off problems or roaming. As a mobile user moves from one service area to the next, a hand-off occurs from one service area to the next. The hand-off would disrupt the call for 100 to 200 ms. this is just enough to disrupt the carrier detect (CD) cycle; hence, the modem assumes that one of the callers has disconnected, and it hangs up. This problem can be overcome similar to fax modems over cellular links. The modem will delay 400 ms before hanging up, giving the hand-off enough time to take place. Some data might be affected, but error detection and error correction procedures (CRCs) will detect and correct the data bits that have been corrupted. But, all these techniques lower the effective throughput of our communication system and the effective throughputs achieved with cellular modems hover around 19200 bits/s [2].

To establish a dedicated wireless data network for mobile users, a consortium of companies in the United States developed the Cellular Digital Packet Data (CDPD) standard. CDPD overlays the conventional analog cellular telephone system, using a channel hopping technique (previous section) to transmit data in short bursts during idle times in cellular channels. CDPD operates full duplex, meaning simultaneous transmission in both directions in the 800 and 900 MHz frequency bands. The main advantage of the analog cellular system is widespread coverage. Since CDPD piggybacks on this system, it will also provide nearly worldwide coverage. The main advantage with CDPD is that, it uses digital signals, making it possible to enhance the transmission of data. With digital signaling, it is possible to encrypt the data stream and provide easier error control. CDPD is a robust protocol that is connectionless and corrects errors at the receiver side without asking the source to retransmit the errored packet.

1.6 TDMA System Operation and Technology

Now that so many analog cellular systems have been replaced by second-generation digital systems, the AMPS (Advanced Mobile Phone System) first generation cellular system lives on as one of the operating modes of the second-generation, digital IS-136 cellular standard. A steady evolution of elaborate digital extensions to AMPS has given us today's second generation TDMA (TIA/EIA-136 also called IS-136 and ANSI-136) protocol with all the functionality of its CDMA and GSM relatives, and its own set of unique features. Today, the TDMA family of standards provides reliable mobile telephony and data services throughout the Western Hemisphere and in dozens of other countries. Ambitious third generation (3G) initiatives and recent convergence with GSM, means that ANSI-136 will likely become one of the world's most important digital cellular systems. It remains the technology of choice for network operators who originally deployed AMPS systems. It fully protects the AMPS investments as it offers subscribers unique digital features and global roaming.

This is an intensive, system-oriented overview of TDMA, including its AMPS mode, using the radio interface signaling protocols to illustrate the system's characteristics and operation. Concentrating on the signaling aspects to make system operation intuitive services the needs of those who seek a strong standards orientation for the course. There is an intensive overview of the whole IS-136 family of standards, in all its deployments. Extensive material is included on the unique features of the protocol: hierarchical cells, IRDBs, and AMPS interoperability. There is a special effort is made to bring order to the library of standards as it explains the system operation in evolutionary terms, from AMPS, to the quasi-digital TDMA (IS-54) systems that appeared in the early 1990s, to the present-day fully digital form converging with GSM.

1.7 Normal Roaming Analog Cellular Telephones

When a normal roaming analog cellular telephone enters a foreign market, it will transmit an Autonomous Registration message over the Reverse Control Channel (RECC) to "make its presence known", for pre-call authentication purposes. This initial Autonomous Registration message is forwarded to the phone's Home switch (HLR) via an SS7/IS-41 RegNot (registration notification) message. The Home switch will respond with authentication parameters and the local switch will build a VLR database entry, so that the roaming phone can readily originate and terminate potential future calls. The cellular telephone will also regularly transmit additional Autonomous Registration messages, under a schedule provided by the cell, so that the cellular system will keep it authenticated, i.e. keep its VLR database entry active.

When the roaming analog cellular telephone does subsequently originate a call, it sends a different, larger message over the RECC – an Originate message indicating that a call setup is requested for the dialed digits.

1.8 Cellemetry Data Service

Cellemetry never transmits anything unless the underlying application has a monitoring or telemetry event to report. In this case, the data is placed into the 32 bit ESN field of the Autonomous Registration message and transmitted. To the cellular system, this appears as a Normal Autonomous Registration message and is forwarded, via an SS7/IS-41 RegNot (Registration notification) message, to the Home HLR, which, in this case, is the centralized Cellemetry Gateway.

The centralized Cellemetry Gateway responds with permission parameters that deny all call Origination or Termination and a few seconds later sends a Registration Cancel message which removes the VLR just as quickly as it was built. The centralized Cellemetry Gateway then forwards the data to the MIN's Application Provider. Since this is not a call origination, no voice channel is activated in any way. While Cellemetry's current dynamic data payload size is 32 bits, the TR45.1 standards body is actively working on expans on of the field to 56 bits. The current Cellemetry data payload is 122 bits when you add the 32 bit dynamic data payload, the 10 decimal digit unit identification and the coarse geographic location of the IS41 MSCID field.

1.9 Cellemetry Uses Excess Control Channel Capacity

Typically, the Analog Control Channel is occupied an average of 1% with an average of 10% during the busy hour. The busiest system measured was the Buenos Aires micro-center with one Control Channel serving 235 NAMPS voice channels. It had a busy hour average of 25% with peak occupancy at 51%. When Cellemetry achieves its business plan volume, its total consumption of FOCC Capacity is 3.4 % Refer to the chart below, which represents actual field measurements.

1.10 The Cellular System

1.10.1 The cellular system analog is comprised of four parts:

- Cells and cell sites (base stations)
- Switching station (mobile telephone switching office or MTSO)
- System operator and its local office
- Cellular telephones

1.10.2 Cells of Cellular system

The heart of the system is made up of individual radio coverage areas called " cells. " Each cell is a self-contained calling area. Within the cell, a cell site is strategically positioned as a base station for receiving, sending and routing the radio signals of cellular phone calls. Because the cellular system is a radio system, no exact boundary can be drawn on a map. In most cases calls can be place and received throughout the service area, except for certain enclosed areas such as underground parking garages. The No Svc (No Service) indicator will illuminate on the cellular phone when in one of those areas or is outside of the service area. The cell site's transmitter is low powered and does not reach much beyond that cell's boundaries. That makes it possible to reuse channels (frequencies) - a given channel can be used at the same time in different cells, as long as the cells do not border one another, without causing signal interference. This is particularly valuable in urban areas where lots of cellular phones are in use at the same time. All cell sites are connected to the Mobile Telephone Switching Office (MTSO), which provides connection into the Public Switched Telephone network (PSTN) - the local telephone company. The MTSO also provides other central functions, including call processing, traffic management, and transferring calls as a phone moves between cell sites.

1.10.3 Making a call

When a cellular user makes a call from a cellular phone, radio signals are transmitted to the cell site. The cell site alerts the Mobile Telephone Switching Office (MTSO) switching station. The MTSO, in turn, provides an open channel (frequency) and connects the call to the Public Switched Telephone Network (PSTN). The PSTN put the call through to the number to be reached, to make a call from a land line phone takes at time.

1.10.4 Receiving a call

These are the steps that occur when you receive a call on a cellular phone. A call placed to a cellular phone may come from either a land line phone or another cellular phone. Whichever the source, the MTSO is notified that a call has been placed to a specific cellular telephone number. At this point, the MTSO searches for the correct cellular phone by sending out data over the radio waves. Cellular phones that are in standby mode (i.e., turned on but not being used in a call) continuously scan the radio waves being transmitted by the MSTO. If a phone "hears " its telephone number, it sends back a signal that informs the closest cell site of its Electronic Serial Number (ESN) and its telephone number (Mobile Identification Number or MIN). The cell site passes this information to the MTSO, where the ESN and MIN are verified and a channel (frequency) is assigned for the call. The cellular phone receives the message directing it to tune to the correct voice channel. The cell site makes the voice channel available, and the call is completed.

1.10.5 Hand-off

Hand-off is the transfer of a call from one cell site to another as the cellular phone moves through the service coverage area. The cell site warns the MSTO that the mobile's signal strength is falling below a predetermined level. The MTSO then alerts all cell sites bordering on the first one. They measure the mobile's transmitting signal and report back to the MTSO. The MTSO, which is programmed to select the site receiving the strongest signal, then switches the call from the weak cell to the strongest cell without interrupting the call. The whole process takes a fraction of a second, and the caller usually is unaware of it. Such hand-offs may occur several times during a single conversation as the caller moves through the coverage area.

1.11 Advanced Mobile Phone Service

AT&T pioneered American mobile wireless communications when it launched the Advanced Mobile Phone Service (AMPS) in Chicago in the early 1980s. AT&T later divested itself of AMPS when the US government forced the company's breakup. The service originally operated in the 800 MHz band, but later expanded to include transmissions in the 1900 MHz range, putting AMPS in the VHF (Very High Frequency) range of radio transmissions, the band in which most wireless carriers operate.

An AMP is a first-generation analog, circuit-switched network. Because it uses analog signals, AMPS is better suited for voice than data. Because it is circuit-switched, each transmission starts and ends with a dedicated connection. An AMP consequently fails to meet several key needs of daily life in the computer age: it cannot transmit digital signals and cannot transport data packets without assistance from newer technologies such as TDMA and CDMA.

2. SECOND GENERATION MOBILE COMMUNICATION SYSTEM

2.1 Introduction

The solution to the problems of first-generation networks is 'digital'. Launched in the late-1980s – early 1990s, the GSM network (Global System of Mobile Communication) provides higher capacity and hence lower cost services. With the European standard widely spread to other parts of the world, international roaming became possible. It is the only standard that fully specifies the complete network architecture. GSM is a voice centric communication network with limited data capabilities. In other words, GSM provides high quality, interference-free speech. As the microprocessor technology becomes mature, the size and battery performances of the handsets have improved greatly.

2.2 Personal Communication System (PCS) Of 2G

PCS is economically communication over wide areas, using a standardized, low-power technology to provide voice and moderate-rate data to small, lightweight, economical, pocket-size personal handsets that can be used for tens of hours without attention to batteries [3]. The development of PCS is a global movement, which evolves from the existing second-generation mobile networks to allow new services to be established as well as to facilitate the steady improvement of the existing networks. The evolution is imposed by technologically driven international standards bodies that concern themselves with elegant and commercially viable engineering improvements to the current state-of-the-art. In fact, GSM has been chosen as one of the standards from which third-generation mobile telecommunications will evolve. The key element in the progression to the third-generation is GSM's network capability and core network architecture

2.3 The Basics of Cellular Technology and the Use of the Radio Spectrum

Mobile operators use radio spectrum to provide their services. Spectrum is generally considered a scarce resource, and has been allocated as such. It has traditionally been shared by a number of industries, including broadcasting, mobile communications and the military. At the World Radio Conference (WRC) in 1993[4], spectrum allocations for 2G mobile were agreed based on expected demand growth at the time. At WRC 2000, the resolutions of the WRC expanded significantly the spectrum capacity to be used for 3G, by allowing the use of current 2G spectrum blocks for 3G technology and allocating 3G spectrum to an upper limit of 3GHz.

Before the advent of cellular technology, capacity was enhanced through a division of frequencies, and the resulting addition of available channels. However, this reduced the total bandwidth available to each user, affecting the quality of service. Cellular technology allowed for the division of geographical areas, rather than frequencies, leading to a more efficient use of the radio spectrum. This geographical re-use of radio channels is knows as "frequency reuse".

In a cellular network, cells are generally organized in groups of seven to form a cluster. There is a "cell site" or "base station" at the centre of each cell, which houses the transmitter/receiver antennae and switching equipment. The size of a cell depends on the density of subscribers in an area: for instance, in a densely populated area, the capacity of the network can be improved by reducing the size of a cell or by adding more overlapping cells. This increases the number of channels available without increasing the actual number of frequencies being used. All base stations of each cell are connected to a central point, called the Mobile Switching Office (MSO), either by fixed lines or microwave. The MSO is generally connected to the PSTN (Public Switched Telephone Network.

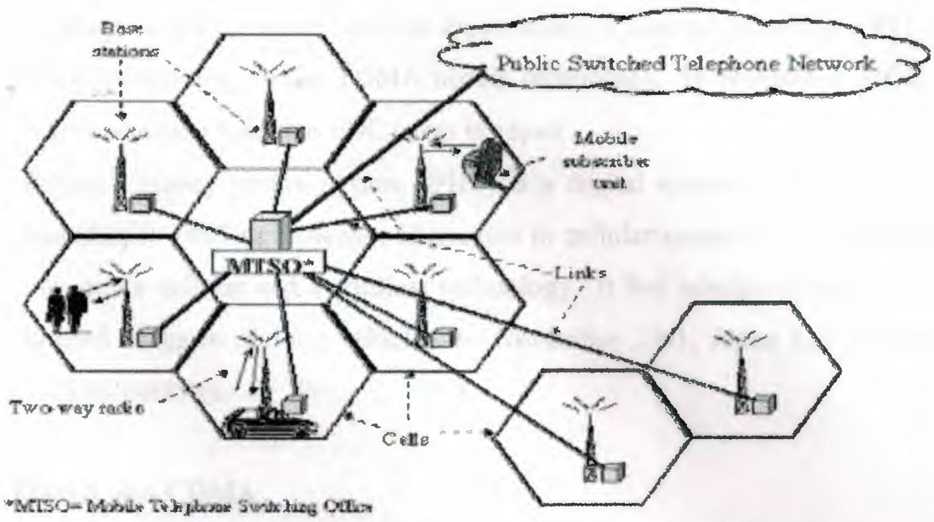


Figure 2.1 MTSO=Mobile Telephone Switching Office

2.4 Cellular Standards for Second Generation

- Global System for Mobile Communications (GSM) was the first commercially operated digital cellular system. It was first developed in the 1980s through a pan-European initiative, involving the European Commission, telecommunications operators and equipment manufacturers. The European Telecommunications Standards Institute was responsible for GSM standardization. GSM uses TDMA (Time Division Multiple Access) technology. It is being used by all European countries, and has been adopted in other continents. It is the dominant cellular standard today, with over (45%) of the world's subscribers at April 1999.
- TDMA IS-136 is the digital enhancement of the analog AMPS technology. It was called D-AMPS when it was fist introduced in late 1991 and its main objective was to protect the substantial investment that service providers had bmade in AMPS technology. Digital AMPS services have been launched in some 70 countries worldwide (by March 1999, there were almost 22 million TDMA handsets in circulation, the dominant markets being the Americas, and parts of Asia)
- CDMA IS-95 increases capacity by using the entire radio band with each using a unique code (CDMA or Code Division Multiple Access) . It is a family of digital communication techniques and South Korea is the largest single CDMA IS-95 market in the world.

