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Chapter 8
Multicast for Mobile Multimedia Messaging Service

(text book: chapter 11)

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Outline

- Existing Multicast Mechanisms for Mobile Networks
- The SMS Multicast Approach
  - Location Tracking of the Multicast Members
  - Mobile Multicast Message Delivery
- The MMS Multicast Approach
  - Location Tracking of the Multicast Members
  - Mobile Multicast Message Delivery
- Concluding Remarks
- Questions

Abstract

- **Chapter 8** discusses short message multicast mechanisms in the Circuit Switched (CS) domain and a multicast mechanism in the Packet Switched (PS)-domain MMS.
- The PS multicast approach is based on the **cell broadcast service** architecture.
- We propose a new interface between the cell broadcast center and the SGSN to track the current locations of the multicast members.
- We describe location tracking procedures (including attach, detach, and location update) for multicast members, and the multicast message delivery procedure.

Cont.

- The implementation and execution of the multicast table are so efficient that the cost for updating this table can be ignored compared to the standard mobility management procedures.

Introduction

- Existing 2G systems support *Short Message Service* (*SMS*), which allows mobile subscribers to send and receive simple text messages (e.g., up to 140 bytes in GSM).
- In the 2.5G systems (e.g., GPRS) and the 3G systems (e.g., UMTS), *Multimedia Messaging Service* (*MMS*) is introduced to deliver messages of sizes ranging from 30K bytes to 100K bytes

Cont.

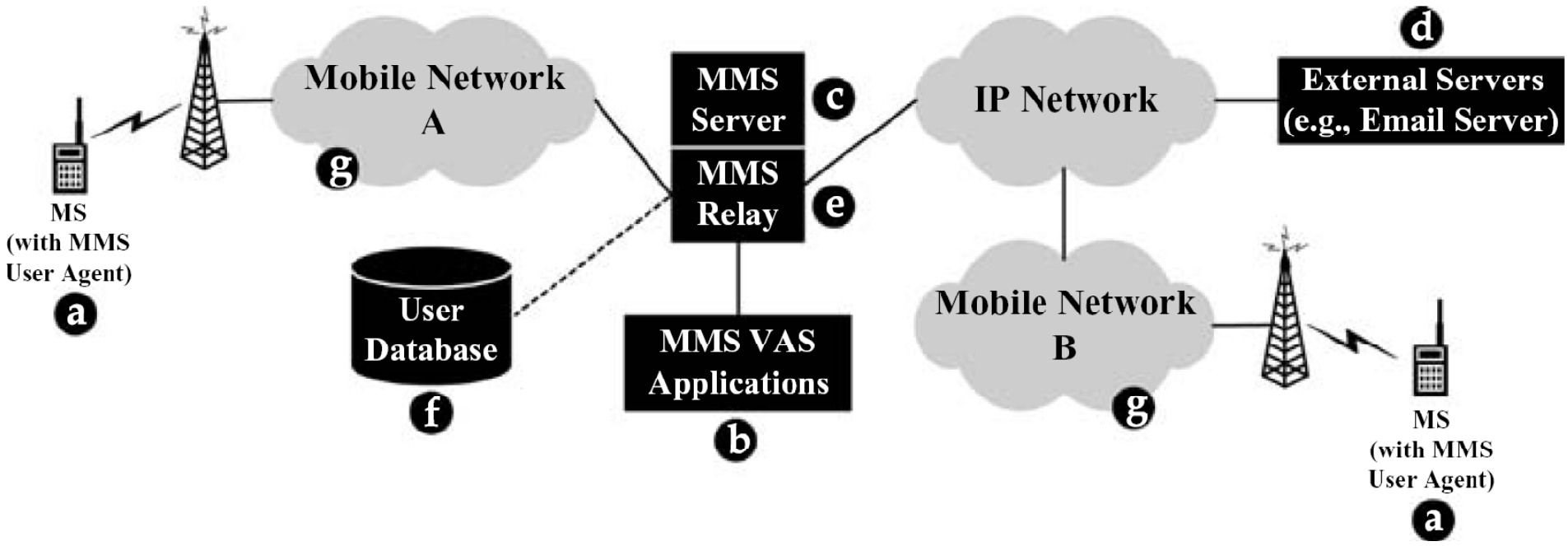
- The content of an MMS can be text (just like SMS), graphics (e.g., graphs, tables, charts, diagrams, maps, sketches, plans, and layouts), audio samples (e.g., MP3 files), images (e.g., photos; see Figure 11.1), video (e.g., 30-second video clips), and so on.

Fig. 11.1 An Example of Photo MMS

Cont.

- Figure 11.2 illustrates an abstract view of the MMS architecture
  - In this architecture, the MMS user agent (Figure 11.2 (a)) resides in a Mobile Station (MS) or an **external device connected to the MS**, which has an application-layer function to receive the MMS.
  - The MMS can be provided by the **MMS value-added service applications** (Figure 11.2 (b)) connected to the mobile networks or by the external servers (e.g., email server, fax server; see Figure 11.2 (d)) in the IP network.

Fig. 11.2 Multimedia Messaging Service Architecture



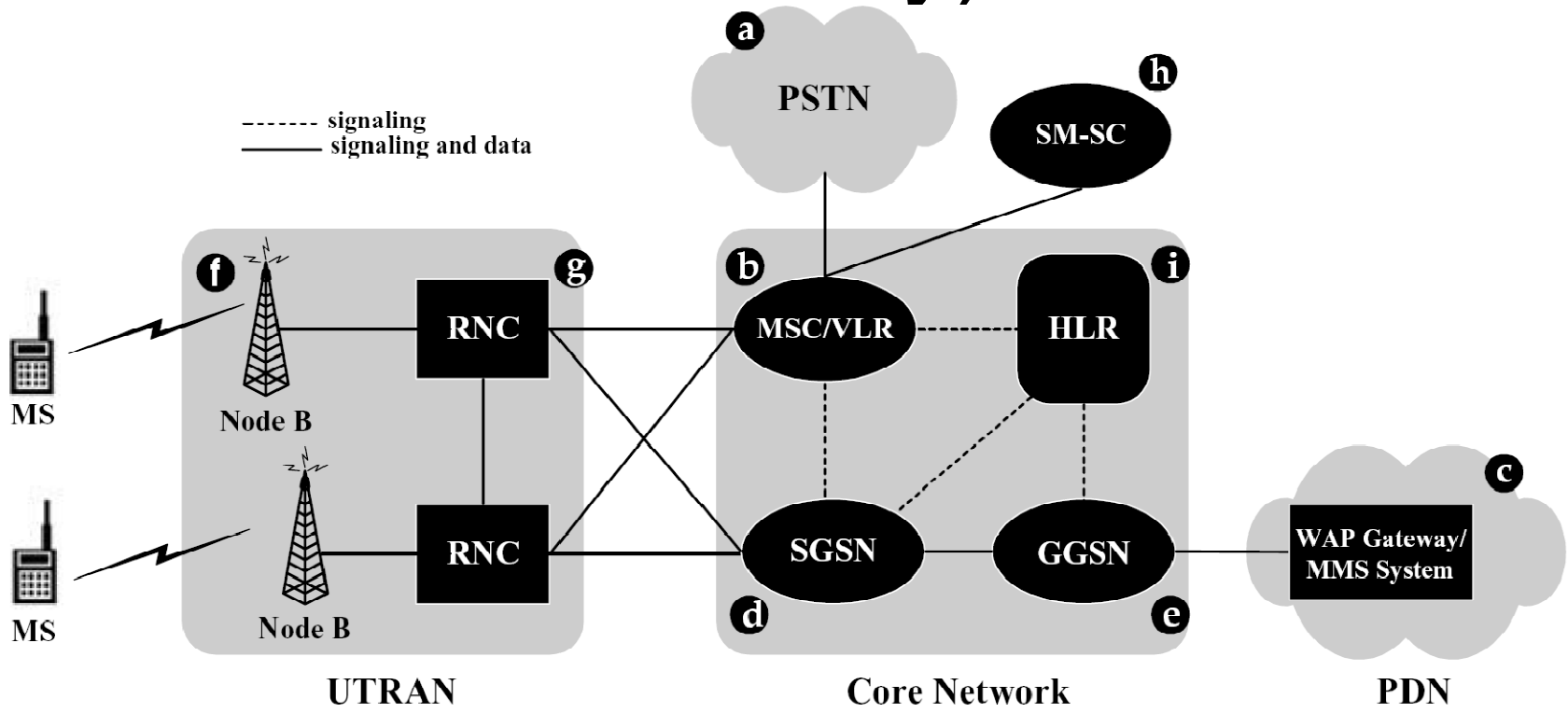
Cont.

