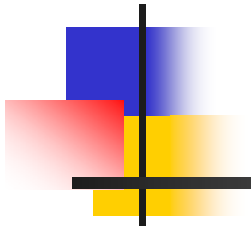
Wireless and Mobile Network Architecture



Chapter 7: GSM Network Signaling

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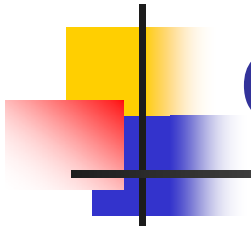
Nov. 2006



Outline

- Introduction
- GSM MAP Service Framework
- The MAP Protocol Machine
- The MAP Dialogue
- Example of MAP Service Primitives
- Summary

Introduction

- GSM network signaling, based on the GSM architecture.
  - **Fig. 10.1** shows various network signaling protocols used by the entity interface in GSM.
  - The GSM architecture can be partitioned into three part.
    - Databases
    - Switches
    - Radio Systems

Fig. 10.1

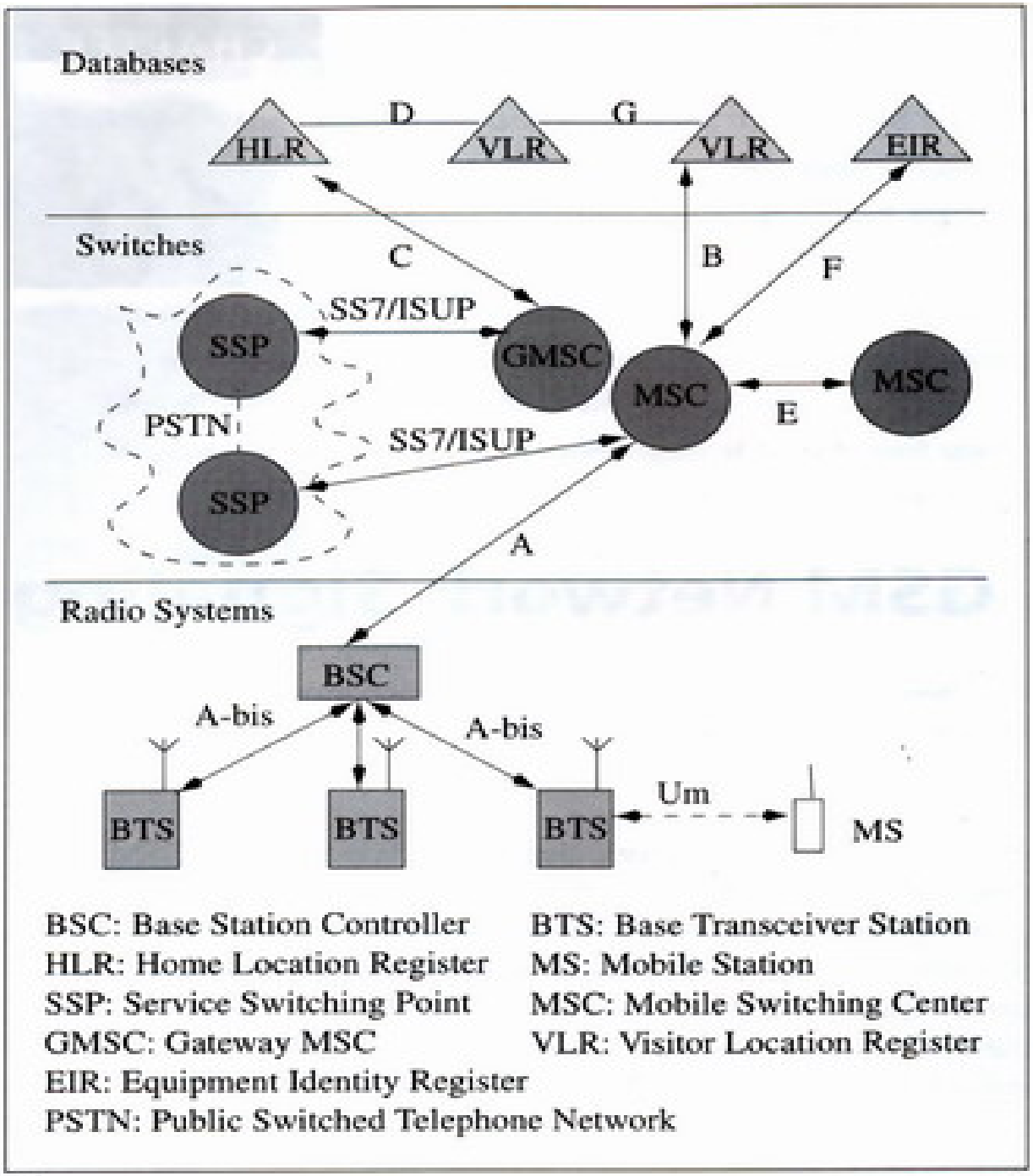


Figure 10.1 GSM protocol interfaces.

Fig. 10.1

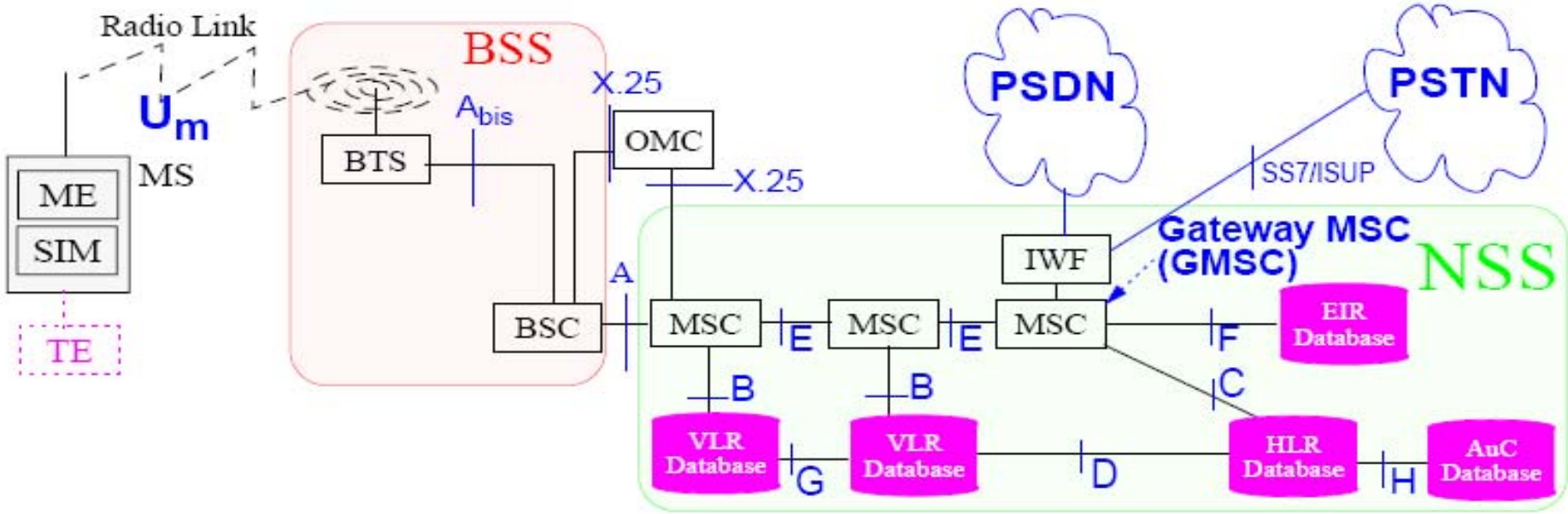


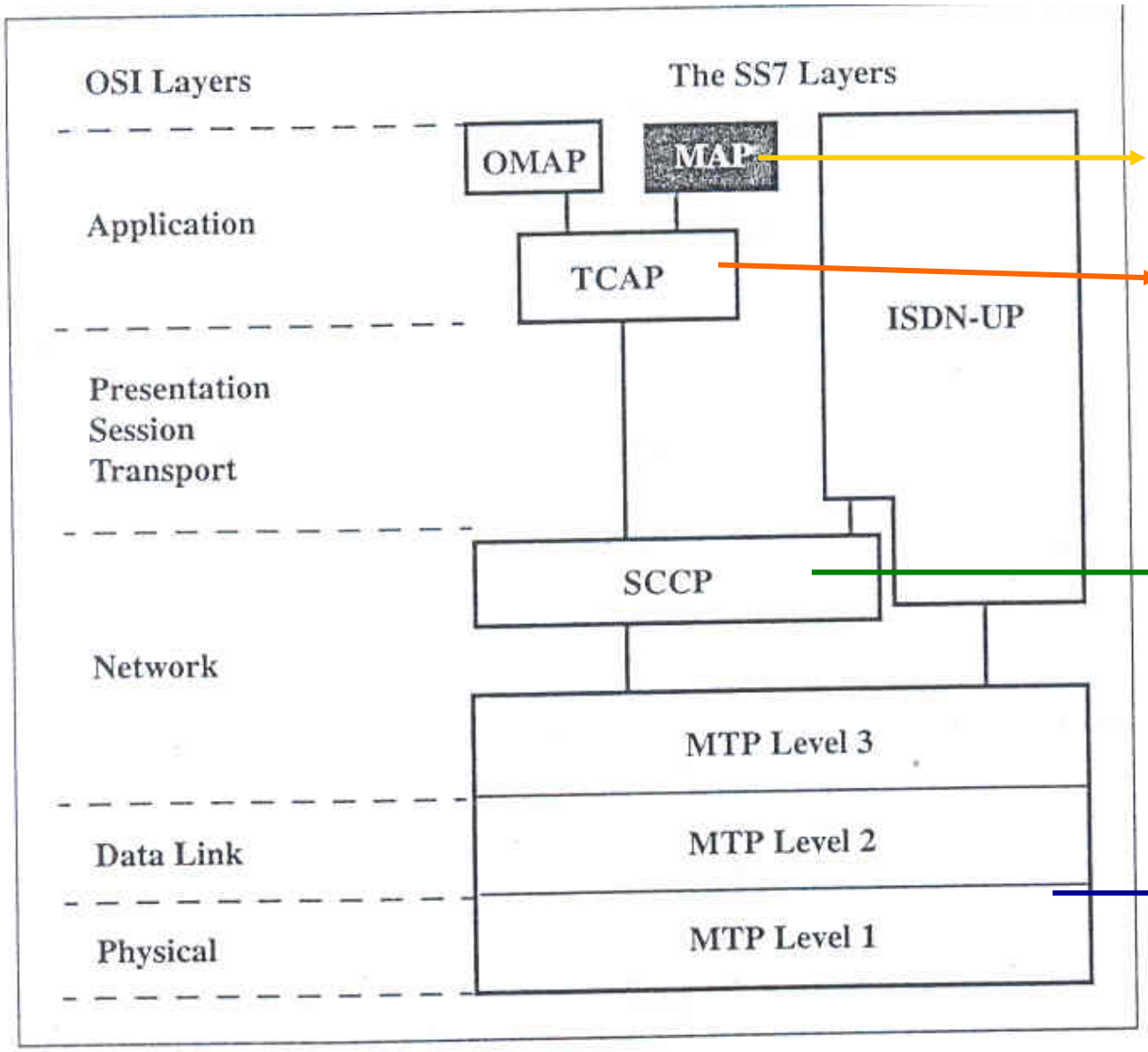
Figure 21: GSM Architecture

MS	Mobile Station
BSS	base station system
NSS	network and switching subsystem

Cont.

- **GSM MAP** (Mobile Application Part)
  - Software platform for implementing the signaling protocol.
  - Used in the B, C, D, E, F and G interface illustrated in **Fig. 10.1.**
  - The GSM MAP is an application of the SS7 protocol.

The SS7 Signaling protocol.



