MOTOROLA

Chapter 3

GSM Network Components

GSM Network Components

Section Objectives

On completion of this section the student will be able to:

- Name the major components of a GSM network and know the functionality of these components.
- Draw a diagram illustrating how the components of the GSM network are connected.

GSM Network Overview

The diagram opposite shows a simplified GSM network. Each network component is illustrated only once, however, many of the components will occur several times throughout a network.

Each network component is designed to communicate over an interface specified by the GSM standards. This provides flexibility and enables a network provider to utilize system components from different manufacturers. For example Motorola Base Station System (BSS) equipment may be coupled with an Ericsson Network Switching System.

The principle component groups of a GSM network are:

- **The Mobile Station (MS)**

  This consists of the mobile telephone, fax machine etc. This is the part of the network that the subscriber will see.

- **The Base Station System (BSS)**

  This is the part of the network which provides the radio interconnection from the MS to the land-based switching equipment.

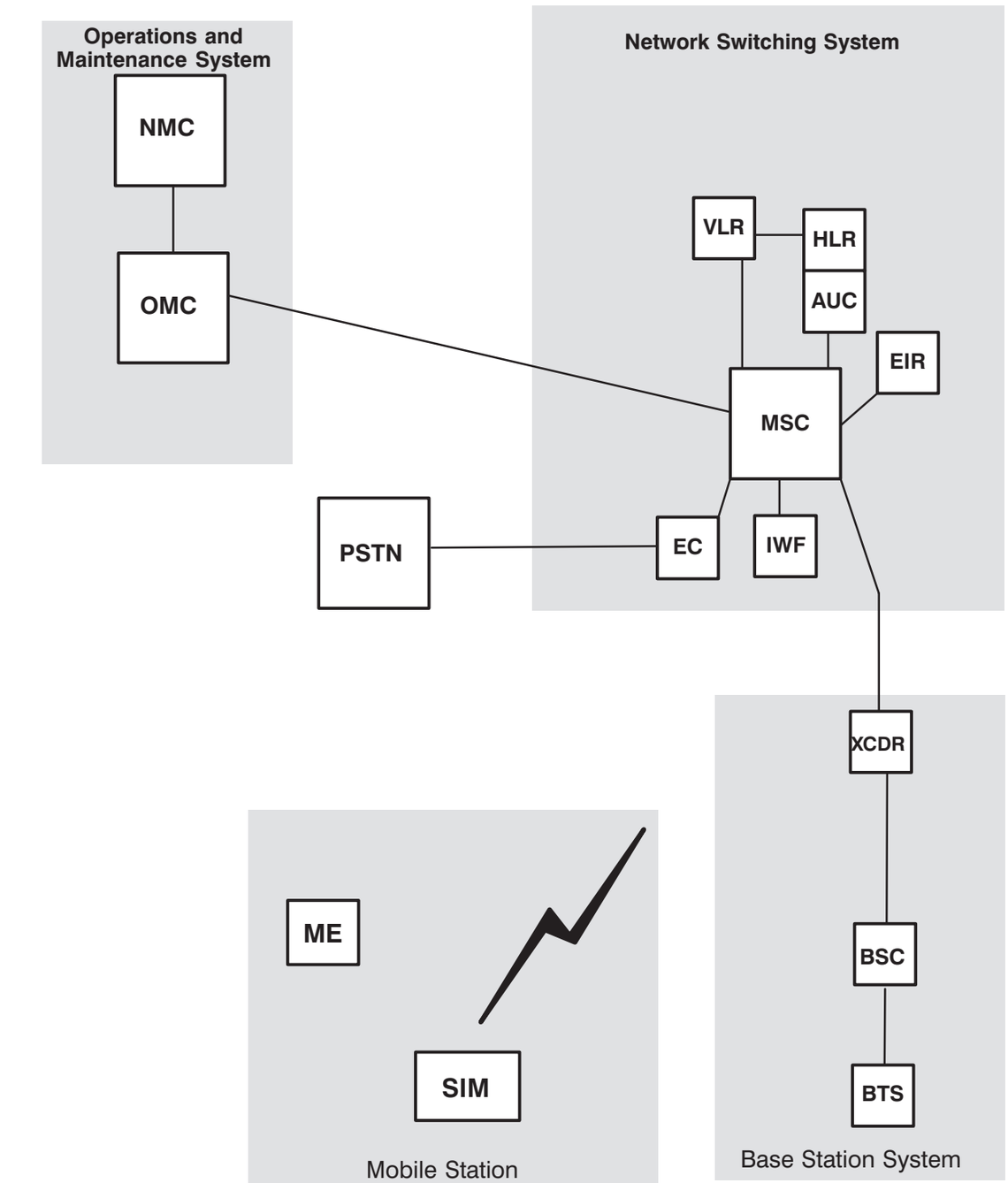
- **The Network Switching System**

  This consists of the Mobile services Switching Centre (MSC) and its associated system-control databases and processors together with the required interfaces. This is the part which provides for interconnection between the GSM network and the Public Switched Telephone Network (PSTN).

- **The Operations and Maintenance System**

  This enables the network provider to configure and maintain the network from a central location.

GSM Network Components



Mobile Station (MS)

The MS consists of two parts, the Mobile Equipment (ME) and an electronic ‘smart card’ called a Subscriber Identity module (SIM).

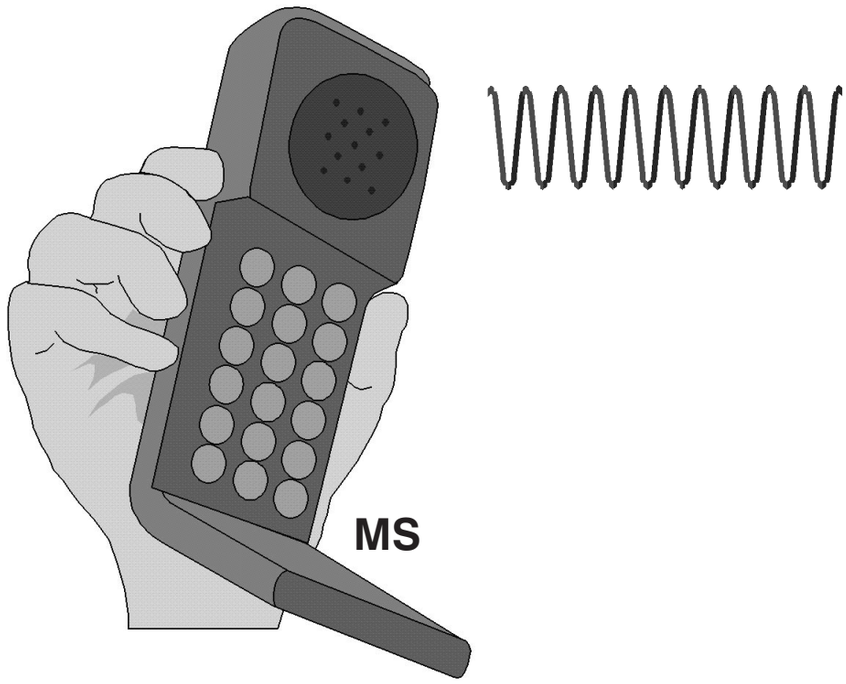
The ME is the hardware used by the subscriber to access the network. The hardware has an identity number associated with it, which is unique for that particular device and permanently stored in it. This identity number is called the International Mobile Equipment Identity (IMEI) and enables the network operator to identify mobile equipment which may be causing problems on the system.

The SIM is a card which plugs into the ME. This card identifies the MS subscriber and also provides other information regarding the service that subscriber should receive. The subscriber is identified by an identity number called the International Mobile Subscriber Identity (IMSI).

Mobile Equipment may be purchased from any store but the SIM must be obtained from the GSM network provider. Without the SIM inserted, the ME will only be able to make emergency calls.

By making a distinction between the subscriber identity and the ME identity, GSM can route calls and perform billing based on the identity of the ‘subscriber’ rather than the equipment or its location.

Mobile Station



Mobile Station (MS)

- **Mobile Equipment (ME)**
- **Subscriber Identity Module (SIM)**

Mobile Equipment (ME)

The ME is the only part of the GSM network which the subscriber will really see. There are three main types of ME, these are listed below:

- **Vehicle Mounted**

  These devices are mounted in a vehicle and the antenna is physically mounted on the outside of the vehicle.

- **Portable Mobile Unit**

  This equipment can be handheld when in operation, but the antenna is not connected to the handset of the unit.

- **Handportable Unit**

  This equipment comprises of a small telephone handset not much bigger than a calculator. The antenna is be connected to the handset.

The ME is capable of operating at a certain maximum power output dependent on its type and use.

These mobile types have distinct features which must be known by the network, for example their maximum transmission power and the services they support. The ME is therefore identified by means of a classmark. The classmark is sent by the ME in its initial message.

