Introduction to Mobile Telecommunication and GSM

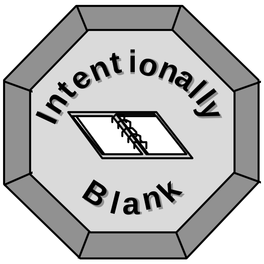
Chapter 1

This chapter is designed to provide the student with an introduction to mobile telecommunications and an overview of the GSM standard. It introduces the main system components, the network structure and basic terminology used.

OBJECTIVES:

Upon completion of this chapter the student will be able to:

- List 1 benefit of having a standard
- Describe the history of GSM development
- List 3 network components and briefly describe their functionality
- Describe the GSM geographical network structure
- List the GSM frequency bands
- List 3 subscriber services provided in the GSM network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1 Introduction to Mobile Telecommunication and GSM

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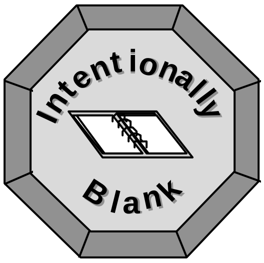
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MOBILE TELEPHONY

The impact of mobile technologies has been immense. Mobile communication is now viewed as a necessity and is one of the fastest growing and most demanding technologies. Mobile systems have evolved over time. When discussing different developments we speak of system generations.

First generation (1G) systems were analog with reasonably reliable networks but limited service offerings and did not permit roaming between networks.

Second generation (2G) mobile systems are digital and bring significant advantages in terms of service sophistication, capacity and quality. GSM is a 2G technology. The increasing demand for wireless access to the Internet has led to further developments within 2G systems. Thus we speak of 2.5G systems. General Packet Radio Services (GPRS) is an example of a 2.5G technology and is a standardized packet switched technology enabling mobile use of the Internet. Other standard and optional features of digital mobile networks have appeared over time including Intelligent Network (IN) features, mobile positioning features, SMS (Short Message Service) and developments in signaling and network management software.

Since there are several 2G systems using incompatible radio technologies, on different frequency spectra, they cannot capture a real worldwide mass-market in the long-term. These factors have led to the concept of third generation (3G) systems which will allow communication, information and entertainment services to be delivered via wireless terminals. The foundation for these services has already been laid in 2G systems, but in order to support such services we need higher capacity on the radio links as well as compatibility between systems in order to provide seamless access worldwide. An example of a 3G system is Universal Mobile Telecommunication Systems (UMTS).

GSM therefore is a pivotal technology from which to look back at previous technologies and examine future trends.

HISTORY OF WIRELESS COMMUNICATION

The origins of mobile communications quickly followed the invention of radio in the late 1800s. The first applications of mobile radio were related to the navigation and safety of ships at sea. As radio concepts developed, radio was used more and more as a communications tool.

The major milestones in the development of wireless communications are summarized in the following table:

Date	Activity
1906	Reginald Fesseden successfully transmits human voice over radio. Until then, radio communications consisted of transmissions of Morse Code.
1915	J. A. Fleming invents the vacuum tube making it possible to build mobile radios.
1921	The Detroit police department used a 2 MHz frequency in the department's first vehicular mobile radio. The system was one way and police had to find a wire-line phone to respond to radio messages.
1930s	Amplitude Modulation (AM), two-way mobile systems in place in the U.S. took advantage of newly developed mobile transmitters and utilized a "push-to-talk" or half-duplex transmission. By the end of the decade channel allocation grew from 11 to 40.
1935	Invention of Frequency Modulation (FM) improved audio quality. FM eliminated the need for large AM transmitters and resulted in radio equipment that required less power to operate. This made the use of transmitters in vehicles more practical.
1940s	The Federal Communications Commission (FCC) recognized a communication service it classified as Domestic Public Land Mobile (DPLM) radio service. The first DPLM system was established in St. Louis in 1946 using the 150 MHz band. In 1947 a "highway" system was developed along the New York - Boston corridor using the 35-40 MHz band.
1947	D. H. Ring, working at Bell Laboratories, envisions the cellular concept.
1948	Shockley, Bardeen and Brittain, at Bell Laboratories, invent the transistor which enables electronic equipment, including the radio, to be miniaturized.
1949	Radio Common Carriers (RCCs) were recognized.
1958	Bell Systems made broadband proposals.

1964	AT&T introduces Improved Mobile Telephone System (IMTS).
1968	The FCC began to address issue of new US spectrum requirements.
1969	Nordic countries of Denmark, Finland, Iceland, Norway and Sweden agree to form a group to study and recommend areas of cooperation in telecommunication. This led to the standardization of telecommunications for all members of the Nordic Mobile Telephone (NMT) group, the first comprehensive international standardization group.
1973	The NMT group specifies a feature allowing mobile telephones to be located within and across networks. This feature would become the basis for roaming.
1979	The FCC authorized the installation and testing of the first developmental cellular system in the US (Illinois Bell Telephone Company).
1981	Ericsson launches the world's first cellular system in Saudi Arabia based on the analog NMT 450 standard.
1991	The first digital cellular standard (GSM) is launched
1998	Mobile subscribers world-wide number 200 million
1999	The GPRS packet data standard released.
2000	First 3G test networks built in Monaco, Isle of Man and Sweden and first 3G licenses auctioned in UK.
2001	First successful test calls made on 3G networks.
2002	TDMA networks in the Americas moving to GSM.

