Location Update (GSM Location Update Procedure)

Subscribers		GSM Network							EventStudio System Designer 6
GSM Mobiles		Maryland Location Area		Maryland GSM Equipment	GSM Databases	Virginia Location Area	Virginia GSM Equipment		
Other GSM Mobile	GSM Mobile	Rockville Cell	Bethesda Cell	Maryland MSC VLR	HLR	Vienna Cell	Virginia BSC	Virginia MSC VLR	12-Jun-14 22:48 (Page 1)

This sequence diagram was generated with EventStudio System Designer 5 (http://www.EventHelix.com/EventStudio). The EventStudio source files for this document can be downloaded from http://www.eventhelix.com/call-flow/gsm-location-update.zip.

Have you ever wondered how your cellular provider is able to route calls to you virtually anywhere? How does the cellular provider know where you are?

The short answer to these questions is that your cell phone keeps the cellular operator informed about your location. In this sequence diagram we will examine how a mobile phones keep selecting the best cell to service your call and also keeps the cellular provider informed about your location.

We will be tracing the journey of a mobile phone from Rockville, Maryland to Vienna, Virginia. The path taken by the mobile phone is described in the following article:

http://www.EventHelix.com/RealtimeMantra/Telecom/GSM_network_example.htm

Before we go any further, let us discuss a few important terms.

Location Area (LA)

A GSM network is divided into cells. A group of cells is considered a location area. A mobile phone in motion keeps the network informed about changes in the location area. If the mobile moves from a cell in one location area to a cell in another location area, the mobile phone should perform a location area update to inform the network about the exact location of the mobile phone.

Home Location Register (HLR)

The HLR maintains a database for the mobile subscribers. At any point of time, the HLR knows the address of the MSC VLR that control the current location area of the mobile. The HLR is informed about a location area update only if the location area change has resulted in a change of the MSC VLR.

Mobile Switching Center - Visitor Location Register (MSC VLR)

The MSC VLR is responsible to switching voice calls and it also keeps track of the exact location area where the mobile user is present. Note that a typical MSC VLR will service several location areas.

Rockville is the primary cell

The mobile phone is currently in the Rockville cell.

GSM Mobile reaches cell boundary (both cells in same Location Area)

Monitor the BCCH from the current cell and the neighboring cells

When idle, the GSM mobile phone keeps monitoring the beacon frequency for its current cell(Rockville) and its neighbors. The GSM mobile measures the cell strength to see if it should change its primary cell. The signal strength of the Broadcast Control CHannel (BCCH) will be monitored to select the best cell.

BCCH

Location Area = Maryland, Signal Strength = Good

The BCCH on the primary cell is monitored for signal strength.

BCCH

Location Area = Maryland, Signal Strength = Great

The BCCH of the neighboring cells is monitored to determine if any of the neighbors have a better signal strength. In this case, the cell has reached the boundary between Rockville and Bethesda cells and it finds that the signal quality of the Bethesda cell is better.

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Bethesda is the primary cell

The mobile phone marks the Bethesda cell as the primary cell.

Skip Location update as the location area for the old cell (Rockville) and the new cell (Bethesda) is the same (Maryland)

Whenever the primary cell changes, the mobile checks if the Location area of the old cell and the new cell are different. In this case, the mobile finds that the location areas are same so no location area update is needed.

GSM Mobile reaches Location Area boundary (old and new cells are in different Location Areas)

BCCH

Location Area = Maryland, Signal Strength = Good

The BCCH on the beacon frequencies is monitored.

BCCH

Location Area = Vienna, Signal Strength = Great

Now the Vienna cell is being received with better signal strength, so cell will be picked as primary.

Vienna is the primary cell

Location area update is needed as the location area has changed from Maryland to Virginia

This time the old and new location areas are different. The mobile initiates the Location Area Update procedure.

RR Connection Setup

RR CHANNEL REQUEST

The mobile establishes a RR connection to send the location update to the network.

RR CHANNEL REQUEST

RR IMMEDIATE ASSIGNMENT

RR IMMEDIATE ASSIGNMENT

A radio channel has been assigned to the GSM mobile.