The following pieces of information are held in the classmark:

- **Revision Level** –

  Identifies the phase of the GSM specifications that the mobile complies with.

- **RF Power Capability –**

  The maximum power the MS is able to transmit, used for power control and handover preparation. This information is held in the mobile power class number.

- **Ciphering Algorithm** –

  Indicates which ciphering algorithm is implemented in the MS. There is only one algorithm **(A5)** in GSM phase 1, but GSM phase 2 specifies different algorithms **(A5/0–A5/7)**.

- **Frequency Capability** –

  Indicates the frequency bands the MS can receive and transmit on. Currently all GSM MSs use one frequency band, in the future this band will be extended but not all MSs will be capable of using it.

- **Short Message Capability** –

  Indicates whether the MS is able to receive short messages.

Mobile Equipment Capabilies

- **RF power capability**

Power class	Power output
1	20 Watts (deleted)
2	8 Watts
3	5 Watts
4	2 Watts
5	0.8 Watts

- **Support of Phase 1, Phase 2 or Phase 2+ specification**
- **Encryption capability**
- **Frequency capability**
- **Short message services capability**

Subscriber Identity Module (SIM)

The SIM as mentioned previously is a “smart card” which plugs into the ME and contains information about the MS subscriber hence the name Subscriber Identity Module.

The SIM contains several pieces of information:

- **International Mobile Subscriber Identity (IMSI)**

  This number identifies the MS subscriber. It is only transmitted over the air during initialization.

- **Temporary Mobile Subscriber Identity (TMSI)**

  This number identifies the subscriber, it is periodically changed by the system management to protect the subscriber from being identified by someone attempting to monitor the radio interface.

- **Location Area Identity (LAI)**

  Identifies the current location of the subscriber.

- **Subscriber Authentication Key (Ki)**

  This is used to authenticate the SIM card.

- **Mobile Station International Services Digital Network (MSISDN)**

  This is the telephone number of the mobile subscriber. It is comprised of a country code, a network code and a subscriber number.

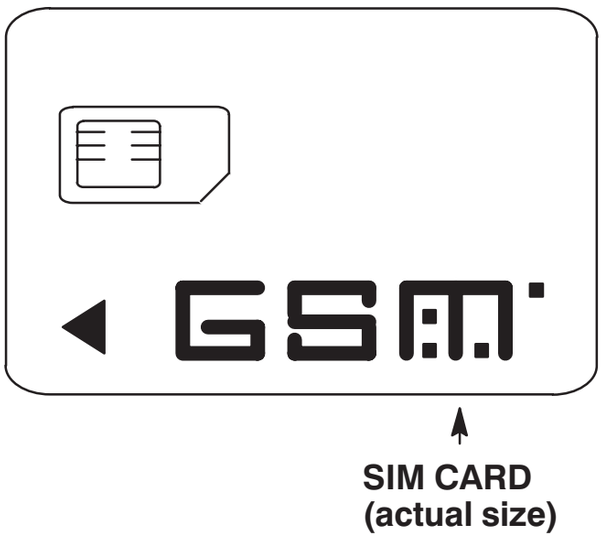
Most of the data contained within the SIM is protected against reading (Ki) or alterations (IMSI). Some of the parameters (LAI) will be continuously updated to reflect the current location of the subscriber.

The SIM card, and the high degree of inbuilt system security, provide protection of the subscriber’s information and protection of networks against fraudulent access. SIM cards are designed to be difficult to duplicate. The SIM can be protected by use of Personal Identity Number (PIN) password, similar to bank/credit charge cards, to prevent unauthorized use of the card.

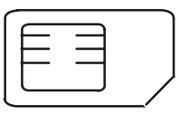
The SIM is capable of storing additional information such as accumulated call charges. This information will be accessible to the customer via handset/keyboard key entry.

The SIM also executes the Authentication Algorithm.

Subscriber Identity Module (SIM)



FULL SIZE SIM CARD



MINI SIM CARD

Base Station System (BSS)

The GSM Base Station System is the equipment located at a cell site. It comprises a combination of digital and RF equipment. The BSS provides the link between the MS and the MSC.

The BSS communicates with the MS over the digital air interface and with the MSC via 2 Mbit/s links.

The BSS consists of three major hardware components:

- **The Base Transceiver Station – BTS**

  The BTS contains the RF components that provide the air interface for a particular cell. This is the part of the GSM network which communicates with the MS. The antenna is included as part of the BTS.

- **The Base Station Controller – BSC**

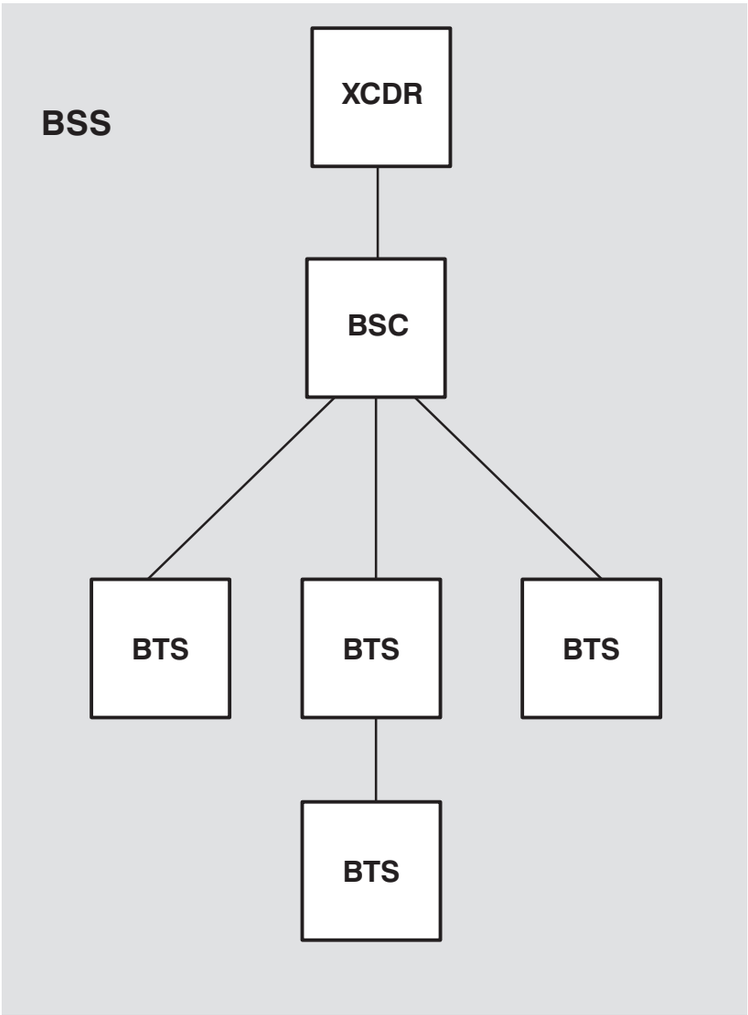
  The BSC as its name implies provides the control for the BSS. The BSC communicates directly with the MSC. The BSC may control single or multiple BTSs.

- **The Transcoder – XCDR**

  The Transcoder **is used to compact the signals** from the MS so that they are more efficiently sent over the terrestrial interfaces. Although the transcoder is considered to be a part of the BSS, it is very often located closer to the MSC.

The transcoder is used to reduce the rate at which the traffic (voice/data) is transmitted over the air interface. Although the transcoder is part of the BSS, it is often found physically closer to the NSS to allow more efficient use of the terrestrial links.

Base Station System (BSS)



Base Station Controller (BSC)

As previously mentioned, the BSC provides the control for the BSS. The functions of the BSC are shown in the table opposite.

Any operational information required by the BTS will be received via the BSC. Likewise any information required about the BTS (by the OMC for example) will be obtained by the BSC.

The BSC incorporates a digital switching matrix, which it uses to connect the radio channels on the air interface with the terrestrial circuits from the MSC.

The BSC switching matrix also allows the BSC to perform “handovers” between radio channels on BTSs, under its control, without involving the MSC.

Base Transceiver Station – BTS

The BTS provides the air interface connection with the MS. I also has a limited amount of control functionality which reduces the amount of traffic passing between the BTS and BSC. The functions of the BTS are shown opposite. Each BTS will support 1 or more cells.

BSS Functionality	*Control*
Terrestrial Channel Management	
Channel Allocation	BSC
Radio Channel Management	BSC
Channel Configuration Management	BSC
Handover Control	BSC
Frequency Hopping	BSC/BTS
Traffic Channel Management	BSC/BTS
Control Channel Management	BSC/BTS
Encryption	BSC/BTS
Paging	BSC/BTS
Power Control	BSC/BTS
Channel Coding/Decoding	BTS
Timing Advance	BTS
Idle Channel Observation	BTS
Measurement Reporting	BTS

Where the BSC and BTS are both shown to control a function, the control is divided between the two, or may be located wholly at one.

