WIRELESS COMMUNICATION (18EC71)- VII SEM ECE
(UNIT - 4)

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UNIT – 4

GSM and TDMA Technology

- GSM system overview-introduction to GSM and TDMA
- GSM Network and System Architecture
- GSM channel concept
- GSM system operations
- GSM identities
- GSM system operations (Traffic cases).

GSM system overview

Introduction to GSM and TDMA:-

- 1982 – Frequency bands of 890-915MHz & 935 – 960Mhz- allotted for a pan European 2G digital cellular system(GSM 900)
- 1987 – Formally adapted by European commission
- 1990-Std's for 1st phase of GSM published
- 1997- A new frequency band in 1800Mhz range added worldwide and
- GSM 900was renamed as GSM 1800
- GSM services in 1900Mhz (GSM1900)using PCS bands in US has started recently.
- Implementation of additional GSM services offered under Phase 2 and Phase 2+ of GSM – ongoing process today.
- Today, GSM system is the most popular cellular wireless system in the world.

GSM Services:-

In order to gain access to GSM services, a user needs three things:

- A billing relationship with a mobile phone operator. This is usually either where services are paid for in advance of them being consumed (prepaid), or where bills are issued and settled after the service has been consumed (postpaid).
- A mobile phone that is GSM compliant and operates at the same frequency as the operator. Most phone companies sell phones from third-party manufacturers.
- A Subscriber Identity Module (SIM) card, which is activated by the operator once the billing relationship is established. After activation the card is then programmed with the subscriber's Mobile Subscriber Integrated Services Digital Network Number (MSISDN) (the telephone number). Personal information such as contact numbers of friends and family can also be stored on the SIM by the subscriber.

GSM Services:-

2 Types of services

- Teleservices – provide std. voice communication between 2 end users
- Bearer Services – provides the user with the ability to transmit data between user N/W interfaces &
- supplementary services – Enhance / support tele-services provided by the N/W

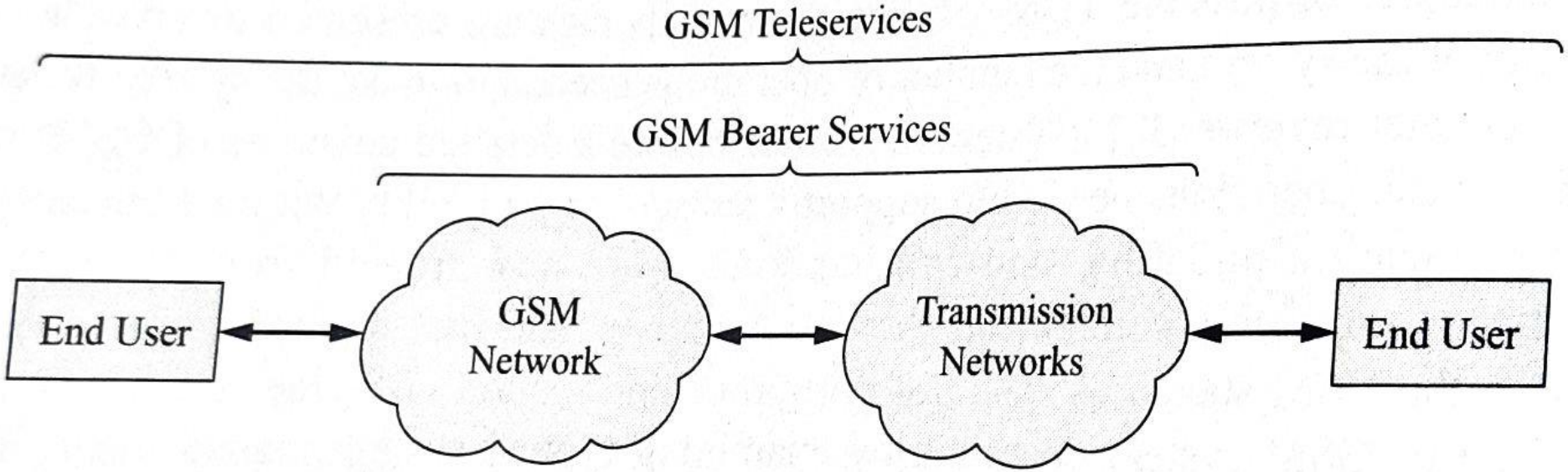


Figure 5–1 *Relationship of teleservices and bearer services to the GSM system (Courtesy of ETSI).*

Table 5–1 Phase 1 GSM services (Courtesy of ETSI).

Service Category	*Service*	*Additional Details*
GSM Teleservices	Telephony Emergency calls Short Message Service Videotext access Teletex, FAX, etc.	Full rate at 13 kbps voice "112" is GSM-wide emergency number Point-to-point (between two users) and cell broadcast types
GSM Bearer Services	Asynchronous data Synchronous data Synchronous packet data Others	300–9600 bps (transparent/nontransparent) 2400–9600 bps transparent
Supplementary Services	Call forwarding Call barring	All calls, when the subscriber is not available Outgoing calls with specifications

Table 5–2 Phase 2 GSM services (Courtesy of ETSI).

Service Category	*Service*	*Additional Details*
GSM Teleservices	Half-rate speech coder Enhanced full rate	Optional implementation
Supplementary Services	Calling line identification Connected line identification Call waiting Call hold Multiparty communications Closed user group Advice of charge Operator determined call barring	Presentation or restriction of displaying the caller's ID Presentation or restriction of displaying the called ID Incoming call during current conversation Put current call on hold to answer another Up to five ongoing calls can be included in one conversation Restriction of certain features from individual subscribers by operator

GSM Radio Frequency Carriers:-

For GSM cellular systems, the air interface consists of channels that have a freq. separation of 200 kHz.

- The GSM900 band has 124 carrier freq.'s
- GSM 1800 " " 374 " "
- GSM 1900 " " 299 " "

Since each carrier can be shared by upto 8 users, the total no. of channels for each system is:-

$124 \times 8 = 992$ channels for GSM 900.
$374 \times 8 = 2992$ " " " 1800
$299 \times 8 = 2392$ " " " 1900.

The freq. bands allocated to present GSM system implementations are shown in Table (3).

The channels have absolute radio freq. channel no's (ARFCN's) associated with them & are numbered as 1-124, 259-293, 306-340, 512-885 & 512-810 for primary GSM 900 (P-GSM 900), GSM 450, GSM 480, GSM 850 & GSM 1900 / PCS 1900. respectively.

Note that extended GSM 900 (E-GSM 900) & Railways GSM 900 (R-GSM 900) have added channels 975-1023 & 955-1023 resp.

Table - GSM frequency bands and channel numbers

GSM Band	*Uplink Frequency*	*Downlink Frequency*
P-GSM 900 ARFCN=1...124	890 - 915 MHz (ARFCN-1) × 0.2 MHz + 890.2 MHz	935 - 960 MHz Uplink frequency + 45 MHz
E-GSM 900 ARFCN=975...1023	880 - 890 MHz (ARFCN = 0 = 890 MHz) (ARFCN-975) × 0.2 MHz + 890 MHz	925 - 935 MHz Uplink frequency + 45 MHz
R-GSM 900 ARFCN=955...1023	876 - 890 MHz (ARFCN-1023) × 0.2 MHz + 890 MHz	921 - 935 MHz Uplink frequency + 45 MHz
GSM 1800 ARFCN=512...885	1710 - 1785 MHz (ARFCN-512) × 0.2 MHz + 1710.2 MHz	1805 - 1880 MHz Uplink frequency + 95 MHz
GSM 1900 ARFCN=512...810	1850 - 1910 MHz (ARFCN-512) × 0.2 MHz + 1850.2 MHz	1930 - 1990 MHz Uplink frequency + 90 MHz
GSM 450 ARFCN=259...293	450.4 - 457.6 MHz (ARFCN-259) × 0.2 MHz + 450.6 MHz	460.4 - 467.6 MHz Uplink frequency + 10 MHz
GSM 480 ARFCN=306...340	478.8 - 486 MHz (ARFCN-306) × 0.2 MHz + 478.8 MHz	488.8 - 496 MHz Uplink frequency + 10 MHz

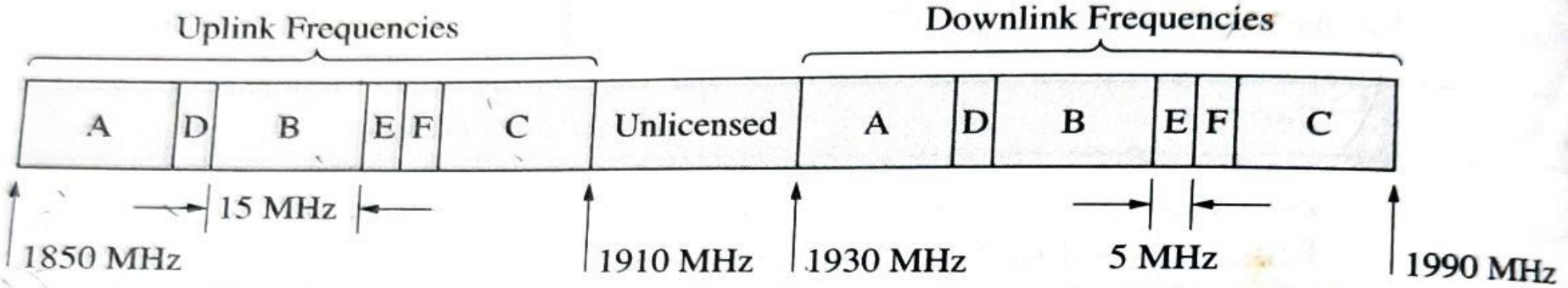


Figure 5–2 GSM frequency allocations in the 1900-MHz PCS bands.

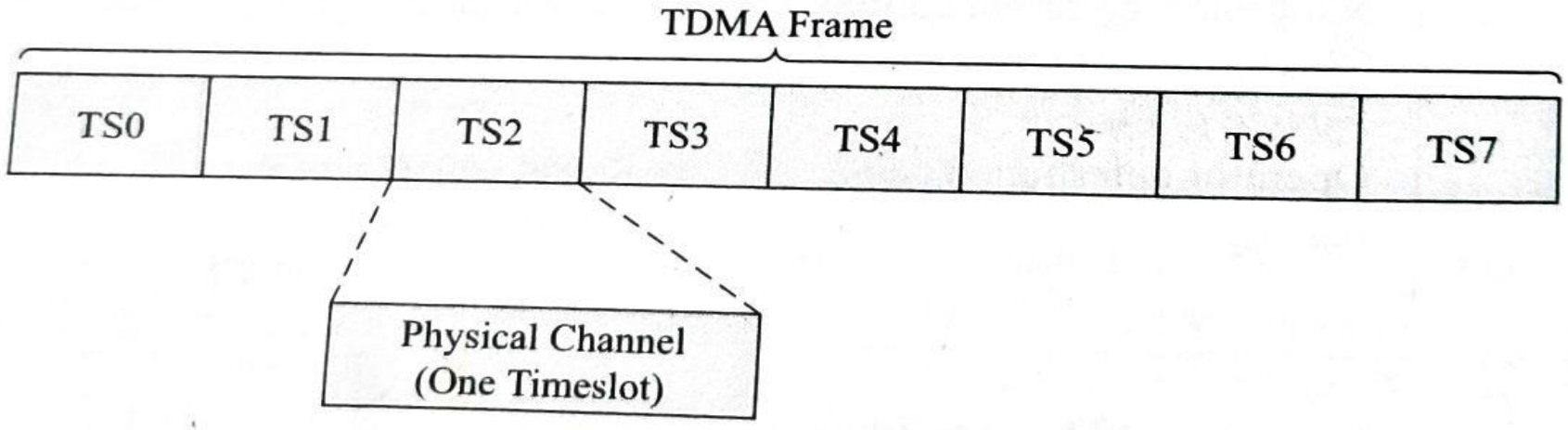


Figure 5–3 GSM timeslot in a TDMA frame.

GSM Network & System Architecture

- Mobile Station - Provides the link between GSM subscriber & wireless mobile network.
- Base Station System – It is the link between MS & GSM mobile services switching center(MSC).
  - BTS
  - BSC
- Network Switching System(NSS)- Provides the necessary interface for connection of wireless network to other networks (ie.,PSTN,PDN,PLMN etc.)
  - MSC
  - VLR&HLR
  - EIR
  - AUC
  - IWF
  - SMS-GMSC
  - SMS-IWMSC
- Operation & Support System(OSS) & other Nodes –

  GSM wireless N/W's monitored & controlled by OSS
- Administrative & Control System –

  - Message center, Mobile intelligent network, service order gateway, Billing gateway.

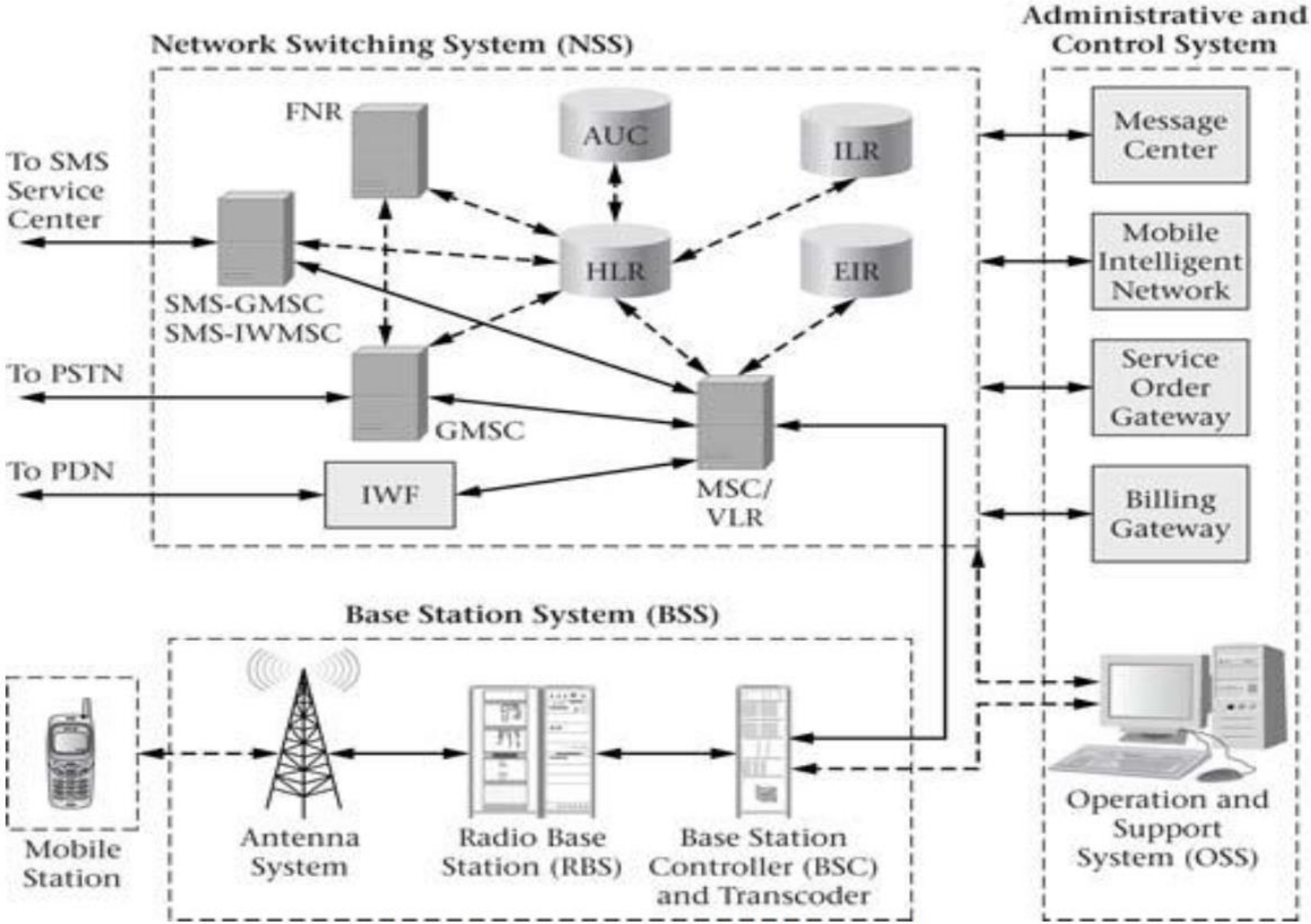


Fig 4.1 components of GSM network

GSM Network interfaces and Protocols

(Recall 7 layer OSI model and layered structure of OSI model)