- The **MMS server** (Figure 11.2 (c)) stores and processes incoming and outgoing multimedia messages.
- The **MMS relay** (Figure 11.2 (e)) transfers messages between different messaging systems, and adapts messages to the capabilities of the receiving devices.
  - It also generates **charging data** for **billing** purposes. The MMS server and the relay can be separated or combined.
- The **MMS user database** (Figure 11.2 (f)) contains user subscriber data and configuration information.

Cont.

- The mobile network can be a *WAP* (*Wireless Application Protocol*) based 2G, 2.5G, or 3G system (Figure 11.2 (g)).
  - Connectivity between different mobile networks is provided by the Internet protocol.
- We consider **UMTS** as the mobile network for MMS. For illustration purposes, Figure 11.3 redraws Figure 2.1.

Fig. 11.3 UMTS Network Architecture (with SM-SC and WAP Gateway)



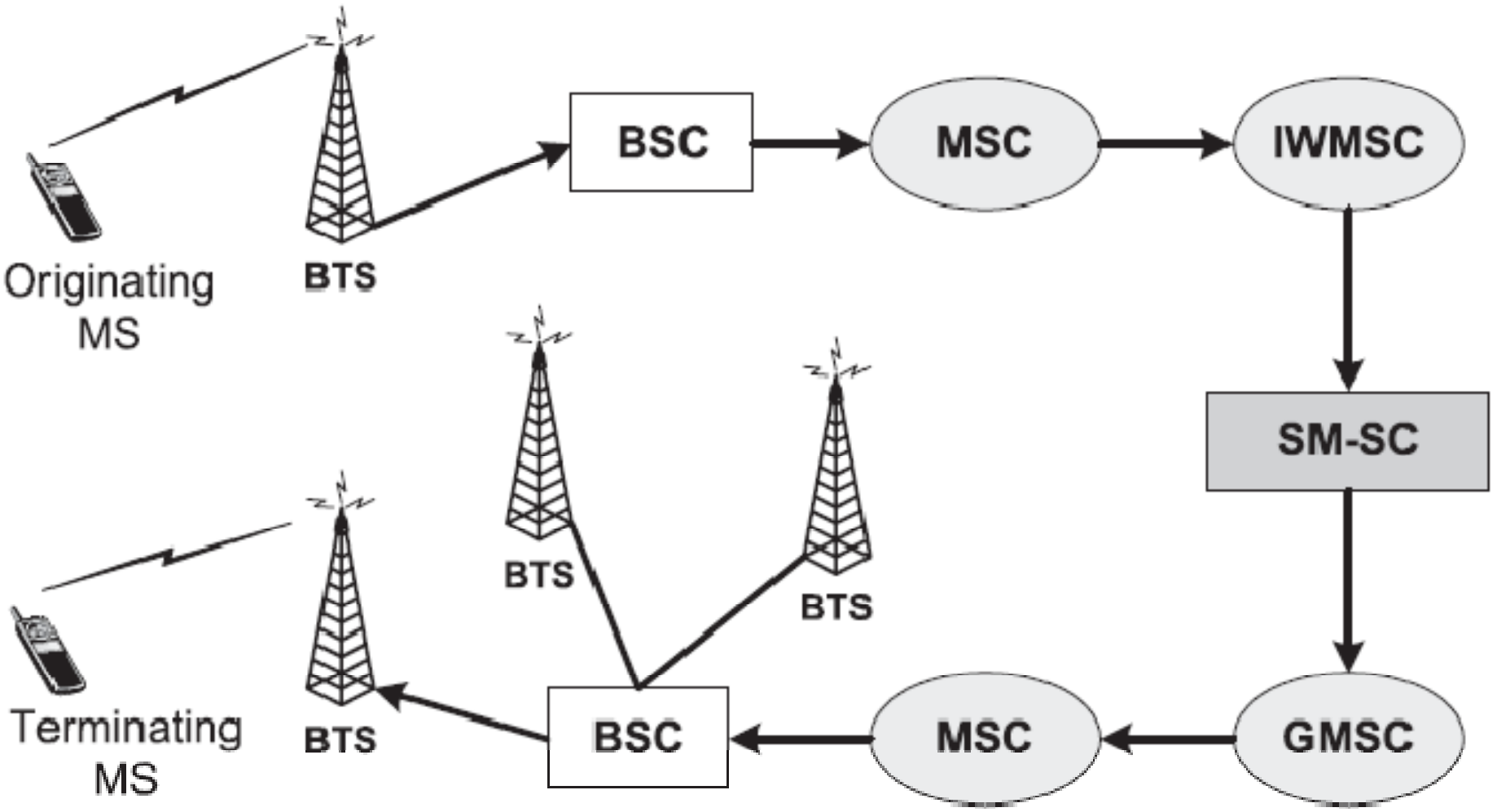
HLR: Home Location Register
MS: Mobile Station
PSTN: Public Switched Telephone Network
SGSN: Serving GPRS Support Node
VLR: Visitor Location Register
PDN: Packet Data Network

GGSN: Gateway GPRS Support Node
MSC: Mobile Switching Center
RNC: Radio Network Controller
SM-SC: Short Message Service Center
Node B: Base Station
UTRAN: UMTS Terrestrial Radio Access Network

Cont.

- In UMTS, short messages are delivered through the control plane of the **CS** domain.
- The short message is issued from a message sender (e.g., an MS or an input device) to a Short Message Service Center (**SM-SC**; Figure 11.3 (h)).
- As described in Chapter 1, the SM-SC is connected to a specific Mobile Switching Center (MSC; Figure 11.3 (b)) called the *Short Message Service Gateway MSC* (***SMS GMSC***).

Fig. 1.1 GSM Short Message Service Network Architecture



Cont.

- The SM-SC may connect to several mobile networks, and to several SMS GMSCs in a mobile network.
- Following the **UMTS roaming protocol**, the SMS GMSC locates the current MSC of the message receiver by querying the Home Location Register (**HLR**; Figure 11.3 (i)), and forwards the message to that MSC.

Cont.

- Then the MSC broadcasts the message to the UMTS Terrestrial Radio Access Network (**UTRAN**; Figure 11.3 (g))
- The corresponding **Node Bs** (Figure 11.3 (f)) **page** the destination MS.
- **Messages** can be stored either in the **SIM card** or in the **memory** of the *mobile equipment* for display on the standard screen of the MS.

Cont.

- Multimedia messages can be delivered through either the user plane of the **PS** or the **CS** domain.
- Without loss of generality, we assume that multimedia messages are transmitted over the user plane of the **PS** domain.
- In the existing MMS architectures, the mechanisms for MMS unicast and broadcast are well defined.
- However, **no efficient multicast** mechanism has been proposed in the literature. In this chapter, we describe efficient multicast mechanisms for messaging.

11.1 Existing Multicast Mechanisms for Mobile Networks

- In order to track the MSs, the cells (i.e., the coverage area of Node Bs) in the UMTS service area are partitioned into several **LAs** (in the **CS** domain) and **RAs** (in the **PS** domain).
- As described in Chapter 2, an RA is typically a subset of an LA. To simply our discussion, this chapter assumes that an RA is equivalent to an LA.

Cont.

- To deliver services to an MS, the cells in the group covering the MS are paged to establish the radio link between the MS and the corresponding Node B.
- The **location change** of an MS is detected as follows:
  - The Node Bs periodically broadcast their cell identities. The MS listens to the broadcast cell identity, and compares it with the cell identity stored in the MS's buffer.

Cont.

  - If the comparison indicates that the location has been changed, then the MS sends the location update message to the network.
- The major task of mobility management is to update the location of an MS when it moves from one LA (RA) to another.
- The location information is stored in the UMTS mobility databases such as the **HLR**, the Visitor Location Register (**VLR**; Figure 11.3 (b)), and the **SGSN** (Figure 11.3 (d)).

Cont.

- In the **CS** domain, the **LA** of an MS is tracked by the **VLR**, and every VLR maintains the information of a group of LAs.
- In the **PS** domain, the **RA** of an MS is tracked by the **SGSN**, and every SGSN maintains the information of a group of RAs.

GSM/UMTS broadcast and multicast services

- **Approach I.** GSM voice group call service: This approach can be used to support MMS when the voice calls are replaced by multimedia messages.
- The GSM voice group call service is provided through a **broadcast** mechanism.
- Specifically, the call is delivered to all LAs when a voice call is destined to the multicast members. Every LA is paged, even when no multicast member is in that area.

Cont.

- **Approach II.** iSMS (see Chapter 1): In this approach, multicast is achieved by sending a message to every individual member in the multicast list. If *n* members are in an LA, then the same message is sent *n* times to this LA.