Table 1-1 Milestones in development of wireless communications

MOBILE STANDARDS

Standards play a major role in telecommunications by:

- Allowing products from diverse suppliers to be interconnected
- Facilitating innovation by creating large markets for common products

The standards-making process is one of co-operation at many levels, both nationally and internationally and includes co-operation between:

- Industrial concerns within a country
- These industrial concerns and their governments
- National governments at an international level

The primary purpose of a standard for mobile communications is to specify how mobile phone calls are to be handled by a mobile network. For example, this includes specification of the following:

- The signals to be transmitted and received by the mobile phone
- The format of these signals
- The interaction of network nodes
- The basic network services which should be available to mobile subscribers
- The basic network structure (i.e. cells, etc.)

☞ Did you know?

GSM accounts for 71% of the World's digital market and 68% of the World's wireless market

Since the development of NMT 450 in 1981, many standards for mobile communication have been developed throughout the world. Each mobile standard has been developed to meet the particular requirements of the country or interest groups involved in its specification. For this reason, although a standard may be suitable for one country, it may not be suitable for another. The main standards and the main markets in which they are used are summarized in the following table.

Year	**Standard**	**Mobile Telephone System**	**Technology**	**Primary Markets**
1981	NMT 450	Nordic Mobile Telephony	Analogue	Europe, Middle East
1983	AMPS	Advanced Mobile Phone System	Analogue	North and South America
1985	TACS	Total Access Communication System	Analogue	Europe and China
1986	NMT 900	Nordic Mobile Telephony	Analogue	Europe, Middle East
1991	GSM	Global System for Mobile communication	Digital	World-wide
1991	TDMA (D-AMPS) (IS136)	Time Division Multiple Access (Digital-AMPS)	Digital	North and South America
1993	CdmaOne (IS95)	Codedivisionmultipleaccess One	Digital	N.America, Korea
1992	GSM 1800	Global System for Mobile communication	Digital	Europe
1994	PDC	Personal Digital Cellular	Digital	Japan
1995	PCS 1900	Personal Communication Services	Digital	North America
2001	GSM 800	Global System for Mobile communications	Digital	North America

Figure 1-1 The main cellular standards

ERICSSON IN MOBILE

Ericsson is one of the leading telecommunication companies in the world and supports over 450 networks world-wide. Ericsson's key product is the AXE digital exchange which is in service in the most sophisticated public networks in Europe, the Americas, Australia, Africa and Asia. One of the key reasons for the success of AXE is that it is modular in design which allows it to adapt easily to a wide variety of applications. The concept of open systems and standardized interfaces is fundamental to the development of all new telecommunication products within Ericsson.

Ericsson has been designing cellular radio systems since the 1970's. It offers network products for all major standards, both analogue and digital. The largest Ericsson markets, measured in number of subscribers using an Ericsson system are Asia Pacific, North America and Europe.

Ericsson is the world's most successful supplier of mobile network infrastructure equipment and supplies 30% of the world's mobile telephony market. Ericsson supplies 40% of the world's GSM/GPRS systems and 40% of 3G/WCDMA systems. Market. The following table summarizes the Ericsson product solution for each mobile standard.

Mobile Standard	Ericsson Product
NMT 450	CMS 45
AMPS	CMS 8800
TACS	CMS 8810
NMT 900	CMS 89
GSM (800 & 900)	CME 20
TDMA (D-AMPS)	CMS 8800-D
GSM 1800	CME 20
PDC	CMS 30
PCS 1900 (using GSM)	CMS 40
PCS 1900 (using DAMPS)	CMS 8800-D
CdmaOne	CMS 11

Figure 1-2 Ericsson's cellular systems

GLOBAL SYSTEM FOR MOBILE COMMUNICATION (GSM)

HISTORY OF GSM

This history of GSM is outlined in the following table:

Date	Activity
1982-1985	• Conférence Européenne des Postes et Télécommunications (CEPT) begin specifying a European digital telecommunications standard in the 900 MHz frequency band. This standard later became known as Global System for Mobile communication (GSM).
1986	• Field tests held in Paris to select which digital transmission technology to use either Time Division Multiple Access (TDMA) or Frequency Division Multiple Access (FDMA).
1987	• A combination of TDMA and FDMA selected as the transmission technology for GSM. • Operators from 12 countries sign a Memorandum of Understanding (MoU) committing to introduce GSM by 1991.
1988	• CEPT begins producing GSM specifications for a phased implementation. • Another five countries sign the MoU.
1989	• European Telecommunication Standards Institute (ETSI) takes over responsibility for GSM specification.
1990	• Phase 1 specifications frozen to allow manufacturers to develop network equipment.
1991	• The GSM 1800 standard was released. • An addendum was added to the MoU allowing countries outside CEPT to sign.
1992	• Phase 1 specifications are completed. • First commercial Phase 1 GSM networks launched. • First international roaming agreement between Telecom Finland and Vodafone in UK.
1993	• Australia becomes the first non-European country to sign the MoU. • The MoU now had a total of 70 signatories. GSM networks launched in Norway, Austria, Ireland, Hong Kong and Australia. • The number of GSM subscribers reaches one million.