GSM Network interfaces

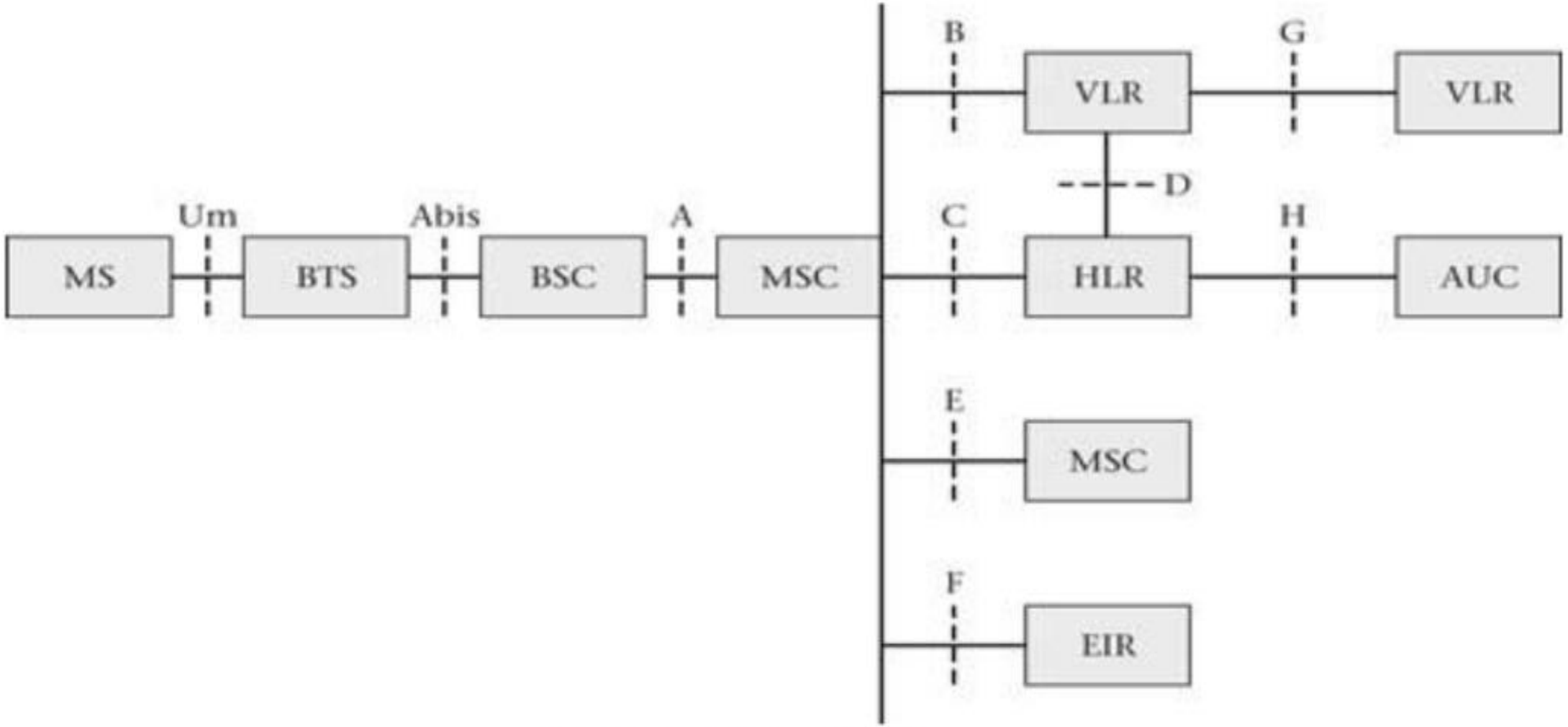


Fig 4.2 interfaces in GSM

GSM Protocols and Signaling Model

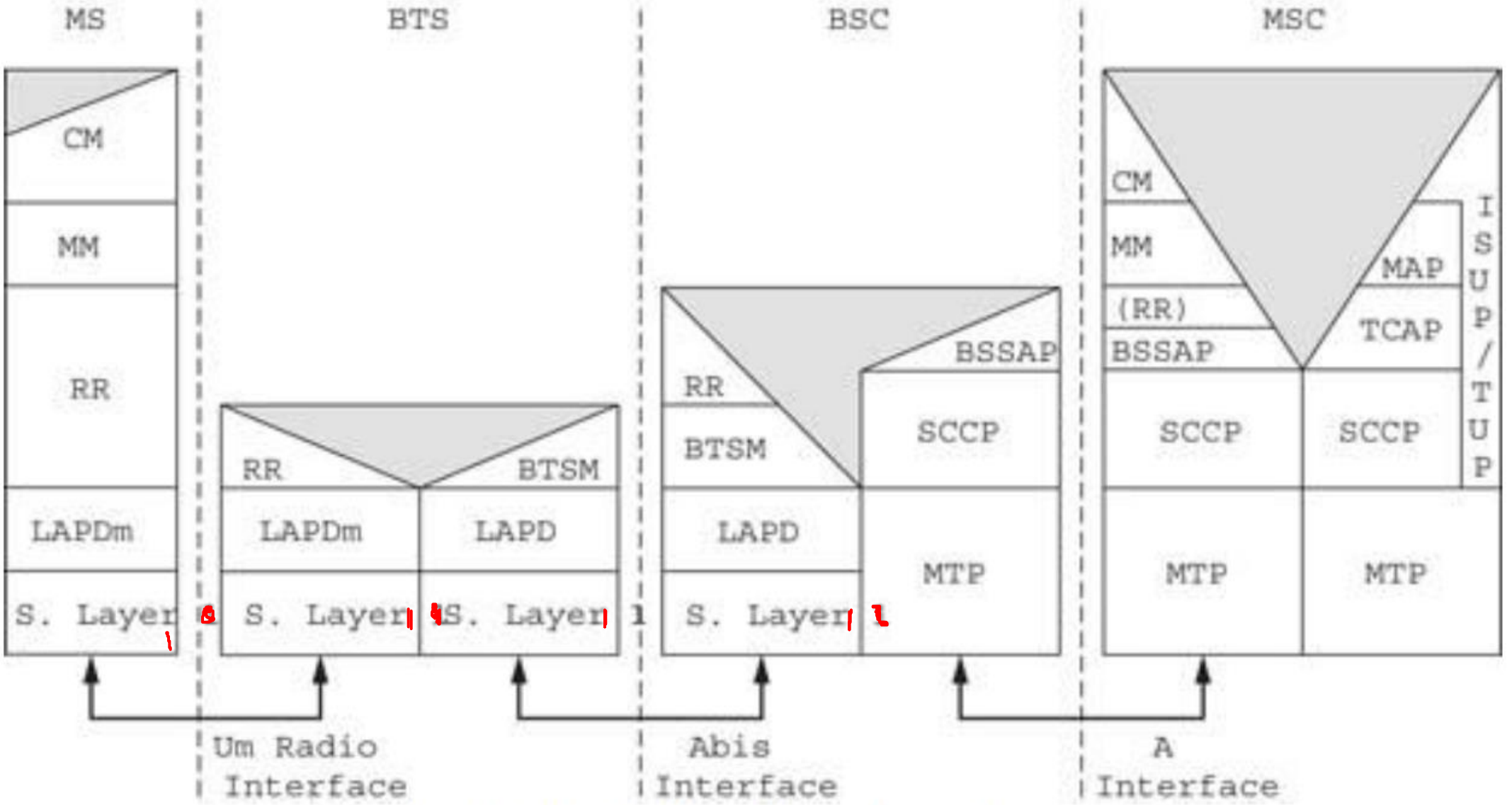


Fig 4.3 GSM network interfaces and protocols

- Um interface
- Abis interface
- A interface
- Ater interface

1. ***Um interface*** The "air" or radio interface standard that is used for exchanges between a mobile (ME) and a base station (BTS / BSC). For signalling, a modified version of the ISDN LAPD, known as LAPDm is used.
2. ***Abis interface*** This is a BSS internal interface linking the BSC and a BTS, and it has not been totally standardised. The Abis interface allows control of the radio equipment and radio frequency allocation in the BTS.
3. ***A interface*** The A interface is used to provide communication between the BSS and the MSC. The interface carries information to enable the channels, timeslots and the like to be allocated to the mobile equipments being serviced by the BSSs.

The messaging required within the network to enable handover etc to be undertaken is carried over the interface.

4. ***B interface*** The B interface exists between the MSC and the VLR . It uses a protocol known as the MAP/B protocol. As most VLRs are collocated with an MSC, this makes the interface purely an "internal" interface. The interface is used whenever the MSC needs access to data regarding a MS located in its area.
5. ***C interface*** The C interface is located between the HLR and a GMSC or a SMS-G. When a call originates from outside the network, i.e. from the PSTN or another mobile network it ahs to pass through the gateway so that routing information required to complete the call may be gained. The protocol used for communication is MAP/C, the letter "C" indicating that the protocol is used for the "C" interface. In addition to this, the MSC may optionally forward billing information to the HLR after the call is completed and cleared down.
6. ***D interface*** The D interface is situated between the VLR and HLR. It uses the MAP/D protocol to exchange the data related to the location of the ME and to the management of the subscriber.
7. ***E interface*** The E interface provides communication between two MSCs. The E interface exchanges data related to handover between the anchor and relay MSCs using the MAP/E protocol.
8. ***F interface*** The F interface is used between an MSC and EIR. It uses the MAP/F protocol. The communications along this interface are used to confirm the status of the IMEI of the ME gaining access to the network.

9. ***G interface*** The G interface interconnects two VLRs of different MSCs and uses the MAP/G protocol to transfer subscriber information, during e.g. a location update procedure.
10. ***H interface*** The H interface exists between the MSC the SMS-G. It transfers short messages and uses the MAP/H protocol.
11. ***I interface*** The I interface can be found between the MSC and the ME. Messages exchanged over the I interface are relayed transparently through the BSS.

Although the interfaces for the GSM cellular system may not be as rigorously defined as many might like, they do at least provide a large element of the definition required, enabling the functionality of GSM network entities to be defined sufficiently.

Ater interface:-

- Ater interface exists only in GSM systems that have separate units for the transcoder controller and BSC

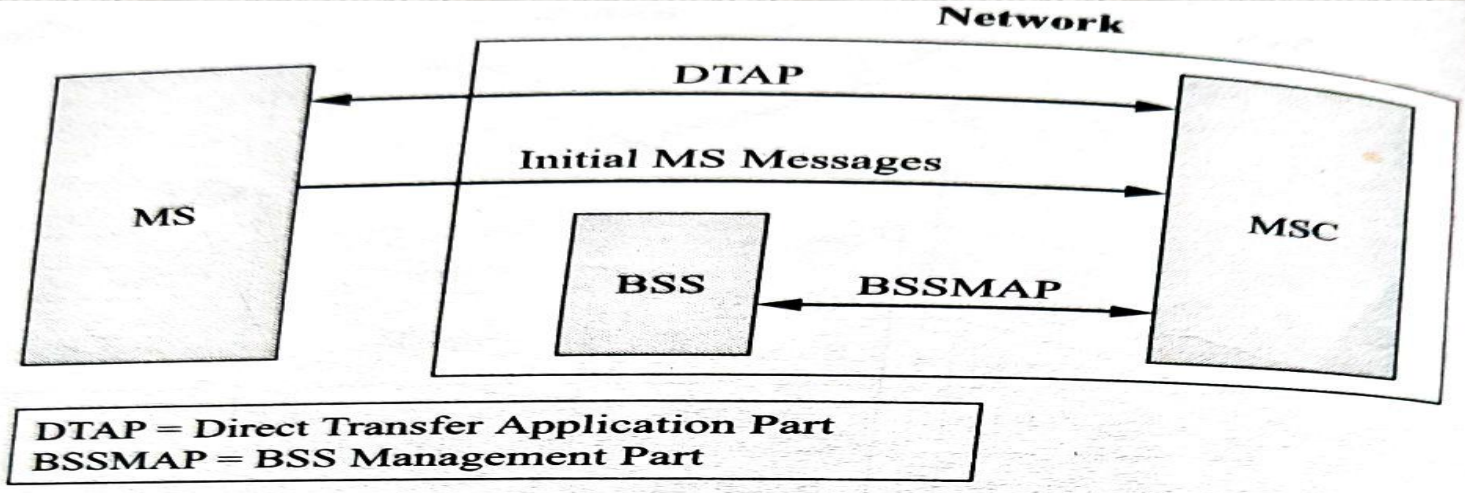


Figure 5–7 Signaling between the MSC, BSS, and MS in a GSM system.

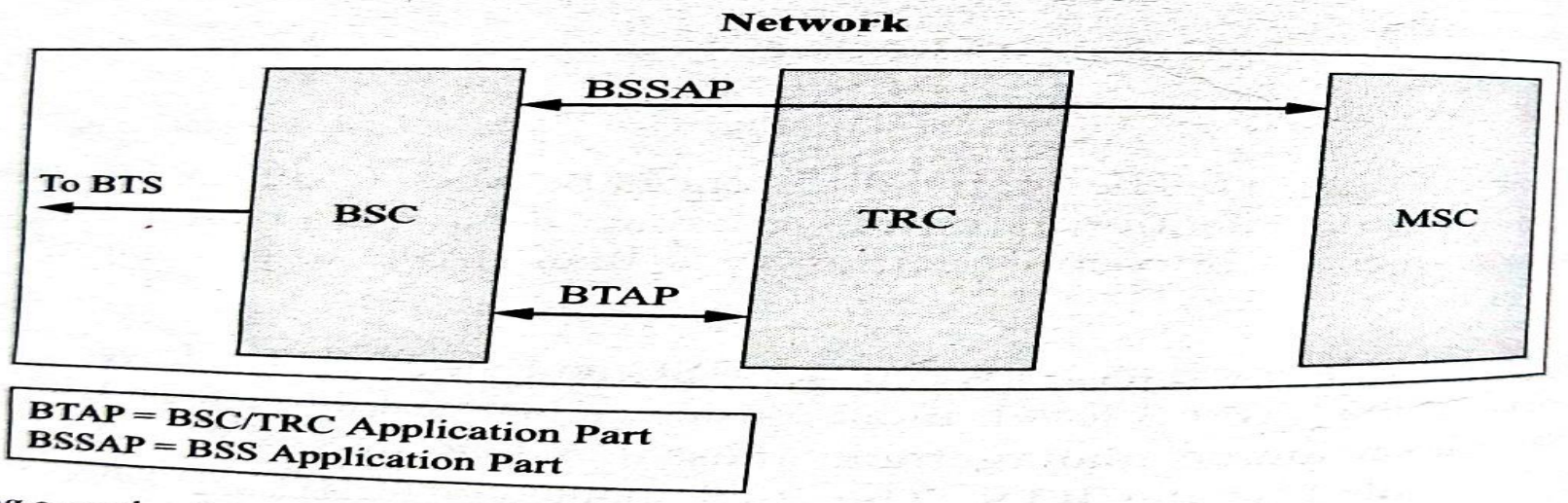


Figure 5–8 Signaling over the GSM Ater interface.

GSM Channel Concept:-

- Time division multiple access
- Frames

Multiframes

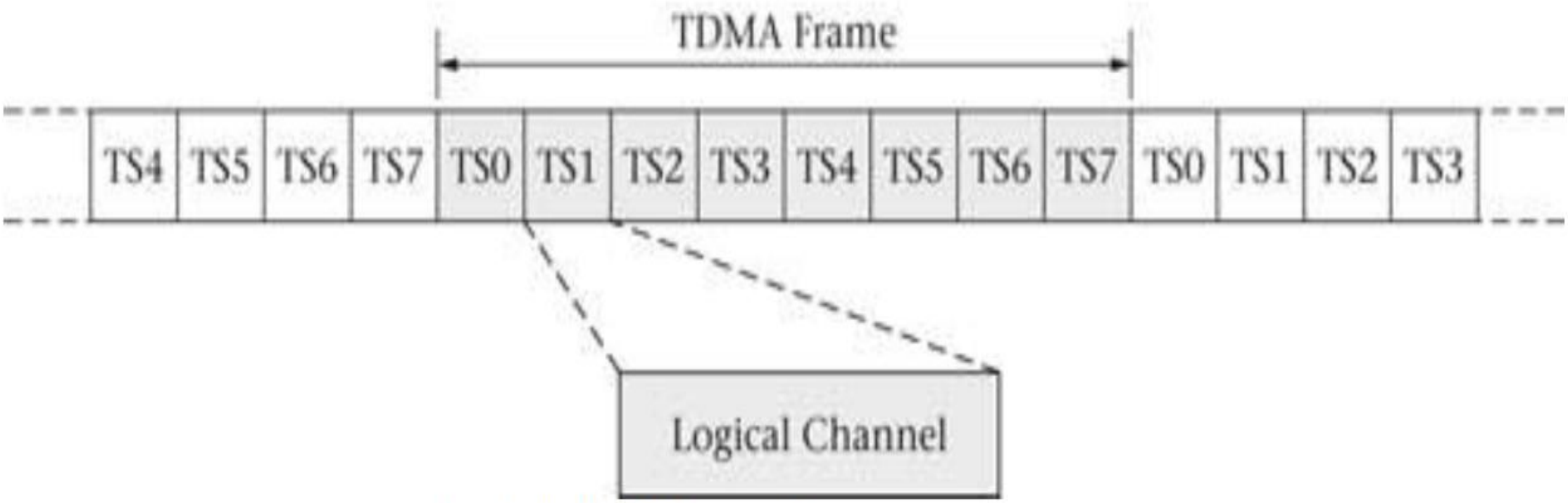


Fig 4.4 TDMA time frame structure

Logical Channels

- Carry either subscriber traffic or signaling and control information to facilitate subscriber mobility
- 3 types of traffic channels(TCH's)

– Full rate traffic channel(TCH/F or Bm)-Carries one conversation by using one time slot.

- Final channel data rate is 22.8Kbps.

- But TCH/F may also carry data at rates 14.4,9.6,4.8 and 2.4Kbps.

- Half rate traffic channel(TCH/H or Lm) – TCH/H carries voice encoded at 6.5Kbps or data at rates of 4.8 or 2.4kbps.

- Enhanced full rate traffic channel(EFR) – Encodes voice at a 12.2kbps rate and like TCH/F adds overhead bits to yield a 22.8kbps channel data rate.

Signaling and control channels – 3 sub category

- Broadcast channels(BCH's)
- Common control channels
- Dedicated control channels

GSM Channel Concept

- Logical channels
  - Broadcast channels
    - Broadcast control channel
    - Frequency correction channel
    - Synchronization channel
- Logical channels
  - Common control channels
    - Paging channel
    - Random access channel
    - Access grant channel

- Dedicated control channels
  - Stand-alone dedicated control channel
  - Slow associated control channel
  - Fast associated control channel
  - Cell broadcast channel
- Speech processing
  - Operations

    Bit rate

Speech Processing

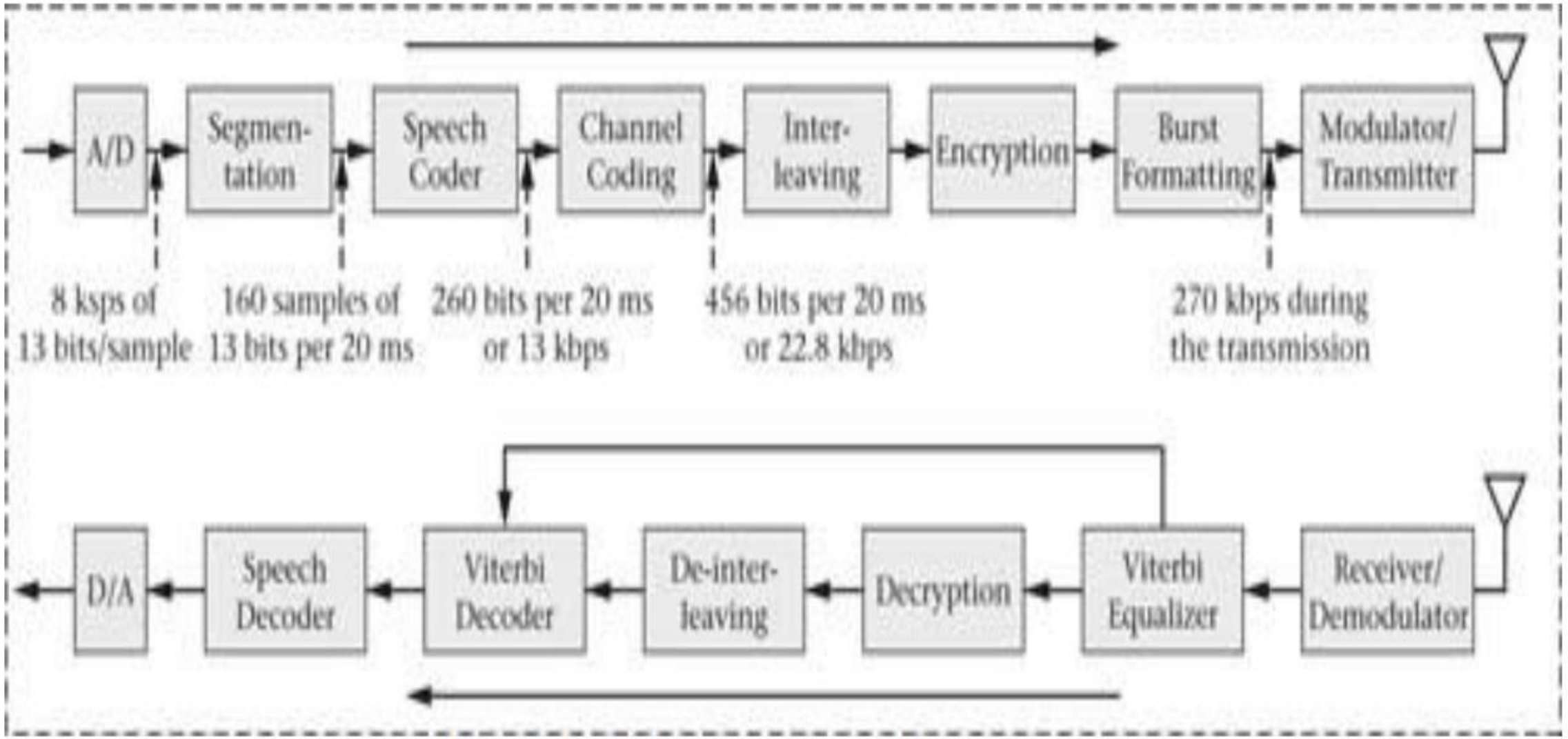


Fig 4.5 GSM processing of speech

Timeslots and TDMA frames

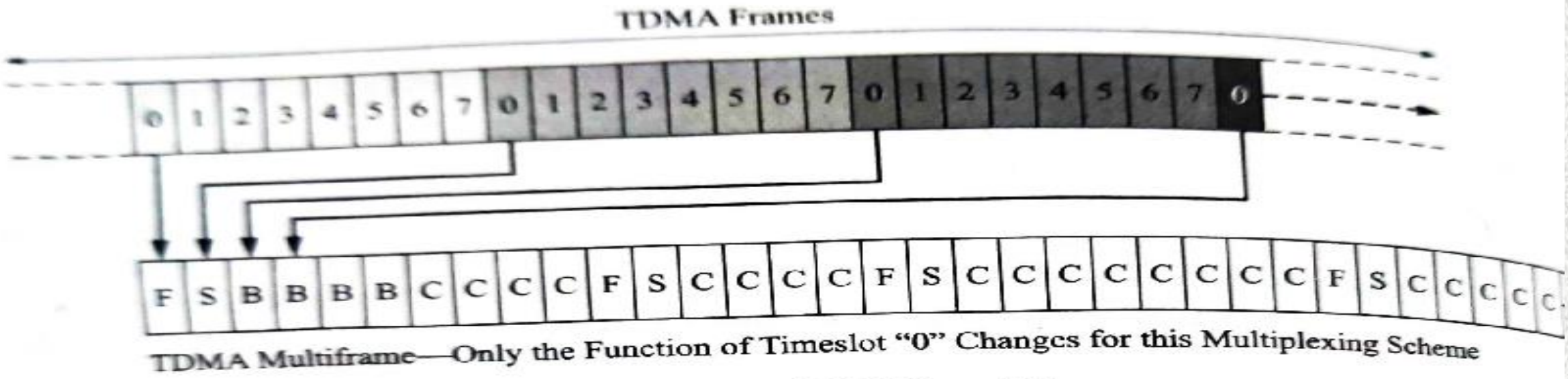


Figure 5–11 Relationship between timeslots and TDMA multiframes.