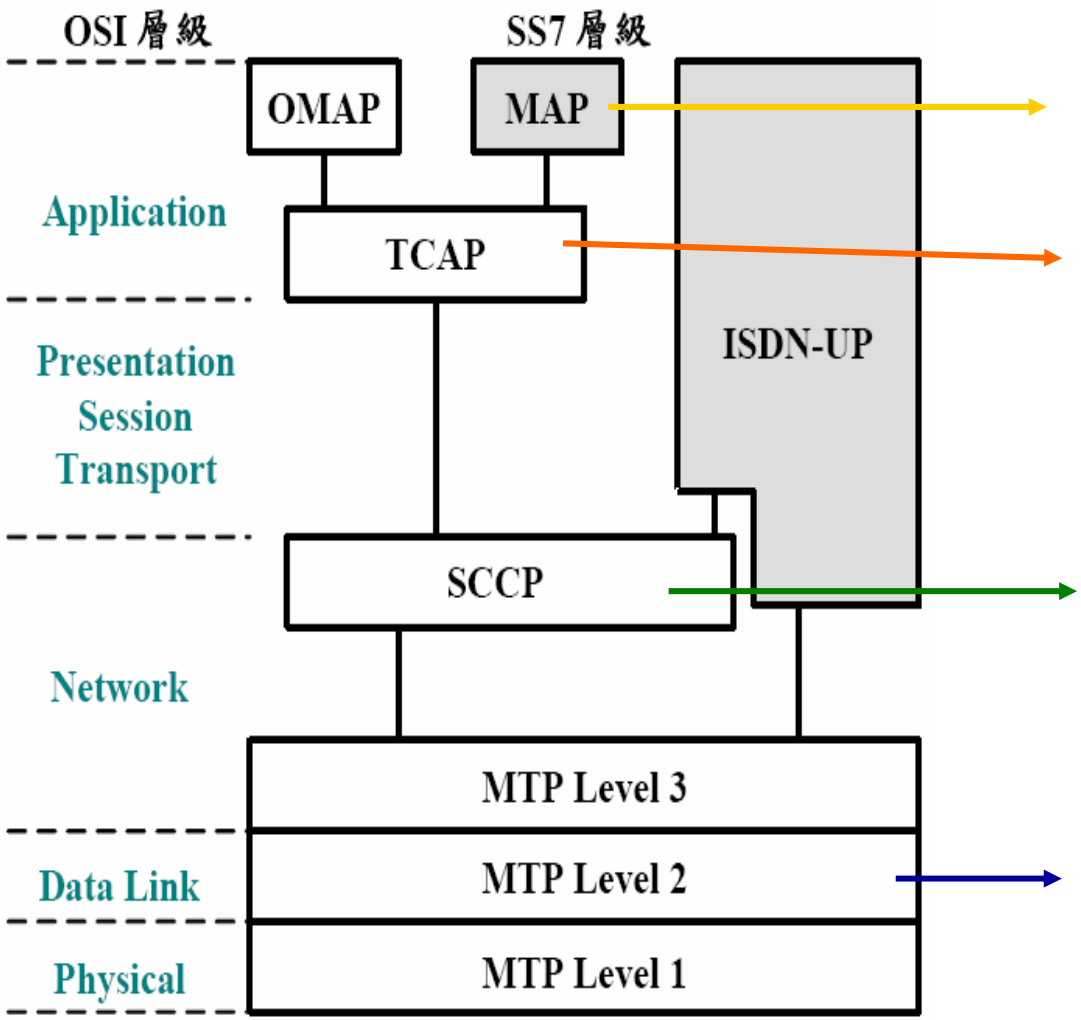
The Mobile Application Part

Transaction Capabilities Application Part

Signaling Connection Control Part

Message Transfer Part

The SS7 Signaling protocol.



The Mobile Application Part

Transaction Capabilities Application Part

Signaling Connection Control Part

Message Transfer Part

GSM Protocol Interfaces (Fig. 10.1)

- Radio system
  - BTS with MSs through the radio interface U_m.
  - BSC with other BTSs through the A-bis interface, using the ISDN link access protocol for D channel (LAPD).
  - BSC with MSC through the A interface, using a signaling protocol compatible with telephone network.

Fig. 10.1

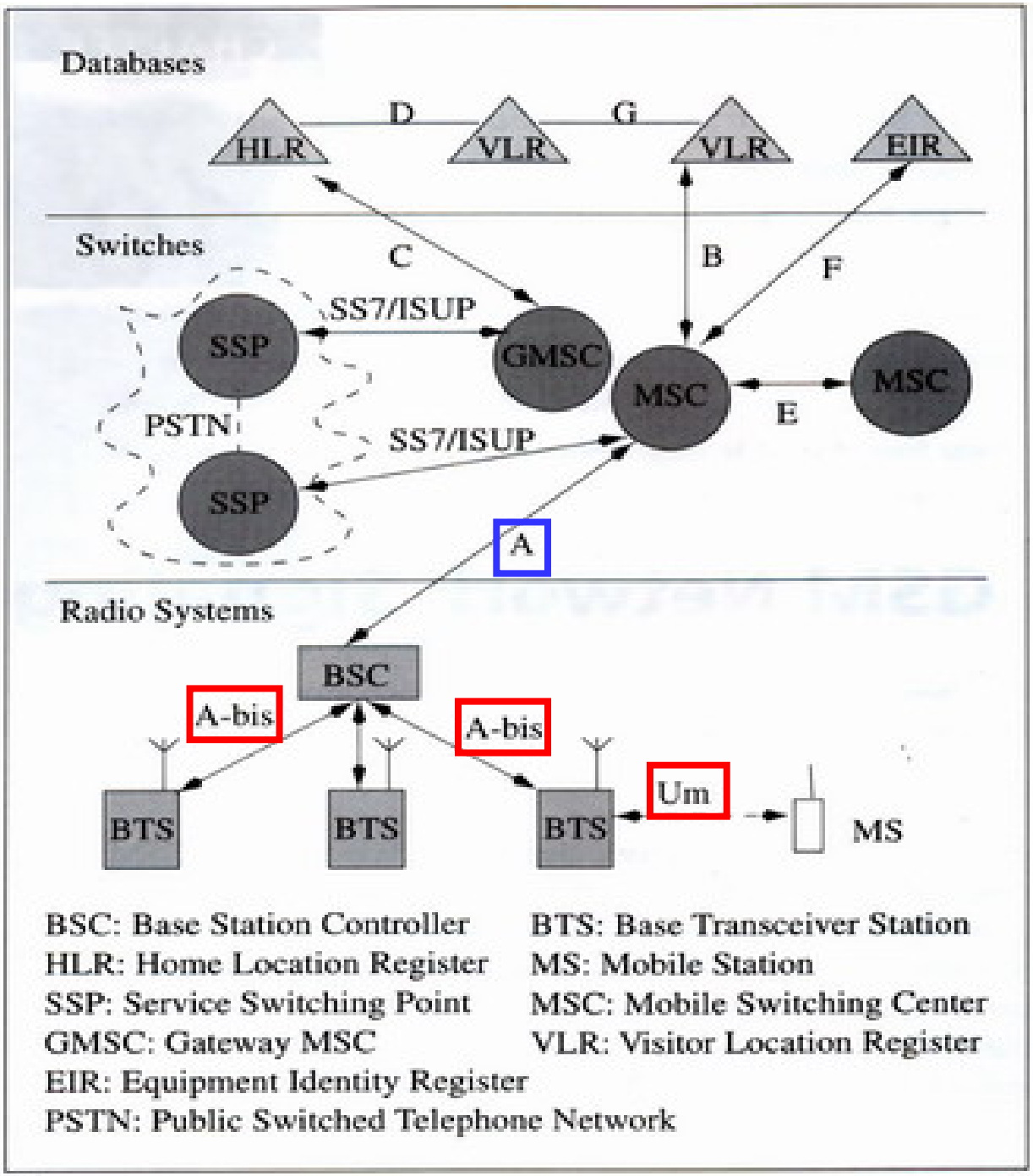


Figure 10.1 GSM protocol interfaces.

Fig. 10.1

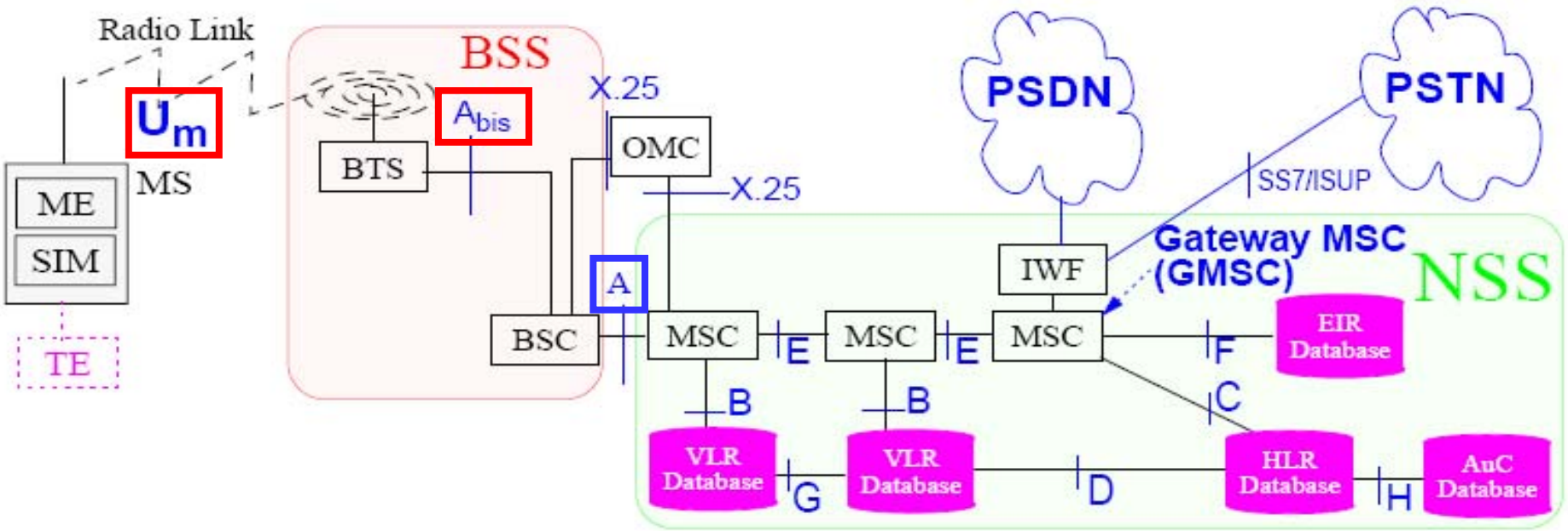


Figure 21: GSM Architecture

MS	Mobile Station
BSS	base station system
NSS	network and switching subsystem

GSM Protocol Interfaces (Fig. 10.1)

- Switches
  - MSC(GMSC) communicates with an SSP in the PSTN using the SS7/ISUP protocol.
  - Two MSC with each other through the E interface.
  - MSC with HLR through the C interface.
  - MSC with VLR through the B interface.
  - MSC with EIR through the F interface.
- Databases
  - HLR with VLR through the D interface.
  - VLRs with each other through the G interface.