	• The first commercial DCS 1800 system is launched in the U.K.
1994	• The MoU now has over 100 signatories covering 60 countries. • More GSM networks are launched. • The total number of GSM subscribers exceeded 3 million.
1995	• The specification for the Personal Communications Services (PCS) developed in the U.S.A. This version of GSM operates at 1900 MHz. • GSM growth trends continue steadily through 1995, with the number of GSM subscribers increasing at the rate of 10,000 per day and rising. • In April 1995, there are 188 members of the MoU from 69 countries.
1996	• The first GSM 1900 systems become available. These comply with the PCS 1900 standard.
1998	• The MoU has a total of 253 members in over 100 countries and there are over 70 million GSM subscribers world-wide. GSM subscribers account for 31% of the world's mobile market.
1999	• GSM networks now exist in over 179 countries.
2002	• Functionality of GSM extended to incorporate EDGE, AMR, and support for flexible positioning services.
2003	• Total number of subscribers expected to soar to over 1 billion.

Table 1-2 GSM Milestones

☞ Did you know?

The headquarters of the GSM MoU are in Dublin, Ireland.

Date	Dec 00	Jun 01	Dec 01	Apr 02
Total GSM Subscribers	**455.1**	**550.1**	**646.5**	**684.2**
GSM 900 Subcribers	229.3	287.6	348.4	361.4
GSM 1800 Subscribers	63.7	75.8	88.5	82.6
GSM 1900 Subscribers	10.6	13.3	15.4	16.9
GSM 900/1800 Subscribers	151.5	173.4	194.2	223.3

Figure 1-3 GSM worldwide Subscribers by Technology (millions)

☞ Did you know?

75 billion text messages were sent in Q1 2002, an increase of more than 50% for same period in 2001

Because GSM provides a common standard, cellular subscribers can use their telephones over the entire GSM service area which includes all the countries around the world where the GSM system is used.

In addition, GSM provides user services such as high-speed data communication, facsimile, a Short Message Service (SMS) and Intelligent Network (IN) services such as Mobile Virtual Private Networks (MVPNs). The GSM technical specifications are also designed to work with other standards as standard interfaces are guaranteed.

Finally, a key aspect of GSM is that the specifications are open-ended and can be built upon to meet future requirements.

GSM SPECIFICATIONS

GSM was designed to be platform-independent. The GSM specifications do not specify the actual hardware requirements, but instead specify the network functions and interfaces in detail. This allows hardware designers to be creative in how they provide the actual functionality, but at the same time makes it possible for operators to buy equipment from different suppliers.

The GSM recommendations consist of twelve series listed in the table below. Each series was written by different working parties and a number of expert groups. A permanent nucleus was established in order to coordinate the working parties and to manage the editing of the recommendations. All these groups were organized by ETSI.

Series	Content
01	General
02	Service aspects
03	Network aspects
04	MS - BSS interface and protocol
05	Physical layer on the radio path
06	Speech coding specification
07	Terminal adaptor for MS
08	BSS - MSC interface
09	Network interworking
10	Service interworking
11	Equipment and type approval specifications
12	Operation and maintenance

Figure 1-4 GSM Recommendations

The GSM 1800 section is written as a delta part within the GSM recommendations, describing only those differences between GSM 900 and GSM 1800. GSM 1900 is based on GSM 1800 and has been adapted to meet the American National Standards Institute (ANSI) standard. As we shall see GSM frequencies have expanded to include GSM at 800 MHz.

GSM PHASES

In the late 1980s, the groups involved in developing the GSM standard realized that within the given time-frame they could not complete the specifications for the entire range of GSM services and features as originally planned. Because of this, it was decided that GSM would be released in phases with phase 1 consisting of a limited set of services and features. Each new phase builds on the services offered by existing phases.

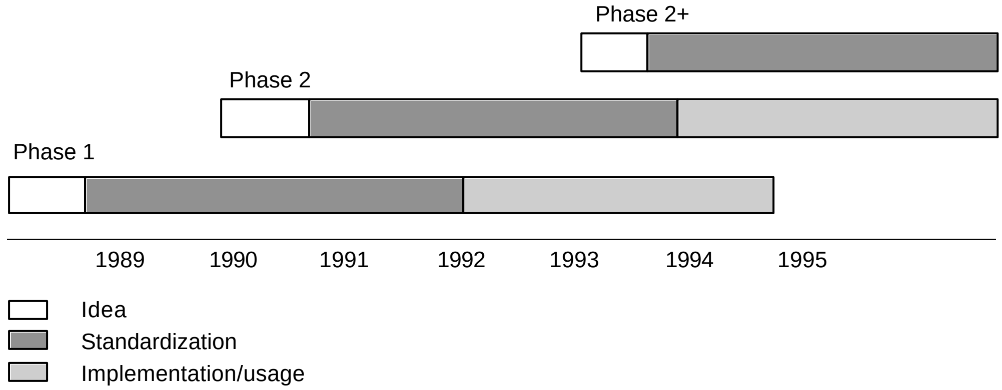

Figure 1-1 GSM phases

Phase 1

Phase 1 contains the most common services including:

- Voice telephony
- International roaming
- Basic fax/data services (up to 9.6 kbits/s)
- Call forwarding
- Call barring
- Short Message Service (SMS)

Phase 1 also incorporated features such as ciphering and Subscriber Identity Module (SIM) cards. Phase 1 specifications were then closed and cannot be modified.