Base Station System

BSC

Controls one or more BTSs.

Switches traffic and signalling to/from the BTSs and the MSC.

Connects terrestrial circuits and channels on the air interface.

Controls handovers performed by BTS's under its control.

BTS

Contains RF hardware.

Limited control functionality.

Supports 1 or more cells.

BSS Configurations

As we have mentioned, a BSC may control several BTSs, the maximum number of BTSs which may be controlled by one BSC is not specified by GSM.

Individual manufacturer's specifications may vary greatly.

The BTSs and BSC may either be located at the same cell site "co-located**",** or located at different sites "Remote**"**. In reality most BTSs will be remote, as there are many more BTSs than BSCs in a network.

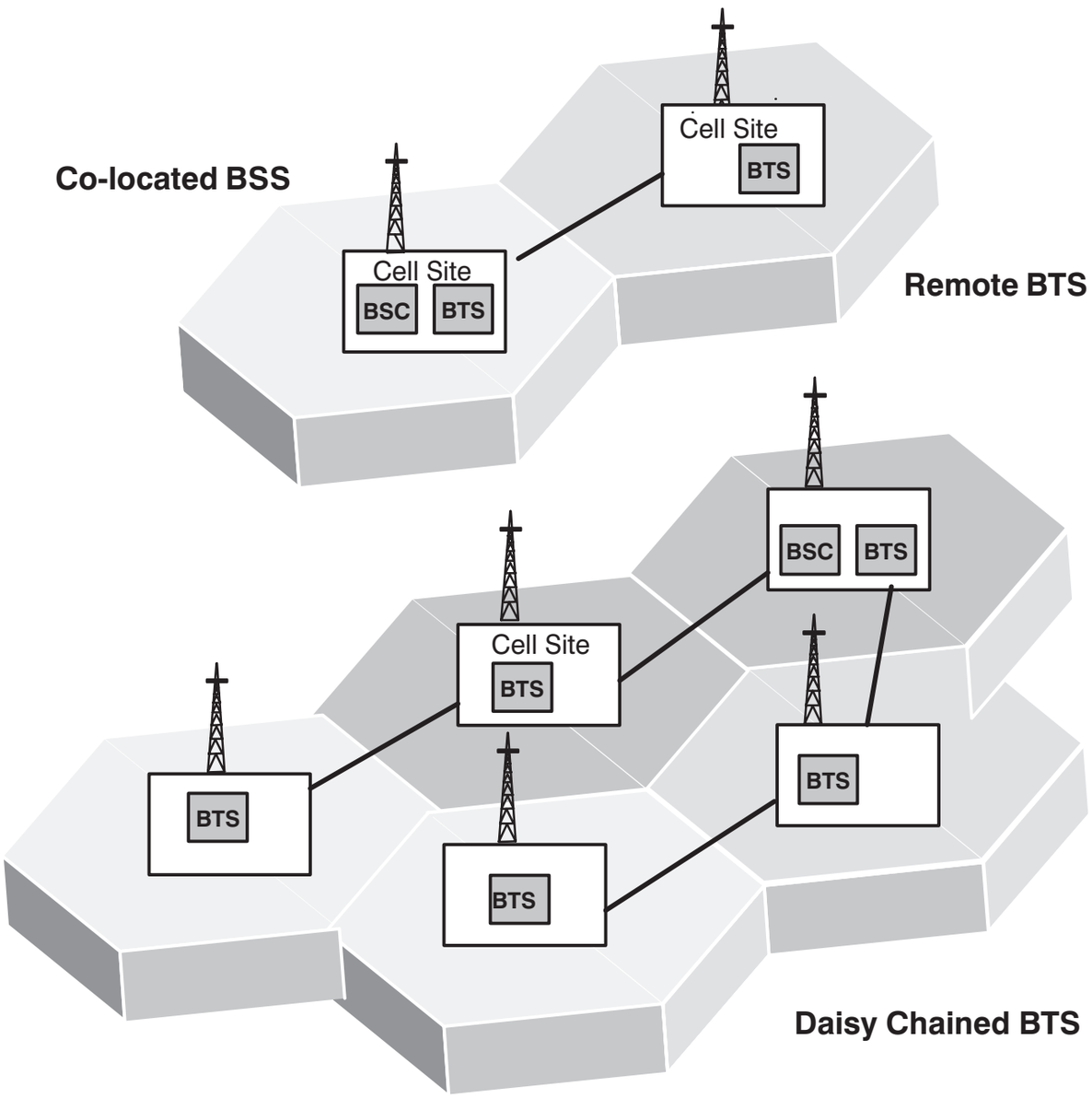
Another BSS configuration is the daisy chain. A BTS need not communicate directly with the BSC which controls it, it can be connected to the BSC via a chain of BTSs.

Daisy chaining reduces the amount of cabling required to set up a network as a BTS can be connected to its nearest BTS rather than all the way to the BSC.

Problems may arise when chaining BTSs, due to the transmission delay through the chain. The length of the chain must, therefore, be kept sufficiently short to prevent the round trip speech delay becoming too long.

Other topologies are also permitted, including stars and loops. Loops are used to introduce redundancy into the network, for example if a BTS connection was lost, the BTS may still be able to communicate with the BSC if a second connection is available.

BSS Configurations



Transcoder (XCDR)

The Transcoder (XCDR) is required to convert the speech or data output from the MSC (64 kbit/s PCM), into the form specified by GSM specifications for transmission over the air interface, that is, between the BSS and MS (64 kbit/s to 16 kbit/s and vice versa)

The 64 kbit/s Pulse Code Modulation (PCM) circuits from the MSC, if transmitted on the air interface without modification, would occupy an excessive amount of radio bandwidth. This would use the available radio spectrum inefficiently. The required bandwidth is therefore reduced by processing the 64 kbit/s circuits so that the amount of information required to transmit digitized voice falls to a gross rate of 16 kbit/s.

The transcoding function may be located at the MSC, BSC, or BTS.

The content of the 16 kbit/s data depends on the coding algorithm used. There are two speech coding algorithms available and selecting which one to use depends on the capabilities of the mobile equipment and the network configuration.

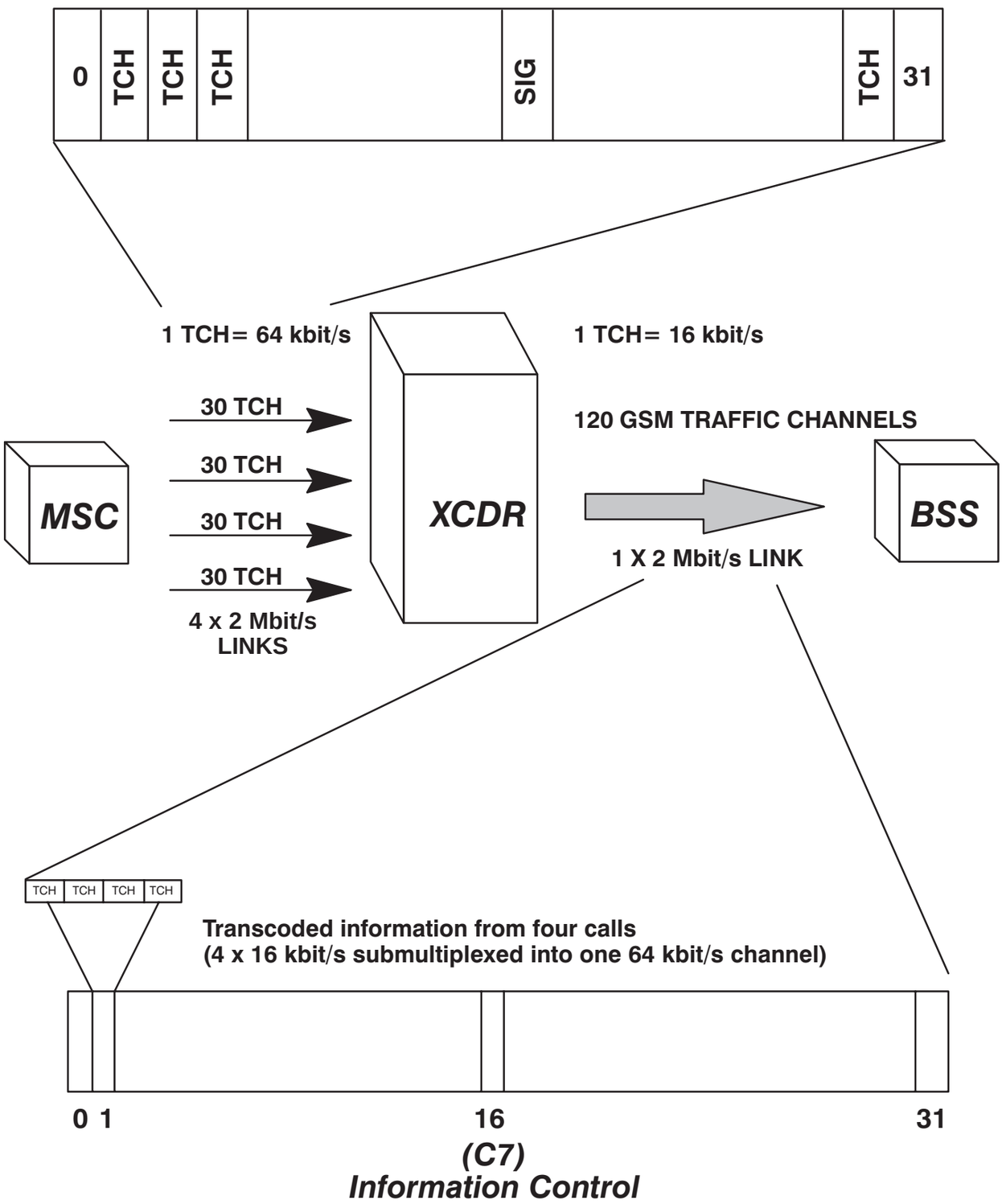
The Full Rate speech algorithm is supported by all mobiles and networks. It produces 13 kbit/s of coded speech data plus 3 kbit/s of control data which is commonly referred to as TRAU data (Transcoder Rate Adaption Unit). The TRAU data on the downlink will be used by the BTS and therefore removed from the 13 k of speech data before transmission on the air interface. the 13 kbit/s of speech data is processed at the BTS to form a gross rate of 22.8 kbit/s on the air interface which includes forward error correction. In the uplink direction the BTS adds in TRAU data which will be used by the transcoder.