TDMA Frames

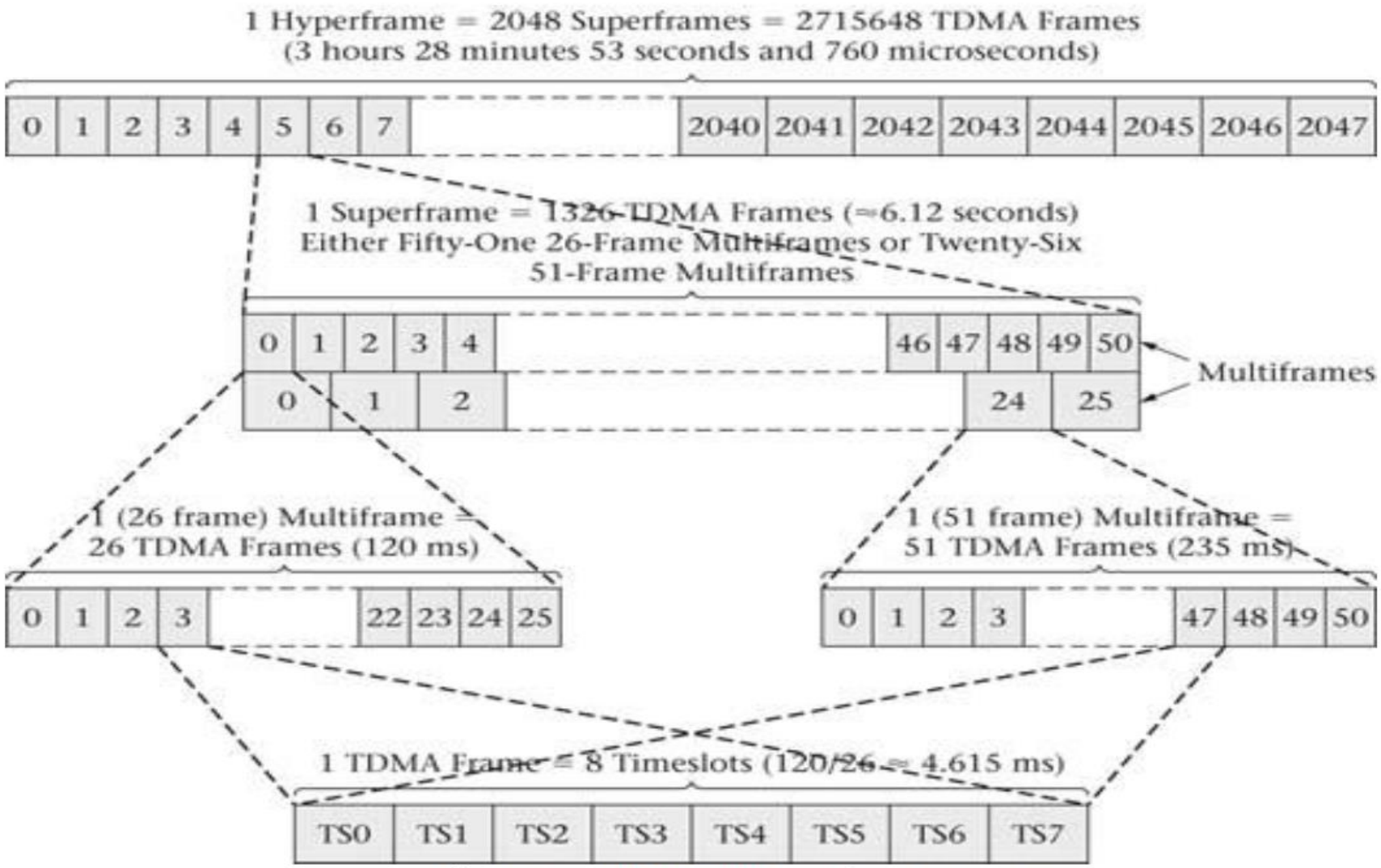


Fig 4.6 TDMA Hyperframe structure

Timeslots

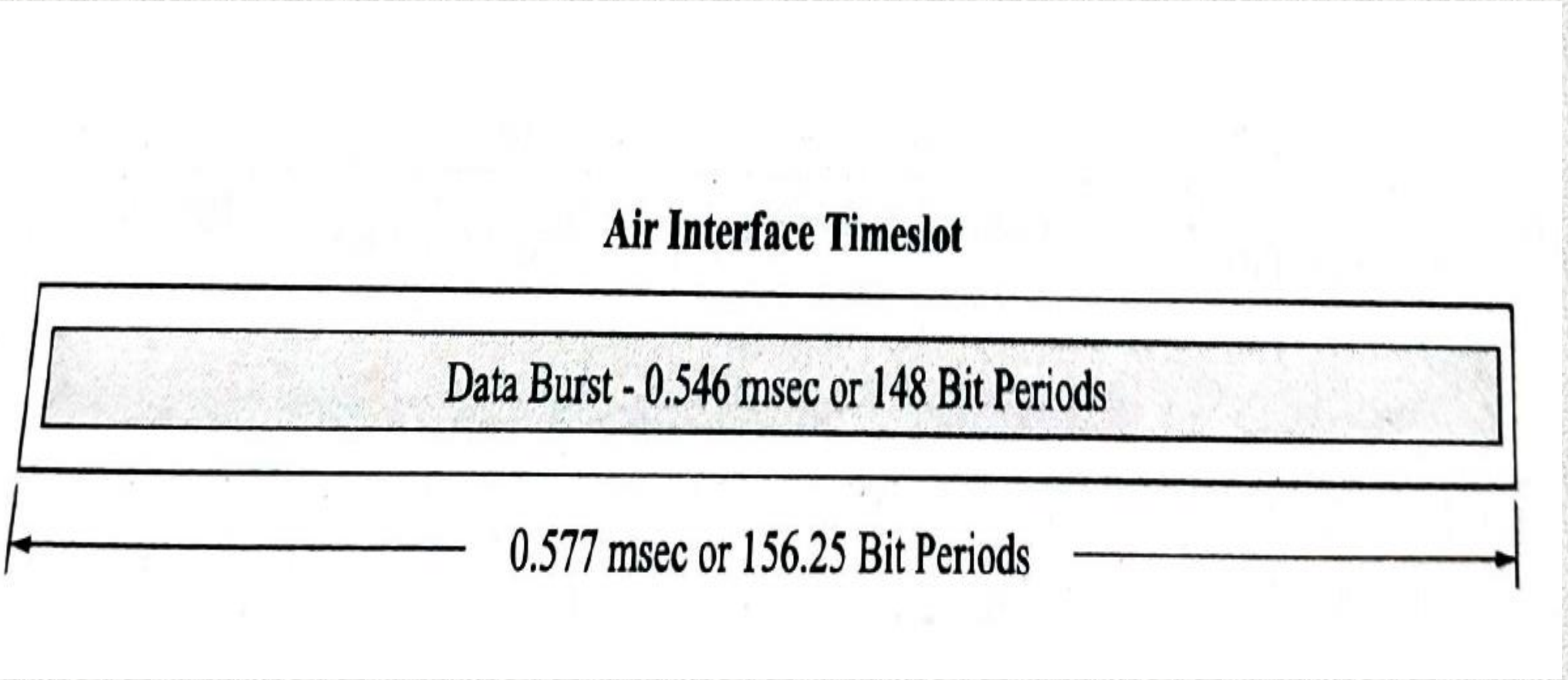


Fig.5.13 - GSM air interface timeslot

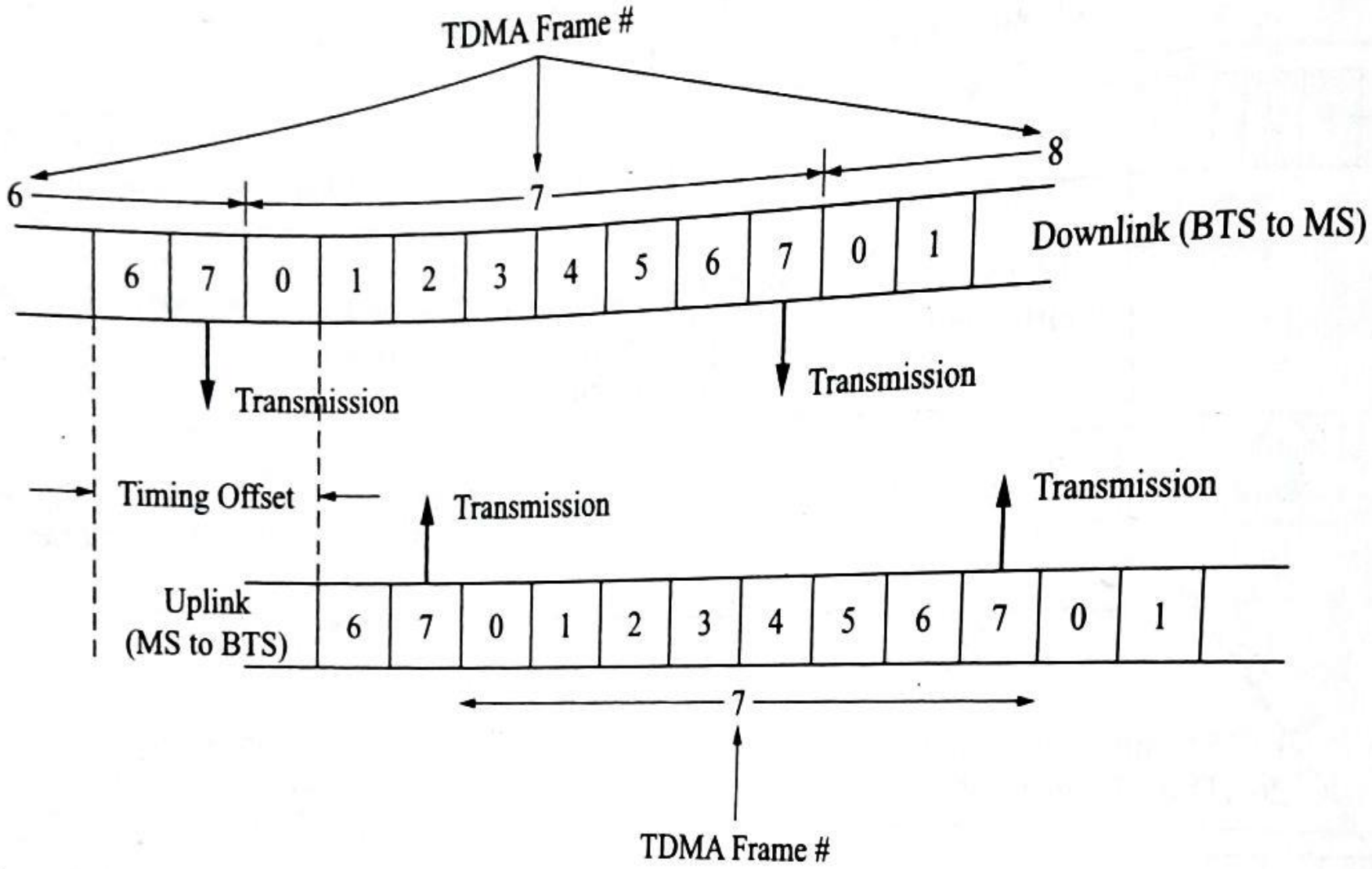


Figure 5–14 TDMA timing offset between uplink and downlink.

Time slot Bursts

- Normal burst
- Frequency correction burst
- Synchronization burst
- Access burst
- Dummy burst

Time slot Bursts

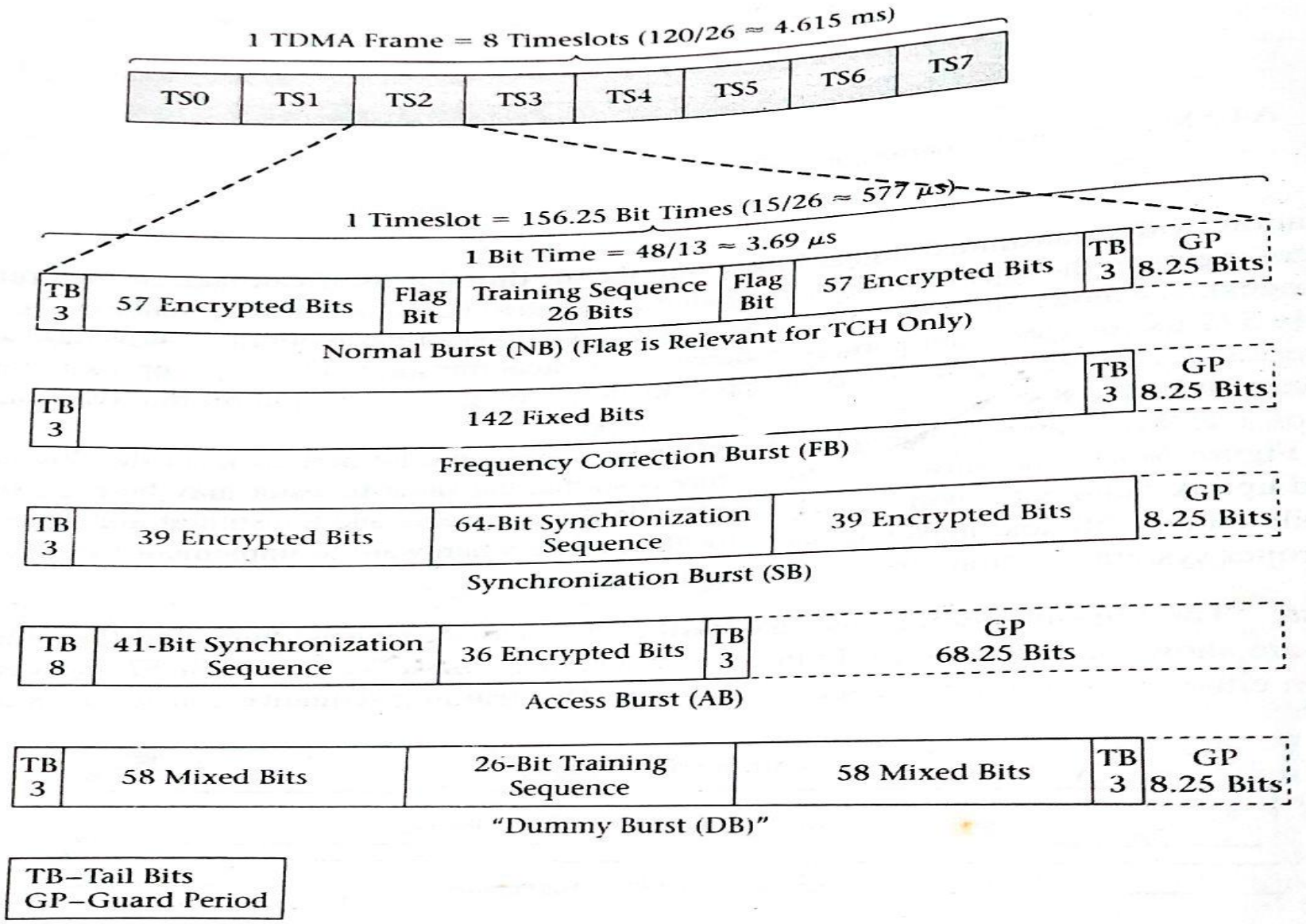


Figure 5–15 GSM traffic and control signal bursts (Courtesy of ETSI).

Mapping of Logical channel to Physical channel

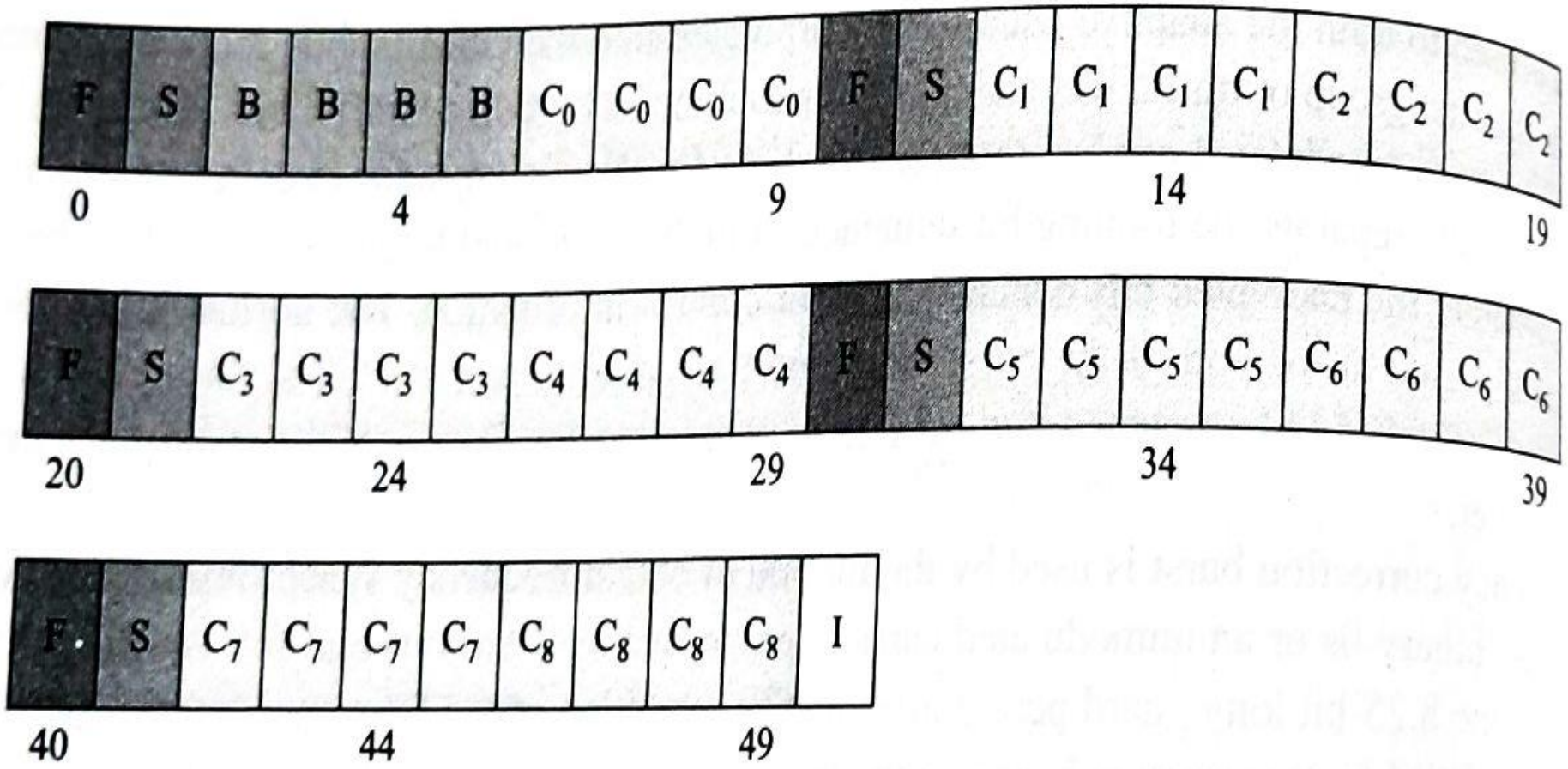


Figure 5–16 The multiplexing of GSM logical channels.

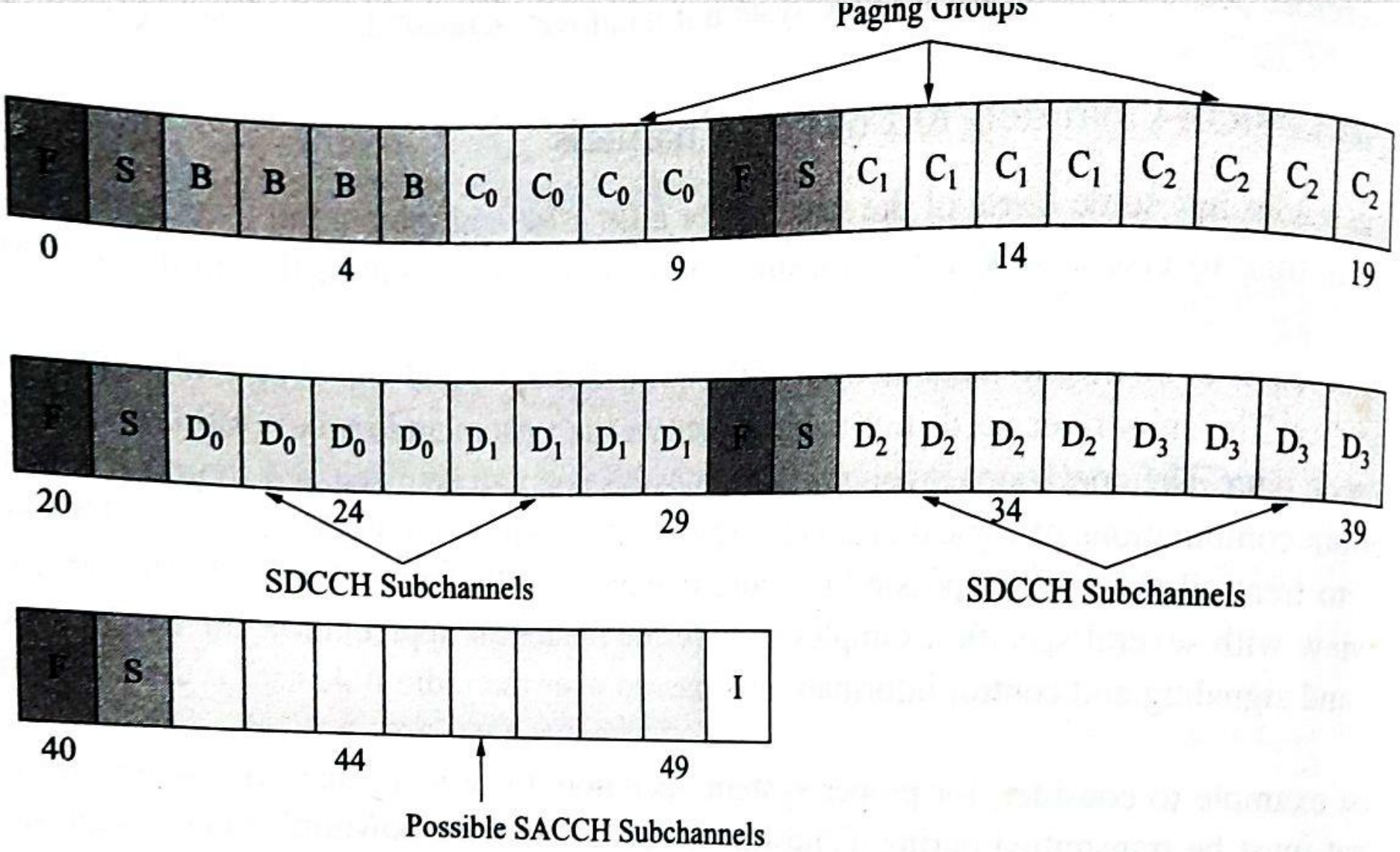


Figure 5–17 Another GSM multiframe configuration.

