UNIT 3

GSM LOGICAL CHANNELS AND FRAME STRUCTURE

- Introduction
- GSM Logical Channels
- Allowed Logical Channel Combinations
- TCH multi frame for TCH/H
- CCH Multi frame
- GSM Frame Structure
- GSM Burst
- Normal Burst, Synchronization Burst
- Frequency Correction Channel Burst, Access Burst
- Data Encryption in GSM
- Mobility Management
- Location Registration
- Mobile Identification

Introduction

- In this chapter, we discuss different logical channels that are used in GSM system
- The logical channels carry user information & control signaling data
- Different logical channels are used for different tasks
- The information transmitted on a logical channel depends on a particular task
- We also discuss different frame structure of GSM & provide details of 5 different kinds of bursts that are used in GSM to carry user & control information
- Mobility management & mobile identification are also discussed

GSM LOGICAL CHANNELS

- A large amount of information is transmitted between MS and BS
- These are the user information (voice and data) and control signaling data
- Depending on the type of information transmitted, different logical channels are used
- These logical channels are mapped onto the physical channels (time slots)
- There are 2 types of logical channels in GSM:

  - TCHs: Traffic Channels
  - CCHs: Control Channels.

GSM LOGICAL CHANNELS

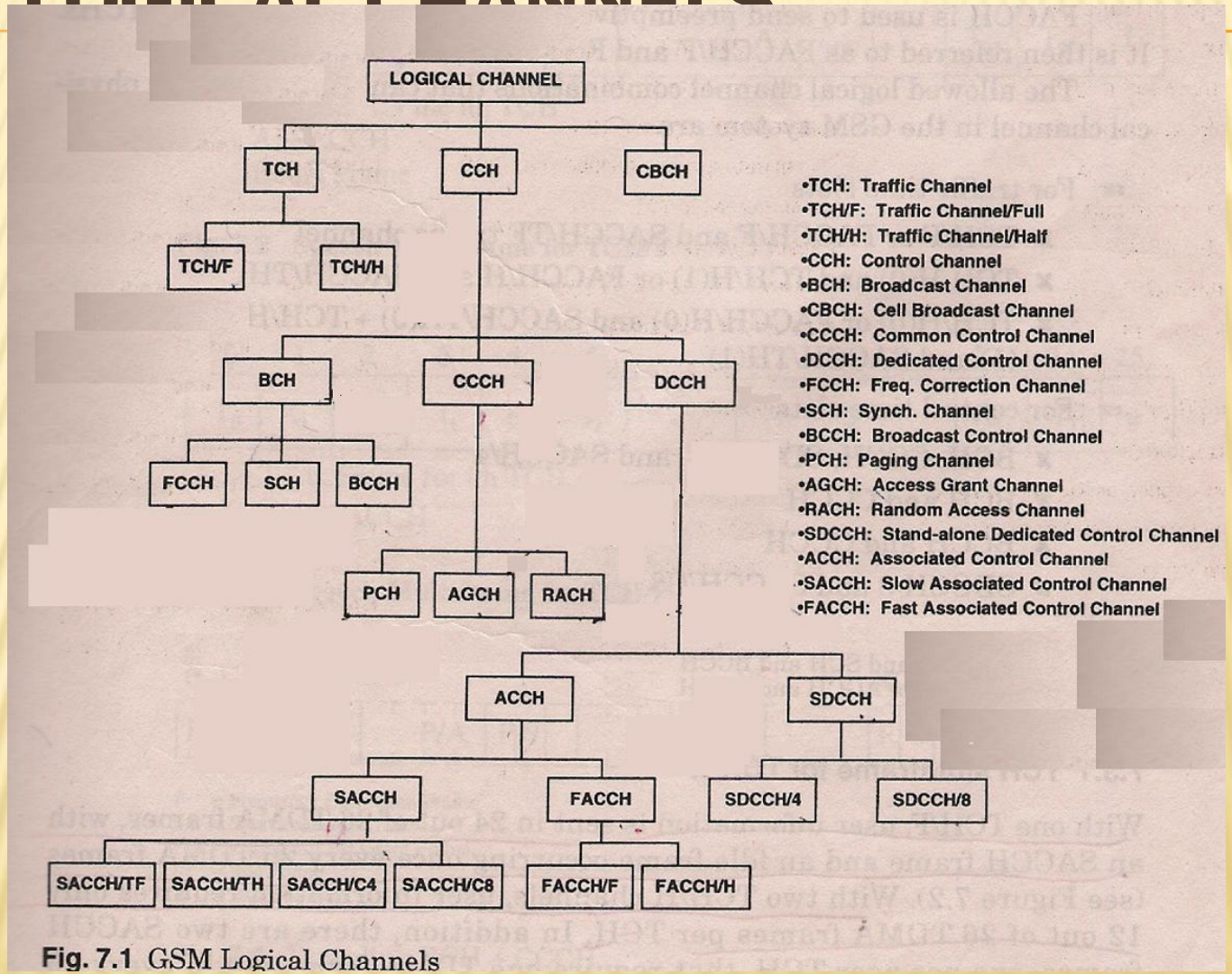

Fig. 7.1 GSM Logical Channels

GSM LOGICAL CHANNELS

TCH :

- Are used to carry either encoded speech or user data both in the uplink and downlink directions.
- TCH supports 2 information rates :- Full rate (TCH/F) & Half Rate (TCH/H)
- TCH/F carries user speech at 13 kbps and data at 9.6 kbps, 4.8 kbps and 2.4 kbps
- TCH/H carries user speech at the rate of 11.4 kbps and data at 4.8kbps and 2.4kbps

GSM Logical Channels

CCH :

There are 3 types of control channels.