Fig. 10.1

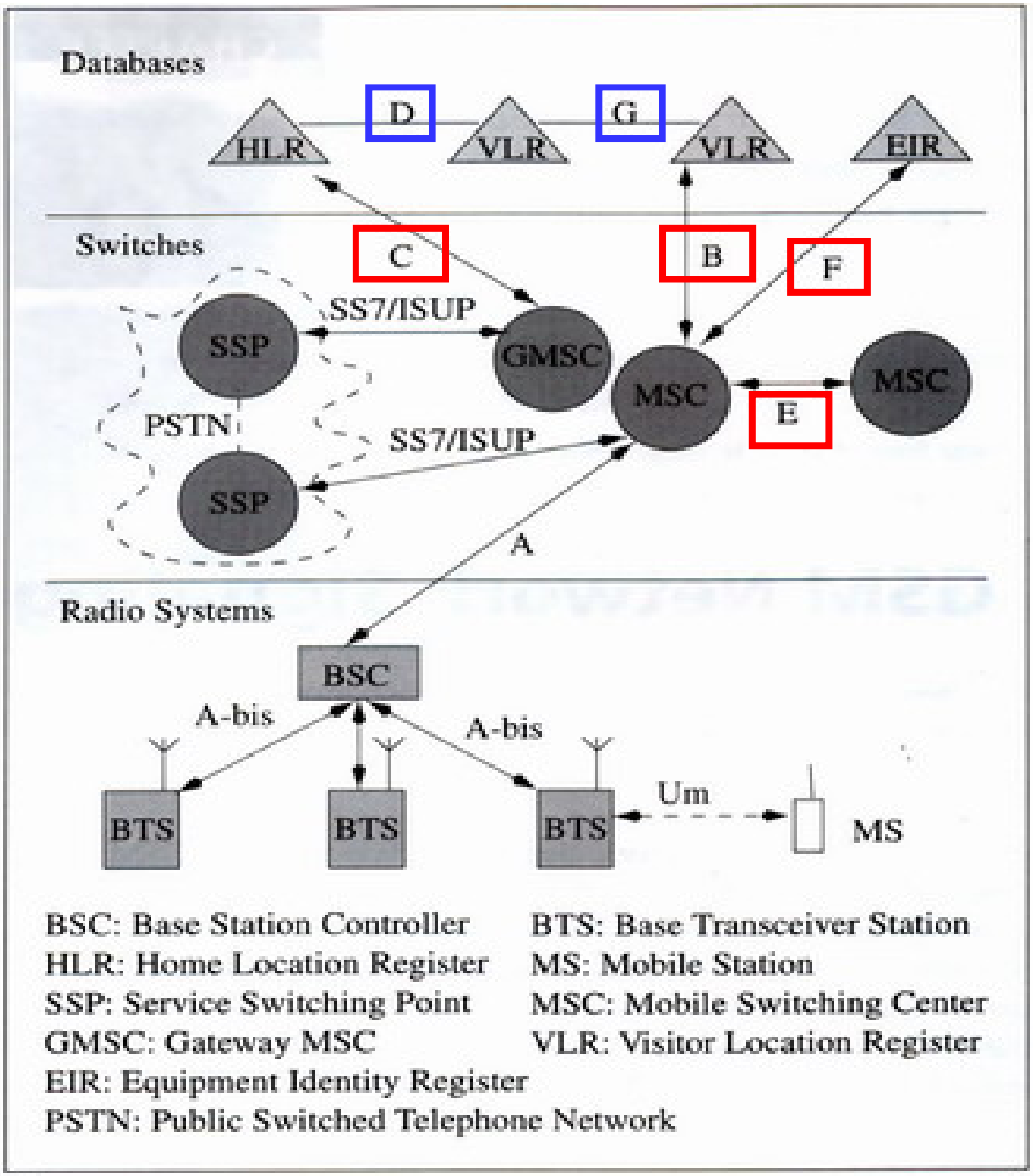


Figure 10.1 GSM protocol interfaces.

Fig. 10.1

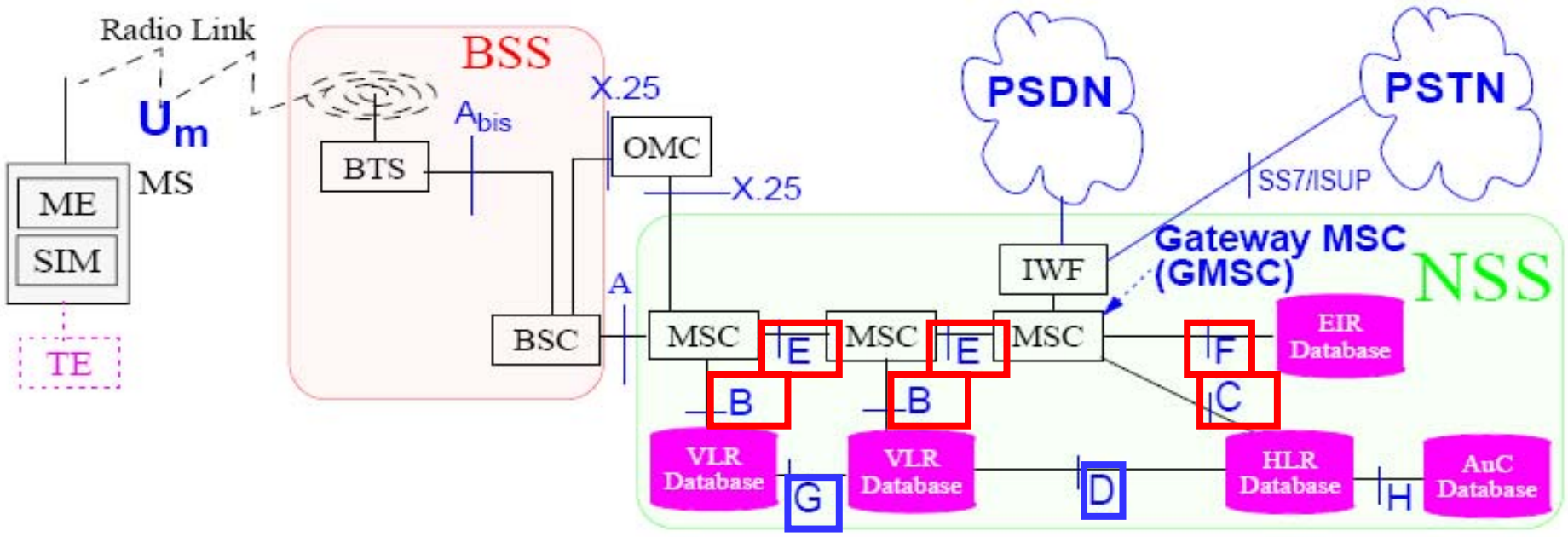


Figure 21: GSM Architecture

MS	Mobile Station
BSS	base station system
NSS	network and switching subsystem

Fig. 10.2

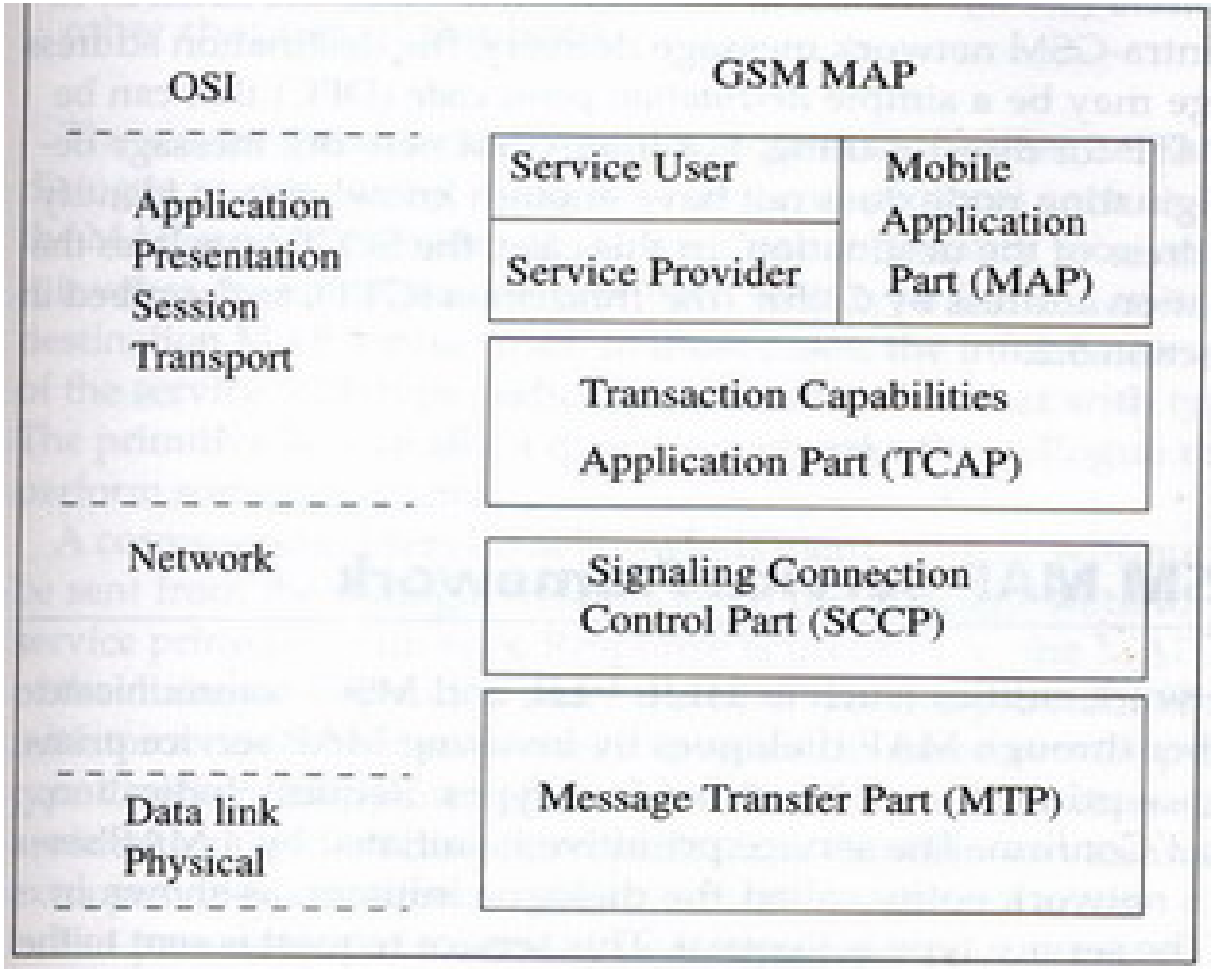


Figure 10.2 GSM MAP protocol hierarchy.

Cont.

- GSM MAP uses Signaling Connection Control Part (SCCP) classes 0 and 1 connectionless service
  - Classes 0 without maintaining message sequencing between two or more message.
  - Otherwise classes 1 with.
- The network entities may consist of several application service element (ASEs)
  - SCCP addresses these ASEs with subsystem numbers (SSNs), listed in TABLE 10.1.
  - SSNs are not the physical address.

Table 10.1

Table 10.1 GSM MAP SCCP Subsystem Numbers

APPLICATION SERVICE ELEMENT	SUBSYSTEM NUMBER
Reserved	00000101
HLR	00000110
VLR	00000111
MSC	00001000
EIR	00001001
(Possible) AuC	00001010

Cont.

- For intra-GSM network message delivery
  - The destination address of the message may be a simple destination point code (DPC) that can be used by the MTP for direct routing.

- For inter-GSM network message delivery
  - The SCCP translates the actual destination address by Global Title Translation (GTT) and sends to the originating node.

10.1 GSM MAP Service Framework

- The GSM network entities (such as HLR, VLR, and MSC) communicate through MAP dialogues by invoking **MAP service primitives** (Fig 10.3)
- Four types
  - Request: IMSU issue a request.
  - Indication: RMSP indicate the request for RMSU.
  - Response: RMSU deliver the result of the request to RMSP.
  - Confirm : IMSP return the result to IMSU.