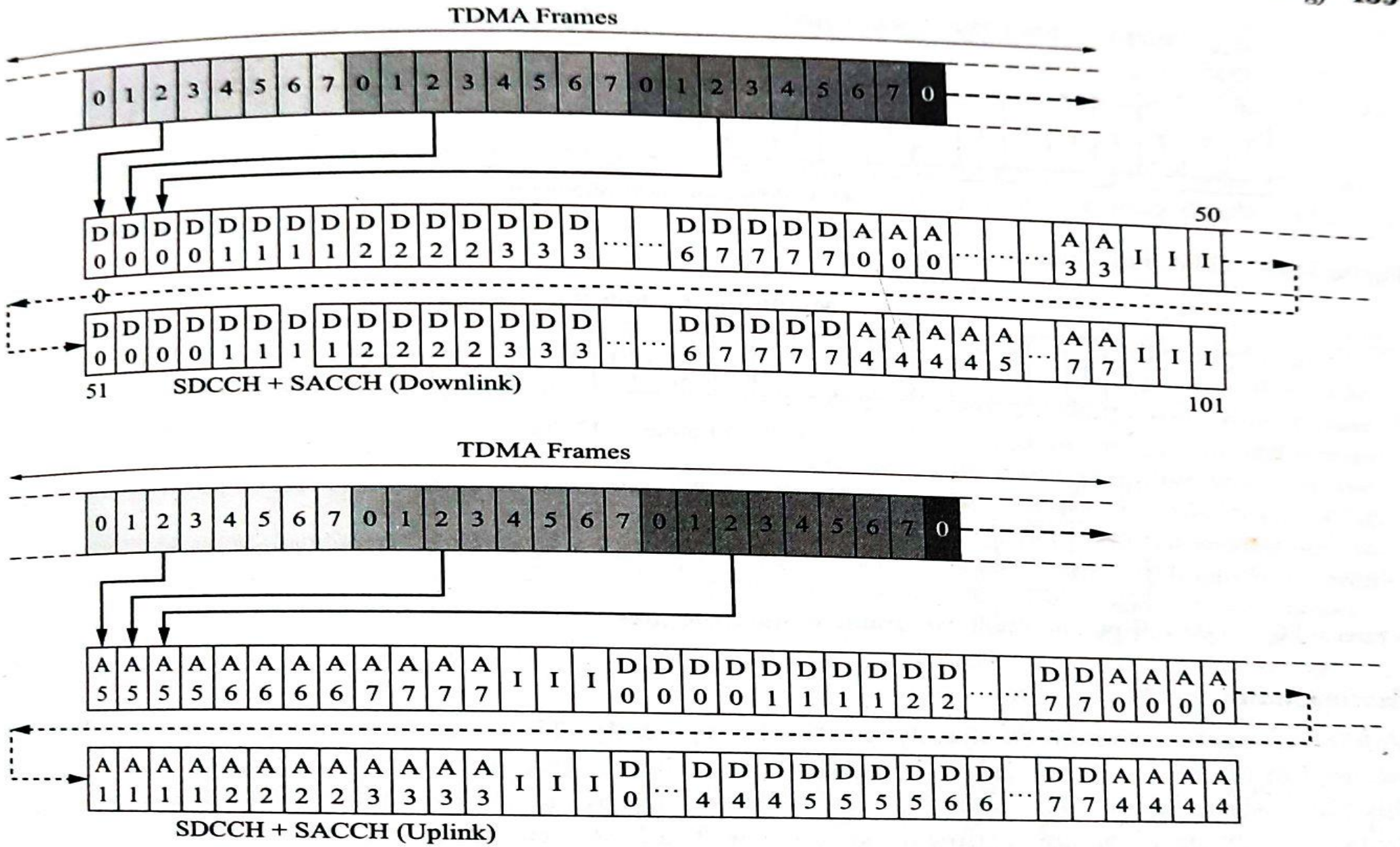


Figure 5–18 High-traffic GSM multiframe.

Transmission of short messages:- Traffic channels- Paging groups

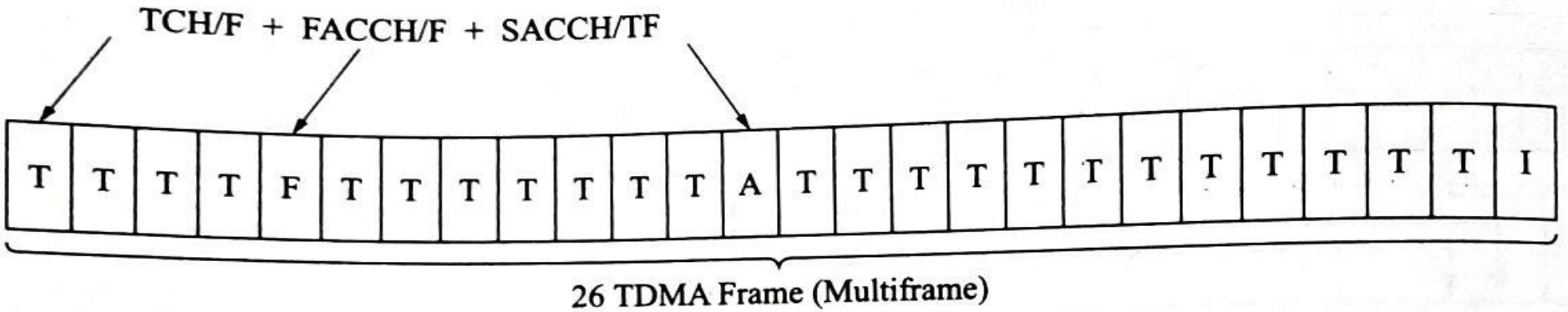


Figure 5–19 GSM traffic channel frames.

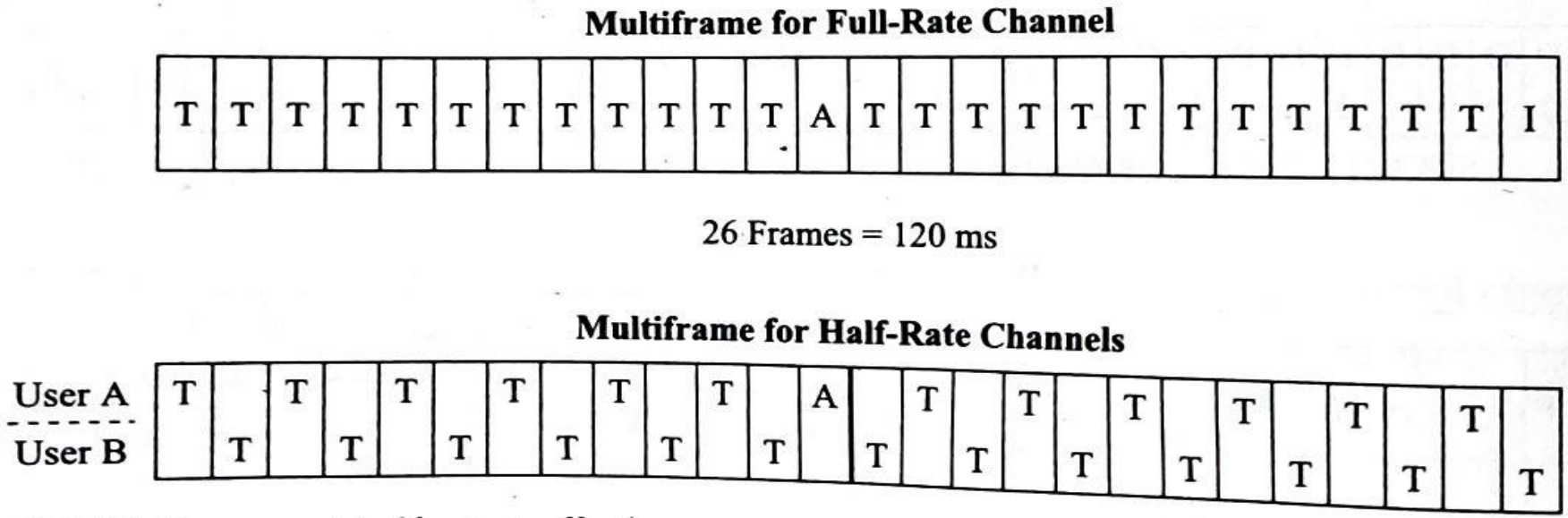


Figure 5–20 GSM full-rate and half-rate traffic frame structures.

GSM system operations

GSM identities:-

To switch a call to a mobile subscriber, the right identities need to be involved. It is therefore important to address them correctly. Followings are those identities;

Mobile Station ISDN Number (MSISDN)

The MSISDN is a number, which uniquely identifies a mobile telephone subscription in the public switched telephone network numbering plan. These are the digits dialed when calling a mobile subscriber.

The MSISDN is consisted with followings;

- Country Code (**CC**)
- National Destination Code (**NDC**)
- Subscriber Number (**SN**)

MSISDN = CC + NDC + SN

International Mobile Subscriber Identity (IMSI)

The IMSI is a unique identity allocated to each subscriber to allow correct identification over the radio path and through the network and is used for all signaling in the PLMN. All network-related subscriber information is connected to the IMSI. The IMSI is stored in the SIM, as well as in the HLR and in the serving VLR.

The IMSI is consisted with followings;

- Mobile Country Code (**MCC**)
- Mobile Network Code (**MNC**)
- Mobile Subscriber Identification Number (**MSIN**)

IMSI = MCC + MNC + MSIN

Temporary Mobile Subscriber Identity (TMSI)

The TMSI is a temporary number used instead of IMSI to identify an MS. The TMSI is used for the subscriber's confidentiality on the air interface. The TMSI has only local significance (that is, within the MSC/VLR area) and is changed at certain events or time intervals.

International Mobile Equipment Identity (IMEI)

The IMEI is used for equipment identification and uniquely identifies a MS as a piece or assembly of equipment.

The IMEI is consisted with followings;

- Type Approval Code (**TAC**), determined by a central GSM body
- Final Assembly Code (**FAC**), identifies the manufacture
- Serial Number (**SNR**), uniquely identifies all equipment within each TAC & FAC
- Spare, a spare bit for future use.

IMEI = TAC + FAC + SNR + Spare

Mobile Station Roaming Number (MSRN)

A MSRN is used during the call setup phase for mobile terminating calls. Each mobile terminating call enters the GMSC in the PLMN. The call is then re-routed by the GMSC, to the MSC where the called mobile subscriber is located. For this purpose MSRN is allocated by the MSC and provided to the GMSC.

The MSRN is consisted with followings;

- Country Code (CC)
- National Destination Code (NDC)
- Subscriber Number (SN)

MSRN = CC + NDC + SN

Location Area Identity (LAI)

The LAI is used for paging, to indicate to the MSC in which Location Area (LA) the MS is currently situated and also for location updating of mobile subscribers.

The LAI is consisted with followings;

- Mobile Country Code (MCC)
- Mobile Network Code (MNC)
- Location Area Code (LAC)

$$\mathbf{LAI = MCC + MNC + LAC}$$

Cell Global Identity (CGI)

Each cell is identified by cell identity (CI). A CI is unique within a location area (LA).

CGI is consisted with following;

- Mobile Country Code (MCC)
- Mobile Network Code (MNC)
- Location Area Code (LAC)
- Cell Identity (CI)

$$\mathbf{CGI = MCC + MNC + LAC + CI}$$

Base Station Identification Code (BSIC)

In GSM, the mobile station uses BSIC to distinguish between neighboring base station.

The BSIC is consisted with

- Network Colour Code (NCC)
- Base Transceiver Colour Code (BCC).

GSM system operations (Traffic cases)

Registration, Call setup and Location Updating:-

Call setup:-

- Call setup
  - Interrogation phase
  - Radio resource connection establishment
  - Service request
  - Authentication

- Ciphering mode setting
- IMEI check
- TMSI reallocation
- Call initiation procedure

- Assignment of a traffic channel
- Call confirmation, call accepted, and call release

Interrogation phase

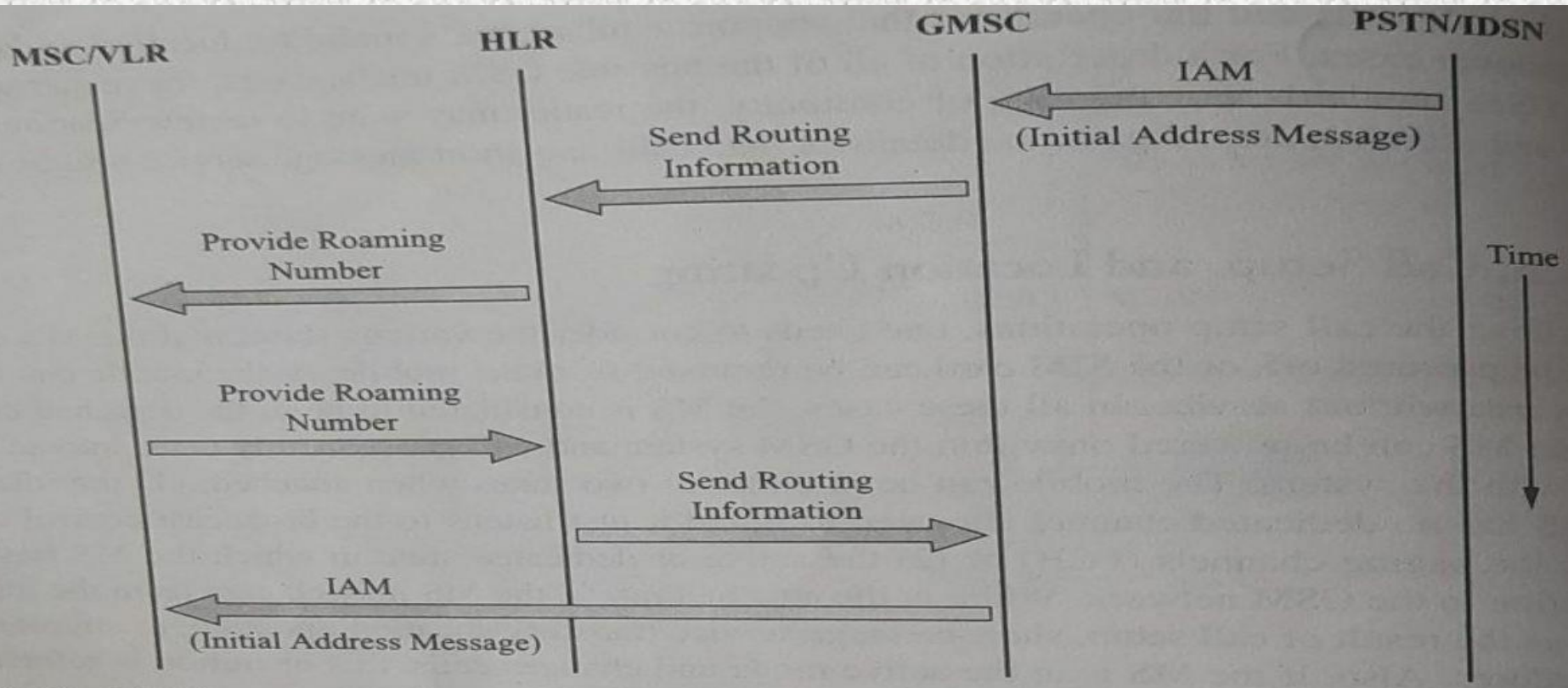


Figure 5–23 GSM interrogation phase of call setup.

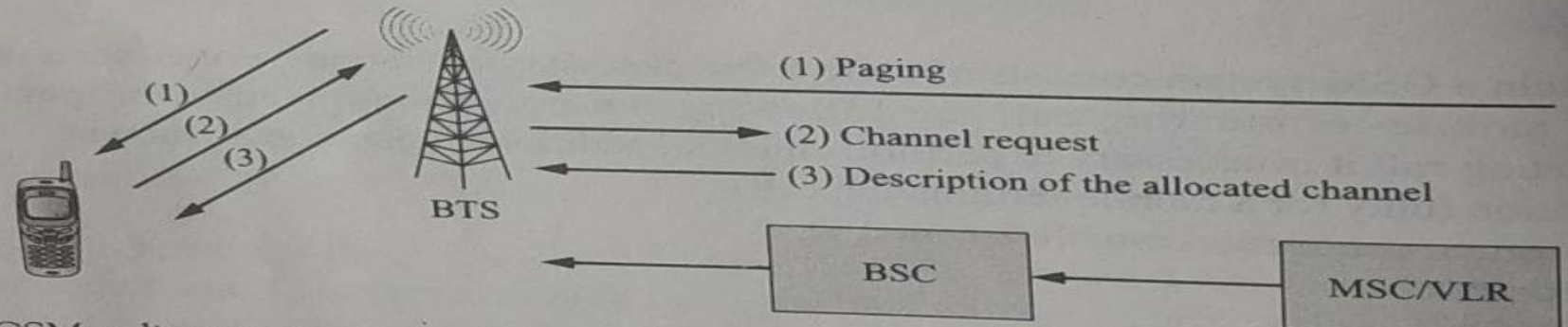


Figure 5–24 GSM radio resource connection establishment. Unit 3

Radio Resource Connection Establishment

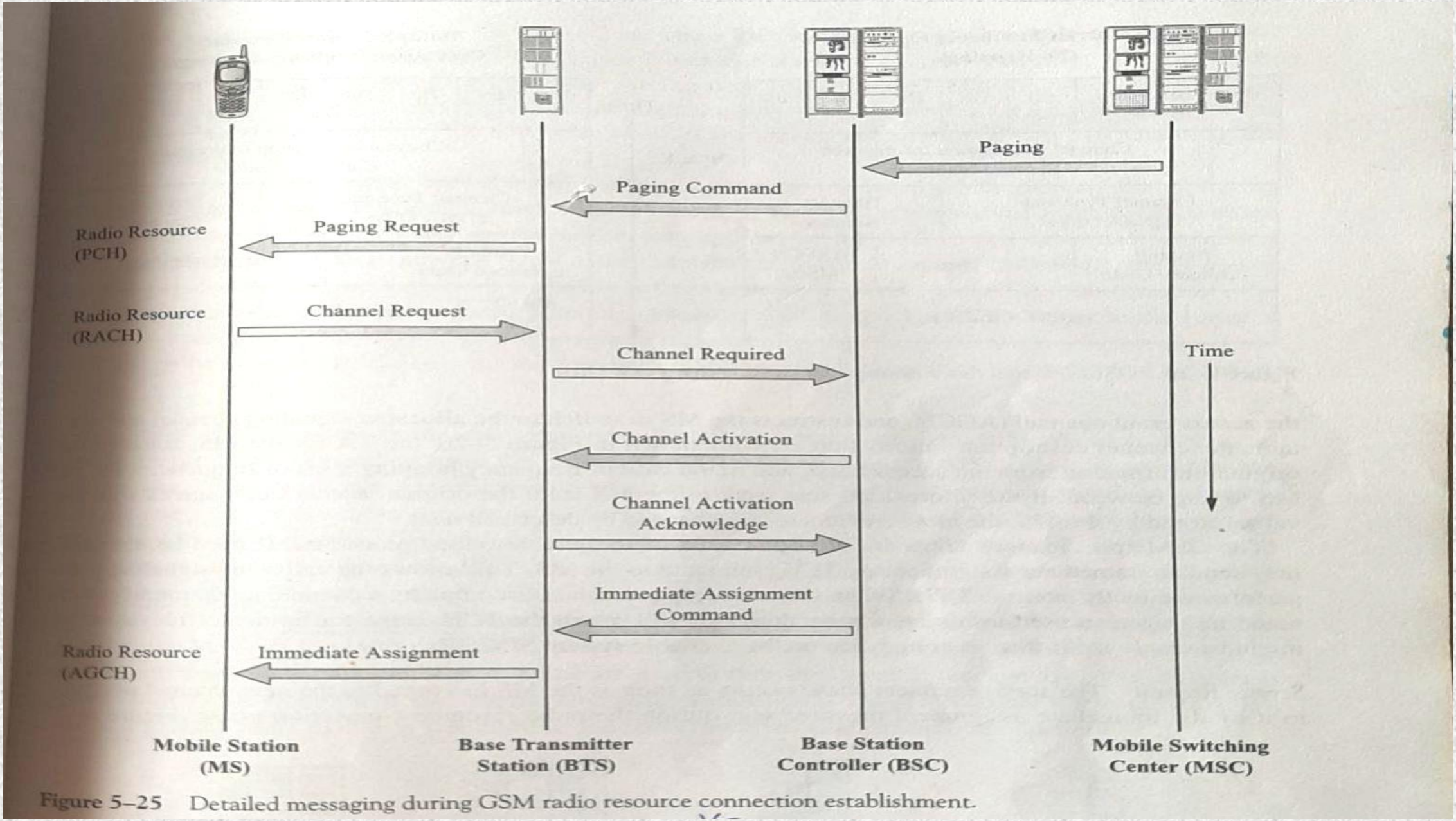


Figure 5–25 Detailed messaging during GSM radio resource connection establishment.