GSM Location Update Procedure

RR SABM + MM LOCATION UPDATING REQUEST

Maryland TMSI, Maryland LAI

The mobile tunes to the assigned radio channel and sends the SABM to initiate the radio connection. The location update is also piggybacked on the message.

SABM + MM LOCATION UPDATING REQUEST

Maryland TMSI, Maryland LAI

The BSC receives the location update with the SABM.

MM LOCATION UPDATING REQUEST

Maryland TMSI, Maryland LAI

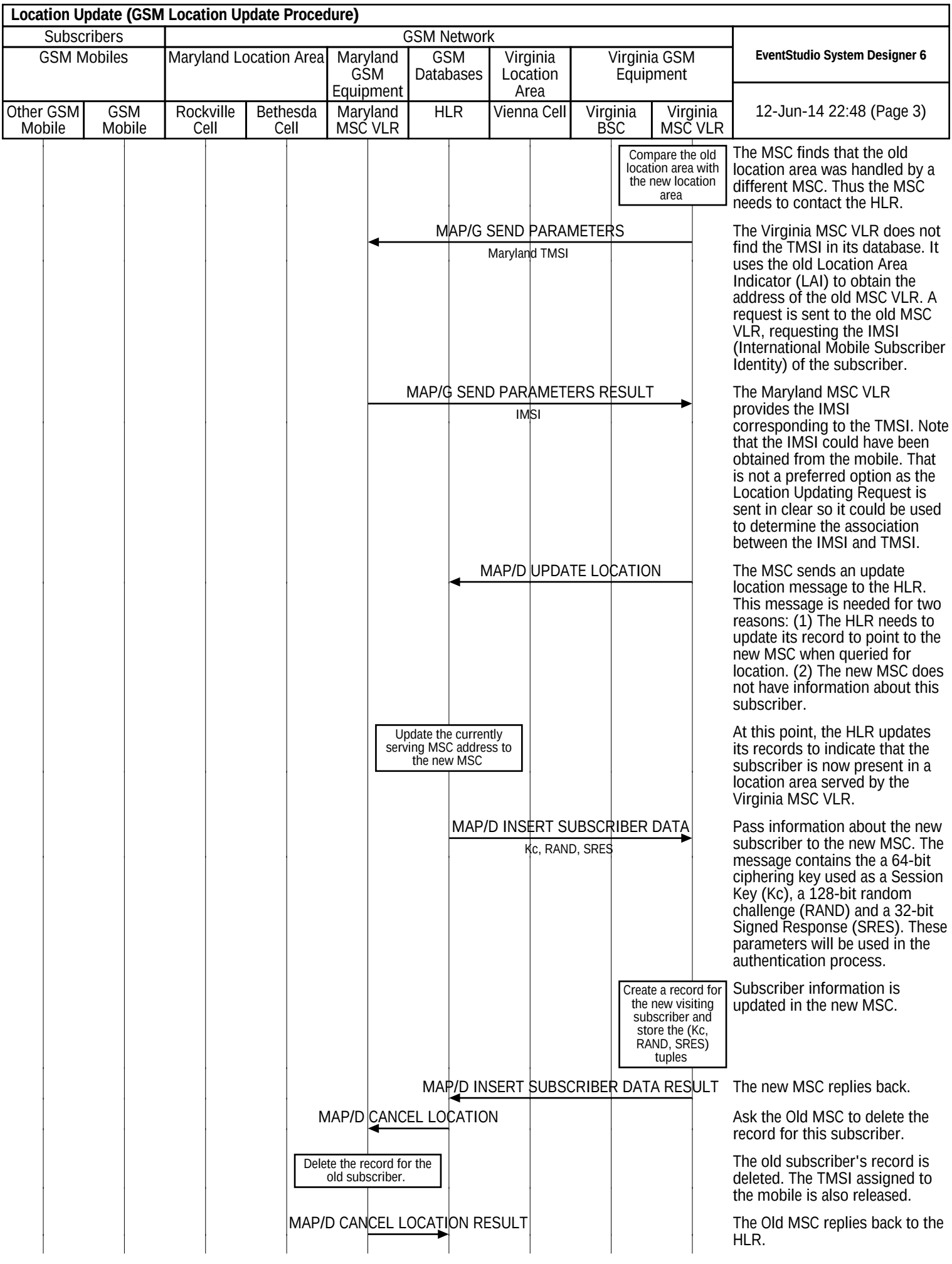
The location updating request is forwarded to the MSC in the "BSSMAP COMPLETE LAYER 3 INFORMATION" message.