Enhanced Full Rate is an improved speech coding algorithm and is only supported by Phase 2+ mobiles and is optional in the Network. It produces 12.2 kbit/s from each 64 kbit/s PCM channel. The TRAU data in this case is made up to 3.8 kbit/s to keep the channel rate to and from the BTS at 16 kbit/s as for Full Rate. As with Full Rate the TRAU data is used at the BTS and Transcoder.

For data transmissions the data is not transcoded but data rate adapted from 9.6 kbit/s (4.8 kbit/s or 2.4 kbit/s may also be used) up to a gross rate of 16 kbit/s for transmission over the terrestrial interfaces, again this 16 kbit/s contains a 3 kbit/s TRAU.

As can be seen from the diagram opposite, although the reason for transcoding was to reduce the data rate over the air interface, the number of terrestrial links is also reduced approximately on a 4:1 ratio.

Transcoder


0
TCH
TCH
TCH
SIG
TCH
31
1 TCH= 64 kbit/s
1 TCH= 16 kbit/s
30 TCH
30 TCH
30 TCH
30 TCH
4 x 2 Mbit/s LINKS
120 GSM TRAFFIC CHANNELS
MSC
XCDR
BSS
1 X 2 Mbit/s LINK
TCH
TCH
TCH
TCH
Transcoded information from four calls
(4 x 16 kbit/s submultiplexed into one 64 kbit/s channel)
0 1
16
31
(C7)
Information Control

Network Switching System

The Network Switching System includes the main switching functions of the GSM network. It also contains the databases required for subscriber data and mobility management. Its main function is to manage communications between the GSM network and other telecommunications networks.

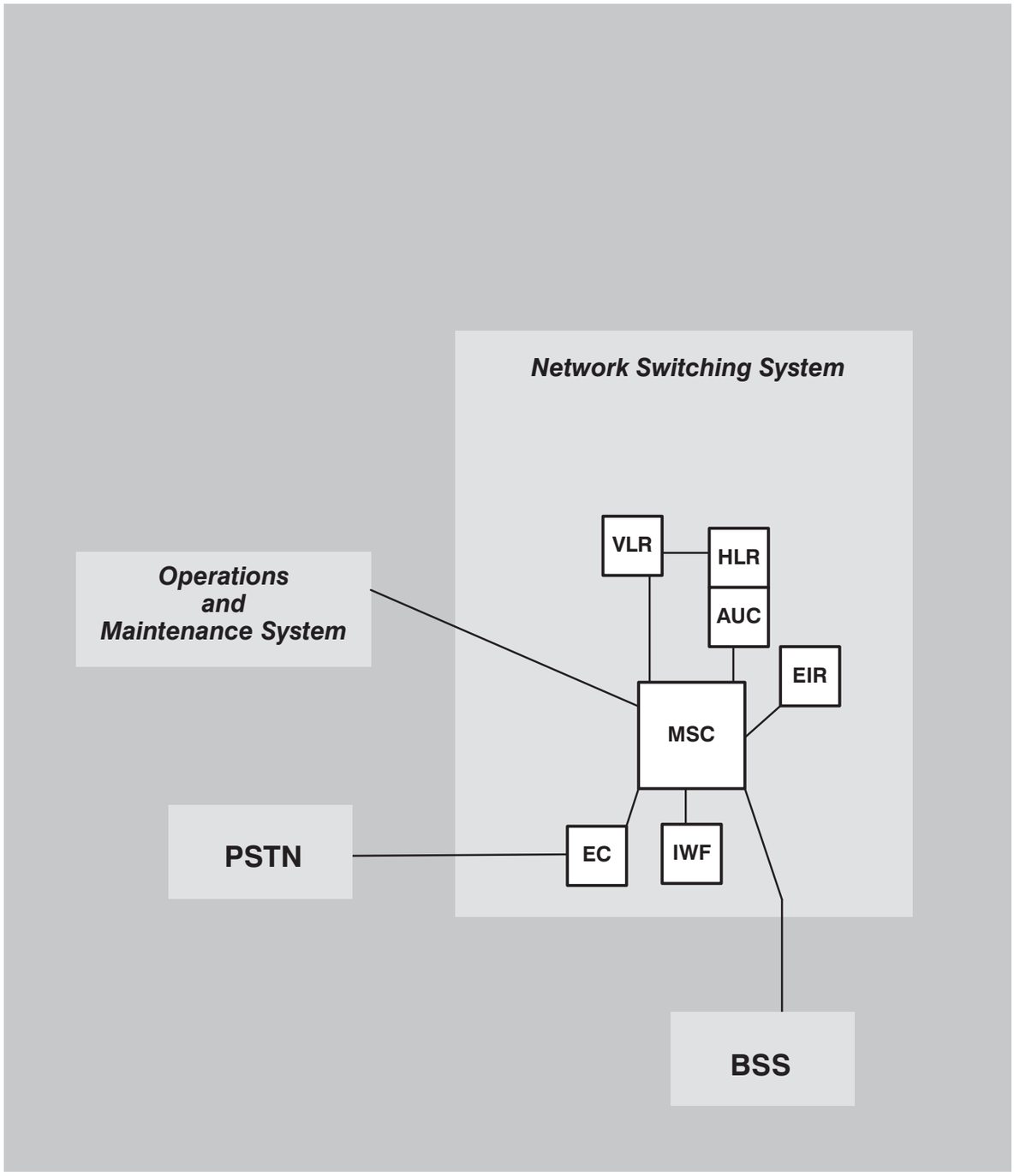
The components of the Network Switching System are listed below:

- Mobile Services Switching Centre – MSC
- Home Location Register – HLR
- Visitor Location Register – VLR
- Equipment Identity Register – EIR
- Authentication Centre – AUC
- InterWorking Function – IWF
- Echo Canceller – EC

In addition to the more traditional elements of a cellular telephone system, GSM has Location Register network entities. These entities are the Home Location Register (HLR), Visitor Location Register (VLR**)**, and the Equipment Identity Register (EIR). The location registers are database-oriented processing nodes which address the problems of managing subscriber data and keeping track of a MSs location as it roams around the network.

Functionally, the Interworking Function and the Echo Cancellers may be considered as parts of the MSC, since their activities are inextricably linked with those of the switch as it connects speech and data calls to and from the MSs.

The Network Switching System



Mobile Services Switching Centre (MSC)

The MSC is included in the GSM system for call-switching. Its overall purpose is the same as that of any telephone exchange.

However, because of the additional complications involved in the control and security aspects of the GSM cellular system and the wide range of subscriber facilities that it offers, the MSC has to be capable of fulfilling many additional functions.

The MSC will carry out several different functions depending upon its position in the network. When the MSC provides the interface between the PSTN and the BSSs in the GSM network it will be known as a Gateway MSC. In this position it will provide the switching required for all MS originated or terminated traffic.

Each MSC provides service to MSs located within a defined geographic coverage area, the network typically contains more than one MSC. One MSC is capable of supporting a regional capital with approximately one million inhabitants. An MSC of this size will be contained in about half a dozen racks.

The functions carried out by the MSC are listed below:

- **Call Processing**

  Includes control of data/voice call setup, inter-BSS and inter-MSC handovers and control of mobility management (subscriber validation and location).

