INTRODUCTION

- GSM stands for **G**lobal **S**ystem for **M**obile Communication and is an open, digital cellular technology used for transmitting mobile voice and data services.
- The GSM emerged from the idea of cell-based mobile radio systems at Bell Laboratories in the early 1970s.
- The GSM is the name of a standardization group established in 1982 to create a common European mobile telephone standard.
- The GSM standard is the most widely accepted standard and is implemented globally.
- The GSM is a circuit-switched system that divides each 200kHz channel into eight 25kHz time-slots. GSM operates in the 900MHz and 1.8GHz bands in Europe and the 1.9GHz and 850MHz bands in the US.
- The GSM owns a market share of more than 70 percent of the world's digital cellular subscribers.
- The GSM makes use of narrowband Time Division Multiple Access (TDMA) technique for transmitting signals.
- The GSM was developed using digital technology. It has an ability to carry 64 kbps to 120 Mbps of data rates.
- Presently GSM support more than one billion mobile subscribers in more than 210 countries throughout of the world.
- The GSM provides basic to advanced voice and data services including Roaming service. Roaming is the ability to use your GSM phone number in another GSM network.

A GSM digitizes and compresses data, then sends it down through a channel with two other streams of user data, each in its own time slot. It operates at either the 900 MHz or 1,800 MHz frequency band.

NEED FOR GSM

The GSM study group aimed to provide the followings through the GSM:

- Improved spectrum efficiency.
- International roaming.
- Low-cost mobile sets and base stations (BSs)
- High-quality speech
- Compatibility with Integrated Services Digital Network (ISDN) and other telephone company services.
- Support for new services.

HISTORY

The first mobile telephone service started in 1946 in St. Louis, Missouri, USA as an manually operated system. Between 1950 and 1960, it evolved as an automatic system with reduced cost and increased, but small subscriber base. Mobile telephony service in its useful form appeared in 1960s.
The period from 1940 – 60

- The 1st mobile telephone service started in 1946 in St. Louis Missouri, USA.
- Between 1950 and 1960 it evolved as an automatic system.
- Mobile telephony service in its useful from appeared in 1960s.

In 1982, the European Conference of Postal and Telecommunications Administrations (CEPT) created the Groupe Spécial Mobile (GSM) to develop a standard for a mobile telephone system that could be used across Europe. In 1987, a memorandum of understanding was signed by 13 countries to develop a common cellular telephone system across Europe. Finally the system created by SINTEF lead by Torleiv Maseng was selected.
In 1989, GSM responsibility was transferred to the European Telecommunications Standards Institute (ETSI) and phase I of the GSM specifications were published in 1990. The first GSM network was launched in 1991 by Radiolinja in Finland with joint technical infrastructure maintenance from Ericsson.

The period from 1980 - 95

- Each country developed its own system
- In 1982 the Conference of European Posts and Telegraphs (CEPT) formed a study group called the Group Special Mobile (GSM) to study and develop a European public land mobile system which had to meet certain criteria :
    - Good subjective speech quality.
    - Low terminal and service cost.
    - Support for international roaming

- Ability to support hand held terminals.
- Support for range of new service and facilities.
- Spectral efficiency.

In 1989, GSM responsibility was transferred to European Telecommunication Standards Institute (ETSI)

GSM specifications were published in 1990 as:-

Commercial service started in mid – 1991

By 1993 there were 36 GSM networks in 22 countries

The First Generation Mobile Communication System appeared in 1970s and remained till 1980s.They used analog transmission techniques for radio link and confined its users to their respective systems areas for which the mobile phone was designed. Capacity of system was limited and roaming between the coverage areas of different systems was impossible. Apart from being very expensive these system provides very poor QoS and supported only voice communication.

The Second Generation Mobile Communication System has grew out of the limitation of first generation systems. They supported large subscriber base, carried both voice and data and have capable of design and deliver new value added services. GSM and CDMA emerged as the trend setting technologies. The domination of 2G systems became apparent in second half of 1990s.

The Third Generation Mobile Communication Systems provide high functionality with seamless global roaming. Apart from providing very high data rates, 3G systems seek to integrate the wire line systems with mobile systems. 3G would provide users consistent voice, data, graphical, multi-media regardless of their location in the network. They also integrate the Intelligent Network (IN) capabilities into mobile systems.

DEVELOPMENTS IN GSM

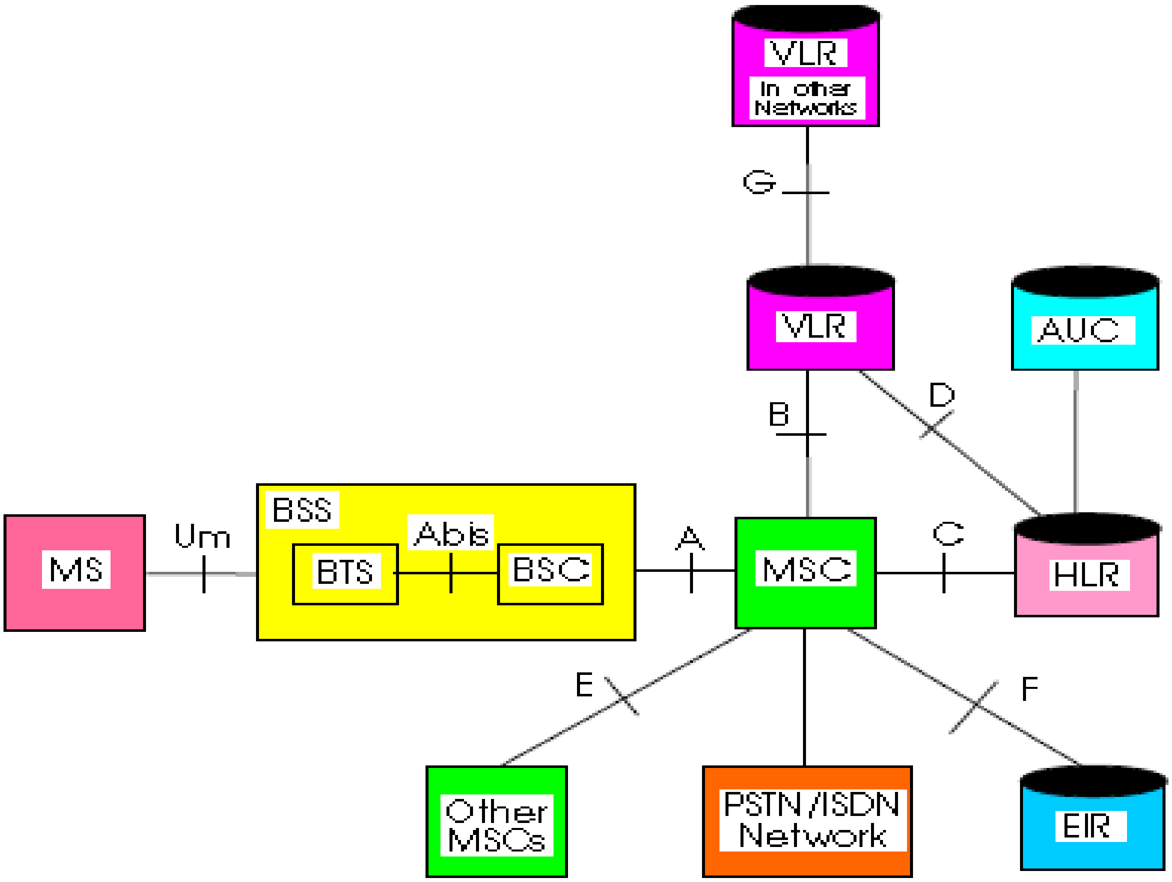
Years	Events
1982	CEPT establishes a GSM group in order to develop the standards for a pan-European cellular mobile system.
1985	A list of recommendations to be generated by the group is accepted.
1986	Field tests are performed to test the different radio techniques proposed for the air interface.
1987	Time Division Multiple Access (TDMA) is chosen as the access method (with Frequency Division Multiple Access [FDMA]). The initial Memorandum of Understanding (MoU) is signed by telecommunication operators representing 12 countries.
1988	GSM system is validated.
1989	The responsibility of the GSM specifications is passed to the European Telecommunications Standards Institute (ETSI).
1990	Phase 1 of the GSM specifications is delivered.
1991	Commercial launch of the GSM service occurs. The DCS1800 specifications are finalized.
1992	The addition of the countries that signed the GSM Memorandum of Understanding takes place. Coverage spreads to larger cities and airports.
1993	Coverage of main roads' GSM services starts outside Europe.
1994	Data transmission capabilities launched. The number of networks rises to 69 in 43 countries by the end of 1994.
1995	Phase 2 of the GSM specifications occurs. Coverage is extended to rural areas.
1996	June: 133 network in 81 countries operational.
1997	July: 200 network in 109 countries operational, around 44 million subscribers worldwide.
1999	Wireless Application Protocol came into existence and 130 countries operational with 260 million subscribers
2000	General Packet Radio Service(GPRS) came into existence.
2001	As of May 2001, over 550 million people were subscribers to mobile telecommunications

EVOLUTION OF GSM STANDARD

- 1980s
  - Advanced Mobile Phone Service (AMPS), in America.
- Early 1980s
  - European nations were developing cellular solutions, but no common standard available.
- 1982

  -CEPT (Conference of European Posts and Telegraph) formed a study group called the Groupe Special Mobile (GSM).
- Objective of GSM
  - Good speech quality.
  - Low terminal and service cost.
  - Support for international roaming.
  - Ability to support handheld terminals.
  - Support for range of new services and facilities.
  - Spectral Efficiency.
  - ISDN Compatibility.
- 1989
  - GSM responsibility transferred to ETSI (European Telecommunications Standards Institute).
  - Global System for Mobile Communication.
- 1990
  - Phase I of GSM Specifications published.
- Mid 1991
  - Commercial services started.
- 1997
  - Commercial services available in 110 countries.

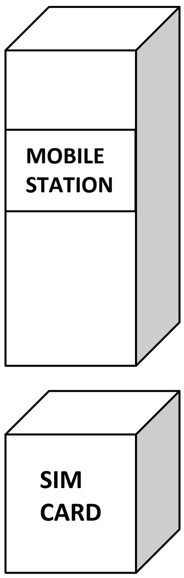
GSM:ARCHITECTURE



AUC - Authentication Center
BSC - Base Station Controller
BSS - Base Station System
BTS - Base Transceiver Station
EIR - Equipment Identity Register
HLR - Home Location Register
ISDN - Integrated Services Digital Network
MS - Mobile Station
MSC - Mobile Switching Center
PSTN - Public Switched Telephone Network
VLR - Visitor Location Register

GSM ELEMENTS AND FUNCTION

MOBILE STATION



INTERNATIONAL MOBILE EQUIPMENT IDENTITY

INTERNATIONAL MOBILE SUBSCRIBER IDENTITY
KEY FOR AUTHENTICATION/SECURITY
PERSONAL IDENTIFICATION NUMBER(PIN)
STORES SMS MESSAGES

- Consists of the Mobile Equipment & SIM Card.
- Mobile Equipment
  - Uniquely identified by IMEI (International Mobile Equipment Identity).
- SIM (Subscriber Identity Module).
  - Uniquely identified by IMSI (International Mobile Subscriber Identity).
  - Also contains a secret key for Authentication.
  - Can be protected against unauthorized use by a PIN (Personal Identity Number).
  - Can also store SMS messages for later retrieval.
- IMSI & IMEI are independent (personal mobility) .

The mobile station (MS) includes radio equipment and the man machine interface that a subscriber needs in order to access the service provided by the GSM PLMN. The MS may include provisions for the data communication as well as voice. A mobile transmits and receives message to and from the GSM system over the air interface to establish and continue connections through the system.

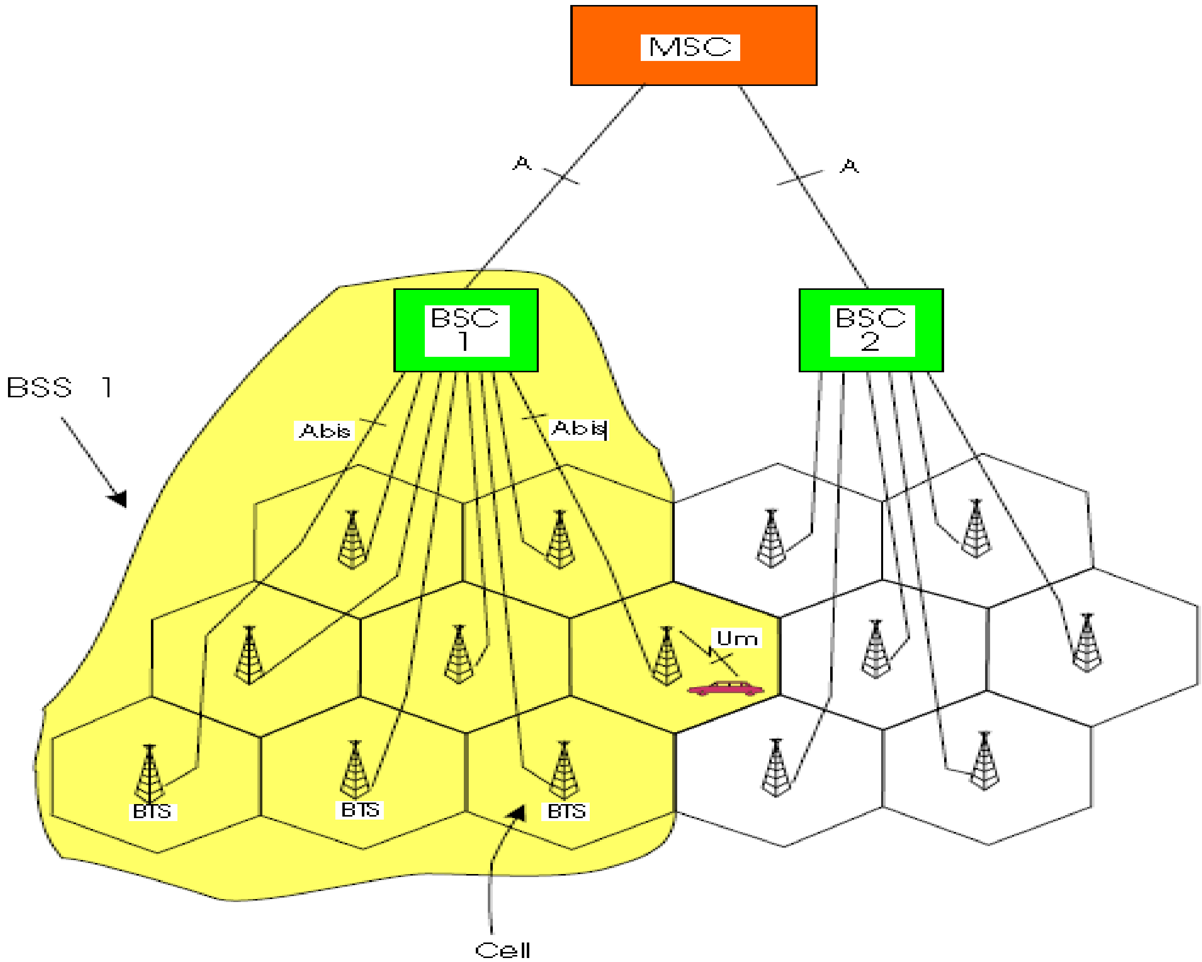
Each MS is identified by an IMEI that is permanently stored in a mobile unit. Upon request, the MS sends this number over the signaling channel to the MSC. The IMEI can be used to identify mobile units that are reported stolen or operating incorrectly.

The mobile subscriber ISDN number (MS ISDN) is the number that the calling party dials in order to reach the subscriber. It is used by the land network to route calls towards an appropriate MSC. The international mobile subscriber identity (IMSI) is permanently assigned to him. Temporary mobile subscriber identity (TMSI) is also assigned by the GSM system which can be periodically changed and protect the subscriber from being identified by those attempting to monitor the radio channel.

