NEAR EAST UNIVERSITY

Faculty of Engineering

Department of Electrical and Electonic Engineering

MOBILE COMUNICATION SYSTEMS

Graduation Project
EE-400

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I am grateful to Mr. **Jamal Fathi** who has helped me in a variety of ways as I prepared this project, which is my graduation project.

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I hope this project will offer a benefit to the other students who are searching for knowledge.

ABSTRACT

IMT-2000 is the term used by the International Telecommunications Union (ITU) for a set of globally harmonized standards for third generation (3G) mobile telecoms services and equipment. 3G services are designed to offer broadband cellular access at speeds of 2Mbps, which will allow mobile multimedia services to become possible. The latest Wireless Application Protocol standard, WAP 2.0, developed by the WAP Forum was revealed in August 2001. WAP 2.0 is intended to bring mobile services closer to Internet standards on desktop PCs. WAP 2.0 is supported by companies like Ericsson, Nokia and Motorola. All three industry giants believe the protocol will further advance mobile services, and have stated their intentions to develop products, content and services based on WAP 2.0.

Bluetooth is an alliance between mobile communications and mobile computing companies to develop a short-range communications standard. This is for wireless data communications of up to 10m.

Bluetooth technology was conceived by Ericsson, but founded and developed by Ericsson, Nokia, IBM, Intel and Toshiba.

Enhanced data for global evolution (EDGE) is a high-speed mobile data standard, intended to enable second-generation global system for mobile communication (GSM) and time division multiple access (TDMA) networks to transmit data at up to 384 kilobits per second (Kbps). As it was initially developed just for GSM systems, it has also been called GSM384. Ericsson intended the technology for those network operators who failed to win spectrum auctions for third-generation networks to allow high-speed data transmission.

CDMA (code division multiple access) is a second-generation digital mobile telephone standard which takes a different approach to the other, competing standards: GSM (Global System for Mobile Communications) and TDMA (Time Division Multiple Access). Where GSM and TDMA divide the available bandwidth into 'channels' using a combination of frequency bands and time-slices, CDMA

spreads the signal over a wide bandwidth, identifying each channel using unique digital codes. This means it can provide greater bandwidth efficiency, and hence a greater potential number of channels.

Connexion is a broadband telecommunications service from Boeing that offers real-time, high-speed, two-way connectivity for commercial airlines, private business jets and US government customers worldwide.

In March 2002 Lufthansa Airlines began installing the first Connexion antenna on a 747-400 for use in a three-month trial in late 2002. Lufthansa is one of 17 airlines working with Boeing on a new Connexion service.

TABLE OF CONTENTS

INTRODUCTION

CELLULAR TELEPHONE, NEEDS ASSESSMENT

In 1921, the Detroit police department used mobile radio at a carrier frequency of about 2 MHz to communicate between the base station and the police cars. This represents one of the earliest recorded uses of two-way mobile communication.
As the FCC added more frequencies to the allocated space for mobile communications (usually in the 400-900 MHz frequency range), usage proliferated, Ambulance services, taxicab companies, construction companies, and sales forces were among the early competitors for limited frequency allocations. These were services, where a base station communicated with a fix number of mobile stations.
As a society became increasingly mobile and consequently spent more and more time in their cars (either moving or standing still in traffic), the need for universal communication capability increased dramatically. Individuals wanted the ability to set up a communication link with anybody in the world. They did not want to go through a base station. This naturally led people to look at the extensive dial-up telephone system that was already existence. It was simply necessary to provide mobile stations the ability to tie into this vast system.

Simple as this sounds, implementation had to wait for a major technological breakthrough. There simply were nowhere near enough frequencies to go around. Multiplex techniques and sophisticated coding systems can increase the number of simultaneous users, but the capability is still far less than required.

Throughout history, the emphasis in communications has been to transmit for farther and farther distances. This meant that a single user tied up a particular frequency band over a large geographic area. The breakthrough that mobile communications was waiting for was an abandonment of the distance goal and an intentional limiting of transmission range. With such limiting, frequency bands could be allocated to separate users who are not as widely spaced, thereby increasing the total capacity of the system. The required companion development is the ability to build hardware that adaptively selects the particular fixed transmitter with which to communicate. That is, with relatively short communication distances and mobile users, the mobile unit must be in the range of fixed station. As the unit moves, it must change from one fixed station to another.

The cellular concept represented the solution. It was reported on in 1979 in the Bell System Technical journal and, in the following decade, experienced a virtual explosion in usage. The concept is to divide a geographic area into cells, as shown in Figure. Each cell contains a fix station near its center. The station receives messages from mobile transmitters within the cell and also transmits to the mobile receivers within the cell. The cell represents the area over which signals have acceptable power levels. Therefore, the cell may not be In the center; this depends on geographic characteristics.

SPECIFICATIONS

The specifications of the system are deceptively simple. Any person should be able to use a portable telephone (either installed in an automobile or carried in a small suit case) in the same manner that they use a hard-wired telephone. That is, they should be able to transmit and receive voice or modem signals. They should be able to dial any telephone in the world and also receive calls from any telephone in the world. This represents ideal specifications.

DESIGN APPROACH

As of this writing, the FCC has allocated frequency space sufficient for 999 two-way communication channels. A number of these channels (42 currently) are needed to carry control signals between fixed stations and cellular phones. The control aspects are much more diverse than those of hard-wired telephones. Each cell covers a few square miles. A mobile station wishing to transmit must first test which fixed station it is closest to (that is, the strongest signal) and continually check that as it moves toward another cell. The hand-off process must be smooth enough such that the user does not realize it is happening.

DESIGN DETAILS

Although multiple cells can use frequency bands, the same band cannot be used by adjacent cell. That is, the cellular concept reduces the transmission range to the point that identical bands can be assigned to transmitters that are relatively close together. However, they would not be assigned to adjacent cells. This complicates the hand-off process.

1. IMT-2000 GLOBAL STANDARD, INTERNATIONAL

1.1 Overview

IMT-2000 is the term used by the International Telecommunications Union (ITU) for a set of globally harmonized standards for third generation (3G) mobile telecoms services and equipment. 3G services are designed to offer broadband cellular access at speeds of 2Mbps, which will allow mobile multimedia services to become possible. In 1998, the ITU called for proposals for IMT-2000 from different interested parties and it received many different ideas based on time division multiple access (TDMA) and code division multiple access (CDMA) technology. The European Telecommunications Standards Institute (ETSI) and Global System for Mobile Communications (GSMC) companies, such as the infrastructure vendors Nokia and Ericsson, are backing wideband code division multiple access (W-CDMA), whilst the US vendors, including Qualcomm and Lucent Technologies, are backing CDMA2000.

Figure 1.1 shows provides information technology and telecommunication integration for IMT-2000.

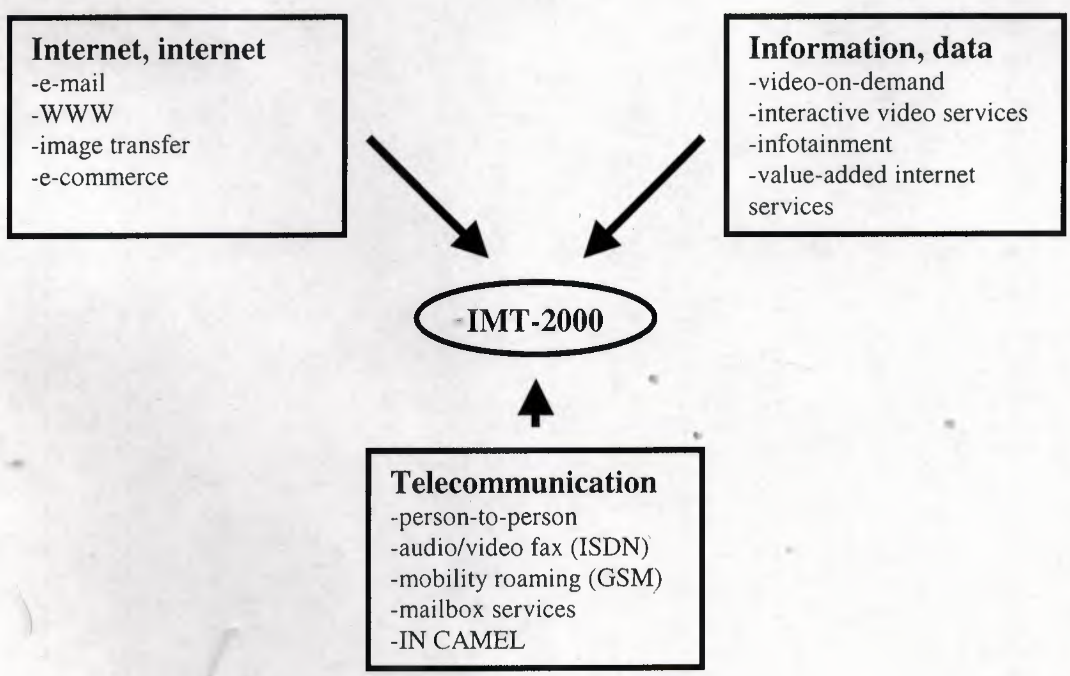


Figure1.1 IMT-2000 Provides Information Technology and Telecommunication Integration.

1.2 ITU Proposal

To take account of the different vested interests, the ITU has proposed that IMT-2000 is a CDMA-based standard, which encompasses three different modes of operation, each of which should be able to work over both the GSM and IS-41 network architectures. The three modes are as follows:

- Direct sequence frequency division duplex (FDD). Based on the first operational node of the UMTS terrestrial radio access (UTRA) proposal, this mode is supported by the GSM network operators and vendors, plus Japan's ARIB community
- Multi-carrier FDD. Based on the CDMA2000 proposal of the US Telecommunications Industry Association, this mode is supported by the US cellular network operators and vendors

Figure 1.2 shows Time division duplex. Based on the second operational node of the UTRA proposal, this unpaired band solution has been harmonized with China's TD-SCDMA proposal

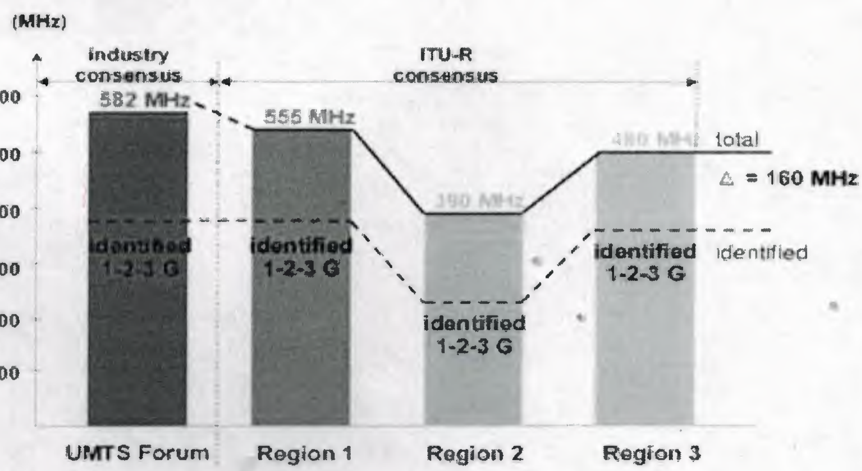


Figure1.2 Time Division Duplex.

Terrestrial Spectrum Calculations Resulted in an Additional 160MHz Worldwide for IMT-2000.

The green light for the development of these services was given at the ITU's World Radio communication Conference, held from 8 May to 3 June 2000 in Istanbul, Turkey. This decision provides for a number of frequency bands available on a global basis for countries wishing to implement IMT-2000. Making use of existing mobile and mobile-satellite frequency allocations, the agreement also provides for a high degree of flexibility, to allow operators to migrate towards IMT-2000 according to market and other national considerations.

At the same time, it does not preclude the use of these bands for other types of mobile applications, or by other services to which these bands are allocated - a key factor that enabled the consensus to be reached. While the decision of the Conference globally provides for the licensing and manufacturing of IMT-2000 in the identified bands on a globally harmonized basis, each country will decide on the timing of availability at the national level according to their specific needs.

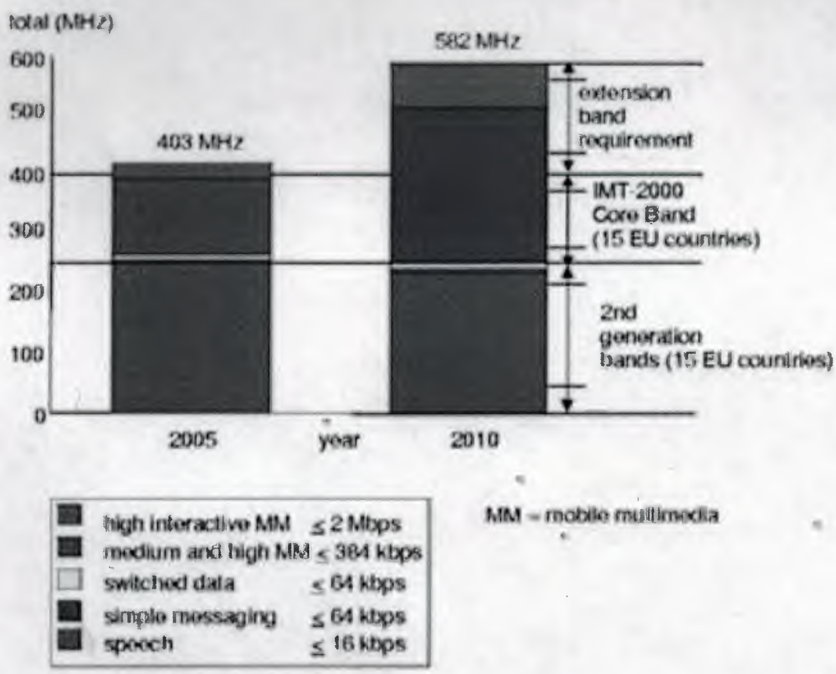


Figure1.3 Mobile Multimedia.

Terrestrial Spectrum Calculation from the UMTS Forum for the years 2005 and 2010.

Example: Traffic Model in Western Europe

1.3 Frequency Bands

The frequencies for IMT-2000 were allocated in two phases, the first made in 1992 when IMT-2000 began development, and the second set at the recent conference. The bands that had initially been identified in 1992, on the basis of which licensing has already been made or is under way in many parts of the world, remained unchanged. Around 100 licenses are expected to be awarded worldwide by the year 2002. These bands are 1885-2025MHz and 2110-2200MHz. The additional bands identified for the terrestrial component of IMT-2000 are: 806-960MHz, 1710-1885MHz and 2500-2690MHz. All bands globally identified for IMT-2000 have equal status.