- **Operations and Maintenance Support**

  Includes database management, traffic metering and measurement, and a man–machine interface.

- **Internetwork Interworking**

  Manages the interface between the GSM network and the PSTN.

- **Billing**

  Collects call billing data.

Mobile Service Switching Centre

- **Call processing**
- **Operations & maintenance**
- **Internetwork interworking**
- **Billing**

Home Location Register (HLR)

The HLR is the reference database for subscriber parameters.

Various identification numbers and addresses are stored, as well as authentication parameters. This information is entered into the database by the network provider when a new subscriber is added to the system.

The parameters stored in the HLR are listed opposite:

The HLR database contains the master database of all the subscribers to a GSM PLMN. The data it contains is remotely accessed by all the MSCs and the VLRs in the network and, although the network may contain more than one HLR, there is only one database record per subscriber – each HLR is therefore handling a portion of the total subscriber database. The subscriber data may be accessed by either the IMSI or the MSISDN number. The data can also be accessed by an MSC or a VLR in a different PLMN, to allow inter-system and inter-country roaming.

Home Location Register (HLR)

- **Subscriber ID (IMSI and MSISDN)**
- **Current subscriber VLR (current location)**
- **Supplementary services subscribed to**
- **Supplementary service information (e.g. current forwarding number)**
- **Subscriber status (registered/deregistered)**
- **Authentication key and AUC functionality**
- **Mobile Subscriber Roaming Number**

Visitor Location Register (VLR)

The VLR contains a copy of most of the data stored at the HLR. It is, however, temporary data which exists for only as long as the subscriber is “active” in the particular area covered by the VLR. The VLR database will therefore contain some duplicate data as well as more precise data relevant to the subscriber remaining within the VLR coverage.

The VLR provides a local database for the subscribers wherever they are physically located within a PLMN, this may or may not be the “home” system. This function eliminates the need for excessive and time-consuming references to the “home” HLR database.

The additional data stored in the VLR is listed below:

- Mobile status (busy/free/no answer etc.).
- Location Area Identity (LAI).
- Temporary Mobile Subscriber Identity (TMSI).
- Mobile Station Roaming Number (MSRN).

Location Area Identity

Cells within the Public Land Mobile Network (PLMN) are grouped together into geographical areas. Each area is assigned a Location Area Identity (LAI), a location area may typically contain 30 cells. Each VLR controls several LAIs and as a subscriber moves from one LAI to another, the LAI is updated in the VLR. As the subscriber moves from one VLR to another, the VLR address is updated at the HLR.

Temporary Mobile Subscriber Identity

The VLR controls the allocation of new Temporary Mobile Subscriber Identity (TMSI) numbers and notifies them to the HLR. The TMSI will be updated frequently, this makes it very difficult for the call to be traced and therefore provides a high degree of security for the subscriber. The TMSI may be updated in any of the following situations:

- Call setup.
- On entry to a new LAI.
- On entry to a new VLR.

Mobile Subscriber Roaming Number

As a subscriber may wish to operate outside its “home” system at some time, the VLR can also allocate a Mobile Station Roaming Number (MSRN). This number is assigned from a list of numbers held at the VLR (MSC). The MSRN is then used to route the call to the MSC which controls the base station in the MSs current location.

The database in the VLR can be accessed by the IMSI, the TMSI or the MSRN. Typically there will be one VLR per MSC.

Visitor Location Register

- **Mobile Status**
- **Location Area Identity (LAI)**
- **Temporary Mobile Subscriber Identity (TMSI)**
- **Mobile Station Roaming Number (MSRN)**

Equipment Identity Register (EIR)

The EIR contains a centralized database for validating the International Mobile Equipment Identity (IMEI).

This database is concerned solely with MS equipment and not with the subscriber who is using it to make or receive a call.

The EIR database consists of lists of IMEIs (or ranges of IMEIs) organized as follows:

- **White List**

  Contains those IMEIs which are known to have been assigned to valid MS equipment.

- **Black List**

  Contains IMEIs of MS which have been reported stolen or which are to be denied service for some other reason.

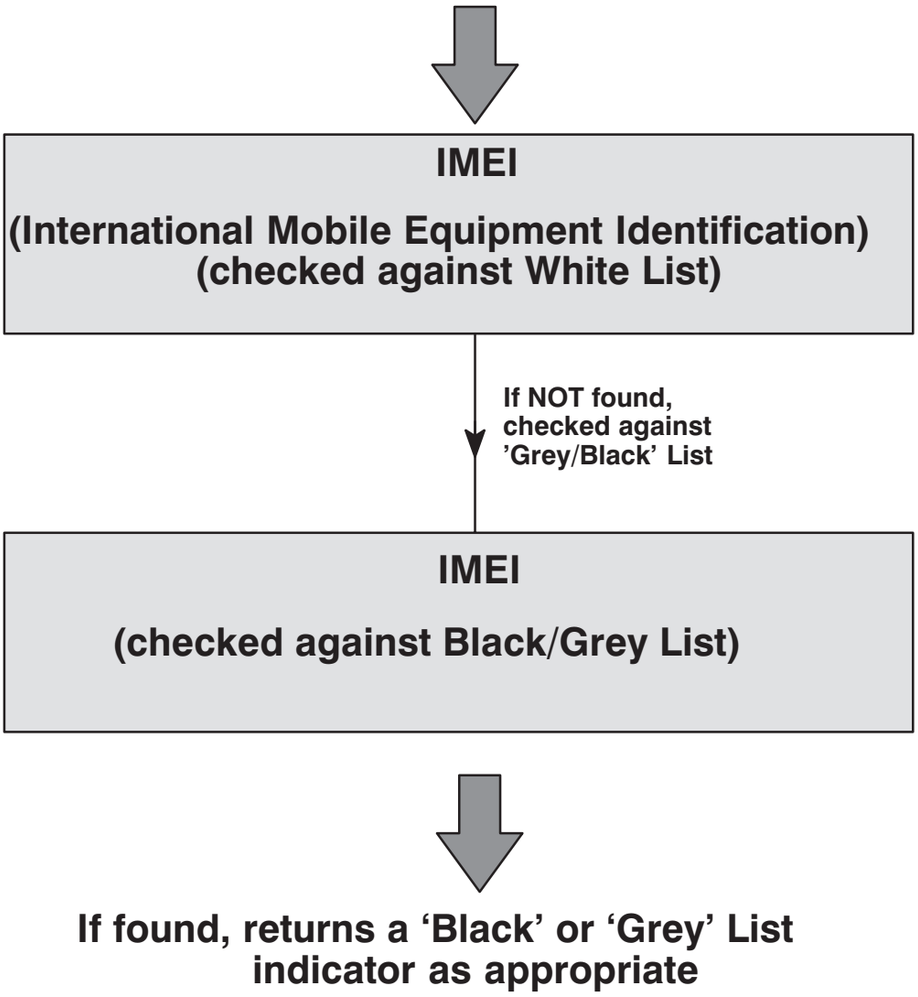
- **Grey List**

  Contains IMEIs of MS which have problems (for example, faulty software). These are not, however, sufficiently significant to warrant a ‘‘black listing”.

The EIR database is remotely accessed by the MSCs in the network and can also be accessed by an MSC in a different PLMN.

As in the case of the HLR, a network may well contain more than one EIR with each EIR controlling certain blocks of IMEI numbers. The MSC contains a translation facility, which when given an IMEI, returns the address of the EIR controlling the appropriate section of the equipment database.

Call Processing Functions (EIR)



Authentication Centre (AUC)

The AUC is a processor system, it performs the “authentication” function.

It will normally be co-located with the Home Location Register (HLR) as it will be required to continuously access and update, as necessary, the system subscriber records. The AUC/HLR centre can be co-located with the MSC or located remote from the MSC.

The authentication process will usually take place each time the subscriber “initializes” on the system.

Authentication Process

To discuss the authentication process we will assume that the VLR has all the information required to perform that authentication process (Kc, SRES and RAND). If this information is unavailable, then the VLR would request it from the HLR/AUC.