Fig 10.3

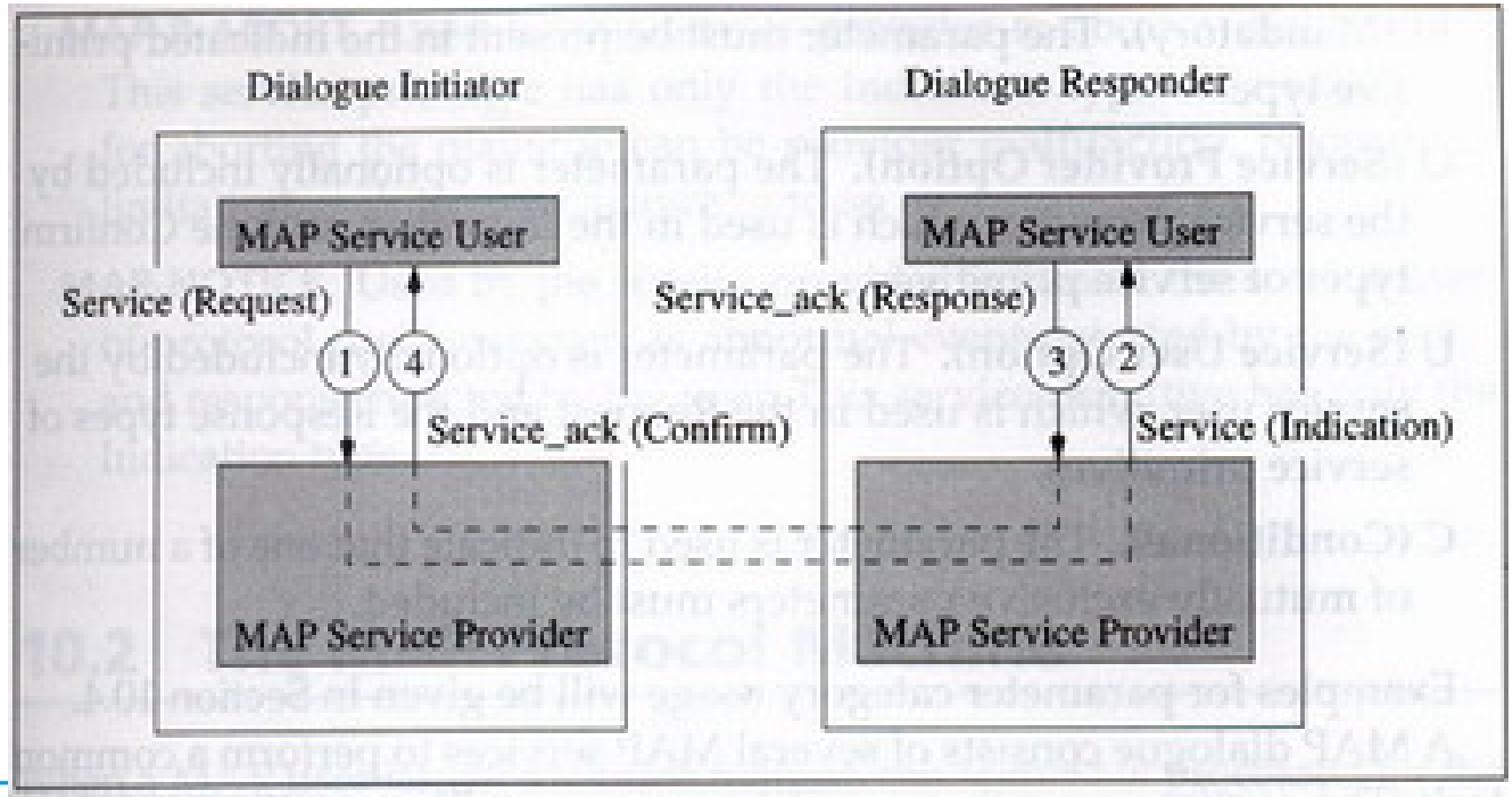
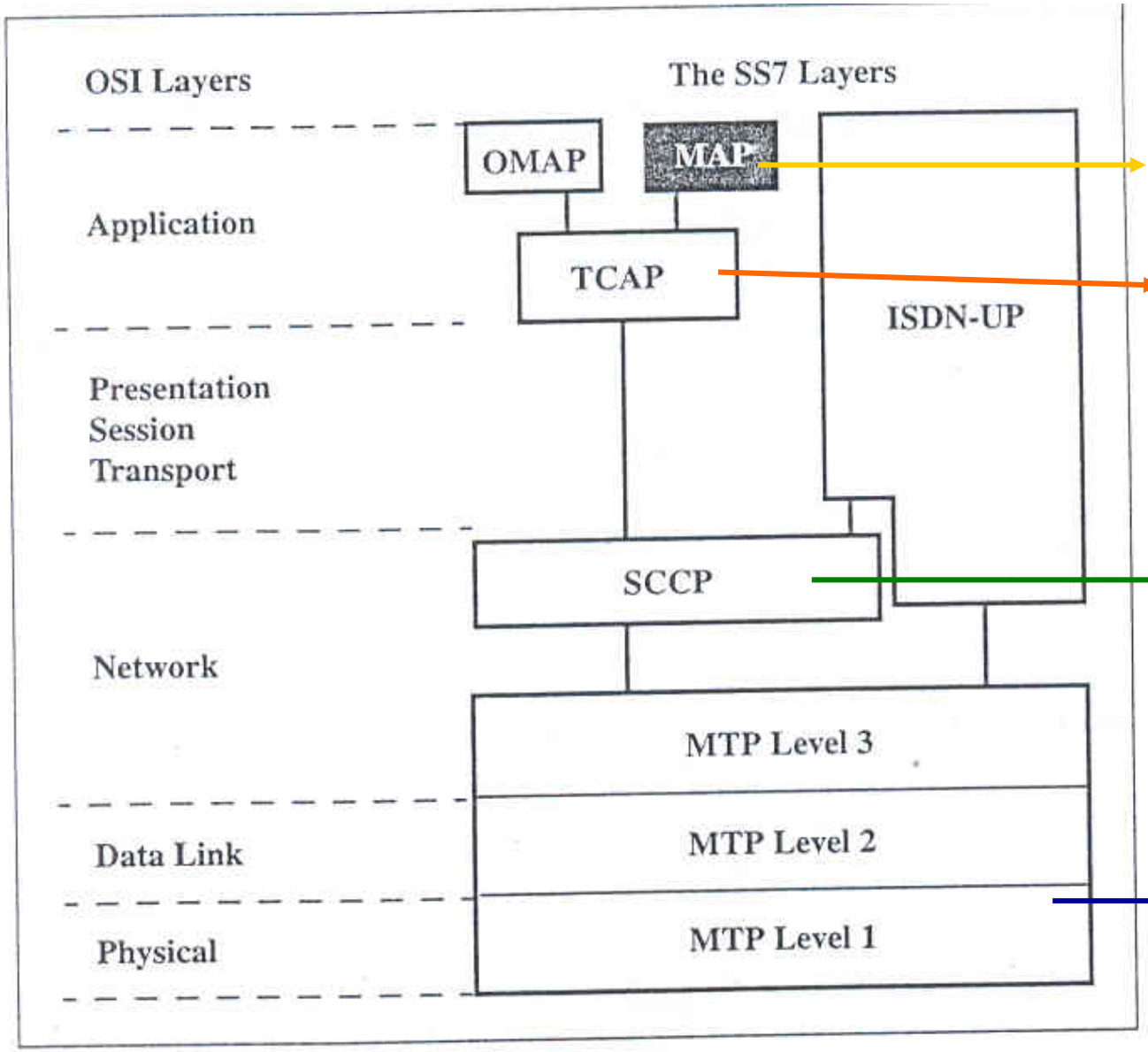


Figure 10.3 GSM MAP service model.

Cont.

- The service primitive
  - Dialogue initiator: The ASE send the request.
  - Dialogue responder: The ASE receive the request.
- The service provider delivers the request to the peer network entity, the dialogue responder, by using a lower-layer protocol such as TCAP (Transaction Capabilities Application Part) in SS7 (Signaling System No. 7)

Fig. 5.2



The Mobile Application Part

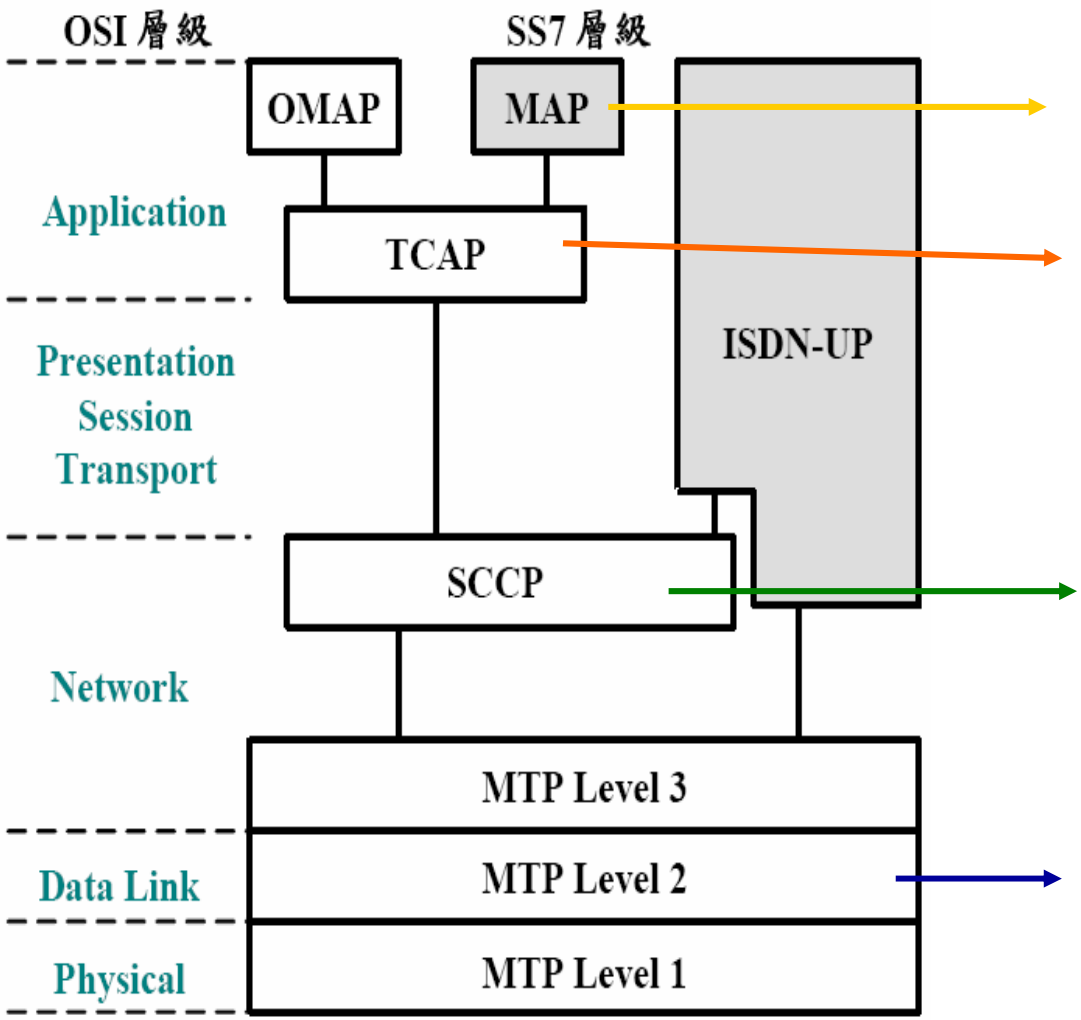
Transaction Capabilities Application Part

Signaling Connection Control Part

Message Transfer Part

Figure 5.2 The SS7 signaling protocol.

Fig. 5.2



The Mobile Application Part

Transaction Capabilities Application Part

Signaling Connection Control Part

Message Transfer Part

GSM MAP service model

- **Step 1.** IMSU sends a request to IMSP.
- **Step 2.**
  - IMSP delivers the request to the peer RMSP by using Transaction Capabilities Application Part (TCAP).
  - The RMSP invoke an Indication to inform the RMSU.

Fig 10.3

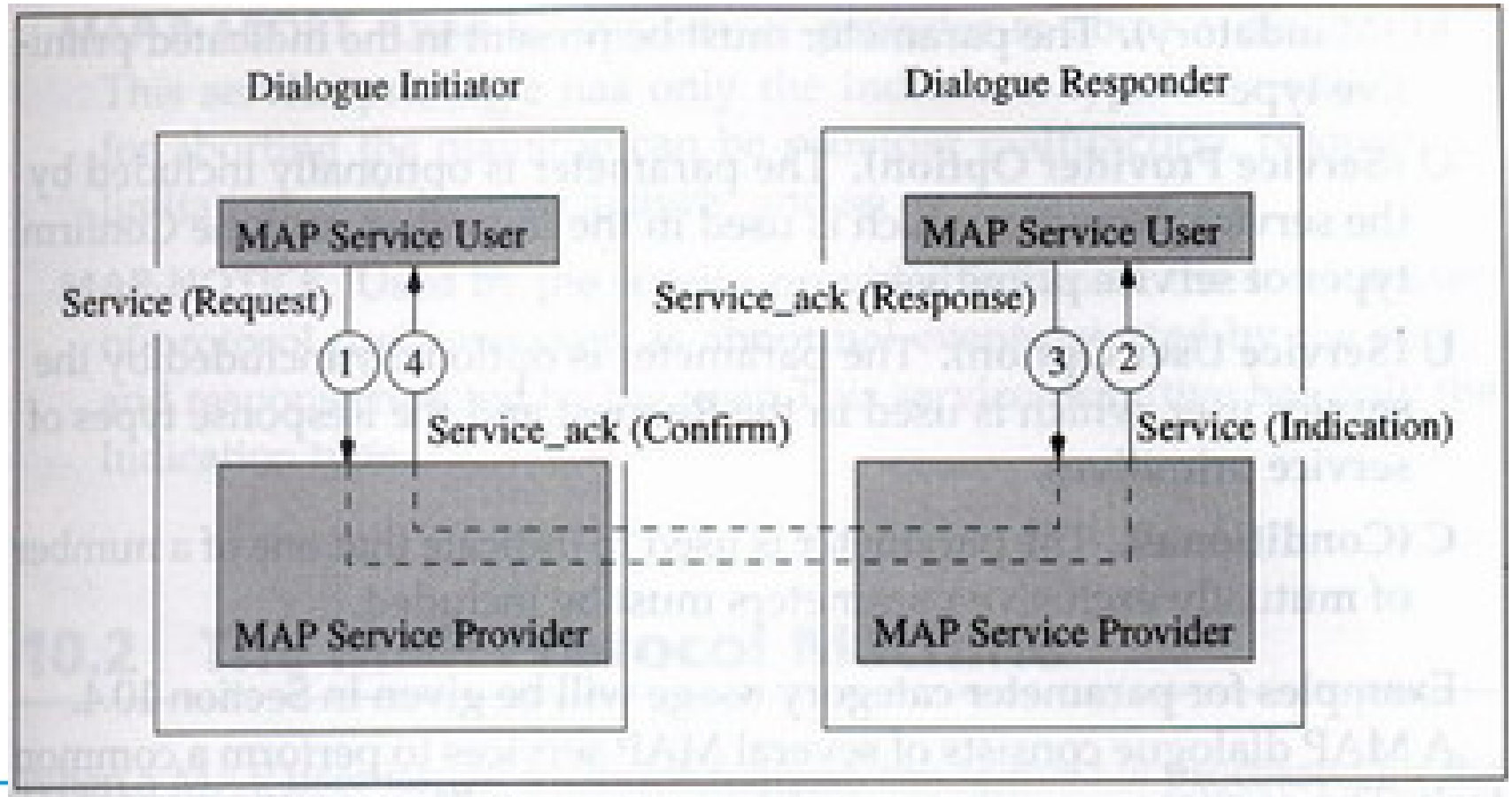


Figure 10.3 GSM MAP service model.