FUNCTIONS OF MOBILE STATION

- The primary functions of MS are to transmit and receive voice and data over the Air interface of the GSM system. MS performs the signal processing function of digitizing, encoding, error protecting, encrypting, and modulating the transmitted signals. It also performs the inverse functions on the received signals from BS.
- In order to transmit voice and data signals, the mobile must be in synchronization with the system.
- To achieve this, the MS automatically tunes and synchronizes to the frequency and TDMA timeslot specified by the BSC.
- The MS monitors the power level and signal quality, determined by the BER for known receiver bit sequences from both its current BTS and up to six surrounding BTSs. This data is received on the downlink broadcast control channel. The system then uses this list for best cell handover decisions.
- MS keeps the GSM network informed of its location during both national and international roaming, even when it is inactive.
- MS includes an equalizer that compensates for multi path distortion on the received signal
- The MS can store and display short received alphanumeric messages on the LCD. These messages are limited to 160 characters in length.

BASE STATION SYSTEM



The BSS is a set of BS equipment (such as transceivers and controllers) that is the entry responsible for communication with Mobile Stations in a certain area. A BSS may consist of one or more BS. The BSS includes two types of machines: -

- The BTS in contact with the MSs through the radio interface.
- The BSC the latter being in contact with the MSC.

BTS

A BTS compares radio transmissions and reception devices, up to and including the antennas, and also all the signal process specific to the radio interface.

A BTS is a network component that serves one cell and is controlled by a BSC. A BTS is typically able to handle 3 to 5 radio carriers, carrying between 24 and 40 simultaneous communications.

An important component of the BSS that is considered in the GSM architecture as a part of the BTS is the Trans coder/Rate Adapter Unit (TRAU). The TRAU is the equipment in which coding and decoding is carried out as well as rate adoption in case of data. Although the specifications consider the TRAU as a subpart of the BTS, it can be sited away from the BTS (at MSC), and even between the BSC and the MSC.

FUNCTIONS OF BTS

- The primary responsibility of BTS is to transmit and receive radio signals from a mobile over as air interface. To perform this function completely the signals are encoded, encrypted, multiplexed, modulated and then fed to the antenna system at the cell site. Transcoding to bring 13-kbps speech to a standard data rate of 16kbps and then combining four of these signals to 64 kbps is essentially a part of BTS.
- The received signals from the mobile is decoded, decrypted, and equalized for channel impairments.
- Random access detection is made by BTS, which then sends the messages to BSC. The channel subsequent assignment is made by BSC.

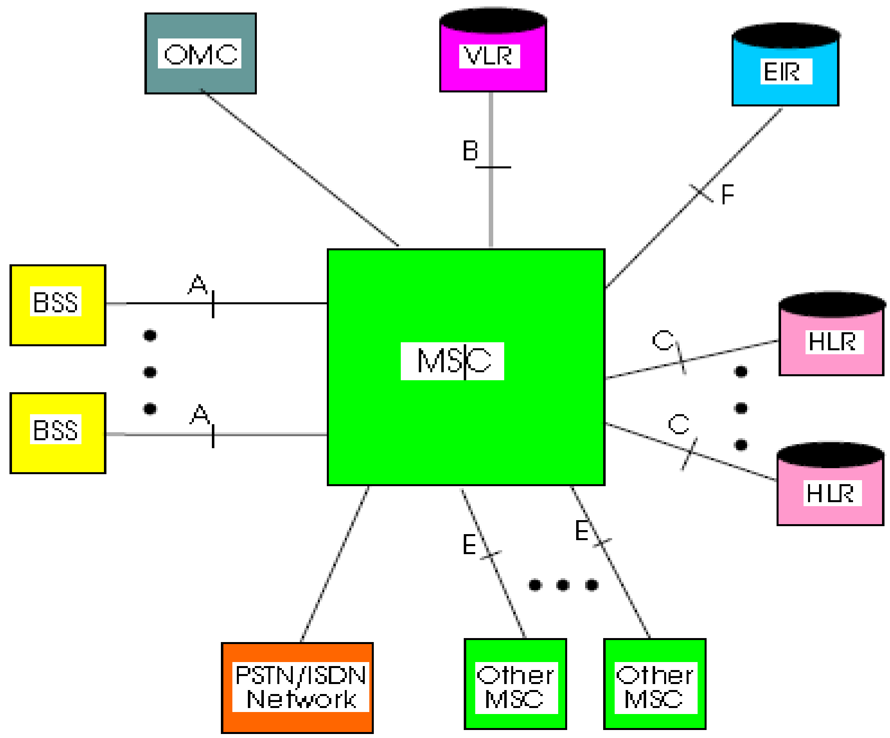
BSC

BTS to notify the MS to advance the timing such that proper synchronization takes place The BSC is connected to the MSC on one side and to the BTS on the other. The BSC performs the Radio Resource (RR) Management for the cells under its control. It assigns and release frequencies and timeslots for all MSs in its own area. It also reallocates frequencies to the BTSs in its area to meet locally heavy demands during peak hours or on special events. The BSC controls the power transmission of both BSSs and MSs in its area. The minimum power level for a mobile unit is broadcast over the BCCH. The BSC provides the time and frequency synchronization reference signals broadcast by its BTSs. The BSC also measures the time delay of received MS is not centered in its assigned timeslot at the BTS, the BSC can direct the.

FUNCTIONS OF BSC

- The BSC also performs traffic concentration to reduce the number of transmission lines from the BSC to its BTSs, as discussed in the last section.

MOBILE SERVICES SWITCHING CENTRE



Functions of the MSC include:

- Call handling that copes with mobile nature of subscribers (e.g., paging)
- Management of required logical radio-link channel during calls
- Management of MSC-BSS signaling protocol
- Control of inter-BSS handovers
- Acting as a gateway MSC to interrogate the HLR for routing incoming calls to the called MS
- Exchange of signaling information with other system entities
- Other normal functions of a local exchange switch in the fixed network

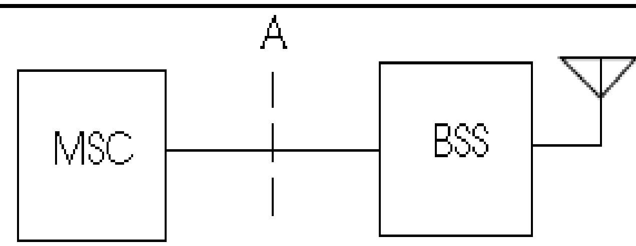
MSC interfaces with other network elements:

- An MSC typically controlled by one OMC.

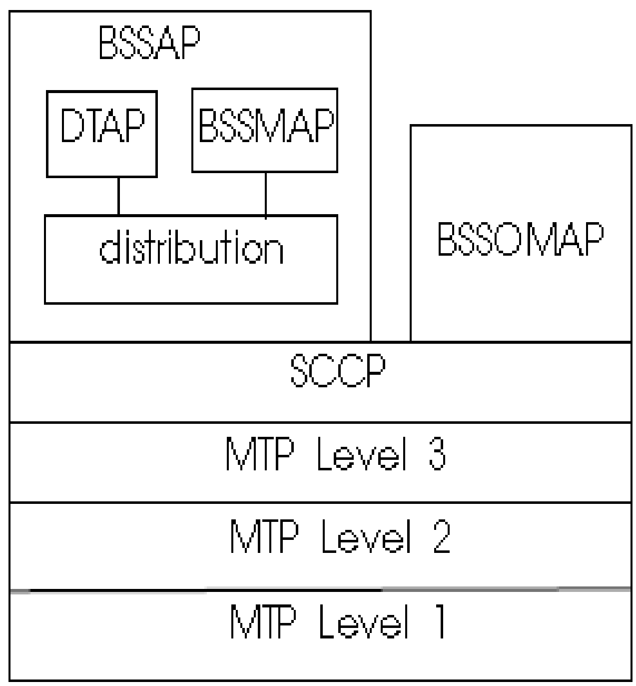
- An MSC can be connected to only one VLR. Therefore, all mobile stations that move around under base stations connected to the MSC are always managed by the same VLR.
- An MSC would communicate typically with one EIR. While it is possible for an MSC to communicate to multiple EIRs, this is highly unlikely since the EIR provides a centralized andgeographic independent function.
- The MSC consults an HLR to determine how a call should be routed to a given mobile station. For incoming calls to a mobile station, the MSC would typically consult one HLR. For mobile-to-mobile calls in larger networks, a MSC could consult HLRs of other systems to help minimize the trunk paths to the other mobile station.
- A given MSC can be interconnected to other MSC to support inter-MSC handovers. The E interface is only a signaling interface and should not be confused as a voice path. How voice facilities are connected between MSC are outside the scope of the GSM recommendations. A detailed discussion on inter-MSC voice facilities is provided in the Handover Section in the Call Management Unit.

BSS/MSC INTERFACE (A)

- The physical layer of the A interface is a 2 Mbps (32 x 64 kbps) standard CCITT digital connection.
- The signaling transport mechanism is handled by the MTP and SCCP parts of SS7. Error free transport is handled by a subset of MTP and the logical connection is handled by a subset of SCCP.
- The application parts of divided between BSSAP and BSSOMAP. The BSSAP is further divided into DTAP and BSSMAP. DTAP is in shape of transferring layer 3 messages between the MS and the MSC without BSC involvement in the analysis. BSSMAP is responsible for all aspects of the radio resource handling at the BSS.
- The BSSOMAP supports all the operations and maintenance communications of BSS.



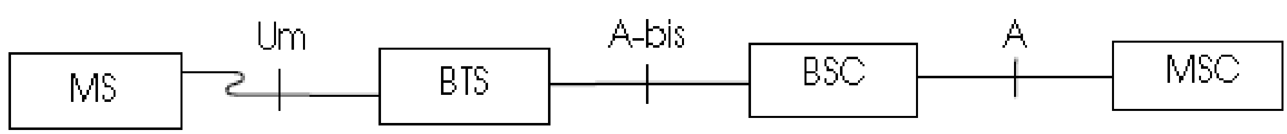
Signaling Protocol Reference Model

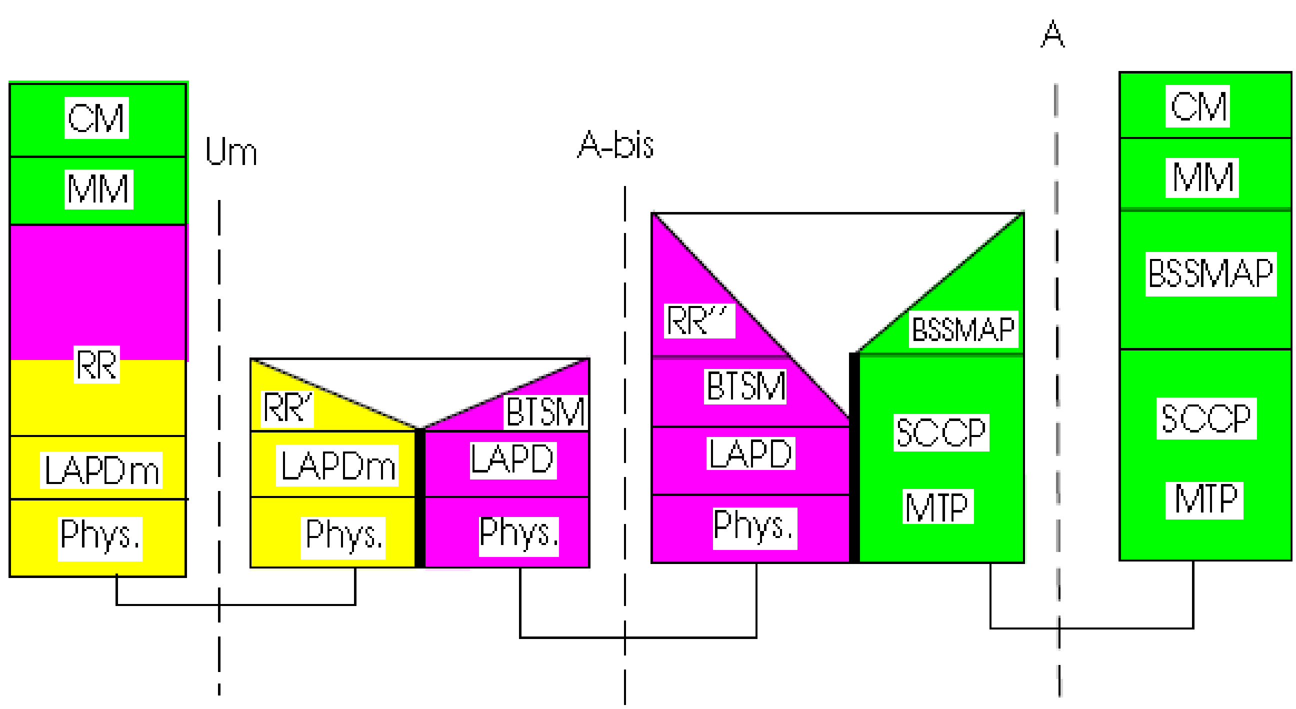


BSSAP	BSS Application Part
DTAP	Direct Transfer Appliation Part
BSSMAP	BSS Management Application Part
BSSOMAP	Operations and Maintenance Application Part
SCCP	Signaling Connection Control Part
MTP	Message Transfer Part

MS-BTS-BSC-MSC SIGNALING PROTOCOL MODEL

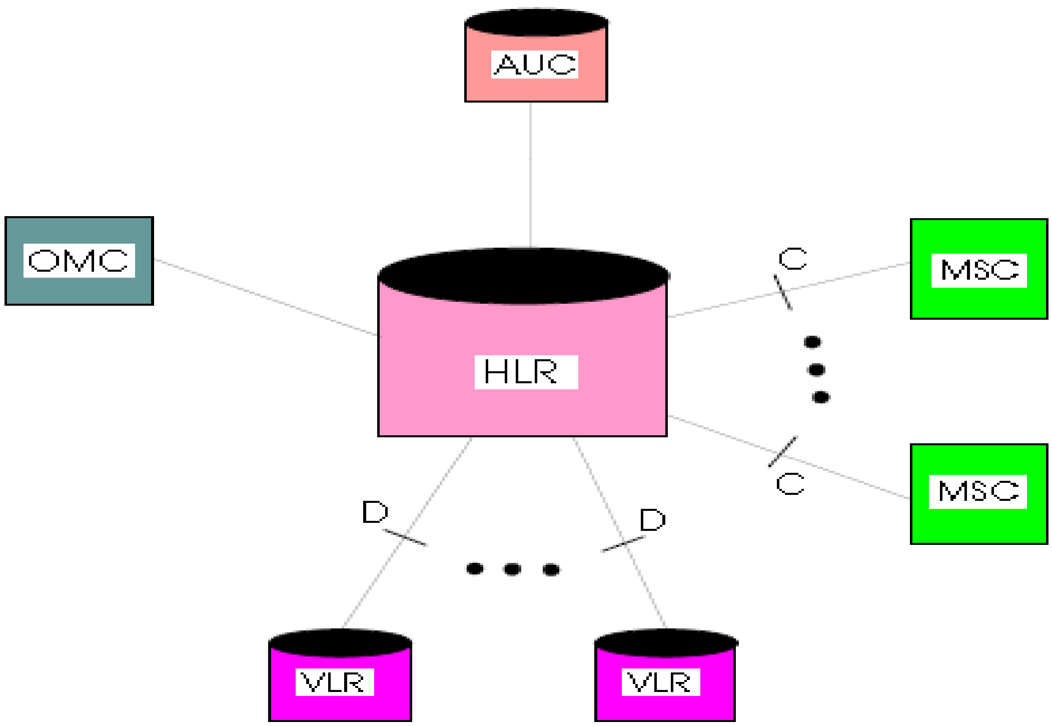
CM	Connection Management
MM	Mobility Management
RR	Radio Resource Management
LAPD	Link Access Procedures on D channel
LAPDm	Link Access Procedures on Dm channel
BTSM	BTS Management
BSSAP	BSS Application Part
SCCP	Signaling Connection Control Part
MTP	Message Transfer Part





HOME LOCATION REGISTER (HLR)

The Home Location Register (HLR) contains the identities of mobile subscribers (called International Mobile Subscriber Identities or IMSIs), their service parameters, and their location information. The location information is stored as a Mobile Station Roaming Number (MSRN) which is a directory number that the network can use to route calls to the Mobile Switching Center (MSC) where the mobile subscriber is located at the time of the call.