1. Triples (Kc, SRES and RAND) are stored at the VLR.
2. The VLR sends RAND via the MSC and BSS, to the MS (unencrypted).
3. The MS, using the A3 and A8 algorithms and the parameter Ki stored on the MS SIM card, together with the received RAND from the VLR, calculates the values of SRES and Kc.
4. The MS sends SRES unencrypted to the VLR
5. Within the VLR the value of SRES is compared with the SRES received from the mobile. If the two values match, then the authentication is successful.
6. If cyphering is to be used, Kc from the assigned triple is passed to the BTS.
7. The mobile calculates Kc from the RAND and A8 and Ki on the SIM.
8. Using Kc, A5 and the GSM hyperframe number, encryption between the MS and the BSS can now occur over the air interface***.***

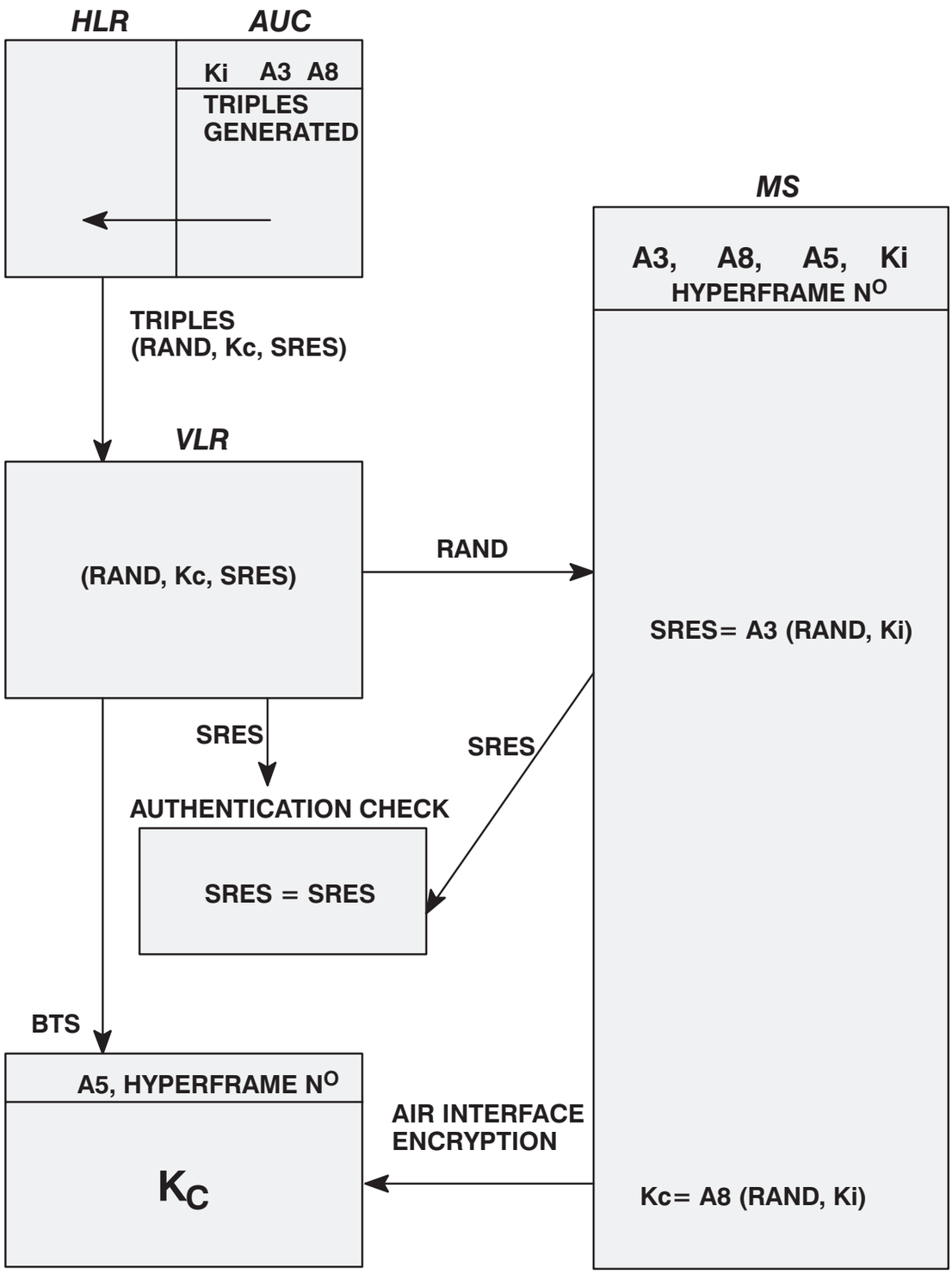
Note: The triples are generated at the AUC by:

RAND	=	Randomly generated number.
SRES	=	Derived from A3 (RAND, Ki).
Kc	=	Derived from A8 (RAND, Ki).
A3	=	From 1 of 16 possible algorithms defined on allocation of IMSI and creation of SIM card.
A8	=	From 1 of 16 possible algorithms defined on allocation of IMSI and creation of SIM card.
Ki	=	Authentication key, assigned at random together with the versions of A3 and A8.

The first time a subscriber attempts to make a call, the full authentication process takes place.

However, for subsequent calls attempted within a given system control time period, or within a single system provider’s network, authentication may not be necessary, as the data generated during the first authentication will still be available.

Authentication Process



Interworking Function (IWF)

The IWF provides the function to enable the GSM system to interface with the various forms of public and private data networks currently available.

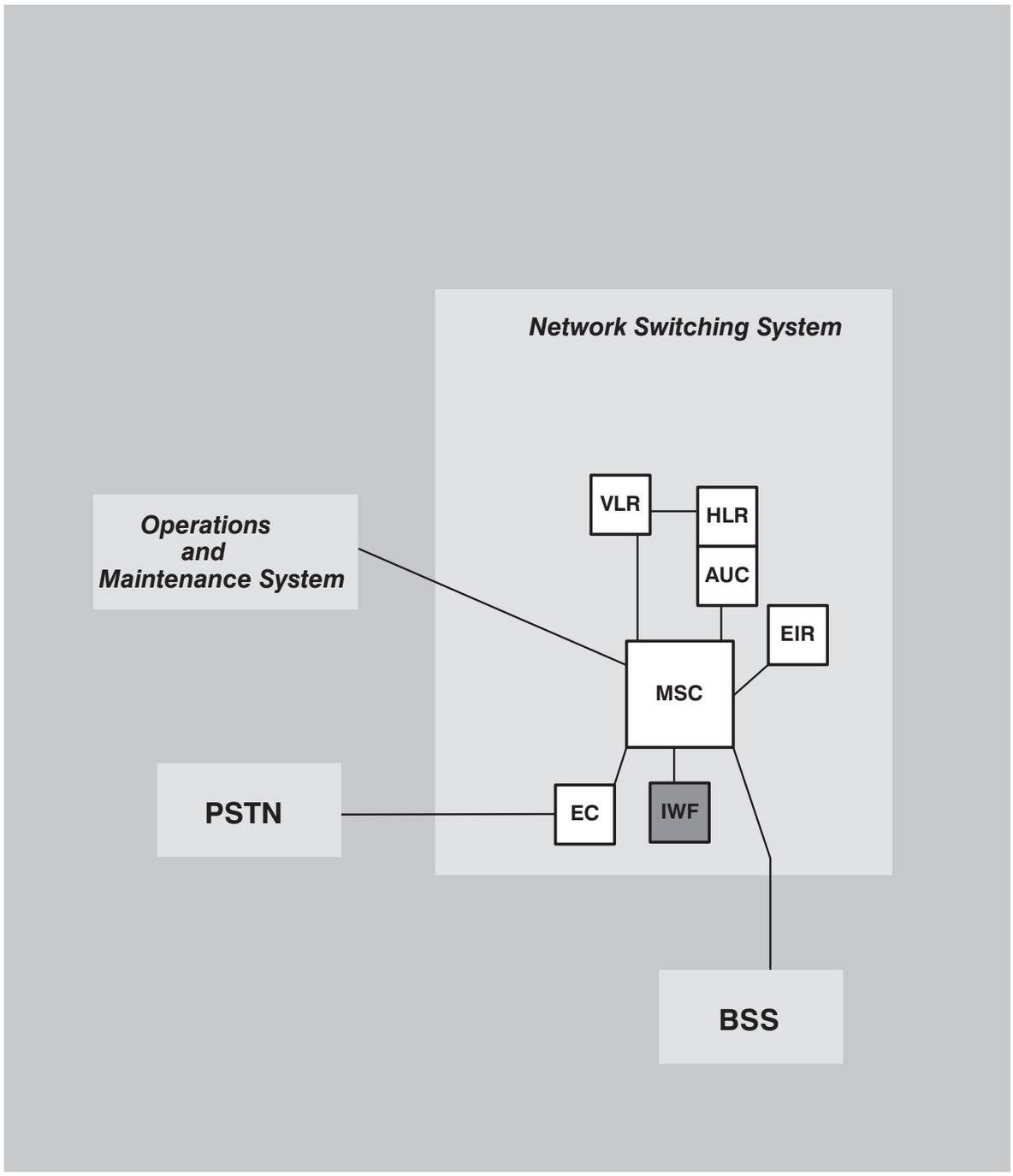
The basic features of the IWF are listed below.

- Data rate adaption.
- Protocol conversion.

Some systems require more IWF capability than others, this depends upon the network to which it is being connected.

The IWF also incorporates a “modem bank”, which may be used when, for example, the GSM **Data Terminal Equipment (DTE)** exchanges data with a land DTE connected via an analogue modem.

