

2 System introduction

Objectives

After this chapter the student will:

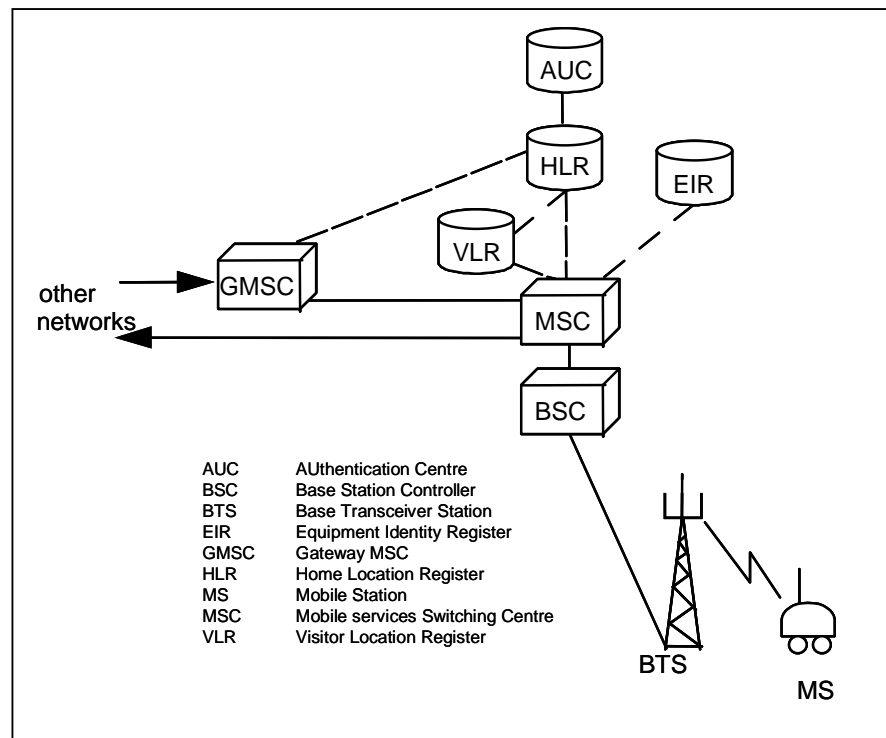
- be able to describe the different nodes in a GSM network.
- be able to describe geographical subdivision of a GSM network.
- be able to describe the most common identity numbers.
- be able to describe some basic traffic cases.

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2.1 Introduction

This chapter will give you a brief orientation of the nodes and their functions in the network, the geographical areas into which the network is divided, and the identity numbers used in the network. Finally a few simplified traffic cases will illustrate the way the system works.

2.2 Nodes and functions



GSM network

The basic nodes of the GSM network will be covered. Some nodes are left out to be covered in a later chapter.

Mobile Station (MS)

The MS is made up of the SIM and the "Mobile Equipment" (ME). The SIM, "Subscriber Identity Module", is a separate physical entity that contains all information regarding the subscription. The SIM is an IC-card, or a "Smart Card". The "Mobile Equipment" is the actual piece of hardware enabling radio communication with the system. Without the SIM, the Mobile Equipment cannot be used in the GSM network, except for emergency calls. The SIM can be put into a different "Mobile Equipment", whereby all calls are routed to that "Mobile Equipment".

"Mobile Stations", belong to different power classes, depending on the maximum power level. The MS:s could be car-mounted, portable or handheld.

Base Station System

Base Transceiver Station (BTS)

This is the radio equipment, the main task of which is communication on radio with the MS:s. One BTS covers a cell with transmitted radio waves. The BTS contains all the radio equipment necessary to stay in touch with the MS.

Base Station Controller (BSC)

The BSC controls and supervises the underlying BTS:s. While the BTS takes care of the actual radio communication, BSC is in charge of all action that is taken. The BSC tells the BTS:s what to do, when to transmit, what power to use, etc.

Switching System

Mobile services Switching Centre (MSC)

This entity sets up, supervises and releases calls. It can connect calls within the GSM network, or between a mobile subscriber and a subscriber in the PSTN (Public Switched Telephone Network) or in some other network.

Up to now we have described the equipment necessary to make a call from the MS: A number is dialled on the MS. When the "send button" is pressed, the call will be set up, via the BTS, onwards via the BSC and to the MSC. The MSC will analyse the digits dialled and set-up the call to wherever it is to go.