- BCCH [Broadcast Control Channel]
- CCCH [Common Control Channel]
- DCCH [Dedicated Control Channel]

- **BCCH** - They are point-to-multipoint unidirectional channels
  - Used for functions such as correcting mobile frequencies, frame synchronization and CCH structure
  - These are downlink only channels
  - Other channels that belong to the BCCH group are the FCCH and SCH

GSM Logical Channels

FCCH [Frequency Correction Channel]

- It is the downlink point-to-multipoint channel.
- It carries information for frequency correction of the MS
- This channel is required for the correct operation of the radio subsystem and allows an MS to accurately tune to a BS.

GSM Logical Channels

SCH [Synchronization Channel]

- It carries information for frame synchronization of the MS and the identification of a BTS
- It has 64-binary sequence that is previously known to the MS
- The MS achieves the exact timing synchronization with respect to a GSM frame by correlating the bits with the internally stored 64 bits
- It carries BTS identification code (BSIC) and reduced TDMA frame number (RFN [Reduced TDMA Frame Number]).

GSM Logical Channels

- CCCH [Common Control Channel]
  - They are point-to-multipoint bidirectional channels
  - They are mainly used to carry signaling information necessary for accessing management functions
  - These channels are used to establish connections between MSs and BSs before a DCCH is assigned to an MS
  - There are 2 down link (BS to MS) channels & 1 uplink (MS to BS) CCCHs defined
  - The downlink channels are : PCH (Paging Channel) & AGCH (Access Grant Channel)
  - The uplink channel is RACH (Random Access Channel)

GSM Logical Channels

PCH [Paging Channel]

- It is a downlink channel
- It is used to page the MSs

AGCH [Access Grant Channel]

- It is a downlink channel
- It is used to assign an MS to a specific DCCH

RACH [Random Access Channel]

- It is a uplink channel
- It is used to request assignment of a DCCH

GSM Logical Channels

- DCCH [Dedicated Control Channel]
  - They are used for signaling and control after call establishment
  - There are 2 types of DCCH :
    - SDCCH [Stand-Alone Dedicated Control Channel]
    - ACCH [Associated Control Channel]

GSM Logical Channels

SDCCH [Stand-Alone Dedicated Control Channel]

- It is a DCCH whose allocation is not linked to the allocation of a TCH (Traffic Channel)
- It is used for the authentication of the MS, for location updates and for assignment to TCHs
- This is used before the MS is assigned a TCH

GSM Logical Channels

ACCH [Associated Control Channels]

The ACCHs are of 2 types:

- SACCH (Slow Associated Control Channel) &
- FACCH (Fast Associated Control Channel)

➢ SACCH

- It is always associated with TCH or SDCCH.
- It is used to carry general control information.
- It includes SACCH/TF/TH/C4/C8.

➢ FACCH

- It is similar to a blank-and-burst channel in that user information is precluded while data is being sent.
- It is used to transmit handover orders.
- It includes FACCH/H/F.

Allowed Logical Channel Combinations

- SDCCHs can share a physical channel with a BCH (Broadcast Channel) & a CCH (Common Control Channel)
- There can be 4 SDCCHs (referred to as the SDCCH/4) mapped onto the same physical channel or there can be 8 SDCCH (referred to as SDCCH/8) that can share a physical channel with themselves
- An SACCH can be sent along with full or half-rate TCHs which is then referred to as SACCH/TF & SACCH/TH respectively
- It can also be sent along with SDCCH/4 & SDCCH/8. Then it is referred to as SACCH/C4 & SACCH/C8 respectively
- FACCH is used to send signaling on full or half rate TCHs. It is then referred to as FACCH/F & FACCH/H respectively

Allowed Logical Channel Combinations

The allowed logical channels that can share the same physical channel in the GSM system are:

- For traffic time-slots:-

1. TCH/F or FACCH/F and SACCH/TF traffic channel.
2. TCH/H(0) and TCH/H(1) or FACCH/H and SACCH/TH
3. TCH/H(0) or FACCH/H(0) and SACCH/TH(0) + TCH/H(1) or FACCH(1) and SACCH/TH(1).