Interworking Function



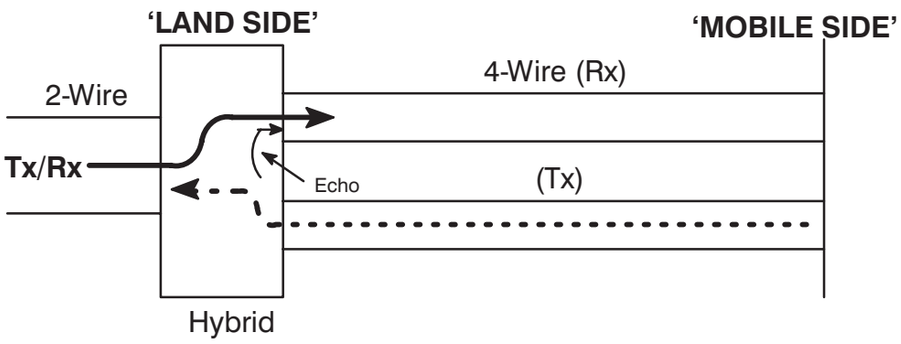
Echo Canceller (EC)

An EC is used on the PSTN side of the MSC for all voice circuits. Echo control is required at the switch because the inherent GSM system delay can cause an unacceptable echo condition, even on short distance PSTN circuit connections.

The total round trip delay introduced by the GSM system (the cumulative delay caused by call processing, speech encoding and decoding etc) is approximately 180 mS. This would not be apparent to the MS subscriber, but for the inclusion of a 2-wire to 4-wire hybrid transformer in the circuit. This is required at the land party's local switch because the standard telephone connection is 2-wire. The transformer causes the echo. This does not affect the land subscriber.

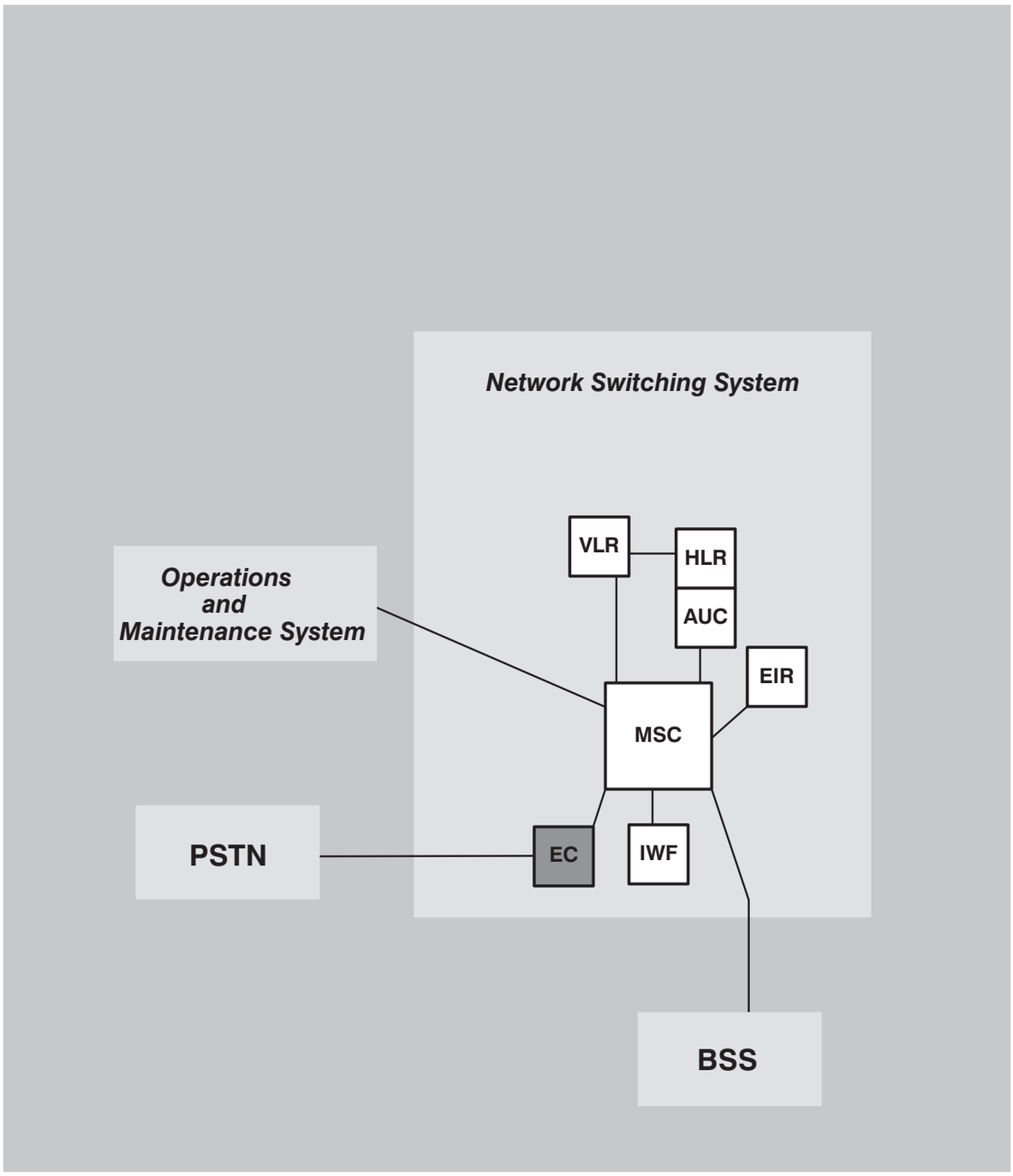
During a normal PSTN land to land call, no echo is apparent because the delay is too short and the user is unable to distinguish between the echo and the normal telephone "side tone". However, without the EC and with the GSM round trip delay added, the effect would be very irritating to the MS subscriber, disrupting speech and concentration.

The standard EC will provide cancellation of up to 68 milliseconds on the "tail circuit" (the tail circuit is the connection between the output of the EC and the land telephone).



Generation of Echoes at 2-Wire to 4-Wire interface

Echo Canceller



Operations and Maintenance System

Overview

The operations and maintenance system provides the capability to manage the GSM network remotely.

This area of the GSM network is not currently tightly specified by the GSM specifications, it is left to the network provider to decide what capabilities they wish it to have. The Operations and Maintenance System comprises of two parts:

Network Management Centre (NMC)

The Network Management Centre (NMC**)** has a view of the entire PLMN and is responsible for the management of the network as a whole. The NMC resides at the top of the hierarchy and provides global network management.

Operations and Maintenance Centre (OMC)

The Operations and Maintenance Centre (OMC) is a centralized facility that supports the day to day management of a cellular network as well as providing a database for long term network engineering and planning tools. An OMC manages a certain area of the PLMN thus giving regionalized network management.

Operations & Maintenance System

OMC *(REGIONAL)*	*NMC* *(GLOBAL)*
Multiple OMCs per network	**Single NMC per network**
Regionalized network management	**Global network management**
Employed in daily operations	**Employed in long term planning**
Used by network operators	**Used by network managers and planners**
	24 hour supervision

Network Management Centre (NMC)

The NMC offers the ability to provide hierarchical regionalized network management of a complete GSM system.

It is responsible for operations and maintenance at the network level, supported by the OMCs which are responsible for regional network management.

The NMC is therefore a single logical facility at the top of the network management hierarchy.

The NMC has a high level view of the network, as a series of network nodes and interconnecting communications facilities. The OMC, on the other hand, is used to filter information from the network equipment for forwarding to the NMC, thus allowing it to focus on issues requiring national co-ordination. The NMC can also co-ordinate issues regarding interconnection to other networks, for example the PSTN.

The NMC can take regional responsibility when an OMC is not manned, with the OMC acting as a transit point between the NMC and the network equipment. The NMC provides operators with functions equivalent to those available at the OMC.