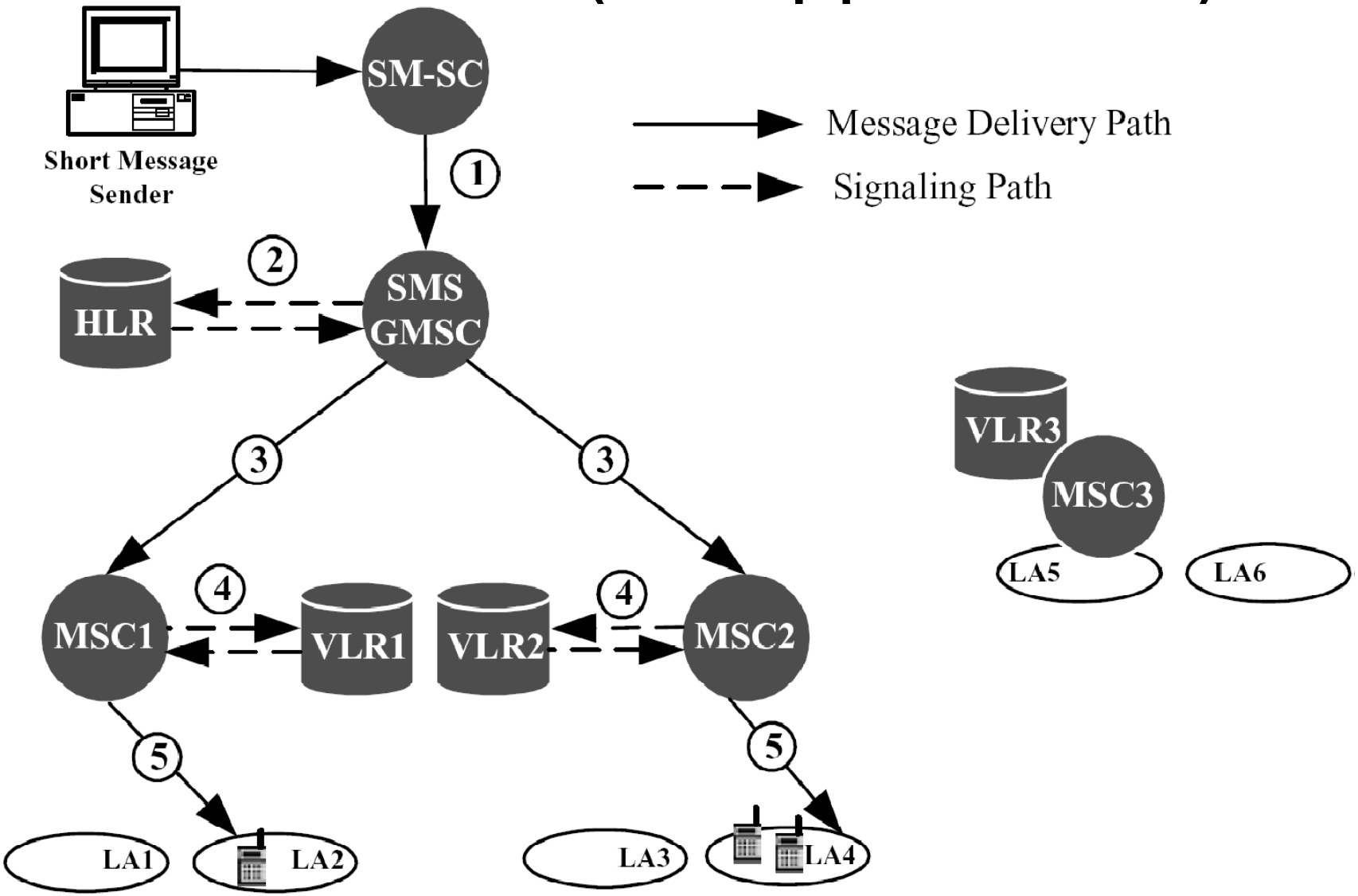
Cont.

- **Approach III.** GSM/UMTS short message multicasting based on multicast tables:
- In this approach, the short messages are only **delivered to the LAs where the multicast members currently reside**, and the LAs broadcast the messages to these MSs.
- The LAs without multicast members do not need to establish the communication link for short message transmission.

Cont.

- Approach III utilizes the existing GSM/UMTS short message architecture as shown in Figure 11.4.
- In this figure, there are three VLRs in the GSM/UMTS network:
  - VLR1, VLR2, and VLR3. VLR1 covers location areas LA1 and LA2. VLR2 covers location areas LA3 and LA4. VLR3 covers location areas LA5 and LA6.

Fig. 11.4 Short Message Multicast Architecture (for Approach III)



Cont.

- To perform multicast, the message sender first issues a short message to the SM-SC, and the SM-SC sends the message to the **SMS GMSC** associated with the multicast group (Figure 11.4 (1)).
- Then the SMS GMSC queries the HLR to identify the MSCs where the multicast members currently reside (Figure 11.4 (2)) and forwards the message to these **MSCs** (Figure 11.4 (3)).

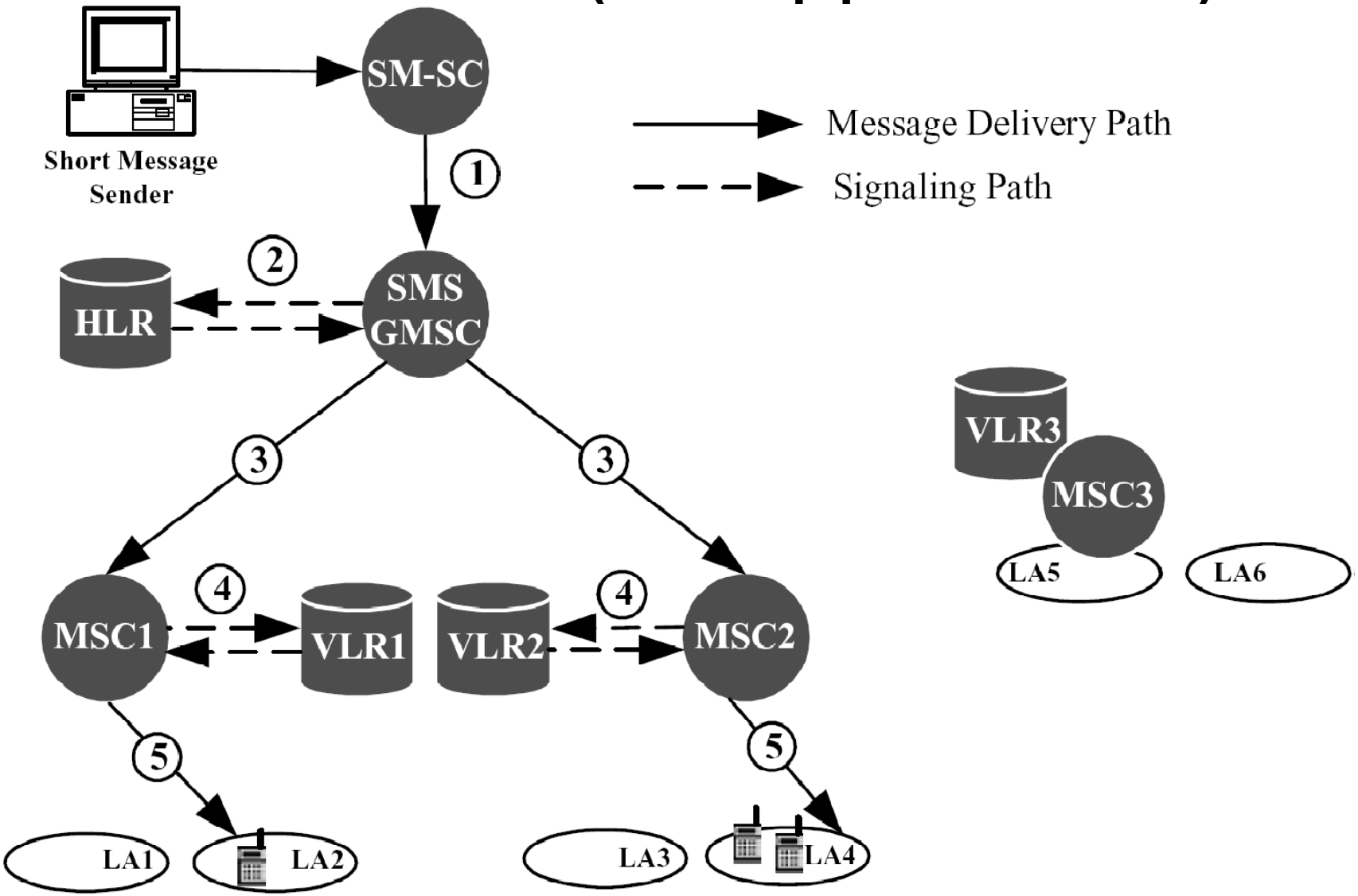
Cont.

- Upon receipt of the short message, the **MSCs** query the corresponding **VLRs** to identify the **LAs** where the multicast members currently reside (Figure 11.4 (4)) and page these LAs to establish the radio links (Figure 11.4 (5)).
- In Figure 11.4 the message delivery path for SMS multicast is (1) → (3) → (5).