Phase 2

Additional features were introduced in GSM phase 2 including:

- Advice of charge
- Calling line identification
- Call waiting
- Call hold
- Conference calling
- Closed user groups
- Additional data communications capabilities

Phase 2+

The standardization groups have already defined the next phase, 2+. This program covers multiple subscriber numbers and a variety of business oriented features. Some of the enhancements offered by Phase 2+ include:

- Multiple service profiles
- Private numbering plans
- Access to Centrex services
- Interworking with GSM 1800, GSM 1900 and the Digital Enhanced Cordless Telecommunications (DECT) standard

Priorities and time schedules for new features and functions depend primarily on the interest shown by operating companies and manufacturers and technical developments in related areas.

Phase 2++

This phase includes sophisticated enhancements to the radio interface including:

- Enhanced Datarates for Global Evolution (EDGE), a new modulation method which increases capacity on the air interface.
- Customized Application for Mobile Enhanced Logic (CAMEL), a standard, governing IN service access while roaming internationally.
- High Speed Circuit Switched Data (HSCSD), a method of delivering higher data rates per subscriber by allocating an increased number of time-slots per call.

GSM NETWORK COMPONENTS

The GSM network is divided into two systems. Each system comprises a number of functional units or individual components of the mobile network. The two systems are:

- Switching System (SS)
- Base Station System (BSS)

In addition, as with all telecommunications networks, GSM networks are operated, maintained and managed from computerized centers.

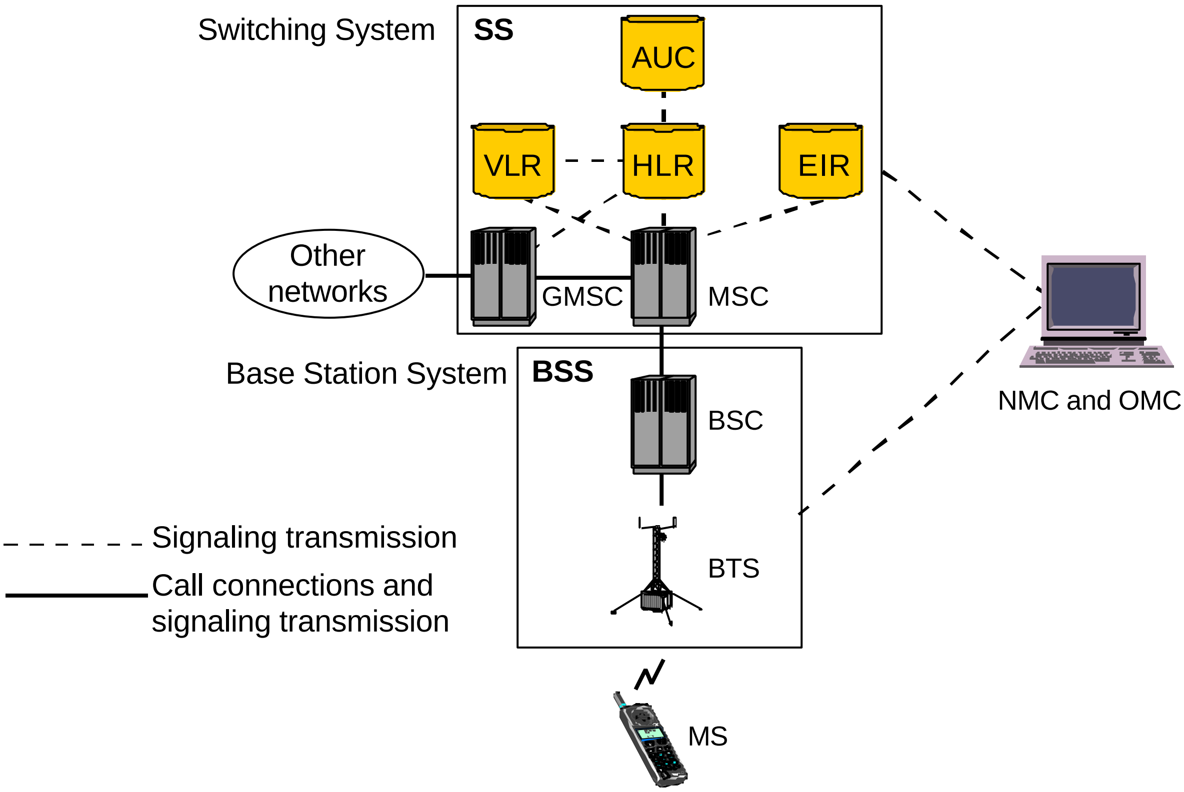

Figure 1-5 System model

Abbreviations:

AUC	AUthentication Center
BSC	Base Station Controller
BTS	Base Transceiver Station
EIR	Equipment Identity Register
HLR	Home Location Register
MS	Mobile Station
MSC	Mobile services Switching Center
NMC	Network Management Center
OMC	Operation and Maintenance Center
VLR	Visitor Location Register

The SS is responsible for performing call processing and subscriber related functions. It includes the following functional units:

- Mobile services Switching Center (MSC)
- Home Location Register (HLR)
- Visitor Location Register (VLR)
- AUthentication Center (AUC)
- Equipment Identity Register (EIR)

The BSS performs all the radio-related functions. The BSS is comprised of the following functional units:

- Base Station Controller (BSC)
- Base Transceiver Station (BTS)

The OMC performs all the operation and maintenance tasks for the network such as monitoring network traffic and network alarms. The OMC has access to both the SS and the BSS.