1.4 The Future

The only IMT-2000 system that was fully operational in the first quarter of 2002 was NTT DoCoMo's 3G service which went online in October 2001. This runs to the ITU' standards (W-CDMA) and spectrum frequency (1.9-2GHz). Other operators plan to start commercial services by the end of 2002 when handsets become available. These include Telenor Mobile and Netcom in Norway; Sonera and Radiolinja in Finland; and Orange Sverige, Europolitan, Hi3g, and Tele2 in Sweden.

In other areas operators have reported field trials and experiments in W-CDMA across these frequencies. These include: Orange SA in France; Telecom Italia Mobile in Italy; Manx Telecom on the Isle of Man; and Monaco Telecoms in Monaco. Operators in Japan and the Republic of Korea have begun to implement systems on other spectra for a similar time-scale.

Table 1.1 IMT-2000 - Specifications

Key Data	
Standard type	Mobile cellular (broadband)
Location	Worldwide
Completion	2001
Key Players	
Controlling body	ITU
Developers	All global bodies and companies

1.5 WAP 2.0 STANDARDIZATION, INTERNATIONAL

The latest Wireless Application Protocol standard, WAP 2.0, developed by the WAP Forum was revealed in August 2001. WAP 2.0 is intended to bring mobile services closer to Internet standards on desktop PCs. WAP 2.0 is supported by companies like Ericsson, Nokia and Motorola. All three industry giants believe the protocol will further advance mobile services, and have stated their intentions to develop products, content and services based on WAP 2.0. New technologies designed to improve the WAP standard include: Multimedia Message Servicing (MMS), Persistent Storage Interface, Provisioning, and Pictograms. The WAP 2.0 standard also makes use of: wireless telephony application (WTA), Push, and user agent profile (UAPROF) in more advanced forms.

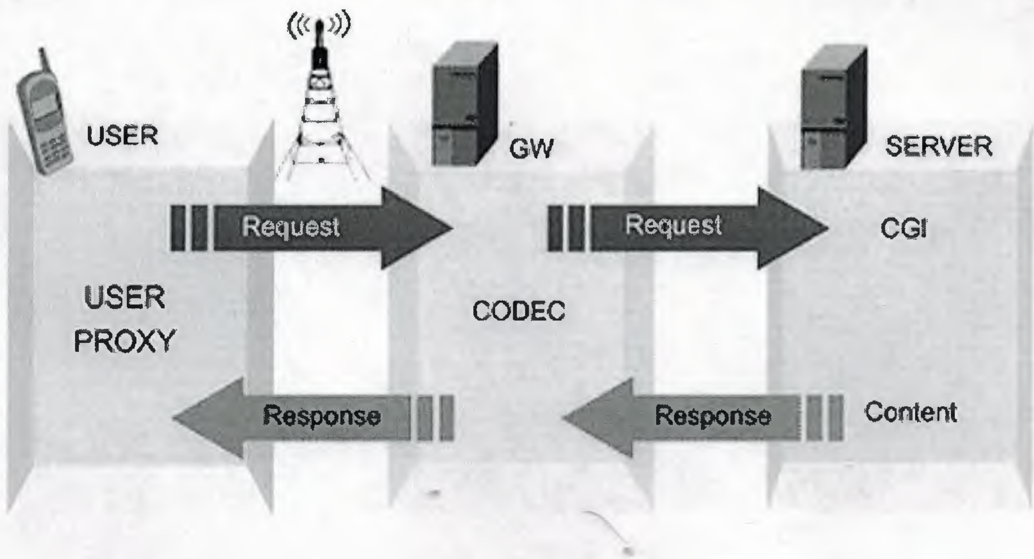


Figure1.4 How the WAP Works.

Generic WAP Networking. WAP Can Come in More than One Version.

1.5.1 WAP 2.0 Specification

The new WAP specification uses language common to the fixed and wireless environments and contains new functionality that allows users to send sound and moving pictures over their telephones, among other things. WAP 2.0 will be based on the XHTML mark-up language, bringing it much closer to i-Mode, which uses another version of HTML, the mark-up language for the Web, called cHTML.

Other Internet standards that have been adopted in WAP 2.0 include Cascading Style Sheets (CSS), Transport Layer Security (TLS), HTTP and TCP. The richer content and multimedia services that will be available in 2.5G/3G networks are going to be based on these and similar standards and will therefore integrate seamlessly with WAP technology.

Additionally, WAP 2.0 further evolves WAP Push, which can be used for services such as online auctions, where it is important for users to receive information at the point of interest, rather than being forced to actively look for the information.

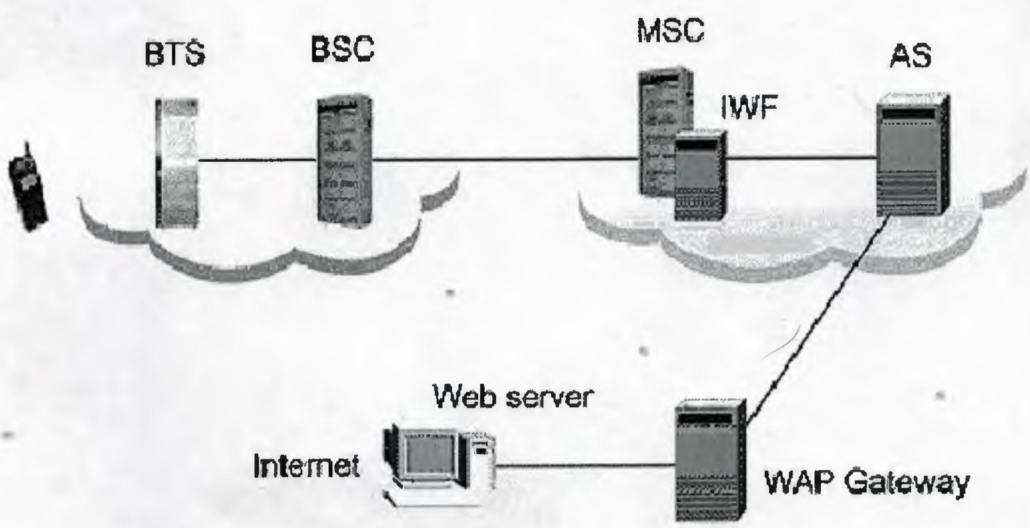


Figure 1.5 WAP Networking Based On CSD

1.5.4 The WAP Forum

Ericsson, Nokia and Motorola co-founded the WAP Forum together with Unwired Planet (now Open wave) in 1997, and the forum has since grown to more than 450 members, representing manufacturers, carriers and content developers from all parts of the world. The primary goal of the WAP Forum is to bring together companies from all segments of the wireless industry value chain to ensure product interoperability and growth of the wireless market. The companies believe that new functionality, such as multimedia messaging, opens up new possibilities for operators and content developers.

The new generation of the WAP specification together with improved handsets and other wireless devices ensure a much better development environment for advanced mobile services. Based on well-established Internet standards including TCP and HTTP as well as the necessary components specifically adapted for wireless environments, WAP 2.0 will provide a simple, yet powerful tool-kit for easy development and deployment of a multitude of useful new services.

Table 1.2 WAP 2.0 Standardization - Specification

Key Data	
Start year	2001
Project type	Broadband
Location	International
Estimated investment	To be announced
Completion	Ongoing
Key Players	
Sponsor	Ericsson, Nokia, Motorola
Others	Unwired Planet (openwave)
Technical Specs	
WAP Mark-up language	XHTML
Jointly developed service	Multimedia Messaging Services (MMS)
WAP adopted Internet standards	Cascading Style Sheets (CSS), Transport Layer Security (TLS), HTTP and TCP

2. BLUETOOTH SHORT-RANGE COMMUNICATIONS STANDARD, INTERNATIONAL

2.1 Overview

Bluetooth is an alliance between mobile communications and mobile computing companies to develop a short-range communications standard. This is for wireless data communications of up to 10m.

Bluetooth technology was conceived by Ericsson, but founded and developed by Ericsson, Nokia, IBM, Intel and Toshiba.

2.2 LANS

Bluetooth has been developed to facilitate wireless local area networks (LANs), in which the networks of different handheld computing terminals and mobile terminals can communicate and exchange data - even on the move or when there is no line-of-sight between the terminals.

This will mean that if users have several Bluetooth-enabled portable terminals, they can use them with all the advantages of an integrated smart phone, without having to re-enter data or find the most recent versions on different terminals.

2.2.1 Applications

This kind of synchronization and exchange of data are Bluetooth's major applications, as are electronic commerce applications such as electronically paying for parking meters, bus tickets, shopping, movies and so on. Smart offices are envisaged, in which an employee with a Bluetooth device is automatically checked in when entering the building, triggering a series of actions such as lights and switching on PCs. The Bluetooth partners see one of the main advantages being that it does not need to be set up. Bluetooth runs in the background and a line of sight is not even needed for the machines to automatically initiate and trigger processes.

This proactive intelligence could turn out to be a nuisance rather than a convenience for users unless it is under the control of the device owner(s). Indeed, the Bluetooth standard does incorporate control mechanisms, since each device is assigned a specific 12 byte address, which must be known to connect to the device. There is also to be an enquiry feature so as to enable a search for other Bluetooth-enabled devices within range.

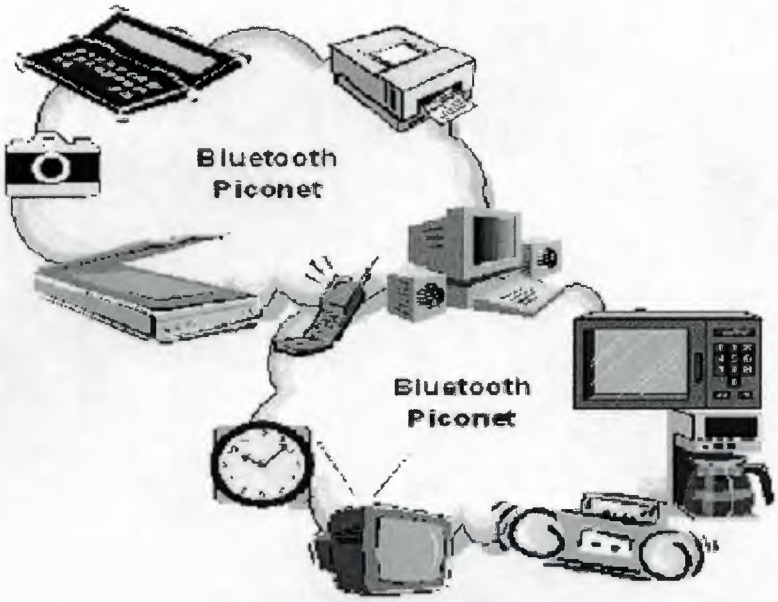


Figure 2.1 Bluetooth Piconet

2.2.2 Technical Details

In July 1999 the Bluetooth special interest group (SIG) announced the public release of the Bluetooth SIG specification, Bluetooth 1.0. Over 1,300 adopter companies now support the Bluetooth specification.

The current Bluetooth technology provides for data transfer at a rate of 1Mbps, with a personal area range of up to 10m in client-to-client open air (5m in a building). In terms of client-to-access point, the current range is 100m in the open air and 30m in buildings.

Bluetooth has three generic applications:

- Personal area networks (PAN), where two or more Bluetooth products can communicate directly. This includes synchronizing the contacts list between mobile phone, PC and hand-held devices. It can also transfer files to another user's Bluetooth-enabled devices and allows access to printers, facsimiles and copiers

- Local area networks (LAN), where products will communicate to a company's broader network via a Bluetooth LAN access point. The applications for this are the downloading of information, emails and files from Bluetooth-enabled laptops, mobile phone and hand-held devices from a corporate server
- Wide area network (WAN), where a product with Bluetooth-enabled technology can communicate with a wireless WAN device, such as the global system for mobile communications (GSM), to allow connectivity. This application can allow for mobile access to the internet and the retrieval of information or files from desktop computers

Wireless LAN technology was calculated to be worth $400 million in 1999 (according to the International Data Corporation) and it looks set to increase. The strength of the companies involved in the Bluetooth development, and the fact that it has quickly gained standardization, make it appear an important part of future PAN and LAN systems.

Table 2.1 Bluetooth - Specification

Key Data	
Standard type	Fixed Wireless (LAN)
Location	Worldwide
Completion	1999
Key Players	
Controlling body	Bluetooth Special Interest Group
Developers	3Com, Lucent, Microsoft, Motorola

2.3 IEEE 802.11B WIRELESS LAN STANDARD, INTERNATIONAL

Wireless local area networking (wireless LAN) was developed in the 1990s as an extension of the wired LAN network technology that had become prevalent and dominant in the networked world. In essence, wirelesses LANs are, as the name suggests, technology for transmitting data and operating local networks without requiring the wires and associated infrastructures this normally brings.

Developed out of the Ethernet (the predominant wired LAN technology), wireless LAN technology was first developed in the early 1990s and initially only available at a lower level to wired LANs. Wireless LANs were capable of 1-2 megabits per second (Mbps) transfer rates, as opposed to 100Mbps for the wired LANs.

In order for the wireless LANs to have the same functionality, compatibility and interoperability as the wired systems, wireless makers, including Aironet, pushed for the implementation of the necessary standards.

In June 1997, the Institute of Electronic and Electrical Engineers, the body that defined the pre-eminent 802.3 Ethernet standard for wired LANs, released the 802.11 standard for wireless local area networking. This is now the industry standard for wireless LAN technology.

Since the late 1990s and the development of IEEE 802.11, this new networking system has experienced rapid growth in a number of vertical markets.

2.3.1 Technical Details

IEEE 802.11b-standard 11Mbps wireless LANs operate in the 2.4 gig hertz (GHz) frequency band. There is also room for an increased bandwidth using an optional modulation technique within the specification. This allows the doubling of its current data rate.

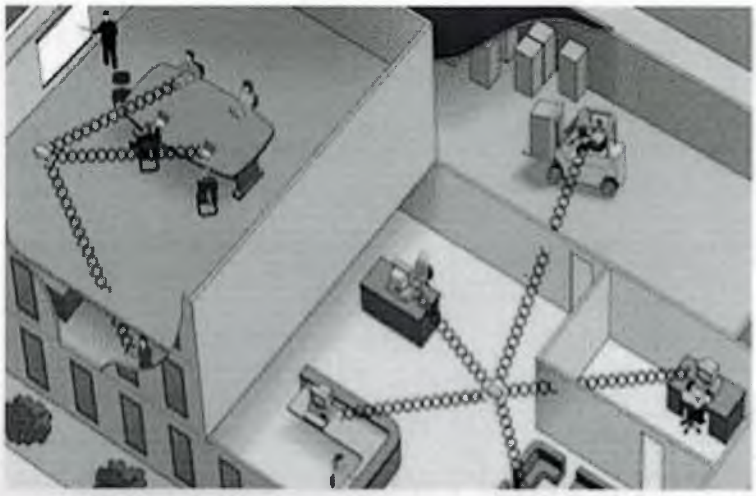


Figure 2.2 Wireless LAN

Wireless LAN manufacturers developed the 900MHz band to the 2.4GHz band to improve the data rate. This pattern looks set to continue, with a broader frequency band capable of supporting the higher bandwidth available at 5.7GHz. The IEEE has already issued a specification (802.11a) for equipment operating at 5.7GHz, which supports a 54Mbps data rate. The initial price premium will decrease over time as the data rate increases and the cost of components comes down. The 5GHz band promises to allow for the next breakthrough data rate of 100Mbps.