Cont.

- **Step 3.**
  - A response with corresponding acknowledgment, with results send from RMSU to RMSP.
  - The RMSP delivers the request to peer IMSP by using TCAP.
- **Step 4.** The IMSP invoke an confirm to inform the IMSU.

Common MAP Service

- Used to establish and clear MAP dialogue between peer MAP service users
  - **MAP-OPEN**
    - Used to establish a MAP dialogue, confirmed by the service provider, has Request, Indication, Response and Confirm types.
  - **MAP-CLOSE**
    - Used to close a MAP dialogue, not confirmed by the service provider, only has Request and Indication type.

Cont.

- **MAP-DELIMITER**
  - Used to explicitly request the TCAP to transfer the MAP protocol data units to the per entities.
  - The service without any parameters and is not confirmed by the service provider.
- **MAP-U-ABORT**
  - Used by the service user to abort a dialogue, the reason for abort can be resource limitation due to congestion, application error, and so on, only has Request and Indication type.

Cont.

- **MAP-P-ABORT**
  - Used by the service Provider to abort a dialogue, the reason for abort can be provider malfunction, resource limitation and so on, only has the Indication type.
- **MAP-NOTICE**
  - Used by the service provider to inform service user of protocol problems such as abnormal event or response rejected by the peer, the service primitive has only the Indication type.

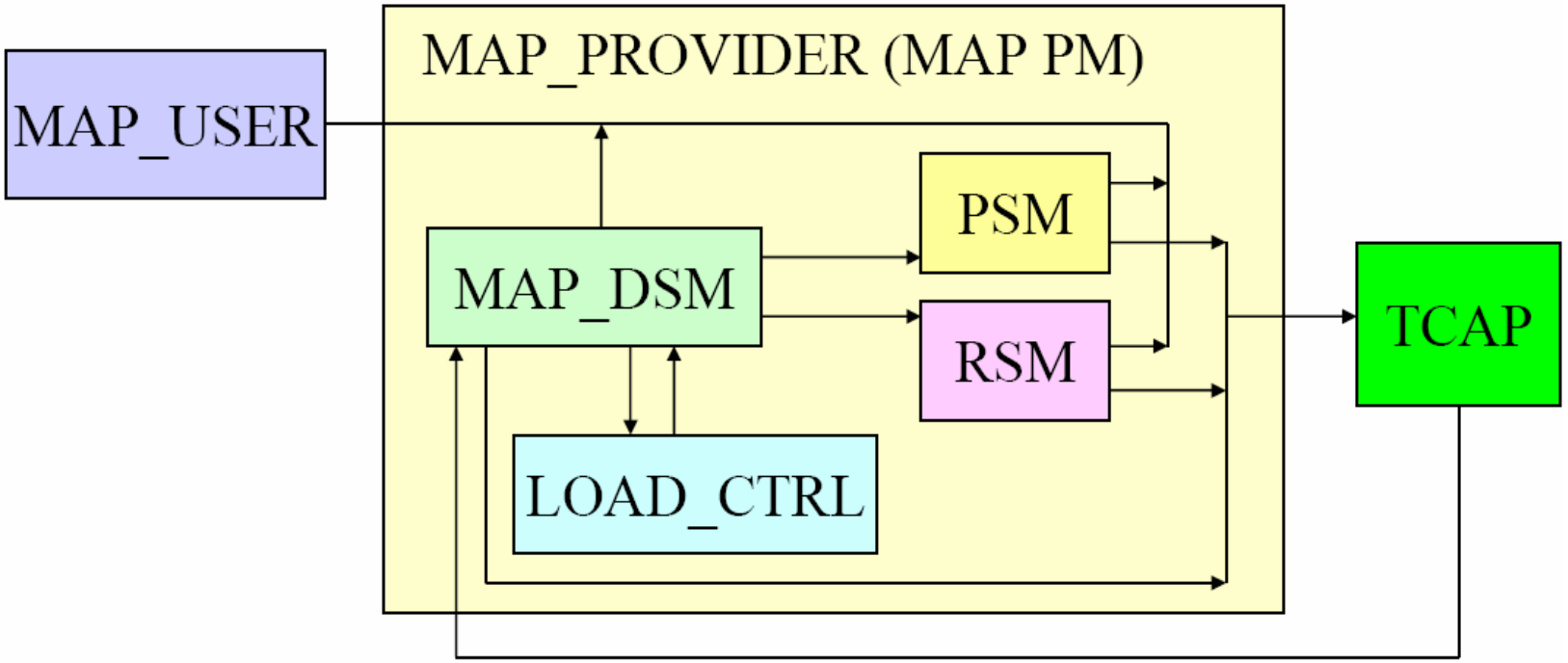
Specific MAP Service

- Mobility service
- Operation and maintenance services
- Call-handling services
- Supplementary service
- Short message service management services

10.2 The MAP Protocol Machine

- When a MAP user **issues a request**, the request is processed by the **MAP protocol machine (PM)** shown in Fig 10.4.
  - Dialogue state machine (DSM)
    - Coordinates the RSM or PSM.
    - For every MAP dialogue, an instance of DSM is created to handle the dialogue.
  - Requesting service state machine (RSM)
    - Handle a MAP service request, created by the DSM for each.
    - And for every service primitive, a RSM is created by the DSM at the initiator's side.

Fig. 10.4



MAP PM: MAP Protocol Machine
MAP_DSM: MAP Dialogue State Machine
PSM: Performing MAP Service State Machine
RSM: Requesting MAP Service State Machine
LOAD_CTRL: Load Control

10.2 The MAP Protocol Machine

- Performing service state machine (PSM)
  - Handle a MAP service performing, created by the DSM for each.
  - And for every service primitive, a PSM is created by the DSM at the performer's side.

Cont.

- Load Control
  - Monitors the traffic generated by the service.
  - There is only one instance of this process in each system, if an overload is detected, low-priority MAP operations may be ignored.
  - GSM spec. suggested the priority level from high to low is Handoff, mobility management, short message services, subscriber-controlled-input.

10.3 The MAP Dialogue (Fig 10.5)

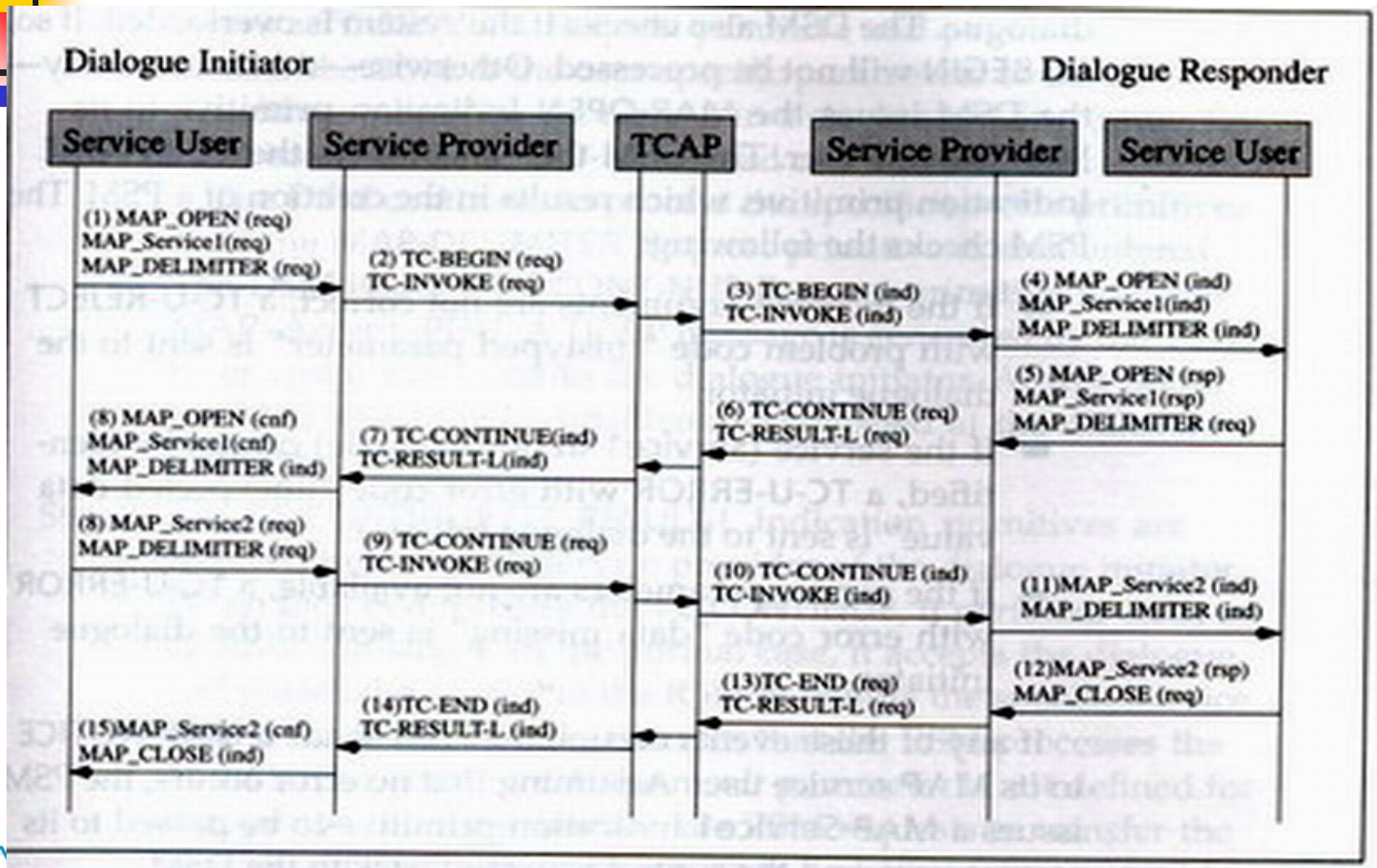
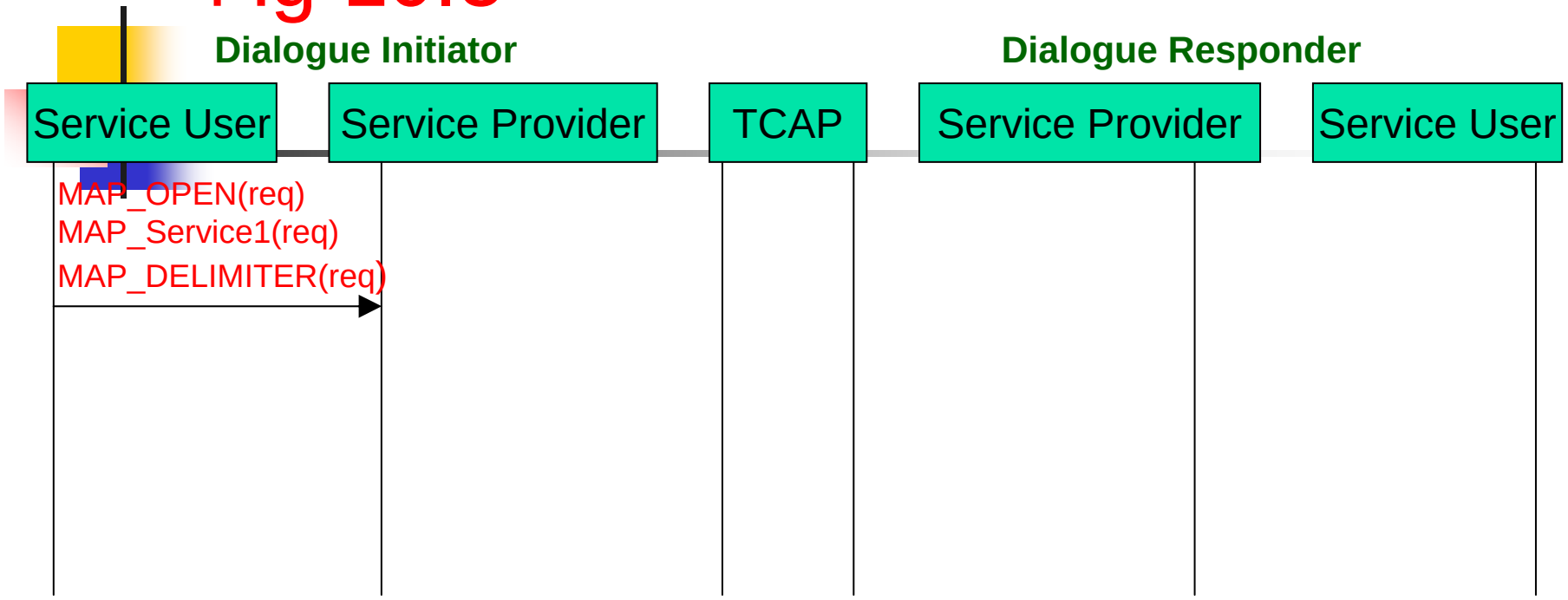