MSs do not belong to any of these systems.

SWITCHING SYSTEM (SS) COMPONENTS

Mobile services Switching Center (MSC)

The MSC performs the telephony switching functions for the mobile network. It controls calls to and from other telephony and data systems, such as the Public Switched Telephone Network (PSTN), Integrated Services Digital Network (ISDN), public data networks, private networks and other mobile networks.

Gateway Functionality

Gateway functionality enables an MSC to interrogate a network's HLR in order to route a call to a Mobile Station (MS). Such an MSC is called a Gateway MSC (GMSC). For example, if a person connected to the PSTN wants to make a call to a GSM mobile subscriber, then the PSTN exchange will access the GSM network by first connecting the call to a GMSC. The same is true of a call from an MS to another MS.

Any MSC in the mobile network can function as a gateway by integration of the appropriate software.

Home Location Register (HLR)

The HLR is a centralized network database that stores and manages all mobile subscriptions belonging to a specific operator. It acts as a permanent store for a person's subscription information until that subscription is canceled. The information stored includes:

- Subscriber identity
- Subscriber supplementary services
- Subscriber location information
- Subscriber authentication information

The HLR can be implemented in the same network node as the MSC or as a stand-alone database. If the capacity of the HLR is exceeded, additional HLRs may be added.

Visitor Location Register (VLR)

The VLR database contains information about all the mobile subscribers currently located in an MSC service area. Thus, there is one VLR for each MSC in a network. The VLR temporarily stores subscription information so that the MSC can service all the subscribers currently visiting that MSC service area. The VLR can be regarded as a distributed HLR as it holds a copy of the HLR information stored about the subscriber.

When a subscriber roams into a new MSC service area, the VLR connected to that MSC requests information about the subscriber from the subscriber's HLR. The HLR sends a copy of the information to the VLR and updates its own location information. When the subscriber makes a call, the VLR will already have the information required for call set-up.

Authentication Center (AUC)

The main function of the AUC is to authenticate the subscribers attempting to use a network. In this way, it is used to protect network operators against fraud. The AUC is a database connected to the HLR which provides it with the authentication parameters and ciphering keys used to ensure network security.

Equipment Identity Register (EIR)

☞ Did you know?

Although useful, the EIR is actually an optional component of a GSM network, and is therefore, often not used.

The EIR is a database containing mobile equipment identity information which helps to block calls from stolen, unauthorized, or defective MSs. It should be noted that due to subscriber-equipment separation in GSM, the barring of MS equipment does not result in automatic barring of a subscriber.

BASE STATION SYSTEM (BSS) COMPONENTS

Base Station Controller (BSC)

The BSC manages all the radio-related functions of a GSM network. It is a high capacity switch that provides functions such as MS handover, radio channel assignment and the collection of cell configuration data. A number of BSCs may be controlled by each MSC.

Base Transceiver Station (BTS)

The BTS controls the radio interface to the MS. The BTS comprises the radio equipment such as transceivers and antennas which are needed to serve each cell in the network. A group of BTSs are controlled by a BSC.

NETWORK MONITORING CENTERS

Operation and Maintenance Center (OMC)

An OMC is a computerized monitoring center which is connected to other network components such as MSCs and BSCs via X.25 data network links. In the OMC, staff are presented with information about the status of the network and can monitor and control a variety of system parameters. There may be one or several OMCs within a network depending on the network size.

Network Management Center (NMC)

Centralized control of a network is done at a Network Management Center (NMC). Only one NMC is required for a network and this controls the subordinate OMCs. The advantage of this hierarchical approach is that staff at the NMC can concentrate on long term system-wide issues, whereas local personnel at each OMC can concentrate on short term, regional issues.

OMC and NMC functionality can be combined in the same physical network node or implemented at different locations.

MOBILE STATION (MS)

An MS is used by a mobile subscriber to communicate with the mobile network. Several types of MSs exist, each allowing the subscriber to make and receive calls. Manufacturers of MSs offer a variety of designs and features to meet the needs of different markets.

The range or coverage area of an MS depends on the output power of the MS. Different types of MSs have different output power capabilities and consequently different ranges. For example, hand-held MSs have a lower output power and shorter range than car-installed MSs with a roof mounted antenna.