2.3.3 Applications

Aironet entered into an agreement with the Bank of America Securities in November 1999, so as to provide a series of wireless LANs to a number of the bank's business units. The bank required flexibility in the intranet systems to allow employees to monitor the markets continuously from anywhere in the offices. The wireless LANs were also useful during relocations, where there was no need for rewiring the networks, leading to savings in time and costs.

Other applications have also been developed to assist hospitals and educational establishments by allowing staff to access information at the point of care with patients or students.

2.3.4 Future of Wireless LAN

Wireless LAN technology will continue to develop its capabilities and market presence. Advantages include its flexibility and the fact that major players such as Cisco Systems will drive it. However, even the providers themselves acknowledge that wireless LANs will be, now and in the future, both more expensive and slower than wired LANs. Until the technology is developed to overcome this, this technology will find it difficult to rival wired LANs.

Table 2.2 IEEE 802.11B - Specification

Key Data	
Standard Type	Fixed Wireless (LAN)
Location	Worldwide
Completion	Ongoing
Key Players	
Controlling Body	Institute of Electronic and Electrical Engineers
Developers	Cisco Systems/Aironet Wireless Communications

2.4 IRDA (INFRARED DATA ASSOCIATION), INTERNATIONAL

Infrared data and communication is a mode of communication that now plays an important role in wireless data communication. It suits the use of laptop computers, wireless data communication and other digital equipment such as personal assistants, cameras, mobile telephones and pagers.

The Infrared Data Association (IrDA) was established in 1993 to create and maintain international standards for the hardware and software used in infrared communication links. This organization has created inter-operable interconnection standards, allowing a point-to-point user-access model to benefit the consumer. Its membership of over 160 companies encompasses all major hardware, software and systems providers, together with manufacturers and service providers.

2.4.1 Technical Details

This form of radio transmission - a focused ray of light in the infrared frequency spectrum - is modulated with information and sent from a transmitter to a receiver. The frequency spectrum is measured in terahertz (trillions of hertz) at cycles per second - the same as that used for activating a television remote control.

The communication between the devices requires that each has a transceiver (a combination of a transmitter and a receiver) in order to communicate. This capability is provided by microchip technology. However, devices may also require further, specialized software allowing communication to be synchronized. One example of this is the designated support that is in Microsoft's Windows 95 operating system.

The IrDA 1.1 standard has a maximum data transmission size of 2,048 bytes and a maximum transmission rate of 4Mbps. It is forecast that this will rise to 16Mbps in the near future. Although the IrDA standard only specifies compliance for the interconnection of products of up to 1m in distance, many IrDA-compliant products can connect at distances of much more than this.

IR can be used over longer interconnections and has applicability to local area networks (LANs). However, the maximum effective distance is approximately 1 mile, with a maximum bandwidth of 16Mbps.

One technological disadvantage is that IR uses a line-of-sight transmission. Thus, it is sensitive to atmospheric conditions and bad weather, particularly fog.

2.4.2 Applications

As mentioned above, the short distance of interconnection drives the main application of this technology between appliances. Thus, according to the IrDA, at present, the main benefits and applications are:

- Sending a document from your notebook computer to a printer
- Co-ordinating schedules and telephone books between desktop and hand-held (notebook) computers

- Sending faxes from a hand-held computer, via a public telephone, to a distant fax machine
- Beaming images from digital cameras to a desktop computer
- Exchanging messages, business cards, and other information between hand-held personal computers

For some of these functions, an interconnection between the hand-held or laptop computer and the desktop PC/printer in the form of an IR port, is required. Alternatively an IR adapter can be used.

2.4.3 The Future of IR Technology

Infrared technology claims to be as secure as cable applications. For example, the access to LANs requires the user to be an authorized user of the network. Also, it claims to be more reliable than wired technology as it obviates wear and tear on the hardware used.

In the future, it is forecast that this technology will be implemented in copiers, fax machines, overhead projectors, bank ATMs, credit cards, game consoles and headsets. All of these have local applications and it is really here where this technology is best suited, owing to the inherent difficulties in its technological process for interconnecting over distances.

Table 2.3 IrDA - Specification

Key Data	
Standard type	Fixed wireless (IR)
Location	Worldwide
Completion	1994
Key Players	
Controlling body	IrDA (Infrared Data Association)
Developers	Approx. 160 companies including Microsoft, IBM, and Ericsson

2.5 MMDS/LMDS MULTIPOINT DISTRIBUTION SERVICES, INTERNATIONAL

The local multipoint distribution service (LMDS) and multichannel multipoint distribution service (MMDS) have their historical roots in television. MMDS's precursor, the multipoint distribution service (MDS), was established by the Federal Communications Commission (FCC) in 1972. The Commission originally thought MDS would be used primarily to transmit business data. However, the service became increasingly popular for transmitting entertainment programming. Unlike conventional broadcast stations, whose transmissions are received universally, MDS programming is designed to reach only a subscriber-based audience.

In 1983 the Commission reassigned eight channels from the instructional television fixed service (ITFS) to MDS. These eight channels make up MMDS. MDS and MMDS channels are frequently used in combination with ITFS channels to provide video-entertainment programming to subscribers. This service is known as wireless cable.

Figure 2.3 shows the local multipoint distribution service (LMDS) architecture.

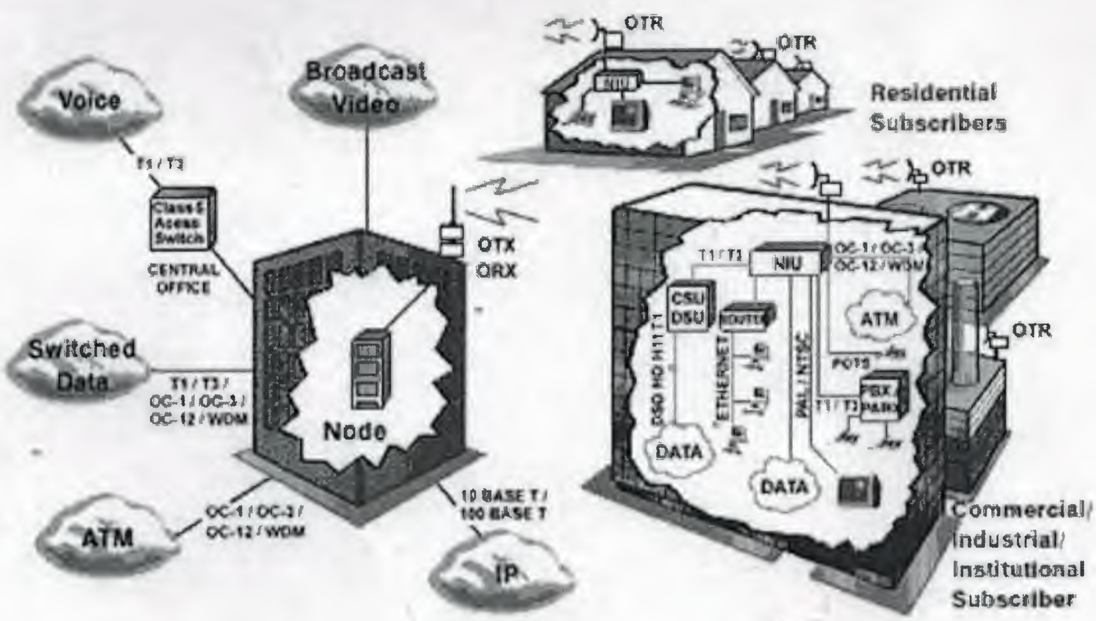


Figure 2.3 Local Multipoint Distribution service (LMDS) Architecture

2.5.1 LMDS

LMDS is a fixed broadband line-of-sight, point-to-multipoint, microwave system, which operates at a high frequency (typically within specified bands in the 24-40GHz range) and can deliver at a very high capacity, depending on the associated technologies. Given the complexity of the equipment required (and the power needed to deliver signals) both of these technologies are regarded as prohibitively expensive for the consumer market. Therefore, LMDS operators will initially be targeting enterprises and network operators, although the consumer market is likely to emerge over time as the cost of CPE comes down (partly driven by the take-up of IP). It should be noted that CPE costs $5,000 for LMDS in the 26GHz range.

2.5.2 MMDS

MMDS allows two-way voice, data and video streaming. It operates at a lower frequency than LMDS (typically within specified bands in the 2-10GHz range) and therefore has a greater range and requires a less powerful signal than LMDS. MMDS is a less complicated, cheaper system to implement. As a consequence, the CPE is cheaper, thus it has a wider potential addressable market. It is also less vulnerable to rain fade - the interference caused by adverse weather conditions that can undermine the quality of the microwave signal. However, the bandwidth offered by LMDS makes this the more viable option.

2.5.3 Technology

LMDS and MMDS share a number of common architectural features although they vary from one manufacturer to another according to features and capabilities. The core components are a base-station transceiver (transmitter and receiver), a customer-premise transceiver and some kind of CPE network interface unit (NIU) or card.

For downstream traffic to the customers' premises, the base station converts the digital bit stream containing voice, data and video information into microwaves that are transmitted to a small antenna on the customer's premises. The microwaves are then reconverted back into a digital bit stream by the NIU and delivered to the end-user. The process is reversed for upstream traffic. When the base station receives the microwave signal and has converted it into a digital bit stream, this is routed through, or 'backhauled' to, the wider network, through which the data or call is delivered to its destination.

Unlike the lower frequency cellular systems, LMDS and MMDS both require a line-of-sight between the base station and customer premise transceivers. This is a prerequisite for any system operating above approximately 2-3.5GHz. The base station is connected to the wide-area network switch or internet POP via either a high-capacity wire line (usually fiber optic) or wireless. Similarly, at the customer's premises, the signal can be delivered to the end-user terminals via either of these.

2.5.4 Benefits

Wireless systems are being deployed to fulfill a number of functions. On a network level they are suitable for both access and backbone infrastructure. It is generally agreed, however, that it is in the access market where the key advantages are held over wire line alternatives. The principal strengths of LMDS/MMDS are:

- Speed of network deployment is much quicker with wireless systems enabling rapid, early market entry
- Entry, deployment and upgrading costs are much lower than for wire line alternatives, for which engineering (cabling and trenching) costs are significantly higher
- The maintenance, management and operation expenditure is lower. Wireless systems can be rolled out much faster, enabling an earlier return on investment
- Scalable architectures enable expanded coverage and services in direct relation to the level of demand

Only one network architecture is required to provide a full suite of interactive voice, video and data services that can be expanded as and when desired.

Table 2.4 MMDS/LMDS - Specification

Key Data	
Standard type	Wireless cable
Location	North America
Completion	1999
Key Players	
Controlling body	FCC
Developers	Various

3. EDGE (ENHANCED DATA GSM ENVIRONMENT) HIGH-SPEED MOBILE DATA STANDARD, INTERNATIONAL

3.1 Overview

Enhanced data for global evolution (EDGE) is a high-speed mobile data standard, intended to enable second-generation global system for mobile communication (GSM) and time division multiple access (TDMA) networks to transmit data at up to 384 kilobits per second (Kbps). As it was initially developed just for GSM systems, it has also been called GSM384. Ericsson intended the technology for those network operators who failed to win spectrum auctions for third-generation networks to allow high-speed data transmission.

EDGE provides speed enhancements by changing the type of modulation used and making a better use of the carrier currently used, for example the 200kHz carrier in GSM systems. EDGE also provides an evolutionary path to third-generation IMT-2000-compliant systems, such as universal mobile telephone systems (UMTS), by implementing some of the changes expected in the later implementation in third-generation systems.

EDGE builds upon enhancements provided by general packet radio service (GPRS) and high-speed circuit switched data (HSCSD) technologies that are currently being tested and deployed. It enables a greater data-transmission speed to be achieved in good conditions, especially near the base stations, by implementing an eight-phase-shift keying (8 PSK) modulation instead of Gaussian minimum-shift keying (GMSK).

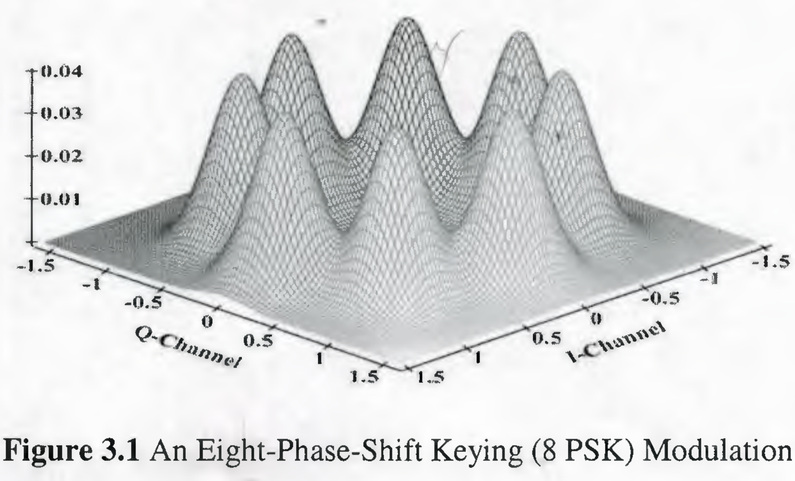


Figure 3.1 An Eight-Phase-Shift Keying (8 PSK) Modulation

3.2 Technology

For EDGE to be effective it should be installed along with the packet-switching upgrades used for GPRS. This entails the addition of two types of nodes to the network: the gateway GPRS service node (GGSN) and the serving GPRS service node (SGSN). The GGSN connects to packet-switched networks such as internet protocol (IP) and X.25, along with other GPRS networks, while the SGSN provides the packet-switched link to mobile stations.

The additional implementation of EDGE systems requires just one EDGE transceiver unit to be added to each cell, with the base stations receiving remote software upgrades. EDGE can co-exist with the existing GSM traffic, switching to EDGE mode automatically.

GPRS is based on a modulation technique called Gaussian minimum-shift keying (GMSK). This modulation technique does not allow as high a bit rate across the air interfaces as 8 PSK modulation if introduced into EDGE systems. 8 PSK modulation automatically adapts to local radio conditions, offering the fastest transfer rates near to the base stations, in good conditions. It offers up to 48Kbps per channel, compared to 14Kbps per channel with GPRS and 9.6Kbps per channel for GSM. By also allowing the simultaneous use of multiple channels, the technology allows rates of up to 384Kbps, using all eight GSM channels.