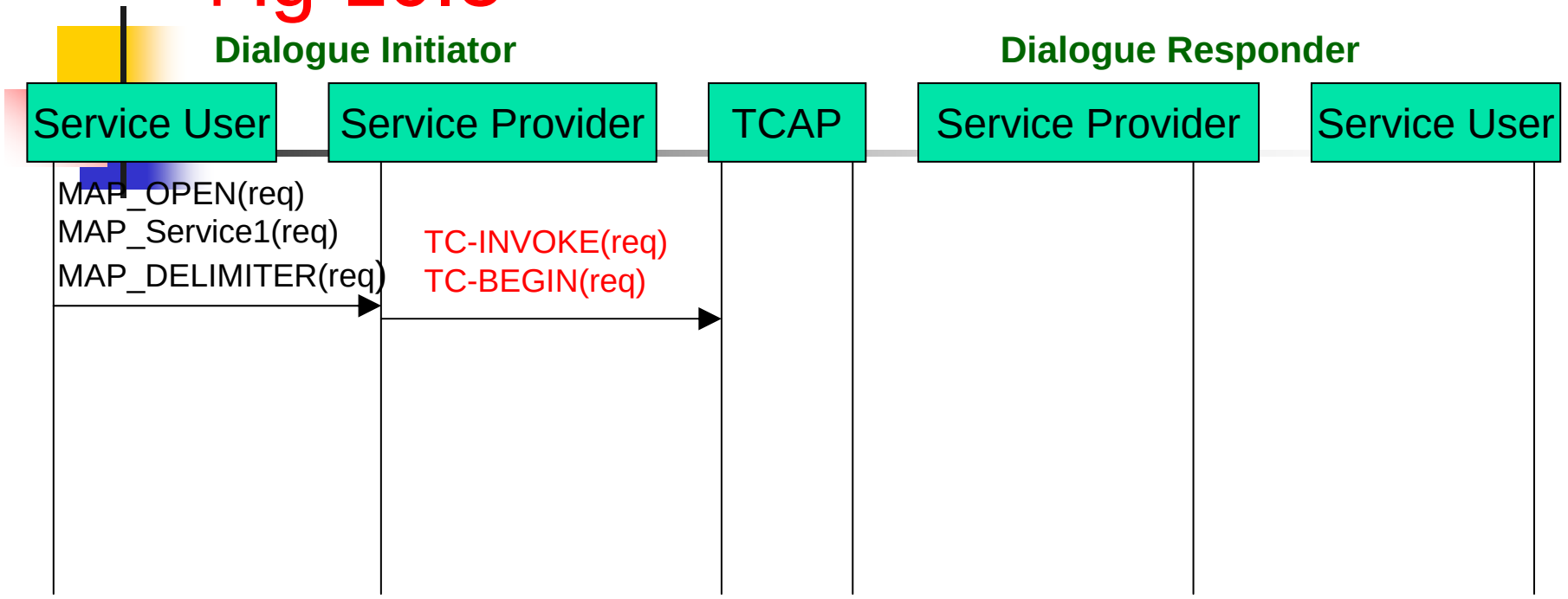
Figure 10.5 Example of MAP dialogue.

Fig 10.5



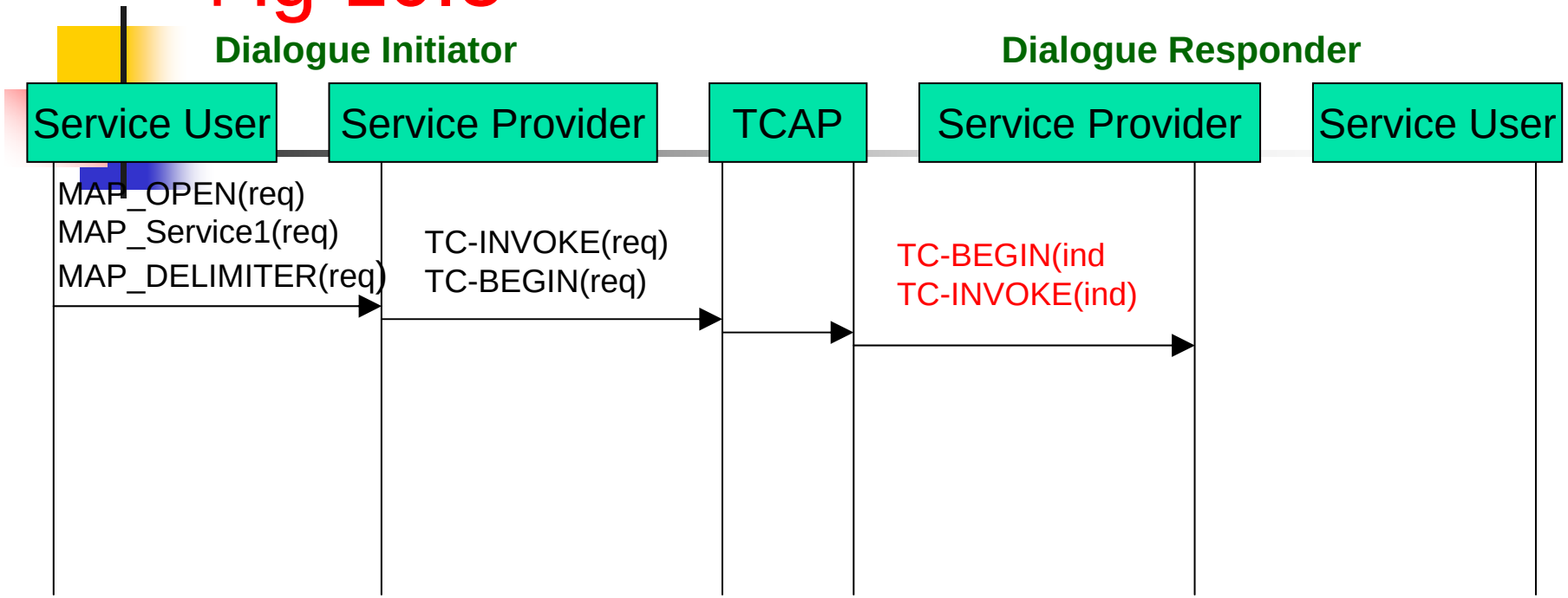
- A service user initiates a MAP dialogue by invoking the **MAP-OPEN** request service primitive.
- **MAP_SERVICE1** is a specific service primitive.
- Then **MAP_DELIMITER** to request TCAP.

Fig 10.5



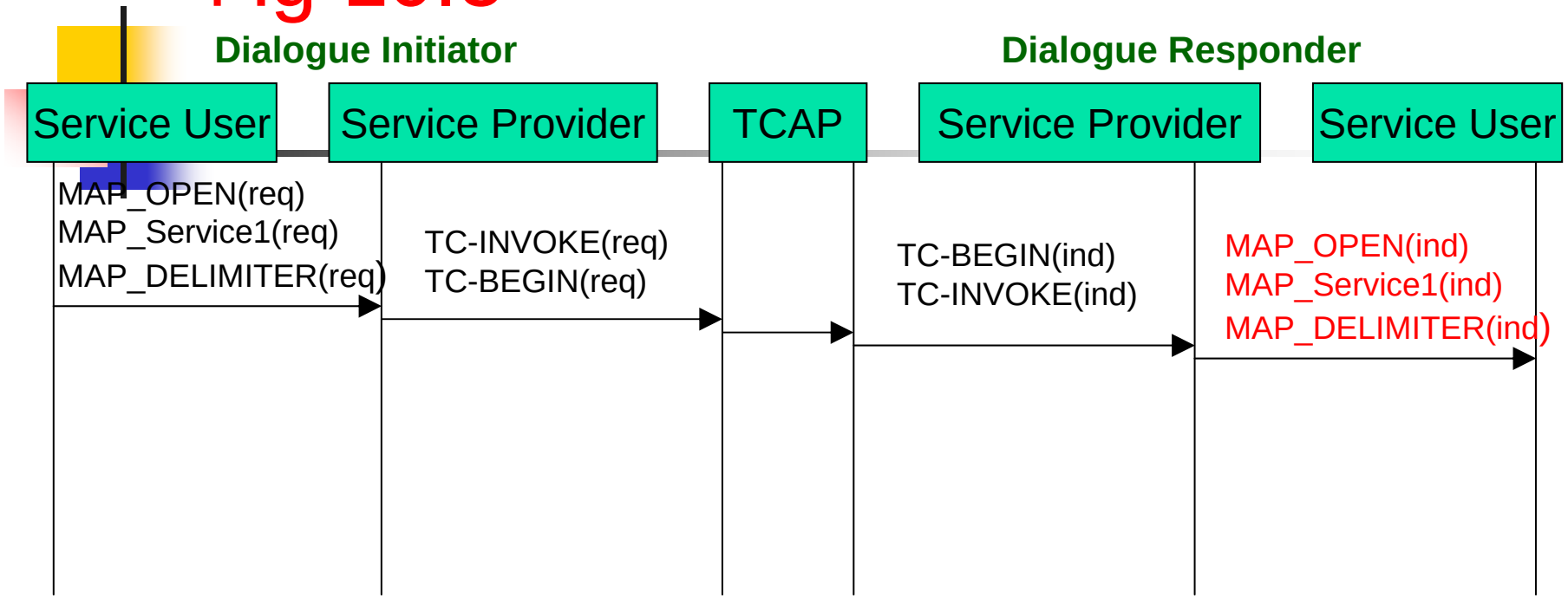
- MAP PM creates a DSM to handle the MAP-OPEN, DSM creates a RSM to use the TC-INVOKE to set TCAP parameters and operation code.
- When MAP_DELIMITER receive, MAP PM enables the TC-BEGIN and wait for response from TCAP.

Fig 10.5



- The TC-* request primitives will be delivered by the TCAP and lower-layer protocol SS7 to the peer MAP PM.
- The primitives type now are **Indication**.

Fig 10.5



- If DSM identified any error from the received TC-BEGIN Indication, a TC-U-ABORT is send back.
- else DSM issues the MAP-OPEN to its user.
- DSM invoke PSM to handle TC-Invoke.