Functionality of the NMC

Monitors nodes on the network

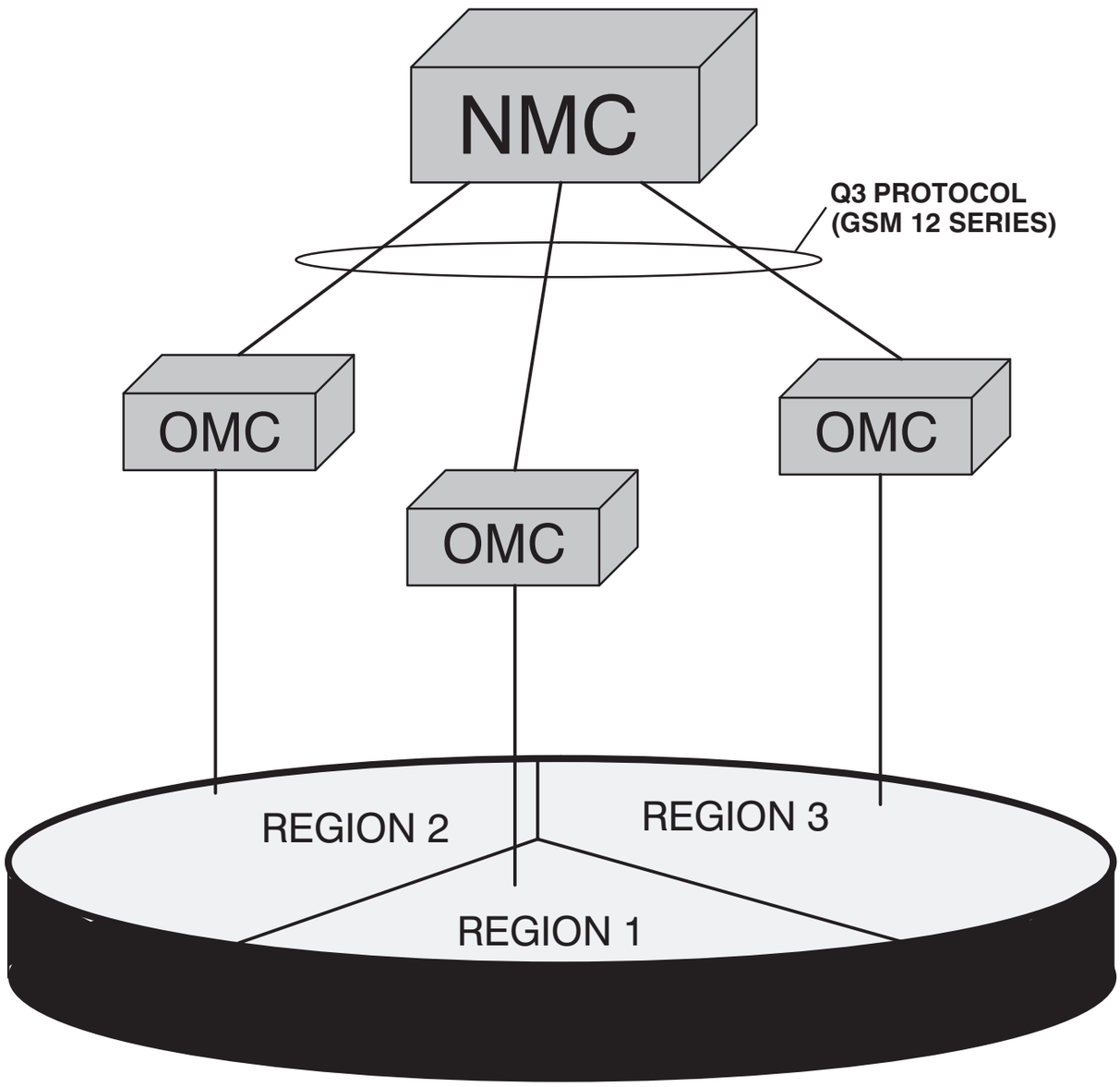
Monitors GSM network element statistics

Monitors OMC regions & provides information to OMC staff

Passes on statistical information from one OMC region to another to improve problem solving strategies

Enables long term planning for the entire network

Network Management Centre



NETWORK

Operations and Maintenance Centre (OMC)

The OMC provides a central point from which to control and monitor the other network entities (i.e. base stations, switches, database, etc) as well as monitor the quality of service being provided by the network.

At present, equipment manufacturers have their own OMCs which are not compatible in every aspect with those of other manufacturers. This is particularly the case between radio base station equipment suppliers, where in some cases the OMC is a separate item and Digital Switching equipment suppliers, where the OMC is an integral, but functionally separate, part of the hardware.

There are two types of OMC these are:

- **OMC (R)**

  OMC controls specifically the Base Station System.

- **OMC (S)**

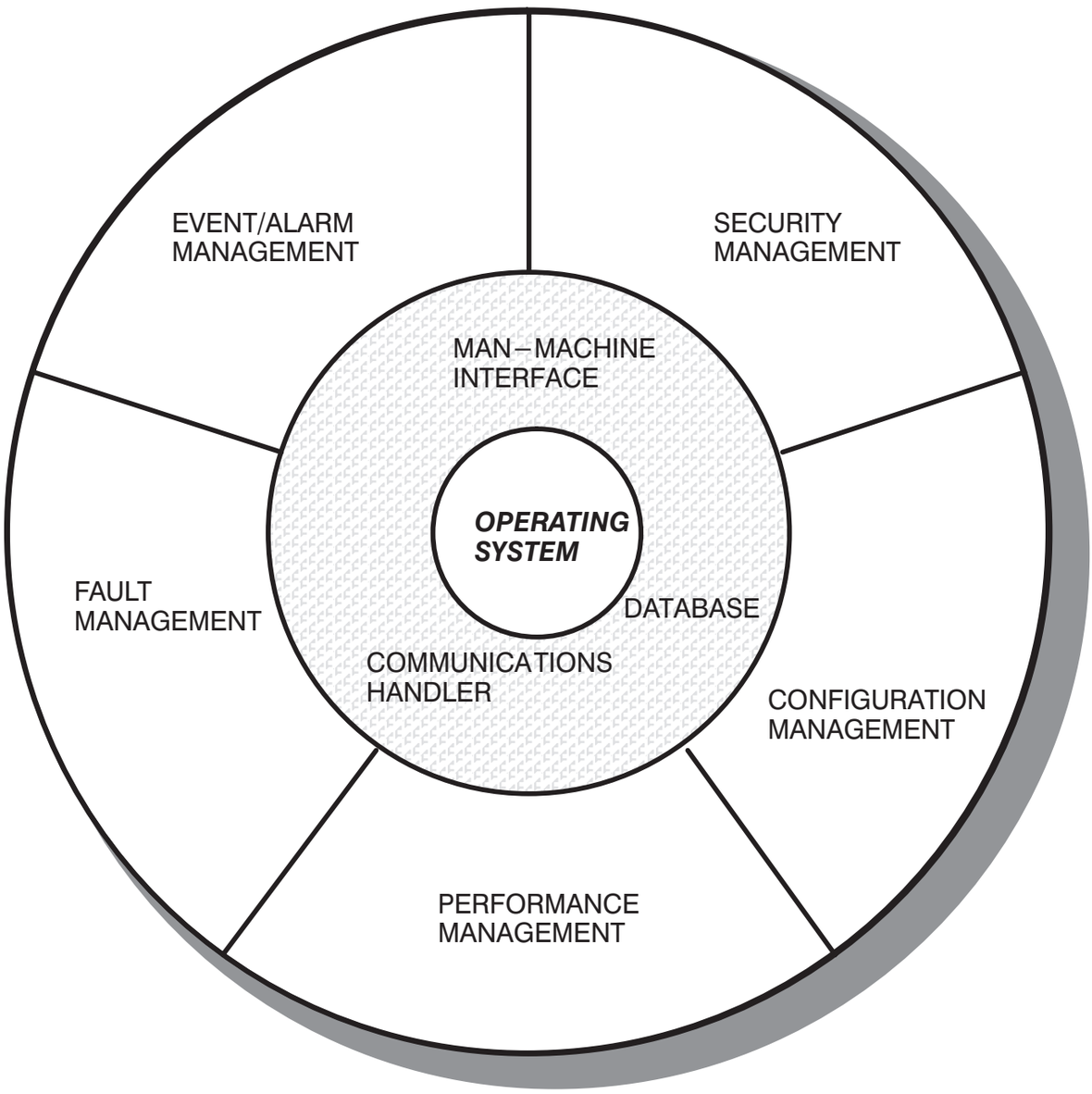
  OMC controls specifically the Network Switching System.

The OMC should support the following functions as per ITS–TS recommendations:

- Event/Alarm Management.
- Fault Management.
- Performance Management.
- Configuration Management.
- Security Management.

The OMC functional architecture is illustrated in the diagram opposite.

OMC Functional Architecture



The Network In Reality

In reality a GSM network is much more complicated than we have seen. The diagram opposite illustrates how multiple BSS and Network Switching System components will be connected within a network.

A typical city for example, London) will have approximately the following number of network components:

Network Component	Quantity
Operations and Maintenance Centre (Base Station Equipment) – OMC(R)	1
Operations and Maintenance Centre (Switching) – OMC(S)	1
Mobile Services Switching Centre – MSC/ VLR	1–2
Base Station Controller – BSC	5–15
Base Transceiver Station – BTS	200–400

A typical network (for example, UK) will have approximately the following number of network components.

Network Component	Quantity
Operations and Maintenance Centre (Base Station Equipment) – OMC(R)	6
Operations and Maintenance Centre (Switching) – OMC(S)	6
Mobile Services Switching Centre – MSC/VLR	6
Base Station Controller – BSC	40+
Base Transceiver Station – BTS	1200+

GSM Network Components