Two types of tables are utilized in this multicast mechanism

- A table MC_H is implemented in the **HLR** to maintain the **addresses** of the **VLRs** and the **numbers of multicast members** residing in the VLRs.
- A table MC_V is implemented in every **VLR** to store the **identities** of the **LAs** and the **numbers of multicast members** in these LAs.

Fig. 11.4 Short Message Multicast Architecture (for Approach III)



In Figure 11.4

- $MC_H[VLR1] = 1$, $MC_H[VLR2] = 2$, and $MC_H[VLR3] = 0$
- For VLR1,
  - $MC_V[LA1] = 0$ and $MC_V[LA2] = 1$
- For VLR2,
  - $MC_V[LA3] = 0$ and $MC_V[LA4] = 2$
- For VLR3,
  - $MC_V[LA5] = 0$ and $MC_V[LA6] = 0$

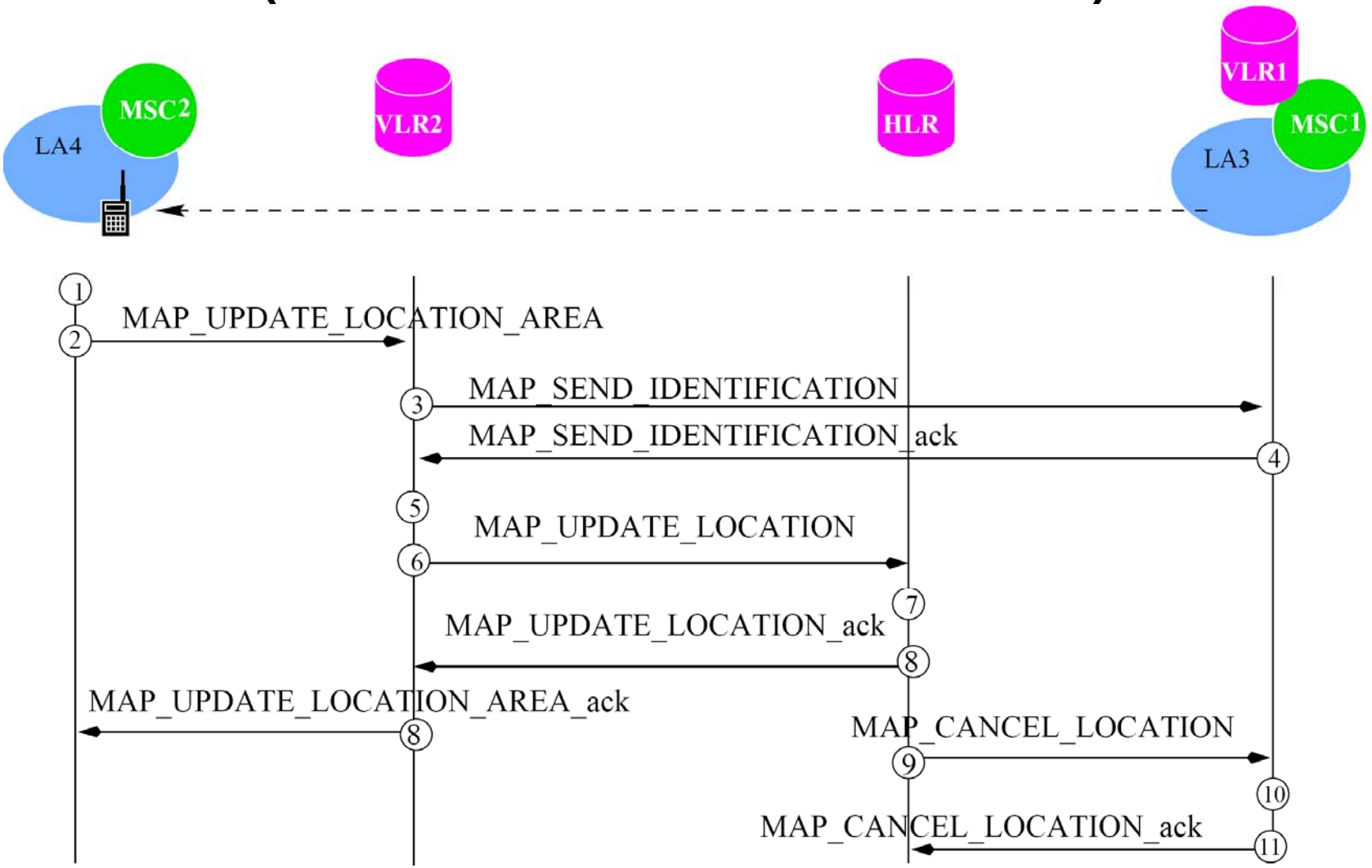
11.2 The SMS Multicast Approach III

- This section describes the CS-domain GSM/UMTS location update and multicast procedures in Approach III, and shows how the multicast tables MC_H and MC_V are maintained through these procedures.

11.2.1 Location Tracking of the Multicast Members

- **Step 1.** A location update request message is sent from the MS to MSC2. MSC2 sends the message MAP Update Location Area to VLR2.
- **Step 2.** Since the MS is a new visitor to VLR2, VLR2 does not have a VLR record of the MS. According to the message received from MSC2 at Step 1, VLR2 identifies the address of the previous VLR (i.e., VLR1).

Fig. 11.5 Registration for a Multicast Member in Approach III (Inter-VLR Movement)



Cont.

- **Step 3.** VLR2 sends the message MAP Send Identification to VLR1. The message provides information for VLR1 to retrieve the International Mobile Subscriber Identity (IMSI) of the MS in the database. IMSI uniquely identifies the HLR of the MS.
- **Step 4.** The IMSI is sent back from VLR1 to VLR2. VLR2 creates a VLR record for the MS, updates the Location Area Identifier (LAI) and the MSC fields of the VLR record, and derives the HLR address of the MS from the MS's IMSI.

Cont.

- **Step 5.** MC_V [*LA*4] (in VLR2) is incremented by 1.
- **Step 6.** VLR2 sends the **MAP Update Location message** to the **HLR**. By using the received IMSI, the HLR identifies the MS's record. The MSC number field and the VLR address field of the record are updated.
- **Step 7.** MC_H[*VLR*1] is decremented by 1, and MC_H[*VLR*2] is incremented by 1.

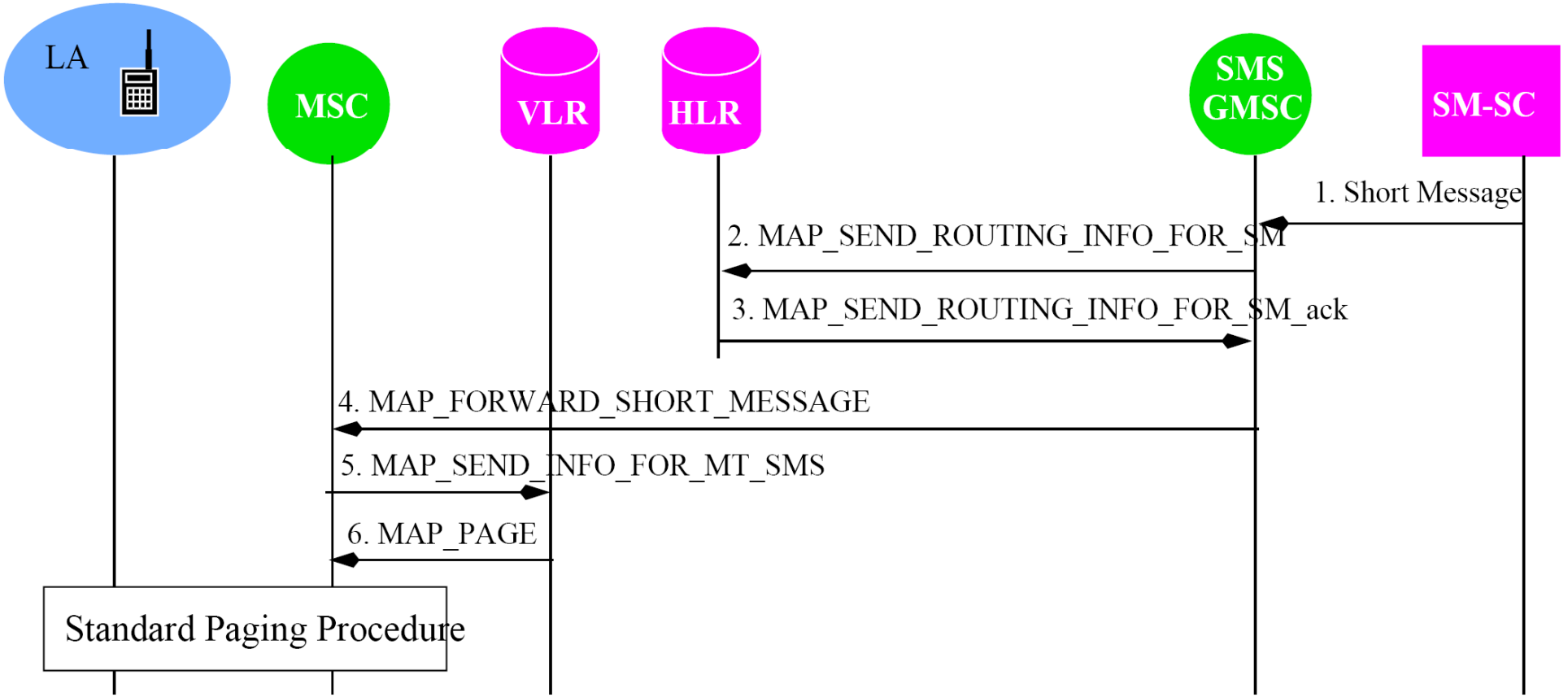
Cont.