- For control time-slots:-

1. BCH,CCCH,SDCCH/4, and SACCH/4.
2. BCH and CCCH.
3. BCCH and CCCH.
4. SDCCH/8 and SACCH/C8.

where

- BCH = FCCH & SCH & BCCH
- CCCH = PCH & AGCH & RACH

TCH Multiframe for TCH/H

- With one TCH/F, user information is send in 24 out of 26 TDMA frames, with an SACCH frame & an idle frame occurring every 26 TDMA frames

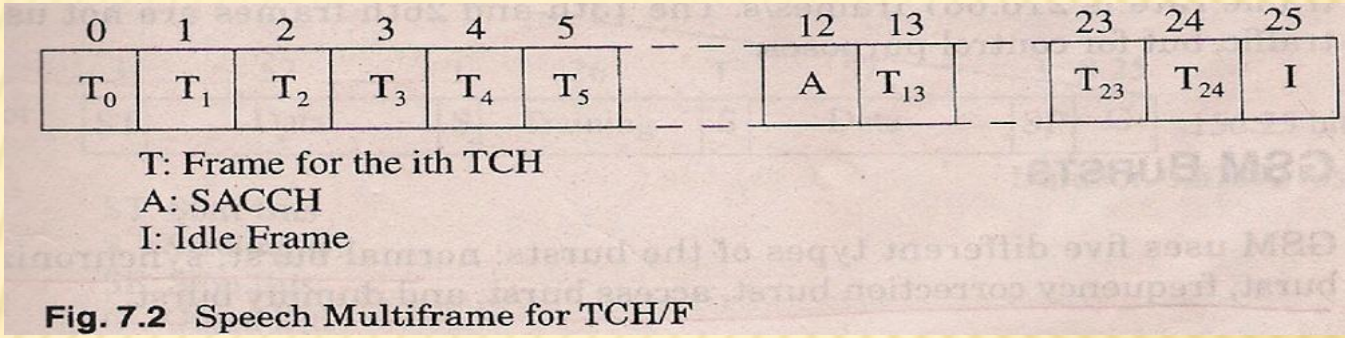

Fig. 7.2 Speech Multiframe for TCH/F

- With 2 TCH/H channels, user information requires only 12 out of 26 TDMA frames per TCH. In addition there are 2 SACCH frames, one per user TCH

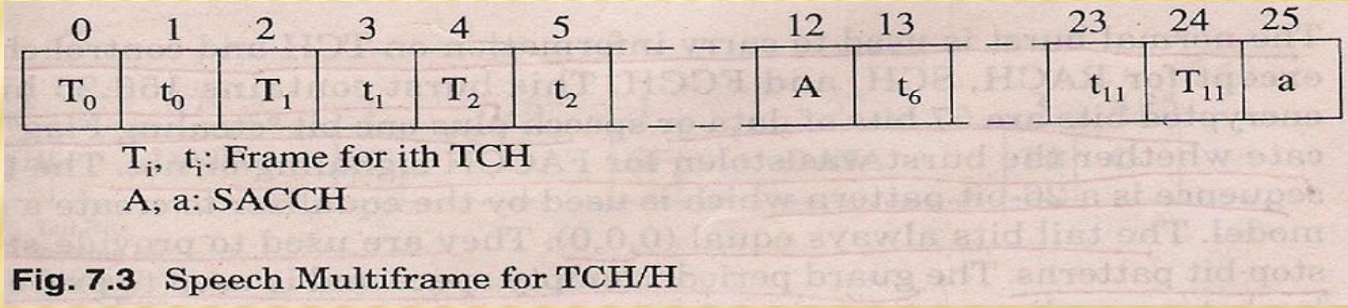

Fig. 7.3 Speech Multiframe for TCH/H

CCH Multiframe

- The BCH & CCCH forward control channels are implemented only on certain Absolute Radio Frequency Channel Number (ARFCN) channels & are allocated time slots in a specific manner
- The multiframe structure used for the 1st timeslot of the radio communication is shown in figure:

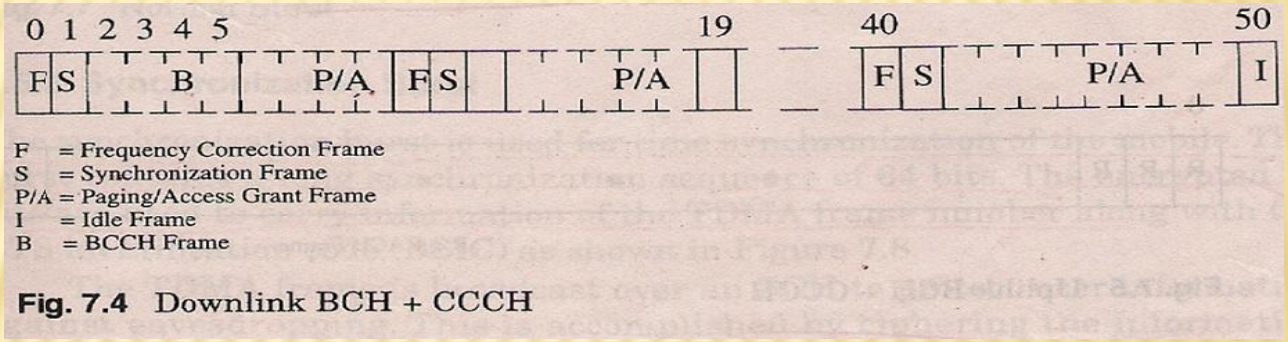

Fig. 7.4 Downlink BCH + CCCH

- Uplink path – RACH instead of PCH/AGCH (P/A) frames

GSM FRAME STRUCTURE

- The available forward (BS to MS, 935-960 MHz) and reverse (MS to BS, 890-915 MHz) bands are divided into 200-kHz channels referred to as AFRCNs (Absolute Radio Frequency Channel Number)
- Each time-slot consists of 156.25 bits, out of which 8.25 bits are used for guard time and 6 bits are used as start and stop bits that are used to prevent overlap between 2 adjacent time-slots
- Each time-slot is 0.57692 ms. Only 148 bits are transmitted at a rate of 270.833kbps
- A single full-rate GSM frame contains 8 time-slots with a time duration of 4.615 ms and 1250 bits
- Frame rate is 216.667 frames/sec. The 13^{th} and 26^{th} frame are not used for traffic, but for control purposes.

GSM FRAME STRUCTURE

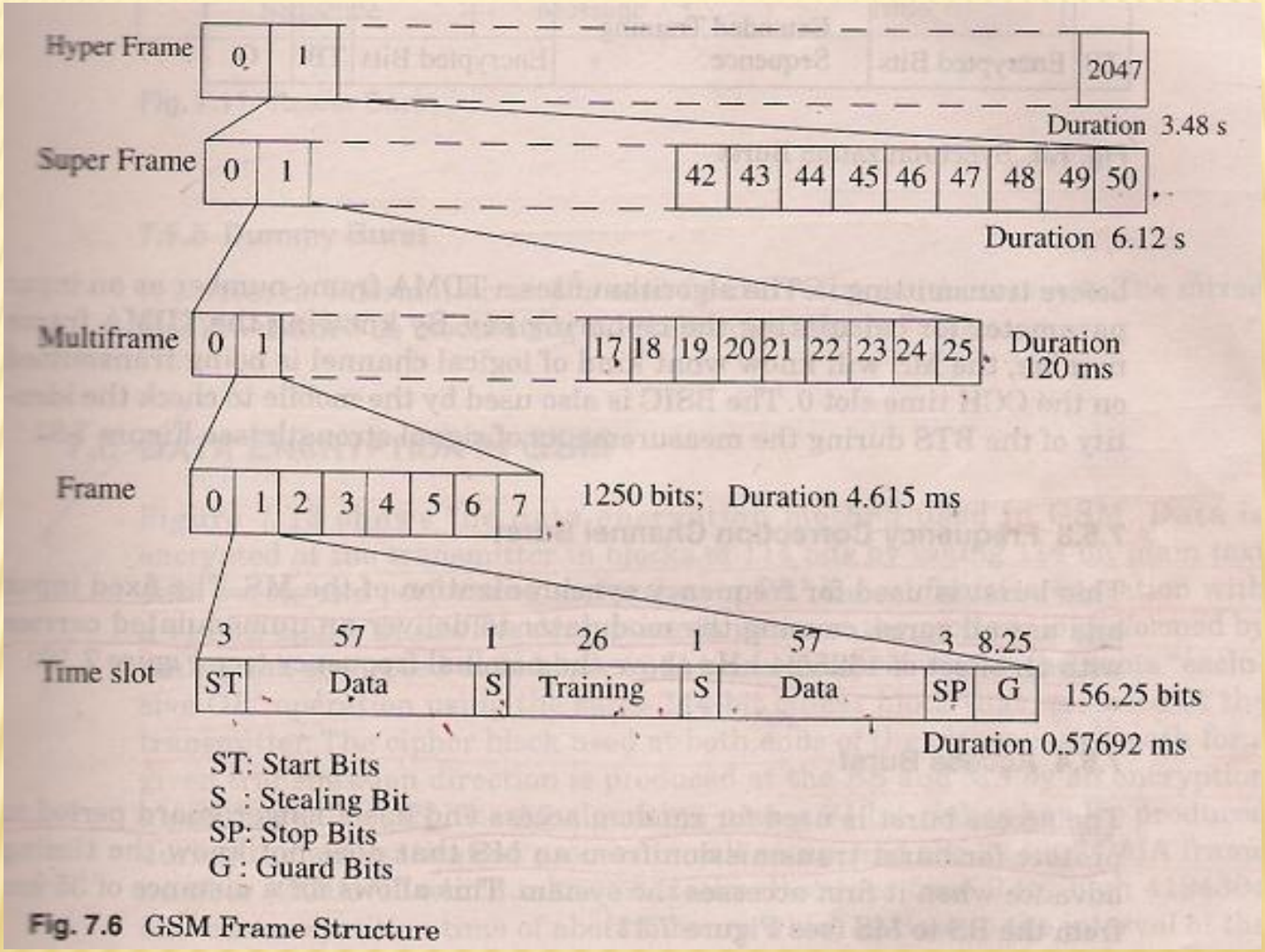

Fig. 7.6 GSM Frame Structure

GSM BURSTS

GSM uses 5 different types of bursts :