- Personal Digital Cellular (PDC) is the second largest digital mobile standard although it is exclusively used in Japan where it was introduced in 1994. Like GSM, it is based on the TDMA access technology. In November 2001, there were some 66.39 million PDC users in Japan.
- Personal Handy phone System (PHS) is a digital system used in Japan, first launched in 1995 as a cheaper alternative to cellular systems. It is somewhere in between a cellular and a cordless technology. It has inferior coverage area and limited usage in moving vehicles. In November 2001, Japan had 5.68 million PHS subscribers.

2.4.1 TDMA and CDMA

TDMA (Time Division Multiple Access) and CDMA (Code Division Multiple Access) are the two most prevalent second-generation attempts to digitize AMPS in order to facilitate wireless data transmission. Bandwidth for TDMA and CDMA is allocated 800MHz, 900MHz, &1900MHz

AMPS are a frequency-division multiple-access (FDMA) system. This means that the frequency band has been chopped up into a number of smaller bands, providing access to more users at the same time. AMPS, however, didn't make efficient use of available bandwidth. Remember the discussion we had earlier regarding channels? It turns out that FDMA channels can be further subdivided into time slots so that multiple users can actually share the same channel. This method of increasing the carrying capacity of the network is the concept underlying TDMA. TDMA makes more efficient use of channels.

In some sense, TDMA is similar to client-server time-sharing systems of the 80s. each voice channel is divided into time slots, enabling up to three simultaneous conversations modulated on the same channel. TDMA consequently enables multiple users to occupy the same channel. The following diagram provides a quick visual comparison of FDMA and TDMA.

As you can see, TDMA effectively triples network capacity. CDMA, which came later, took an entirely different tack. Created by Qualcomm in the mid 1990s, CDMA is a so-called spread-spectrum technology. Rather than split the frequency bands into smaller and smaller subunits, CDMA allows all users to share the same frequency at the same time. The entire frequency band is fair game for all users. The secret to managing this wireless free-for-all lies in the packaging.

FDMA and TDMA and Modulation

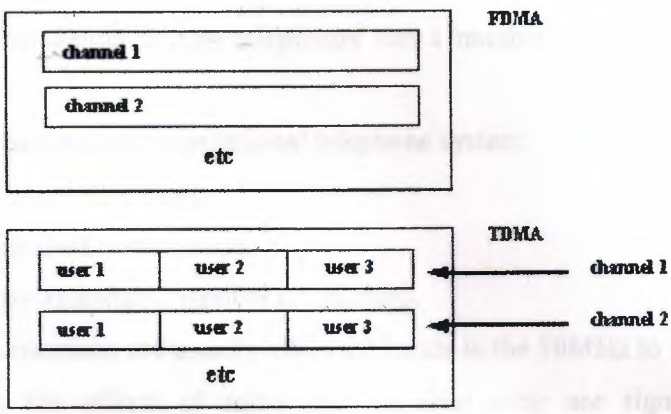


Figure 2.2 visual comparisons of FDMA and TDMA.

Signals from different users are distinguished by unique code sequences. Each voice (or data) communication is broken up into little pieces, and each piece is given an identifying code. At the receiving end, knowledge of the code sequence being sent allows the signal to be extracted and reconstructed. This process is closely analogous to the way TCP/IP packets are sent across the Internet; it is much more complicated, however, because all the transmissions may occur at the same time. Even so, the code sequence enables the receiving software to isolate and reassemble the pieces of each message.

2.4.2 Modulation

At the heart of TDMA and CDMA is a trick of physics called modulation. A high-frequency digital signal is grafted onto a lower-frequency analog wave, so that digital packets are able to ride piggyback on the analog airwave.

This hybrid, modulated approach to signal processing has helped bridge the evolution of analog to digital services, but at its core it's an imperfect technology. Still, until full-scale digital services arrive, with packet-switched delivery of built-from-the-ground-up digital voice and data services, it will have to do. And, at least in Europe, it hasn't done half bad.

2.5 Mobile Communication

The use of mobile radio-telephones has seen an enormous boost in the 1980s and 1990s. Previous to this time, citizen band (CB) radio had served a limited market.

However, the bandwidth assignation for CB radio was very limited and rapidly saturated. Even in the U.S., a total of only 40 10 KHz channels were available around 27MHz. The use of digital mobile telephones has a number of advantages over CB radio:

- Access to national and international telephone system.
- Privacy of communication.
- Data independent transmission.
- An infinitely extendable number of channels.

Mobile communications are usually allocated bands in the 50MHz to 1GHz band. At these frequencies the effects of scattering and shadowing are significant. Lower frequencies would improve this performance, but HF bandwidth is not available for this purpose. The primary problems associated with mobile communication at these frequencies are:

- Maintaining transmission in the fading circumstances of mobile communication.
- The extensive investigation of propagation characteristics required prior to installation.

Mobile communication work by limiting transmitter powers. This restricts the range of communication to a small region. Outside this region, other transmitters can operate independently. Each region is termed a cell. These cells are often represented as hexagons. In practice the cell shape is determined by local propagation characteristics. Together the cells will completely cover the area supplied with mobile communication coverage figure 2.3[5] and 2.4[6].

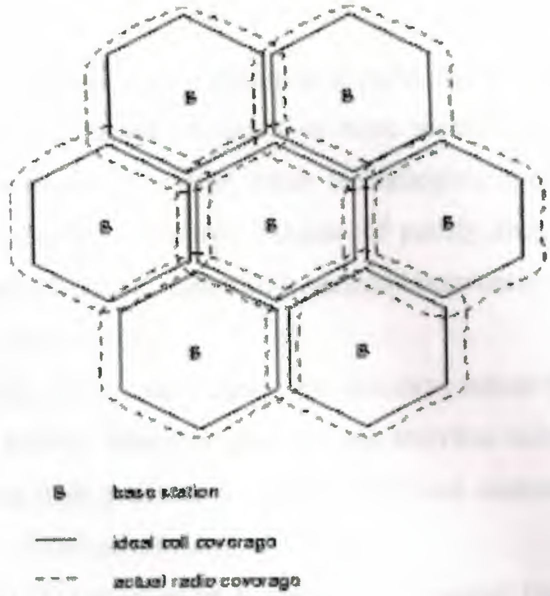


Figure 2.3 *Use of cells to provide geographical coverage for mobile phone service*

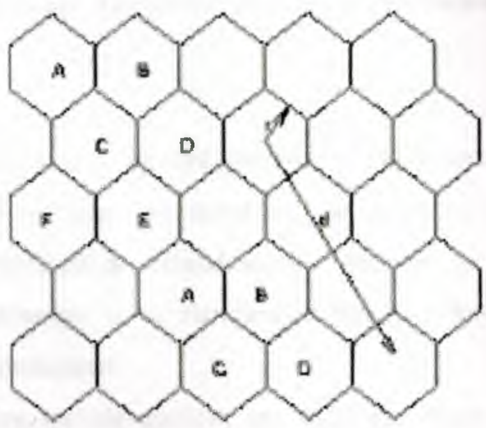


Figure 2.4 Frequency re-use in cells

Within each cell, the user communicates with a transmitter within the cell. As the mobile approaches a cell boundary, the signal strength fades, and the user is passed on to a transmitter from the new cell. Each cell is equipped with cell-site(s) that transmit/receive to/from the mobile within the cell. Within a single cell, a number of channels are available. These channels are (usually) separated by frequency. Then a mobile initiates a call, it is assigned an idle channel within the current cell by the mobile-services switching centre (MSC). He/she uses the channel within the cell until he/she reaches the boundary. He/she is then allocated a new idle channel within the next cell.

2.5.1 Security

Security for mobile, wireless computing is a particularly difficult problem. Some technologies, such as Free Space Optics, have more security because of the physical characteristics of the media. However, other technologies, such as cell phones and digital pagers, have almost no security because of poorly designed communications protocols. More detail about this potentially serious shortcoming can be found in the white paper by Cisco Systems [7].

There are options for bolstering security. For instance, industry analysts recommend firewalls for mobile devices wherever practical and antivirus software developers have added extensions into their products to support the most common handheld devices. Even then, there are no fool-proof solutions.

According to Giga [8] the situation is made more complex because mobile workers tend to be less technically adept than tethered workers are. Therefore, security for their devices must be automatic and transparent in order to be effective.

2.5.2 Support

Most organizations offer very limited support for PDAs because the devices are not mission-critical. As PDAs take on more of the roles of the traditional PC, IT departments will be required to extend similar support to those users. The most commonly advocated strategy is to standardize the PDA/handheld PC environment within the supported organization.

In those cases where mobile devices are used for more extensive applications, additional back office support is required. This includes support for data replication and synchronization, bandwidth management, and asset and configuration management. These tasks may be handled by database software, or by special software that has been developed to support mobile clients. Either way, additional IT support personnel are required.

2.6 Communication & Control Channels

The radio spectrum, which includes microwave frequencies, is divided into channels, each occupying a 30 kHz band. These may be both control or communications channels Communication channels carry both voice and data content. Control channels, operating at slightly higher frequencies than the voice and data channels they command, control signaling inputs and outputs, and manage other network transmission chores.

2.6.1 The Radio

So, the big advantage of radio frequencies and don't use the higher end of electromagnetic spectrum to transmit data, several reasons: Unlike short wavelengths, which are easily absorbed by objects and materials, long wavelengths penetrate obstructions — forests, hills, towns, cities — without significant distortion. They can travel long distances, bounce off satellites, and reflect halfway across a continent. Moreover, because low-frequency waves are characterized by low energy, there is little health hazard to human populations. So low energy means cheap transmission.

2.7 Wireless Internet & Voice Communications for the RVer

In recent months it has become apparent that the new technology for accessing the internet via your satellite dish, for both receiving and sending data, has had disappointing results for the mobile user, such as RVers. The settings and adjustments are too difficult and touchy for the average user. It is not a do-it-yourself project. However, while all the hubbub and hand-wringing were going on over this technology (Starband), interesting developments were taking place with that old friend, the cell phone.

When speaking of the past, present, and future of the cell phone, the terms 1G, 2G, and 3G are used. These simply stand for "first generation," "second generation," and "third generation." 1G represents the older analog system and 2G the newer digital system. But now we come to 3G, which is the latest development. It should be of particular interest to the highly mobile RVer who likes to "surf the net." 3G represents digital wireless communications on "packet switched networks." We'll skip the technical stuff and just get to the bottom line by saying that packet switched networks will allow us much better voice communications and much faster access to the internet through our digital wireless phones.

When will all of this happen, and what do you have to do to take advantage of it? Before we answer these questions, let's take a look at the present system. I will refer only to national wireless phone service providers. If you are a full-time RV road warrior who wants to be "connected" in as many places as possible, as fast as possible, and as economically as possible, you'll want to look at what I call the "big 6." They are: Voice stream, Cingular, Verizon, AT & T, Nextel, and Sprint. The first five got a jump start by piecing together existing regional, local and "mom & pop" systems. This allowed them to rapidly develop national networks. But, like the tortoise and the hare, Sprint decided to develop its own exclusive network. They purchased the 1900 MHz frequency from the government for their exclusive use and began to build a seamless, digital network for wireless phone communications. So, we now have five national services traveling on combination analog/digital networks (1G and 2G) and Sprint with its all digital network (3G). Note that Sprint can still connect to analog networks by mutual agreements and what is called reverse technology.

So, why all the fuss about analog and digital networks? I can sum it up in two words; capacity and speed. Analog has limitations as to how much traffic it can carry. Now that America has fallen in love with the cell phone, the system is rapidly reaching its limitations. But the digital system is coming to the rescue in the form of those "packet switched networks." Just imagine traveling from Chicago to Denver on old 2-lane highways. That's 1G analog. If you take the same trip on the Interstate system. That's 2G digital. Now imagine that interstate expanded to 50 lanes or more, with everyone traveling 200 miles per hour. That's the new 3G digital technology coming down the road.

2.7.1 Digital Wireless Networks

Unlike long-distance networks, digital wireless networks use echo cancellers to remove echo that is made audible primarily by processing delays caused by speech compression equipment and not by transmission facility delays. All digital wireless networks use some form of compression to reduce the amount of radio bandwidth required to carry the conversation. Compression induces delays that can cause echo to be heard on calls made by the mobile telephone user. Echo cancellers are used in all digital wireless networks to ensure that the digital mobile telephone user does not hear echo when placing a call into the local telephone exchange.

Also, unlike long-distance networks, digital wireless networks normally use only one echo canceller on each facility. This echo canceller points into the public switched telephone network (PSTN) and protects the mobile subscriber from hearing echo caused by reflections in the 2wire local loop (see Figure below).

Some echo protection may be provided for the PSTN subscriber by echo control circuitry built into the mobile telephone. The quality of this echo control can be limited and may vary from one phone manufacturer to the next. Better mobile to mobile voice quality can be maintained by placing high quality echo cancellers in between the Mobile Switching Center (MSC) and the Base Station Controllers (BSC).