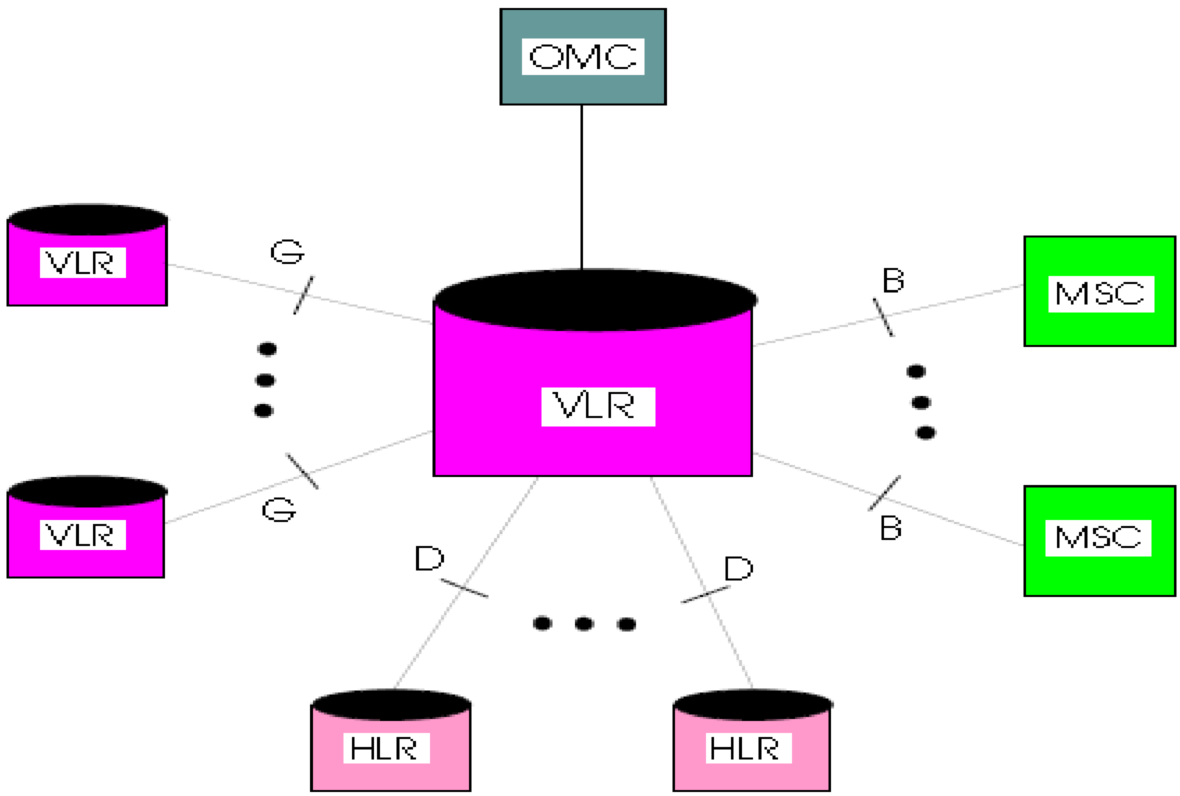


Contains:

- Identity of mobile subscriber
- Directory number of mobile subscriber
- Subscription information on teleservices and bearer services
- Service restrictions (if any)
- Supplementary services

VISITOR LOCATION REGISTER (VLR)

The Visitor Location Register (VLR) contains the subscriber parameters and location information for all mobile subscribers currently located in the geographic area (i.e., cells) controlled by that VLR. The VLR allocates the MSRN and (when required) a Temporary Mobile Subscriber Identity(TMSI) for secret identification of the mobile subscriber on the radio link.



Contains:

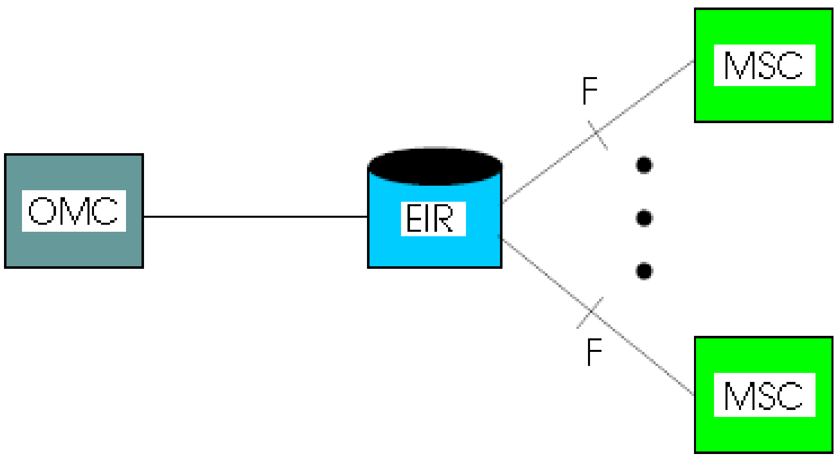
- Identity of mobile subscriber
- Directory number of mobile subscriber
- Copy of subscriber data from HLR

- Location area where mobile is registered
- Temporary mobile subscriber identity

EQUIPMENT IDENTITY REGISTER (EIR)

IMEI: International Mobile Equipment Identity

This database is accessed during the equipment validation procedure when a mobile accesses the system. It contains the identities of mobile station equipments (IMEIs) which may be valid, suspect, or known to be fraudulent. In the GSM recommendations, the valid, suspect, and fraudulent list are referred to as the: white, gray and black lists.



Contains:

- Valid list — list of valid Mobile Equipment identities
- Suspect list — list of Mobile Equipment identities under observation
- Fraudulent list — list of Mobile Equipment identities for which service should be barred

AUTHENTICATION CENTER (AUC)

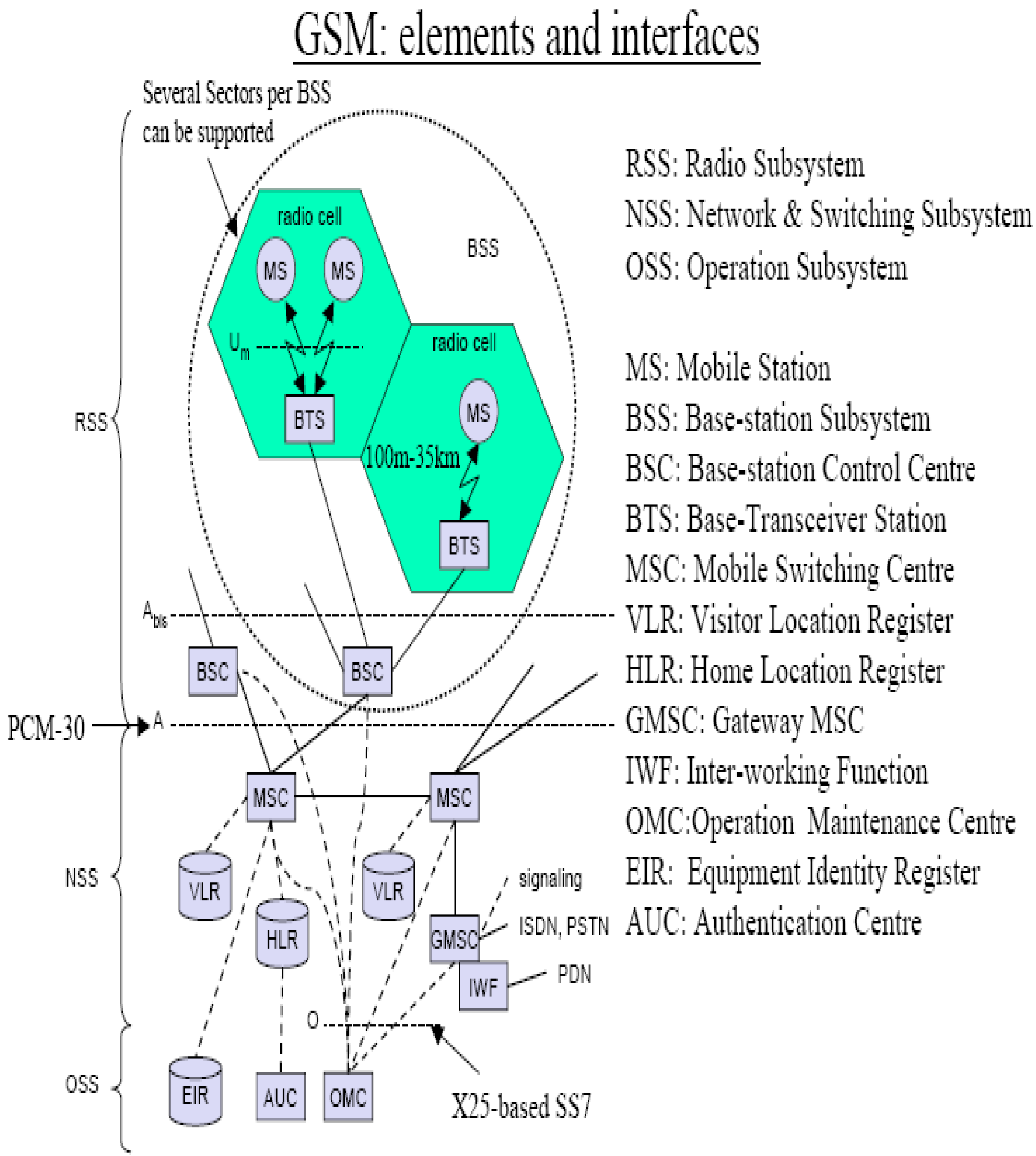
- Since a GSM cellular system is based on a wireless access method, it is necessary for mobile stations to transmit their identity to the network. The purpose of an Authentication Center(AUC) is to generate authentication parameters that are used by Visitor Location Registers(VLRs) to make sure the identity transmitted by a mobile station is the correct identity and to generate encryption/cipher keys that will be used to encrypt the radio path.
- The Operational Maintenance Center (OMC) interfaces with the AUC for administration purposes, such as adding/changing/deleting Authentication Keys (Ki).
- The only other network element that communicates with an AUC is the corresponding Home Location Register (HLR). No other network elements communicate with the AUC. If a mobile station is visiting other networks, the VLR in the other networks communicate the mobile station's HLR. The HLR, in turn, retrieves information from the AUC and passes this information to the requesting VLR.
- The AUC is a database that contains a unique Authentication Key (Ki) for each mobile subscriber. The AUC also contains algorithms which generate authentication parameters. These algorithms can be CPU intensive.
- GSM does not define the interface between the HLR and AUC. Consequently, this interface is not an open interface. The AUC can be viewed as an adjunct computer to the HLR, which has been delegated the responsibility of managing authentication keys and generating authentication parameters.
- Most vendors will probably integrate the AUC and HLR. The main reason one might want to separate the AUC from an HLR is to not burden an HLR with CPU intensive algorithms.

OSS (OPERATIONAL SUPPORT SUBSYSTEM)

- Contains subscriber authentication data called Authentication Keys (Ki)
- Generates security related parameters needed to authorize service using Ki
- Generates unique data pattern called a Cipher Key (Kc) needed for encrypting user speech and data

GSM SYSTEM INTERFACE

SYSTEM INTERFACES:



Air interface or U m –interface

The air interface is the interface between the BTS and the MS. The air interface is required for supporting:

- Universal use of any compatible mobile station in a GSM network
- A maximum spectrum efficiency

A bis –interface

The A bis interface between the BSC and BTS. The interface comprises traffic and control channels. Function implemented at the A bis:

- Voice data traffic exchange
- Signaling exchange between BSC and BTS
- Transporting synchronization information from the BSC to the BTS

A –interface

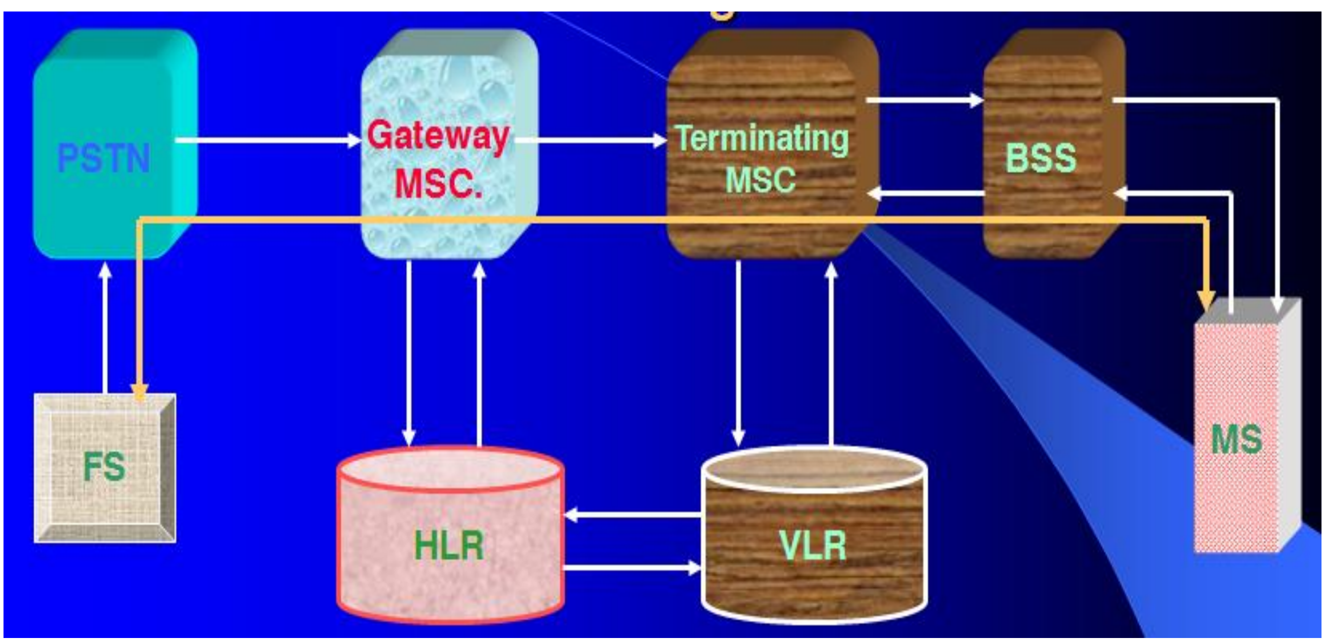
The A interface is the interface between the BSC and the MSC

Proprietary M-interface

BSC includes the TRAU (transcoder /rate adapter unit).

The TRAU adapts transmission bit rate of the A –interface(64 Kilo bit per second) to the A-bis interface(16 kilo bit per second).the interface between the physical BSC and the TRAU is known as the M-interface.

GSM Network: Call Routing



UPLINK AND DOWNLINK

In the frequency range specified for the GSM-900 mobile radio networks,124 frequency channels with a bandwidth of 200 kHz are available for both the uplink and downlink direction. The uplink (mobile station to bts) uses the frequencies between 890-915 MHz and downlink(bts to mobile station) uses the frequencies between 935 and 960 MHz.