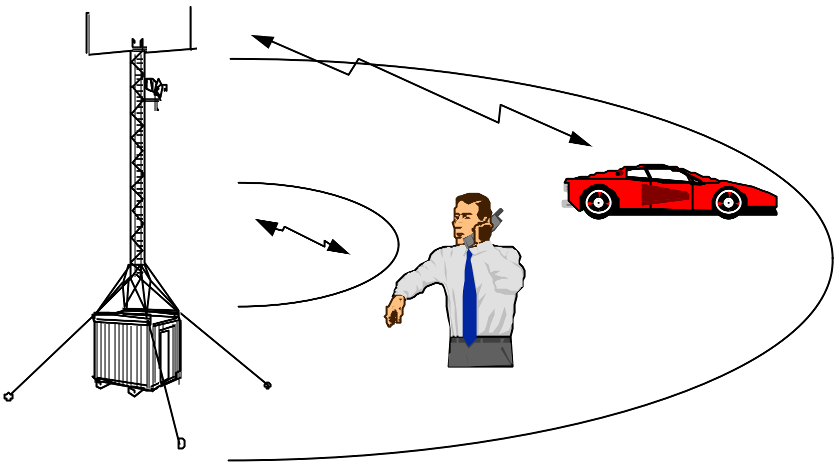

Figure 1-6 Ranges for different types of MSs

GSM MSs consist of:

- A mobile terminal
- A Subscriber Identity Module (SIM)

Unlike other standards, in GSM the subscriber is separated from the mobile terminal. Each subscriber's information is stored as a "smart card" SIM. The SIM can be plugged into any GSM mobile terminal. This brings the advantages of security and portability for subscribers. For example, subscriber A's mobile terminal may have been stolen. However, subscriber A's own SIM can be used in another person's mobile terminal and the calls will be charged to subscriber A.

GSM GEOGRAPHICAL NETWORK STRUCTURE

Every telephone network needs a specific structure to route incoming calls to the correct exchange and then on to the subscriber. In a mobile network, this structure is very important because the subscribers are mobile. As subscribers move through the network, these structures are used to monitor their location.

CELL

A cell is the basic unit of a cellular system and is defined as the area of radio coverage given by one BS antenna system. Each cell is assigned a unique number called Cell Global Identity (CGI). In a complete network covering an entire country, the number of cells can be quite high.

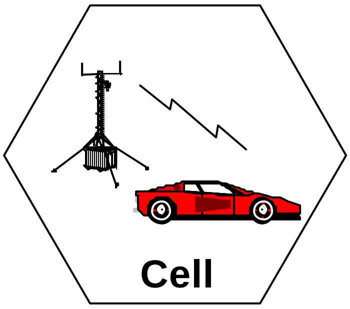

Figure 1-7 A cell

LOCATION AREA (LA)

A Location Area (LA) is defined as a group of cells. Within the network a subscriber's location is linked to the LA in which they are currently located. The identity of the current LA is stored in the VLR.

When an MS crosses the boundary between two cells belonging to different LA's, it must report its new Location Area to the network[1]. If it crosses a cell boundary within a LA, it does not report its new cell location to the network. When there is a call for an MS, a paging message is broadcast within all the cells belonging to the relevant LA.

[1] Note: This only occurs when the MS is idle. The location is not updated during a call, instead the updating takes place after the release.

MSC SERVICE AREA

An MSC service area is made up of a number of LAs and represents the geographical part of the network controlled by one MSC. In order to be able to route a call to an MS, the subscriber's MSC service area is also recorded and monitored. The subscriber's MSC service area is stored in the HLR.

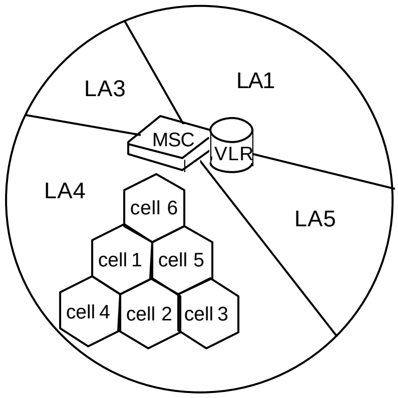

Figure 1-8 MSC service area

PLMN SERVICE AREA

A Public Land Mobile Network (PLMN) service area is the entire set of cells served by one network operator and is defined as the area in which an operator offers radio coverage and access to its network. In any one country there may be several PLMN service areas, one for each mobile operator's network.

GSM SERVICE AREA

The GSM service area is the entire geographical area in which a subscriber can gain access to a GSM network. The GSM service area increases as more operators sign contracts agreeing to work together. Currently, the GSM service area spans dozens of countries across the world from Ireland to Australia, South Africa and the Americas.

International roaming is the term applied when an MS moves from one PLMN to another when abroad.

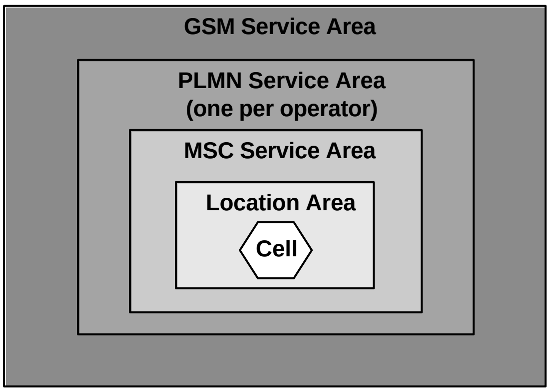

Figure 1-9 Relation between areas in GSM

The figures below show alternative views of the same network:

- The first figure shows the network nodes and their layout across the network. For simplicity, this may be referred to as the hardware view of the network.
- The second figure shows the geographical network configuration. For simplicity, this may be referred to as the software view of the network.