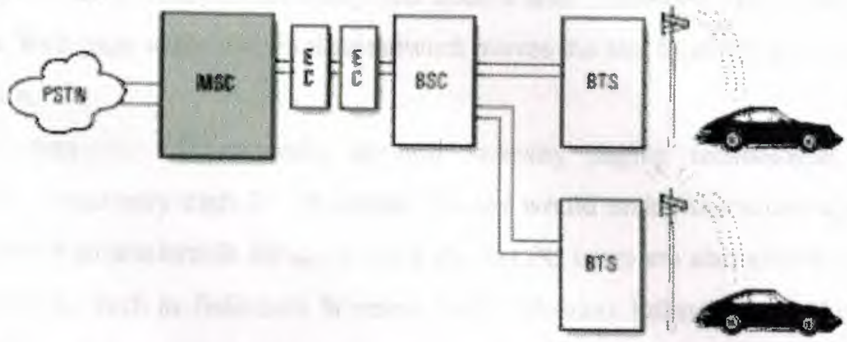


Figure 2.5 Echo Cancellations in a Digital Cellular Network

2.7.2 Wireless Networks Through the "ages"

In the early to mid 90's, the most popular option for wireless data communications with mobile devices was the Advanced Mobile Phone System (AMPS) cellular telephone network. This still-very-popular analog-only network can be used with a traditional external or PC Card modem to translate the bits pushed out the device's serial port into the analog signal expected by the cell phone. Users could expect blistering data throughputs on the order of 4.8 kbps, and lots of dropped calls (unless specialized error-correcting cellular protocols were used to maintain connectivity in roaming situations). AMPS are an example of what the industry calls a "1st Generation" or "1G" network.

The digital cellular network revolution in the mid to late 90's allowed users to eliminate the expensive, battery-hungry modem from the loop. Instead of an external modem, digital networks use native modulation techniques inside the telephone itself. This allowed companies such as Socket Communications [9] to offer their Digital Phone Card product that provides a direct conduit through your Pocket PC's Compact Flash slot to your digital cell phone without the need for a modem.

Moreover, in contrast to the older analog AMPS networks, reliability and data throughput are better on these "2nd Generation" ("2G") digital networks (somewhere on the order of 14.4 kbps for CDMA networks such as that offered by Sprint PCS). Other digital providers such as AT&T and Verizon offer similar (though technologically incompatible) digital networks to keep PC connected wirelessly to the Internet.

Besides the ubiquitous hybrid voice/data 2G networks, there is a veritable "alphabet soup" of acronyms for technologies which provide data-only networks for the use of

Pocket PC owners. For example, AT&T and other companies offer an analog/digital technology called Cellular Digital Packet Data (CDPD). CDPD improves throughput slightly (to 19.2 kbps) but at the expense of higher latency than with hybrid voice/data digital networks. Latency is the delay that occurs after pressing a key or tapping on a link on a Web page while the wireless network moves the bits from PC to the server and back again.

Other data-only 2G networks include two-way paging technologies such as REFLEX, whose very high 25–30 second latency would make interactive applications such as the Web intolerable for most users. Pocket PC users are also able to use packet radio networks such as Bellsouth Wireless Data's Mobitex infrastructure (this network makes most of those nifty RIM interactive pagers and Palm VII's communicate). The problems with all of these systems are high latency (12–15 seconds) and low throughput (8 kbps). Users are bound to get frustrated with the performance and reliability of most of these existing 2G solutions.

Other companies offer higher-performance wireless LAN technologies (up to 128kbps in some cities); however, coverage is again a big issue—currently the service is only available in 11 cities. Moreover, in those cities where there are quite a few hills, coverage will continue to be a problem for many users.

2.8 Architecture of 2G

The functional architecture of a GSM system can be broadly divided into the mobile station, the base station subsystem, and the network subsystem. Each subsystem is comprised of functional entities which communicate through the various interfaces using specified protocols [10].

2.8.1 Mobile Station

The mobile station in GSM is really two distinct entities. The actual hardware is the mobile equipment, which is anony-mous. The subscriber information, which includes a unique identifier called the International Mobile Subscriber Identity (IMSI), is stored in the. Subscriber Identity Module (SIM), implemented as a smart card. By inserting the SIM card in any GSM mobile equipment, the user is able to make and re-ceive calls at that terminal and receive other subscribed ser-vices, by decoupling subscriber information from a specific terminal, personal mobility is provided to GSM users.

2.8.2 Base Station Subsystem

The Base Station Subsystem is composed of two parts, the Base Transceiver Station (BTS) and the Base Station Con-troller (BCS). The BTS houses the radio transceivers that de-fine a cell and handles the radio (Um) interface protocols with the mobile station. Due to the potentially large number of BTSs, the requirements for a BTS are ruggedness, reliability, portability, and minimum cost. The Base Station Controller (BSC) manages the radio resources for one or more BTSs, across the Abis interface. It manages the radio interface channels (setup, teardown, frequency hopping, etc.) as well as handovers.

2.8.3 Network Subsystem

The central component of the Network Subsystem is the Mo-bile services Switching Center (MSC). It acts like a normal switching node of the PSTN or ISDN, and in addition pro-vides all the functionality needed to handle a mobile sub-scriber, including registration, authentication, location up-dating, inter-MSC handovers, and call routing to a roaming subscriber.

These services are provided in conjunction with four intelligent databases, which together with the MSC form the Network Subsystem. The MSC malso provides the connections to the public fixed networks. The Home Location Register (HLR) contains all the administrative information of each subscriber registered in the corresponding GSMnetwork, along with the current loca-tion of the subscriber. The location assists in routing incom-ing calls to the mobile, and is typically the SS7 address of the visited MSC there is logically one HLR per GSM network, although it may be implemented as a distributed database.

The Visitor Location Register contains selected ad-ministrative information from the HLR, necessary for call control and provision of the subscribed services, for each mo-bile currently located in the geographical area controlled by the VLR although the VLR can be implemented as an in-dependent unit, to date all manufacturers of switching equip-ment implement the VLR together with the MSC, so that the geographical area controlled by the MSC corresponds to that controlled by the VLR. The proximity of the VLR information to the MSCspeeds up access to information that the MSC requires during a call.

The other two registers are used for authentication and security purposes. The Equipment Identity Register (EIR) is a database that contains a list of all valid mobile equipment on the network, where each mobile equipment is identified by its International Mobile Equipment Identity (IMEI). An IMEI is marked as invalid if it has been reported stolen or is not type approved.

The Authentication Center (AuC) is a protected database that stores a copy of the secret key stored in each subscriber's SIM card, used for authentication and ciphering on the radio channel.

2.9 UMTS-Universal Mobile Telecommunication System

2.9.1 Network Development

The development of UMTS has got two aspects, the radio access network and the core network. The radio access network comprises the mobile station (handy), the base station (transceiver, antenna, and controller) and the radio interface between them. The core network consists of nodes (switches) with connecting lines. This core network does not only connect the base stations with each other but offers also gateways to other networks (ISDN, Internet.

The core network of UMTS is an evolution of the present GSM-core network. The radio access network of UMTS, especially the method of radio transmission (radio interface), is revolutionary new. The UMTS radio access network URAN will not be an evolution of the GSM radio access network. However, the GSM radio access network will be in use and also under development even after the introduction of UMTS. This means that there will be a common core network but two independent radio access networks for UMTS and for GSM. The UMTS radio access network will allow for multimedia applications because of the larger bandwith of the radio channels (5 MHz instead of 200 kHz in GSM) and the new access method CDMA (Code division multiple access). Multimedia in UMTS means that the simultaneous transfer of speech, data, text, pictures, audio and video with a maximum data rate of 2 Mbit/s will be possible. Transmission of speech and low data rate applications will go on to be carried out by GSM (lower price); at least during the first years after the introduction of UMTS around 2002.

2.9.2 Hierarchical Cell Structure

UMTS will offer global radio coverage and world-wide roaming. For that purpose the URAN will be built in a hierarchical way in layers of varying coverage. A higher layer will cover a larger geographical area than a lower layer.

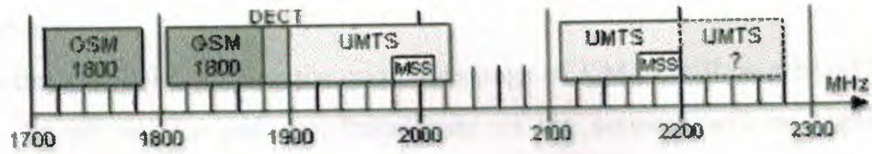
In the highest layer there will be satellites covering the whole planet, the lower layers form the UMTS terrestrial radio access network UTRAN. They are divided into macro-, micro- and Pico layer. Each layer is divided into cells. The lower the hierarchical level, the smaller the cells. Smaller cells allow for a higher user-density. Therefore macro cells are used for land-wide coverage; additional micro cells are installed in areas with higher population density and Pico cells in buildings and for so called "hot spots" (e.g. airports, railway stations).

2.9.3 Data Rate

The maximum data rate and the maximum speed of the user are different in each hierarchical layer. In the macrolayer at least 144 kbit/s with maximum speed of 500 km/h shall be possible. In the microlayer 384 kbit/s with maximum speed of 120 km/h shall be supported. The picolayer offers up to 2 Mbit/s with a maximum speed of 10 km/h. It shall be possible for the user to trade off bit error rate versus delay in certain limits. For real-time applications with constant delay (speech, video) the bit error rate can be in the range of 10^{-3} to 10^{-7}, the maximum delay can be in the range of 20 ms to 300 ms. For non-realtime applications (e-mail, SMS) with variable delay the bit error rate can be in the range of 10^{-5} and 10^{-8}. The maximum delay can be 150 ms and more.

2.9.4 Spectrum

The spectrum for UMTS lies between 1900 MHz to 2025 MHz and 2110 MHz to 2200 MHz. For the satellite service an own sub band in the UMTS spectrum is reserved (uplink 1980 MHz to 2010 MHz, downlink 2170 MHz to 2200 MHz). The remaining spectrum for terrestrial use is divided between two modes of operation. In the FDD (Frequency Division Duplex) mode there are two equal bands for the uplink (1920 MHz to 1980 MHz) and for the downlink (2110 MHz to 2170 MHz). In the operation mode TDD (Time division duplex) uplink and downlink are not divided by use of different frequency carriers but by using different timeslots on the same carrier. So there is no need for a symmetrical spectrum but the remaining unpaired spectrum can be used.



Spectrum for UMTS -	1920 MHz - 1980 MHz	FDD Uplink
	2110 MHz - 2170 MHz	FDD Downlink
	1900 MHz - 1920 MHz *2010 MHz - 2025 MHz*	*TDD*
	1980 MHz - 2010 MHz	MSS (Mobile Satellite Service) Uplink
	2170 MHz - 2200 MHz	MSS Downlink

Figure 2.6 Spectrums for UMTS

2.9.5 Operation modes

The operation in FDD mode is assigned for macro- and micro cells, the operation in TDD mode is assigned for Pico cells. The TDD mode does not allow large propagation delays between mobile station and base station as this would cause a collision between transmit- and receive timeslots. Therefore this mode can only be used in environments where the propagation delay is small (Pico cells). Yet the TDD mode has the advantage that a large asymmetry of data transfer between uplink and downlink is possible. Many internet applications are characterized by large asymmetry of data transfer as more data is received (downlink) than transmitted (uplink). The FDD mode uses a different multiple access method (W-CDMA) than the TDD mode (TD-CDMA Time Division CDMA). This decision has not only technology reasons but it is a political compromise between different groups in ETSI (European Telecommunication Standards Institute).

2.9.6 Protocols

UMTS is supposed to support real-time services including multimedia as well as packet data services. A candidate for the transport mode in the core network is ATM (Asynchronous Transfer Mode) for it has the flexibility needed to carry these various services. Many people believe that ATM will be selected as transport mechanism for UMTS in the core network. The Internet Protocol will be used for the routing of packet data in the core network. It is for further discussion to what extent the IP and ATM will also be used in the radio access network.

2.9.7 Services

From the user point of view the main advantage of UMTS will be a broad offer of services. Speed, variety and user-friendliness of the services will be significantly improved as compared with GSM. For example the download of a foto from the internet that takes one minute in GSM with 9.6 kbit/s will last only half a second in UMTS with 2 Mbit/s. In order to increase the variety of services and the competition between operators ETSI defines only a framework for the services. Only so-called bearer services will be standardized specifying bit rate, bit error rate and delay time. The actual application (incl. man-machine interface) from the user's point of view is called teleservice. A teleservice can make use of several bearer services. Teleservices can be created independently by each service provider or network operator and offered in the network to the customers. Exception: Four UMTS teleservices will be standardized completely by ETSI; these are speech, fax, SMS and emergency call. In the following some examples of UMTS (tele-) services are given:

Entertainment

- audio on demand
- games
- video clips
- virtual sightseeing

Community services

- emergency call
- administration services
- democratic procedures

Information services

- www-browsing
- interactive shopping
- on-line newspaper
- on-line translation
- location based broadcasting services
- intelligent search- and filtering facilities

Education

- virtual schools
- on-line science lab
- on-line library
- on-line language labs
- training

Business services

- mobile office
- narrowcast business TV

Communication services

- video telephony
- video conference

2.9.8 Terminal and USIM Card

The user service identity module USIM stores the identity of the subscriber (user), operator and service provider and (at least one) user service profile. This service profile defines the services that a customer is subscribed to, the time and the network where he can use them. The USIM-card is a modular IC-card (integrated circuit card). It contains one or more USIMs and possibly other applications (e.g. credit card functionality). By inserting the USIM-card into a UMTS terminal the user is recognized by the UMTS network and can be addressed on this terminal either via his personal telephone number or his personal email address.

In contrast to GSM there will be a multitude of different types of terminals in UMTS, e.g. multi-mode or multi-band handies, notebook-like communicators or UMTS-laptops with camera, speakers and microphone all equipped with a USIM-card. There will be terminals too where more than one USIM-card can be inserted. This means that some terminals (e.g. fax terminals) shall be used by several UMTS-customers simultaneously.