If we would like to give a ring to an MS though, the task will be trickier. Since the MS could be moving around, virtually anywhere in the GSM-world, we need to know where it is. This brings us to the next few entities necessary:

Gateway Mobile services Switching Centre (GMSC)

A gateway between the GSM and other networks is necessary. At a call to a subscriber in the GSM network, the call will first be routed to the GMSC. The GMSC is responsible for finding out in what part of the GSM network the MS is by questioning HLR and also for routing the call there.

Home Location Register (HLR)

The global data base will keep track of approximately where the subscriber is. There is normally one HLR per operator (this is not the case with some operators). In that HLR, data about all subscribers belonging to that

particular network is stored. Among that data, the information about in what MSC/VLR service area the MS is, will be stored.

Visitor Location Register (VLR)

This is a regional data base that is found together with every MSC. This data base stores information about all the subscribers that are registered (visiting) in that MSC-service area at the moment. When the HLR has informed the GMSC about in which MSC/VLR service area the subscriber is, a more detailed description of in which Location area the MS will be found in the VLR.

Authentication Centre (AUC)

This is a database that deals with security. It produces keys for authentication and encryption. For this, it contains parameters for all the subscribers belonging to that operator.

All MS:s can be asked to go through an authentication procedure before they are allowed to do anything in the system. All necessary means for authentication are found on the SIM-card.

Equipment Identity Register (EIR)

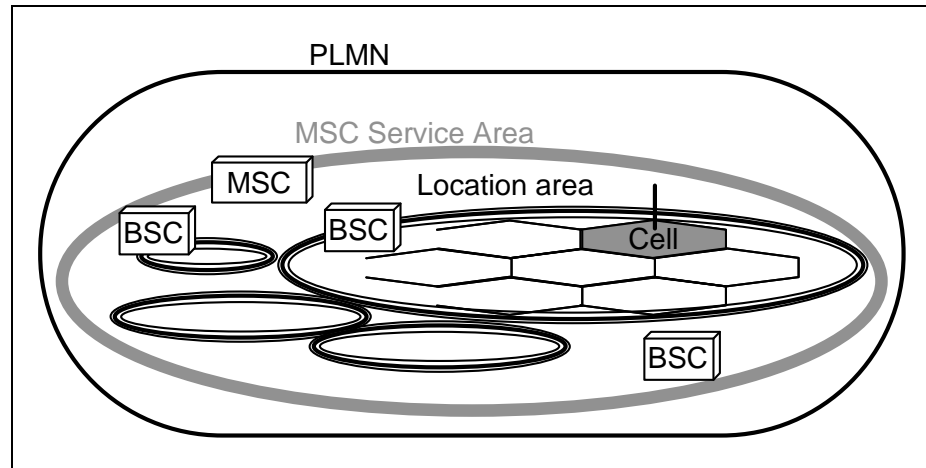
This data base stores information about the pieces of mobile equipment (i.e. the hardware). It can keep track of information such as stolen equipment, non-type approved equipment, etc. While the AUC is concerned with the SIM, the EIR is concerned with the mobile equipment.

Operation and Maintenance Centre (OMC)

This entity can be used for supervision and control of all the other entities in the network. Even though this part is not obligatory, it is highly needed. While the parameters set in the analogue network can be counted in tens, the corresponding parameters in a GSM network can be counted in hundreds.

2.3 Areas

Every telephone network needs a structure to be able to route calls to the right MSC and to the right subscriber. In a GSM network, structure is even more essential as the subscribers are mobile, and could be virtually anywhere in the world.



Geographical structure of a GSM network

GSM PLMN(Public Land Mobile Network)

(Compare PSTN: Public Switched Telephone Network)

A GSM PLMN is the complete GSM network belonging to one operator in one country. Each country can have one or several PLMN:s (today one or two PLMN:s is most common. In Australia and Sweden there are three).

MSC/VLR(Service Area)

If the system has more than one MSC, the PLMN is subdivided into several MSC/VLR service areas. To be able to route calls to the right MSC and eventually to the right MS, it is necessary to know in which MSC/VLR service area the MS is. In the largest GSM networks today, the number of MSC:s seldom exceeds 10.

The HLR stores the data, about which MSC/VLR service area the MS is in. The VLR contains detailed information about all the MS:s in the MSC/VLR service area.

Location area

Each MSC/VLR Service Area is subdivided into a number of location areas (LA). The subdivision is made for the system to keep better track of where a particular MS is. Information about in which location area an MS is registered, is also stored in the VLR together with subscriber data of all the visiting subscribers in that MSC/VLR service area.