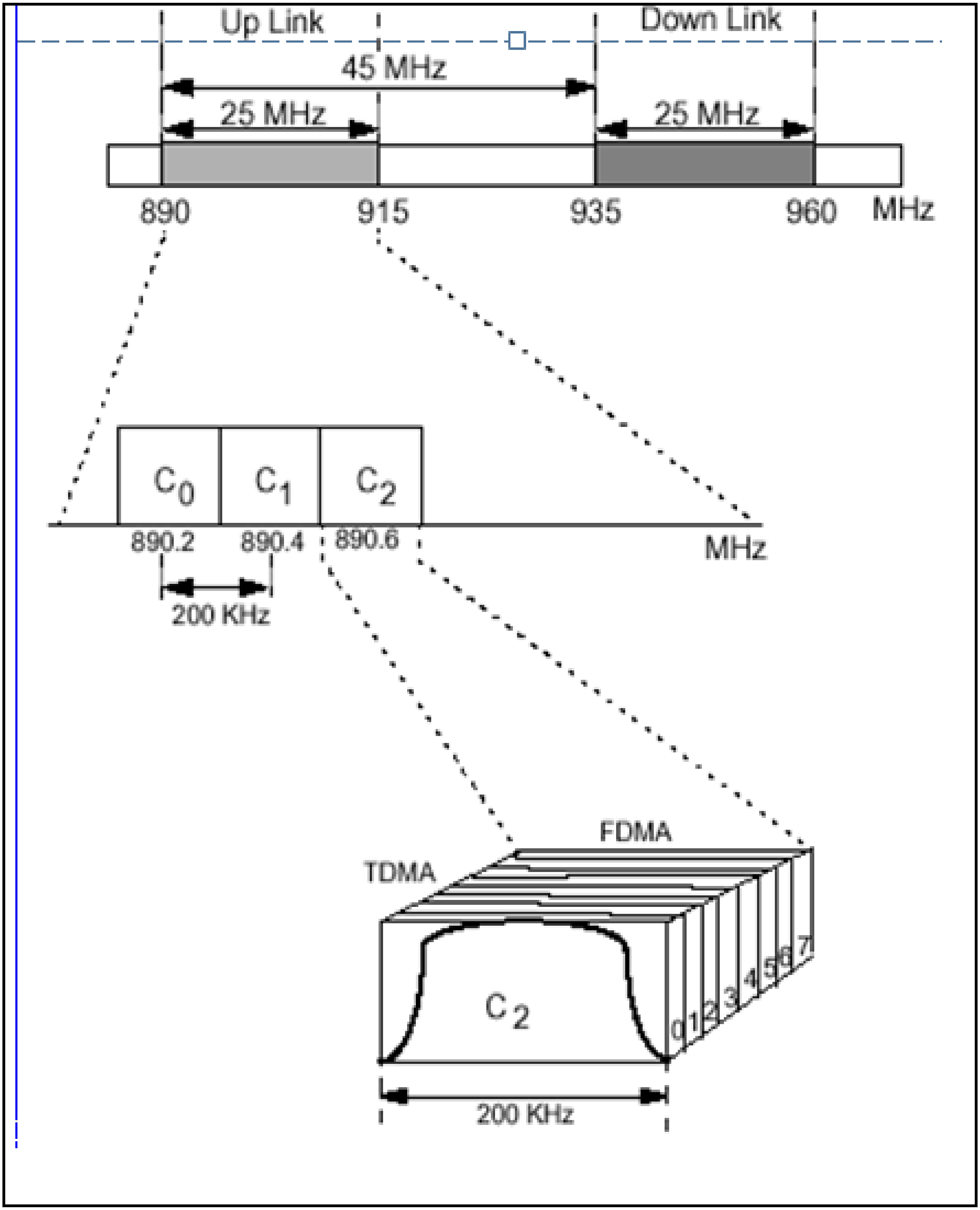
- **The duplex spacing, the spacing between the uplink and downlink channel, is 45 MHz**

U m-INTERFACE

U m or air interface. This interface is to achieve a full compatibility between mobile stations of various manufactures and networks of different operators.

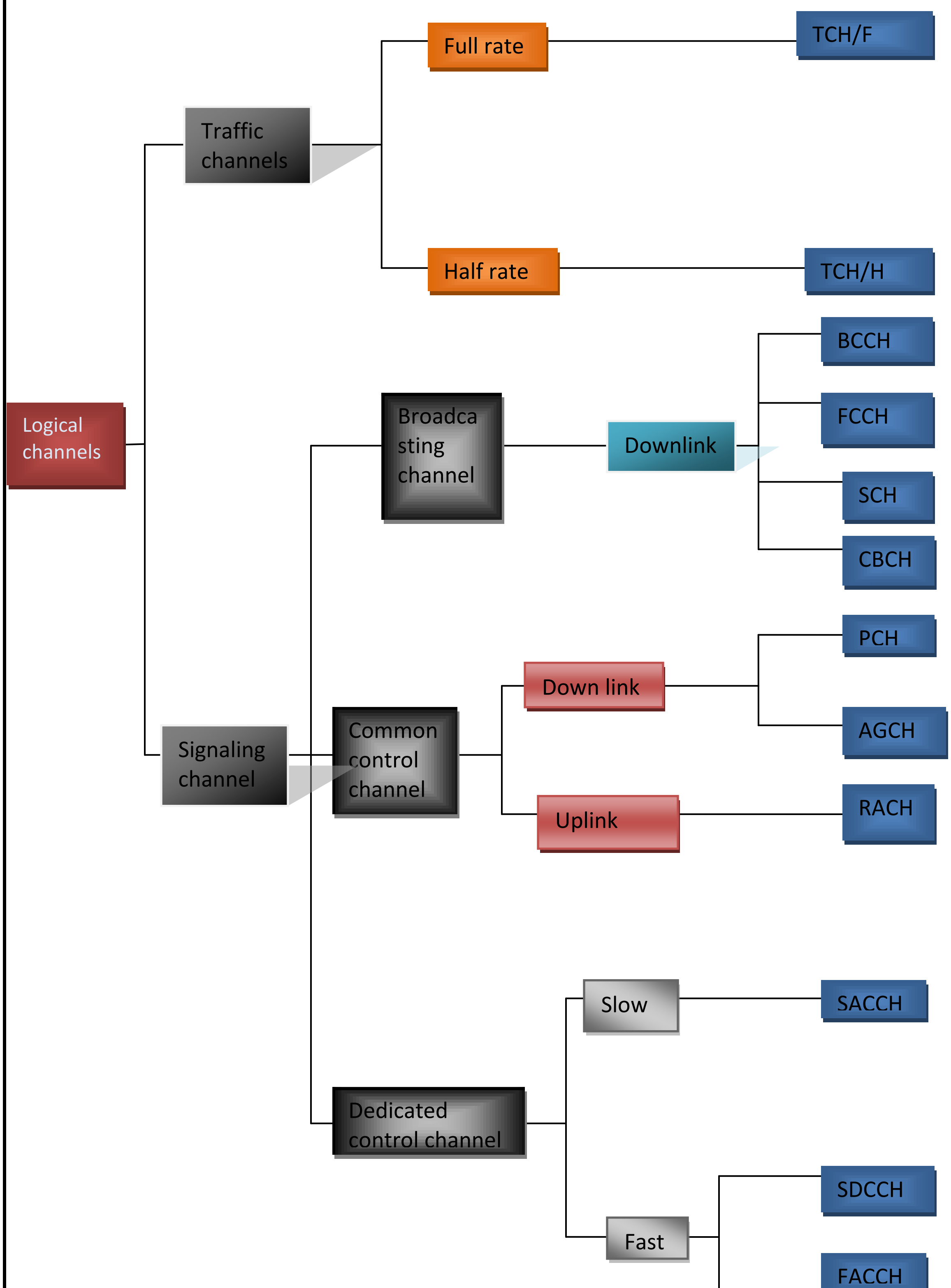
FDMA and TDM methods:

To achieve a high spectral efficiency in the cellular network a combination FDM and TDM is used.
FDM part involves the division by frequency of 25MHz bandwidth into 124 carrier frequencies spaced 200 KHz for GSM -900.
For GSM-1800 frequency spectrum of 75 MHz BW is divided into 374 carrier frequencies spaced 200 KHz.
One or more frequencies are assigned to each bts.
Each of these carrier frequencies then divided in time , using a TDMA scheme to increase number of channels per carrier frequency.
Each carrier frequency channel carrier eight time-divisions multiplexed physical channel.
A physical channel is determined by the carrier frequency (or a number of carrier frequencies and a defined hopping sequence) and the time slot number.
Mobile stations can speech data only during its assigned timeslot.



Up Link
Down Link
45 MHz
25 MHz
25 MHz
890
915
935
960
MHz
C_0
C_1
C_2
890.2
890.4
890.6
MHz
200 KHz
FDMA
TDMA
C_2
0 1 2 3 4 5 6 7
200 KHz

Logical channel types:



Traffic channels

- TCH/F
    - Traffic channel full rate
    - @13Kbps
- TCH/H
    - Traffic channel half rate
    - @6.5Kbps
- EFR
    - Enhanced full rate
    - @13Kbps

Broadcasting Channels Downlink

- BCCH
    - Broadcast control channel
    - Broadcast network/cell specific information
- FCCH
    - Frequency correction control channel
    - Used by the mobile for frequency correction
- SCH
    - Synchronization channel
    - Synchronization mobiles(TDMA FN & BSIC)
- CBCH
    - Cell broadcast control channel

Dedicated Control Channel

- **Slow**

  -SACCH

  - Slow associated control channel(duplex)
  - Transmission of signaling data(radio link supervision meas., transmit power control, timing advance)

- **Fast**

  -SDCCH

  - Standalone dedicated control channel(duplex)
  - Signaling channel used for service request

  -FACCH

  - Fast associated control channel
  - Stealing flag and preemption
  - Used during call set up, handover

Common Control Channel

- Downlink

  -PCH

  - Paging channel
  - For altering mobiles

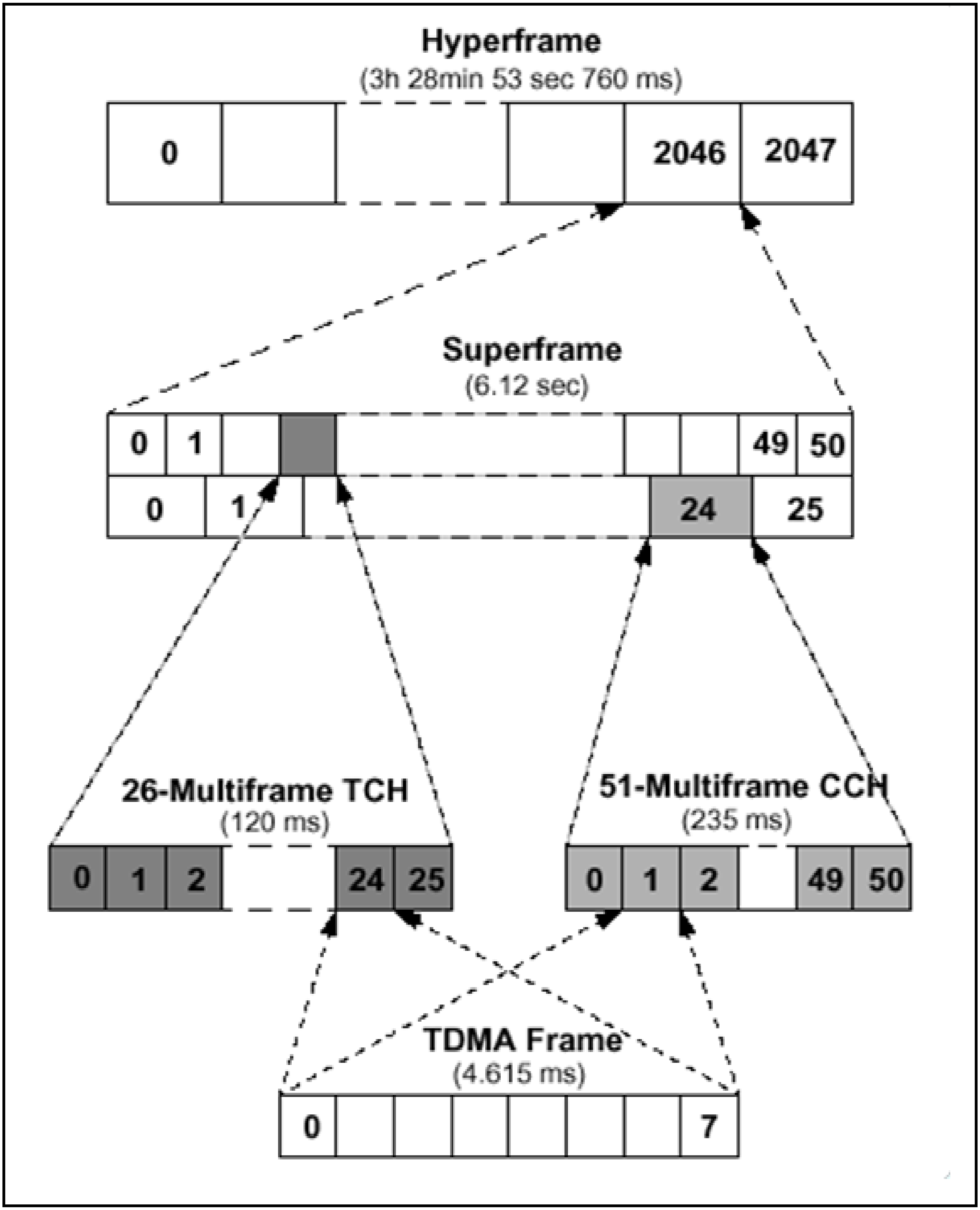
  -AGCH

  - Access Grant Channel
  - For granting access to mobile

- Uplink

  -RACH

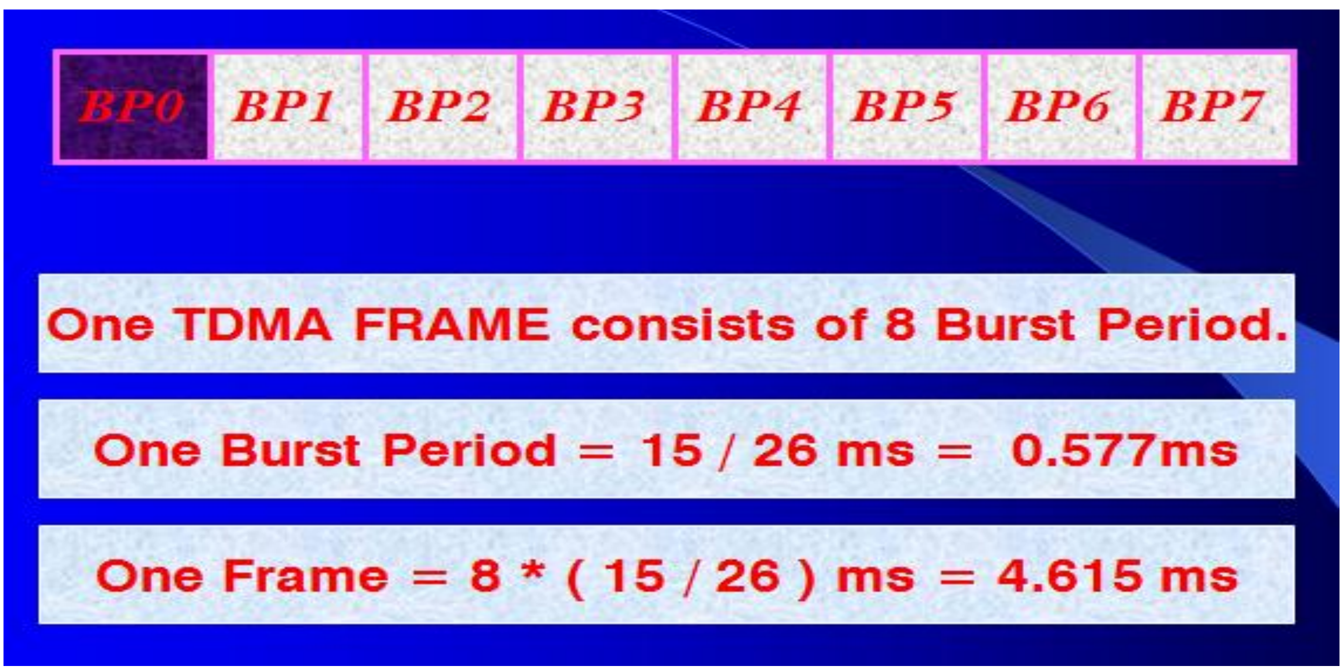
  - Random access channel
  - Mobiles seeking attention of the BTS