1. Normal Burst
2. Synchronization Burst
3. Frequency Correction Burst
4. Access Burst
5. Dummy Burst

GSM BURSTS

Normal Burst:

- It is used to carry information on TCH and CCH except for RACH, SCH and FCCH.
- This burst contains 156.25 bits
- The encrypted bits are 57 bits of data or speech, plus 1 bit of “stealing Flag” to indicate whether the burst was stolen for FCCH signaling or not
- The tail bits always equal (0,0,0) and are used to provide start and stop bit patterns

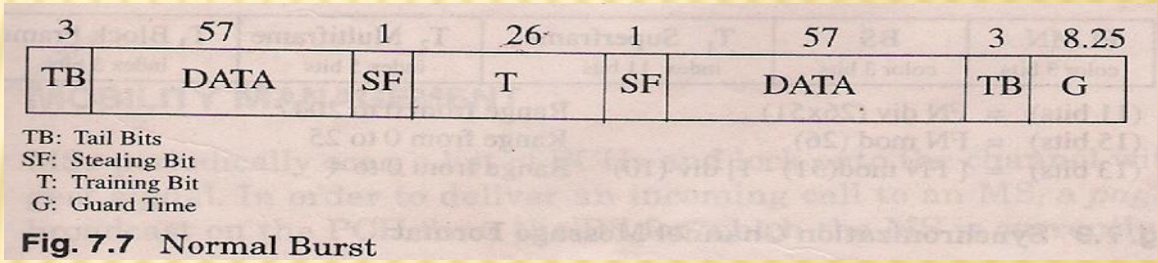

Fig. 7.7 Normal Burst

- The guard period is empty space and is used to prevent overlap between adjacent time slots during transmission

GSM BURSTS

- Synchronization Bursts:

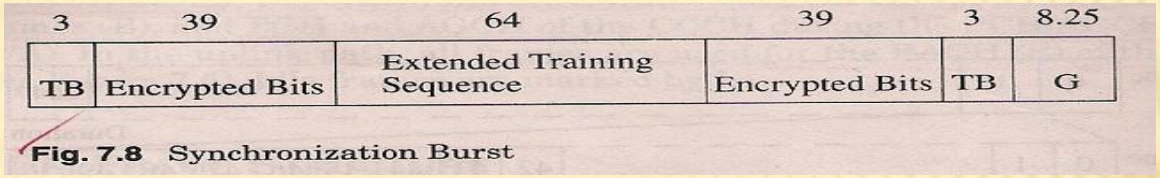

Fig. 7.8 Synchronization Burst

- It is used for time synchronization of the mobile. This burst contains a long synchronization sequence of 64 bits
- The encrypted 78 bits are used to carry information of the TDMA frame number along with the BTS identification code (BSIC)
- The TDMA frame is broadcast over an SCH to protect user information against eavesdropping, this is done by ciphering the information before transmitting
- The algorithm uses TDMA frame number as an important parameter for calculating the ciphering key.
- By knowing the TDMA frame number, the MS will know what type of logical channel is being transmitted.

GSM BURSTS

Frequency Correction Channel Bursts:

- This burst is used for frequency synchronization of the MS
- The fixed input bits are all zeros

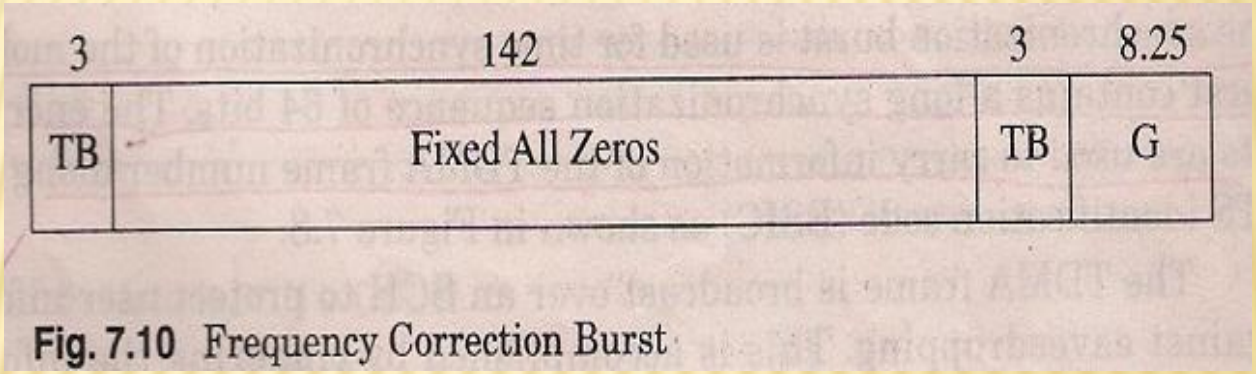

Fig. 7.10 Frequency Correction Burst

GSM BURSTS

Access Burst:

- This is used for random access and has a longer guard period to protect for burst transmission from an MS that does not know the timing in advance when it first accesses the system
- This allows for a distance of 35 km from BS to MS

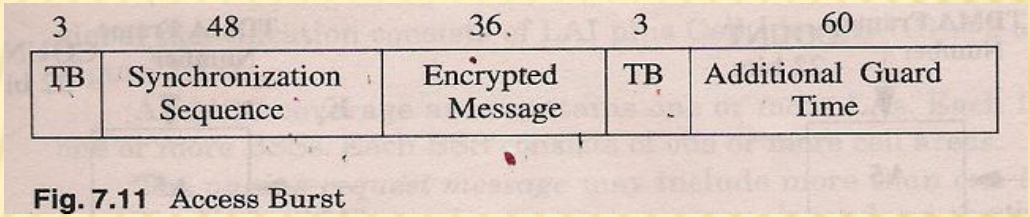

Fig. 7.11 Access Burst

Dummy Bursts:

- It carries no information and is sent from BTS on some occasions. The mixed bits are defined as modulating bit states.

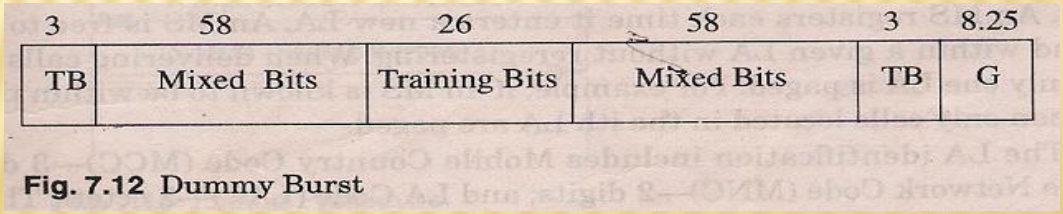

Fig. 7.12 Dummy Burst

DATA ENCRYPTION IN GSM

- Data is encrypted at the transmitter in blocks of 114 bits by taking 114-bit plain text data burst and performing an “EX-OR” logical function operation with a 114-bit cipher block
- The decrypting function at the receiver is performed by taking the encrypted data block of 114 bits and performing the same “EX-OR” operation using the same 114-bit cipher block that was used at the transmitter

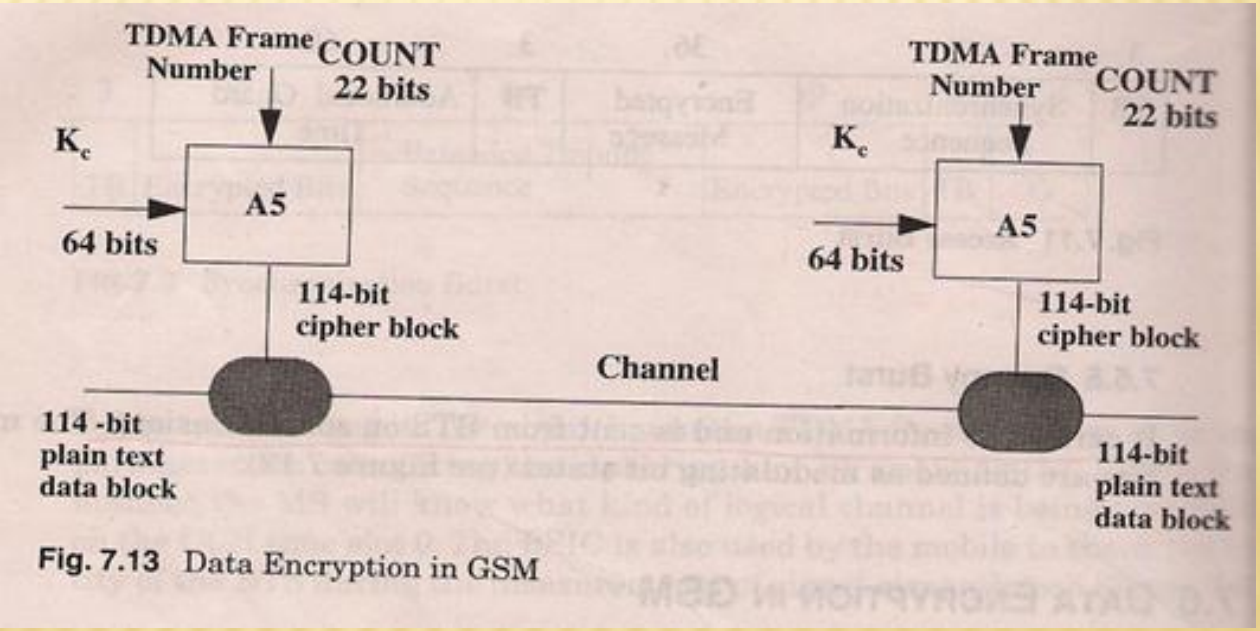

Fig. 7.13 Data Encryption in GSM

DATA ENCRYPTION IN GSM

- The cipher block used at both ends of the transmission path for a given transmission direction is produced at the BS and MS by an encryption algorithm called A5

- The A5 algorithm uses a 64-bit cipher key K_c produced during the authentication process in call setup, and the 22-bit TDMA frame number (COUNT) which takes on (decimal) values from 0 through 4194304 and has a repetition time of about 5 hr which is close to the interval of the GSM hyperframe.