Because the basic infrastructure interfaces with the existing GPRS, GSM or TDMA infrastructure, the major vendors are the incumbent GPRS and GSM suppliers such as Ericsson, Nokia, Motorola and Alcatel.

3.2.1 Future

By providing an upgrade route for GSM/GPRS and TDMA networks, EDGE forms part of the evolution to IMT-2000 systems. Since GPRS is already being deployed, and IMT-2000 is not expected until 2002, there is a definite window of opportunity for EDGE systems to fill in as a stop-gap measure.

Table 3.1 EDGE (Enhanced Data GSM Environment) - Specification

Key Data	
Standard type	Mobile cellular (data)
Location	Worldwide
Completion	Expected 2001
Key Players	
Controlling body	Universal Wireless Communications Consortium
Developers	Ericsson and other developers

3.3 GPRS (GENERAL PACKET RADIO SYSTEM) WIRELESS DATA COMMUNICATION SERVICES, INTERNATIONAL

General packet radio service (GPRS) is a packet-based wireless data communication service designed to replace the current circuit-switched services available on the second-generation global system for mobile communications (GSM) and time division multiple access (TDMA) IS-136 networks. GSM and TDMA networks were designed for voice communication, dividing the available bandwidth into multiple channels, each of which is constantly allocated to an individual call (circuit-switched). These channels can be used for the purpose of data transmission, but they only provide a maximum transmission speed of around 9.6Kbps (kilobits per second).

In Figure 3.2 we can understand the GPRS functionality.

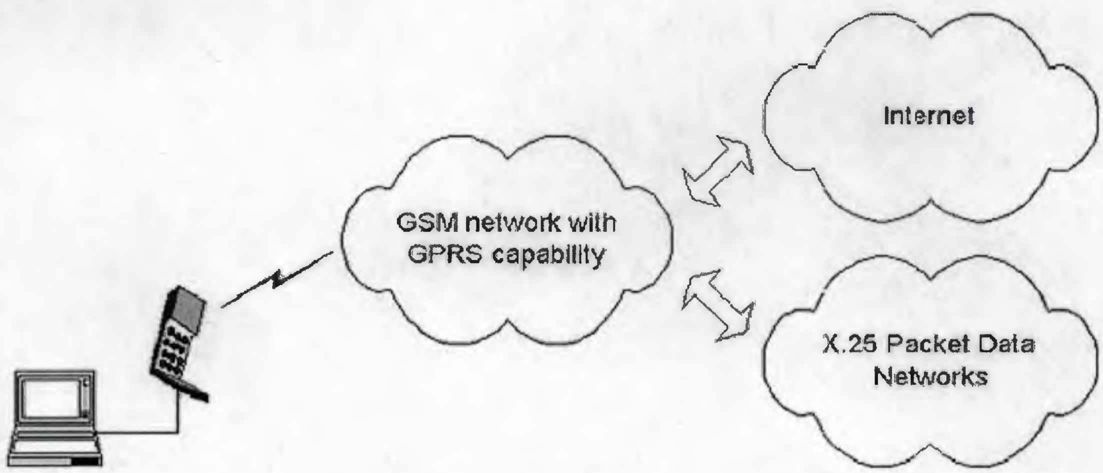


Figure 3.2 GPRS Functionality

3.3.1 GPRS

GPRS distributes packets of data from several different terminals in the system across multiple channels, making a much more efficient use of the bandwidth currently available for 'bursty' applications such as internet access. In theory, using all eight channels in a GSM network at once, a GPRS connection can achieve a data transfer rate of up to 114Kbps. These higher data rates will allow users to interact with multimedia websites and similar applications using a mobile handset or notebook computer. In theory, GPRS services should be cheaper than circuit-switched connections, with the network only being used when data is being transmitted.

GPRS communication is designed to compliment but not replace current circuit-switched networks, being used solely as an extra means of data communication. In practice, connection speeds will be significantly lower than the theoretical maximum, depending upon the amount of traffic on the network and upon the number of simultaneous channels supported by the handsets. In practice, GPRS is an evolutionary step towards enhanced data for global evolution (EDGE) and IMT-2000 systems.

Figure 3.3 shows us a GPRS configuration diagram.

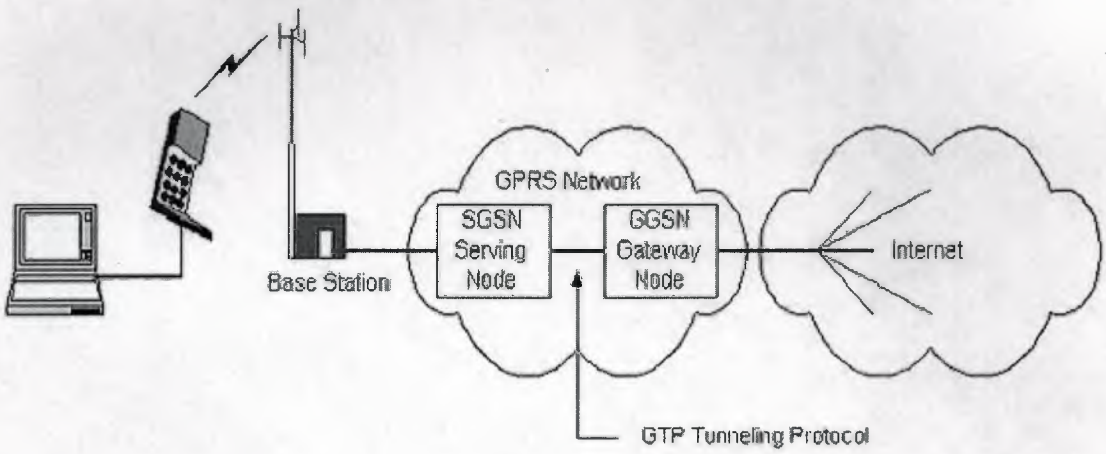


Figure 3.3A GPRS Configuration Diagram

3.3.2 Technology

As a packet-switched technology, GPRS supports the internet protocol (IP) and X.25, packet-switched standards currently used in wireline communications. As such, any service that is used on the fixed internet today will also be able to be used over GPRS. Because GPRS uses the same protocols as the internet, the networks can be seen as subsets of the internet, with the GPRS devices as hosts, potentially with their own IP addresses.

GPRS is based on a modulation technique called Gaussian minimum-shift keying (GMSK). This is where the rectangular pulses corresponding to the bitstream are filtered, using a Gaussian-shaped impulse response filter, producing lower side lobes than would otherwise be the case. This modulation technique does not allow as high a bit rate across the air interfaces as eight-phase-shift keying (8 PSK) modulation, which is being introduced in EDGE systems.

Enabling GPRS on a GSM or TDMA network requires the addition of two core modules, the Gateway GPRS Service Node (GGSN) and the Serving GPRS Service Node (SGSN). The GGSN acts as a gateway between the GPRS network and the public data networks such as IP and X.25. They also connect to other GPRS networks to enable roaming. The SGSN provides packet routing to all of the users in its service area.

As well as the addition of these nodes, GSM and TDMA networks have to have several extra upgrades to cope with GPRS traffic. Packet control units have to be added and mobility management, air interface and security upgrades have to be performed.

Because the basic infrastructure interfaces with the existing GSM or TDMA infrastructure, the major vendors are the incumbent GSM suppliers such as Ericsson, Nokia, Motorola and Alcatel.

Table 3.2 GPRS (General Packet Radio System) - Specification

Key Data	
Standard type	Mobile cellular (data)
Location	Worldwide
Completion	2000 (Phase 1)
Key Players	
Controlling body	GSM Association
Developers	European telecommunication companies

3.6.1 WAP Technology

WAP incorporates a simple micro browser, designed to work on the limited platforms of mobile handsets, with a central WAP gateway that performs the more processor-heavy operations. It defines a standard for data transmission to the handset, WDP (WAP datagram protocol), which is a variation of the internet standard transmission protocol, HTTP (Hypertext Transport Protocol), but redesigned for wireless network characteristics. WDP mostly differs from HTTP by stripping out much of the text information, replacing it with more efficient binary information for the low-bandwidth connection. The WAP data can be sent over any available network, be it the circuit-switched connection of TDMA (Time Division Multiple Access) IS-136 or packet-switched GPRS.

Added to this core transmission protocol are several scalable layers that can develop independently. The wireless transport layer security (WTLS) layer adds optional encryption facilities that enable secure transactions. WTP (WAP transaction protocol) adds transaction support, adding to the datagram service of WPD, while WSP (WAP session protocol) allows efficient data exchange between applications.

WAP also defines an application environment (WAE) that enables third-party developers to develop more advanced services and applications, along with the microbrowser used to access web pages on the handset itself.

To access Internet content, the user's handset sends a request to the WAP gateway, which retrieves the information in either HTML (Hypertext Markup Language) or WML (Wireless Markup Language) from the host server. WML is a variation of HTML, designed specifically to enable viewing on the limited mobile terminal platform. If the information retrieved is in HTML, a filter in the gateway will attempt to convert it to WML. The information will then be transmitted to the handset over whatever network is available, using the transmission protocols described above.

In some cases, where HTML data is generated using a style sheet to convert XML data using an XSL processor, a WML style sheet can be added to the system to generate seamless information in the correct format for wireless viewing.

3.6.2 Future of WAP

Because WAP is a protocol designed to work over any mobile network, its use will continue to increase as more sophisticated data transmission technologies are introduced (e.g. GPRS, EDGE (Extended Data for Global Evolution) and W-CDMA (Wideband-CDMA)). As the bandwidth available to mobile terminals and the quality of displays improve, WAP can be enhanced to provide as effective an internet viewing experience as is possible on fixed terminals.

Table 3.4 WAP (Wireless Application Protocol) - Specification

Key Data	
Standard type	Mobile cellular (data)
Location	Worldwide
Completion	Version 1.2 standardized 1999
Key Players	
Controlling body	WAP Forum
Developers	Nokia, Ericsson, Motorola, Phone.com

3.7 TURKEY GPRS MOBILE DATA NETWORK, TURKEY

A recent agreement between Motorola and Turkish GSM (Global System for Mobile Communications) operator Telsim looks to expand Turkey's countrywide GSM. The project includes the supply of GSM 900Mhz infrastructure equipment for the next three years and a full trial overlay general packet radio service (GPRS) core mobile data network.

Currently, 2.8 million subscribers are on the Telsim network, and the expansion will help enable service to over five million subscribers. GPRS handsets will be used in the data trial to allow easy and secure access to the internet and corporate intranets, so users have mobile access to email, train timetables, weather and traffic conditions wherever roaming agreements are in place. The GSM expansion contract will enable the network capacity and coverage to handle the expected increase in mobile data users, with the GPRS overlay delivering the content and services to the wireless devices. The expansion work will begin with immediate effect, with the GPRS trial scheduled for second quarter of 2000.

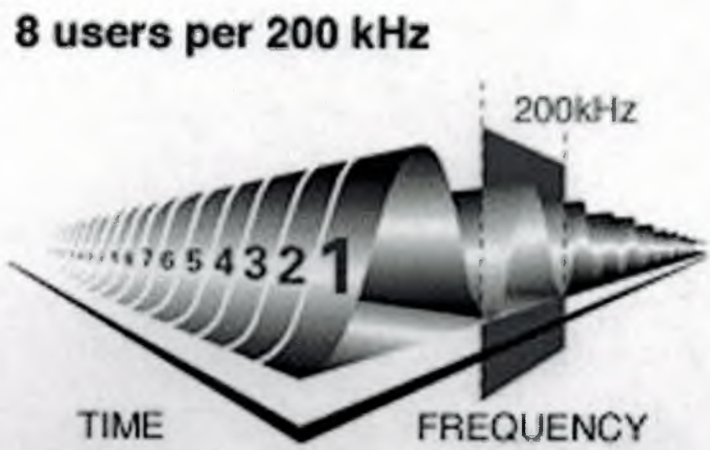


Figure 3.7

3.7.1 GSM 900 and DCS 1800

The large subscriber growth and demand for cohesive coverage and service in Western Europe resulted in an unprecedented collaboration among many telecommunication organizations. This collaboration produced the Global System for Mobile Communication (GSM) - a Pan European cellular radio standard now used by operators around the world.

GSM and DCS 1800 systems use the Time Division Multiple Access (TDMA) technique. TDMA systems begin with a discrete part of the radio frequency spectrum referred to as one carrier. Each carrier is then divided into time slots and one user is assigned to each time slot. GSM and DCS 1800 systems divide a 200kHz carrier into 8 time slots. A time slot is referred to as a 'channel' in TDMA-based systems.

GSM defines a complete and integrated digital cellular network system. The development of GSM started in 1982 as the logical evolution of mobile radio within Europe to overcome the difficulties arising from the operation of numerous incompatible analogue cellular systems throughout the region. Its operators changed the meaning of the acronym GSM from Groupe Spécial Mobile to Global System for Mobile Communications as a marketing decision to underline the international nature of the standard, with international roaming as a key selling feature.

3.7.2 GPRS

As a packet-switched technology, GPRS supports the internet protocol (IP) and X.25, packet-switched standards currently used in wireline communications. As such, any service that is used on the fixed internet today will be able to be used over GPRS. Because GPRS uses the same protocols as the internet, the networks can be seen as subsets of the Internet, with GPRS devices as hosts, potentially with their own IP addresses.

GPRS is based on a modulation technique called Gaussian minimum-shift keying (GMSK). This is where the rectangular pulses corresponding to the bit stream are filtered using a Gaussian-shaped impulse response filter, producing lower sidelobes than would otherwise be the case. This modulation technique does not allow as high a bit rate across the air interfaces as eight-phase-shift keying (8 PSK) modulation, being introduced in EDGE (Enhanced Data GSM Environment) systems.

Enabling GPRS on a GSM or TDMA network requires the addition of two core modules, the Gateway GPRS Service Node (GGSN) and the Serving GPRS Service Node (SGSN). The GGSN acts as a gateway between the GPRS network and the Public Data Networks such as IP and X.25. They also connect to other GPRS networks to enable roaming. The SGSN provides packet routing to all users in its service area.

Table 3.5 Turkey GPRS - Specification

Key Data	
Project type	Mobile Cellular (data)
Standard	GPRS
Location	Turkey
Estimated Investment	Unknown
Completion	2000
Key Players	
Developer	Motorola
Customer	Telsim

4. CDMA IS-95 (CODE DIVISION MULTIPLE ACCESS) DIGITAL MOBILE TELEPHONE STANDARD, INTERNATIONAL

4.1 Overview

CDMA (code division multiple access) is a second-generation digital mobile telephone standard which takes a different approach to the other, competing standards: GSM (Global System for Mobile Communications) and TDMA (Time Division Multiple Access). Where GSM and TDMA divide the available bandwidth into 'channels' using a combination of frequency bands and time-slices, CDMA spreads the signal over a wide bandwidth, identifying each channel using unique digital codes. This means it can provide greater bandwidth efficiency, and hence a greater potential number of channels.

