GSM Architecture

1 GSM Network Infrastructure

The following figure depicts a typical GSM network (called, Public Land Mobile Network or PLMN) infrastructure.
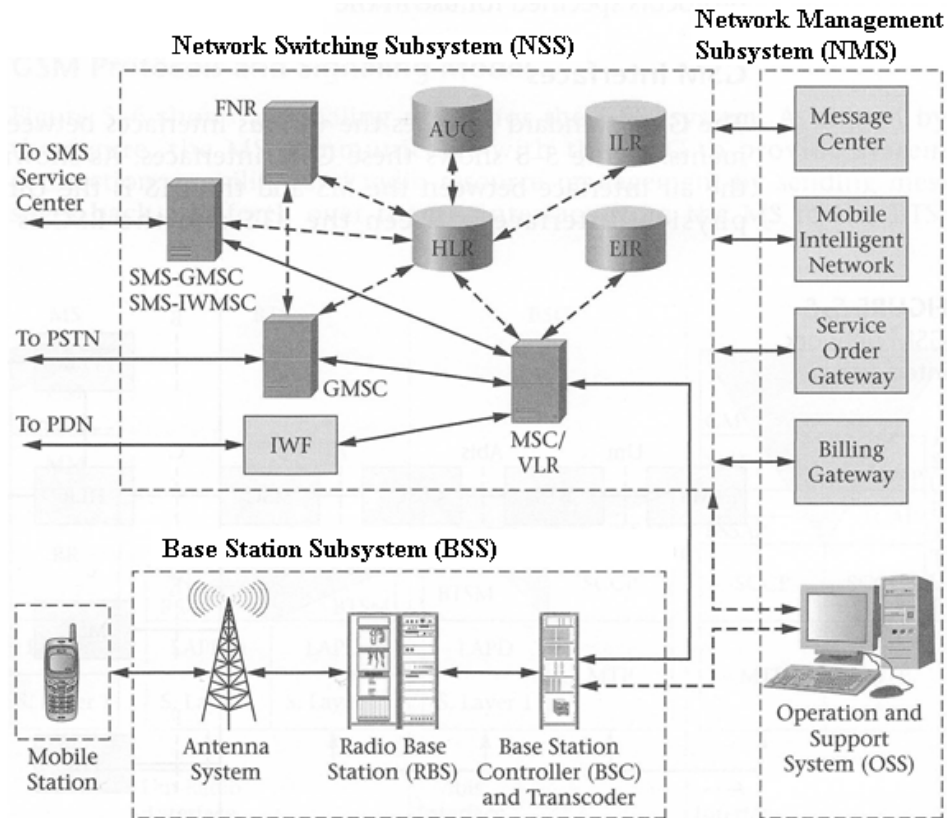

Ref: Wireless Communications Systems and Networks, By Mullett, Thomson Publisher
Note: The solid lines are for user traffic plus control signalling, if any. The dotted lines represent control/management signalling/messaging only.

AUC	Authentication Center
BSC	Base Station Controller
BSS	Base Station Subsystem
BTS	Base Transceiver System (Antenna System + Radio Base Station)
EIR	Equipment Identification Register (for IMEI verification)
IMEI	International Mobile Equipment Identity
FNR	Flexible Numbering Register (for number portability)
GMSC	Gateway MSC
HLR	Home Location Register
ISDN	Integrated Services Digital Network
IWF	Interworking Function
ILR	Interworking Location Register (for roaming between AMPS and GSM system)
IWMSC	Interworking MSC
MS	Mobile Station
MSC	Mobile Switching Center
NSS	Network Switching Subsystem
OSS	Operation and Support System
PDN	Public Data Network
PSTN	Public Switched Telephone Network
SMS	Short Message Service
VLR	Visitor Location Register