2.9.9 Convergence

UMTS stands also for the convergence of mobile and fixed line communication networks. If the user is close to a fixed line network termination he will be registered automatically in the fixed line network and will communicate via fixed line (with fixed line tariff). His UMTS-handy works then as a cordless terminal. If he leaves the coverage of the fixed line network termination he will be registered automatically in the mobile (cellular) network and will communicate via UTRAN (UMTS Terrestrial Radio Access Network). His telephone number is always the same (UPT Universal Personal Telecommunication). The term "convergence" is often used in another meaning too. During the next decades computing, telecommunication, broadcast and television will merge together. UMTS is the mobile part of this scenario and a milestone towards its realization.

ETSI develops the HIPERLAN [11] standard for data rates above 2 Mbit/s. It will offer up to five channels with 25 Mbit/s each for a connectionless traffic and a wireless extension to modern computer networks. Compared to Ethernet LANs HIPERLAN has the higher bandwith, improved flexibility, less installation costs and a protocol specially designed to meet with the requirements of mobile radio channels and portable computers? We are investigating the quality of service parameters these systems will offer and how we can adapt and expand it to different environments.

3. THIRD GENERATION MOBILE COMMUNICATION SYSTEM

3.1 Introduction

The phenomenal growth in the mobile communications industry has been one of the success stories of the last decade. Growth rates of up to 165% per annum in developing countries and almost 5 million new mobile users per month have meant that the global market for mobile communications is forecast to grow from today's figure of 200 million to around 2.4 billion users by 2015. Wireless access will overtake fixed access to global telecommunication early in the 21st century. Figure 3.1 demonstrates the expected growth into the next century.

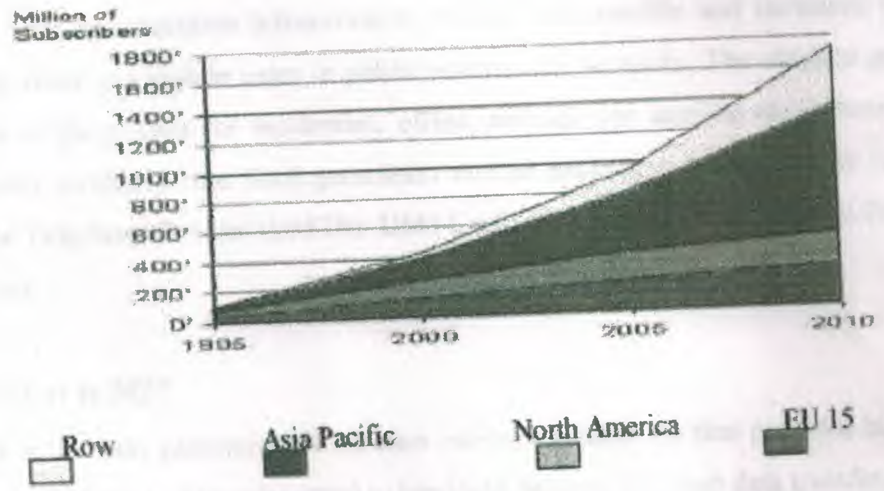


Figure 3.1 World Mobile Subscribers (Reproduced from UMTS- The next generation of Mobile radio[12].

It is clear that mobile communications is set to play an integral part in future society. Furthermore, with the trend towards globalization of the world's economy it is desirable that communications should be able to take place globally providing 'communications anywhere-anytime.' This is not possible with today's mobile industry. The communications scene of today is an international bazaar, with a wide variety of equipment on offer to provide for difference types of networks. These include first generation analogue cellular, second generation digital cellular, analogue and digital cordless, satellite networks for land, sea and air mobiles, as well as fixed networks. Despite the fact that some of the more recent systems work on similar principles most of them are incompatible with each other. Another drawback of existing mobile systems is that they are not capable of supporting the high bandwidth applications, which characterize the kind of systems users, will demand as we move into the next century. Today's cellular phones generally operate at a maximum speed of just 9600 bits/sec which is too slow to support applications like high quality audio and video, real time video conferencing or high-speed Internet connection. It is clear that a new generation of wireless services are required which can address the above problems. This new generation of wireless services is described as third generation mobile systems (TGMS), also referred to as 30 systems. The International Telecommunications Union (ITU) started work a decade ago to create a 'framework' for new systems in which true global coverage could be achieved this scheme is now known as the International Mobile Telecommunications 2000 (LMT-2000), Its purpose is to provide wireless access to the global telecommunication infrastructure through both satellite and terrestrial systems, serving fixed and mobile users in public and private networks. The ultimate goal is to have a single system for residential, office, cellular and satellite environments. The European version of the third generation mobile systems is known as the Universal Mobile Telephone System (UMTS). UMTS will play a core role within the IMT-2000 structure

3.2 What is 3G?

3G is the next generation of wireless network technology that provides high speed bandwidth (high data transfer rates) to handheld devices. The high data transfer rates will allow 3G networks to offer multimedia services combining voice and data. Specifically, 3G wireless networks support the following maximum data transfer rates:

- 2.05 Mbits/second to stationary devices.
- 384 Kbits/second for slowly moving devices, such as a handset carried by a walking user.
- 128 Kbits/second for fast moving devices, such as handsets in moving vehicles

These data rates are the absolute maximum numbers. For example, in the stationary case, the 2.05 Mb/second rate is for one user hogging the entire capacity of the base station. This data rate will be far lower if there is voice traffic (the actual data rate would depend upon the number of calls in progress).

The maximum data rate of 128Kbits/second for moving devices is about ten times faster than that available with the current 2G wireless networks. Unlike 3G networks, 2G networks were designed to carry voice but not data and 3G wireless networks have the bandwidth to provide converged voice and data services. 3G services will seamlessly combine superior voice quality telephony, high-speed mobile IP services, information technology, rich media, and offer diverse content.

3.3 3G Wireless

3G systems will provide access, by means of one or more radio links, to a wide range of telecommunication services supported by the fixed telecommunication networks and to other services that are specific to mobile users. A range of mobile terminal types will be encompassed, linking to terrestrial and/or satellite-based networks, and the terminals may be designed for mobile or fixed use. Key features of 3G systems are a high degree of commonality of design worldwide, compatibility of services, use of small pocket terminals with worldwide roaming capability, Internet and other multimedia applications, and a wide range of services and terminals. According to the International Telecommunication Union (JTU) International Mobile Telecommunications 2000 initiative (IMT-2000) third generation mobile (3G) system services are scheduled to be initiated around the year 2000, subject to market considerations. The following Table describes some of the key service attributes and capabilities expected of 3G systems.

Capability to support circuit and packet data at high bit rates ▪ 144 kilobits/second or higher in high mobility (vehicular) traffic ▪ 384 kilobits/second for pedestrian traffic ▪ 2 Megabits/second or higher for indoor traffic
Interoperability and roaming
Common billing/user profiles • Sharing of usage/rate information between service providers Standardized user profiles • Standardized call detail recording • Standardized user profiles

Table 3.1 System Capabilities

On October 13, 2000, it was selected radio frequency spectrum to satisfy the United States' future needs for mobile voice, high-speed data, and Internet-accessible wireless capability, and must be selecting spectrum that could be made available for 3G wireless systems, and strongly encouraged to follow the same principles in any actions they take related to the development of 3G systems.

And make Commerce to work cooperatively with the FCC to develop a plan to select spectrum for third generation wireless systems by October 20, 2000; and to issue by November 15, 2000 an interim report on the current spectrum uses and potential for reallocation or sharing of the bands identified at the 2000 World Radio communication Conference that could be used for 3G systems. These actions were taken to enable the Commission to identify spectrum for 3G systems by July 2001 and auction licenses by September 30, 2002.

In ccordance to the Department of Commerce released a "Plan to Select Spectrum for Third Generation (3G) Wireless Systems in the United States" (Study Plan) on October 20, 2000. The Study Plan noted that although various frequency bands have been identified for possible 3G use, the Commission and the National Telecommunications and Information Administration (NTIA) needed to undertake studies of the 2500-2690 MHz and the 1755-1850 MHz frequency bands in order to provide a full understanding of all the spectrum options available. The Study Plan called for the Commission to complete an Interim Report on the 2500-2690 MHz band and for NTIA to complete an Interim Report on the 1755-1850 MHz band by November 15, 2000, and In March 2001, the Commission issued a Final Report on the 2500-2690 MHZ band and NTIA issued a Final Report on the 1755-1850 MHz band.

The NTIA Final Report also addressed the 1710-1755 MHz., In September 2001, the Commission added a mobile allocation to the 2500-2690 MHz band to provide additional near-term and long-term flexibility for use of this spectrum, there by making this band potentially available for advanced mobile and fixed terrestrial wireless services, including 3G and future generations of wireless systems. However, because the 2500-2690 MHz band is extensively used by incumbent Instructional Television Fixed Service and Multi channel Multi point Distribution Services licensees, and in order to preserve the viability of the incumbent services, the Commission did not relocate the existing licensees or otherwise modify their licenses.

3.4 3G Wireless Applications

Third generation wireless applications are software programs that require wireless communication technology that can take advantage of the mobility and high bit-rate data transmission offered by 3rd generation wireless systems. Many of the communications applications and services that were available for mobile communications in the 1990's were limited by low bit-rate (less than 10 kbps) data transmission. With 2nd generation mobile systems, it was not possible to offer streaming video, rapid image file transfer or high bit-rate data file transfer services.

The worldwide wireless communications market has grown from 190 million subscribers in 1996 to over 680 million by the end of the year 2000. The wireless market is expected to exceed one billion in 2003, approximately one phone for every seven people on earth! To sustain this high growth market trend and to persuade customers to upgrade to 3rd generation products and services, there must be new attractive and imaginative applications.

Third generation systems provide for two key advancements in mobile communication technology that allow for new advanced applications: packet data transmission and high bit-rate data services. Packet data transmission allows the wireless systems to transfer information only as the customer requires information transfer. This is compared to 2nd generation data transmission services that use a dedicated portion of a radio channel regardless of actual usage on the radio channel (amount of data transmission activity). Although the peak data transfer rate when a customer is browsing the web may be high, the average data transfer rate of the customer is low. Packet transmission allows a wireless service provider to cost-effectively provide service to many wireless data devices or customers. 3rd generation systems also allow high bit-rate data transmission (up to 2 Mb/s) that permits new services and applications such as video and high quality audio broadcast services. These services could not be provided on 1st or 2nd generation systems.

There are hundreds of key applications that require high-bit rate data transfer services that can be provided via 3rd generation wireless service. These include distance learning, high graphic online commerce, video and audio entertainment, interactive advertising, news and other information services, advanced manufacturing processes, media production, remote security, public safety, tele-medicine, utility management, and alternative (bypass) communication systems. If these applications become readily

There are hundreds of key applications that require high-bit rate data transfer services that can be provided via 3rd generation wireless service. These include distance learning, high graphic online commerce, video and audio entertainment, interactive advertising, news and other information services, advanced manufacturing processes, media production, remote security, public safety, tele-medicine, utility management, and alternative (bypass) communication systems. If these applications become readily available and the cost of providing these services is low, the demand for 3rd generation products and services will be high.

Customers do not care or need to know how the underlying 3G communication technologies function. They just care that technology works for whatever application they want to use, and the benefit of using the application is perceived to be higher than the cost to use its service.

Much of the demand for wireless data access has come from the combination of availability of Internet information applications and low cost mobile communication. The Internet's standardized global collection of interconnected computer networks has allowed for access to information sources that provide significant benefits to those companies and individuals looking for knowledge. The Internet has created an awareness (culture change) of many new information services, and these new information services themselves.

3.5 The Features of 3G Systems

The boom which made 3G popular to use is based on the following features:

a)Flexibility: 3G mobile systems should be able to incorporate a variety of systems, both terrestrial and satellite based, to give true global 'seamless' access (see figure 3.2).The provision of a small pocket worldwide terminal is also an important aim within the IMT-2000 and UMTS structure.

b) High speed data: 3G mobile systems will support a variety of high-speed broadband services including audio, video, multimedia, internet, data and speech services in a variety of environments. To achieve these 3G systems will have to provide adequate performance for each user in each of the operating environments, shown in Figure 3.2

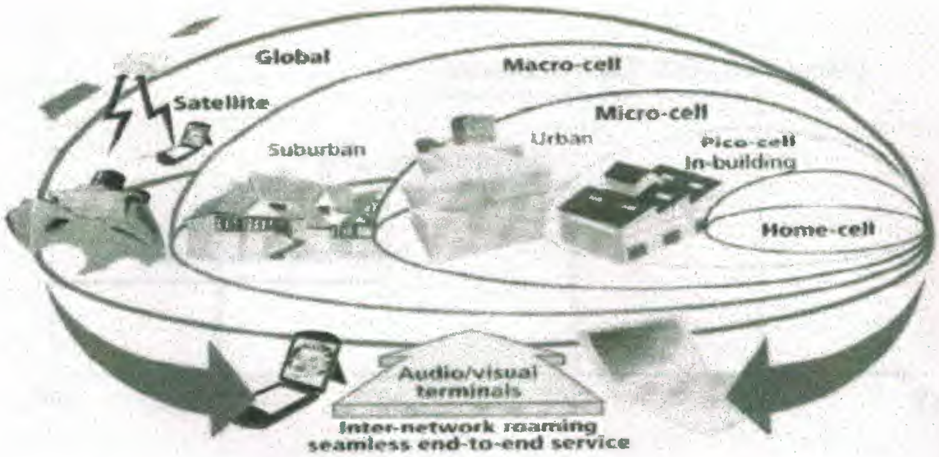


Figure 3.2 Illustration demonstrating how future mobile systems will provide a Worldwide seamless end-to-end service for the consumer, UMTS proposes new technologies to improve Wireless Communications [13].