- **Step 8.** An acknowledgment is sent back to VLR2, and then to the MS.
- **Step 9.** The HLR sends the MAP Cancel Location message to VLR1. The obsolete record of the MS in VLR1 is deleted.
- **Step 10.** MC_V [$LA3$] (in VLR1) is decremented by 1.
- **Step 11.** VLR1 acknowledges the cancel location operation.

11.2.2 Mobile Multicast Message Delivery

- **Step 1.** The SM-SC sends a multicast message to the SMS GMSC.
- **Steps 2 and 3.** Through the message **MAP Send Routing Info For SM**, the SMS GMSC requests the routing information from the HLR. The HLR searches the multicast table MC_H. If $MC_H[VLR_i] > 0$, then the Mobile Station Roaming Number (MSRN) for the VLR_i is returned from the HLR to the SMS GMSC through **MAP Send Routing Info For SM Ack**.
- The MSRN is used to identify the destination MSC of the message.

Fig. 11.6 The Multicast Procedure in Approach III



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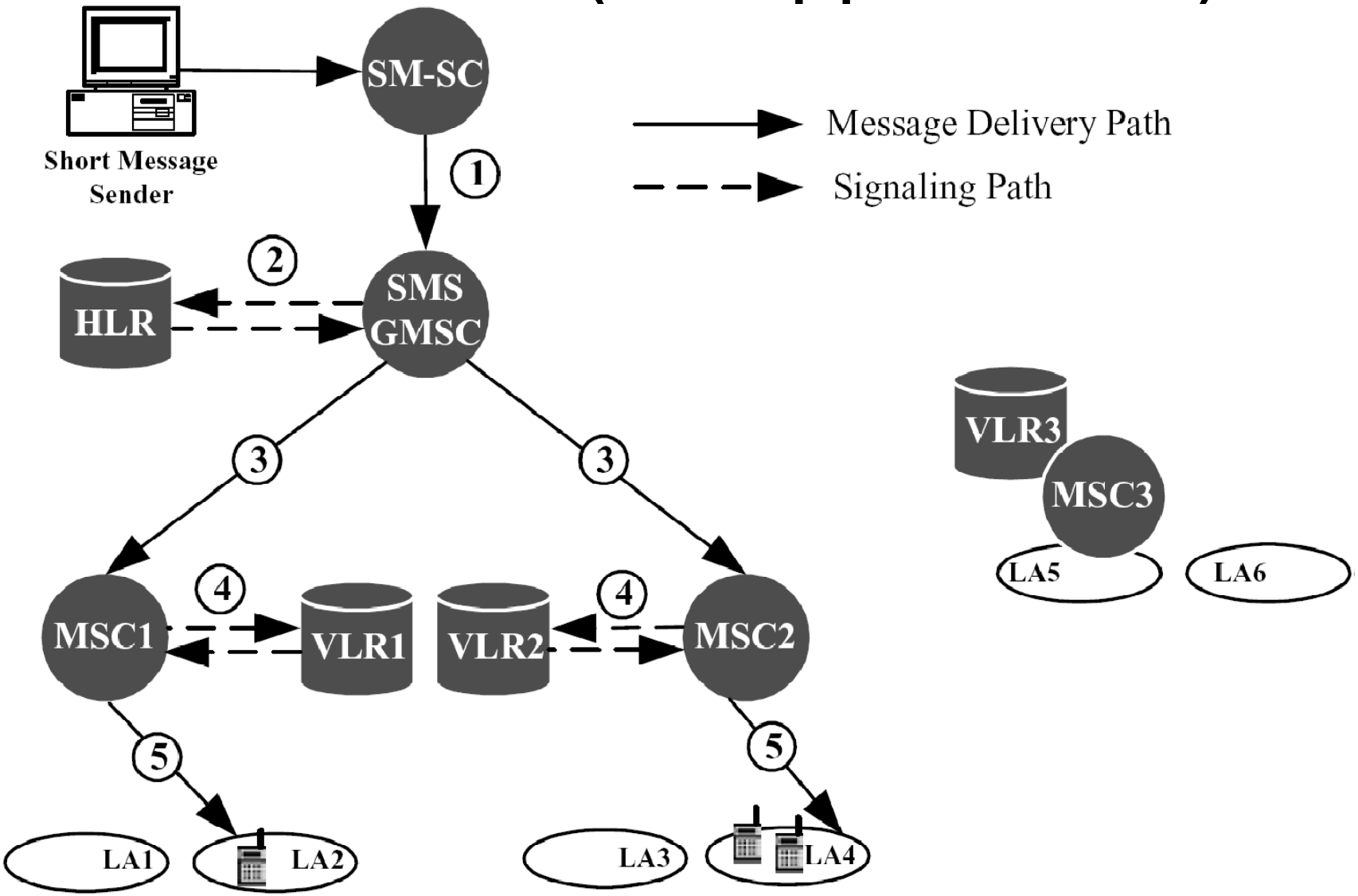
- **Step 4.** The SMS GMSC delivers the multicast message to the destination MSCs (based on the MSRNs received from the HLR) by sending MAP Forward Short Message.
  - In Figure 11.4, the multicast message is sent to MSC1 and MSC2.

Fig. 11.4 Short Message Multicast Architecture (for Approach III)



Cont.

- **Steps 5 and 6.** Every destination MSC sends **MAP Send Info For MT SMS** to its VLR to obtain the subscriber-related information. When the VLR receives this message, it searches the multicast table MC_V to identify the LAs in which the multicast members reside. These location areas LA_j satisfy the condition $MC_V[LA_j] > 0$.
  - In Figure 11.4, such an LA is LA2 in VLR1, and is LA4 in VLR2. A micro procedure Check Indication in the VLR is invoked to verify the data value of the message. If the tests are passed, the VLR requests the MSC to page LA_j.

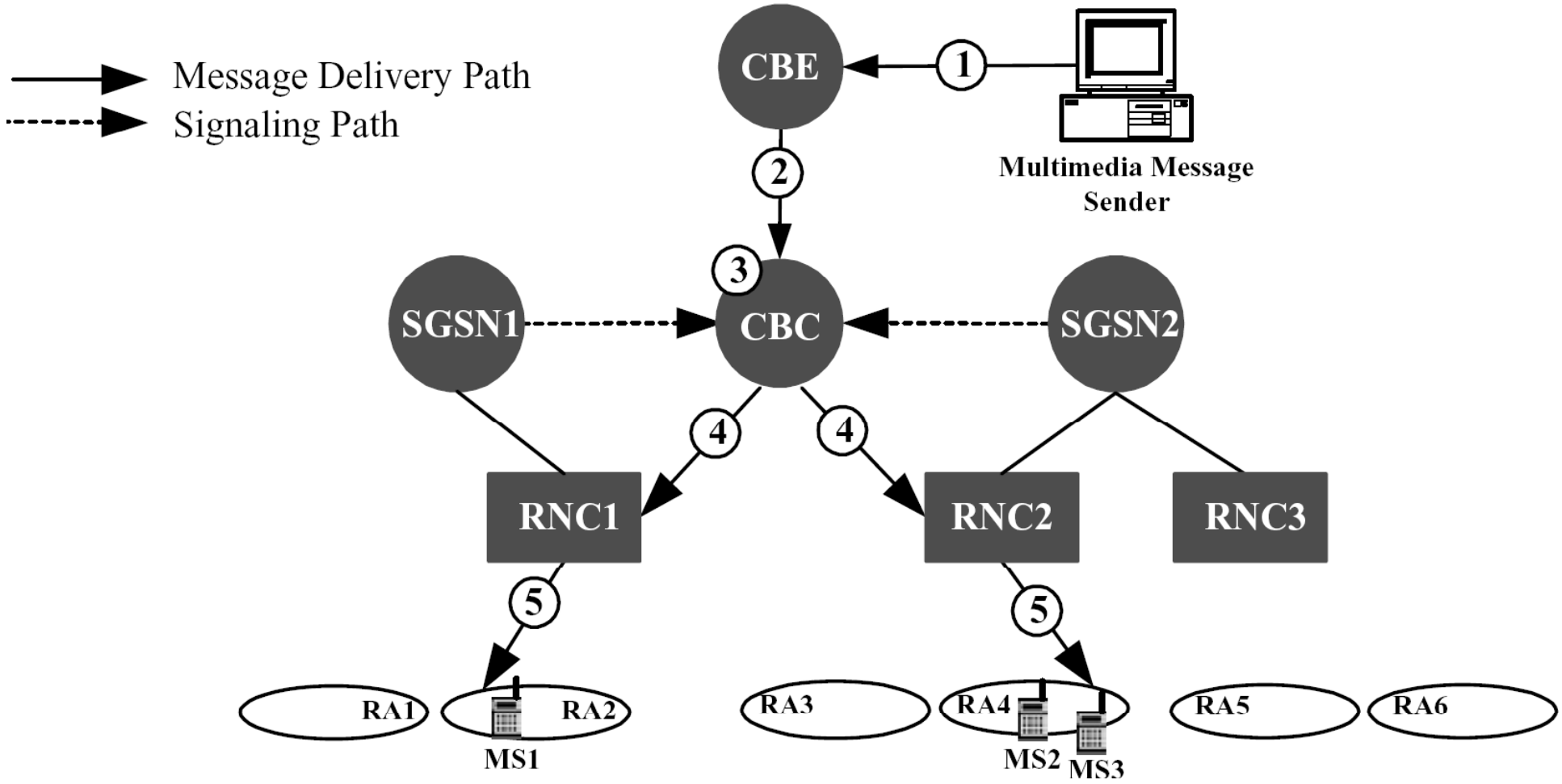
Cont.