If an MS moves within the LA, the system does not need to change the information in the subscriber registers i.e VLR and HLR. If the MS crosses over into a cell belonging to a new location area however, the system must be informed. This report done by the MS to the system is called "Location Updating".

The subdivision into location areas has nothing to do with what BSC the cells belong to. One LA may include cells from different BSC:s, and cells belonging to one BSC may be subdivided into several LA:s.

Cell

A location area is subdivided into a number of cells. A cell is the geographical area covered by one Base Transceiver Station. A cell is the smallest geographical entity in a PLMN. A cell could be any size, from a radius of tens of kilometres down to a radius of tens or hundreds of metres.

2.4 Identity numbers

To understand how the system works, a basic knowledge of some identity numbers is necessary.

Mobile Station ISDN Number (MSISDN)

This number is used when calling a mobile subscriber. For instance, to call a GSM subscriber in Sweden you would dial the number + 46-(0)-70-Y-xxxxxx, where Y separates the PLMNs. For Telia Y is 5, Comviq 7 and Europolitan 8.

International Mobile Subscriber Identity (IMSI)

This is the internal subscriber identity within the GSM network. The user does not need to keep track of this number as it is only used by the system itself.

Temporary Mobile Subscriber Identity (TMSI)

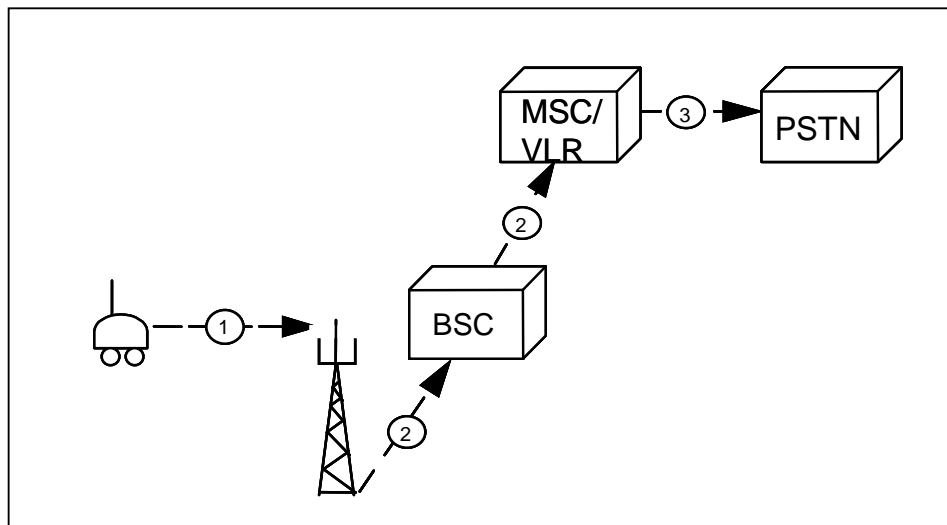
This number is sometimes used instead of the IMSI. One reason for this is to avoid somebody tracing the user by monitoring a specific IMSI. The TMSI can be changed an infinite number of times.

International Mobile Equipment Identity (IMEI)

Just like the IMSI is used to identify the subscription, IMEI is used to identify the "Mobile Equipment". Each "Mobile Equipment" unit, has its own unique IMEI.