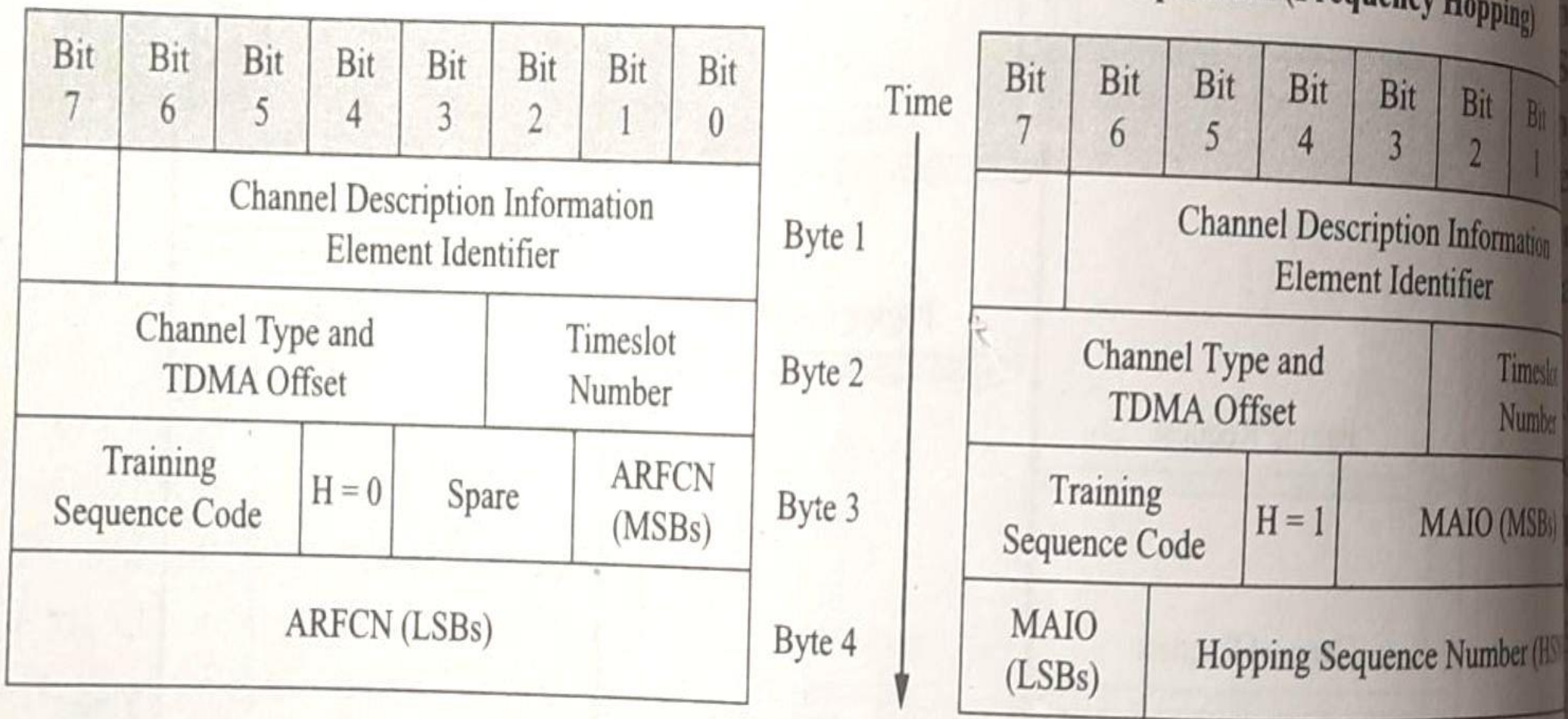


Figure 5–26 GSM channel description messages (Courtesy of ETSI).

Service Request Operation

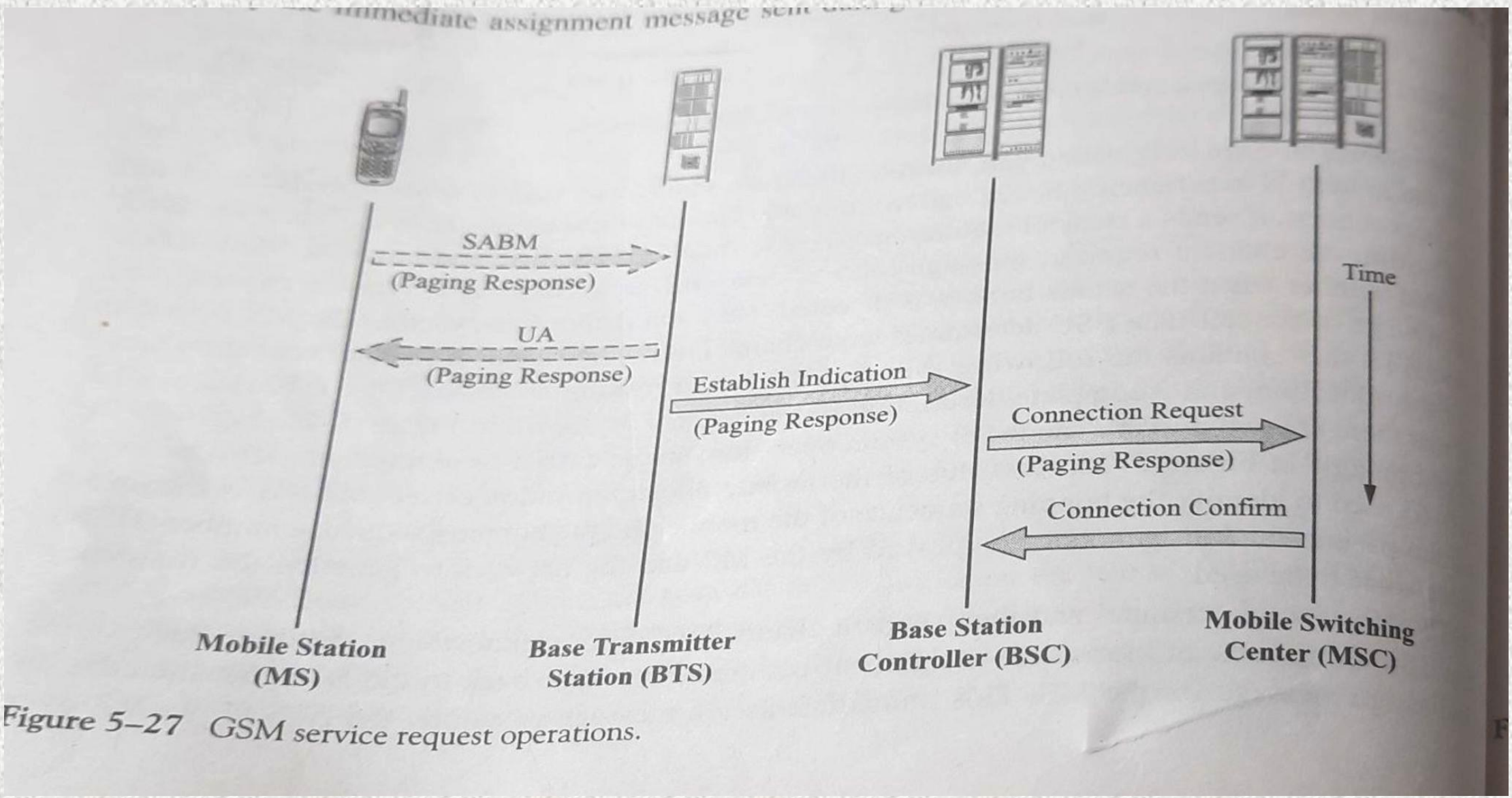


Figure 5–27 GSM service request operations.

Authentication

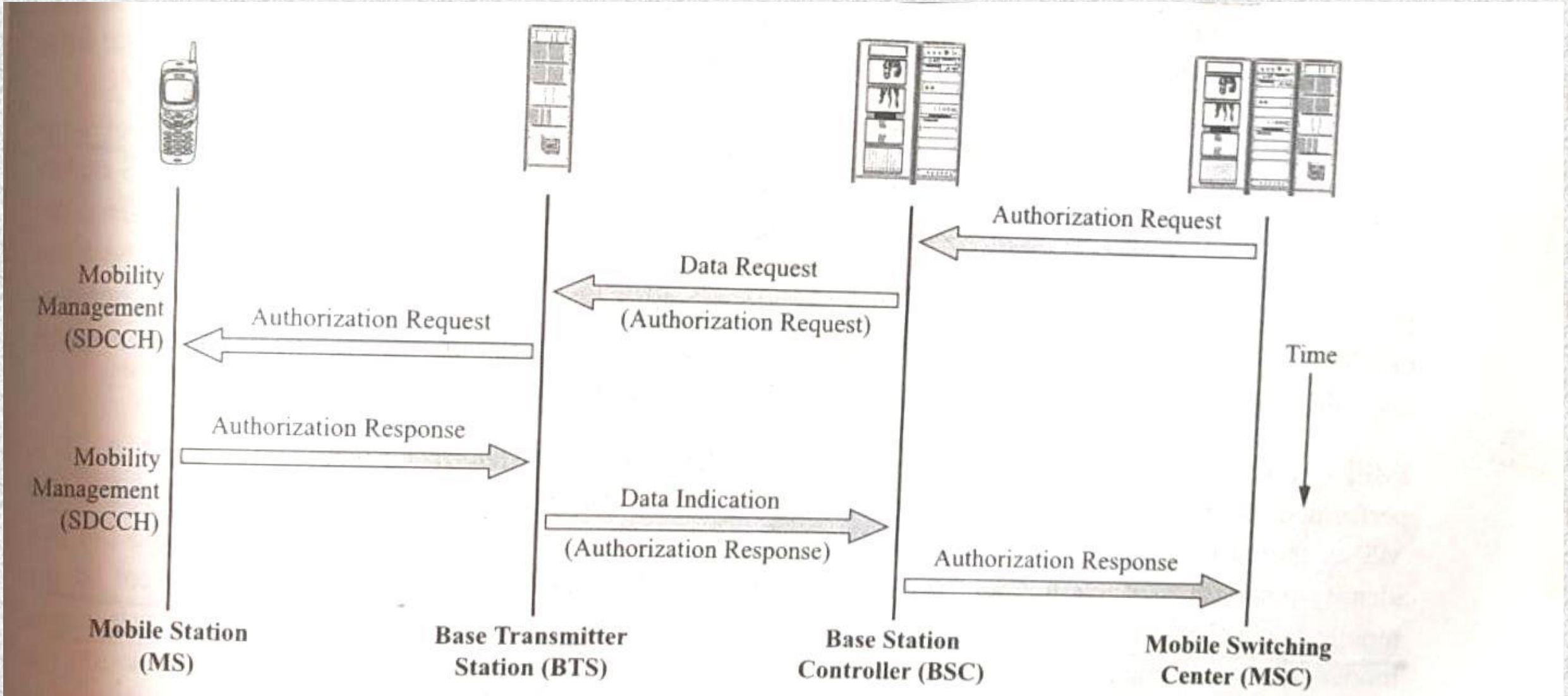


Figure 5–28 GSM authentication operations.

Ciphering mode technique

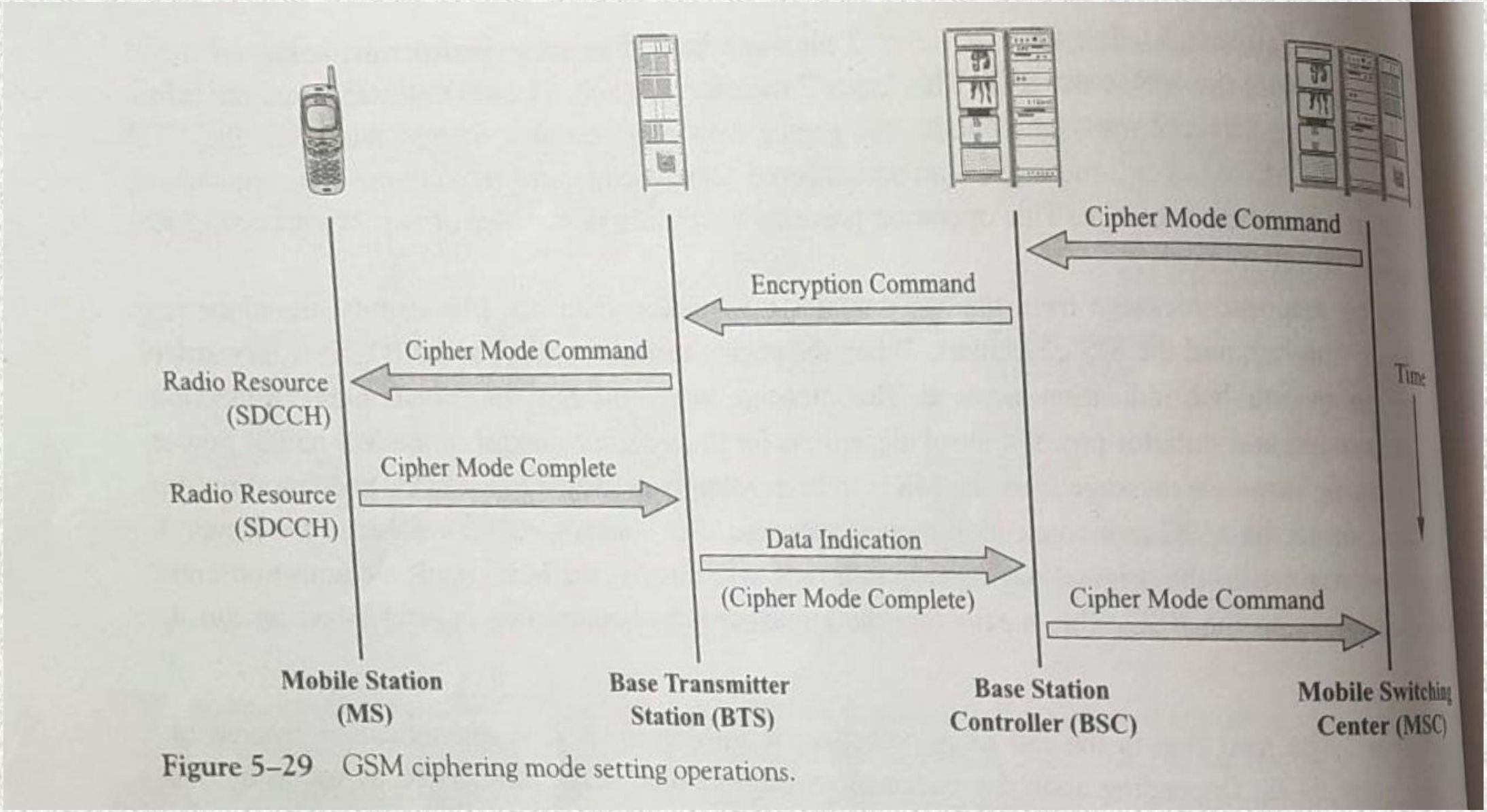


Figure 5–29 GSM ciphering mode setting operations.

IMEI Check

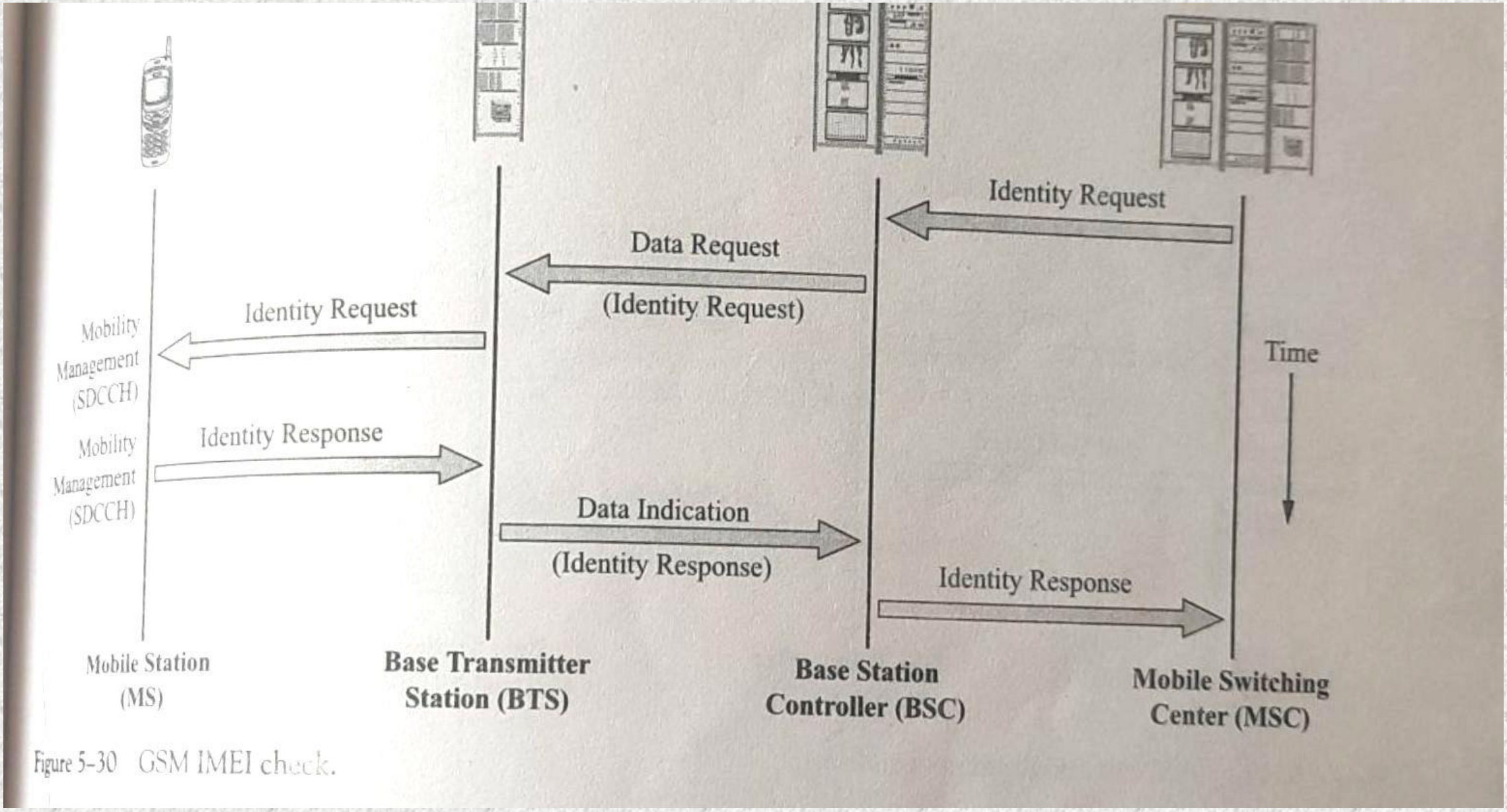


Figure 5-30 GSM IMEI check.

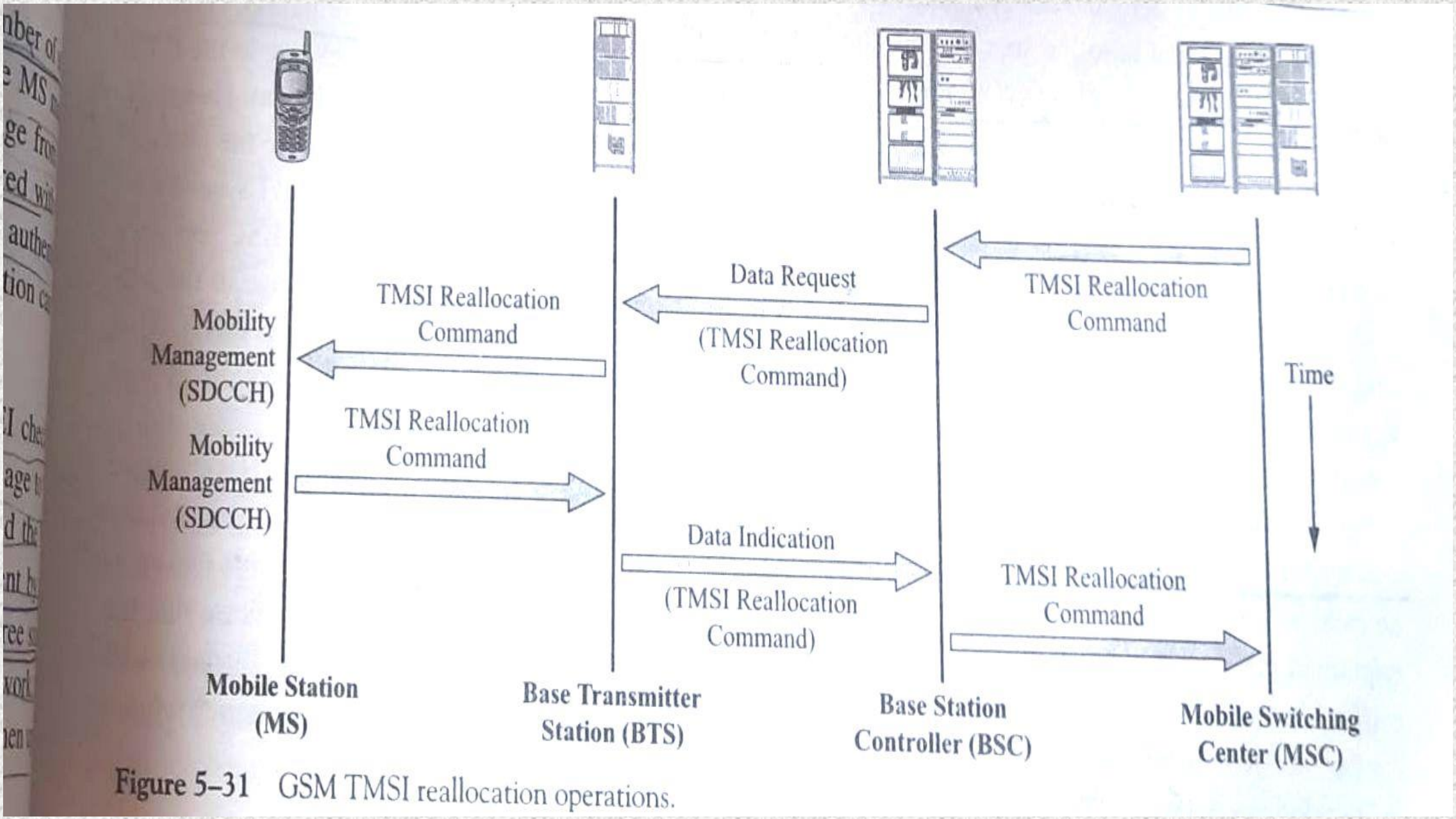


Figure 5–31 GSM TMSI reallocation operations.