Future mobile systems architecture will be divided into a set of different coverage regions. Some of these regions will be privately operated, while others may be publicly operated. Pico cells will typically cover building areas, with micro-cells covering dense urban areas. Within the UMTS model, rates of up to 2 Mbit/s are expected in these environments. Macro cells will provide wide-area coverage giving data rates of around 384 kbit/s. Finally, satellite segments will give terminal data rates starting from 144 kbits/s.

c) Compatibility: 3G services have to be compatible with existing networks. The enormous investments made in developing the world's 2nd generation cellular networks over the last decade means there has to be a transitional phase for the implementation of 3G generation systems. Figure 3.3 demonstrates the expected transitional periods required for the switchover to 3G systems.

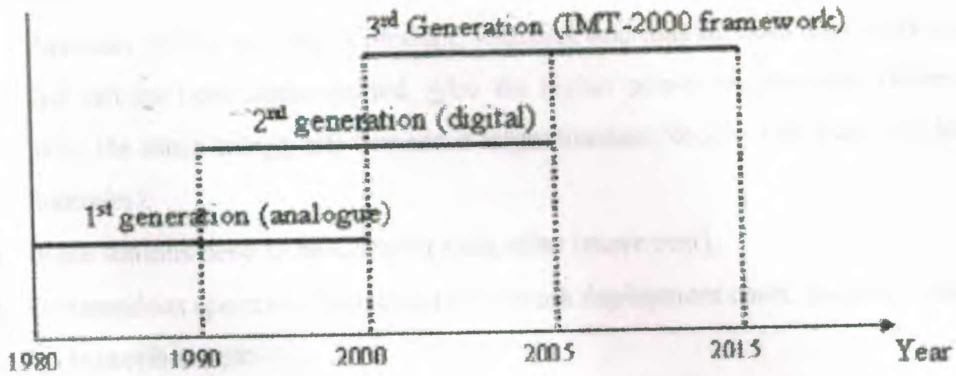


Figure 3.3 Transitional Periods Required for Different Generations of Mobile Systems

d) Affordable: For commercial success 3G systems will have to be as affordable as today's mobile systems [14].

e) Spectrum Efficiency: Efficient use of the radio spectrum consistent with providing service at an acceptable cost will have to be accomplished. IMT-2000 based systems have been assigned the frequency bands 1885 2025 MHz and 2110-2200 MHz.

f) The different broadband service: aspects and service environments for IMT-2000 systems calls for new network architecture. The IMT-2000 based systems will be based upon common standardized flexible platforms to meet the demands of fixed and mobile markets around the world.

3.6 What are the Advantages and Disadvantages of 3G?

3.6.1 3G Networks Offer Users Advantages Such as:

- New radio spectrum to relieve overcrowding in existing systems.
- More bandwidth, security, and reliability.
- Interoperability between service providers.
- Fixed and variable data rates.
- Asymmetric data rates.
- Backward compatibility of devices with existing networks.
- Always-online devices. 3G will use IP connectivity, IP is packet based

3.6.2 3G Users Some Disadvantages Such as:

- The cost of upgrading base stations and cellular infrastructure to 3G is very high.

- Requires different handsets and there is the issue of handset availability. 3G handsets will be a complex product. Roaming and making both data/voice works has not yet been demonstrated. Also the higher power requirements (more bits with the same energy/bit) demand a larger handset, shorter talk time, and larger batteries).
- Base stations need to be closer to each other (more cost).
- Tremendous spectrum-license costs, network deployment costs, handset subsidies to subscribers, etc.
- Wireless service providers in Germany and Britain who won spectrum licenses in auctions, paid astronomical prices for them. As a result, they have little money left for building the infrastructure. Consequently, deployment of 3G in Germany and Britain will be delayed.

3.7 3G Personal Wireless Communications Devices (PCD-3G)

Third Generation (3G) Personal Communications Devices (PCD-3G) are small pocket sized mobile terminals that combine broadband wireless communications technology with a graphic user interface (GUI) and operating system (OS). These devices provide standard voice band communications, and support graphics applications such as web browser, email, address book, and personal organizer. As technology evolves teleconferencing, telegram- ming, web browsing with real-time audio and video streaming will also be supported.

3.8 3G Architecture

The 3G network will have a layered architecture, which will enable the efficient delivery of voice and data services. Layered network architecture, coupled with standardized open interfaces, will make it possible for the network operators to introduce and roll out new services quickly. These networks will have a connectivity layer at the bottom providing support for high quality voice and data delivery. Using IP or ATM or a combination of both, this layer will handle all data and voice info. The layer consists of the core network equipment like routers, ATM switches and transmission equipment. Other equipment provides support for the core bit stream of voice or data, providing QOS etc. Note that in 3G networks, voice and data will not be treated separately which could lead to a reduction in operational costs of handling data separately from voice. The application layer on top will provide open application service interfaces enabling flexible service creation. This user application layer will contain services for which the end user will be willing to pay. These services will include eCommerce, GPS and other differentiating services. In between the application layer and the connectivity layer, will run the control layer with MSC servers, support servers, HLR etc. These servers are needed to provide any service to a subscriber.

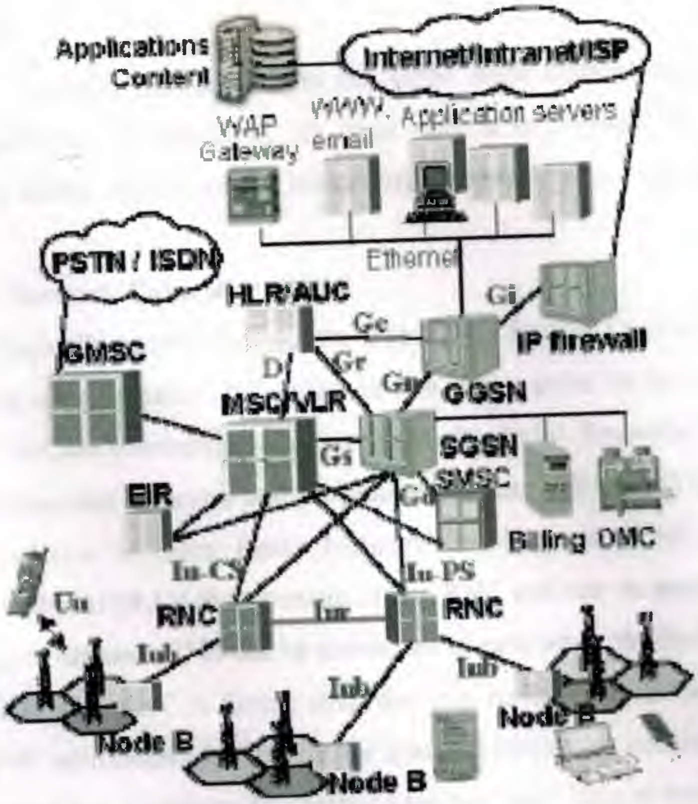
3.9 UMTS Architecture

3.9.1 UMTS (Universal Mobile Telecommunication System)

UMTS is the European member of theIMT2000 family of third generation cellular mobile standards. The goal of UMTS is to enable networks that offer true global roaming and to support awide range of voice, data and multimedia services. Data rates offered by UMTS are; vehicular - 144 kbit/s; pedestrian 384 kbit/s;in-building 2Mb/s.The new UMTS networks will build on the success of GSM, and on the GSM operators' existing investment in infrastructure. The first stage of service and network evolution is from today's GSM systems, through the implementation of GPRS, to commercial UMTS networks. The UMTS core network can continue to use the current 2G network structure to process voice and packet data. The major introduction of UMTS are a new air interface operating at around 2GHz,and a packet-based network architecture which supports both voice and data services.

3.9.1.1 UMTS Network Architecture

A UMTS network consists of three interacting domains (see Figure 3.4): User Equipment (UE), UMTS Terrestrial Radio Access Network (UTRAN) [15], and Core Network (CN). The UE is a Mobile that communicates with UTRAN via the air-interface. UTRAN provides the air interface access method for the UE. CN provides switching, routing, and transit for user traffic. It also stores data bases and provides network management functions from the specification and standardization point of view, both UE and UTRAN consist of completely new protocols, the design of which is based on the needs of the new W-CDMA radio technology. On the contrary, the definition of CN is adopted from GSM network. This gives the system with new radio technology a global base of known and rugged CN technology that accelerates and facilitates its introduction, and enables such competitive advantages as global roaming.



.**Figure 3.4** UMTS Architecture

3.9.1.2 User Equipment (UE)

A UE consists of two parts:

- The Mobile Equipment (ME) is a radio terminal used for communicating over the Uuinterface (air-interface).
- The UMTS Subscriber Identity Module (USIM) is a smartcard that stores subscribers' identity and encryption keys, performs.

3.9.1.3 UMTS Terrestrial Radio Access Network (UTRAN)

A UTRAN consists of two distinct elements: Node B and Radio Network Controller (RNC). The main functions of the UTRAN[15] architecture are to Support soft handoff and W-CDMA Specific radio resource management._ Share and reuse of voice and packet data interfaces (ie. Iu-CS and Iu-PS). Share and reuse of GSM infrastructure._ Use ATM as the main transport Mechanism within UTRAN.

3.9.1.4 Node B

A Node B (logically corresponds to the GSM Base Station) converts data flow between the Iub and Uu interfaces. Its main duty is to perform the physical layer processing, e.g. modu- lation, coding, interleaving, rate adaptation, spreading, etc.

3.9.1.5 Radio Network Controller (RNC)

An RNC (logically corresponds to the GSM Base Station Controller) controls the radio resources in its domain. RNC is the service access point for all services UTRAN providing to the Core Network. It also terminates the Radio Resource Control Protocol (RRC) that defines the messages and procedures between UE and UTRAN. A UTRAN may consist of one or more Radio Network Sub-Systems (RNS). An RNS is a sub-network within UTRAN that consists of one RNC and one or more Node B. RNCs which belongs to different RNS can be connected to each other via the Iur interface. The logical function of an RNC is further divi- ded into controlling, serving, and drift. The controlling RNC administers the Node B for load and congestion control. It also executes admission control and channel code allocation for new radio links to be established by the Node B.

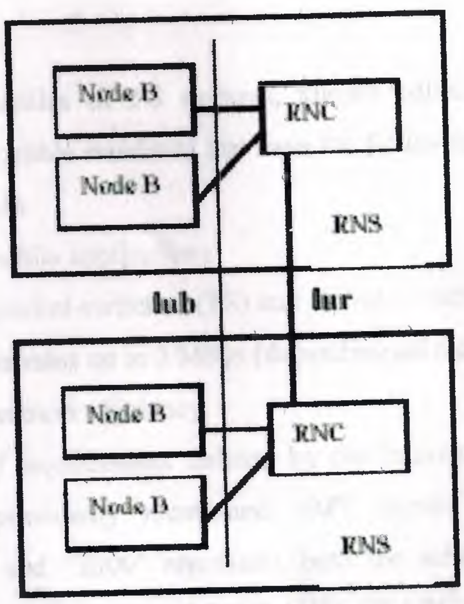


Figure 3.5 UTRAN Architecture

The serving RNC is the RNC that terminates both the Iu and Iub links from the core network and user equipment respectively. It performs L2 (MAC layer) processing of data to/from the radio interface. Mobility management functions such as power control, handoff decision, etc are also handled by the serving RNC. Note that one UE connected to the UTRAN has one and only one SRNC. The drift RNC compliments the serving RNC by providing diversity when the UE is in the state of inter-RNC soft handoff (which requires two RNCs). During the handoff, the drift RNC does not perform L2 processing; rather it routes data transparently between the Iub and Iur interfaces.

3.9.1.6 Core Network (CN)

UMTS CN is divided into circuit switched and packet switched domains. ATM is the transport mechanism to be used in the UMTS core. In particular, ATM AAL 2 handles circuit and packet switched signal ling while AAL 5 is designed for data delivery. The core network consists of the following elements inherited from the incumbent GSM network.

3.9.1.7 Home Location Register (HLR)

An HLR is a database located in the user's home system that stores the user's service profile. A service profile is created when a new user subscribes to the system, and remained as long as the subscription is active. It consists of information such as user service type and roaming permission etc.

3.9.2 IMT—2000

The main characteristics of 3G systems, known collectively as IMT—2000 are a~ingle family of compatible standards that have the following characteristics:

- Used worldwide
- Used for all mobile applications
- Support both packet-switched (PS) and circuit-switched (CS) data transmission
- Offer high data rates up to 2 Mbps (depending on mobility/velocity)
- Offer high spectrum efficiency

IMT-2000 is a set of requirements defined by the International Telecommunications Union (ITU). As previously mentioned, IMT stands for International Mobile Telecommunications and "2000" represents both the scheduled year for initial trial systems and the frequency range of 2000 MHz (WARC'92: 1885—2025 MHz and 2110—2200 MHz). All 3G standards have been developed by regional standards developing organizations (SDOs). In total, proposals for 17 different IIMT—2000 standards were submitted by regional SDOs to ITU in 1998—11 proposals for terrestrial systems and 6 for mobile satellite systems (MSSs). Evaluation of the proposals was completed at the end of 1998, and negotiations to build a consensus among differing views were completed in mid 1999. All 17 proposals have been accepted by ITU as IMT—2000 standards. The specification for the Radio Transmission Technology (RTT) was released at the end of 1999.

The most important IMT—2000 proposals are the UMTS (W-CDMA) as the successor to GSM, CDMA2000 as the interim standard '95 (15—95) successor, and time division—synchronous CDMA (TD—SCDMA) (universal wireless communication—i 36 [UWC-i36]/EDGE) as TDMA-based enhancements to D-AMPS/GSM—all of which are leading previous standards toward the ultimate goal of IMT—2000.

UMTS allows many more applications to be introduced to a worldwide base of users and provides a vital link between today's multiple GSM systems and JMT—2000. The new network also addresses the growing demand of mobile and Internet applications for new capacity in the overcrowded mobile communications sky. UMTS increases transmission speed to 2 Mbps per mobile user and establishes a global roaming standard.