- **Step 7.** The MSC broadcasts the message to the multicast members in the LAs following the standard GSM/UMTS paging procedures. The multicast members listen and receive the message broadcast in the LAs.

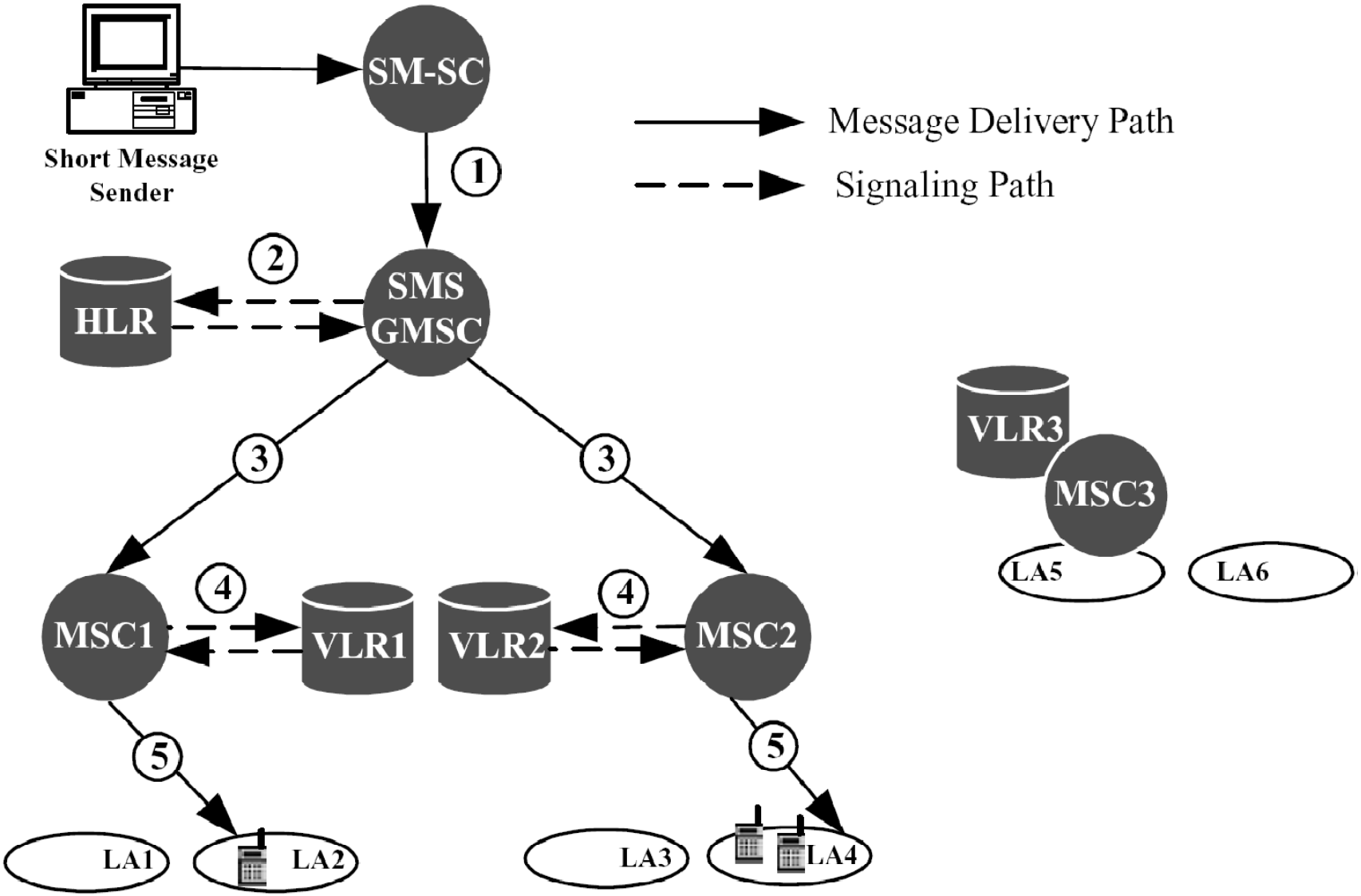
11.3 The MMS Multicast Approach IV

- Approach IV is implemented in the UMTS PS domain, which utilizes the existing *Cell Broadcast Service* (*CBS*) architecture.
  - Figure 11.7 illustrates an example of the CBS architecture. This example consists of two SGSNs: SGSN1 and SGSN2. SGSN1 covers routing areas RA1 and RA2.
  - SGSN2 covers routing areas RA3, RA4, RA5, and RA6. We assume that radio network controller RNC1 (covering RA1 and RA2) connects to SGSN1. Both RNC2 (covering RA3 and RA4) and RNC3 (covering RA5 and RA6) connect to SGSN2.

Fig. 11.7 UMTS Multimedia Message Multicast Architecture (PS Domain)



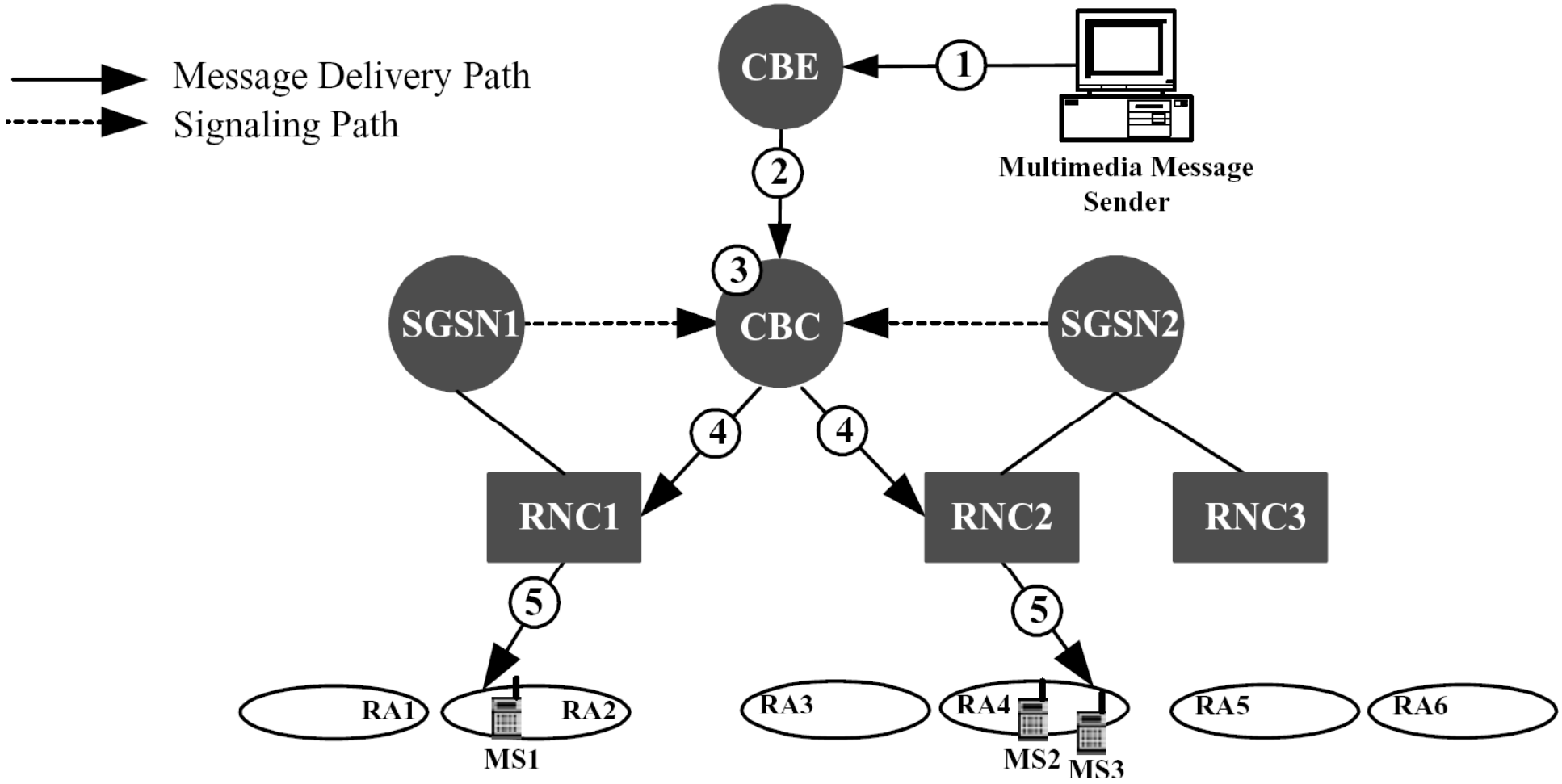
Approach III (CS Domain)