The figure below depicts only the basic elements of the network architecture.
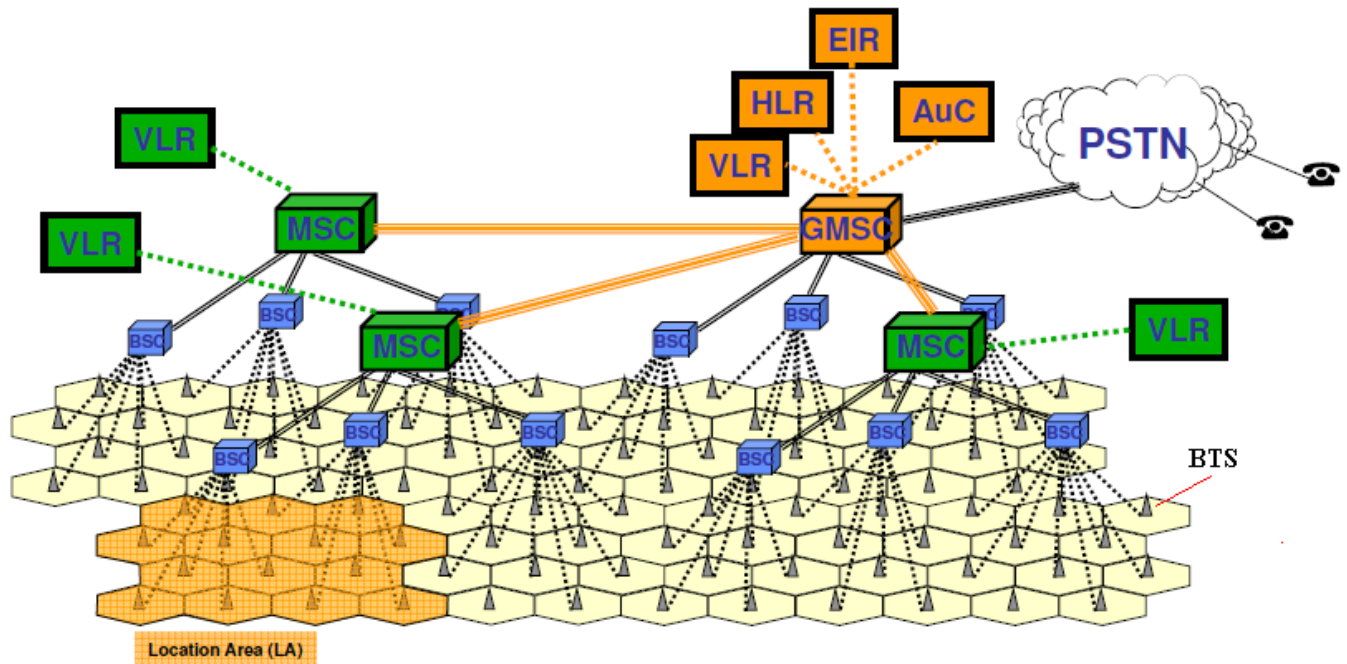
The GSM divides the infrastructure into the following three parts.
- Network Switching Subsystems (NSS)
- Base Station Subsystem (BSS)
- Network Management Subsystem (NMS)

If we count the Mobile Station (MS) or cell-phone is the 4th element.

Any telecommunications network requires some kind of NMS. A part of NMS is generic for any telecom system. The billing and messaging are two examples. The core of the NSS is the MSC (Mobile Switching Center) which is basically a PSTN switch with mobility management related enhancement/add-on. The BSS is entirely new (compared to PSTN) that are required for wireless access and mobility. The following sections of this document provide an overview of the network elements and their functions. The role of these elements will be clearer as we learn more.

2 Network Switching Subsystem (NSS)

Fundamentally, the network and switching subsystems (NSS) is responsible for call connection, supervision and release operations between calling and called stations, where one or both of them are mobile stations (MS). Other functions include:
- Handling short messages and packet data (email, fax and a variety of notifications)
- Providing 'bearer' channel for data communications
- Maintaining database of its own users as well as visitors
- Variety of authentication and encryption
- Gateway to PSTN, other mobile networks and data networks including the Internet

Further Reading: http://en.wikipedia.org/wiki/Network_and_Switching_Subsystem

2.1 Home Location Register

The home location register (HLR) is a database used for storing and managing subscriptions. Generally a PLMN (Public Land Mobile Network) consists of several HLRs. The first two digits of the mobile directory number (e.g. 0171 **26**20757) are the number of the HLR where the mobile subscriber is stored. The data includes permanent data on subscribers (such as subscriber's service profile) as well as dynamic data (such as current location and activity status). When an individual buys a subscription from one of the GSM operators, he or she is registered in the HLR of that operator.

Data Elements (Subscriber) Examples:
- Mobile Station's Identities:
  - IMSI (International Mobile Subscriber Identity) (the primary Key),
  - Current TMSI (Temporary IMSI)
  - IMEI (International Mobile Equipment Identity)
- Mobile Station's Telephone number
  - MSISDN (Mobile Stations ISDN number)
  - Current MSRN (Mobile Station Roaming Number), if assigned
- Name and address of the subscriber
- Current service subscription profile
- Current location (MSC/VRL address)
- Authentication and encryption keys
  - Individual Subscriber Authentication Key (K_I)
- Mobile Country Code (MCC) and MNC (Mobile Network Code)
- List of MSC/VLR that belongs to this HLR

2.2 Mobile Switching Center and Visitor Location Register

The mobile switching center (MSC) performs the telephony switching function. A mobile station must be attached to a single MSC at a time (either homed or visitor), if it is currently active (not switched off). The visitor location register (VLR) is a database attached to an MSC to contain information about its currently associated mobile stations (not just for visitors).