Despite being mostly confined to the US, CDMA systems accounted for 13% of digital subscribers worldwide, with 49 million subscribers in December 1999. CDMA shares the 1900MHz frequency bands with GSM in the US but, as mentioned above, spreads each channel across a wider spectrum.

CDMA is currently incompatible with TDMA and GSM, and since most networks are confined to the US, it does not cater for global roaming. The best features of all three standards are being brought together to allow inter-operability for the third-generation networks, such as UMTS (Universal Mobile Telecommunication System) using the IMT-2000 standard.

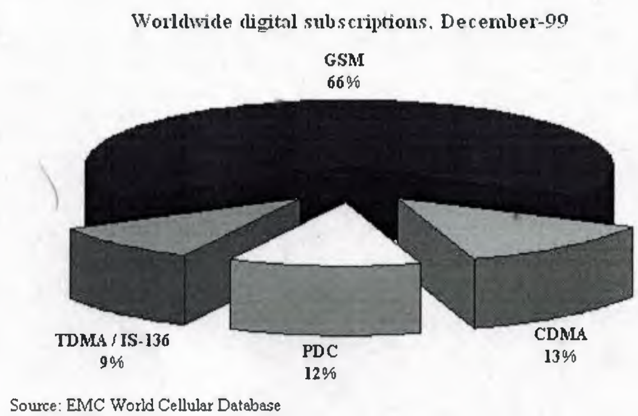


Figure 4.1 Worldwide Digital Subscriptions.

4.2 CDMA Technical Details

TDMA and GSM systems commonly start with a slice of spectrum referred to as one "carrier". Each carrier is then divided into time slots. Only one subscriber at a time is assigned to each time slot, or channel. No other conversations can access this channel until the subscriber's call is finished, or until that original call is handed off to a different channel by the system. For example, GSM systems create 8 time-division channels in 200kHz(kilohertz) wide carriers.

With CDMA, all users share the same 1,250kHz wide carrier, but unique digital codes are used to differentiate subscribers. The codes are shared by both the mobile station and the base station and are called "pseudo-random code sequences". Base stations in the system distinguish themselves from each other by transmitting different portions of the code at a given time. In other words, the base stations transmit time-offset versions of the same pseudo-random code. In order to ensure that the time offsets used remain unique from each other, CDMA stations must remain synchronized to a common time reference. The global positioning system (GPS) provides this precise common time reference. GPS is a satellite-based radio navigation system capable of providing a practical and affordable means of determining continuous position, velocity, and time to an unlimited number of users.

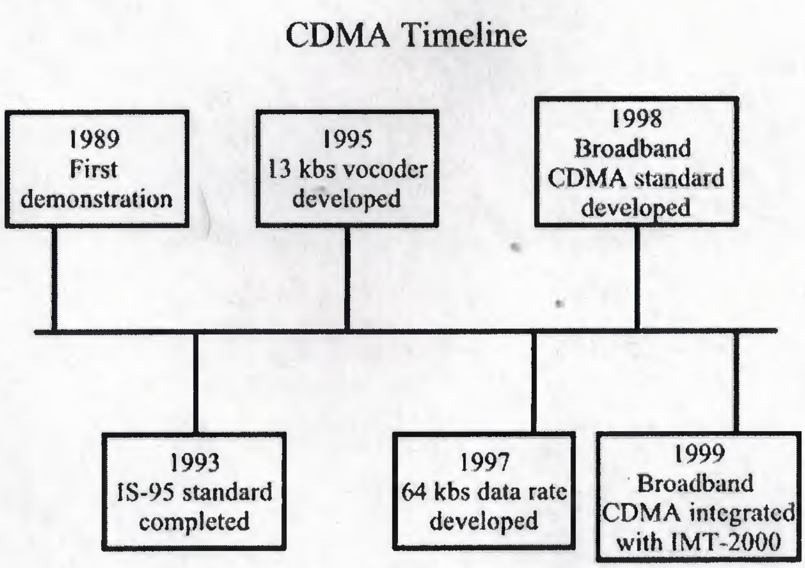


Figure 4.2 CDMA Timeline

4.2.1 Spread Spectrum

One of the unique aspects of CDMA is that while there are certainly limits to the number of phone calls that can be handled by a carrier, this is not a fixed figure. The number of simultaneous connections any base station is able to handle is the result of a trade-off with the range of the base station and the quality of each connection. A standard CDMA connection has a digital transfer rate of 9.6Kbps (kilobits per second), the same as GSM. The voice data part of the connection is transmitted at a rate of 8Kbps. All connections are shared around the spread spectrum with a maximum transfer rate of 1.23Mbps (Megabits per second), theoretically allowing a maximum of 131 connections, compared to 48 GSM connections in a similar bandwidth.

CDMA supports variable bandwidth connections, with enhanced standards at 13Kbps and 64Kbps for superior quality speech and faster data connections. This 'bandwidth-on-demand' limits the number of simultaneous connections to a particular base station.

4.2.2 Privacy

Traditional uses of spread spectrum are in military operations. Because of the wide bandwidth of a spread spectrum signal, it is very difficult to jam, difficult to interfere with, and difficult to identify. This is in contrast to technologies using a narrower bandwidth of frequencies. Since a wideband spread spectrum signal is very hard to detect, it appears as nothing more than a slight rise in the "noise floor" or interference level. With other technologies, the power of the signal is concentrated in a narrower band, which makes it easier to detect. The narrow band is also more prone to interference than the spread-spectrum of CDMA.

Increased privacy is inherent in CDMA technology. CDMA phone calls will be secure from the casual eavesdropper since, unlike an analog conversation, a simple radio receiver will not be able to pick individual digital conversations out of the overall RF radiation in a frequency band. TDMA (time division multiple access) and GSM systems have to add an extra stage of encryption to the signal to ensure privacy, whereas encryption is inherent to the CDMA system.

4.2.3 Future of CDMA

Aspects of CDMA technology have been incorporated into the third-generation IMT-2000 standard, designed to allow interoperability between the different networks and integration with satellite technology. This third-generation technology will allow broadband data access that can be used for voice, video and data communication at speeds of up to 2Mbps.

Table 4.1 CDMA IS-95 (Code Division Multiple Access) - Specification

Key Data	
Standard Type	Mobile Cellular (voice)
Location	US
Completion	1993
Key Players	
Controlling Body	Telecommunications Industry Association (TIA)
Developers	TIA TR-45.5 subcommittee

4.3 GSM (GLOBAL SYSTEM FOR MOBILE COMMUNICATIONS) DIGITAL MOBILE TELEPHONE STANDARD, INTERNATIONAL

GSM (Global System for Mobile Communications) is a second-generation digital mobile telephone standard using a variation of Time Division Multiple Access (TDMA). It is the most widely used of the three digital wireless telephone technologies - CDMA (Code Division Multiple Access), GSM and TDMA. GSM digitizes and compresses voice data, then sends it down a channel with two other streams of user data, each in its own time slot. It operates at either the 900, 1800 or 1,900MHz frequency bands.

GSM was initially developed as a pan-European collaboration, intended to enable mobile roaming between member countries. It is now the most widely used mobile standard worldwide, operational in some form in 132 countries. From December 1999, 66% of all digital mobile subscriptions in the world used GSM phones on GSM networks.

One of the key advantages of GSM over the other networks is that many GSM network operators have roaming agreements with foreign operators so users can often continue to use their mobile phones when they travel to other countries.

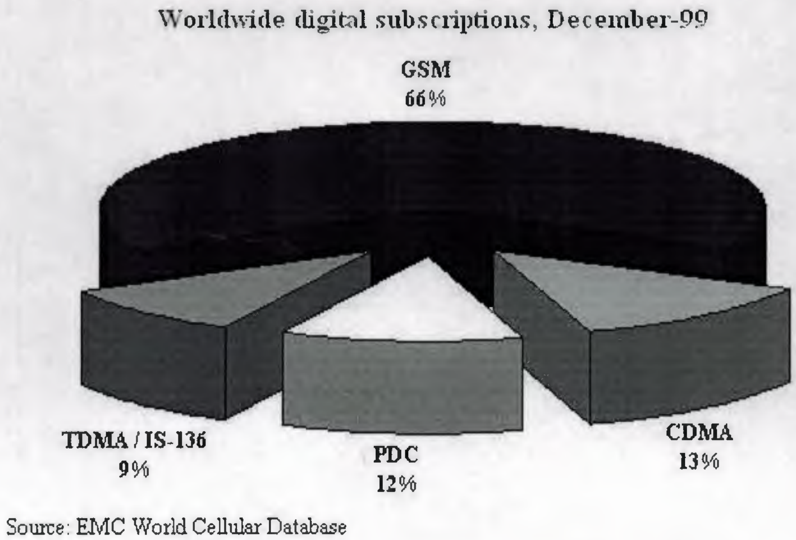


Figure 4.3 Worldwide Digital Subscription

4.3.1 Technical Details

The GSM network can be divided into three broad parts

- The subscriber carries the mobile station
- The base station subsystem controls the radio link with the mobile station
- The network subsystem performs the switching of calls between the mobile users and other mobile and fixed network users

4.3.2 Mobile Station

The mobile station consists of the mobile equipment, i.e. the handset, and a smart card called the Subscriber Identity Module (SIM). The SIM provides personal mobility, so that the user can have access to subscribed services irrespective of a specific terminal.

By inserting the SIM card into another GSM terminal, the user is able to receive and make calls from that terminal, and receive other subscribed services.

The International Mobile Equipment Identity (IMEI) uniquely identifies the mobile equipment. The SIM card contains the International Mobile Subscriber Identity (IMSI) used to identify the subscriber to the system, a secret key for authentication and other information. The IMEI and the IMSI are independent, thereby allowing personal mobility. The SIM card may be protected against unauthorized use by a password or personal identity number.

4.3.3 Base Station Subsystem

The base station subsystem is composed of two parts, the base transceiver station and the base station controller. These communicate across a standardized "Abis" interface, allowing operation between components made by different suppliers.

The base transceiver station houses the radio transceivers that define a cell and handles the radio-link protocols with the mobile station. In a large urban area, there will potentially be a large number of base transceiver stations deployed, thus the requirements for a base transceiver station are ruggedness, reliability, portability and minimum cost. The base station controller manages the radio resources for one or more base transceiver stations. It is the connection between the mobile station and the mobile services switching center.

4.3.4 Network Subsystem

The central component of the network subsystem is the mobile services switching center. This acts like a normal switching node of the PSTN (Public Switched Telephone Network) or ISDN (Integrated Services Digital Network) and connects the mobile signal to these fixed networks. It additionally provides all the functionality needed to handle a mobile subscriber, such as registration, authentication, location updating, handovers and call routing to a roaming subscriber.

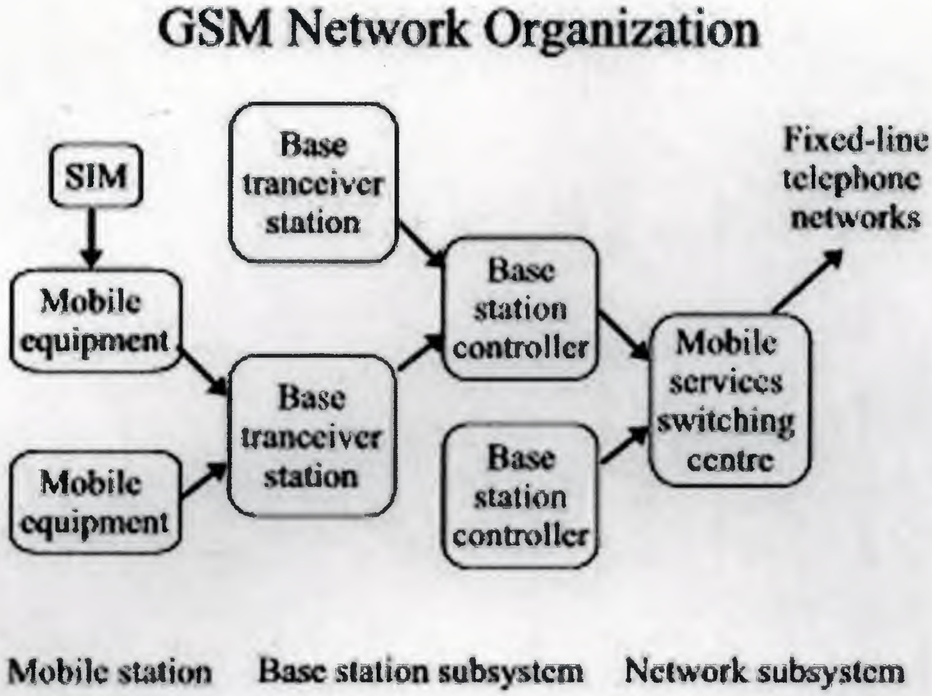


Figure 4.4

GSM Network Organization

4.3.5 Radio Spectrum

Since radio spectrum is a limited resource shared by all users, a method must be devised to divide up the bandwidth among as many users as possible. The method chosen by GSM is a combination of Time and Frequency Division Multiple Access (TDMA/FDMA). The FDMA part involves the division by frequency of the (maximum) 25MHz bandwidth into 124 carrier frequencies spaced 200kHz apart. One or more carrier frequencies are assigned to each base station.

Each of these carrier frequencies is then divided in time, using a TDMA scheme. The fundamental unit of time in this TDMA scheme is called a burst period and it lasts 15/26 milliseconds (ms) (or approximately 0.577ms). Eight burst periods are grouped into a TDMA frame (120/26ms, or approximately 4.615ms), which forms the basic unit for the definition of logical channels. One physical channel is one burst period per TDMA frame.

The number and position of their corresponding burst periods define channels. All these definitions are cyclical, and the entire pattern repeats approximately every three hours. Channels can be divided into dedicated channels, which are allocated to a mobile station, and common channels, which are used by mobile stations in idle mode.

4.3.6 Speech Coding

GSM is a digital system, so speech, which is inherently analog, has to be digitised. The GSM group studied several speech coding algorithms on the basis of subjective speech quality and complexity (which is related to cost, processing delay and power consumption once implemented) before arriving at the choice of a Regular Pulse Excited - Linear Predictive Coder (RPE-LPC) with a long-term predictor loop. Basically, information from previous samples, which does not change very quickly, is used to predict the current sample. The coefficients of the linear combination of the previous samples, plus an encoded form of the residual, the difference between the predicted and actual sample, represent the signal. Speech is divided into 20 (ms) samples, each of which is encoded as 260 bits, giving a total bit rate of 13Kbps (kilobits per second). This is the so-called full-rate speech coding. Recently, an enhanced full-rate (EFR) speech-coding algorithm has been implemented by some North American GSM1900 operators. This is said to provide improved speech quality using the existing 13Kbps bit rate.