Call Initiation procedure

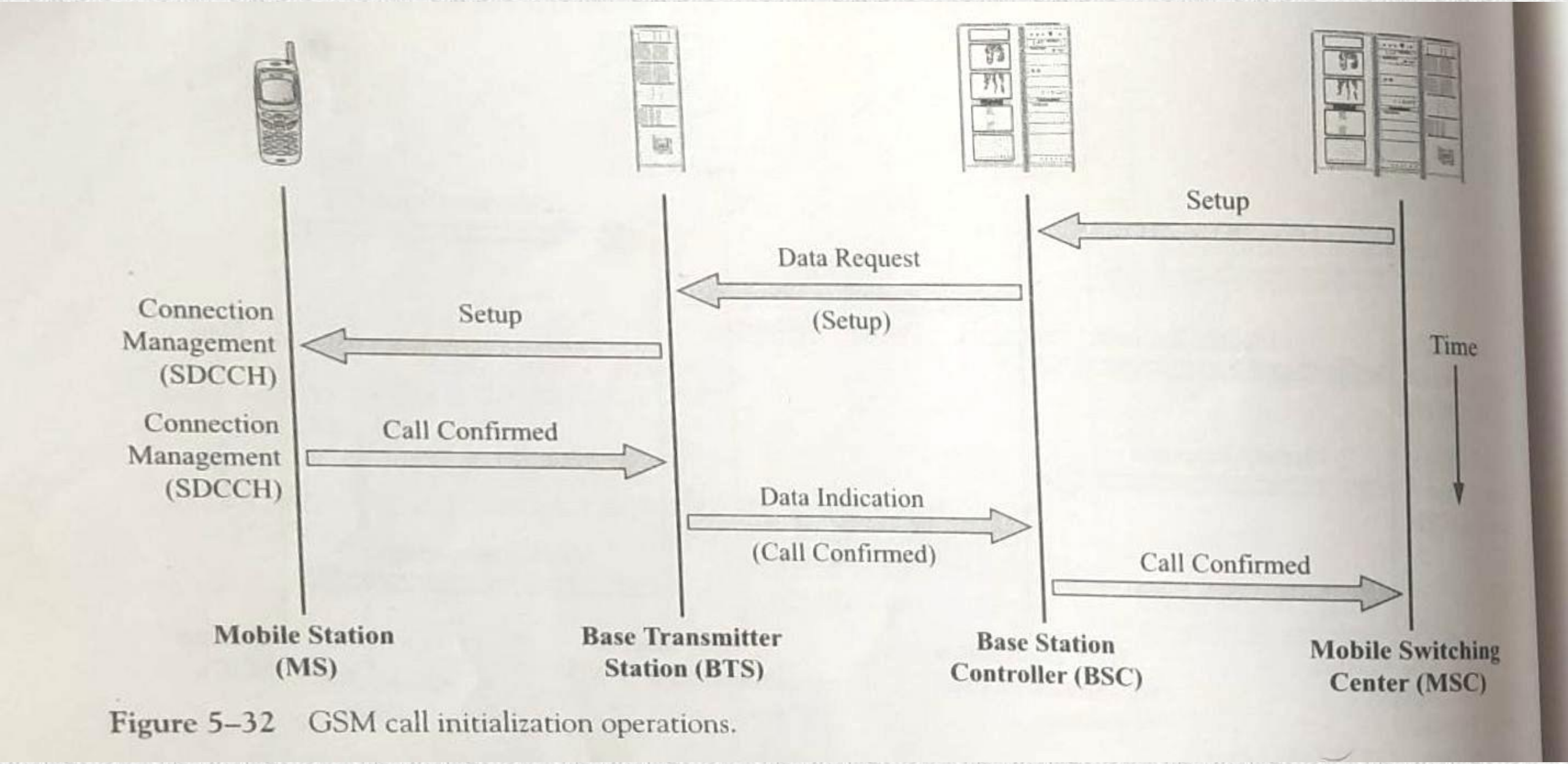


Figure 5–32 GSM call initialization operations.

Assignment of traffic channels

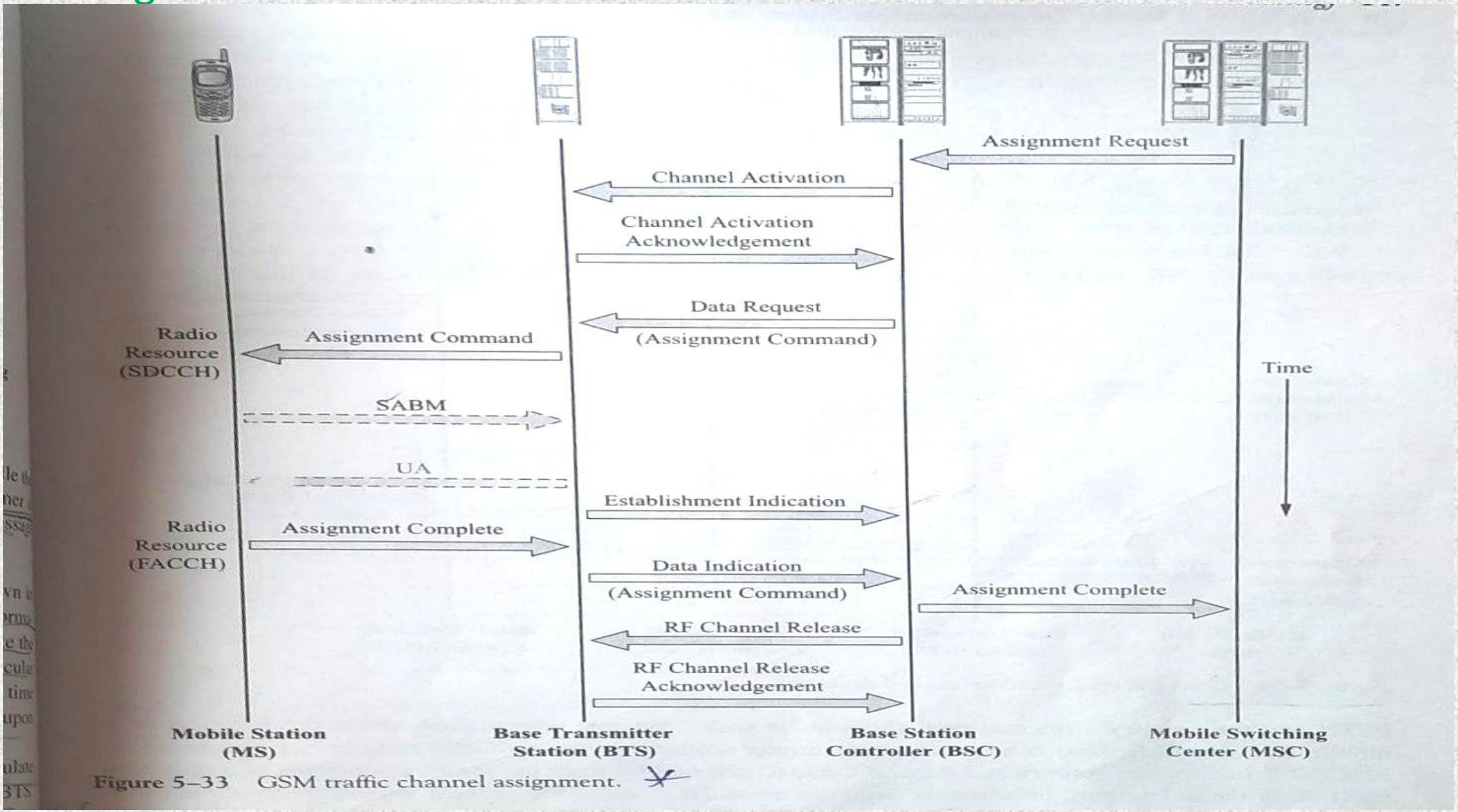


Figure 5–33 GSM traffic channel assignment.

Call confirmation, Call accepted and Call Release

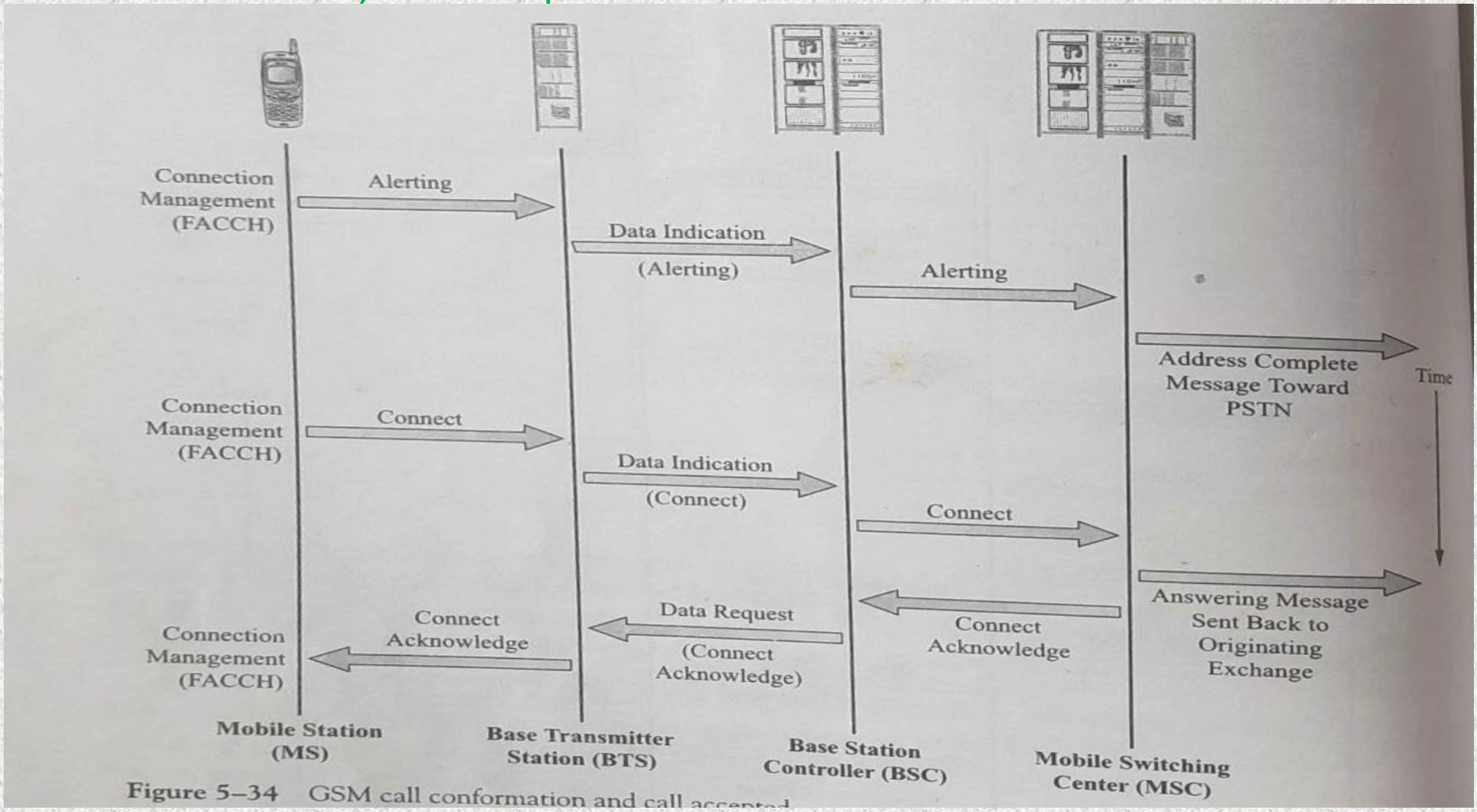


Figure 5–34 GSM call conformation and call accepted

Location Updating

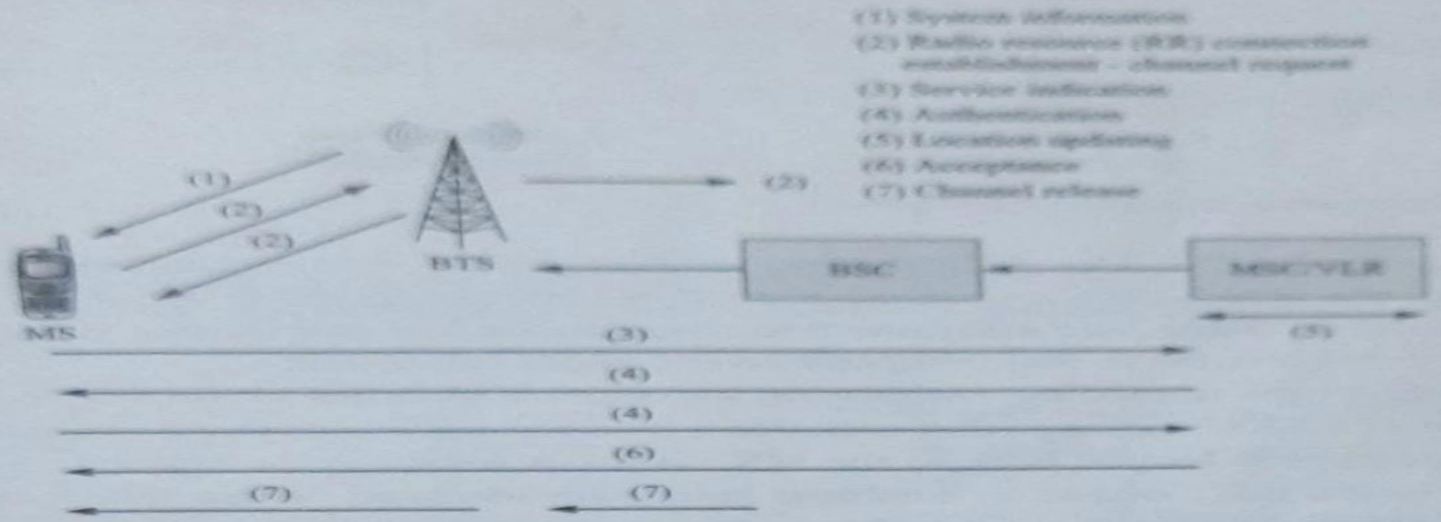


Figure 5–35 GSM location updating (Courtesy of Ericsson).

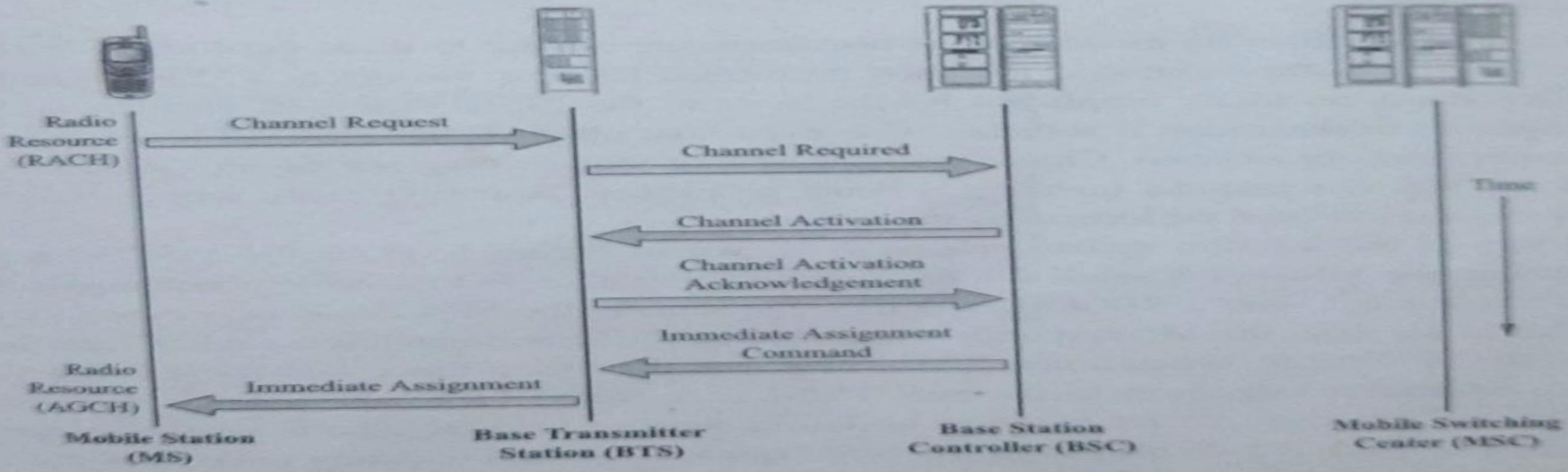


Figure 5–36 GSM location updating.

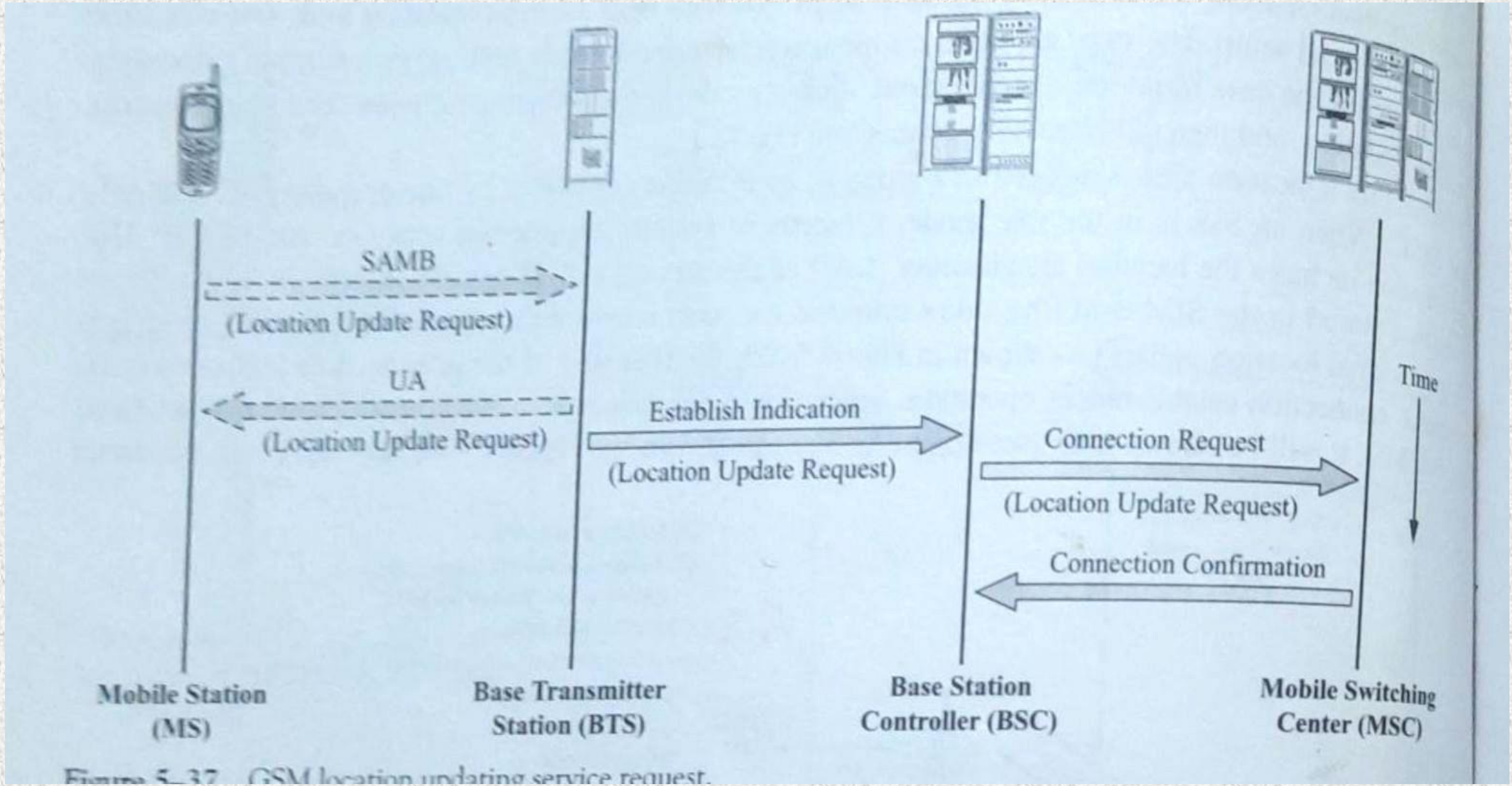


Figure 5–37 GSM location updating service request.