Cont.

- **Step 1.** The multimedia message is first delivered from the message sender to the *Cell Broadcast Entity* (***CBE***; see (1) in Figure 11.7).
- **Step 2.** The CBE sends the message to the *Cell Broadcast Center* (***CBC***; see (2) in Figure 11.7).
- **Steps 3 and 4.** The CBC determines the RAs that should receive the multimedia message (Figure 11.7 (3)), and forwards the message to the corresponding RNCs (Figure 11.7 (4)).
- **Step 5.** Then the RNCs multicast the multimedia message to the multicast members (Figure 11.7 (5)).

Fig. 11.7 UMTS Multimedia Message Multicast Architecture (PS Domain)



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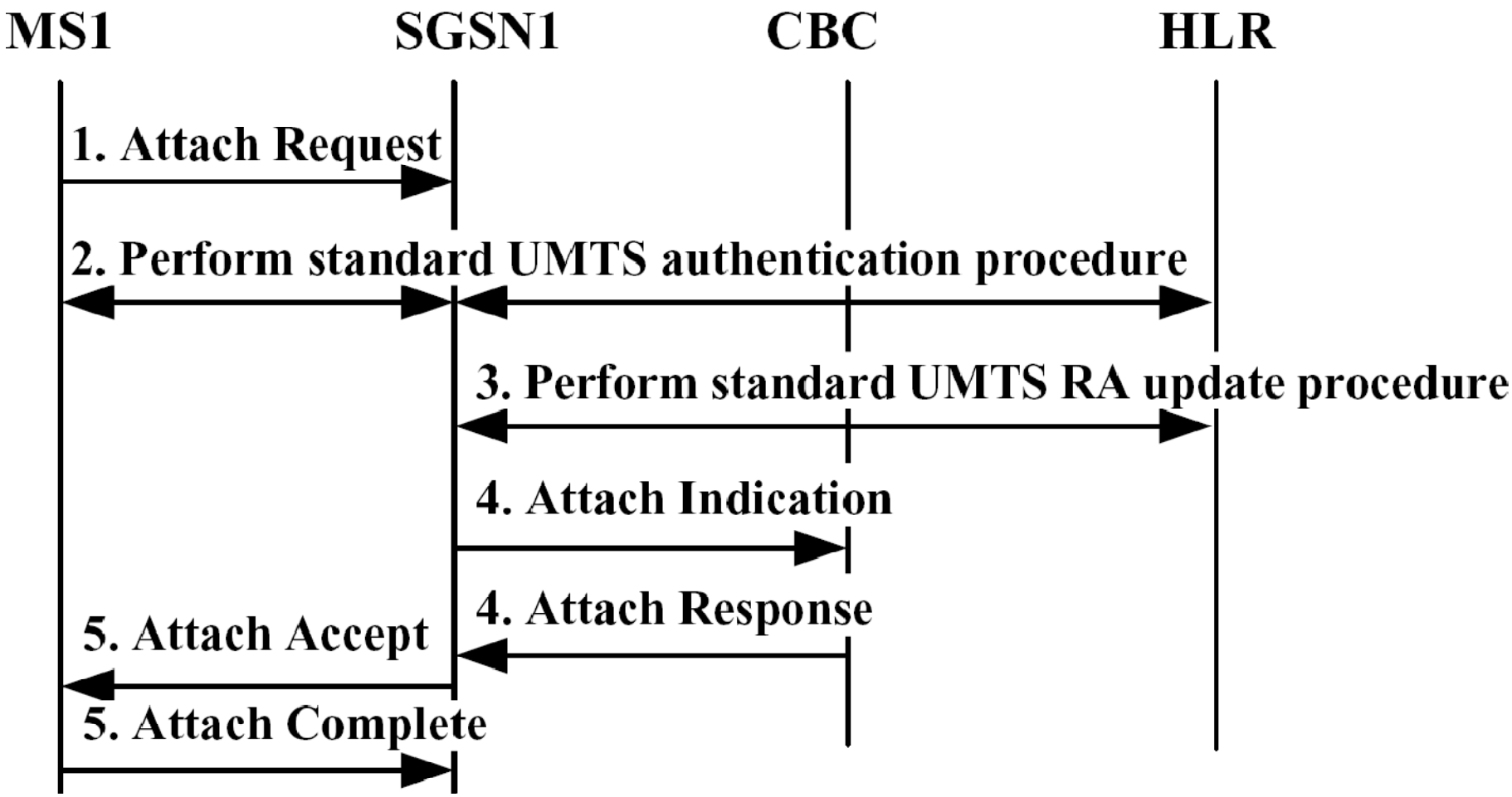
- In Figure 11.7, the message delivery path for MMS multicast is (1)→(2)→(4)→(5).
- In Figure 11.7, there is one multicast member in RA2 and two multicast members in RA4. Thus, we have
  - $MC_C[RA1] = 0$, $MC_C[RA2] = 1$, $MC_C[RA3] = 0$,
  - $MC_C[RA4] = 2$, $MC_C[RA5] = 0$, and $MC_C[RA6] = 0$

11.3.1 Location Tracking of the Multicast Members

Attach for a Multicast Member

- **Step 1.** MS1 initiates the attach procedure by sending the Attach Request message to SGSN1.
- **Step 2.** The **authentication function** is performed between MS1, SGSN1, and the HLR as described in Section 9.1.
- **Step 3.** Through the standard UMTS RA update procedure, SGSN1 informs the HLR of the MS1's current location and obtains the MS1's user profile from the HLR.