UMTS is being developed by Third-Generation Partnership Project (3GPP), a joint venture of several SDOs—ETSI (Europe), Association of Radio Industries and Business/Telecommunication Technology Committee (ARIB/TTC) (Japan), American National Standards Institute (ANSI) T-1 (USA), telecommunications technology association (TTA) (South Korea), and Chinese Wireless Telecommunication Standard (CWTS) (China). To reach global acceptance, 3GPP is introducing UMTS in phases and annual releases. The first release (UMTS Rel. '99), introduced in December of 1999, and defines enhancements and transitions for existing GSM networks. For the second phase (UMTS Rel. '00), similar transitions are being proposed as enhancements for IS—95 (with CDMA2000) and TDMA (with TD-CDMA and ED).

3.9.3 Code Division Multiple Access

CDMA2000 is another wireless standard designed to support 3G services as defined by the ITU and its IMT-2000 vision. It is evolved from the North American IS-95 cdma standard. CDMA2000 system uses 2.1GHz band and it maintains backward compatibility by allowing current frequency bands of 800, 1800 and 1900 MHz to operate seamlessly.

3.10 Satellite System

Satellite systems will form a small yet useful part of third generation systems. They are the only means of providing true global communications over large regions. It is estimated that 11.5 million users of Mobile Satellite Services (MSS) will exist by 2005. Demonstrates the main components of a Mobile Satellite Service.

The mobile satellite system consists of a ground segment and a space segment. The space segment consists of the satellites and the control ground stations, used for monitoring and controlling satellites. The ground segment consists of several types of mobile terminals connected to the fixed telecommunication networks via the satellite and one or more large gateway earth stations. Users communicate with other mobiles or with fixed users via one of the visible satellites. Users in the fixed network are accessed through large fixed stations called 'gateways' which carry large amounts of traffic. Gateways are connected to the public switched network via a standard interface.

1st and 2nd generation mobile satellite systems offered services to relatively large mobile terminals. The 3rd generation geostationary satellite systems, sometimes called 'super-geo systems' to distinguish them from the 2nd generation geostationary systems, are expected to offer voice or multimedia services to hand-held or desktop size terminals.

3.10.1 Orbits for Mobile Satellite Services

Satellite providing MSS are either in a geostationary orbit or a non-geostationary orbit. The key feature of a geostationary satellite is that it remains almost fixed with respect to the earth and comprises of one or more 'static' footprints. Therefore terminals on the planet can operate with a single antenna using minimal tracking. Also, the coverage offered by one satellite in such an orbit is adequate for most populated areas (+ 76° latitude).

The main disadvantages of a geostationary orbit is that propagation delays are quite significant (~250 ms from transmitter to receiver), due to the satellite range. Also, it is unable to provide adequate coverage to locations beyond 76° latitude.

Other types of orbits used for MSS are Low Earth Orbit (LEO) and Medium Earth Orbit (MEO). Satellites in such orbits can provide true global coverage. Since the satellite is closer to the Earth, the power and antennae of a satellite phone can be reduced to a size similar to that of a cellular hand-phone. MEOs and LEOs have the added advantage that they offer higher-frequency reuse than their geostationary counterparts. This is because they illuminate a smaller segment of the Earth, allowing frequencies to be reused within they illuminate a smaller segment of the Earth, allowing frequencies to be reused within shorter distances. Additionally, any propagation delays of signals will be considerably reduced relative to that experienced by geostationary satellites. This makes the provision of interactive services easier to provide.

The disadvantage of medium and low earth orbits is that a large number of satellites are necessary Furthermore; the architecture of non-geostationary satellite systems is more complicated due to the movement of satellite beams relative to a user. This is because satellite visibility may vary from 10-30 minutes. Therefore a call may have to be routed through more than one beam and satellite, if the beam or satellite via which the link is established moves away during the call. This process is called a 'hand-over.' Another recent consideration is that the large number of satellites required for such systems are likely to cause an increase in orbital debris.

3.11 Impulse Transmission

Impulse transmission is entirely different. Instead of transmitting a carrier it relies on the transmission of single waves called monocycles by having very short monocycles a system can transmit multiple megabits of information

The main disadvantage of using impulse transmission lies in the exceptional timing required in generating and detecting intervals. The accuracy required is to within a 10-picosecond interval.

The main advantages of impulse transmission are that it offers higher data rates but also, unlike normal radio, it does not require large quantities of power to have good signal to noise ratio. A normal radio receiver assumes that information is transferred all the time so the signal must be stronger then noise. With impulse transmission no information is transmitted for the majority of time. During the time when no information is transmitted the noise content of the channel is irrelevant. The receiver must only deal with noise when it expects the monocycle. Noise energy is reduced as monocycles get shorter. By allowing multiple monocycles to contain a single bit of information, the receiver can also build up a statistical analysis increasing the effective signal gain. Because the receiver/timing window is small, multi-path distortion is eliminated as the delayed copy of the signal arrives outside of the window, making it ideal in urban areas.

Impulse transmission also requires less power then ordinary transmitters making it very attractive to mobile communication systems. The other implication for impulse transmission is that a large number of stations can co-exist in the same physical area without interfering. This makes impulse transmission suitable for high density, high bandwidth applications, such as future mobile systems.

3.12 Software Radio

Software radio is a revolutionary concept. Instead of building separate hardware for different systems, a single general-purpose platform is used to perform these different functions by simply running a different program. In other words, a software radio is a wireless communications device in which some or all of the physical layer functions are implemented in software.

The flexibility provided by the software implementation enables a single device to inter-operate with other devices using different wireless physical technology, by simply invoking the appropriate software [16]. This would not only enable seamless anytime, anywhere connectivity, but also provide users the flexibility of choosing from the available connectivity options to best suit their price/performance requirements.

For example, our generic receiver can inter-operate with multiple different cellular systems by running different programs. In other words, software radios would enable travelers to overcome the difficulties in going through areas that use different standards. As you go into an area that uses a different cellular telephone the infrastructure could notify your phone about the local requirements, and the phone would automatically reconfigure for use in that area. This allows different regions to adopt the standards that best suit their For the manufacturing of software radio, Field Programmable Gate Arrays[17] (FPGA) are used. The approach taken is to create a run-time re-configurable Computing Platform that uses an FPGA device as the core computing element to create customized data paths and operations at run-time. This results in high computational rates for relatively low power consumption.

3.12.1 Development Challenges and Conceptual Scheme of Software Radio

Technological challenges are the main barrier of software radio. The design of software radio demands a small size, light-weight device with batteries that can last for weeks on a single charge. In the near future, there is no doubt that software radios can freely mix analogue and digital technology to achieve optimum performance, cost and reliability [18]. The 'future proof' structure of software radio structure would enable consumers to upgrade their phones with new applications - much like purchasing new programs for their computers.

Software radio is closely tied to the third-generation mobile communication system, which may provide the necessary foundation for the rapid emergence of software radio products and systems of the future.

3.13 Health and Safety

The mobile phone is becoming an essential part of the way people live and work. However the largest study of mobile phone users to date conducted by Swedish researchers, found significant health problems in those using mobile phones for more than one hour a day.

The study found that symptoms of headaches, dizziness, fatigue, loss of concentration, memory problems and even heat sensation were found in those using GSM (digital) phones. The electromagnetic energy that fuels a cell-phone is microwave radiation pulsing from the antenna. Human brains may absorb up to 60 percent of that energy, and although some researchers say those levels are far from hazardous, they are near the top end of international safety recommendations [19].

International bodies such as the National Radiological Protection Board (NRPB) set the standards. Recommended radiation limits are measured in 'specific absorption rates' - the amount of radiation absorbed averaged over one gram of tissue. The NRPB, which says the vast majority of studies have shown radiation levels from cell-phones are too low to harm humans, recommends a limit of 10 milliwatts per gram. Proposed European guidelines are five times more stringent.

Despite research around the world, it is still unproven that cellular phones pose a human health risk. 'We can't categorically prove they will not harm you but that is not the same as saying they will harm you,' a spokesman for Vodafone, Britain's biggest mobile phone company said.

The study compared radiation absorbed from 16 different cellular phones to a Global-Handy phone, designed with an antenna inside the handset. It claimed the Global-Handy phone deflected 35% of radiation away from the head.

3.13.1 Precautions

Despite the industry denials of any risk, public concern has prompted manufactures to develop low-radiation phones. The following measures are being recommended to reduce any health hazards that mobile phones may pose:

- Minimize the use of mobile (10-30 minutes a day maximum).
- Use a mobile phone with a protective shield
- Buy low radiation mobiles, more of which will be available in the future.
- Buy a hands free toolkit, which will keep the mobile telephone away from the body.

It is too early to tell if these health risks will significantly hamper mobile sales. However, such scares will cause the industry to re-evaluate, and if necessary redesign their products to nullify any health concerns. Hence it is unlikely if such health scares will damage the mobile industry in the long term.

3.13.2 WISDOM – Wireless Information Service for Deaf People on the Move

WISDOM will realize a mobile video telecommunication device for deaf people with access to a video server through text/graphic menus and directly through sign language recognition. Specific design features for deaf and elderly people will be included. Trials will be conducted with remote interpreting. For the first time, deaf people will be able to communicate anywhere with other people at a distance and in their own language, anywhere, anytime.

3.13.3 System Architecture and Planned Services

WISDOM will develop and test a video communication device for deaf people for use in UMTS network in Europe. The Bluetooth enabled Device comprises a.

a) video camera - for sending user sign language,
b) a pocket keyboard - for text interface to legacy telecommunications devices, internet access and to integrate text/video communications.
c) A display.
d) An innovative alert device for incoming calls – wrist vibrator.
e) A UMTS Bluetooth enabled mobile interface. The development with 3rd generation network services and the provision to ensure that deaf people enter a new age of telecommunications with at least the same access to each other and information content as hearing people.

Integration of all components will be completed to provide trial units for lab and field work. Different services, especially for the needs of deaf people will also be included during the project period. The services are as follows:

- Create a 24/7 video information service for deaf people on the move allowing them to reach information sources interactively from any part of the network and throughout Europe.
- Provide access to the information service and to emergency services through sign language recognition by a user interface to the video server, activated directly by the users' signing.
- Provide access to voice telephone users through a video relay service with sign language interpreters providing the fluent translation in a call that gives the users equal status in interaction.
- Develop a service and quality of service model for network operators which will support future developments in other member states.
- Incorporate standards for Global Text Telephony to ensure that a text/video interface is developed and tested.

In Figure 3.6 the main idea of WISDOM is depicted. The centre of the picture shows a deaf person with a fictitious WISDOM terminal and possible fields of application for that terminal. For instance in the top right a deaf person with a fixed videophone can communicate through the WISDOM terminal with a person on the move. Through a remote interpreter service it is also possible to communicate with a hearing person. This could be either a distance call (upper left corner) or a face-to-face communication (bottom left corner), where the remote interpreter is in both cases connected with the deaf person via the WISDOM terminal and translates for the hearing person either by another telephone line or also through the WISDOM terminal, in case both persons have a face-to-face communication. Below an example

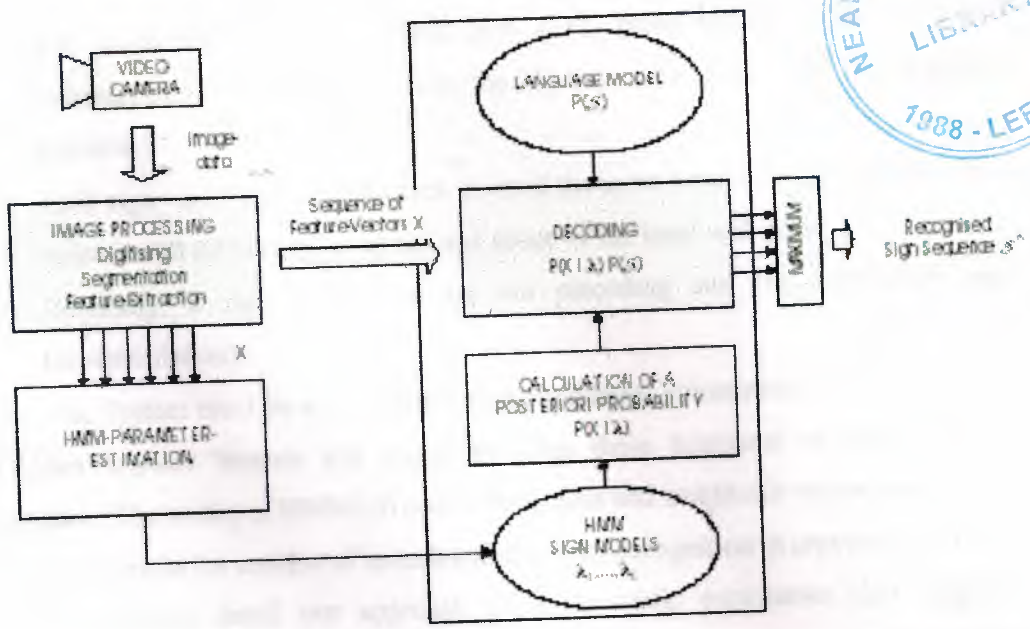


Figure 3.6 WISDOM System

Of the video information server is illustrated. During the project period a video information sever will be set up, which contains information that is of interest to deaf people (e.g. deaf news, daily news). For activating the video information server, two different modes exist. Firstly, the server can be controlled by common graphical menus. A second possibility and a more user-friendly mode for deaf people will by sign language. In order to do so, an automatic language recognition system is part of WISDOM, which currently shows good performance under laboratory conditions but needs future modification for integration into the WISDOM terminal. In the following section the current sign language recognition system is described.

3.13.4 WISDOM and Sign Language Recognition

This section details our current approach of a video based continuous sign language recognition system. As the developed system uses a single color video camera for data acquisition, the following problems in terms of sign language recognition must be taken into account:

- While signing some fingers, or even a whole hand, can be occluded.
- The position of the signer in front of the camera may vary. Movements, like shifting in one direction or rotating around the body axis must be considered.