4.3.7 Future of GSM

GSM, together with other technologies, is part of an evolution of wireless mobile telecommunication that includes Enhanced Data GSM Environment (EDGE), General Packet Radio System (GPRS), High-Speed Circuit-Switched Data (HSCSD) and Universal Mobile Telecommunications Service (UMTS).

Table 4.2 GSM (Global System For Mobile Communications) – Specifications

Key Data	
Standard type	Mobile cellular (voice)
Location	Europe / Worldwide
Completion	1991
Key Players	
Controlling body	GSM Association
Developers	European telecommunication companies

4.4 PDC (PERSONAL DIGITAL CELLULAR) TELEPHONE TECHNOLOGY, INTERNATIONAL

PDC (Personal Digital Cellular) is a second-generation technology used in digital cellular telephone communication in Japan. It uses a variation of TDMA (time division multiple access), which divides each cellular channel into individual time slots in order to increase the amount of data that can be carried. Several different mutually incompatible implementations of TDMA technologies are in use worldwide, the most prolific being GSM (Global System for Mobile Communications).

PDC is currently only used in Japan, with the first systems introduced by NTT DoCoMo in 1991 as a replacement for the earlier analog networks. It operates in the 800MHz and 1,500MHz bands, making very efficient use of the available bandwidth. With bandwidth demand so high in Japan, the system can operate in two modes: full rate and half rate. Half-rate channels have reduced speech quality and data transmission rates, but allow more channels to occupy the same bandwidth. Subscriber numbers are so high in Japan that, although PDC is only operational in this one country, it accounted for 12% of global digital subscriptions in December 1999.

Along with the other mobile communication standards, PDC can be developed along a gradual evolutionary path to the global IMT-2000 standard. Indeed, one of the IMT-2000 technologies, WCDMA (Wideband Code Division Multiple Access), is going through initial testing in Japan.

4.4.1 PDC Technical Details

PDC is the most spectrally efficient of TDMA technologies, with six half-rate (or three full-rate) channels possible in a 25kHz frequency space, compared to three channels in 30kHz in IS-136 and eight channels in 200kHz for GSM. It even compares favorably to CDMA (code division multiple access), using spread-spectrum technology to allow up to 131 channels in a 1,250kHz spectrum band.

Full-rate speech normally requires a digital data transfer rate of 9.6Kbps (kilobits per second), as is used in GSM, TDMA IS-136 and CDMA networks. PDC offers two alternative rates; 9.6Kbps in full-rate channels or 5.6Kbps in the half-rate channel. The quality of speech along a 5.6Kbps connection is significantly lower than the standard 9.6Kbps connection, but is a useful trade-off with the number of channels available.

The PDC network supports many advanced features in-line with the other second-generation technologies, such as text messaging and caller identification. Utilizing its Intelligent Network (IN) capabilities, PDC also supports pre-paid calling, personal numbers, Universal Access Numbers, advanced charging schemes and wireless virtual private networks (VPNs). VPNs are closed user groups that allow colleagues working in different locations to communicate through the mobile phone network as though they were using a conventional office phone system.

In Japan indoor coverage is of high importance, providing an important service differentiator for the different networks. PDC has been designed to enable solutions to improve congestion in places such as shopping malls, offices and subway stations. A network of micro and pico base stations can be deployed indoors, along with distributed antenna systems and repeaters, all building upon the planning strengths of the PDC standard.

For the purposes of data transmission, PDC-P (PDC Mobile Packet Data Communication System) has been introduced. This utilizes a packet-based system, letting users use a single channel simultaneously. This is valuable for 'bursty' applications such as internet browsing, where the conventional 'circuit-switched' approach wastes bandwidth by requiring the channel to be permanently dedicated to an individual user. Packet-switched data transmission is also more convenient for the user who is permanently on-line, with them only paying for the volume of data transmitted. By enhancing network efficiency, PDC-P allows a data transfer rate of 28.8Kbps.

4.4.2 The Future

The move to packet-switched data transfer is one of the important steps towards the common IMT-2000 standard for global mobile communication. PDC therefore offers an upgrade path to networks with a mobile data transfer rate of up to 2Mbps.

Table 4.3 PDC (Personal Digital Cellular) - Specification

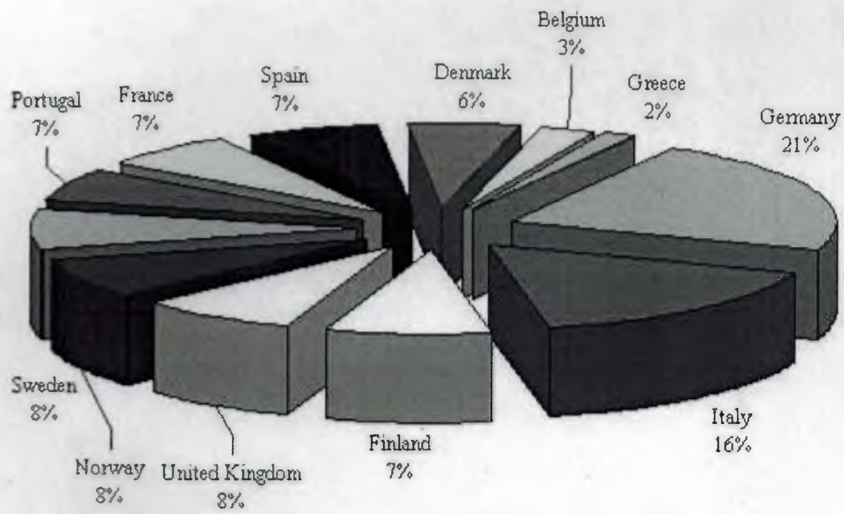
Key Data	
Standard type	Mobile cellular (voice)
Location	Japan
Completion	1991
Key Players	
Controlling body	Various
Developers	NTT DoCoMo

4.5 SMS (SHORT MESSAGE SYSTEM) MOBILE TECHNOLOGY, INTERNATIONAL

The Short Message Service (SMS) allows text messages to be sent and received to and from mobile telephones. The text can comprise words or numbers or an alphanumeric combination. SMS was created as part of the GSM Phase 1 standard. The first short message is believed to have been sent in December 1992 from a PC to a mobile phone on the Vodafone GSM network in the UK. Each short message is up to 160 characters in length when Latin alphabets are used, and 70 characters in length when non-Latin alphabets such as Arabic and Chinese are used.

There is no doubting the success of SMS. The market in Europe alone had reached over three billion short messages per month as of December 1999, despite little in proactive marketing by network operators and phone manufacturers. Key market drivers over the next two years, such as the Wireless Application Protocol (WAP), will continue this growth path.

Typical uses of SMS include notifying a mobile phone owner of a voicemail message, alerting a salesperson of an inquiry and telling a driver the address of the next. pickup



Source: GSM Association

Figure 4.5

SMS Traffic in Europe by Country, April 1999

4.5.1 SMS Technology

SMS is essentially similar to paging, but SMS messages do not require the mobile phone to be active and within range, as they will be held for a number of days until the phone is active and within range. SMS messages are transmitted within the same cell or to anyone with roaming capability. They can also be sent to digital phones from a web site equipped with a PC Link or from one digital phone to another. An SMS gateway is a web site that lets you enter an SMS message to someone within the cell served by that gateway or acts as an international gateway for users with roaming capability.

The SMS is a store and forward service. In other words, short messages are not sent directly from sender to recipient, but via an SMS Center. Each mobile telephone network that supports SMS has one or more messaging centers to handle and manage the short messages.

The SMS features confirmation of message delivery. This means that, unlike paging, users do not simply send a short message and trust and hope that it gets delivered. Instead the sender of the short message can receive a return message back notifying them whether the short message has been delivered or not.

Short messages can be sent and received simultaneously with GSM (Global System for Mobile Communications) voice, data and fax calls. This is possible because whereas voice, data and fax calls take over a dedicated radio channel for the duration of the call, short messages travel over and above the radio channel using the signaling path. As such, users of SMS rarely, if ever, get a busy or engaged signal as they can do during peak network usage times.

Ways of sending multiple short messages are available. SMS concatenation (stringing several short messages together) and SMS compression (getting more than 160 characters of information within a single short message) have been defined and incorporated in the GSM SMS standards.

The network operator needs to purchase its first generation SMS Center as part of the network-commissioning plan. The initial SMS Center may simply be a voice mail platform module or a stand-alone SMS Center. It is not possible to make the SMS available without an SMS Center since all short messages pass through the SMS Center.

4.5.2 Recent SMS Developments

Because simple person-to-person messaging is such an important component of total SMS traffic volumes, anything that simplifies message generation is an important enabler of SMS. Predictive text input algorithms significantly reduce the number of keystrokes that need to be made to input a message. T9, from Tegic, anticipates which word the user is trying to generate. Widespread incorporation of such algorithms into the installed base of mobile phones will typically lead to an average uplift in SMS traffic of 25% per enabled user. These predictive text algorithms support multiple languages.

The introduction of standardized protocols such as SIM Application Toolkit and the Wireless Application Protocol (WAP) contribute to an increase in messaging usage by providing a standard service development and deployment environment for application developers and business partners. These protocols also make it easier for users to reply to and otherwise access messaging services through custom menus on the phone. While these protocols are only a means to an end and not new messaging destinations or services, they are likely to lead to a 10-15% uplift in total SMS volumes.

The introduction of more user-friendly terminals contributes to increases in messaging usage. Terminals such as smart phones make it easier for users to originate reply to and otherwise access messaging services through the provision of a QWERTY keyboard, rather than the limited keypad on standard mobile phones.

Table 4.4 SMS (Short Message System) – Specification

Key Data	
Standard type	Mobile cellular (voice)
Location	Europe
Completion	1992
Key Players	
Controlling body	GSM Association
Developers	European telecommunication companies

4.6 TDMA IS-136 (TIME DIVISION MULTIPLE ACCESS) MOBILE TELEPHONE TECHNOLOGY, INTERNATIONAL

TDMA (Time Division Multiple Access) is a second-generation technology used in digital cellular telephone communication, which divides each cellular channel into individual time slots in order to increase the amount of data that can be carried. Several different mutually incompatible implementations of TDMA technologies are in use worldwide, the most prolific being GSM (Global System for Mobile Communications).

However, the implementation that is commonly referred to as TDMA is that defined by IS-136 by the Telecommunication Industries Association (TIA).

TDMA forms part of the evolution from first-generation analog systems to second- and then third-generation digital systems. It builds upon the original analog Advanced Mobile Phone Service (AMPS), using the same frequency band of 800MHz, but also operates in the Personal Communication Services (PCS) band of 1,900MHz in the US. Although TDMA could be considered as the least technologically advanced of the second-generation mobile systems, it has proven very popular in the US and developing world as a simple upgrade from analog to digital services. As of December 1999, there were approximately 36 million TDMA subscriptions, accounting for 9% of the digital market.

Although TDMA is currently incompatible with other second-generation systems, there is now a common upgrade path to IMT-2000, which should become the world-wide standard for third-generation mobile communication.

4.6.1 TDMA Technical Details

TDMA enhances the AMPS service by dividing each of the original 30kHz analog channels into three digital time-division channels, thereby tripling the capacity of the system (called D-AMPS).

Like AMPS, D-AMPS uses frequency ranges within the 800 and 900 MHz spectrum. Each service provider can use half of the 824-849MHz range for receiving signals from cellular phones and half the 869-894MHz range for transmitting to cellular phones. The receiving channels are called reverse channels and the sending channels are called forward channels. The division of the spectrum into sub-band channels is achieved by using frequency division multiple access (FDMA). The TDMA processing is added to each sub-band channel created with FDMA to triple the number of channels available.

TDMA IS-136 was first specified in 1994 and is an evolution of the older IS-54 (also known as Digital AMPS or D-AMPS) standard. IS-54 used the three time-division channels for the voice information only, while IS-136 also used TDMA on the control channel.

A Digital Control Channel (DCCH) increases paging capacity, and sharing TDMA traffic and control on the same digital radio improves efficiency and reduces hardware costs. DCCH also provides the platform for a new generation of advanced wireless capabilities.

TDMA supports text messaging, caller identification and closed-user groups. Using a hierarchical cell structure, it is possible to overlay extra capacity in particular hotspots and offer different services to particular subscribers or areas within the network.

IS-136 supports a variety of digital value-added services, at the same time as being able to coexist with the AMPS network. The inherent compatibility between AMPS and TDMA, coupled with the deployment of dual-mode wireless handsets, ensures ubiquitous network access for the subscriber whether in an analog or digital serving area.

TDMA is designed to allow for seamless interworking and infrastructure sharing with IS-136 TDMA networks at 800MHz and 1,900MHz, as well as the analog AMPS networks. This allows new PCS operators to offer full wide-area coverage from day one through infrastructure sharing or roaming agreements with 800MHz operators in the same geographical area.

The newer IS-136+ and IS-136HS (based upon Enhanced Data Rates for Global Evolution [EDGE] standards) allow a higher bit rate transmission, along with the introduction of General Packet Radio Service (GPRS) data throughput can be increased to over 473Kbs per channel. This packet-switched upgrade can be overlaid on existing networks and allows the system to retain its backward compatibility.

A combined GPRS-136HS technology, known simply as EGPRS, is an ideal bearer for any packet-switched application, including internet connections using TCP/IP. From the end user's point of view, the EGPRS network is an extension of the internet via wireless access.

4.6.2 The Future

The enhancements available to convert an existing TDMA system to a high-throughput packet-switched system can bring some of the proposed advantages from IMT-2000 to existing networks not needing the increased radio spectrum allocation the third-generation (3G) system requires. It can also be seen as part of a gradual progression to 3G systems, eventually allowing interoperability with the other networks using the IMT-2000 standard.

4.7 TETRA (TERRESTRIAL TRUNKED RADIO) MOBILE TELEPHONE TECHNOLOGY, INTERNATIONAL

Terrestrial trunked radio (TETRA) is the modern digital private mobile radio (PMR) and public access mobile radio (PAMR) technology for police, ambulance, fire, transport and security services. It is use by utilities, the military, public access, fleet management, closed user groups, factory site services, mining, etc. In short, TETRA is digital radio.

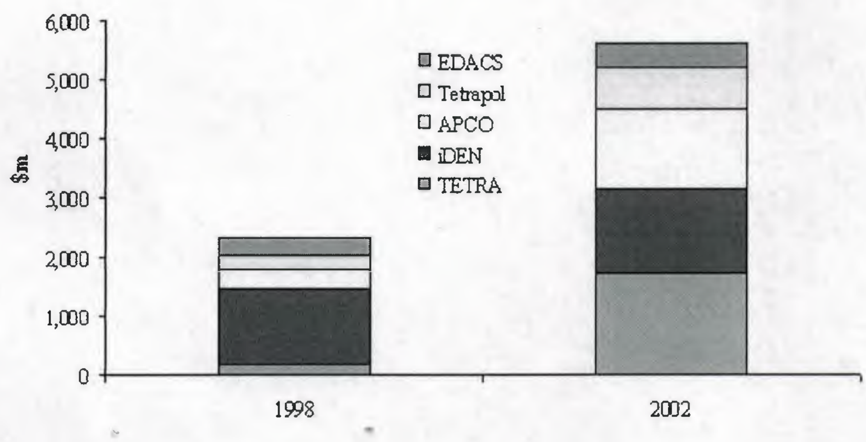


Figure 4.6 The World-Wide Market for Digital Mobile Radio Infrastructure, 1998-2002.