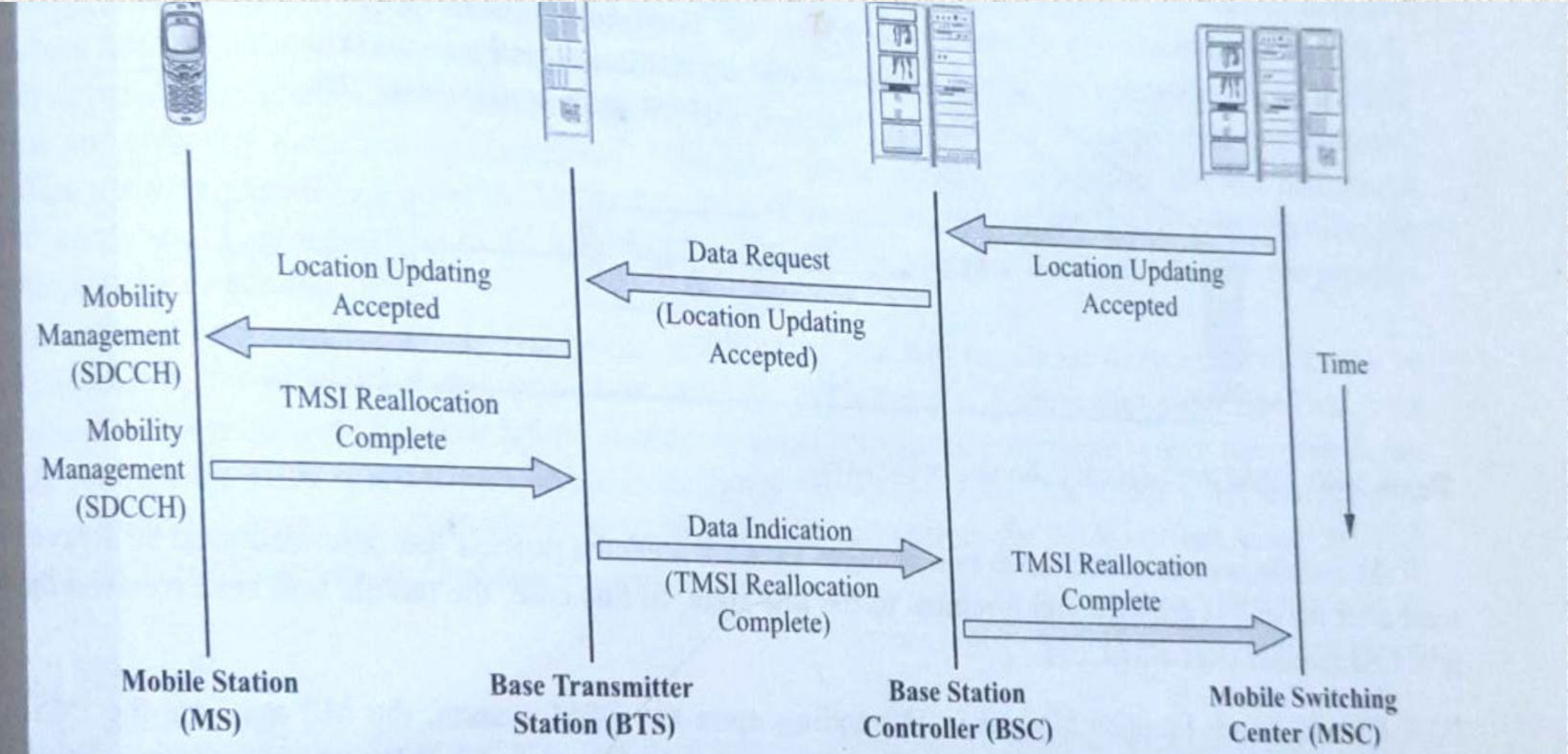


Figure 5–38 GSM location updating accepted.

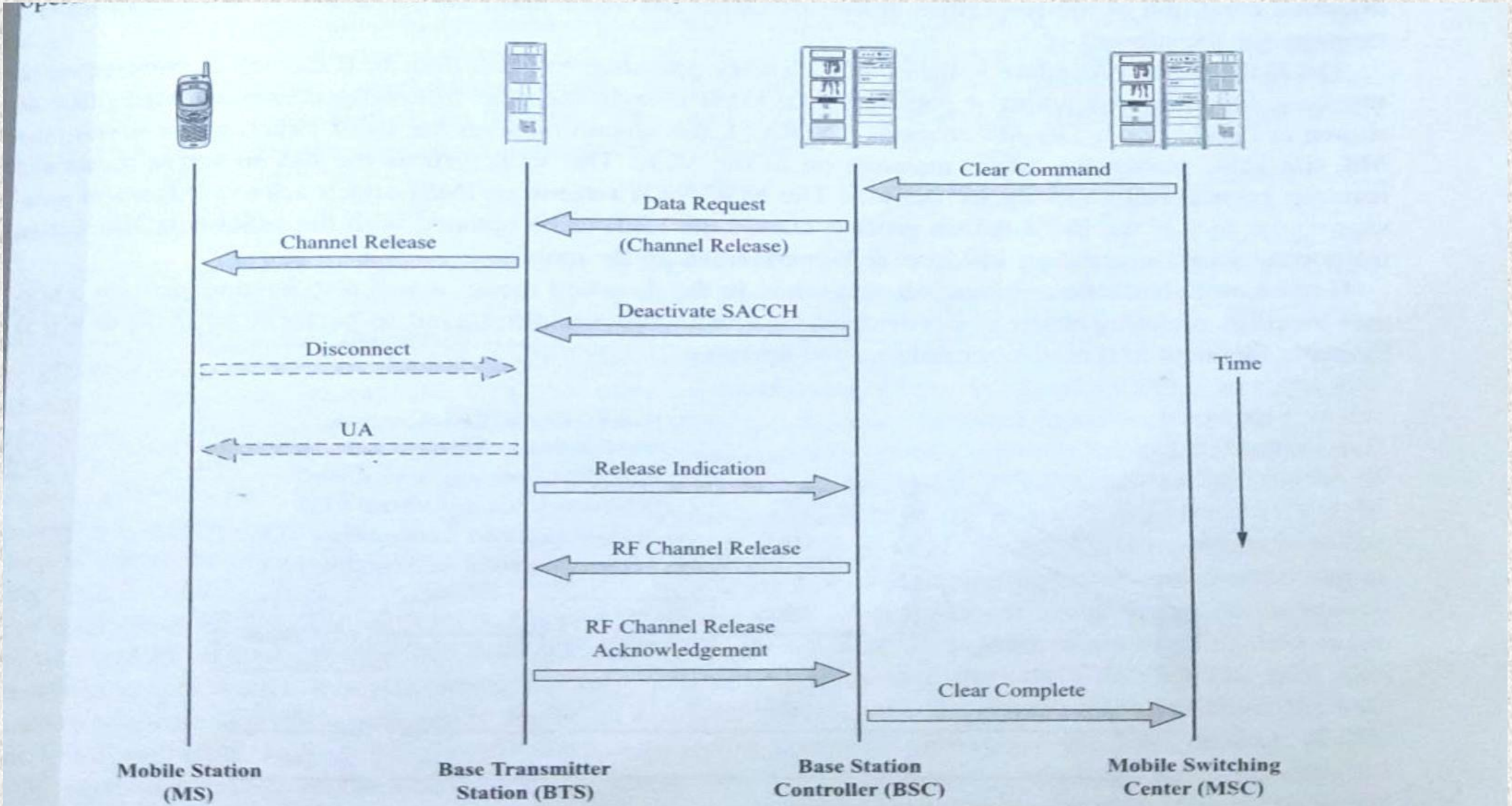


Figure 5–39 GSM connection release.

IMSI Detach/Attach location updating

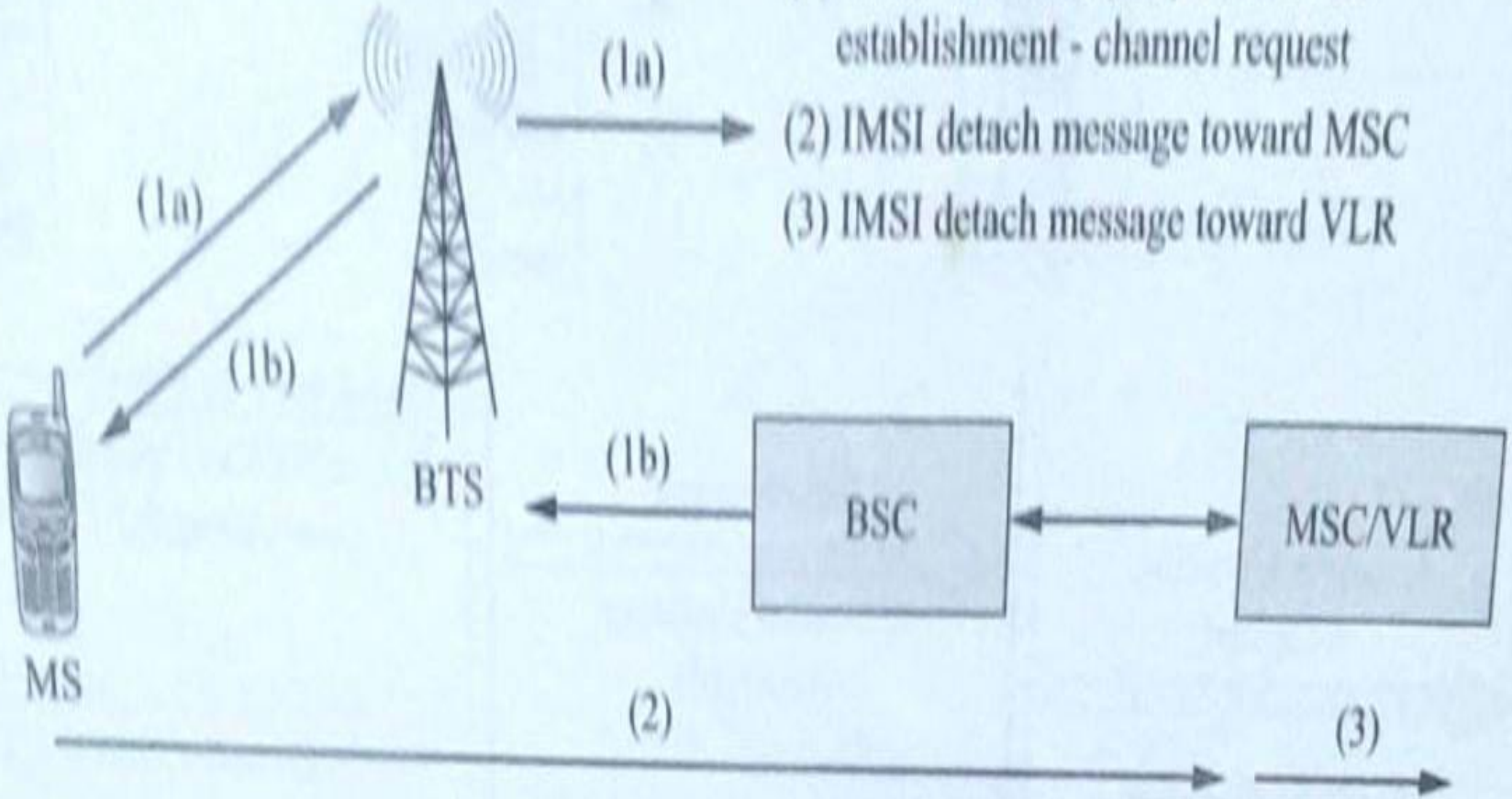


Figure 5–40 GSM IMSI detach (Courtesy of Ericsson).

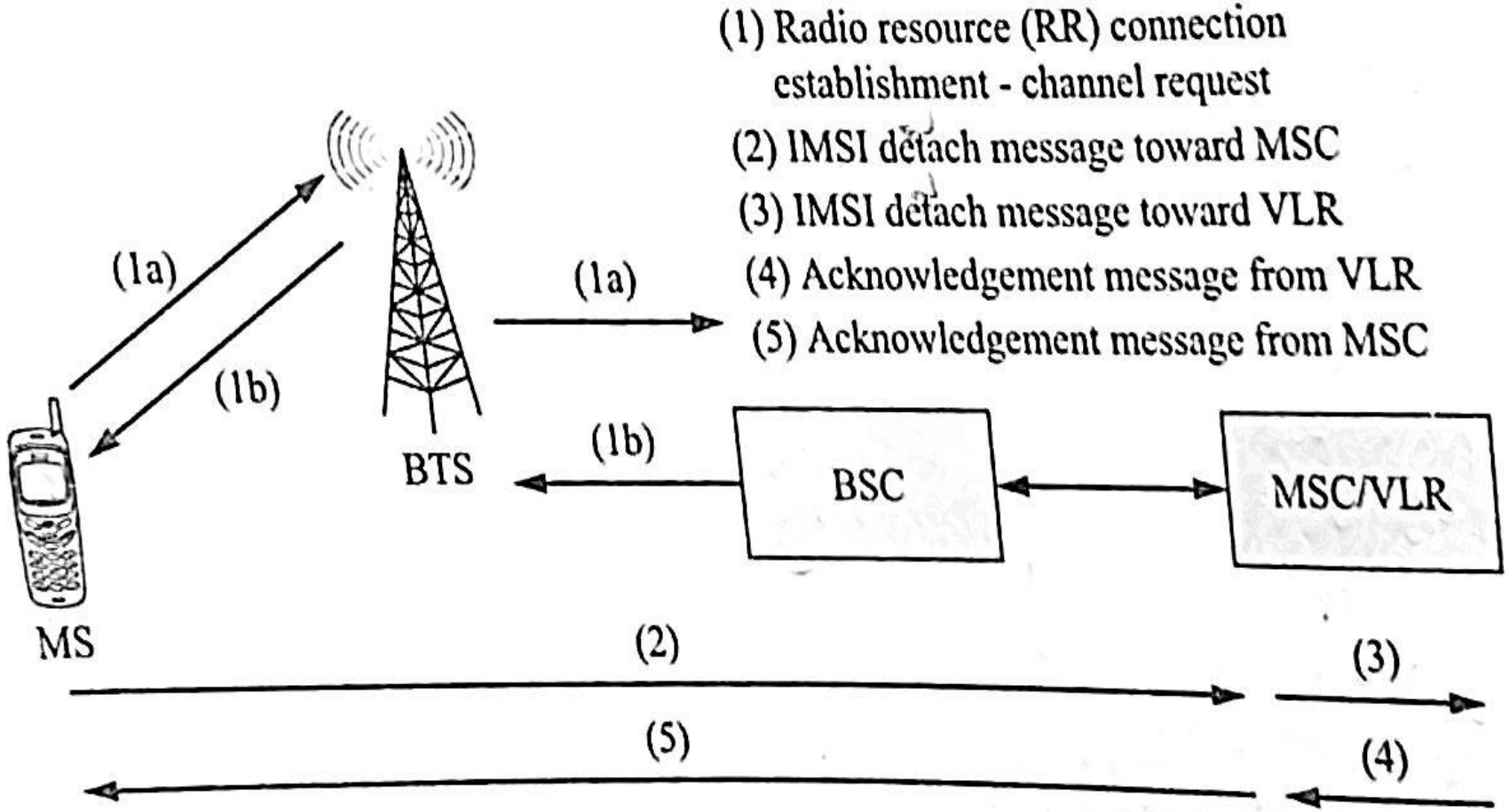


Figure 5–41 GSM IMSI attach (Courtesy of Ericsson).

Periodic location updating:-

- Used to prevent unnecessary use of network resources such as paging of a detached MS.

Call Handoff

- Intra BSC Handover
- Inter BSC Handover
- Inter MSC Handover

Intra BSC Handover

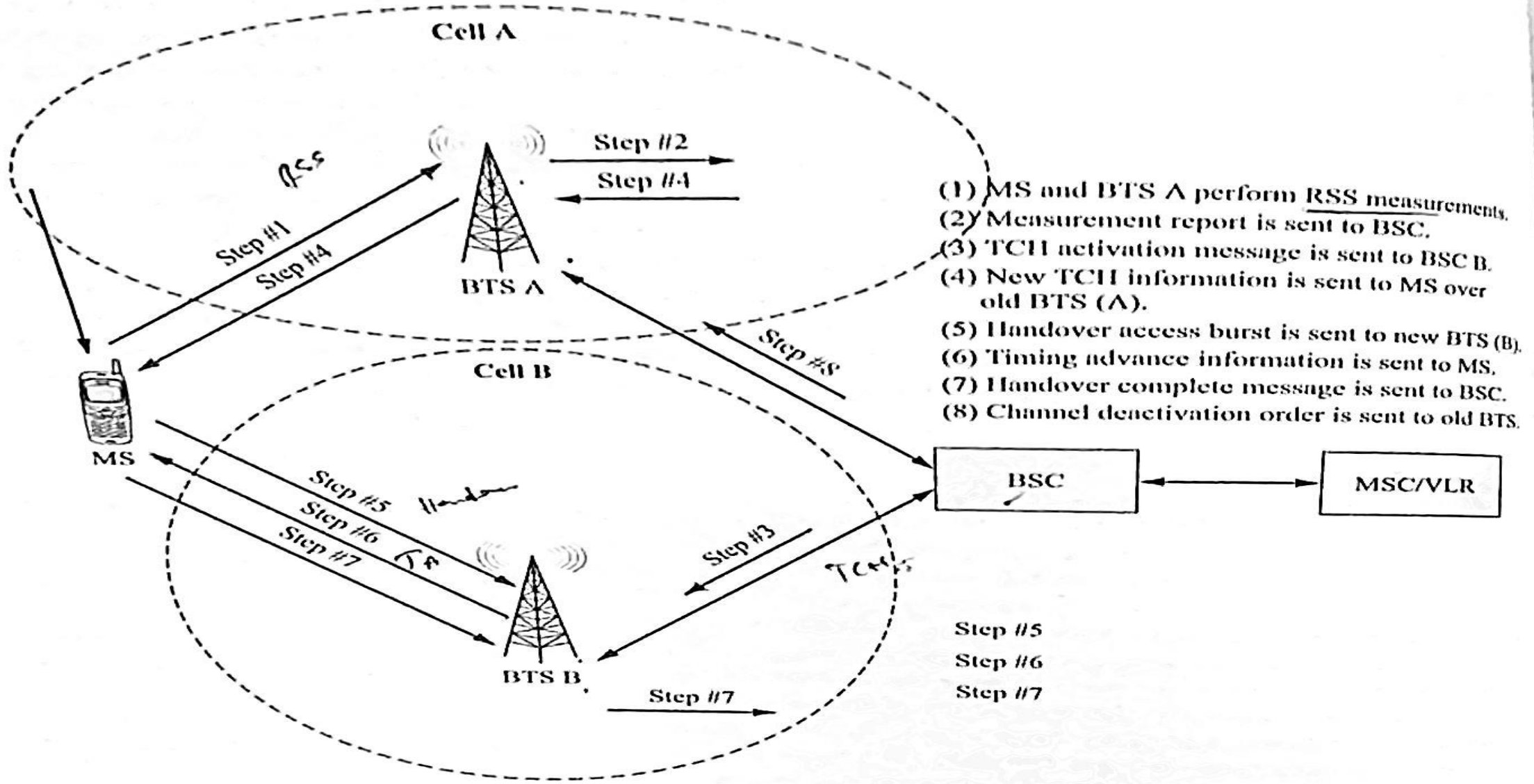
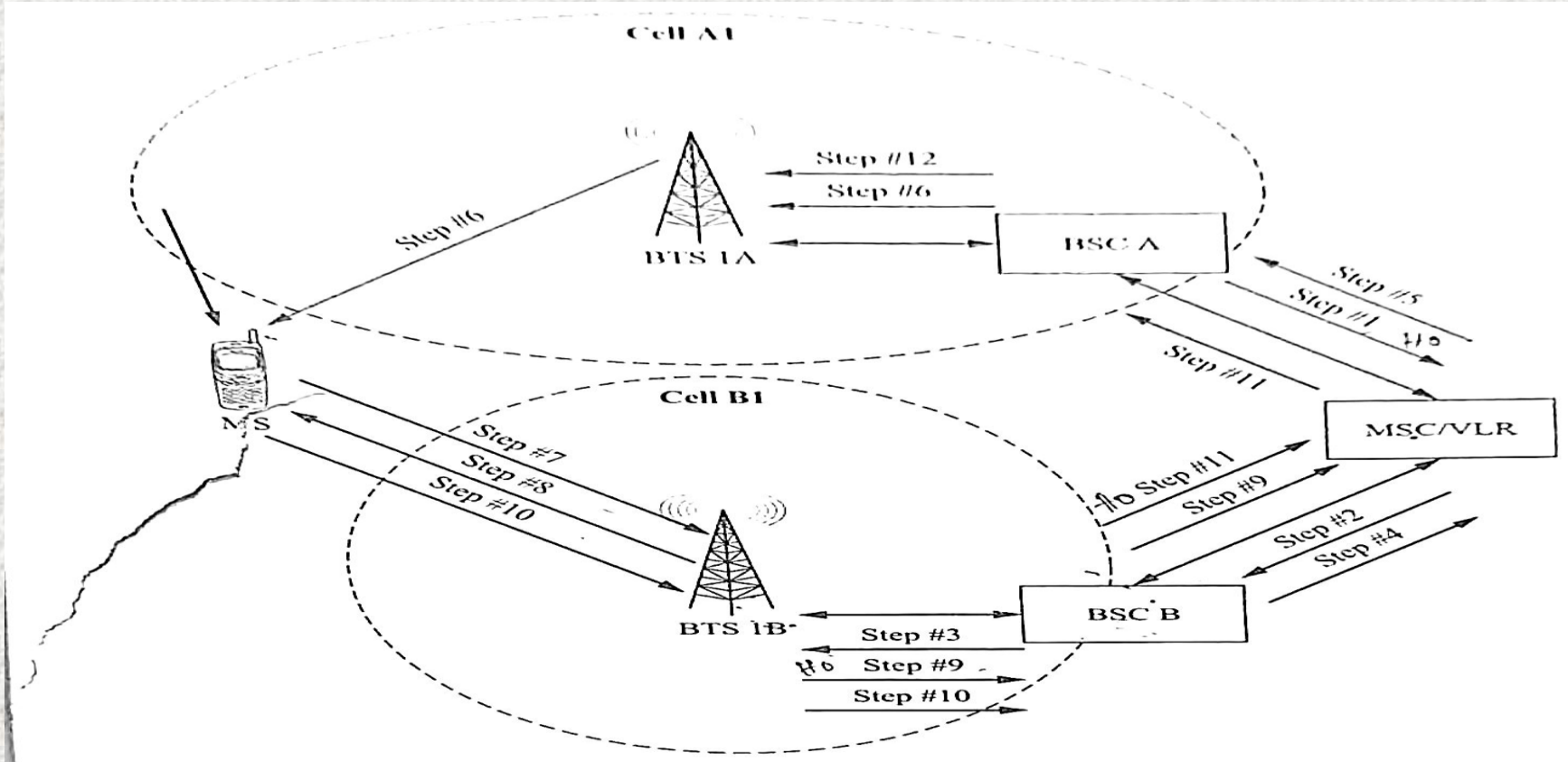


Figure 5–42 GSM Intra-BSC handover (Courtesy of Ericsson).