Fig. 11.8 Attach Procedure for a Multicast Member



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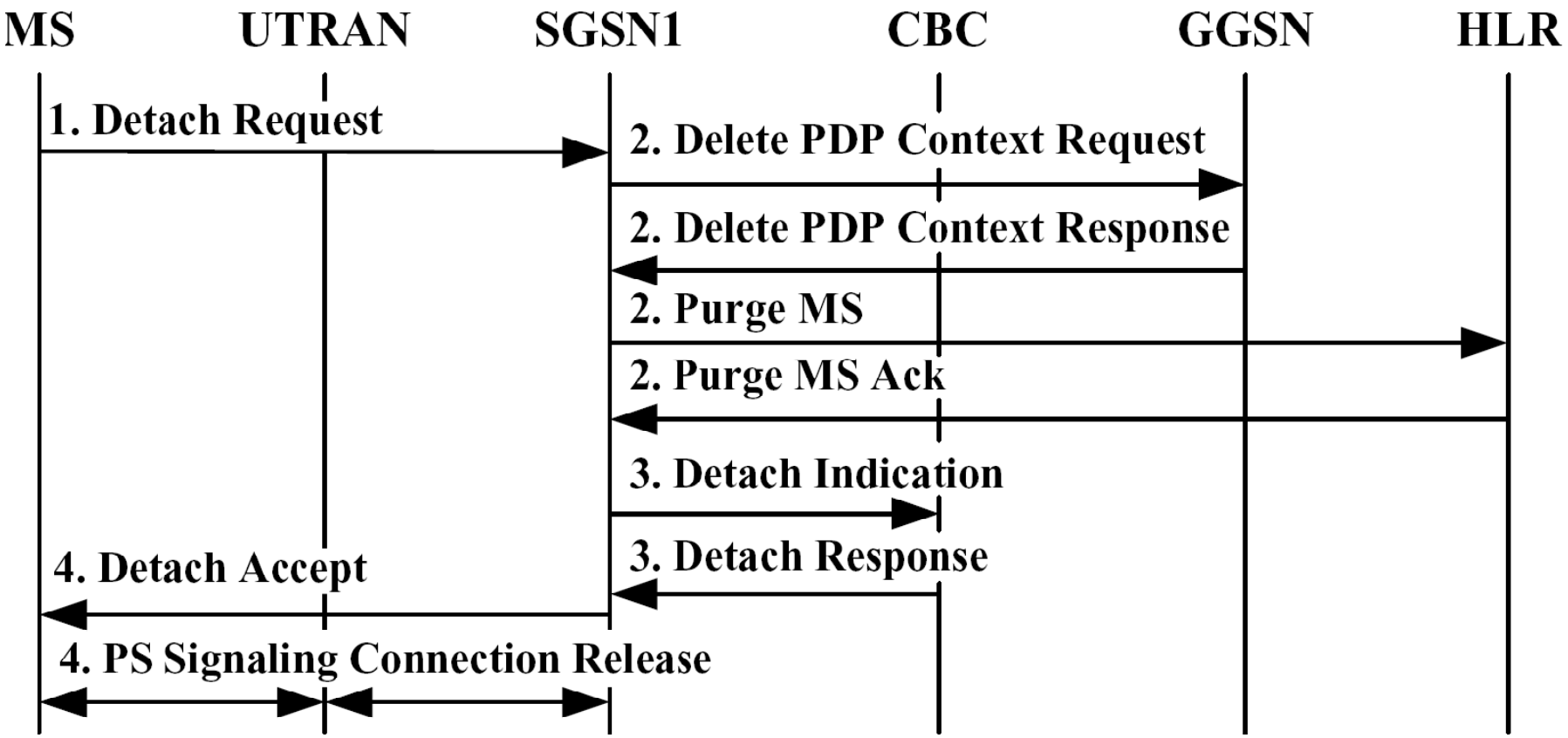
- **Step 4. SGSN1** informs the **CBC** of the MS1's RA identity (i.e., RA2 in Figure 11.7) by sending the **Attach Indication message**. The CBC increments $MC_C[RA2]$ by 1. Then it acknowledges SGSN1 by sending the Attach Response message.
- **Step 5.** SGSN1 and MS1 exchange the Attach Accept and the Attach Complete message pair to indicate that the attach procedure is complete.

Detach for a Multicast Member

- **Step 1.** MS1 **detaches** from the **UMTS PS domain** by sending the Detach Request message to SGSN1.
- **Step 2.** Upon receipt of the MS1's detach request, SGSN1 and the GGSN exchange the **Delete PDP Context Request** and **Delete PDP Context Response message** pair to deactivate the MS1's **Packet Data Protocol (PDP)** context. SGSN1 sends the Purge MS message to the HLR. This message indicates that SGSN1 has deleted the MS1's Mobility Management (MM) and PDP contexts. The HLR acknowledges with the Purge MS Ack message. Then Steps 3 and 4 are executed in parallel.

Fig. 11.9 Detach Procedure for a Multicast Member



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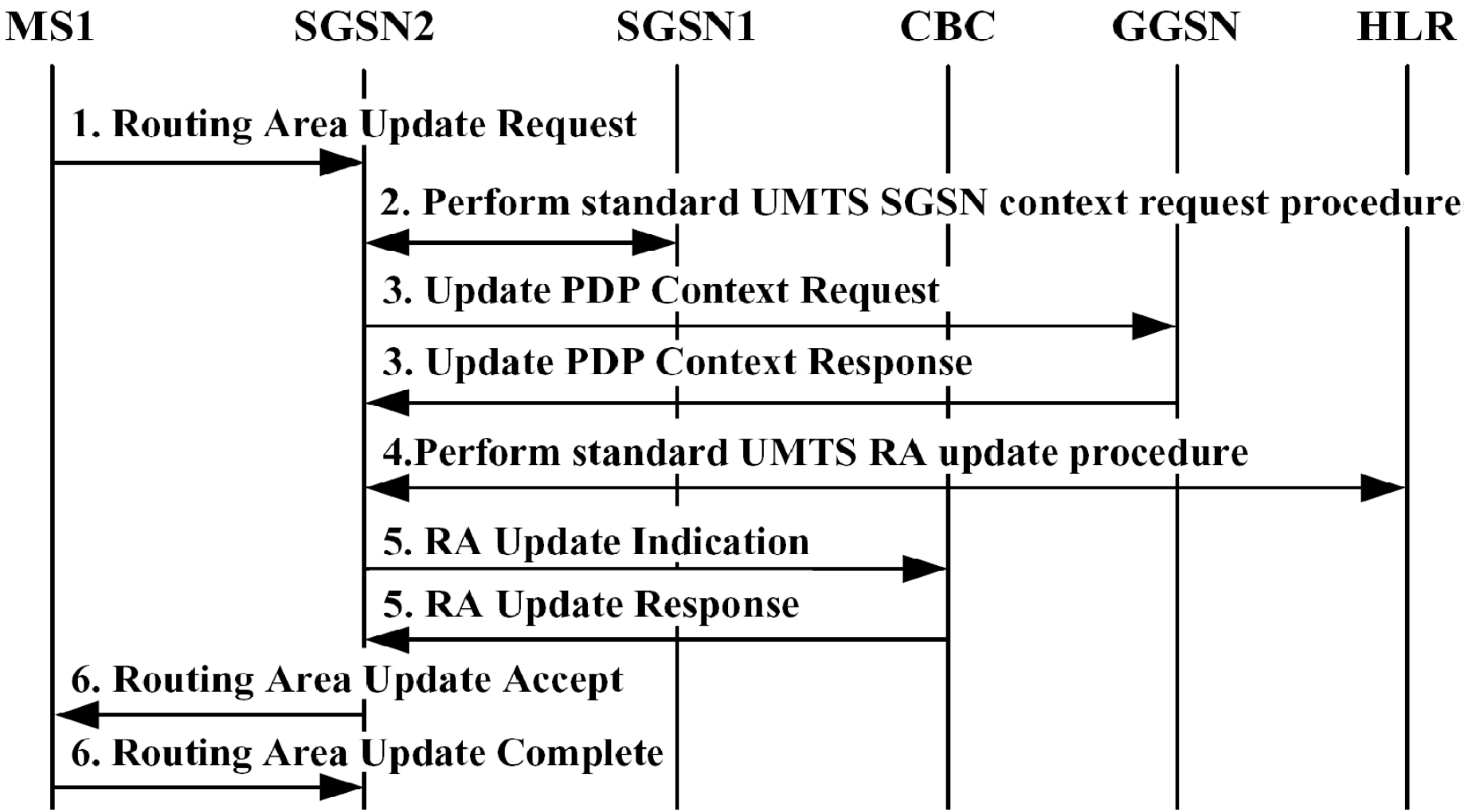
- **Step 3.** SGSN1 sends the Detach Indication message to the CBC to indicate that MS1 in RA2 has been detached from the network. The CBC decrements $MC_C[RA2]$ by 1. Then it replies with the Detach Response message to SGSN1.
- **Step 4.** If the MS1's detach is not caused by power-off, SGSN1 sends the **Detach Accept message** to MS1.
  - At the same time, SGSN1 initiates the PS signaling connection release procedure to release the signaling connections between SGSN1 and the UTRAN, and between the UTRAN and MS1.

Location Update for a Multicast Member

- **Step 1.** When detecting the RA location change, MS1 issues the **Routing Area Update Request message** to SGSN2.
- **Step 2.** Through the standard UMTS SGSN context request procedure, SGSN2 obtains the MM and PDP contexts of MS1 from SGSN1.

Fig. 11.10 Location Update Procedure for a Multicast Member



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- **Step 3.** SGSN2 sends the **Update PDP Context Request message** to the corresponding GGSN. With this message, the GGSN PDP context is modified to indicate that SGSN1 has been replaced by SGSN2. The GGSN returns the Update PDP Context Response message.
- **Step 4.** The standard UMTS RA update procedure is performed to inform the HLR that the SGSN for MS1 has been changed.

Cont.

- **Step 5.** Upon receipt of the location update acknowledgment from the HLR, SGSN2 sends the previous RA identity (RA2) and current RA identity (RA3) to the **CBC** through the RA Update Indication message.
  - Then $MC_C[RA2]$ is decremented by 1 and $MC_C[RA3]$ is incremented by 1. The CBC replies with the RA Update Response message to SGSN2.
- **Step 6.** Through the **Routing Area Update Accept** and **Routing Area Update Complete message exchange**, SGSN2 informs MS1 that the location update procedure is successfully performed.