The standard is defined by the European Telecommunications Standards Institute (ETSI), which established a memorandum of understanding (MoU) in 1994 and now has 56 members across 19 countries. The Technical Body has over 150 representatives involved in the various technical working groups, with support from the TETRA MoU Association providing further expertise in specialist areas. Besides representatives from Europe, activity has now extended worldwide to include the US, China, Asia and the Middle East.

4.7.1 TETRA Technology

TETRA offers the automatic operation and frequency efficiency of trucking combined with the terminal autonomy of a conventional PMR. TETRA has a multi-mode capability by combining these two modes, trunking and direct (conventional), into a single terminal equipment, and it also provides the standardized way of inter-working between these t designed to offer bandwidth-on-demand, a facility to have a variable amount of bandwidth allocated for the call duration, depending on the application.

TETRA is also designed for emergency situations, when almost instantaneous communication is required, both between individuals and within a group of an unlimited size. Priority calls can be made, backed by call pre-emption if required, and on occasions an all-informed communication.

4.7.2 Benefits of TETRA

TETRA offers fast call set-up time, group communication support, direct mode operation between radios, packet data and circuit data transfer services, frequency economy and security features. TETRA uses time division multiple access (TDMA) technology with four user channels on one radio carrier and 25kHz spacing between carriers. This makes it inherently efficient in the way that it uses the frequency spectrum. For emergency systems in Europe the frequency bands 380-383MHz and 390-393MHz have been allocated by a single harmonized digital land mobile system. Additionally, whole or appropriate parts of the bands 383-395MHz and 393-395MHz can be utilized should the bandwidth be required.

For civil systems in Europe, the frequency bands 385-389.9MHz and 395-397.9MHz, 410-420MHz and 420-430MHz, 450-460MHz and 460-470MHz, 870-876MHz and 915-921MHz have been allocated for TETRA.

A TETRA trunking facility provides a pooling of all radio channels, which are then allocated on demand to individual users, in both voice and data modes. By the provision of national networks, countrywide roaming can be supported, the user being in constant seamless communications with his colleagues. TETRA supports point-to-point and point-to-multipoint communications both through the TETRA infrastructure and by use of direct mode without infrastructure.

4.7.3 The Future

TETRA standardization has reached a mature state. The major future developments involve the installation and maintenance of the technology across the world. The end of 1999 has awarded more than 40 infrastructure contracts awarded worldwide, with a combined value of $1.5 billion. TETRA systems are being installed in most of the EU and EFTA countries, as well as many of the neighboring ones, to serve both the emergency services and the civil market.

A pan-European PMR TETRA network is being rolled out, starting with the UK, France and Germany. The emergency services in the UK, Holland, Belgium, Gibraltar, Norway and Finland are using TETRA technology for their nationwide public safety networks, with most of them are already in the process of setting up the network.

Table 4.5 TETRA (Terrestrial Trunked Radio) - Specification

Key Data	
Standard type	Mobile cellular (voice)
Location	Europe, and selected countries
Completion	1998
Key Players	
Controlling body	ETSI
Developers	TETRA MoU Group

5. CONNEXION BROADBAND SATELLITE TELECOMMUNICATIONS, INTERNATIONAL

5.1 Overview

Connexion is a broadband telecommunications service from Boeing that offers real-time, high-speed, two-way connectivity for commercial airlines, private business jets and US government customers worldwide.

In March 2002 Lufthansa Airlines began installing the first Connexion antenna on a 747-400 for use in a three-month trial in late 2002. Lufthansa is one of 17 airlines working with Boeing on a new Connexion service.

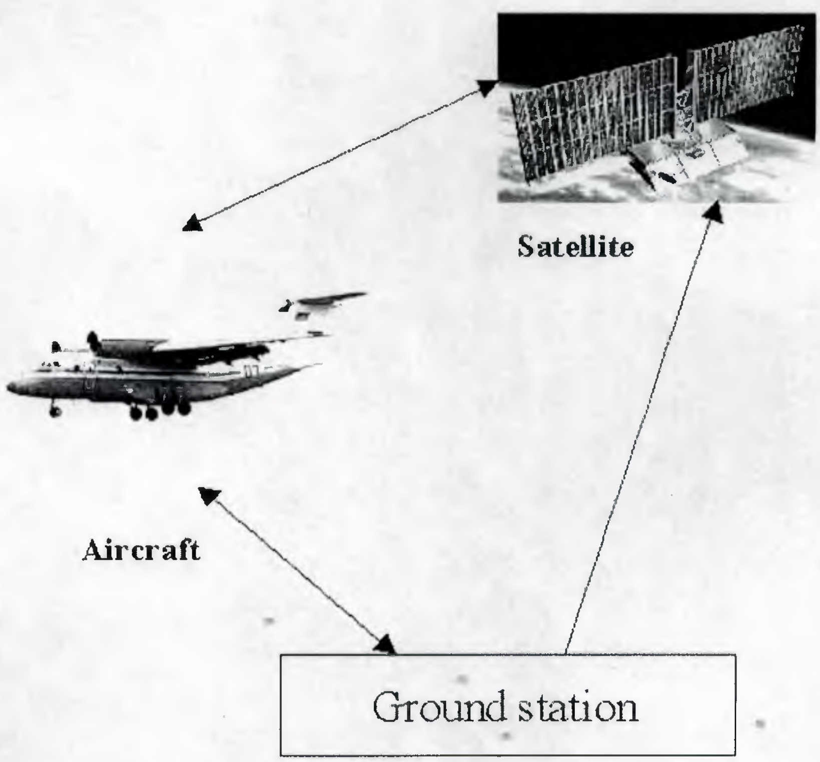


Figure 5.1 Connexion Architecture

Passengers will be able to access the following:

- Internet
- Check-in for ongoing flights, plus the ability to print out boarding passes
- Carrier information (e.g. travel planning, travel support and frequent flier mileage)
- E-commerce (e.g. shopping and duty free)
- News and information
- Live television
- Flight facts (e.g. airport maps, flight maps and gate information)
- Company intranet
- Destination information (e.g. plan itinerary, check the weather and make dinner reservations)

It differs from existing in-flight entertainment (IFE) systems by providing a high-value, two-way-live data and live television service to highly mobile users, who are traveling at up to 40,000 feet and at 500 miles per hour.

5.2 The Potential Market

Anticipated revenues for the service have not been made public. However, industry experts anticipate the market for Connexion to be worth $70bn over the next ten years.

Customers subscribe to Connexion and can access the system via their laptops from any seat in the aircraft. Corporate accounts can be set up for businesses, while private travelers are billed directly to their credit cards. Initially the aim is to make the services available to those airlines that transport some three million passengers traveling on 42,300 flights per day on Boeing built aircraft, before extending this to all aircraft.

5.2.1 Technical Details

Connexion will provide two-way broadband data services to passengers and crew at 5Mbps (megabits per second) receive and 1.5Mbps transmit, with this expanded over time as technologies are improved.

The infrastructure consists of an airborne system, a ground system and a space system. The airborne system includes airborne antennae, servers, routers and associated wiring.

The ground system consists of a network operations center, associated satellite uplink and downlink equipment, and a business operation center. Finally the space system includes leased satellite transponders.

The average weight for supporting antenna electronics and network connections to the seat is approximately 800lbs for a single-aisle aircraft and 1,200lbs for a twin-aisle aircraft. The average power requirement is 1kW.

5.2.2 Partners and Service Suppliers

Boeing has signed a memorandum of agreement with a number of service providers including CNN In-flight Services; Mitsubishi Electric Corp.; Alenia Spazio, a Finmeccanica Company; Loral Skynet; Matsushita Avionics Systems Corp. and CNBC.

5.2.3 The Company

Boeing is the largest aerospace company in the world, producing commercial jetliners, military aircraft, rotorcraft, electronic and defense systems, missiles, rocket engines launch vehicles, and advanced information and communication systems. Manufacturing operations are spread across the US, Canada and Australia and the company have customers in 145 countries.

Table 5.1 Connexion - Specification

Key Data	
Project type	Satellite
Location	Worldwide
Completion	Ongoing. First installation completed March 2002.
Key Players	
Controlling body	Boeing
Developers	Boeing

5.3 GPS (GLOBAL POSITIONING SYSTEM) SATELLITE NAVIGATION, INTERNATIONAL

The Global Positioning System (GPS) is a system consisting of 24 operational satellites in six circular orbits that lie in non-synchronous orbits at inclinations of 55 degrees, 20,200km above the earth. The constellation circles the earth once every 12 hours and consists of four groups of six satellites, including 21 that provide the positioning service and three back-ups.

The GPS satellites are used to calculate the position of a GPS receiver on or above the surface of the earth by applying simple geometry together with computing algorithms that assist the receiver in determining which satellites to use and resolve any ambiguity related to location. GPS allows users to determine their three-dimensional position, velocity and time (regulated by atomic clocks) 24 hours a day across the world. GPS reached full operational capability on 17 July 1995. The three segments to GPS are space, control and user.

Figure 5.2 GPS Satellite Ground Control Stations

5.3.1 Space Segment

The space segment consists of the 24 satellites mentioned above. Each weighs around 2,000lbs and measures 17ft across from one solar panel wing tip to the other. By having 21 in use at any one time and three back-ups, it enables up to three to be switched off simultaneously for maintenance and older ones to be replaced when they reach the end of their working lives.

5.3.2 Control Segment

The control segment consists of a master control station in Colorado Springs, plus a further five monitor stations and three ground antennas located across the world. The five monitor stations track the GPS satellites that are in view, with a minimum of six in view at any one time, and collect ranging information from the satellite broadcasts. These stations then send back the information they collect to the master control station that precisely calculates the satellite orbits. The information is then converted into updated navigation messages for each satellite and transmitted via the three ground antennas, which also transmit and receive satellite control and monitoring signals.

5.3.3 User Segment

The GPS user segment consists of the receivers, processors and antennae that enable the user community to receive satellite broadcasts and convert signals into their precise position, velocity and time. A total of four satellites are required to compute the three-dimensional position and the time.

Although the system was developed by the US Department of Defense, the system can be used by anyone. Typically the positioning system is used in aircraft, ships, ground vehicles, and also for hand carrying by individuals. As well as land, sea and airborne navigation, GPS is also used for surveying, geophysical exploration, mapping and geodesy and vehicle location systems. Astronomical observatories and telecommunications facilities use the time system, while laboratory standards can be set to precise time signals or controlled to accurate frequencies by special purpose GPS receivers.

There are two levels of service, a Standard Positioning Service (SPS) and a Precise Positioning Service (PSP). The SPS is for general public use and is intentionally degraded to protect US national security interests through a process called Selective Availability (SA) which controls the availability of the system's full capabilities. It is accurate to within 100 meters (2drms) horizontal, 156 meters (2 Sigma) vertical, 300 meters (99.99% probability) horizontal, 340 nanoseconds time (95% probability).

Table 5.2 GPS (Global Positioning System) - Specification

Key Data	
Project Type	Mobile Positioning
Location	Worldwide
Completion	17 July 1995 (fully operational)
Key Players	
Controlling Body	US Department of Defense
Developers	Various

5.4 INMARSAT BROADBAND SATELLITE NETWORK, INTERNATIONAL

A broadband global network area is to be expanded with the construction of three satellites for a fourth generation broadband satellite network known as the Inmarsat I-4. Inmarsat has awarded the contract for the construction of the satellites to Astrium. Inmarsat owns and operates a global satellite network, and has operating licenses in 171 countries. The satellites will be able to communicate with a variety of terminals as small as personal digital assistants in what Inmarsat refers to as its Broadband Global Area Network or B-GAN.

The network will enable Inmarsat to deliver higher bandwidth services on the internet and intranet content and solutions, video-on-demand, video conferencing, fax, Email, voice and LAN access at speeds up to 432Kbps (kilobits per second) anywhere on the globe via notebook or palm top computers. Two of the I-4 satellites will be launched in 2003; the remaining one will be an on-ground spare. The satellites and B-GAN system will be operational in 2004. The system will cost about $1.7 billion. Of this $700 million will be spent on launching the satellites, earth stations, telecommunications infrastructure, distribution and billing and support systems. It will also be compatible with third generation (3G) mobile systems.

The I-4 satellites will be 100 times more powerful than Inmarsat's current world global mobile 64Kbps network. In addition, the new Broadband Global Area Network (B-GAN) will provide at least ten times the capacity for new users. The new network will be interoperable with Inmarsat's current I-3 satellite network allowing existing users to migrate on to the new system and take advantage of new enhanced capabilities.

Recent forecasts indicate that the mobile satellite market will be worth over US$4 billion in 2004, doubling to over US$8 billion in 2009. The B-GAN has been designed in response to the dramatic rise in customer demand for bandwidth. This growth has been driven by a number of forces, including that of B2B eBusiness, which is forecast to be a US $1.1 trillion market by 2003. Data communications over Inmarsat's satellite network has grown by an average of 50% year-on-year since 1995, and it is expected that data traffic will use 70% of its current network by 2003.

5.4.1 The Satellite System

The satellites will be positioned at 54° West (the western Atlantic slot) and 64° East (the Indian Ocean slot). Each satellite will carry about 200 spot beams, which will allow them to cover North and South America, Europe, Africa and Asia. Each of the satellites will require one earth station and a backup earth station for interconnection with terrestrial lines. The satellites will have about 10.5kW power and a payload power of about 9kW. The satellites' effective isotropic radiated power will be 68dbw and the I-4 system will communicate with three classes of terminal. A briefcase-size terminal will run at 432Kbps to and from the satellite. A 'nominal' terminal will weigh 1,000g (2 lbs, 3 1/4 oz), will fit into the carrying case for a personal computer and cost about $1,000. It will run at 432Kbps from the satellite to the terminal and 144Kbps from the terminal to the satellite. A PDA-size terminal will measure about four by five inches, weigh 700g (1 lb, 9 oz), cost about $700 and run at 144Kbps to and from the satellite. The I-4 system is seen as a logical extension of the work that has been done with the ACeS (Asia Cellular Satellite) and the Middle Eastern Thuraya systems.

Astrium plans to manufacture the satellite buses in its plant at Stevenage and the payloads in its Portsmouth plant in the United Kingdom. The integration and testing will be done in Toulouse, France. The company has previously been involved in the construction of three Marecs satellites, part of the original maritime satellite system and four Inmarsat 2 satellites, and supplied the advanced payload for the five Inmarsat 3 spacecraft.