- The projection of the 3D scene onto a 2D plane results in loss of depth information. The reconstruction of the 3D-trajectory of the hand is not always possible.
- Each sign varies in time and space. Even if the same person performs a same sign twice, small differences in speed and space of the hand will occur.
- Generally, a sign is affected by the preceding and the subsequent sign (co-articulation).
- The System must be able to detect sign boundaries automatically.

Hidden Markov Models are suited to solve these problems of sign language recognition. The ability of HMMs to compensate time and amplitude variances of signals has been proven in the context of speech and character recognition in previous years. The following sections detail our approach of a automatic continuous sign language recognition system. A block diagram of our sign language recognition system is depicted in Figure 3.6 A single video camera is employed for data acquisition. After recording, the stream of input images is digitised and segmented. In the next processing step features regarding size, shape and position of the fingers, hands and body of the signer are calculated. This step is described in the following section (3.13.5). Using this information a feature vector is built that reflects the manual sign parameters of sign language, without explicitly modeling them. For training period HMM parameters are estimated (see Section 3.13.6). These HMM parameters serve as a base for the decoding problem – the recognition of continuous sign language with bakis topology for each HMM, the system is able to compensate variations in speed and signing.

3.13.5 Feature Extraction

Since HMMs require feature vectors, an important task covers the determination and extraction of features. In our approach the signer wears simple coloured cotton gloves, in order to enable real-time data acquisition and to easily retrieve information about the performed hand shape. Taking into account the different amount of information represented by the hand shape of the dominant and non-dominant hand and the fact that many signs can be discriminated only by looking at the dominant hand, different gloves have been chosen: one with seven colures - marking each finger, the palm, and the back of the dominant hand and a second glove in an eighth colour for the nondominant hand. A threshold algorithm generates input/ output-code for the colures of the gloves, skin, body and background. In the next processing step the size and the centre of gravity (COG) of the colored areas are calculated and a rule-based classifier estimates the position of the shoulders and the central vertical axis of the body silhouette. Using this information a feature vector is built that reflects the manual parameters of sign language, without explicitly modeling them

3.13.6 Training of Continuous Sign Language

Goal of the training period is the estimation of HMM parameters for whole signs (not sentences), which are later used for the recognition procedure. For training a specific number of observation (training) sequences are needed. In our approach these are sign language sentences of various lengths (two to nine signs). Since the entire sentence is trained, variations caused by preceding and subsequent signs are later incorporated into the model parameters for whole signs. One of the advantages of hidden Markov modeling is that it can absorb a range of boundary information of models automatically for continuous sign language recognition. However, in a first step model parameters are calculated for whole sentences. After performing the training step and time alignment on sentences, an assignment of feature vectors to single signs is possible, thereby enabling the detection of sign boundaries. Now, model parameters for single signs can be calculated. These parameters are later used for the recognition procedure. Hence, the overall training is partitioned into the following components, the estimation of the model parameters for the complete sentence, the detection of the sign boundaries, and the estimation of the model parameters for each sign. For both, the training of the model parameters for the entire sentence as well as for Signs, the Viterbi training is employed. After performing the training step on sentences an assignment of feature vectors to signs is clearly possible. Bakis topology is employed for all HMMs.

The number of states for an HMM of a sentence is equal to the sum of states of HMMs for each sign within the sentence. Next, the system assigns the vectors of each sequence evenly to the states and initializes the matrix A, i.e., all transitions is set equally probable. Using the initial assignment the mean and deviation values of all components of the emission distributions of each state can be calculated.

After Viterbi alignment the transition probabilities ij a are re-calculated and the split criterion is examined. With sufficient convergence the parameters of an HMM ( ) B A,, P = l are available, otherwise the next iteration is requested. Figure 3.7 illustrates how the modelling of continuous signs is carried our. The first row of the figure shows two images of the sign DAS (this), four images of the sign WIEVIEL (how much) and three images of the sign KOSTEN (cost) as recorded by the video camera. For each image a feature vector is calculated (second row). The stream of feature vectors represents the observation sequence O. The third row illustrates the three HMMs for each sign of the sentence with Bakis topology. Through this topology the system is able to compensate different speeds of signing. The initial state of a sign model can only be reached from the last state of a previous model.

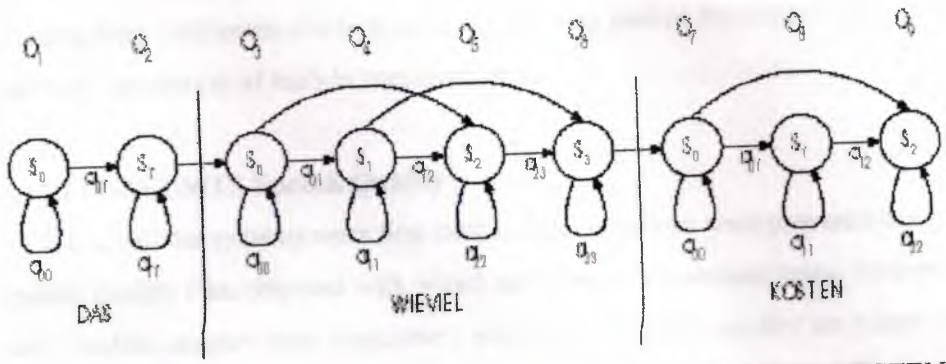


Figure 3.7 Image sequence of the sentence DAS WIEVIEL KOSTEN

3.14 Enhancing GSM Audio Quality in the Evolution To 3G Networks

The year 2000 presents many challenges for the mobile operator. Mobile penetration is growing rapidly, requiring significant increases in capacity to meet the customer's needs. As more and more customers use the mobile as their primary speech communications system, they are demanding wireline speech quality in all environments. The introduction of WAP and GPRS heralds the arrival of the wireless Internet and poses questions as to the most cost-effective way to roll out the new packet overlay network. In addition, 3G is already appearing on the horizon, and with it comes a host of new challenges for optimising speech quality in the new multi-media environment. In short, operators require solutions that allow rapid increase in network capacity plus solutions that allow new wireless Internet services to be introduced in a cost-effective manner, at the same time ensuring that their investment is protected with an evolution path to third-generation networks (3G).

GSM Release'99 has passed and with it, the first stage of 3G standardisation; the focus is now switching to the all-IP 3G network. However, the extent to which new innovative services will be standardised is, as yet, unclear. New multimedia services, such as mobile video telephony, will require the same speech quality as the basic speech service. The ability of the network to interact with the services to allow quality optimisation is vital to the introduction of cost-effective terminals that customers will want to buy; the terminal must not be overburdened with processing that can be more efficiently carried out in the network.

In recent years, significant developments have taken place to allow GSM systems to offer wireline quality speech services and to allow operators to add capacity at reduced cost. In addition, these developments can be used within UMTS multi-media services and as part of the evolutionary process. This will take GSM from a second-generation digital cellular system to a communications medium able to offer wireline quality to customers, whether they require mobility or not, thus forming part of the evolutionary path towards the third generation of mobile communications.

3.14.1 GSM/UMTS Speech Quality

When cellular systems were first introduced, customers were prepared to accept worse speech quality than obtained with wired networks at a premium price. However, today's mass mobile market sees consumers expecting wireline quality or better from their mobile terminals at comparable or cheaper tariffs. Experience in the European mobile market shows that customers now expect their mobiles to offer the same quality as their fixed PSTN/ISDN terminals.

The GSM system incorporates a variety of functions that, if not designed and planned properly, can seriously degrade the speech quality of the end-to-end connection. Mobile terminals are frequently used in conditions of high ambient noise and, because of the long propagation delay introduced by the speech and channel codecs, have to exhibit good acoustic echo loss performance. These two aspects place difficult design criteria on terminal equipment designers who also have to meet the public's demands for small, lightweight terminals. Complemen-tary network-based methods now exist, such as the Tellabs VQE that allows the network to compensate for the acoustic shortcomings of terminal; these methods enhance the perceived quality and ease the pressure on terminal designers.

Speech and channel codecs that are used to compress the amount of transmitted speech data, and to protect that speech data in the potentially difficult radio environment, make a fundamental contribution to the system's quality. For GSM, these coding techniques have evolved from the initial GSM Full-Rate (FR) codec to the current Half-Rate (HR), Enhanced Full-Rate (EFR) and Adaptive Multi-Rate (AMR) codecs.

3.14.2 Mobile Terminal Acoustic Design and Testing

Many of the key speech quality parameters are determined solely within the mobile terminal. Moreover, several of these parameters are critical to the interworking between the mobile network and any interconnected networks. Current standard test methods for GSM do not represent the actual operating conditions of the mobile and have lead to operational problems. There is a need to understand the complex interactions between these various parameters and to develop appropriate, representative tests that meet the needs of the customer, operator and terminal manufacturer. New test methods to ensure the speech performance is assessed correctly for 3G are being examined in the 3GPP_TSG_ SA_WG4 working group. However, at present, current testing procedures fall far short of real-world requirements.

3.14.3 The EFR Codec

The first step on the road to GSM wireline quality is the EFR codec. The 12.2kbit/s ACELP codec has been available in network and terminal equipment since the end of 1997 and offers wireline quality in good radio conditions and, since it uses the same channel coding as the GSM full-rate codec, degrades at a similar rate with radio errors. Although an immediate comparison between the FR and EFR codecs often shows little benefit, the greater clarity becomes evident over a longer period of conversation.

It should be noted that the EFR codec is the highest mode of the AMR codec and is being used by ETSI TIPHON for Internet telephony standards along with the AMR codec and the TFO standard (see below). Hence, EFR is not only the first step towards moving GSM speech quality towards wireline quality but also a key development on the road to 3G.

3.14.4 Voice Quality Enhancement Solutions

The second step is Tellabs' VQE (Voice Quality Enhancement). This uses a network-based audio enhancement system to remove 75% of the background noise without affecting the basic speech quality. In addition, VQE is used to carry out acoustic echo cancellation.

These features are combined in a bi-directional system, which also carries out the network echo cancellation. When combined with EFR, the usual perception of the distant party is that they do not know the user is on a mobile or even in a noisy environment.

Tellabs has deployed the system in a number of operator networks and have thousands of systems in service today.

Objective handset measurements have been carried out on real handsets on GSM networks using real handsets. The results showed that a network with Tellabs VQE has an 6-9dB additional noise reduction over and above its competitors. Since the original introduction of Tellabs VQE, further enhancements have been made to improve the operation and hence call quality.

Currently, the 3G standards are still considering the issues of terminal acoustic performance and audio quality optimisation. It is unlikely that terminal performance will improve significantly for UMTS systems. This is especially true when considering the additional coding schemes required for wideband (7 kHz) speech and other higher bandwidth audio services and their acoustic requirements. Tellabs firmly believes that a 3G VQE will be needed that can enhance the audio quality of all speech and multi-media audio services. The main challenge for such systems is to offer the VQE features in a low bit-rate environment, since the transport of speech at 64kbit/s throughout the new 3G network is neither efficient nor sensible from a quality perspective. The adaptive multi-rate (AMR) codec the next stage in the quest for wireline quality is the AMR codec, designed to overcome the problems of GSM radio error performance. The AMR has its roots in the EFR development, with this new codec aiming to offer wireline quality in a seamless manner, allowing robustness against errors and EFR quality, but in a half-rate channel.

The AMR codec offers GSM operators the potential to deliver a consistent wireline quality speech service to customers, and to offer this service with fewer infrastructures than for the current EFR codec: all operators should examine the potential of AMR. In addition, AMR offers the opportunity for rural coverage improvements and deeper in-building coverage because of the greater robustness of the full-rate channel. By building AMR into network build plans, operators can deliver capacity requirements with significantly less infrastructure, reducing capital investment and operating cost.

This codec is the 3G narrow-band speech codec and the speech codec for the circuit-switched multi-media service based on ITU-T H.324 so the codec must be suitable to each other for operation.

3.14.5 Tandem Free Operation (TFO)

The TFO protocol, recently standardized by ETSI SMG as GSM 08.62, was originally conceived to allow transcoder bypass for mobile-to- mobile calls. This bypass would negate the tandem codec effect, thus improving speech quality. An extension was proposed to the protocol to allow transmission savings in the GSM core network. Hence the TFO protocol, combined with core network re-sub multiplexing between MSCs, became known as GCME or GSM Circuit Multiplication Equipment.

GCME allows the GSM network operator to make significant savings in core network transmission requirements as GCME can be made applicable to all calls, rather than simply mobile-to-mobile. This would still allow mobile-originated calls to be routed to the PSTN, with those that have Far-End Handover (FEH) being routed through the GSM network at 13kbit/s to the GMSC where FEH to the PSTN is to occur. At this point, the 13kbit/s speech would be transcoded to 64kbit/s A-law.

In the other direction (incoming from PSTN to GSM) the PSTN does not have the necessary functionality to allow traffic to be passed directly to the MSC where the called mobile is connected. The PSTN has to pass mobile traffic to the gateway interconnect point and the mobile operator routes it to the correct MSC. TFO, through the GCME, provides a core transmission bandwidth saving for these calls as well.

This functionality could be extended to a value added service (VAS) interface, allowing GSM 13kbit/s speech to be passed directly to voice mail and other services such as Voice Over IP (VoIP) gateways, rather than employing further low rate coding schemes. Such a system would allow the mobile network operator to gain at least 75% reduction in core network bandwidth required for speech calls. Speech traffic remains the largest proportion of inter-switch traffic and hence a considerable saving can be made in operational costs.

TFO can also be used between 2G and 3G networks and can help facilitate the common packet core network for GSM and 3G voice as well as data to develop pure voice speech calls and saving in operational cost.

3.15 Development Cycle of 3G System

3.15.1 3G Wireless Simulations

The Monte Carlo simulations of the physical layer of the 3G wireless systems require large simulation times because of three major issues:

- Higher sampling rates and more complex algorithms
- Higher quality of service (lower error rates)

We have addressed the last issue [20] in where we have suggested direct co-simulation techniques to help reduce the simulation time for a system testbench including both C and RTL. Hardware acceleration, emulation, and rapid prototyping techniques can also be used further down the implementation path. In this paper, we will focus on the first two issues in the context of software simulations.