2.5 Simplified traffic cases

Call from a Mobile Station

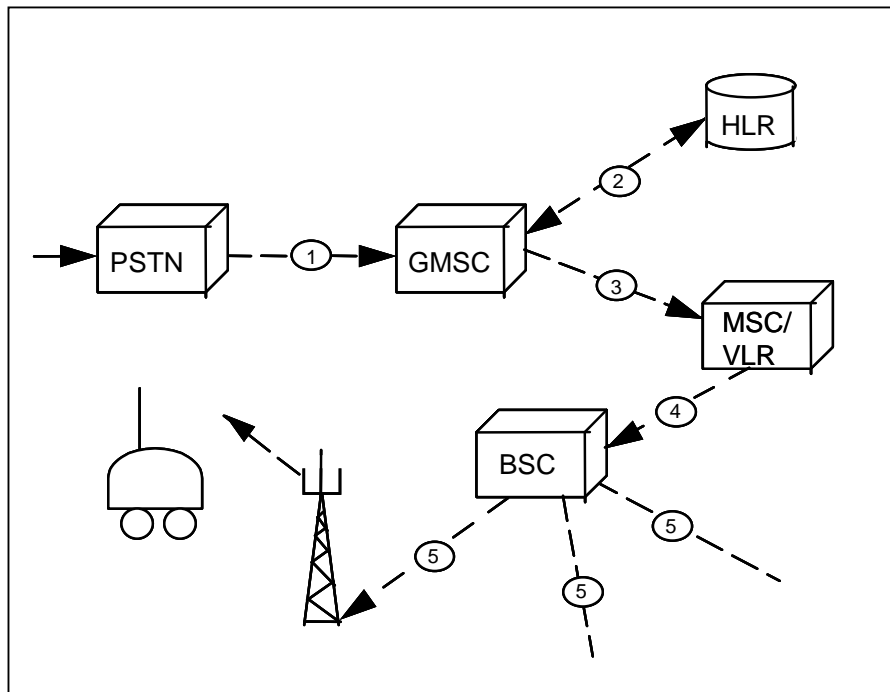


Call from a mobile station

The GSM subscriber calls a subscriber in the PSTN:

1. When the "send" button is pressed the dialled digits will be sent. A radio connection with the BTS will then be established.
2. The digits, together with some other information, will be sent via the BSC to the MSC.
3. The MSC will analyse the digits and route the call onwards to the subscriber in the PSTN.

Call to a Mobile Station

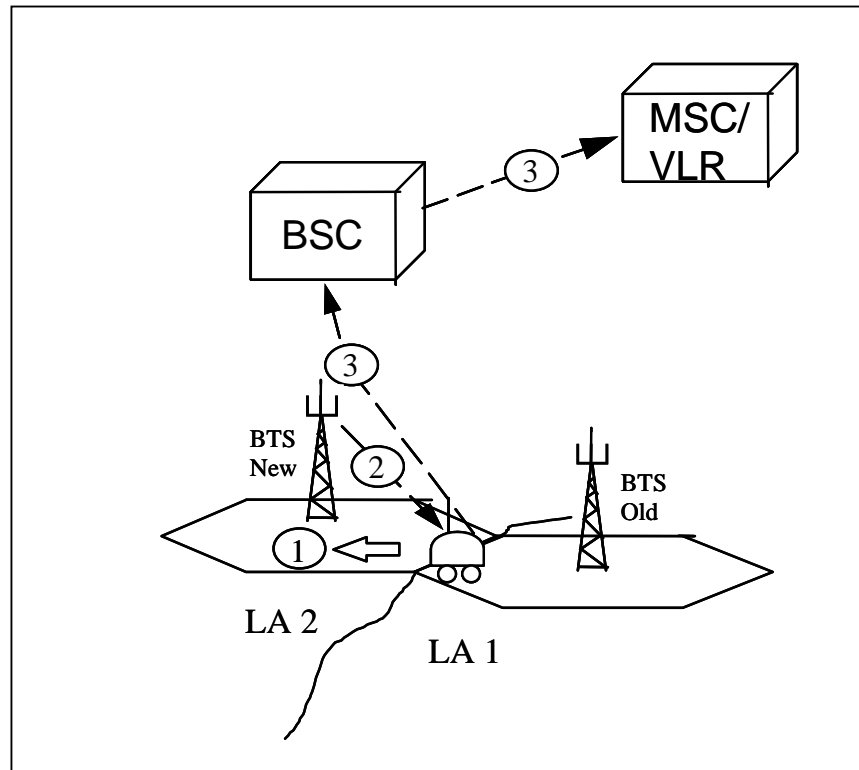


Call to a mobile station

A subscriber in the PSTN calls a GSM subscriber:

1. As the digits dialled have been analysed by the exchange in the PSTN, the call will be routed to a GMSC in the GSM network.
2. The GMSC will signal to the HLR to find out in what MSC/VLR service area the MS is.
3. The GMSC will route the call to the right MSC.
4. Information about in which location area the MS is located will be fetched from the VLR where it is stored. The MSC will send paging orders to the BSC(s) handling that LA.
5. All BTS:s in that LA will then send paging messages to the GSM subscriber.

Location Updating



Location updating

As the idle MS (an MS that has no traffic at the moment) moves around in the network the following may happen:

1. The MS moves away from the BTS that it is monitoring.
- 2a. The signal strength from the other BTS becomes stronger. The MS starts monitoring this new BTS instead of the old one.
 - b. The BTS transmits information about what LA it belongs to. This new BTS belongs to another LA and therefore the MS must do a location updating.
- 3a. The MS makes access to the system and a radio connection is set up.
 - b. The MS reports its new location, up to the VLR via the BTS and BSC. In the VLR the new LA of the MS will be stored. Then the radio connection is released.