5.4.2 Leading Contractors

With a project of this size, there are a number of contractors and sub-contractors. Thrane & Thrane won a £30 million contract to build the satellite communications equipment, and awarded a £6 million contract to Logica in September 2001 to develop higher bandwidth communications. Ericsson will provide the call routing and mobility management network for the ground stations.

Table 5.3 Inmarsat - Specification

Key Data	
Project type	Satellite
Standard	B-GAN
Location	Worldwide
Estimated investment	$1.4 billion
Completion	2004
Key Players	
Developers	Astrium
Customer	Inmarsat

5.5 ORBCOMM COMMUNICATIONS SATELLITE NETWORK ORBITAL - TELEGLOBE INC., INTERNATIONAL

On 30 November 1998, Orbcomm Global, L.P. (Orbcomm), became the first commercial provider of global low Earth orbit (LEO) satellite data and messaging communications services, as it formally inaugurated full commercial service with its pioneering satellite based global data communications network.

With its constellation of 28 satellites in low Earth orbit and 14 gateway earth stations installed or under construction on five continents, Orbcomm is able to provide fixed site monitoring, mobile asset tracking and two-way messaging/wireless Email services on a global scale.

A partnership of Orbital and the Canadian telecommunications giant, Teleglobe Inc., the Orbcomm network allows customers to send and receive short text messages almost anywhere on Earth at a very low cost. Primarily focused on industrial markets, Orbcomm allows companies to extend their MIS capabilities to mobile or remotely located assets that were previously beyond the reach of their computer networks.

5.5.1 Market Rationale

Over 115 companies in the transportation, oil and gas, utilities and construction industries, as well as numerous US and international government agencies, are already using Orbcomm services in North America, South America, Europe, Asia, the Middle East and Africa. The company predicts a high level of growth.

5.5.2 Background

Orbcomm was the first company to formally propose a commercial low-orbit communications satellite network when it filed its original US Federal Communications Commission (FCC) license application in February 1990. It was also the first to be licensed to construct and operate such a system, receiving FCC approval in October

1994. In March 1998, the FCC expanded Orbcomm's original license from 36 to 48 satellites.

The Orbcomm system was conceived by Orbital Sciences Corporation in the late 1980s and developed as an internal project by the company through the launch of two prototype satellites in April 1995. Teleglobe joined Orbital as a full joint-venture partner in Orbcomm in September 1995.

5.5.3 Satellite Technology

Depending on the application, an Orbcomm customer can use a small fixed site or handheld mobile device to transmit messages to an Orbcomm satellite. This information is instantly relayed to a ground gateway station and is then sent to Orbcomm's network control center, where messages are routed to their final destination via the internet, dedicated telephone line, pager or fax. Messages typically contain about 25 to 500 characters.

Orbcomm's two-way digital packet data network is made up of space, ground and customer equipment elements. These are: a multi-satellite constellation, which consists of 28 satellites now in space in five orbital planes, plus an additional ten ground spare satellites for future capacity upgrades; an advanced ground tracking, control and switching system, including 14 gateway earth station sites currently in operation or under construction; and subscriber equipment and application software packages, which cover over 25 specific uses, that easily integrate with the most commonly used enterprise management systems.

In 1998, when the $500 million project was first launched, message delivery reliability exceeded 99.99% and end-to-end latency averaged less than 20 seconds from satellite contact. Orbcomm satellite system's capacity is approximately 1 million messages per hour, or nearly 10 billion per year.

Orbcomm applications include monitoring of fixed assets such as electric utility meters, oil and gas storage tanks, wells and pipelines and environmental projects; tracking of mobile assets such as commercial vehicles, trailers, rail cars, heavy equipment, fishing vessels, barges and government assets; and messaging services for consumers, commercial and government entities.

5.5.4 Sponsors - Orbital - Teleglobe Inc.

Orbcomm is a partnership owned by Orbital Sciences Corporation, Teleglobe Inc. of Canada, and Technology Resources Industries Bhd. of Malaysia. Orbital is a space technology company that designs, manufactures, and markets a broad range of space products and satellite-based services. Teleglobe Inc. is in global telecommunications. Technology Resources Industries Bhd., a publicly traded holding company, controls the largest cellular operator in Malaysia.

Table 5.4 Orbcomm Communication Satellite Network - Specification

Key Data	
Start year	1990
Project type	Satellite
Location	Virginia, USA
Estimated investment	$500 million
Completion	1998
Key Players	
Sponsors	Orbital Sciences Corporation, Teleglobe Inc, Technology Resources Industries Bhd.
Size	
Number of satellites	28

5.6 TELEDESIC BROADBAND SATELLITE TELECOMMUNICATIONS, INTERNATIONAL

Teledesic will use a large number (288 plus spares) of Low Earth Orbit (LEO) satellites to offer access to fibre-like broadband digital transmission telecommunications services across the world. The main services LEO's will provide include computer networking, fast broadband internet access, interactive multimedia and high-quality voice technology.

Investors are Craig McCaw, Bill Gates, Motorola, Abu Dhabi Investment Company, Boeing Company and His Royal Highness Prince Alwaleed Bin Talal Bin Abdul Aziz Alsaud. Motorola joined the effort to build the Teledesic Network in 1998, and is leading the team developing and deploying the network, with this targeted to begin in 2004.

Teledesic will expand by developing alliances with service partners across various countries worldwide. This will enable the service partners to expand their services, both geographically and in the scope of services they can offer. Ground-based gateways will enable service providers to offer seamless links to other wireless and wireless networks such as the internet. Teledesic will also offer services direct to clients.

5.6.1 Technical Details

The system will be able to support millions of simultaneous users, all using 'standard' user equipment. Most users will have two-way connections providing 64Megabits per second (Mbps) on the downlink and 2Mbps on the uplink, although higher-speed terminals will provide 64Mbps or more of two-way capacity.

As it is able to handle multiple channel rates, protocols and service priorities, it is flexible enough to support a wide range of applications including the internet, corporate intranets, multimedia communication, LAN interconnect and wireless backhaul. Its flexibility is, of course, critical since many of the applications and protocols Teledesic will serve in the future have yet to be conceived.

The network will consist of 288 satellites split into 12 planes each with 24 satellites. To reduce environmental pressures, between six and eight satellites will be launched with each rocket. Each satellite is a node in a fast-packet-switch network and has intersatellite communication links with other satellites in the same and adjacent orbital planes. This 'mesh' network is robust and is tolerant to faults and local congestion.

The satellites will be made of a tough composite material, and therefore will be able to sustain impacts from space debris. In the occasion that one of the satellites was to be destroyed or damaged, the aggregate system will compensate and another of the 36 spare satellites can be launched to take its place.

Within any circular area with a 100km radius the Teledesic Network can support more than 500Mbps of data to and from user terminals. The network supports bandwidth-on-demand, which allows the user to request and release capacity as and when it is needed. This means that the user only pays for the capacity they actually use, and the network can support a larger number of users.

Teledesic will operate in the high-frequency Ka-band portion of the radio spectrum, equivalent to 28.6-29.1GHz uplink and 18.8-19.3GHz downlink. Since it utilizes LEO satellites it eliminates the long signal delay normally experienced with traditional geostationary-earth-orbit (GEO) satellites and enables the use of low-power terminals and antennae. Teledesic's LEO satellites will orbit at 1,375km, some 25 times closer than geostationary satellites that orbit at around 36,000km. Since low-power terminals and antennae can be used, compact terminals can be fitted to a rooftop and connected to a PC or computer network inside a building.

Figure 5.3 Teledesic Will Use a Large Number of LEO Satellites to Offer Access to Broadband Digital Transmission Telecommunications

5.6.2 African Focus

Since Teledesic satellites move in relation to the Earth, the service is the same quality and capacity to all parts of the world, including those that could not be served economically by any other means. The Teledesic Network will cover 100% of the world's population and 95% of the landmass.

The Teledesic Corporation believes that its project could be extremely effective and profitable in areas such as Africa. In the majority of the African nations there is low teledensity (less than one phone line per 100 people), limited interconnectivity between the countries and a growing, unmet demand for telecommunication services (less than a quarter of African nations have direct access to the internet), which makes the African telecommunication issue a considerable challenge.

African nations realize the importance of having an effective communication system to promote international investments, which in turn will lead to job creation and improvement in the standards of living of the African people. The issue so far has been how to ensure a cost-effective access to advanced telecommunication while respecting the national sovereignty.

Using a constellation of several hundred low Earth orbit satellites, Teledesic should enable affordable, world wide access to fibre-like telecommunications services such as broadband internet access, digital voice, data, video-conferencing and interactive multimedia.

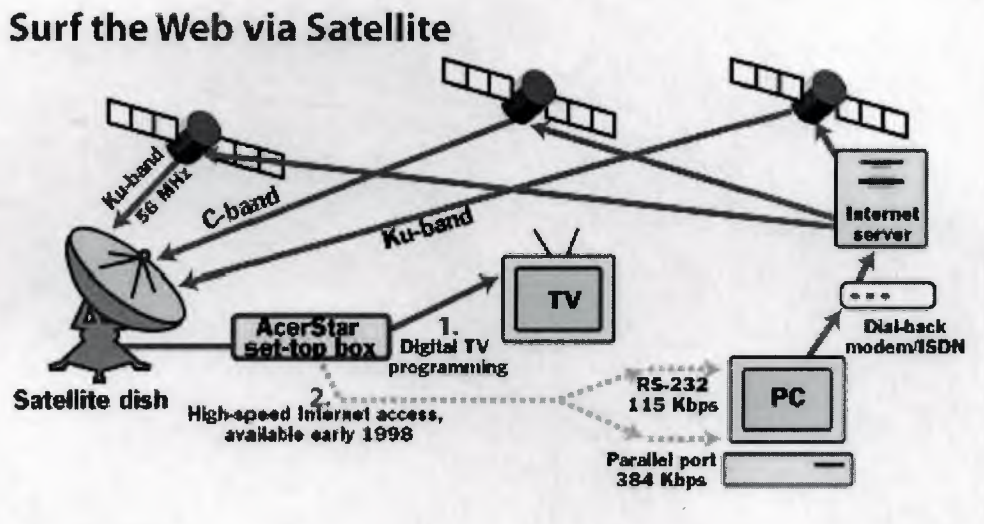


Figure 5.4 The Teledesic Network Will Increase Bandwidth and Speed for Internet Use Via Satellite

Table 5.5 Teledisc - Specification

Key Data	
Standard type	Satellite
Location	Worldwide
Completion	2004
Key Players	
Controlling body	Teledesic Company
Developers	Motorola and Lockheed Martin

CONCLUSION

IMT-2000 is the term used by the International Telecommunications Union (ITU) for a set of globally harmonized standards for third generation (3G) mobile telecoms services and equipment. 3G services are designed to offer broadband cellular access at speeds of 2Mbps, which will allow mobile multimedia services to become possible

The latest Wireless Application Protocol standard, WAP 2.0, developed by the WAP Forum was revealed in August 2001. WAP 2.0 is intended to bring mobile services closer to Internet standards on desktop PCs.

Bluetooth is an alliance between mobile communications and mobile computing companies to develop a short-range communications standard. This is for wireless data communications of up to 10m.

Wireless local area networking (wireless LAN) was developed in the 1990s as an extension of the wired LAN network technology that had become prevalent and dominant in the networked world.

Infrared data and communication is a mode of communication that now plays an important role in wireless data communication. It suits the use of laptop computers, wireless data communication and other digital equipment such as personal assistants, cameras, mobile telephones and pagers.

The local multipoint distribution service (LMDS) and multichannel multipoint distribution service (MMDS) have their historical roots in television. MMDS's pre-cursor, the multipoint distribution service (MDS), was established by the Federal Communications Commission (FCC) in 1972.

Enhanced data for global evolution (EDGE) is a high-speed mobile data standard, intended to enable second-generation global system for mobile communication (GSM) and time division multiple access (TDMA) networks to transmit data at up to 384 kilobits per second (Kbps).

General packet radio service (GPRS) is a packet-based wireless data communication service designed to replace the current circuit-switched services available on the second-generation global system for mobile communications (GSM) and time division multiple access (TDMA) IS-136 networks. GSM and TDMA networks were designed for voice communication, dividing the available bandwidth into multiple channels, each of which is constantly allocated to an individual call (circuit-switched). These channels can be used for the purpose of data transmission, but they only provide a maximum transmission speed of around 9.6Kbps (kilobits per second).

HSCSD (High-Speed Circuit-Switched Data) is essentially a new high-speed implementation of GSM (Global System for Mobile Communication) data transfer. Four times faster than GSM, with a transfer rate of up to 57.6Kbps, it achieves this speed by allocating up to eight time slots to an individual user

Both Sun Microsystems and Microsoft are working on developing next generation software for mobile web services. However, while Sun expects Java's new technology to be rolled out in mid-2003, Microsoft expects to introduce its .Net software by the end of 2002. Consumer tests are due in the summer, and initial analyst comment has been very positive.

A recent agreement between Motorola and Turkish GSM (Global System for Mobile Communications) operator Telsim looks to expand Turkey's countrywide GSM. The project includes the supply of GSM 900Mhz infrastructure equipment for the next three years and a full trial overlay general packet radio service (GPRS) core mobile data network.

CDMA (code division multiple access) is a second-generation digital mobile telephone standard which takes a different approach to the other, competing standards: GSM (Global System for Mobile Communications) and TDMA (Time Division Multiple Access).

The Short Message Service (SMS) allows text messages to be sent and received to and from mobile telephones. The text can comprise words or numbers or an alphanumeric combination. SMS was created as part of the GSM Phase 1 standard. The first short message is believed to have been sent in December 1992 from a PC to a mobile phone on the Vodafone GSM network in the UK.

TDMA (Time Division Multiple Access) is a second-generation technology used in digital cellular telephone communication, which divides each cellular channel into individual time slots in order to increase the amount of data that can be carried.

Terrestrial trunked radio (TETRA) is the modern digital private mobile radio (PMR) and public access mobile radio (PAMR) technology for police, ambulance, fire, transport and security services.

Connexion is a broadband telecommunications service from Boeing that offers real-time, high-speed, two-way connectivity for commercial airlines, private business jets and US government customers worldwide.

A broadband global network area is to be expanded with the construction of three satellites for a fourth generation broadband satellite network known as the Inmarsat I-4. Inmarsat has awarded the contract for the construction of the satellites to Astrium. Inmarsat owns and operates a global satellite network, and has operating licenses in 171 countries.

On 30 November 1998, Orbcomm Global, L.P. (Orbcomm), became the first commercial provider of global low Earth orbit (LEO) satellite data and messaging communications services, as it formally inaugurated full commercial service with its pioneering satellite based global data communications network.

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