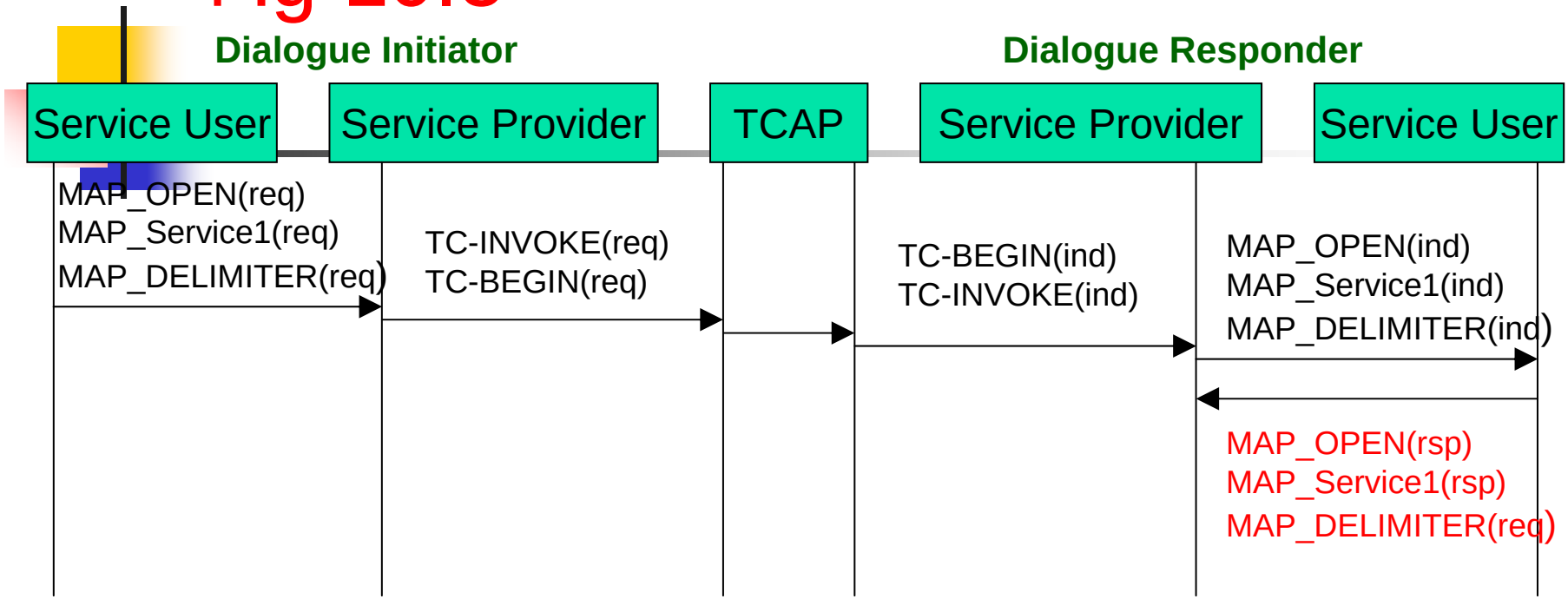
Cont.

- PSM will check
  - Receive arguments error then TC-U-REJECT send back.
  - Service cannot be identified or service parameters are not available then TC-U-ERROR send back.
  - If any error occurs, PSM sends a MAP-NOTICE to its user.
- Assuming no error, PSM issues a MAP-Service1 to its user and passed back control.

Cont.

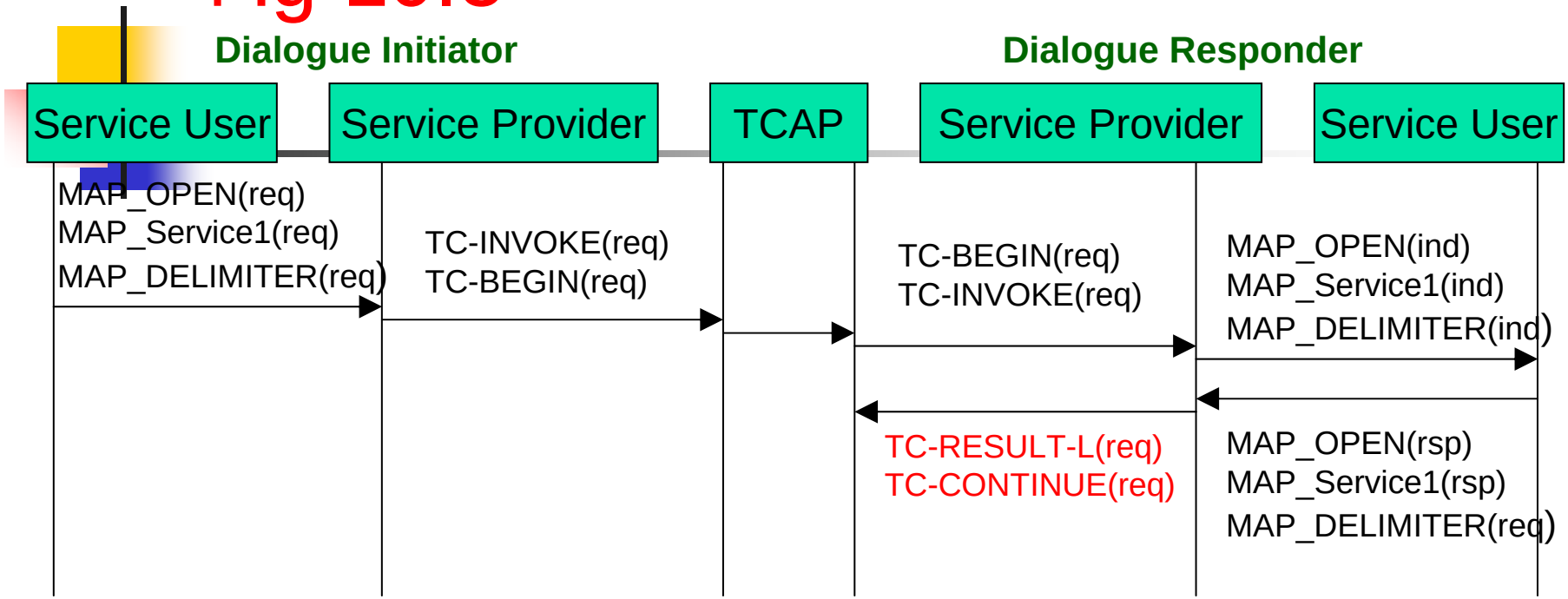
- After MAP-DELIMITER inform to its user, the MAP PM waits for a MA_OPEN response from its user.

Fig 10.5



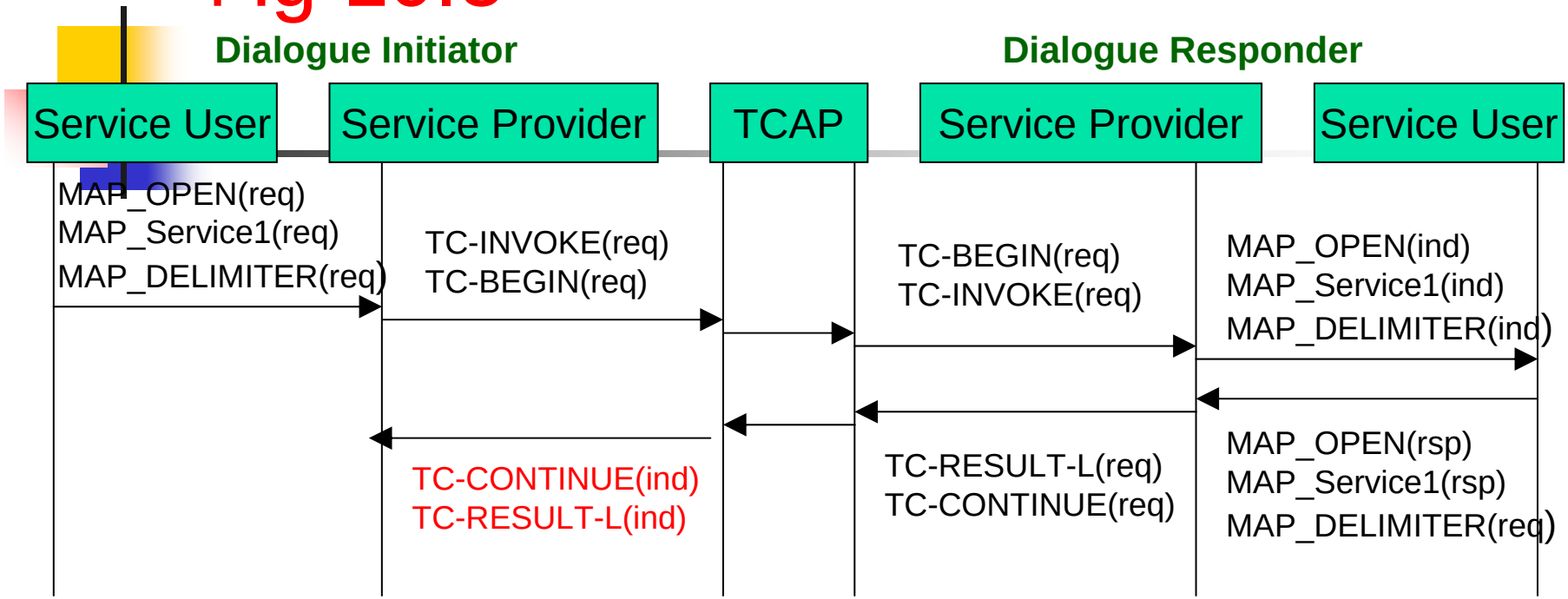
- The user process the **Indication** primitives and returns the results with **MAP_OPEN** and the MAP_Service1.
- Then MAP_DELIMITER request.

Fig 10.5



- When MAP PM receives the response, DSM generated a **MAP_Accept_PDU** (protocol data unit).
- PSM handle MAP_Service1 issues a TC-RESULT-L and until MAP_DELIMITER received, issues a TC-CONTINUE with MAP_Accept_PDU.

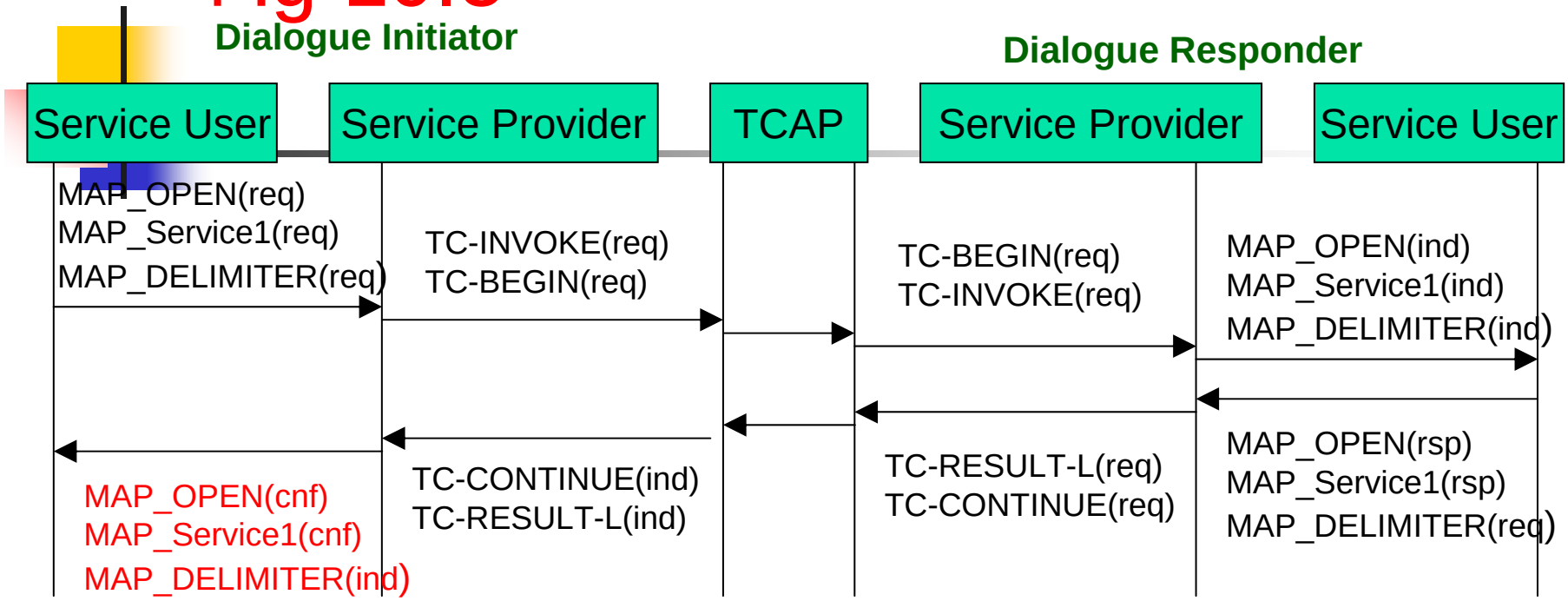
Fig 10.5



- The DSM of **provider of initiator**, receives the TC-CONTINUE pass the control to the RSM.
- RSM processes the TC-RESULT-L, then maps that parameters to the MAP-SERVICE1.