Hyperframe
(3h 28min 53 sec 760 ms)
0
2046
2047
Superframe
(6.12 sec)
0
1
49
50
0
1
24
25
26-Multiframe TCH
(120 ms)
0
1
2
24
25
51-Multiframe CCH
(235 ms)
0
1
2
49
50
TDMA Frame
(4.615 ms)
0
7

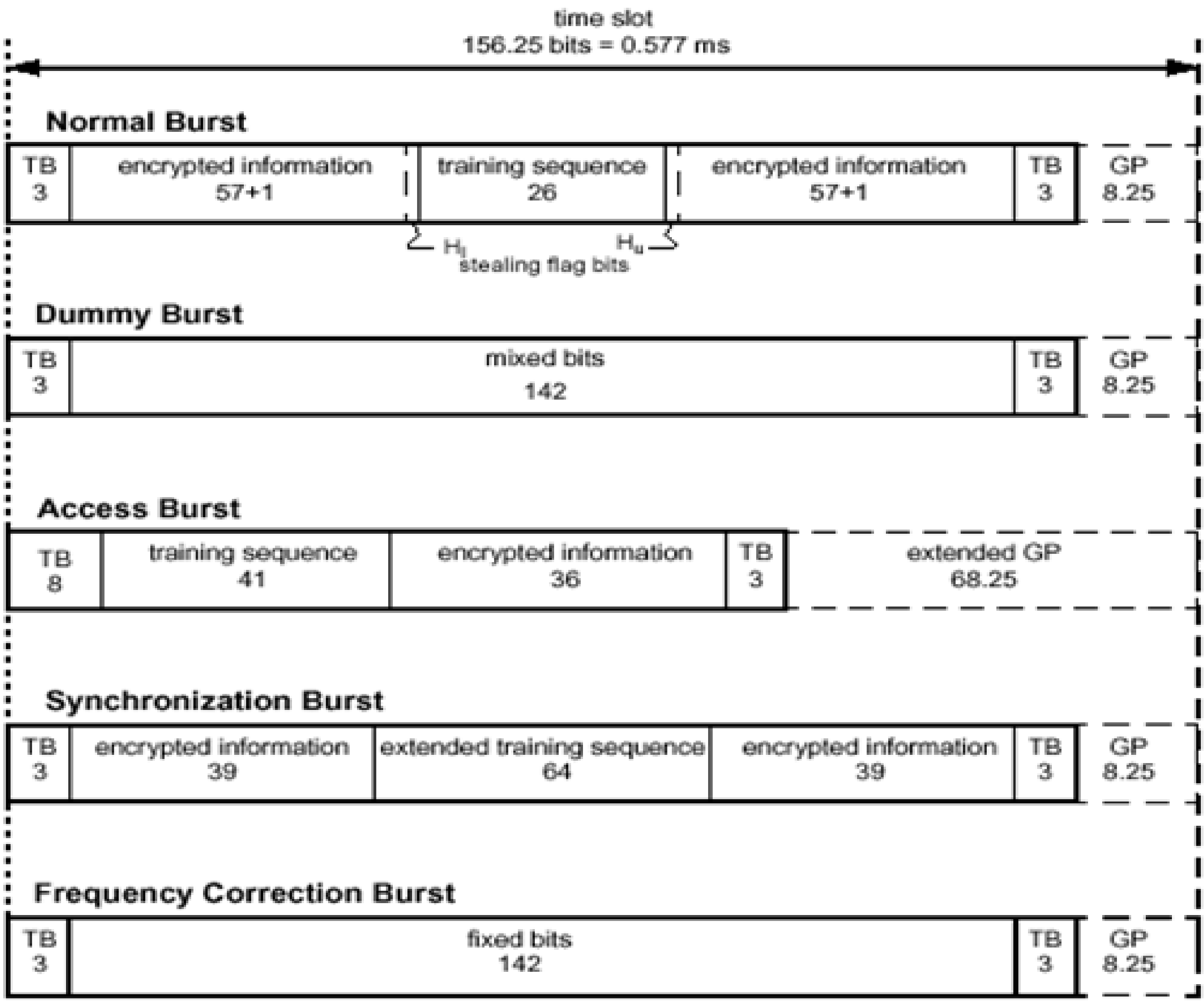
Normal Burst Period Structure

Frame Structure



Burst Types

- Normal Burst.
  - Carry data.
- F Burst.
  - Used in FCCH (Frequency Correction Channel).
- S Burst.
  - Used in SCH (Synchronization Channel).
- Access Burst.
  - Used in RACH (Random Access Channel).
- Dummy Burst

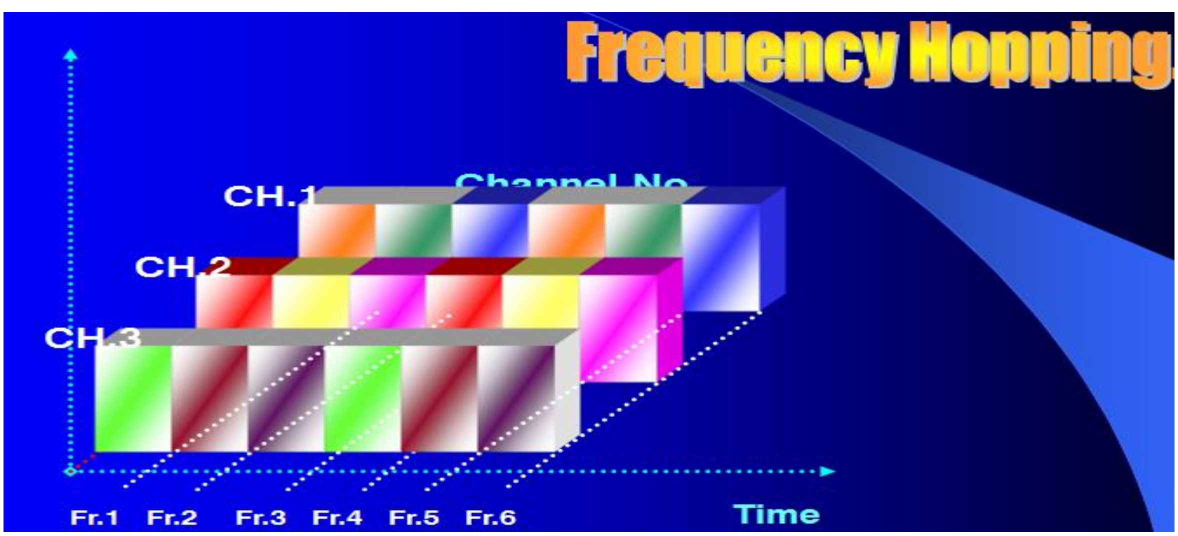


Radio Link Aspects

- ITU Allocation for GSM 900
  - Band 890 - 915 MHz for Uplink (MS to BSS).
  - Band 935 - 960 MHz for Downlink (BSS to MS).
- To maximize the capacity utilization,
  - Access Technique is FDMA / TDMA / FDD.
- 25 MHz bandwidth divided into
  - 124 Carriers (ARFCN).
  - Spaced 200 KHz apart.
- TDMA Superposed on the carrier frequencies.
- Each Base Station assigned multiple frequencies.

Frequency Hopping

- Objective
  - Multi-Path fading is dependent on carrier frequency. Changing the carrier frequency slowly, helps alleviate the problem.
  - Co-channel interference is in effect randomized.
- Realization
  - The ARFCN for the channels is changed in each successive frame, based on Hopping Sequence.



GSM RADIO PROPAGATION

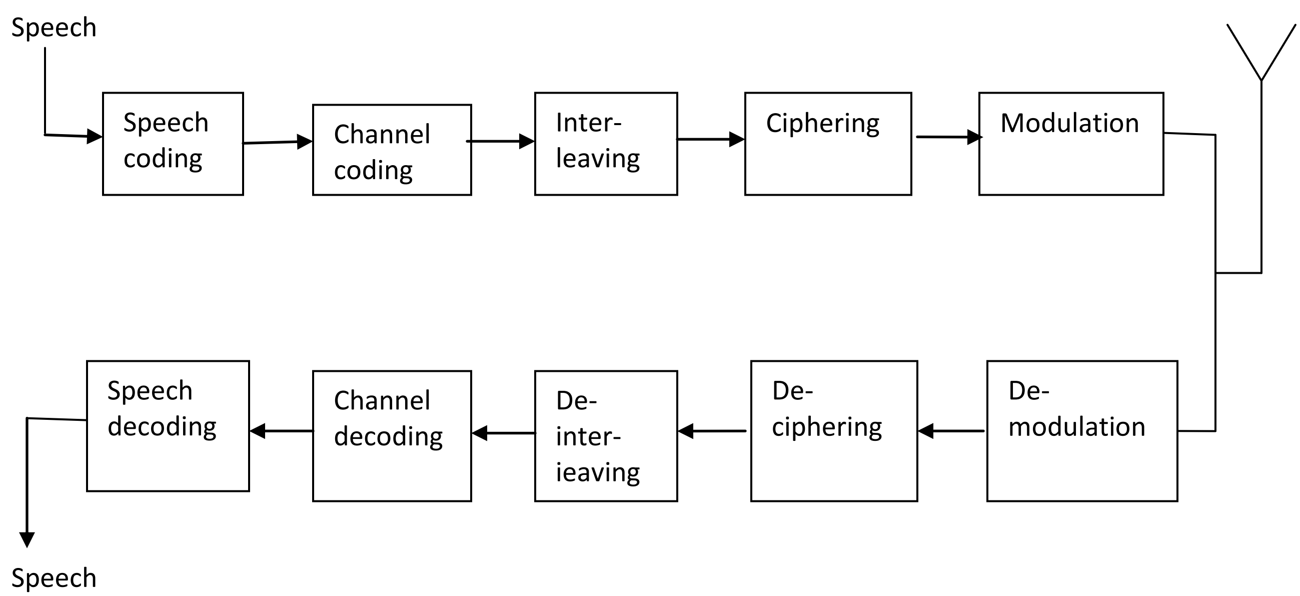
GSM RADIO LINK CHARACTERSTICS

GSM- 900 AND GSM-1800 RADIO LINK	
Access method	TDMA
Modulation method	GMSK
RF channel spacing	200KHz
Voice circuit per carrier	8
Gross bit rate	271Kbps
Spectral efficiency	1.35 bit per sec per Hz
Speech coder rate	13 Kbps(full rate)
Error protected coded speech	22.8Kbps
Overhead	11.1Kbps

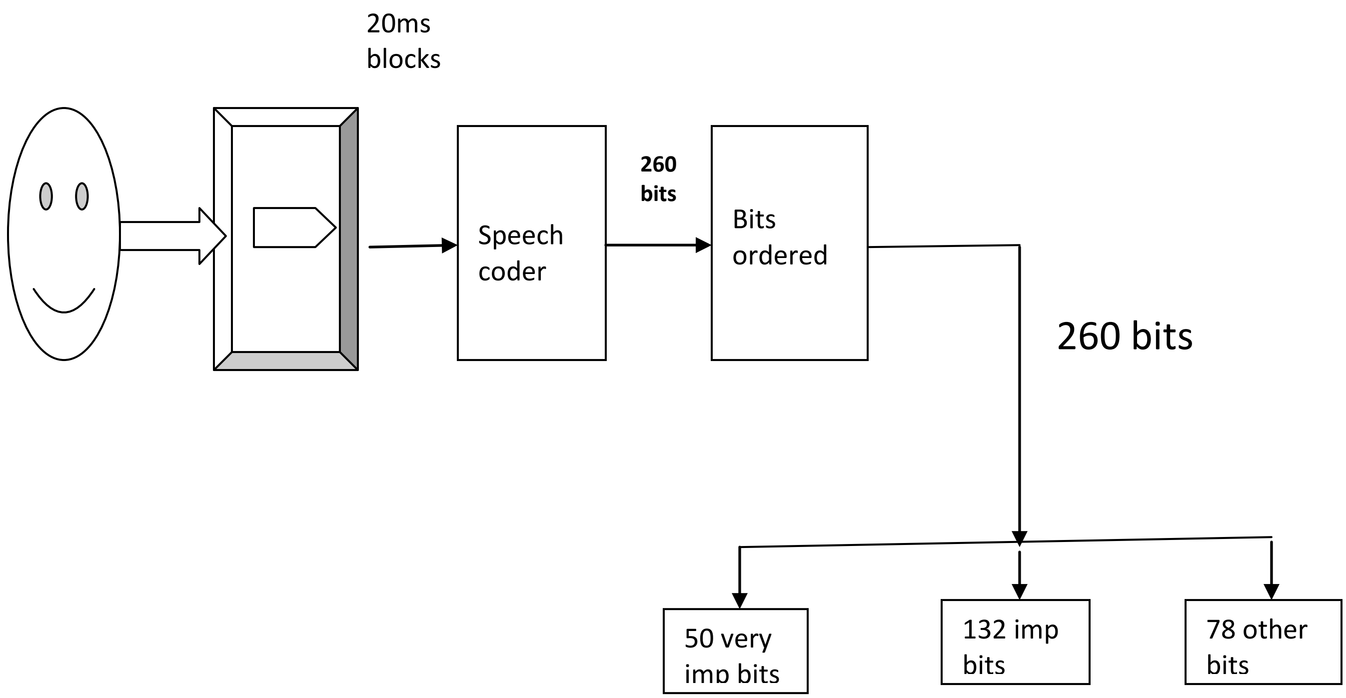
FULL RATE SPEECH CODING

The GSM speech coding scheme at 13Kbps is called RPE-LTP(regular pulse excitation long term prediction)