- The A5 algorithm produces 2 cipher blocks during each TDMA period, one for uplink and another for downlink path.

Mobility Management

- MSs periodically scan a list of PCHs (Paging Channels) and lock onto the channel with the strongest signal
- In order to deliver an incoming call to an MS, a page message is broadcast on the PCH from the BS for which the MS is currently monitoring
- If the MS hears its identification code broadcast on the PCH it responds with a page response message.

Mobility Management

Difficulties Faced While Delivering a Call to an MS:

- It is difficult to know which cell area should be paged and how many cell areas should be paged.
- Performance related problems arise when too many cells are paged when attempting to deliver a call to an MS.
- As the page attempt rate increases to a given BS, a resource becomes a bottleneck.
- BS real-time might become a bottleneck if a BS is unable to perform other call-handling functions because of the volumes of pages it is being required to broadcast

Mobility Management

- If the BS does not have adequate overload controls, the number of successful pages start to decrease as the page attempt rate increases beyond saturation point.
- To keep the paging performance within a safe range it is necessary to form a cluster of cells and page only the cluster of cells for which the MS is known to be situated.
- These cell clusters are referred to as Location Area (LA).

Mobility Management

Functions of LA:

- The GPA (GSM PLMN Area) is divided into LAs. Each LA is made up of one or more cell areas.
- An MS registers as soon as it enters into a new LA. An MS is free to move around within a given LA without re-registering.
- When delivering calls to an MS only the LA known to contain the MS is paged.

Mobility Management

The LAI (Location Area Identification) includes :

1. MCC [Mobile Country Code-3 digits]
2. MNC [Mobile Network Code-2 digits]
3. LAC [Location Area Code-2 octets]

The cell global identification consists of LAI + Cell Identity(CI) of 2 octets.