DSM informs the MAP service user.

Fig 10.5



- The user handle the confirm primitives and possibly makes new requests.

Fig 10.5

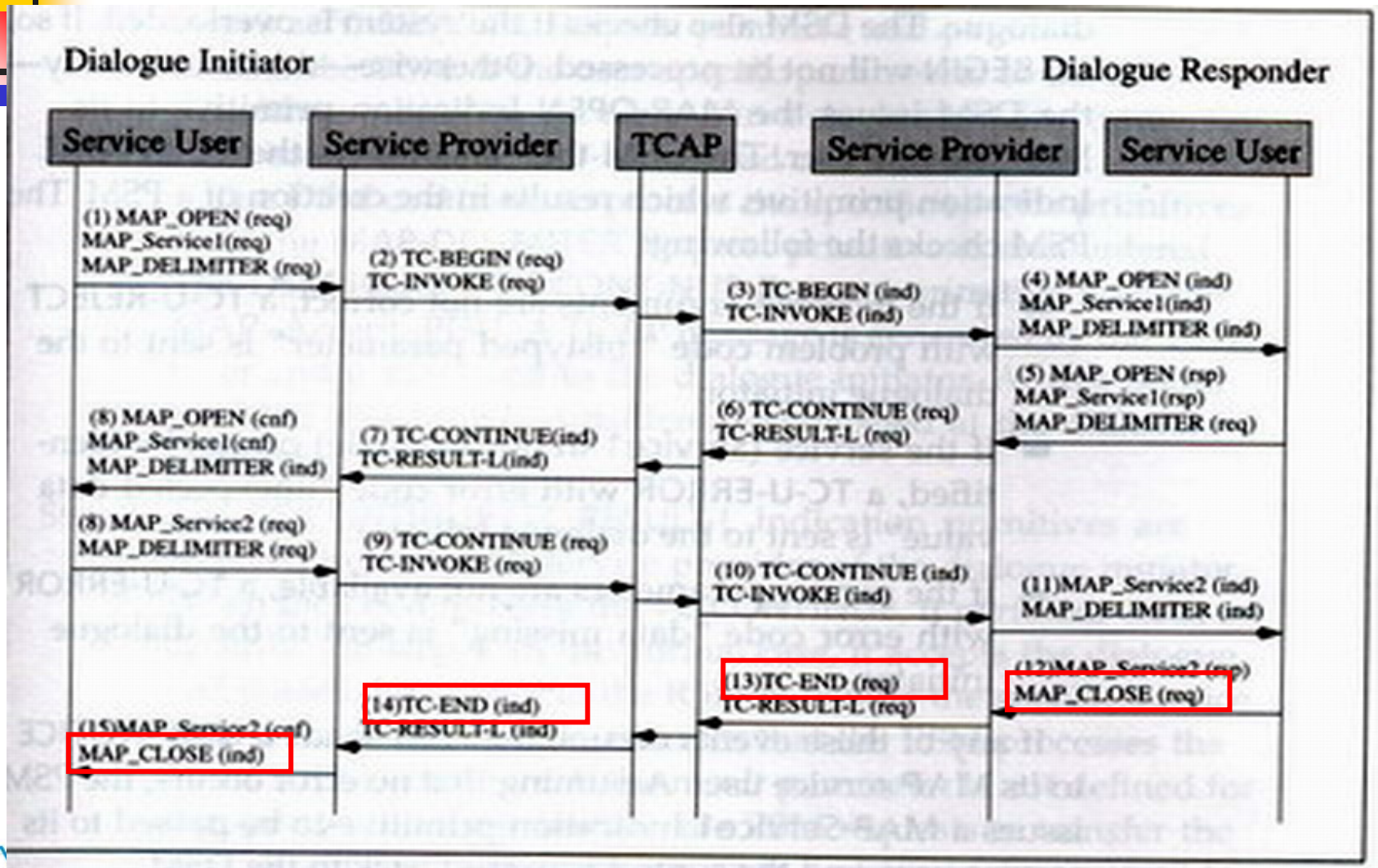


Figure 10.5 Example of MAP dialogue.

10.4 Example of MAP Service Primitives

- Consider the call delivery process where a PSTN user calls a GSM subscriber, retrieval of routing information Fig 10.6.
  - When a user dialed, set up by the SS7 ISUP message IAM to a specific GMSC, that to ask the HLR for routing information.
  - HLR requests the current VLR of the MS to provide the roaming number. VLR send this number to GMSC through the HLR.
  - With the roaming number is set up from the GMSC to the destination MSC by IAM message.

Fig 10.6

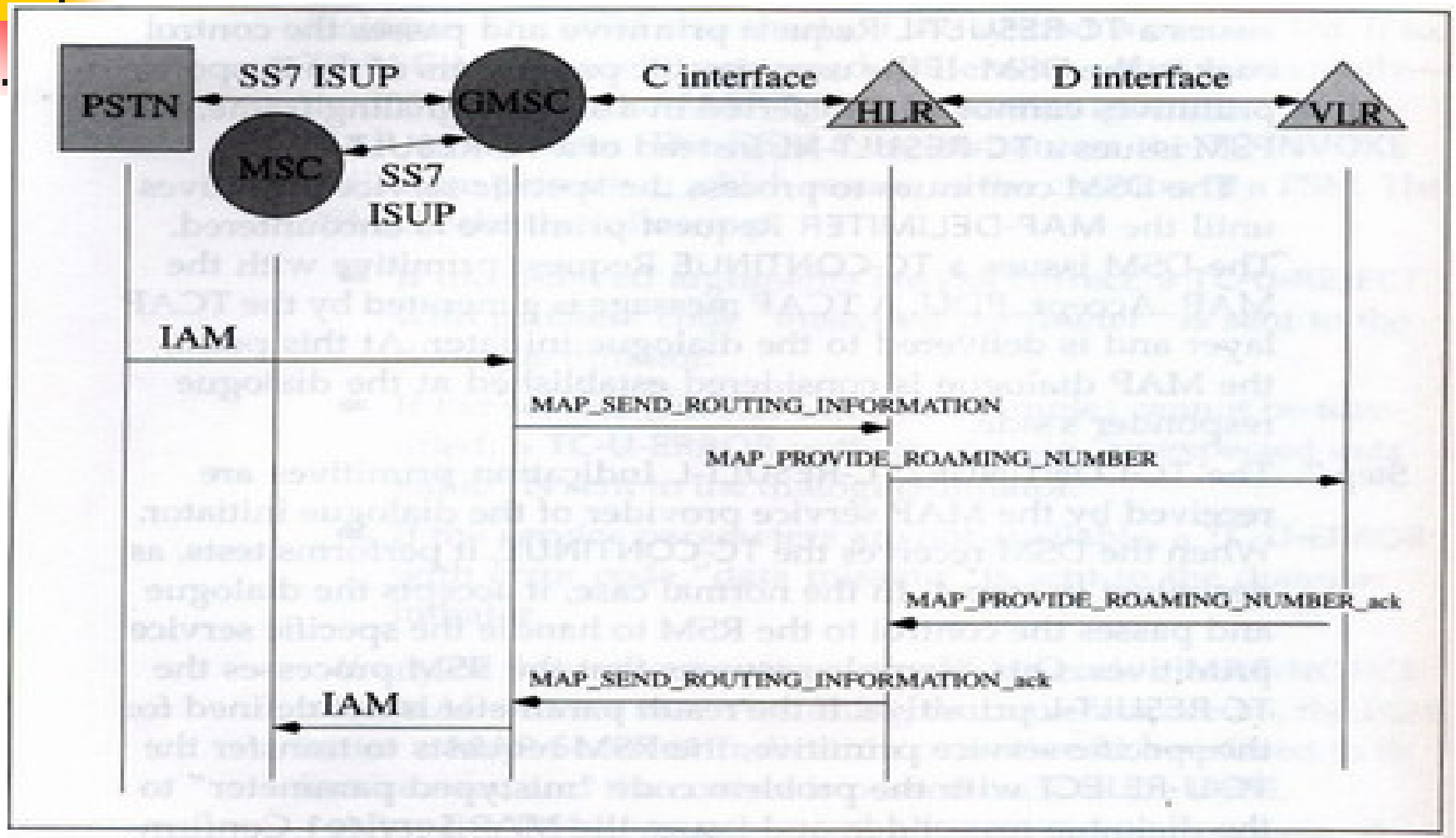


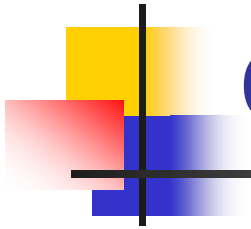
Figure 10.6 Retrieval of routing information.

TABLE 10.2(a)

Table 10.2 Primitives for Routing Information Retrieval

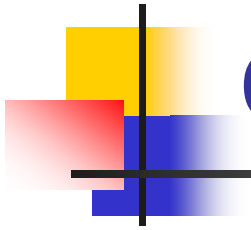
PARAMETER NAME	REQUEST	INDICATION	RESPONSE	CONFIRM
Invoke ID	M	M(=)	M(=)	M(=)
MSISDN	M	M(=)		
CUG Interlock	C	C(=)	C	C(=)
CUG Outgoing Access	C	C(=)	C	C(=)
Number of Forwarding	C	C(=)		
Network Signal Info	C	C(=)		
IMSI			C	C(=)
MSRN			C	C(=)
Forwarding Data			C	C(=)
User Error			C	C(=)
Provider Error				O

(a) MAP_SEND_ROUTING_INFORMATION Parameters



Cont.

- The parameters of service primitive type have four categories
  - M (Mandatory)
    - Must be present in the indicated primitive type.
  - O (Service Provider Option)
    - Optionally included by the service provider, which used in the Indication and the Confirm type.



Cont.

- U (Service User Option)
  - Optionally included by the service User, which used in the Request and the Response type.
- C (Conditional)
  - Indicate one of a number of mutually exclusive parameters must be included.

MAP _SEND_ROUTING_INFORMATION

- Invoke ID
  - A unique number generated by the user to identify the corresponding service in the MAP service user-provider interface.
- MSISDN
  - That is “telephone number” of the MS.
- CUG Interlock
  - The closed user group interlock code. Defined in ETS 300-138 specification.
  - CUG defines a group of users with specific network services.

Cont.

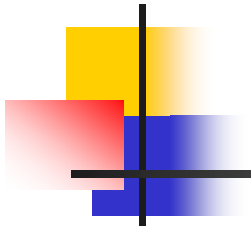
- CUG Outgoing Access

Cont.

- Number of Forwarding
  - Counts the number of times then the call has been forwarded.
- Network Signal Info
  - Provides external signal information, that is the signaling protocol between the GSM network and the PSTN.
- IMSI (International Mobile Subscriber Identity)
  - Used to identify the call MS, but not known to the GSM user, used by GSM network only, stored in the SIM, HLR, VLR.

Cont.

- MSRN (Mobile Subscriber Roaming Number)
  - The routing number that identifies the current location of the MS, MSRN is temporary network identity assigned during the call establishment to a mobile.
- Forwarding Data
  - The address to which a call is to be forwarded, used to invoke the call-forwarding service.



- User Error
  - Sent by the responder when error is detected.
  - Unknown subscriber.
  - System failure.
  - Data missing etc..

TABLE 10.2(a)

PARAMETER NAME	REQUEST	INDICATION	RESPONSE	CONFIRM
Invoke ID	M	M(=)	M(=)	M(=)
IMSI	M	M(=)		
MSC Number	M	M(=)		
MSISDN	C	C(=)		
LMSI	C	C(=)		
GSM Bearer Capability	C	C(=)		
Network Signal Info	C	C(=)		
MSRN			C	C(=)
User Error			C	C(=)
Provider Error				O

(b) MAP_PROVIDE_ROAMING_NUMBER Parameters

MAP _PROVIDE_ROAMING_ NUMBER

- MSC Number
  - The ISDN number of the MSC where the called MS resides.
- LMSI (local Mobile Station Identity)
  - Used by the VLR for internal data management of the calls MS.
- GSM Bearer capability
  - Included if the connection is for nonspeech services such as short message services.

10.5 Summary

- Overview to the MAP protocol used in the GSM.
- Described the general platform of MAP service primitives and provided an example.
- Primitives with services , service with parameters .