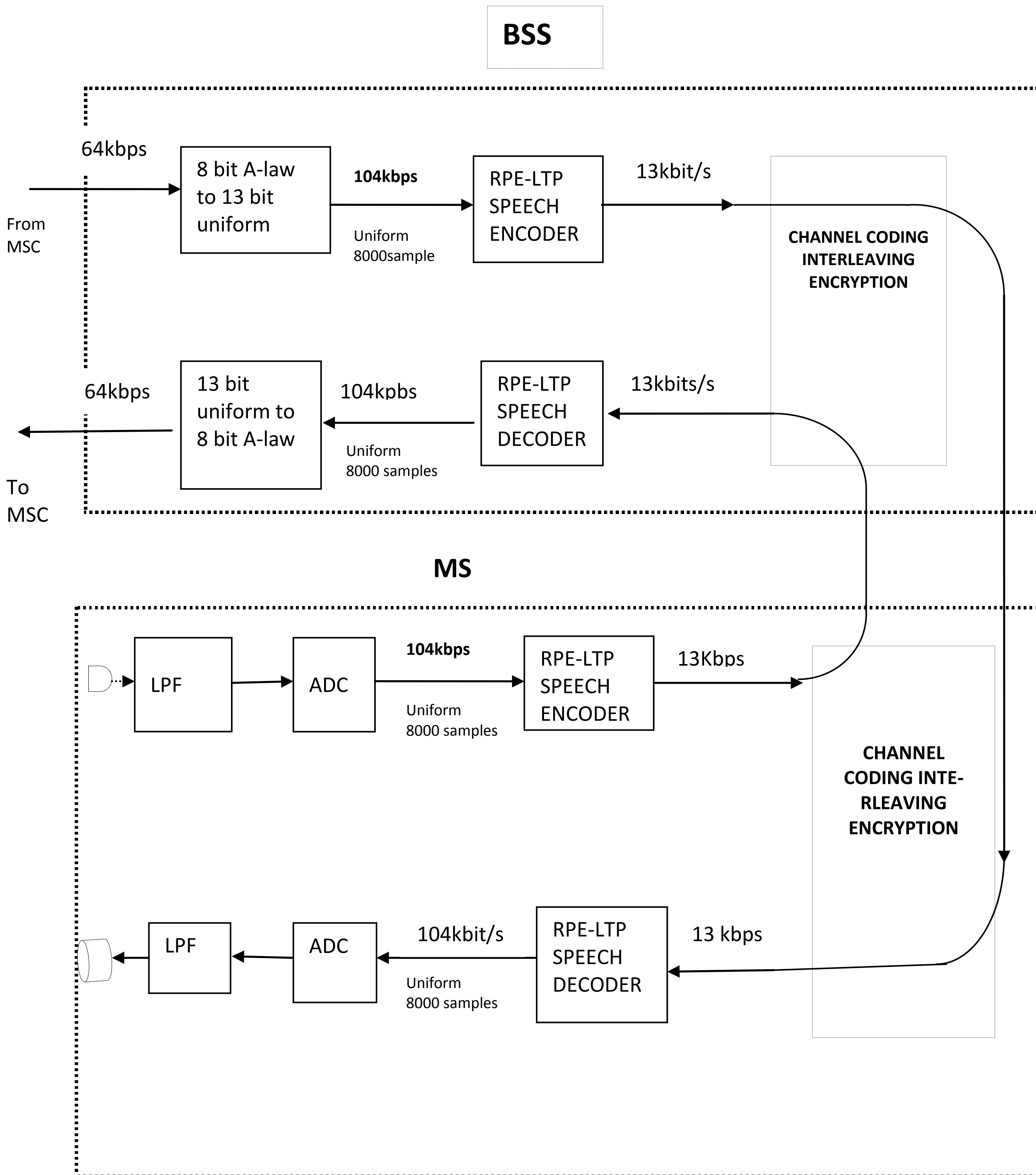
VOICE PROCESSING



Speech coder



Speech coding



MOBILITY MANAGEMENT

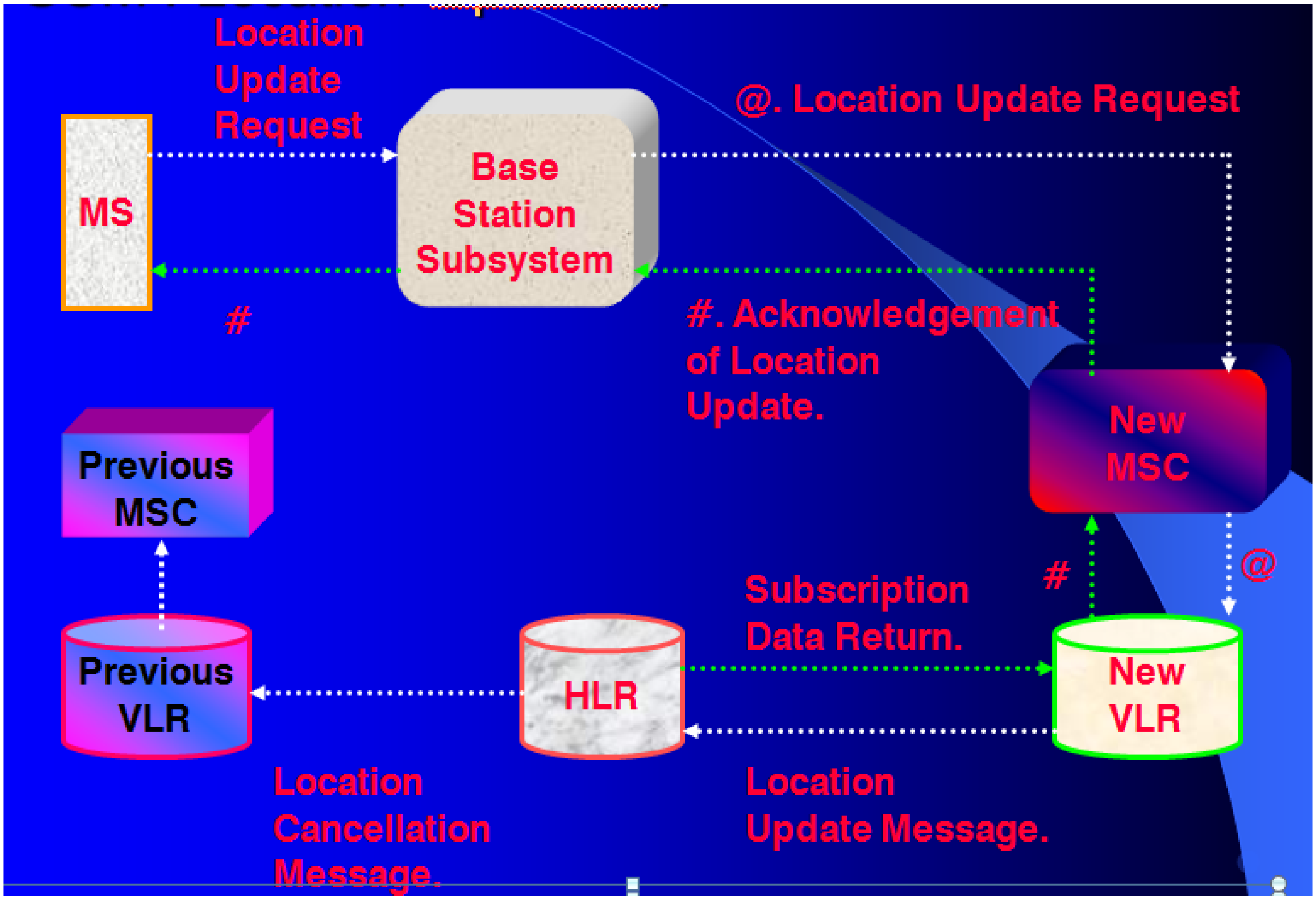
The Mobility management layer (MM) is built on top of the RR layer, and handles the functions that arise from the mobility of the subscriber, as well as the authentication and security aspects. Location management is concerned with the procedures that enable the system to know the current location of a powered – on mobile station so that incoming call routing can be completed.

LOCATION UPDATE

A powered-on mobile is informed of an incoming call by a paging message sent over the PAGCH channel of a cell. One extreme would be to page every cell in the network for each call, which is obviously a waste of radio bandwidth. The other extreme would be for the mobile to notify the system, via location updating messages, of its current location at the individual cell level. This would require paging messages to be sent to exactly one cell, but would be very wasteful due to the large number of location updating messages. A compromise solution used in GSM is to group cells into *location areas*. Updating messages are required when moving between location areas, and mobile stations are paged in the cells of their current location area.

The location updating procedures, and subsequent call routing, use the MSC and two location registers: the Home Location Register (HLR) and the Visitor Location Register (VLR). When a mobile station is switched on in a new location area, or it moves to a new location area or different operator's PLMN, it must register with the network to indicate its current location. In the normal case, a location update message is sent to the new MSC/VLR, which records the location area information, and then sends the location information to the subscriber's HLR. The information sent to the HLR is normally the SS7 address of the new VLR, although it may be a routing number. The reason a routing number is not normally assigned, even though it would reduce signaling, is that there is only a limited number of routing numbers available in the new MSC/VLR and they are allocated on demand for incoming calls. If the subscriber is entitled to service, the HLR sends a subset of the subscriber information, needed for call control, to the new MSC/VLR, and sends a message to the old MSC/VLR to cancel the old registration.

GSM:LOCATION UPDATE:



MOBILE CALL SETUP

Mobile call setup involves exchange of no. of message between the various elements in the system. For setting up a mobile call following process is involved. It deals with two examples: -

- Terminating call when the MS is in the HPLMN.
- Terminating call when the MS is roaming.

The call set up broadly involves the following steps: -

- PSTN subscriber dials MSISDN
- Call is routed by PSTN network to GMSC of HPLMN of the dialed mobile subscriber.

- GMSC interrogates HLR for verification of the access privileges profile and for obtaining the location details if the call is permitted.
- HLR directs the call to VLR of MSC area in which the mobile customer is currently located.
- MSC interrogates VLR to obtain exact location of the MS.
- VLR provides LAC to the MSC.
- MSC translates the LAC code into BTS identity.
- BSS pages all the BTSs identified by MSC within which MS is located using IMSI .
- MS responds to the paging
- Call is connected .
- In case of roaming call MS will be located in a VPLMN
- In such case steps are as follows:
- On registration with VPLMN ,HLR will place a pointer in the data base for MS indicating the current VLR address.
- On interrogation by GMSC of the HPLMN ,HLR will in turn interrogate VLR of VPLMN using the already stored pointer
- VLR in VPLMN will assign a roaming number called in MSRN . To enable the HPLMN to route the call to the VPLMN
- Using MSRN , call is routed back from HPLMN to VPLMN and VMSC interrogates the VLR
- VLR provides the LAC and call proceeds exactly in the same manner as for the call in.

TIMING DIAGRAM ILLUSTRATING HOW A CALL TO A MOBILE USER INITIATED BY A LANDLINE SUBSCRIBER IS ESTABLISHED

MSC		RECIEVES CALL FRON PSTN, SENDS THE REQUESTED MIN TO ALL BASE STATION			VERFIES THAT THE MOBILE HAS A VALID MIN,ESN PAIR	REQUESTS BS TO MOVE MOBILE TO UNUSED VOICE CHANNEL PAIR		CONNECTS THE MOBILE WITH THE CALLING PARTY ON THE PSTN
BASE STATION	FCC		TRANSMITS PAGE(MIN) FOR SPECIFIED USER				TRANSMITS DATA MESSAGE FOR MOBILE TO MOVE TO SPECIFIC VOICE CHANNEL	
	RCC			RECEIVES MIN,ESN,STATION CLASS MARK AND PASSES TO MSC				
	FVC							BEGIN VOICE TRANSMISSION
	RVC							BEGIN VOICE RECEPTION
MOBILE	FCC		RECEIVES PAGE AND MATCHES THE MIN WITH ITS OWN MIN				RECEIVES DATA MESSAGES TO MOVE TO SPECIFIED VOICE CHANNEL	
	RCC			ACKNOWLEDGES RECEIPT OF MIN AND SENDS ESN AND STATION CLASS MARK				
	FVC							BEGIN VOICE RECEPTION
	RVC							BEGIN VOICE TRANSMISSION

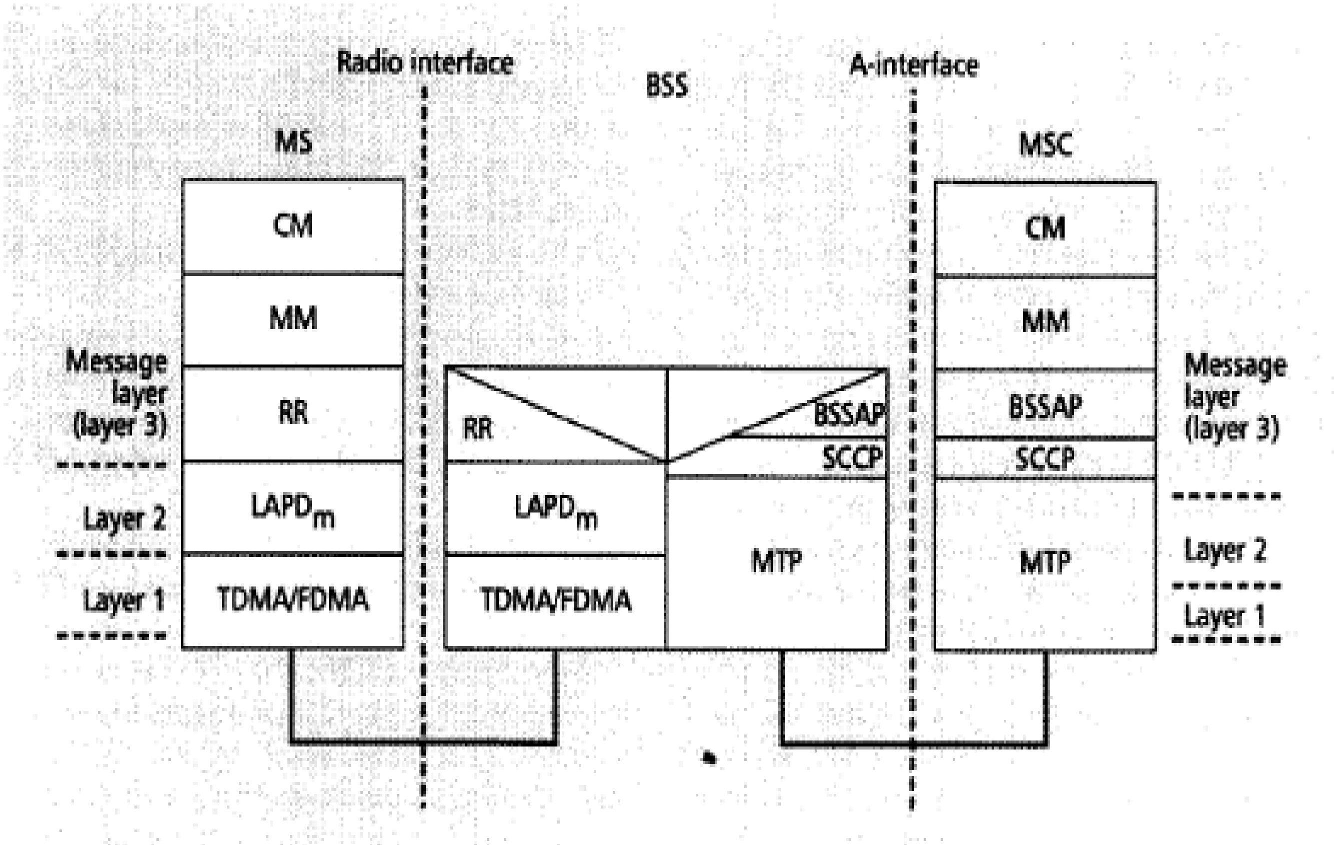
time →

TIMING DIAGRAM ILLUSTRATING HOW A CALL INITIATED BY A MOBILE IS ESTABLISHED

MSC			RECIEVES CALL INFORMATION FROM BASE STATION AND VERIFIES THAT THE MOBILE HAS A VALID MIN,ESN PAIR	INSTRUCTS FCC OF ORIGINATING BASE STATION TO MOVE MOBILE TO A PAIR OF VOICE CHANNELS		CONNECTS THE MOBILE WITH THE CALLED PARTY ON THE PSTN	
BASE STATION	FCC				PAGE FOR CALLED MOBILE ,INSTRUCTING THE MOBILE TO MOVE TO VOICE CHANNEL		
	RCC	RECEIVES CALL INITIATION REQUEST AND MIN ,ESN,STATION CLASS MARK					
	FVC						BEGIN VOICE TRANSMISSION
	RVC						BEGIN VOICE RECEPTION
MOBILE	FCC				RECEIVES PAGE AND MATCH THE MIN WITH ITS OWN MIN, RECEIVES INSTRUCTION TO MOVE TO VOICE CHANNEL		
	RCC	SENDS A CALL INITIATION REQUEST ALONG WITH SUBSCRIBED MIN AND NUMBER OF CALLED PARTY					
	FVC						BEGIN VOICE RECEPTION
	RVC						BEGIN VOICE TRANSMISSION

time→

GSM PROTOCOLS



MS Protocols:

The signaling protocol in GSM is structured into three general layers, depending on the interface.