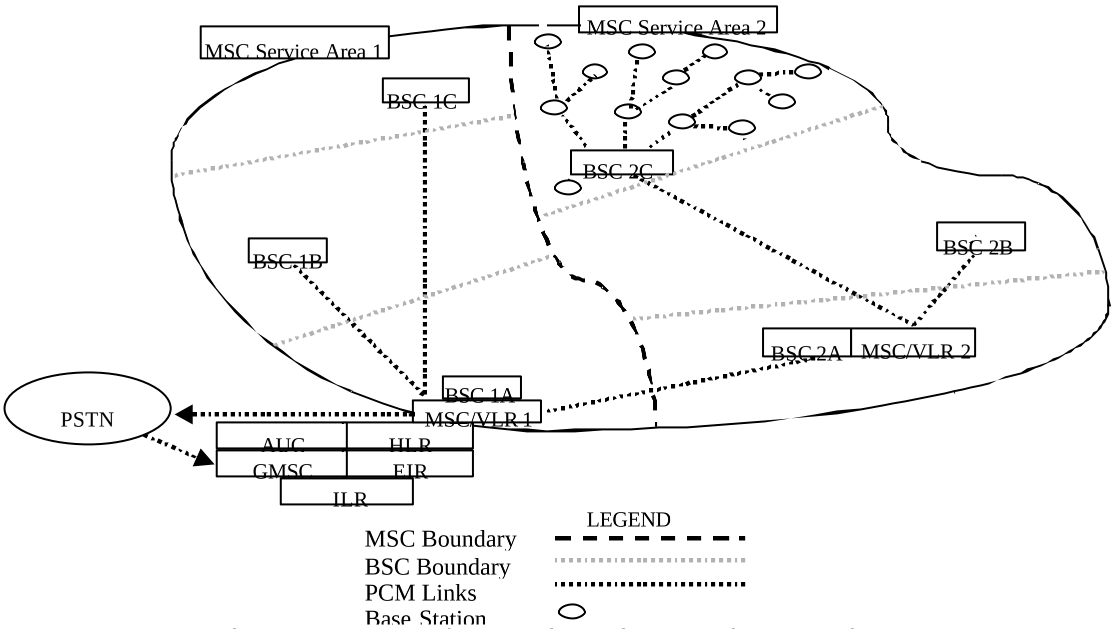

Figure 1-10 "Hardware" view of a sample network

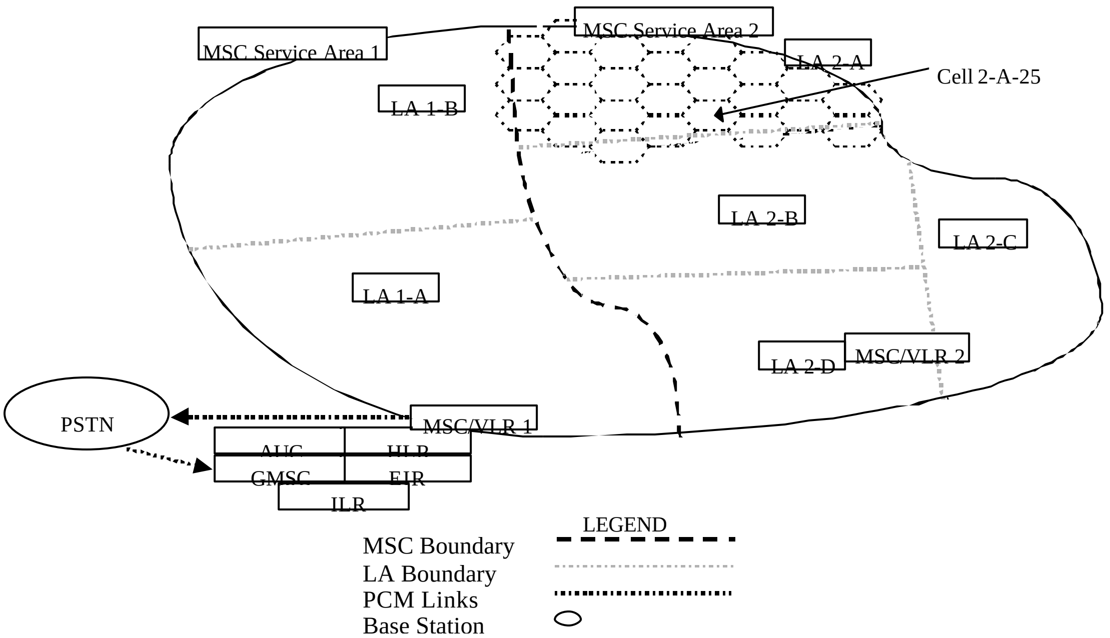

Figure 1-11 "Software" view of a sample network

GSM FREQUENCY BANDS

As GSM has grown worldwide, it has expanded to operate at four main frequency bands: 900, 1800,1900 and 800.

Figure 1-12 GSM frequency bands

GSM 900

The original frequency band specified for GSM was 900 MHz. Most GSM networks worldwide use this band. In some countries and extended version of GSM 900 can be used, which provides extra network capacity. This extended version of GSM is called E-GSM, while the primary version is called P-GSM.

GSM 1800

☞ Did you know?

This was originally named Digital Cellular System (DCS) 1800 MHz. In 1997 it was renamed GSM 1800.