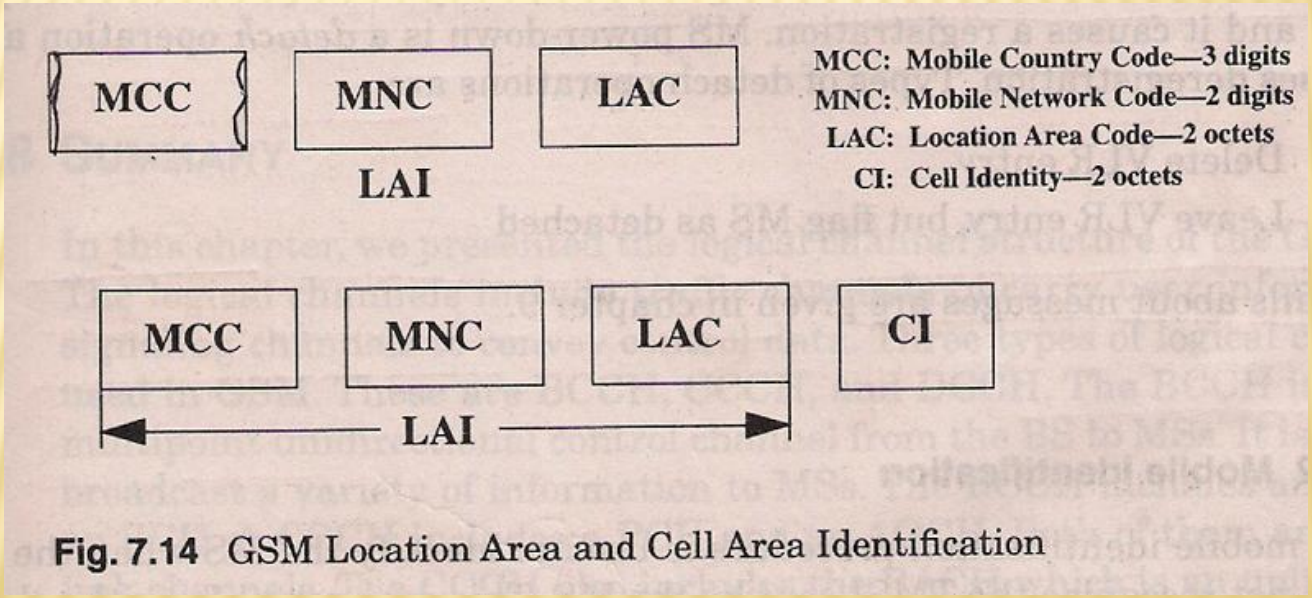

Fig. 7.14 GSM Location Area and Cell Area Identification

Mobility Management

Mobile Identification

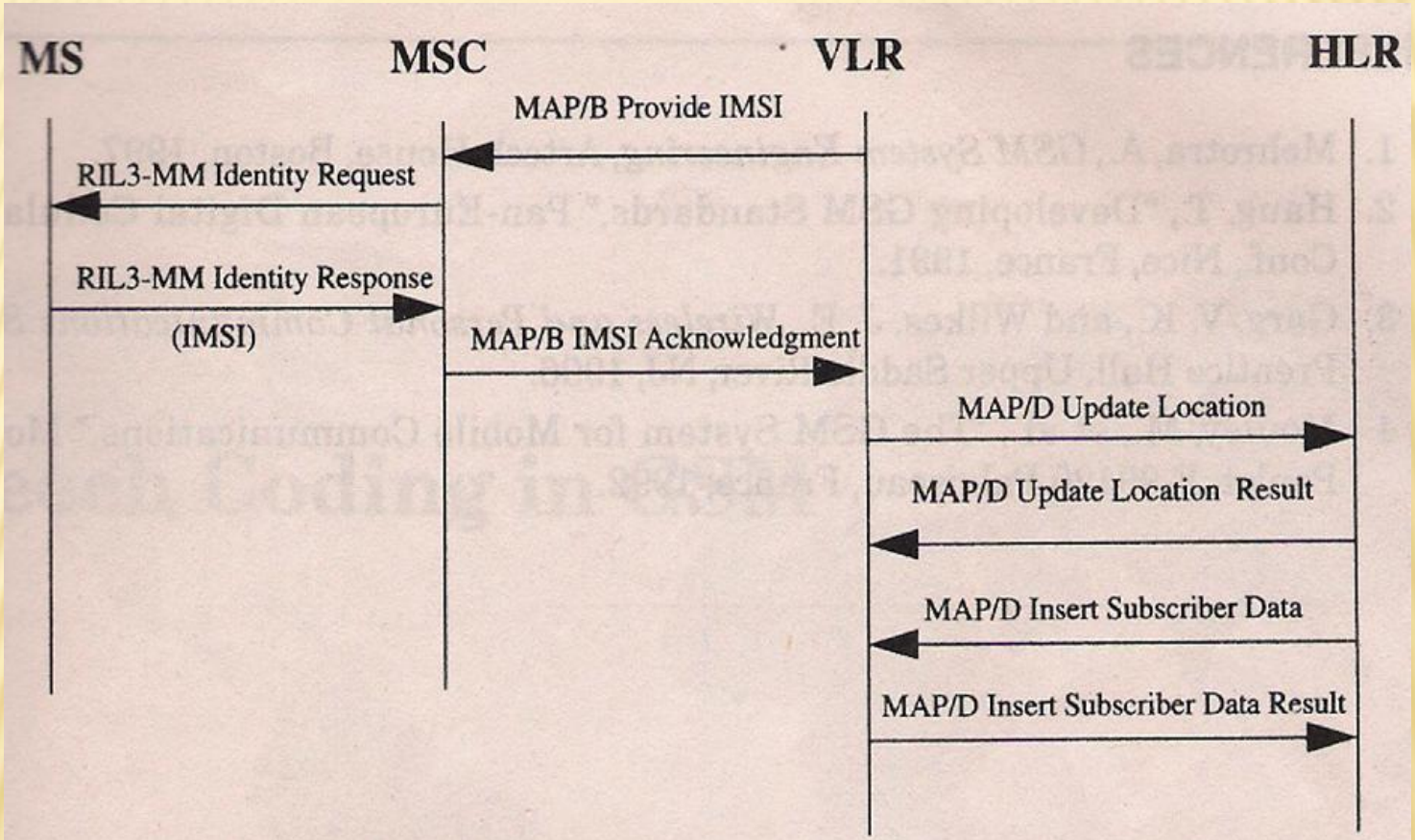

Fig. 7.16 Mobile Identification Process

Mobility Management

Mobile Identification

- The Mobile Identification process is used to identify the MS when the VLR does not recognize the TMSI (Temporary Mobile Subscriber Identity) send by the MS
- If MS identification is required, the VLR first sends a message (MAP / B provide IMSI) to the MSC
- On receiving this message, the MSC sends an RIL 3 – MM Identity Request Message to the MS
- The MS responds to this message by returning an RIL-3 MM Identity Response message to the MSC

Mobility Management

Mobile Identification

- This message includes the MS's IMSI.
- On receiving this message, the MSC sends the MAP/B IMSI Acknowledge message to the VLR
- If the VLR does not have the MSs IMSI, it requests the HLR for the user's profile which contains MS's IMSI
- To do this, the VLR sends to the HLR a MAP/D Update Location message
- The HLR responds with a MAP/D Update Location Result message, which is followed by a MAP/D Insert Subscriber Data message containing other MS data required by the VLR
- The VLR acknowledges this message by the MAP/D Insert Subscriber Data Result message to the HLR