- **Layer 1:** The physical layer, which uses the channel structures over the air interface.
- **Layer 2:** The data-link layer. Across the Um interface, the data-link layer is a modified version of the Link access protocol for the D channel (LAP-D) protocol used in ISDN, called Link access protocol on the Dm channel (LAP-Dm). Across the A interface, the Message Transfer Part (MTP), Layer 2 of SS7 is used.
- **Layer 3:** The third layer of the GSM signaling protocol is divided into three sublayers:
  - Radio Resource management (RR)
  - Mobility Management (MM) and
  - Connection Management (CM).

The MS to BTS Protocols:

The RR layer oversees the establishment of a link, both radio and fixed, between the MS and the MSC. The main functional components involved are the MS, the BSS, and the MSC. The RR layer is concerned with the management of an RR-session, which is the time that a mobile is in dedicated mode, as well as the configuration of radio channels, including the allocation of dedicated channels.

The MM layer is built on top of the RR layer and handles the functions that arise from the mobility of the subscriber, as well as the authentication and security aspects. Location management is concerned with the procedures that enable the system to know the current location of a powered-on MS so that incoming call routing can be completed.

The CM layer is responsible for CC, supplementary service management, and Short Message Service (SMS) management. Each of these may be considered as a separate sublayer within the CM layer. Other functions of the CC sublayer include call establishment, selection of the type of service (including alternating between services during a call), and call release.

BSC Protocols:

After the information is passed from the BTS to the BSC, a different set of interfaces is used. The Abis interface is used between the BTS and BSC. At this level, the radio resources at the lower portion of Layer 3 are changed from the RR to the Base Transceiver Station Management (BTSM). The BTS management layer is a relay function at the BTS to the BSC.

The RR protocols are responsible for the allocation and reallocation of traffic channels between the MS and the BTS. These services include controlling the initial access to the system, paging for MT calls, the handover of calls between cell sites, power control, and call termination. The RR protocols provide the procedures for the use, allocation, reallocation, and release of the GSM channels. The BSC still has some radio resource management in place for the frequency coordination, frequency allocation, and the management of the overall network layer for the Layer 2 interfaces.

From the BSC, the relay is using SS7 protocols so the MTP 1-3 is used as the underlying architecture, and the BSS mobile application part or the direct application part is used to communicate from the BSC to the MSC.

MSC Protocols:

At the MSC, the information is mapped across the A interface to the MTP Layers 1 through 3 from the BSC. Here the equivalent set of radio resources is called the BSS MAP. The BSS MAP/DTAP and the MM and CM are at the upper layers of Layer 3 protocols. This completes the relay process. Through the control-signaling network, the MSCs interact to locate and connect to users throughout the network. Location registers are included in the MSC databases to assist in the role of determining how and whether connections are to be made to roaming users.

Each user of a GSM MS is assigned a HLR that is used to contain the user's location and subscribed services. A separate register, the VLR, is used to track the location of a user. As the users roam out of the area covered by the HLR, the MS notifies a new VLR of its whereabouts. The VLR in turn uses the control network (which happens to be based on SS7) to signal the HLR of the MS's new location. Through this information, MT calls can be routed to the user by the location information contained in the user's HLR.

GSM SERVICES

GSM has much more to offer than voice telephony. Additional services allow you greater flexibility in where and when you use your phone. You should contact your local GSM network operator for information on the specific services available to you.

But there are three basic types of services offered through GSM which you can ask for:

- Telephony (also referred to as teleservices) Services
- Data (also referred to as bearer services) Services.
- Supplementary Services

Teleservices or Telephony Services:

A Teleservice utilises the capabilities of a Bearer Service to transport data, defining which capabilities are required and how they should be set up.

Telephony Service:

These services can be charged on per call basis. Only call initiator has to pay the charges and now a days, all the incoming charges are free. A customer can be charged based on different parameters like:

- International call or long distance call.
- Local call
- Call made during peak hours.
- Call made during night time
- Discounted call during weekends.
- Call per minute or per second.
- Many more other criteria can be designed by a service provider to charge their customers.

SMS Service:

Most of the service providers are charging their customer's SMS services based on number of text messages sent from their mobile phone. There are other prime SMS services available where service providers are charging more than normal SMS charge. These services are being used in collaboration of Television Networks or Radio Networks to demand SMS from the audiences

Most of time charges are paid by the SMS sender but for some services like stocks and share prices, mobile banking facilities and leisure booking services etc. recipient of the SMS has to pay for the service.

GPRS Services

Using GPRS service you can browse Internet and can play games on the Internet, you can download movies or music etc. So a service provider will charge you based on the data uploaded as well as data downloaded on your mobile phone. These charges will be based on per Kilo Byte data downloaded/uploaded.

Additional parameter could be a Quality of Service provided to you. If you want to watch a movie then a low quality may work because some data loss may be acceptable to you but if you are downloading a zip file then a single byte loss will corrupt your complete downloaded file.

Another parameter could be peak and off peak time to download a data file or to browse the Internet.

Supplementary Services

Most of the supplementary services are being provided based on monthly rental or absolutely FREE. Like Call Waiting, Call Forwarding, Calling Number Identification, and call on hold are available at very low or zero prices.

Call Baring is a service which service providers use just to recover their dues etc. otherwise this service is not being used by any subscriber.

Call conferencing service is a form of simple telephone call where customer will be charged for multiple calls made at a time. No service provider charges extra charge for this service.

Closed User Group (CUG) is very popular and is mainly being used to give special discounts to the users if they are making calls to a particular defined group of subscribers.

Advice of Charge (AoC) can be charged based on number of queries made by a subscriber.

Voice Calls:

The most basic Teleservice supported by GSM is telephony. This includes Full-rate speech at 13 Kbps and emergency calls, where the nearest emergency� service provider is notified by dialing three digits. A very basic example of emergency service is 911 service available in USA.

Videotext and Facsmile:

Another group of teleservices includes Videotext access, Teletex transmission, Facsimile alternate speech and facsimile Group 3, Automatic facsimile Group 3 etc.

Short Text Messages:

SMS (Short Messaging Service) service is a text messaging which allow you to send and receive text messages on your GSM Mobile phone. Services available from many of the world's GSM networks today - in addition to simple user generated text message services - include news, sport, financial, language and location based services, as well as many early examples of mobile commerce such as stocks and share prices, mobile banking facilities and leisure booking services.

Bearer Services or Data Services

Using your GSM phone to receive and send data is the essential building block leading to widespread mobile Internet access and mobile data transfer. GSM currently has a data transfer rate of 9.6k. New developments that will push up data transfer rates for GSM users are HSCSD (high speed circuit switched data) and GPRS (general packet radio service) are now available.

Supplementary Services

Supplementary services are provided on top of teleservices or bearer services, and include features such as caller identification, call forwarding, call waiting, multi�party conversations, and barring of outgoing (international) calls, among others. A brief description of supplementary services is given here:

- **Multiparty Service or conferencing:** The multiparty service allows a mobile subscriber to establish a multiparty conversation.that is, a simultaneous conversation between three or more subscribers to setup a conference call. This service is only applicable to normal telephony.
- **Call Waiting:** This service allows a mobile subscriber to be notified of an incoming call during a conversation. The subscriber can answer, reject, or ignore the incoming call. Call waiting is applicable to all GSM telecommunications services using a circuit-switched connection.
- **Call Hold:** This service allows a subscriber to put an incoming call on hold and then resume this call. The call hold service is only applicable to normal telephony.
- **Call Forwarding:** The Call Forwarding Supplementary Service is used to divert calls from the original recipient to another number, and is normally set up by the subscriber himself. It can be used by the subscriber to divert calls from the Mobile Station when the subscriber is not available, and so to ensure that calls are not lost. A typical scenario would be a salesperson turns off his mobile phone during a meeting with customers, but does not with to lose potential sales leads while he is unavailable.
- **Call Barring:** The concept of barring certain types of calls might seem to be a supplementary disservice rather than service. However, there are times when the subscriber is not the actual user of the Mobile Station, and as a consequence may wish to limit its functionality, so as to limit the charges incurred. Alternatively, if the subscriber and user are one and the same, the Call Barring may be useful to stop calls being routed to international destinations when they are routed. The reason

for this is because it is expected that the roaming subscriber will pay the charges incurred for international re-routing of calls. So, GSM devised some flexible services that enable the subscriber to conditionally bar calls.

- **Number Identification:** There are following supplementary services related to number identification:

  - **Calling Line Identification Presentation:** This service deals with the presentation of the calling party's telephone number. The concept is for this number to be presented, at the start of the phone ringing, so that the called person can determine who is ringing prior to answering. The person subscribing to the service receives the telephone number of the calling party.
  - **Calling Line Identification Restriction:** A person not wishing their number to be presented to others subscribes to this service. In the normal course of event, the restriction service overrides the presentation service.
  - **Connected Line Identification Presentation:** This service is provided to give the calling party the telephone number of the person to whom they are connected. This may seem strange since the person making the call should know the number they dialled, but there are situations (such as forwardings) where the number connected is not the number dialled. The person subscribing to the service is the calling party.
  - **Connected Line Identification Restriction:** There are times when the person called does not wish to have their number presented and so they would subscribe to this person. Normally, this overrides the presentation service.
  - **Malicious Call Identification:** The malicious call identification service was provided to combat the spread of obscene or annoying calls. The victim should subscribe to this service, and then they could cause known malicious calls to be identified in the GSM network, using a simple command. This identified number could then be passed to the appropriate authority for action. The definition for this service is not stable.

- **Advice of Charge (AoC):** This service was designed to give the subscriber an indication of the cost of the services as they are used. Furthermore, those Service Providers who wish to offer rental services to subscribers without their own

Subscriber Identity Module (SIM) can also utilize this service in a slightly different form. AoC for data calls is provided on the basis of time measurements.

- **Closed User Groups (CUGs):** This service is provided on GSM to enable groups of subscribers to only call each other. This type of services are being offered with special discount and is limited only to those members who wish to talk to each other.
- **Unstructured supplementary services data (USSD):** This allows operator-defined individual services.

GSM:SECURITY

The security methods standardized for the GSM System make it the most secure cellular telecommunications standard currently available. Although the confidentiality of a call and anonymity of the GSM subscriber is only guaranteed on the radio channel, this is a major step in achieving end-to- end security.

The subscriber's anonymity is ensured through the use of temporary identification numbers. The confidentiality of the communication itself on the radio link is performed by the application of encryption algorithms and frequency hopping which could only be realized using digital systems and signaling.

This chapter gives an outline of the security measures implemented for GSM subscribers.

Mobile Station Authentication:

The GSM network authenticates the identity of the subscriber through the use of a challenge-response mechanism. A 128-bit random number (RAND) is sent to the MS. The MS computes the 32-bit signed response (SRES) based on the encryption of the random number (RAND) with the authentication algorithm (A3) using the individual subscriber authentication key (Ki). Upon receiving the signed response (SRES) from the subscriber, the GSM network repeats the calculation to verify the identity of the subscriber.

Note that the individual subscriber authentication key (Ki) is never transmitted over the radio channel. It is present in the subscriber's SIM, as well as the AUC, HLR, and VLR databases as previously described. If the received SRES agrees with the calculated value, the MS has been successfully authenticated and may continue. If the values do not match, the connection is terminated and an authentication failure indicated to the MS.

The calculation of the signed response is processed within the SIM. This provides enhanced security, because the confidential subscriber information such as the IMSI or the individual subscriber authentication key (Ki) is never released from the SIM during the authentication process.

Signaling and Data Confidentiality:

The SIM contains the ciphering key generating algorithm (A8) which is used to produce the 64-bit ciphering key (Kc). The ciphering key is computed by applying the same random number (RAND) used in the authentication process to the ciphering key generating algorithm (A8) with the individual subscriber authentication key (Ki). As will be shown in later sections, the ciphering key (Kc) is used to encrypt and decrypt the data between the MS and BS.

An additional level of security is provided by having the means to change the ciphering key, making the system more resistant to eavesdropping. The ciphering key may be changed at regular intervals as required by network design and security considerations. In a similar manner to the authentication process, the computation of the ciphering key (Kc) takes place internally within the SIM. Therefore sensitive information such as the individual subscriber authentication key (Ki) is never revealed by the SIM.

Encrypted voice and data communications between the MS and the network is accomplished through use of the ciphering algorithm A5. Encrypted communication is initiated by a ciphering mode request command from the GSM network. Upon receipt of this command, the mobile station begins encryption and decryption of data using the ciphering algorithm (A5) and the ciphering key (Kc).

Subscriber Identity Confidentiality:

To ensure subscriber identity confidentiality, the Temporary Mobile Subscriber Identity (TMSI) is used. The TMSI is sent to the mobile station after the authentication and encryption procedures have taken place. The mobile station responds by confirming reception of the TMSI. The TMSI is valid in the location area in which it was issued. For communications outside the location area, the Location Area Identification (LAI) is necessary in addition to the TMSI.

ADVANTAGES OF GSM:

- GSM is already used worldwide with over 450 million subscribers.
- International roaming permits subscribers to use one phone throughout Western Europe. CDMA will work in Asia, but not France, Germany, the U.K. and other popular European destinations.
- GSM is mature, having started in the mid-80s. This maturity means a more stable network with robust features. CDMA is still building its network.
- GSM's maturity means engineers cut their teeth on the technology, creating an unconscious preference.
- The availability of Subscriber Identity Modules, which are smart cards that provide secure data encryption give GSM m-commerce advantages.

COMPARISION BETWEEN GSM AND CDMA

International Roaming with GSM and CDMA

Where international business travel is an issue, GSM leaps forward in the race for the title of “Most Accessible.” Because GSM is used in more than 74% of the markets across the globe, users of tri-band or quad-band handsets can travel to Europe, India, and most of Asia and still use their cell phones. CDMA offers no multiband capability, however, and therefore you can’t readily use it in multiple countries.

Data Transfer Methods in GSM vs. CDMA

Another difference between GSM and CDMA is in the data transfer methods. GSM’s high-speed wireless data technology, GPRS (General Packet Radio Service), usually offers a slower data bandwidth for wireless data connection than CDMA’s high-speed technology (1xRTT, short for single carrier radio transmission technology), which has the capability of providing ISDN (Integrated Services Digital Network)-like speeds of as much as 144Kbps (kilobits per second). However, 1xRTT requires a dedicated connection to the network for use, whereas GPRS sends in packets, which means that data calls made on a GSM handset don’t block out voice calls like they do on CDMA phones.