In 1990, in order to increase competition between operators, the United Kingdom requested the start of a new version of GSM adapted to the 1800 MHz frequency band. Licenses have been issued in several countries and networks are in full operation.

By granting licenses for GSM 1800 in addition to GSM 900, a country can increase the number of operators. In this way, due to increased competition, the service to subscribers is improved.

GSM 1900

In 1995, the Personal Communications Services (PCS) concept was specified in the United States. The basic idea is to enable "person-to-person" communication rather than "station-to-station". PCS does not require that such services be implemented using cellular technology, but this has proven to be the most effective method. The frequencies available for PCS are around 1900 MHz. As GSM 900 could not be used in North America due to prior allocation of the 900 MHz frequencies, GSM 1900 MHz is seen as an opportunity to bridge this gap. The main difference between the American GSM 1900 standard and GSM 900 is that it supports ANSI signaling.

GSM 800

The multi band support in Ericsson’s GSM system is now enhanced to include support for the GSM 800 MHz band, thus increasing capacity for operators with a licence for this frequency. This frequency band was traditionally used by TDMA in USA.

KEY TERMS

The primary terms used to describe call cases and situations involving an MS are set out below.

An MS can have one of the following states:

- **Idle:** the MS is ON but a call is not in progress
- **Active:** the MS is ON and a call is in progress
- **Detached:** the MS is OFF

The following table defines key terms used to describe GSM traffic cases (there are no traffic cases in detached mode):

Mode	Term	Description
Idle	Registration	This is the process in which an MS informs a network that it is attached.
	Roaming	When an MS moves around a network in idle mode, it is referred to as roaming.
	International Roaming	When an MS moves into a network which is not its home network, it is referred to as international roaming The home network must have a roaming agreement with the visited network.
	Location Updating	An MS must inform the network when it enters a new LA.
	Locating	This is a BSC function which continuously evaluates the radio connection to the MS and if necessary suggests a handover to another cell. The decision is based on measurement reports sent to the BSC by the MS and BTS.
	Paging	This is the process whereby a network tries to contact an MS. A paging message is broadcast containing the MS identity.
Active	Handover	This is the process, where a call is switched from one physical channel to another, while the MS moves around.

Table 1-4 Key terms

MS REGISTRATION AND ROAMING

When an MS is powered off it is detached from the network. When the subscriber switches power on, the MS scans the GSM frequencies for special channels called control channels. When it finds a control channel, the MS measures the signal strength it receives on that channel and records it. When all control channels have been measured, the MS tunes to the strongest one.

When the MS has just been powered on, the MS must register with the network which will then update the MS's status to idle. If the location of the MS is noticed to be different from the currently stored location then a location update will also take place.

As the MS moves through the network, it continues to scan the control channels to ensure that it is tuned to the strongest possible channel. If the MS finds one which is stronger, then the MS re-tunes to this new control channel[2]. If the new control channel belongs to a new LA, the MS will also inform the network of its new location.

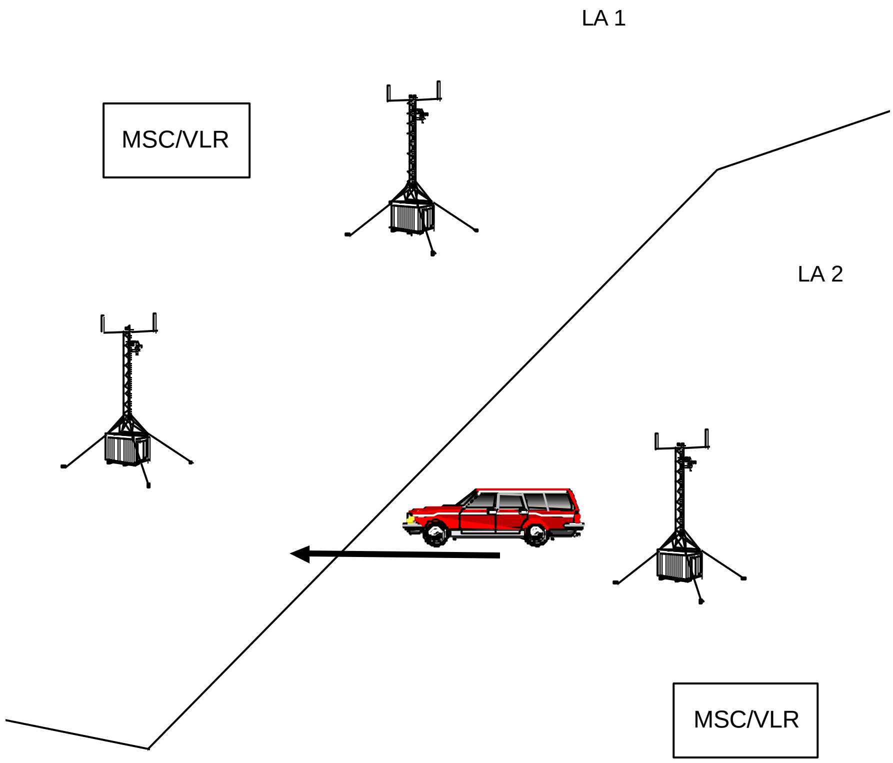

Figure 1-13 Roaming

[2] Note: In idle mode, it is the MS which decides which cell to move into. In active mode, the network makes this decision.