3.15.2 Higher Base Band Sampling Rate and Complex Algorithm

The chip rate for wideband code division multiple access (WCDMA) is 3.84 Mchips/s. The highest baseband sampling rate is the chip rate times the oversampling factor. Therefore, for the common oversampling factor of 4 the baseband sampling rate is over 15 MHz, which is at least an order of magnitude higher than for the global system for mobile (GSM). Moreover, the base band algorithms-including turbo encoding and decoding and the Rake receiver implementation are significantly more complex than 2G systems. Additional transmitter and receiver diversity techniques increase the complexity at the transmitter and the receiver side. This is true both for user terminals and base stations. Multiuser detection and smart antenna algorithms further augment the complexity of the baseband algorithms at the base station.

3.15.3 Lower Bit Error Rate (BER) Requirements

3G wireless systems have very stringent BER requirements as compared to 2G systems. The typical BER requirement for a 2G system is about 10^{-2} whereas, for a 3G system, it can be as low as 10^{-6} for real-time multimedia applications.

In general, in stochastic simulations the lower the BER requirements the more bits need be simulated to achieve statistically valid results. If the target BER is denoted by P_b, and the estimate (obtained from simulations) by Q_b, we would have to reduce the standard deviation of Q_b denoted by $\sigma(Q_b)$ to be considerably less than P_b. The ratio $\varepsilon=\sigma(Q_b)/P_b$ determines the accuracy of the simulations.

Assuming random bit errors, the number of bits M simulated to ensure a given accuracy is given by the following formula: $M = B / P_b$.

Where B is the number of bit errors. To ensure that $\varepsilon < 0.1$, we need $B > 100$, or equivalently: $M > 100/P_b$.

In other words, there is an inverse linear relationship between the BER and the number of required bits in a simulation. Therefore, assuming random errors, the number of simulation bits for a target BER of 10^{-6} is 10,000 times the number required for a target BER of 10^{-2}.

Furthermore, in wireless systems operating in multipath fading environments, the errors occur in bursts. Burst errors occur during fading events when the signal level goes below the threshold for the receiver to correctly detect the signal. As a rule of thumb, if the average length of the burst errors is L, the simulation length must be on the order of ML points to get similar accuracy. To make matters worse, the slower the fading, the longer the fade duration thus requiring longer simulation times.

Considering that the algorithms are at least an order of magnitude more complex than 2G systems, it becomes apparent that some 3G simulations may be 100,000 times longer than the same simulations for 2G.

Fortunately, computer speeds have improved significantly and simulations can now be run 10 to 100 times faster than similar simulations for 2G systems. Assuming an optimistic figure of 100 for processor speed improvement, we can conclude that some of the 3G simulations can take at least 1000 times longer than similar 2G simulations. To show the magnitude of the problem, Table 3.2 shows a comparison of the simulation times for 2G and 3G using the above assumptions.

	2G	**3G**
Simulation run times	1 hour	41 days
	1 day	2.75 years

Table 3.2 Comparisons of Typical Run Times for 2G and 3G Simulations

Obviously, the simulation times for 3G are not acceptable and solutions to reduce the simulation time must be found. However, with such BER performance targets it is even harder to design a wireless system than it is to simulate one. It seems that most designs will target BERs in the range of 10^{-3} to 10^{-4}, requiring significantly less simulation time. We will therefore concentrate on practical solutions that can speed up the simulation time by a factor of 100.

There are simulations techniques such as importance sampling, through that can be used to reduce the required simulation time. All these techniques are based on introducing a bias into the statistical distribution of the channel so that errors occur more frequently and therefore less time is spent on generating the error events. However, the big drawback of these techniques is that the statistical distribution of the channel effect should be known, and in most instances the channel must be "reasonably linear." Furthermore, the efficiency of the importance sampling techniques is a direct function of the statistical distribution of the channel effects.

3.16 GSM Evolution 2G To 3G

Phase1of the standardization of GSM900 was completed by the European Telecommunications Standards Institute (ETSI) in 1990 and included all necessary definitions for the GSM network operations. Several tele-services and bearer services have been defined (including data transmission up to 9.6 kbps), but only some very basic supplementary services were offered. As a result, GSM standards were enhanced in Phase 2 (1995) to incorporate a large variety of supplementary services that were comparable to digital fixed network integrated services digital network (ISDN) standards. In 1996, ETSI decided to further enhance GSM in annual Phase 2+ releases that incorporate 3G capabilities.

GSM Phase 2+ releases have introduced important 3G features such as intelligent network (IN) services with customized application for mobile enhanced logic (CAMEL), enhanced speech compression/decompression (CODEC), enhanced full rate (EFR), and adaptive multirate (AMR), high—data rate services and new transmission principles with high-speed circuit-switched data (HSCSD), general packet radio service (GPRS), and enhanced data rates for GSM evolution (EDGE). UMTS is a 3G GSM successor standard that is downward-compatible with GSM, using the GSM Phase 2+ enhanced core network

3.16.1 The Technology behind the 3G Evolution

There are two dominant competing 3G options for American wireless carriers to follow; CDMA 2000 and W-CDMA (Wideband-CDMA). Carriers must roll the dice and choose which standard to follow, because both of these technologies cannot be implemented together within a network. W-CDMA is the natural progression for GSM and TDMA networks, while CDMA 2000 builds on platforms currently using CDMA technology. There are major U.S. wireless providers that are backing each of these technologies. What this means is that the American 3G market will evolve having two widely used wireless standards. The transition from GSM and TDMA to W-CDMA will not be a simple one. It will first be necessary to transition these networks to GPRS (General Packet Radio Service), then upgrade them to EDGE (Exchange Data Rates for Global Evolution) before it will be possible to make the transition to full 3G. GPRS speeds should reach up to 144 Kbps, with EDGE further enhancing data transfer speeds up to 384 Kbps. These two interim stages of technology represent what is referred to as "2.5G".

CDMA's evolution to 3G will be a bit more straightforward. The migration to 3G for CDMA will move from its current 2G speeds of up to 14.4 Kbps, to a 2.5G standard called IS95B. This 2.5G technology utilizes the same spectrum, but offers speeds up to 64 Kbps. The next step will involve carriers moving to a realm known as CDMA 2000. CDMA 2000 will begin with a 1X version, then move to 2X, and reach full 3G capacity at 3X. The 1-3X represents the various steps that CDMA 2000 will take before reaching its full 3G capacity. "Upgrading networks to 1X will facilitate data rates up to 144 Kbps. Once networks are upgraded to CDMA 2000 wireless transmission should be able to achieve speeds of up to 2 Mbps. To migrate through these steps, carriers will basically only have to change a channel card in their base stations, which will allow them to continue to utilize their infrastructures. The speed of this migration is a true economic incentive for carriers" says Perry LaForge, executive director of the CDMA Development Group (CDG). LaForge contends that upgrading to 3G will be a much more cumbersome process for those currently using GSM and TDMA.

IMT-2000 (International Mobile Telephone Standard) is a framework developed by the International Telecommunications Union that is designed to set global standards and spectrum allocation for 3G. Under these guidelines 3G packet-based technology is capable of 144 kbps in a moving location, such as a car or train, and up to 2 Mbps in a fixed location. These guidelines also spell out the capability of global roaming, which is not possible using today's wireless technology. IMT-2000 offers support for both W-CDMA and CDMA 2000.

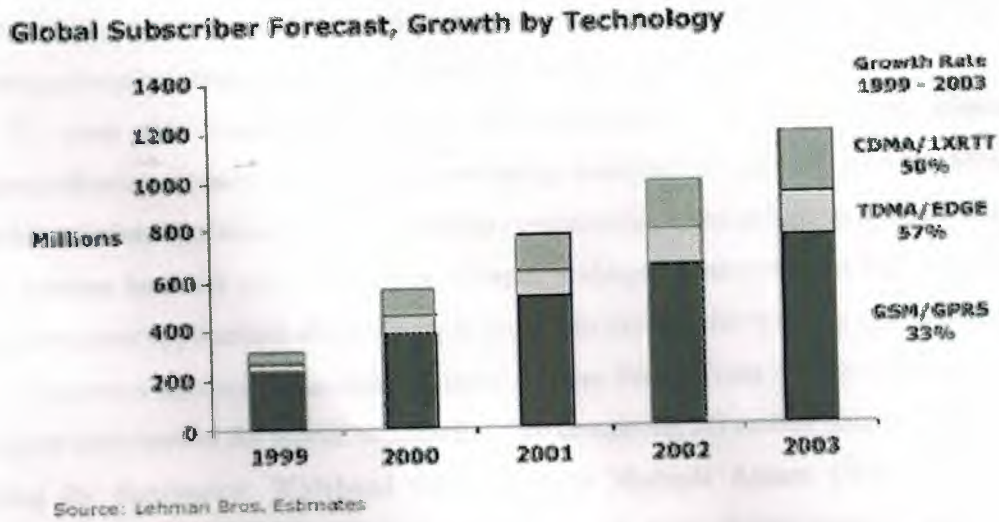


Figure 3.8 illustrates the projected growth rates of the different technologies.

3.17 Third Generation (3G) Wireless Market Opportunity

Wireless technologies have become an affordable, convenient alternative to fixed wireline communications for everything from telephone conversations to Internet connectivity and data access, adding mobility and ease of access unavailable with fixed wires. As a result, the market for digital wireless communication devices is growing dramatically. Most of the current 1000 million digital wireless communications subscribers worldwide utilize second-generation handsets for data and voice communications over existing GSM, CDMA or TDMA systems.

However, wireless communications, despite their rapid proliferation into everyday life, are still in their infancy in terms of features and applications. The digital cellular technologies in widespread use today are voice-centric and offer limited data services such as Caller ID and SMS (short messaging service). Limited feature support is a direct result of the low transmission rates supported by existing wireless wide-area networks and standards. Peak data rates of 19.2 kbps for second-generation systems are unsuitable for commercial data service support. As a result, the expansion of cellular phones into the role of data terminal devices for data-centric applications such as web-browsing and online services has been significantly limited.

Hence, the performance requirements for digital mobile wireless communication devices have expanded dramatically from their inception as mobile telephones. Consumers are demanding expanded wireless subscriber services such as web browsing, MP3 audio, MPEG4 video, video telephony, and even online video gaming. Specifically, consumers are now demanding full data & voice integration and flexible combinations of computationally intense applications from mobile handsets.

To meet this consumer demand, third generation, or 3G, digital wireless communication system architectures are being designed to provide true broadband mobile wireless application support with data transmission rates as high as 2 Mbps. These 3G wireless handsets are on the verge of rapid, widespread adoption, as both corporate and consumer applications drive the rapid growth in demand for wireless data access.

Consumers also want handheld wireless devices that provide consistent operational support anywhere in the world. Worldwide, two competing 3G mobile data standards are vying for dominance: Wideband Code Division Multiple Access (W-CDMA) and CDMA2000. These mobile wireless communication technologies promise peak data rates up to 384Kbps, with as much as 2Mbps achievable in some instances. In 2001 new cellular technologies, so-called 2.5G systems such as General Packet Radio Service (GPRS) raised commercially available data rates to 144Kbps. However, 2.5G systems are merely transitional steps on the way to wide-scale mobile wireless broadband via 3G cellular networks.

Market research firm Cahners In-Stat conservatively projects 40M W-CDMA handsets shipping in 2005, while Allied Business Intelligence projects a more optimistic 110M. The growth curve through 2005, as shown below (**Figure 3.9**), is exponential for even the conservative case, presenting a significant market opportunity for the right technologies

The development of the necessary technologies to realize these goals presents challenges for the design and manufacture of 3G systems.

- Wireless handheld device manufacturers are challenged to deliver products that are reliable, offer desirable and expanded feature services, and operate transparently worldwide, despite regional variations in the implementation of the 3G standard.
- Product designers are challenged to create extremely power-efficient broadband wireless handheld devices that operate transparent to the user, no matter where they are in the world.

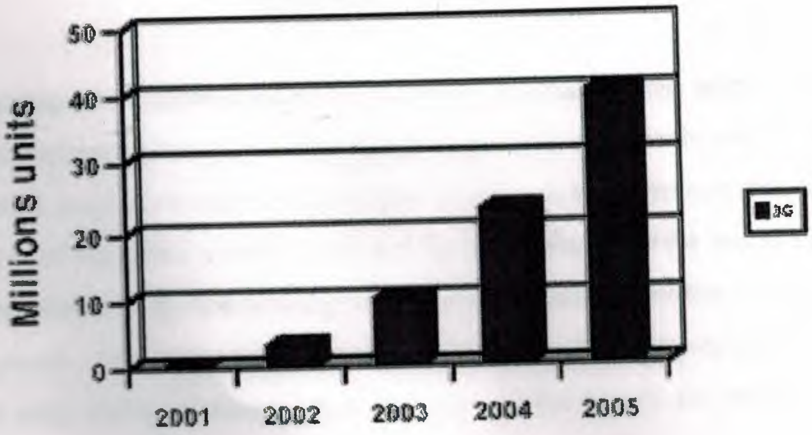


Figure 3.9 illustrate the growth curve through 2005

CONCLUSION

The development of wireless communication system had started with 1G as analog that made widespread coverage, which was the first step in the developing of 2G which is digital system used to increase data transmission, speech transmission, sms, and fax.

The advent of the global mobile boom and the globalization of the world's economy the long term prospects for the development of third generation mobile communication system is secure. As we approach the new millennium 3G systems offer a way to provide not only global communication, but also global broadband services such as multimedia applications and high-speed internet access.

The success of third generation system will depend upon market forces. 3G mobile systems will not only have to deliver the promised services but also at a price attractive to the consumer. The success of the UMTS licenses to be awarded these days by the United Kingdom will provide an early indication as to the success of 3G mobile communication system.

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