Note: A basic switch (that is a PSTN/ISDN switch) already has a database for its telephone connections. However, it is not designed to include visitors since a visitor has telephone number that does not belong to this switch. That is why a separate VLR is needed. An MSC, with the help of the HLR, allocates a visitor a 'local' telephone number (the MSRN), which is not currently allocated to anyone. This allocation is temporary (like visitor ID card). The VLR stores the MSRN as mobile station's telephone number (along with other information). However, VLR also stores some information like 'security triple' (authentication and encryption information) for each mobile station that are currently attached to the MSC. A VLR stores such information not only for its visitors but also for the homed mobile stations. From this perspective VLR is for homed mobile stations as well.

Data
- Information of currently attached mobile stations
  - IMSI/TMSI numbers
  - MSISDN/MSRN numbers
  - Security triple (authentication and encryption information)
  - Location Area Identity (where the mobile station is currently located)
- List of base stations that belong to this MSC/VLR (by their BSIC or Base Station Identity Code)
- List of location areas that belong to this MSC/VLR (by their LAI or Location Area Identity code)

2.3 Authentication Center

The authentication center (AUC) provides authentication and encryption parameters that verify the user's identity and ensure the confidentiality of each call. The AUC protects network operators from different types of fraud found in today's cellular world. The GSM has standard encryption and authentication algorithm which are used to dynamically compute challenge keys and encryptions keys for a call.

2.4 Equipment Identity Register

The equipment identity register (EIR) is a database that contains information about the identity of mobile equipment that prevents calls from stolen, unauthorized, or defective mobile stations. The AUC and EIR can be implemented as stand-alone nodes or as a combined AUC/EIR node.

2.5 Gateway MSC

The Gateway MSC (GMSC) is an MSC that connects the PLMN (Public Land Mobile Network) to a PSTN/ISDN.

2.6 GSM Interworking Unit/Function

The GSM Interworking (IW) function or Unit (GIWF/U) is for data communication (such as the Internet access) support. Though the basic function of MSC is voice traffic switching the MSC has additional capability to forward data between the mobile station and GIWF/U

2.7 Message Service Gateway

The NMS (network Management subsystem) includes a message center. This includes Short Message Service (SMS), Multimedia Message Service (MMS), Fax, Voice Mail, Email and a variety of notifications. The MSC requires special capability to forward those messages between the message center and the mobile station.

2.8 Flexible Numbering Register

The local number portability (LNP) service is an advance intelligent network (AIN) service of telecommunications network. This service allows a person to move his residence to a new city/province and still retain his/her old telephone number. The local telephone service provider/switch will recognize the old telephone number, and no new number will be assigned. A cell-phone with LNP service can do the same and Flexible Numbering Register (RNR) takes care of that.

3 Base Station Subsystem (BSS)

All radio-related functions between mobile stations and network are performed in the base station subsystem (BSS). The BSS consists of:

- One base station controller (BSC) and

- All base transceiver stations (BTS) under the BSC

Further reading: http://en.wikipedia.org/wiki/Base_Station_Subsystem

3.1 Base Transceiver Station

A Base Station Transceiver (BTS) is a radio transceivers station that communicates with the mobile stations. Its backend is connected to the BSC. More detail about BTS will be covered later. A BTS is usually placed at the center of a cell. Its transmitting power defines the size of a cell. There are more on this later.

3.2 Base Station Controller

A Base Station Controller (BSC) is a high-capacity switch with radio communication and mobility control capabilities. The functions of a BSC include radio channel allocation, location update, handover, timing advance, power control and paging. There are more on this later.