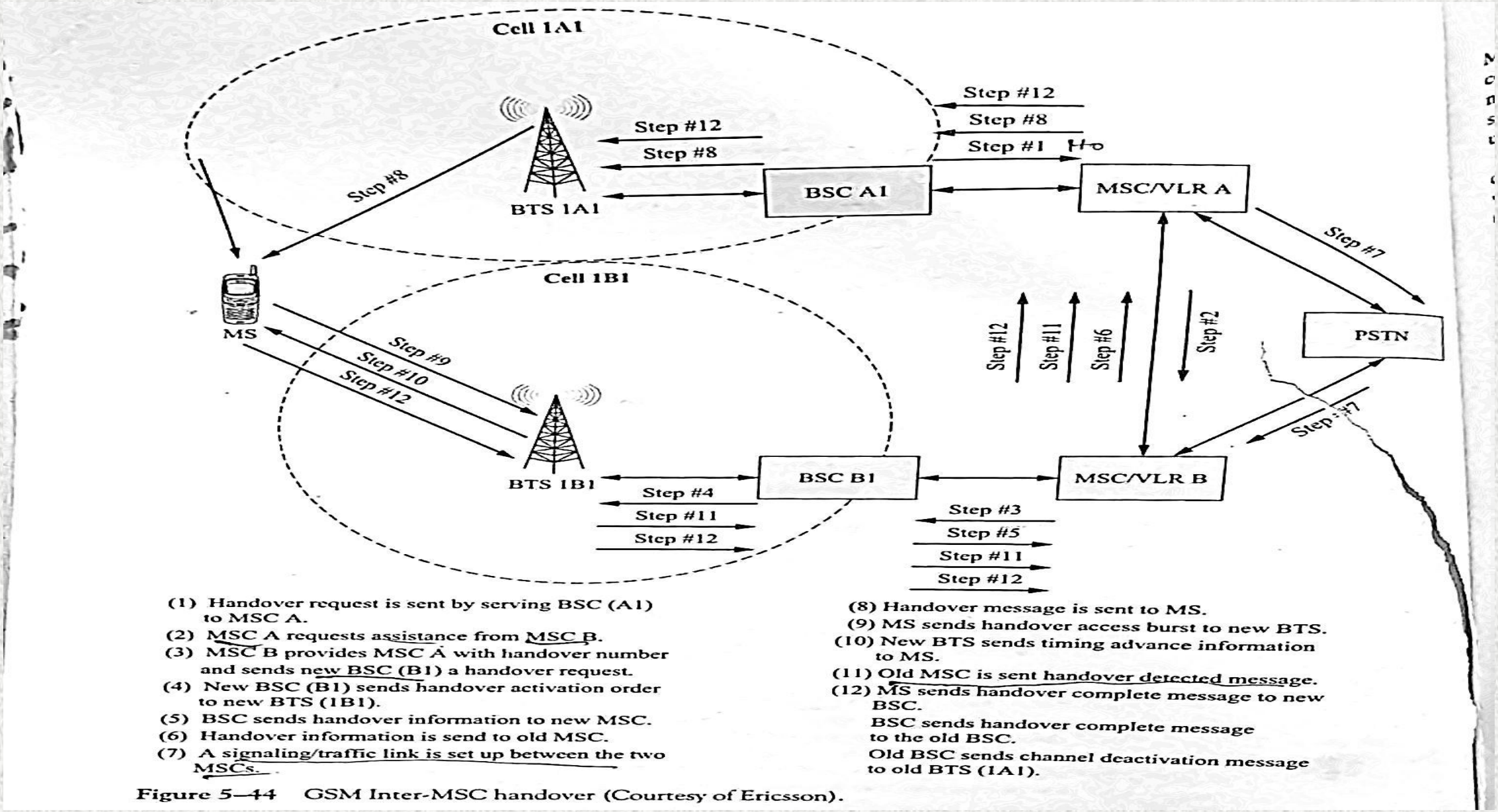
Inter BSC Handover



(1) Handover request is sent by serving BSC to MSC.
(2) Handover request is sent by MSC to new BSC (B).
(3) BSC B sends activation order to BTS 1B.
(4) BSC B sends handover information to MSC.
(5) MSC sends handover information to BSC A.
(6) BSC A sends MS new TCH information.
(7) MS sends handover access burst to new BTS (1B).
(8) Timing advance information is sent to the MS.
(9) BTS 1B sends handover detection message to BSC B.
(10) MS sends handover complete message to BSC B.
(11) BSC B sends handover complete message to the old BSC (A).
(12) Old BSC (A) sends channel deactivation message to old BTS (1A).

Figure 5–43 GSM Inter-BSC handover (Courtesy of Ericsson).

Inter MSC Handover



(1) Handover request is sent by serving BSC (A1) to MSC A.
(2) MSC A requests assistance from MSC B.
(3) MSC B provides MSC A with handover number and sends new BSC (B1) a handover request.
(4) New BSC (B1) sends handover activation order to new BTS (1B1).
(5) BSC sends handover information to new MSC.
(6) Handover information is send to old MSC.
(7) A signaling/traffic link is set up between the two MSCs.
(8) Handover message is sent to MS.
(9) MS sends handover access burst to new BTS.
(10) New BTS sends timing advance information to MS.
(11) Old MSC is sent handover detected message.
(12) MS sends handover complete message to new BSC.
BSC sends handover complete message to the old BSC.
Old BSC sends channel deactivation message to old BTS (1A1).

Figure 5–44 GSM Inter-MSC handover (Courtesy of Ericsson).

GSM Infrastructure Communications(UM Interface)

- Review of GSM protocol Architecture
- Layer 3 Networking layer operations
- Message format for layer 3
- Layer 2 : Data link layer operations

GSM Infrastructure Communications (Um Interface)

A GSM network is a bearer data communication protocol families. Any protocol stack for data communication, for example TCP/IP, can be implemented to use a bearer. GSM protocol architecture is - as for ISDN - structured into three independent planes .

User plane ,Control plane,Management plane

The user plane defines protocols to carry connection oriented voice and user data. At the radio interface Um, user plane data will be carried by the logical traffic channel called TCH. The control plane defines a set of protocols for controlling these connections with signalling information, for example signalling for connection setup. Such signalling data is carried over logical control channels called D-channels (Dm-

channels). As the control channels often have spare capacities, also user data, the packet oriented SMS data, is transported over these channels (see Figure gsm8). All logical channels, however, will be finally multiplexed onto the physical channel.

Management plane function are:

Management plane function are:

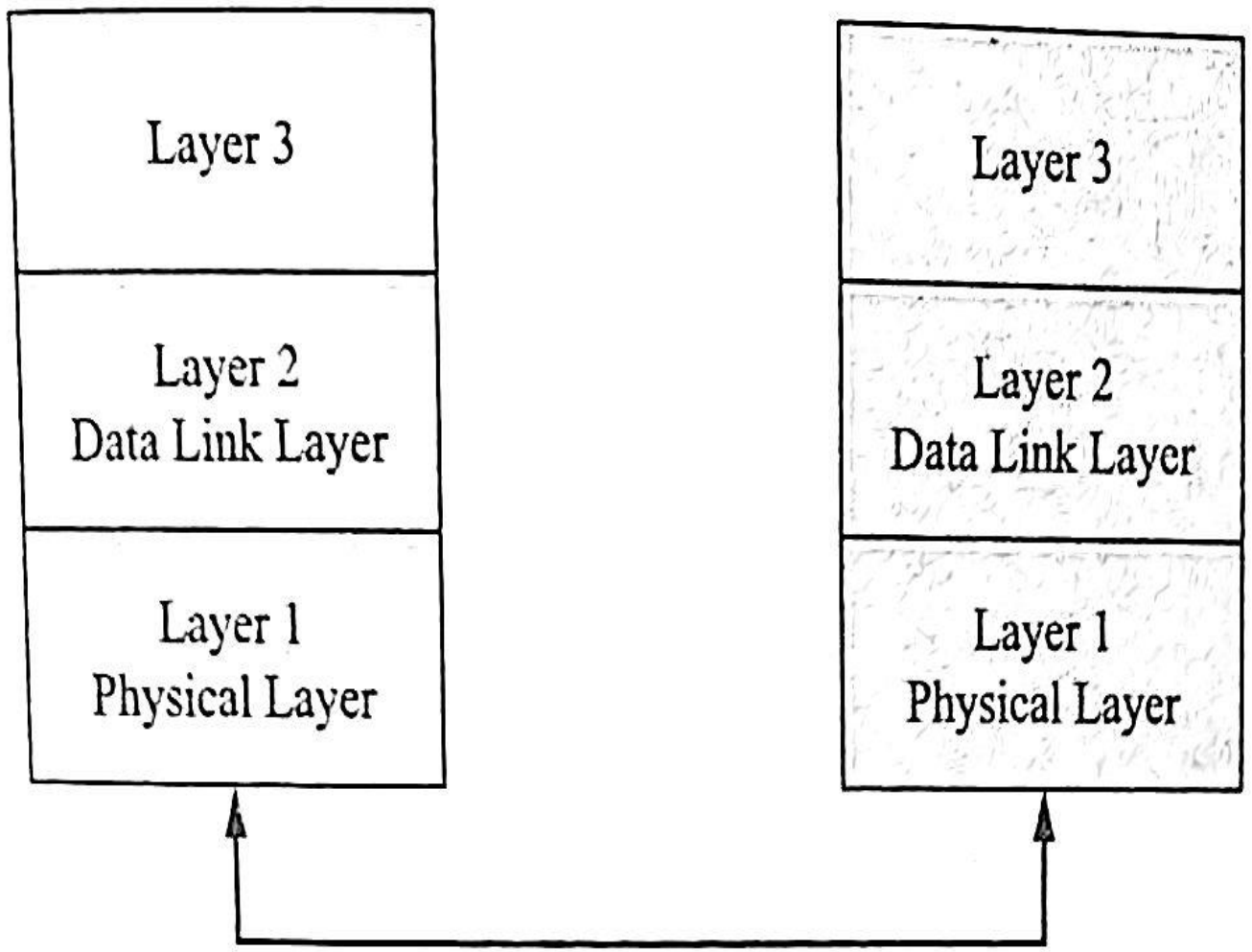
- plane management functions related to the system as a whole including plane coordination
- functions related to resources and parameters residing in the layers of the control and/or user plane.

Management of network element configuration and network element faults are examples of management plane functionality

The basic GSM bearer service, Circuit Switched Data (CSD), simply consists of transmitting and receiving signals representing data instead of voice across the air interface. Modems are used for the conversion between data bit streams and modulated radio signals. Data transmission is either transparent or non-transparent.

radio signals. Data transmission is either transparent or non-transparent.

Review of GSM protocol Architecture



gure 5-45 Information flow between two nodes in a network.

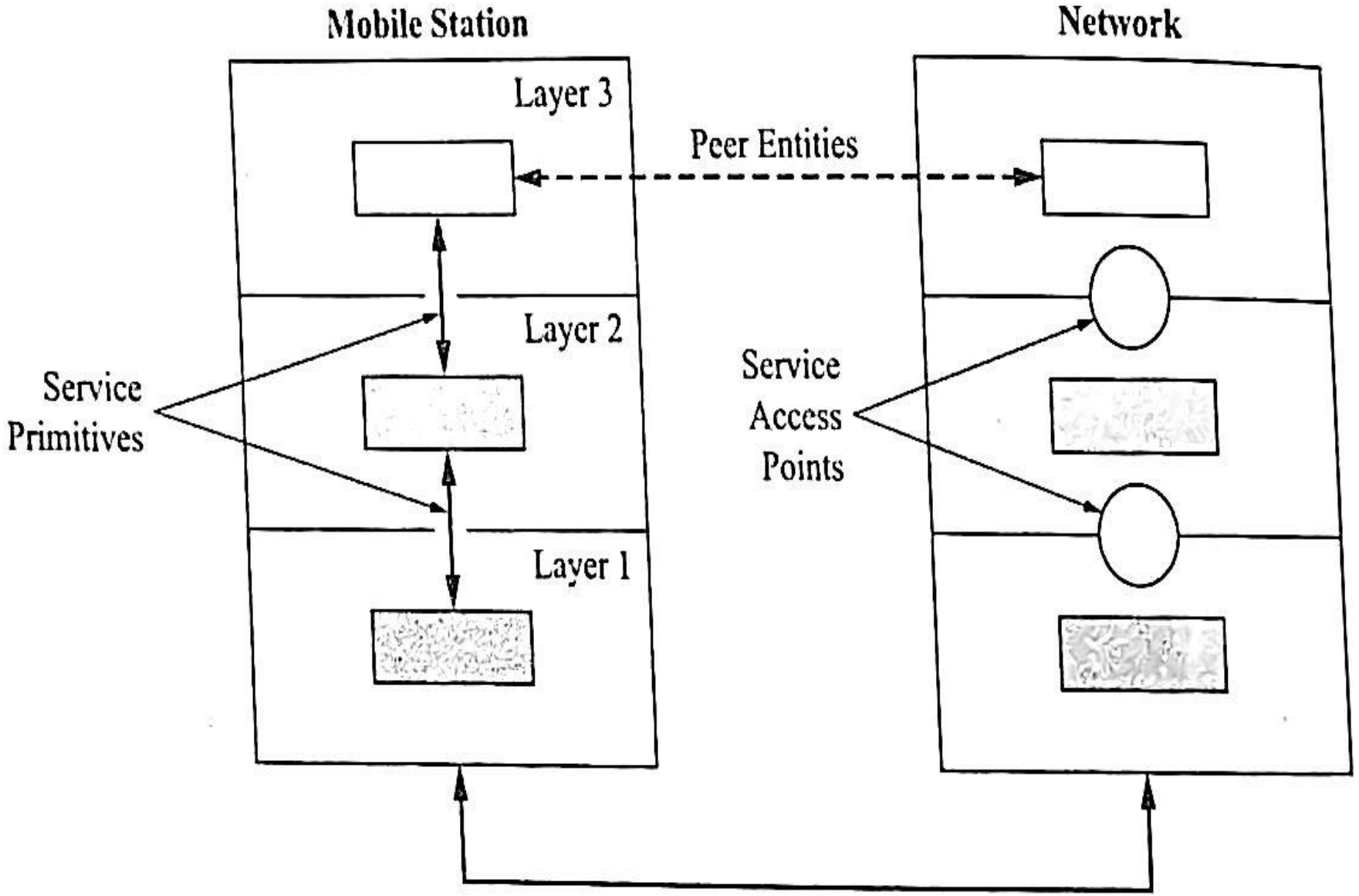


Figure 5–46 Information flow between two nodes in a GSM network (Courtesy of ETSI).

GSM Infrastructure Communications (Um Interface)

- Layer 3: Networking layer operations
  - Connection management
  - Mobility management
  - Radio resource management

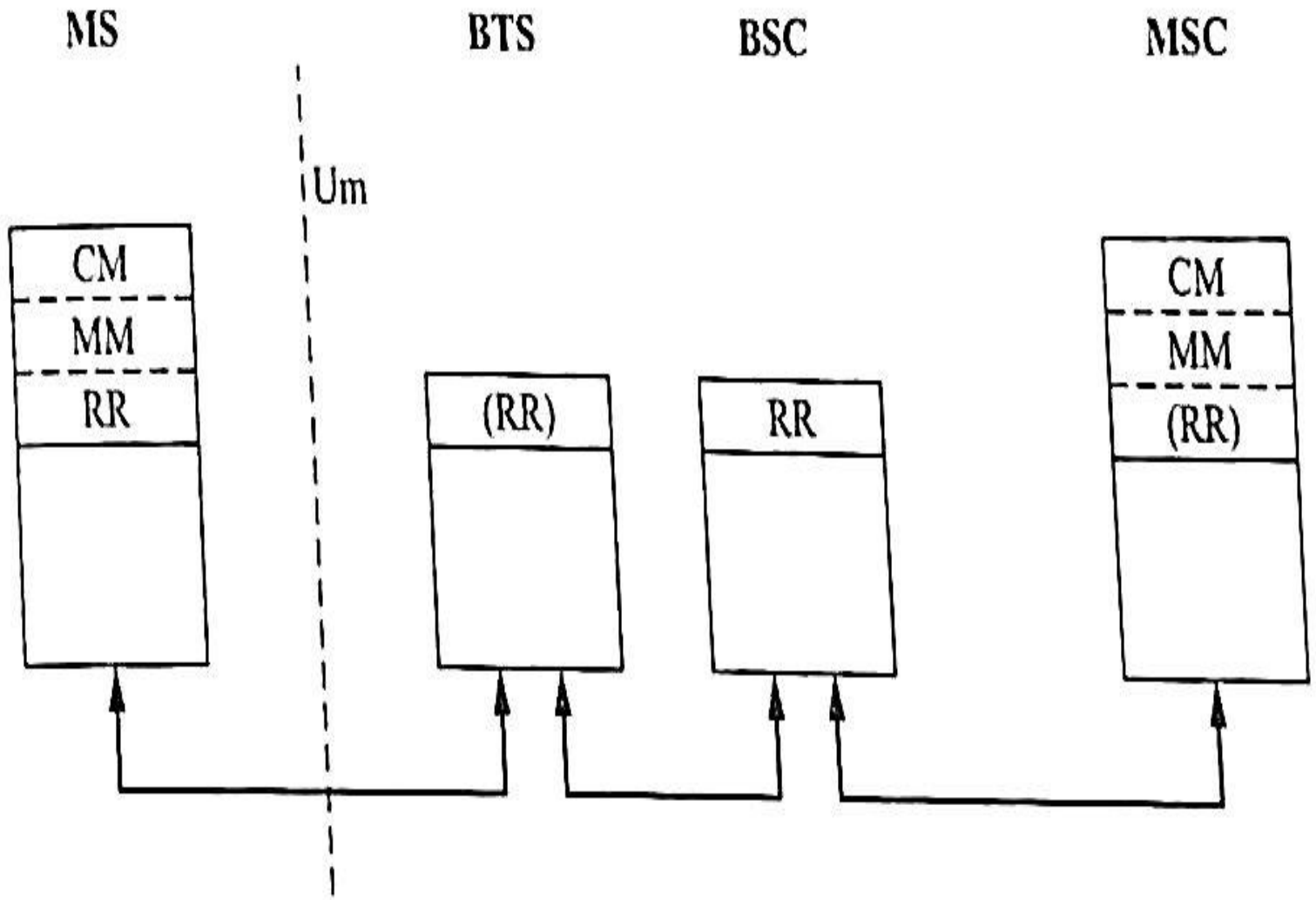


Figure 5–47 Distribution of Layer 3 signaling functions (Courtesy of ETSI).

- GSM Infrastructure Communications (Um Interface)
  - Layer 2: Data Link layer operations
    - LAPD operations
    - Service access points
    - Data link procedures
    - Physical services required by the Data Link layer
    - Data link timers
- North American TDMA
  - TIA/EIA-136 basics
  - TIA/EIA-136 channel concept
  - TIA/EIA-136 timeslots and frame details

THANK YOU