Interaction between GSM and CDMA

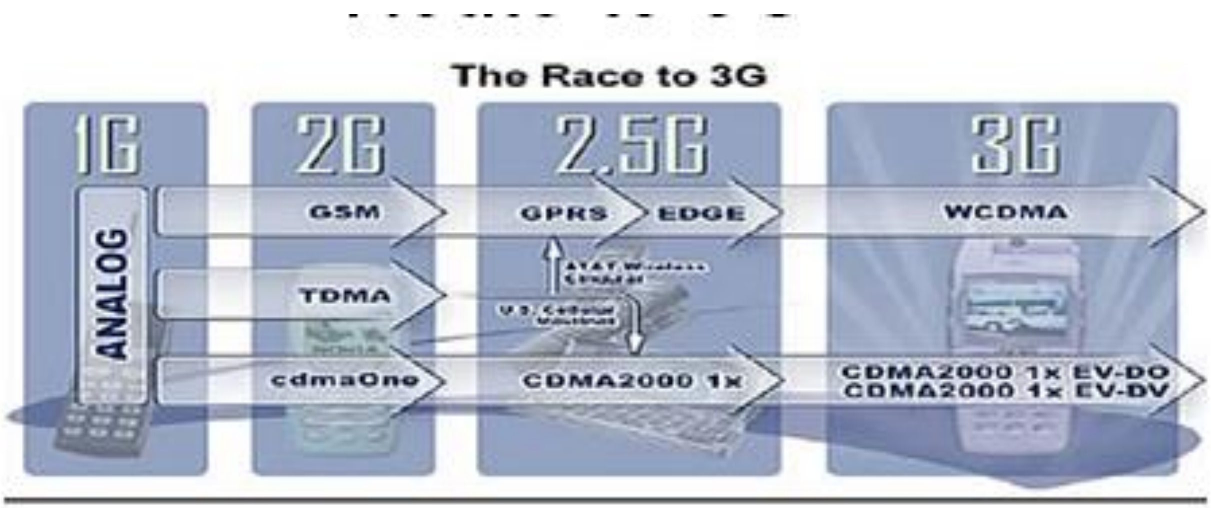
In cities and densely populated areas, there are often high concentrations of GSM and CDMA connection bases. In theory, GSM and CDMA are invisible to one another and should “play nice” with one another. In practice, however, this is not the case. High-powered CDMA signals have raised the “noise floor” for GSM receivers, meaning there is less space within the available band to send a clean signal. This sometimes results in dropped calls in areas where there is a high concentration of CDMA technology. Conversely, high-powered GSM signals have been shown to cause overloading and jamming of CDMA receivers due to CDMA’s reliance upon broadcasting across its entire available band.

The result of this little cross-broadcasting joust has led some cities to pass ordinances limiting the space between cell towers or the height they can reach, giving one technology a distinct advantage over the other. This is something to note when choosing a wireless provider. The distance between towers will severely affect connectivity for GSM-based phones because the phones need constant access to the tower’s narrow band broadcasting.

INRODUCTION OF 3G AND 4G

3RD GENERATION OF MOBILE SERVICES

International Mobile Telecommunications-2000 (IMT-2000), better known as **3G** or **3rd Generation**, is a family of standards for mobile telecommunications fulfilling specifications by the International Telecommunication Union, which includes UMTS, and CDMA2000 as well as the non-mobile wireless standards DECT and WiMAX. While the GSM EDGE standard also fulfils the IMT-2000 specification, EDGE phones are typically not branded 3G. Services include wide-area wireless voice telephone, video calls, and wireless data, all in a mobile environment. Compared to 2G and 2.5G services, 3G allows simultaneous use of speech and data services and higher data rates (at least 200 kbit/s peak bit rate to fulfill to IMT-2000 specification). Today's 3G systems can offer practice of up to 14.0 Mbit/s on the downlink and 5.8 Mbit/s on the uplink.

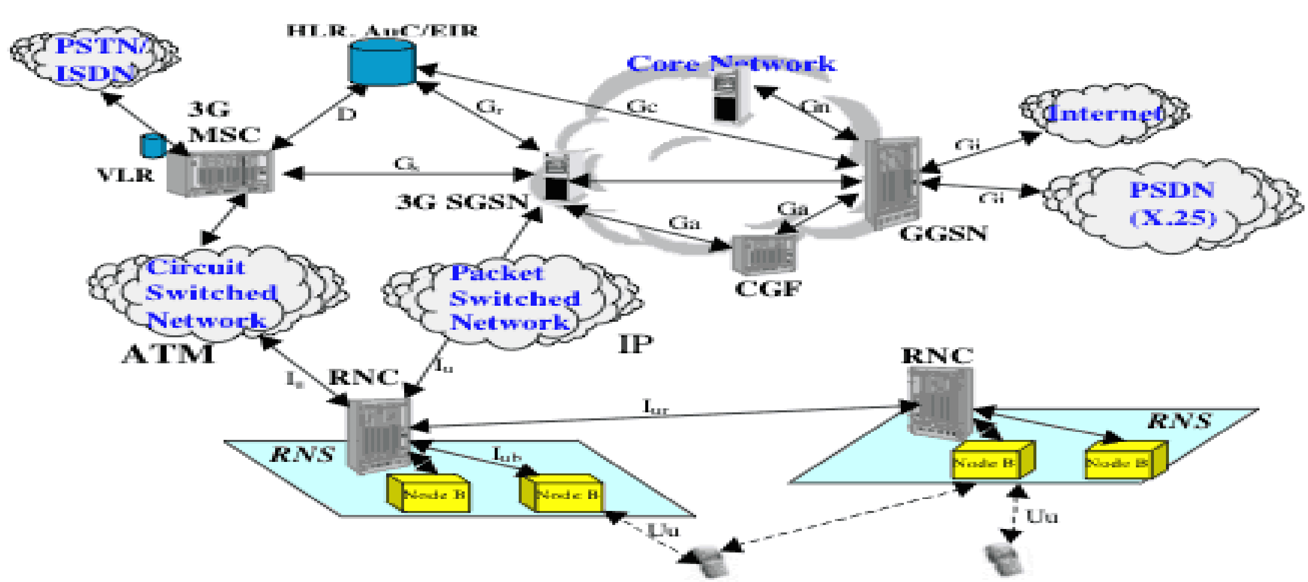


- 1G: analog
- 2G : 1st digital mobile telephony
- 2.5G: transition from 2G to 3G
- 3G standard: IMT 2000

3G STANDARDS

ITU IMT-2000	common name(s)		bandwidth of data	pre-4G	duplex	channel	description	geographical areas
TDMA Single-Carrier (IMT-SC)	EDGE (UWT-136)		EDGE Evolution	none	FDD	TDMA	evolutionary upgrade to GSM/GPRS[nb 1]	worldwide, except Japan and South Korea
CDMA Multi-Carrier (IMT-MC)	CDMA2000		EV-DO	UMB[nb 2]		CDMA	evolutionary upgrade to cdmaOne (IS-95)	Americas, Asia, some others
CDMA Direct Spread (IMT-DS)	UMTS[nb 3]	W-CDMA[nb 4]	HSPA	LTE			family of revolutionary standards.	worldwide
CDMA TDD (IMT-TC)		TD-CDMA[nb 5]			TDD			Europe
		TD-SCDMA[nb 6]						China
FDMA/TDMA (IMT-FT)	DECT		none			FDMA/TDMA	short-range; standard for cordless phones	Europe, USA
IP-OFDMA			WiMAX (IEEE 802.16)			OFDMA		worldwide

3G NETWORK



Features

Data rates

ITU has not provided a clear definition of the data rate users can expect from 3G equipment or providers. Thus users sold 3G service may not be able to point to a standard and say that the rates it specifies are not being met. While stating in commentary that "it is expected that IMT-2000 will provide higher transmission rates: a minimum data rate of 2 Mbit/s for stationary or walking users, and 384 kbit/s in a moving vehicle,"the ITU does not actually clearly specify minimum or average rates or what modes of the interfaces qualify as 3G, so various rates are sold as 3G intended to meet customers expectations of broadband data.

Security

3G networks offer greater security than their 2G predecessors. By allowing the UE (User Equipment) to authenticate the network it is attaching to, the user can be sure the network is the intended one and not an impersonator. 3G networks use the KASUMI block crypto instead of the older A5/1 stream cipher. However, a number of serious weaknesses in the KASUMI cipher have been identified .

In addition to the 3G network infrastructure security, end-to-end security is offered when application frameworks such as IMS are accessed, although this is not strictly a 3G property.

Applications

The bandwidth and location information available to 3G devices gives rise to applications not previously available to mobile phone users. Some of the applications are:

- **Mobile TV** – a provider redirects a TV channel directly to the subscriber's phone where it can be watched.
- **Video on demand** – a provider sends a movie to the subscriber's phone.
- **Video conferencing** – subscribers can see as well as talk to each other.
- **Tele-medicine** – a medical provider monitors or provides advice to the potentially isolated subscriber.
- **Location-based services** – a provider sends localized weather or traffic conditions to the phone, or the phone allows the subscriber to find nearby businesses or friends.

ADVANTAGES

3G phones promise :-

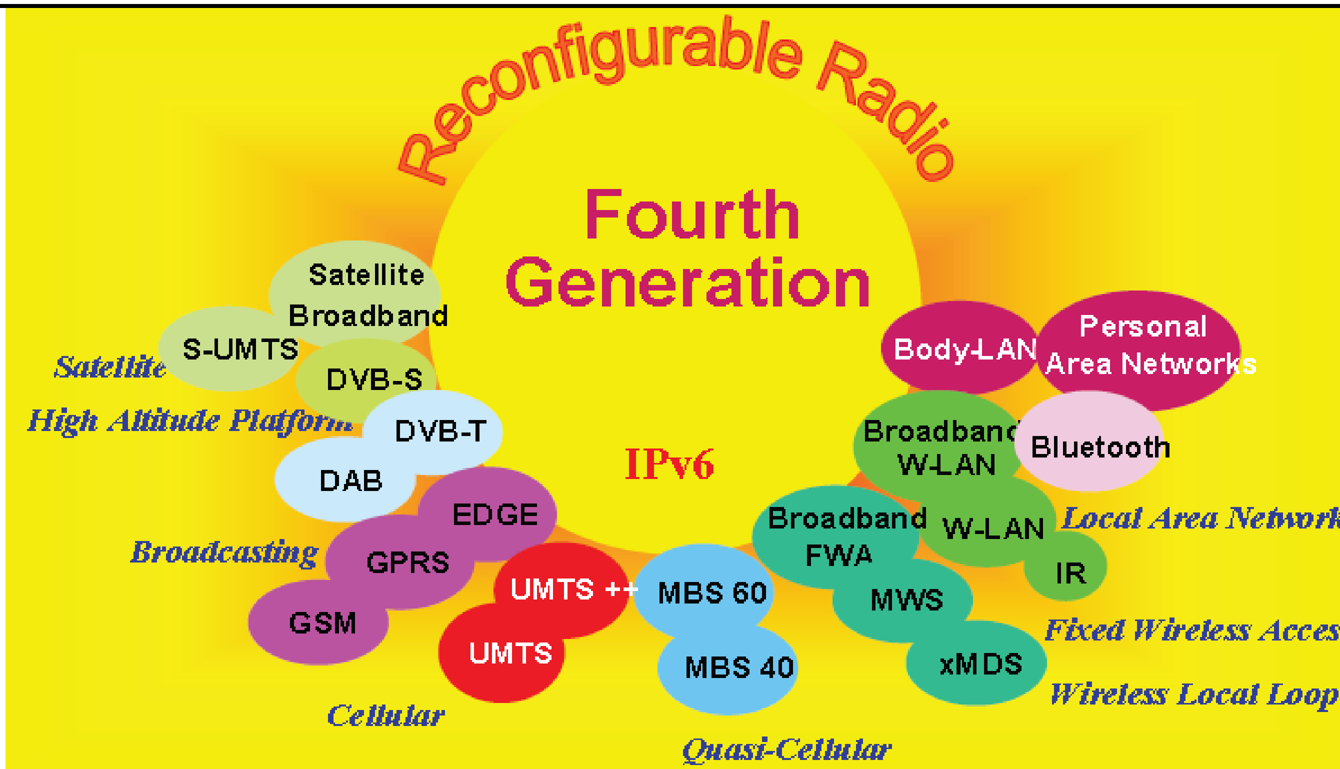
- Improved digital voice communications
- Larger Bandwidth – Higher Data rate
- Greater subscriber capacity
- Fast packet-based data services like e-mail, short message service (SMS), and Internet access at broadband speeds.
- Most carriers also expect consumers to want :-
  - location services
  - interactive gaming
  - streaming video
  - home monitoring and control
  - and who knows what else, while being fully mobile anywhere in the world.

3G CAPABILITIS

- Voice quality comparable to the public switched telephone network
- 144 Kbps- user in high-speed motor vehicles
- 384 Kbps- pedestrians standing or moving slowly over small areas
- Up to 2 Mbps- fixed applications like office use
- Symmetrical/asymmetrical data transmission rates
- Support for both packet switched and circuit switched data services like Internet Protocol (IP) traffic and real time video

4TH GENERATION OF MOBILE COMMUNICATION

4G refers to the fourth generation of cellular wireless standards. It is a successor to 3G and 2Gstandards, with the aim to provide ultra-broadband (gigabit-speed) internet access to mobile as well as stationary users. Although 4G is a broad term that has had several different and more vague definitions, this article uses 4G to refer to **IMT Advanced** (*International Mobile Telecommunications Advanced*), as defined by ITU-R.



4G OBJECTIVES

The 4G working group has defined the following as objectives of the 4G wireless communication standard:

- Flexible channel bandwidth, between 5 and 20 MHz, optionally up to 40 MHz.
- A spectrally efficient system (in bits/s/Hz and bits/s/Hz/site),
- High network capacity: more simultaneous users per cell,
- A nominal data rate of 100 Mbit/s while the client physically moves at high speeds relative to the station, and 1 Gbit/s while client and station are in relatively fixed positions as defined by the ITU-R,
- A data rate of at least 100 Mbit/s between any two points in the world,
- Smooth handoff across heterogeneous networks,
- Seamless connectivity and global roaming across multiple networks,
- High quality of service for next generation multimedia support (real time audio, high speed data, HDTV video content, mobile TV, etc)
- Interoperability with existing wireless standards, and
- An all IP, packet switched network.

IPv6 support

- Unlike 3G, which is based on two parallel infrastructures consisting of circuit switched and packet switched network nodes respectively, 4G will be based on packet switching *only*. This will require low-latency data transmission.
- By the time that 4G is deployed, the process of IPv4 address exhaustion is expected to be in its final stages. Therefore, in the context of 4G, IPv6 support is essential in order to support a large number of wireless-enabled devices. By increasing the number of IP addresses, IPv6 removes the need for Network Address Translation (NAT), a method of sharing a limited number of addresses among a larger group of devices, although NAT will still be required to communicate with devices that are on existing IPv4networks.
- As of June 2009, Verizon has posted specifications that require any 4G devices on its network to support IPv6.

COMPARISION OF 3G AND 4G

	3G (including 2.5G, sub3G)	4G
Major Requirement Driving Architecture	Predominantly voice driven - data was always add on	Converged data and voice over IP
Network Architecture	Wide area cell-based	Hybrid - Integration of Wireless LAN (Wi-Fi, Bluetooth) and wide area
Speeds	384 Kbps to 2 Mbps	20 to 100 Mbps in mobile mode
Frequency Band	Dependent on country or continent (1800-2400 MHz)	Higher frequency bands (2-8 GHz)
Bandwidth	5-20 MHz	100 MHz (or more)
Switching Design Basis	Circuit and Packet	All digital with packet voice
Access Technologies	W-CDMA, 1xRTT, Edge	OFDMA and MC-CDMA (Multi Carrier CDMA)
Forward Error Correction	Convolutional rate 1/2, 1/3	Concatenated coding scheme
Component Design	Optimized antenna design, multi-band adapters	Smarter Antennas, software multi-band and wideband radios Software-Defined Radio
IP	A number of air link protocols, including IP 5.0	All IP (IP6.0)

BIBLIOGRAPHY

- www.en.wikipedia.org
- www.123eng.com
- www.electronicdesign.com
- www.3g-generation.com
- www.3gtoday.com
- http://www.pctechguide.com
- **Fourth Generation Cellular Systems:**
  Spectrum Requirements-By Joseph M. Nowack-Motorola Labs
- **IMT Project. What is IMT-2000, Geneva-2001**
- **WIRELESS COMMUNICATION- BY-THEODORE S.RAPPAPORT**
- **ECE DEPARTMENT- RIT KODERMA**
- **INDIAN TELECOMMUNICATION INDUSTRY Ltd., MANKAPUR,U.P**