Database (Subscriber)
- Associated IMSI (Primary key)
- Paging Groups

Database (Network)
- MSC Address
- List of Paging Groups
- List of LAI
- List of BSIC
- List of Cell ID (CI)

3.3 Transcoder/Rate Adaptation Unit

The Transcoder/Rate Adaptation Unit (TRAU) is the data rate conversion unit. The PSTN/ISDN switch is a switch for 64 kbps voice. Current technology permits to decrease the bit-rate (in GSM radio interface it is 13 kbps for full rate and 6.5 kbps for half rate). Since MSC is basically a PSTN/ISDN switch its bit-rate is still 64 kbps. That is why a rate conversion is required in between the BSC and MSC (see the figure below)
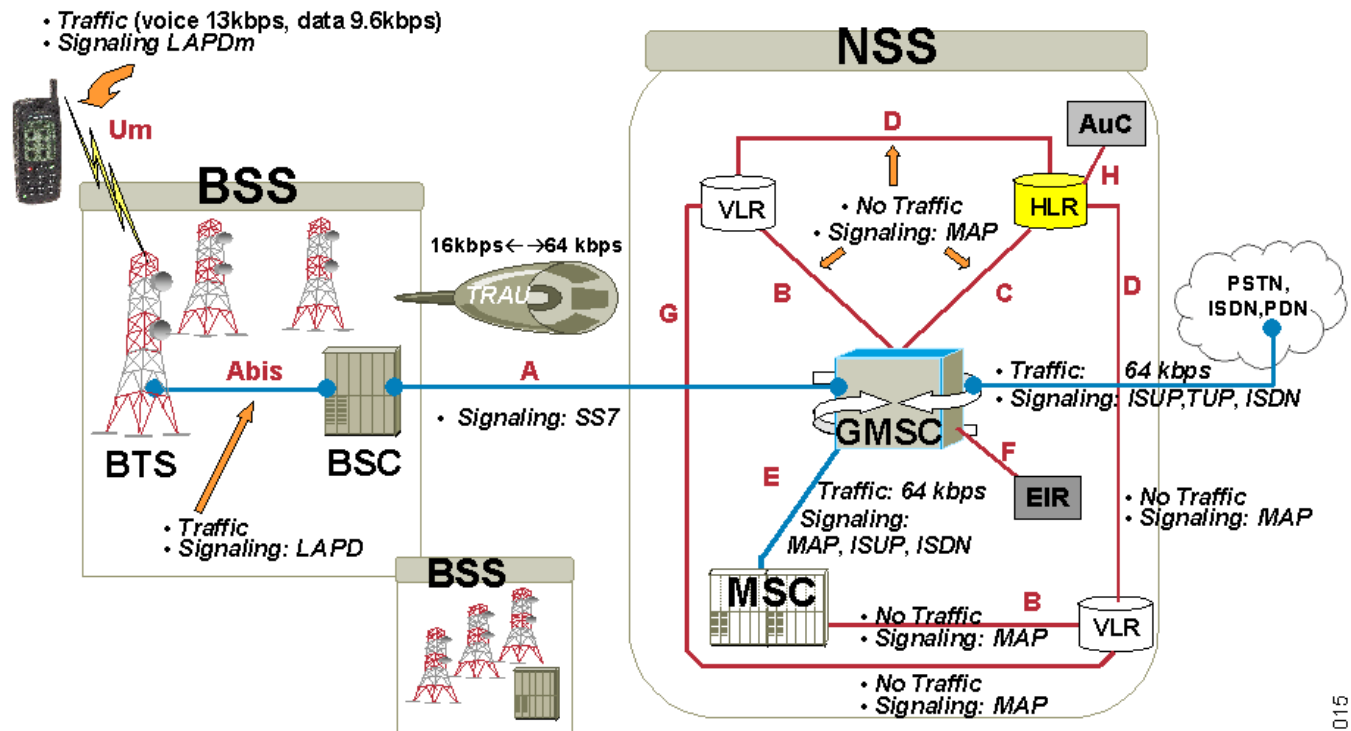
http://www.cisco.com/univercd/cc/td/doc/product/wireless/moblwrls/cmx/mmg_sg/cmxgsm.htm

4 Network Management Subsystem (NMS)

Network Management Subsystem (NMS) includes network management center (NMC), operations and maintenance center (OMC) and a variety of other functions (see the network infrastructure diagram at the beginning of this document). A telecommunications network requires some kind of NMS. A part of NMS is generic for any telecom system.

4.1 Operation and Support System

The operation support system (OSS) is to do a variety of operation and maintenance works such as commissioning and integrating new network elements to the existing system, software upgrade, collecting network performance statistics, reconfiguring network dimension and frequency planning.

4.2 Message Center (MXE)

The MXE, also called Short Message Service Center (SMSC), is a node that provides integrated voice, fax, and data messaging. Specifically, the MXE handles short message service, cell broadcast, voice mail, fax mail, e-mail, and notification.

4.3 Mobile Intelligent Service Node

Like PSTN/ISDN the GSM system supports AIN (Advanced Intelligent Network) services through its mobile intelligent services node (MISN). This enables an operator to develop an innovative service and deploy that in its network.