RR UA

The RR connection setup is completed by responding with UA for the received SABM.

RR UA

LEG: Inter MSC-VLR location update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Other GSM Mobile
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Virginia MSC VLR
Compare the old location area with the new location area
The MSC finds that the old location area was handled by a different MSC. Thus the MSC needs to contact the HLR.
MAP/G SEND PARAMETERS
Maryland TMSI
The Virginia MSC VLR does not find the TMSI in its database. It uses the old Location Area Indicator (LAI) to obtain the address of the old MSC VLR. A request is sent to the old MSC VLR, requesting the IMSI (International Mobile Subscriber Identity) of the subscriber.
MAP/G SEND PARAMETERS RESULT
IMSI
The Maryland MSC VLR provides the IMSI corresponding to the TMSI. Note that the IMSI could have been obtained from the mobile. That is not a preferred option as the Location Updating Request is sent in clear so it could be used to determine the association between the IMSI and TMSI.
MAP/D UPDATE LOCATION
The MSC sends an update location message to the HLR. This message is needed for two reasons: (1) The HLR needs to update its record to point to the new MSC when queried for location. (2) The new MSC does not have information about this subscriber.
Update the currently serving MSC address to the new MSC
At this point, the HLR updates its records to indicate that the subscriber is now present in a location area served by the Virginia MSC VLR.
MAP/D INSERT SUBSCRIBER DATA
Kc, RAND, SRES
Pass information about the new subscriber to the new MSC. The message contains the a 64-bit ciphering key used as a Session Key (Kc), a 128-bit random challenge (RAND) and a 32-bit Signed Response (SRES). These parameters will be used in the authentication process.
Create a record for the new visiting subscriber and store the (Kc, RAND, SRES) tuples
Subscriber information is updated in the new MSC.
MAP/D INSERT SUBSCRIBER DATA RESULT
The new MSC replies back.
MAP/D CANCEL LOCATION
Ask the Old MSC to delete the record for this subscriber.
Delete the record for the old subscriber.
The old subscriber's record is deleted. The TMSI assigned to the mobile is also released.
MAP/D CANCEL LOCATION RESULT
The Old MSC replies back to the HLR.

MAP/D UPDATE LOCATION RESULT

The HLR has updated all records, so it replies back to the new MSC.

Authenticate subscriber

MM AUTHENTICATION REQUEST

RAND

The MSC VLR decides to authenticate the subscriber. The RAND value received from the HLR is sent to the mobile.

Pass the RAND value to the SIM and obtain the Kc and SRES values

The SIM applies secret GSM algorithms on the RAND and the secret key Ki to obtain the session key Kc and SRES.

MM AUTHENTICATION RESPONSE

SRES

The mobile passes the computed SRES value in the response.

Compare the SRES reported by the mobile with the SRES obtained from HLR

If the SRES obtained from the mobile matches the SRES value obtained from the HLR, the subscriber authentication procedure completes successfully.

Enable Ciphering

BSSMAP CIPHER MODE COMMAND

The MSC initiates ciphering of the data being sent on the channel.

RR CIPHERING MODE COMMAND

mode = CLEAR

The BSC sends the CIPHERING MODE COMMAND to the mobile.

RR CIPHERING MODE COMPLETE

mode = CIPHERED

Ciphering has already been enabled, so this message is transmitted with ciphering.

BSSMAP CIPHER MODE COMPLETE

The BSC replies back to the MSC, indicating that ciphering has been successfully enabled.

MM LOCATION UPDATING ACCEPT

Virginia TMSI

The new MSC replies back to the mobile via the Virginia BSC. The message also assigns a new Temporary Mobile Subscriber Id (TMSI) to the terminal. Since the TMSI assignment is being sent after ciphering is enabled, the relationship between TMSI and the subscriber cannot be obtained by unauthorized users.

Start using the new TMSI

MM TMSI REALLOCATION COMPLETE

The GSM mobile replies back indicating that the new TMSI allocation has been completed.

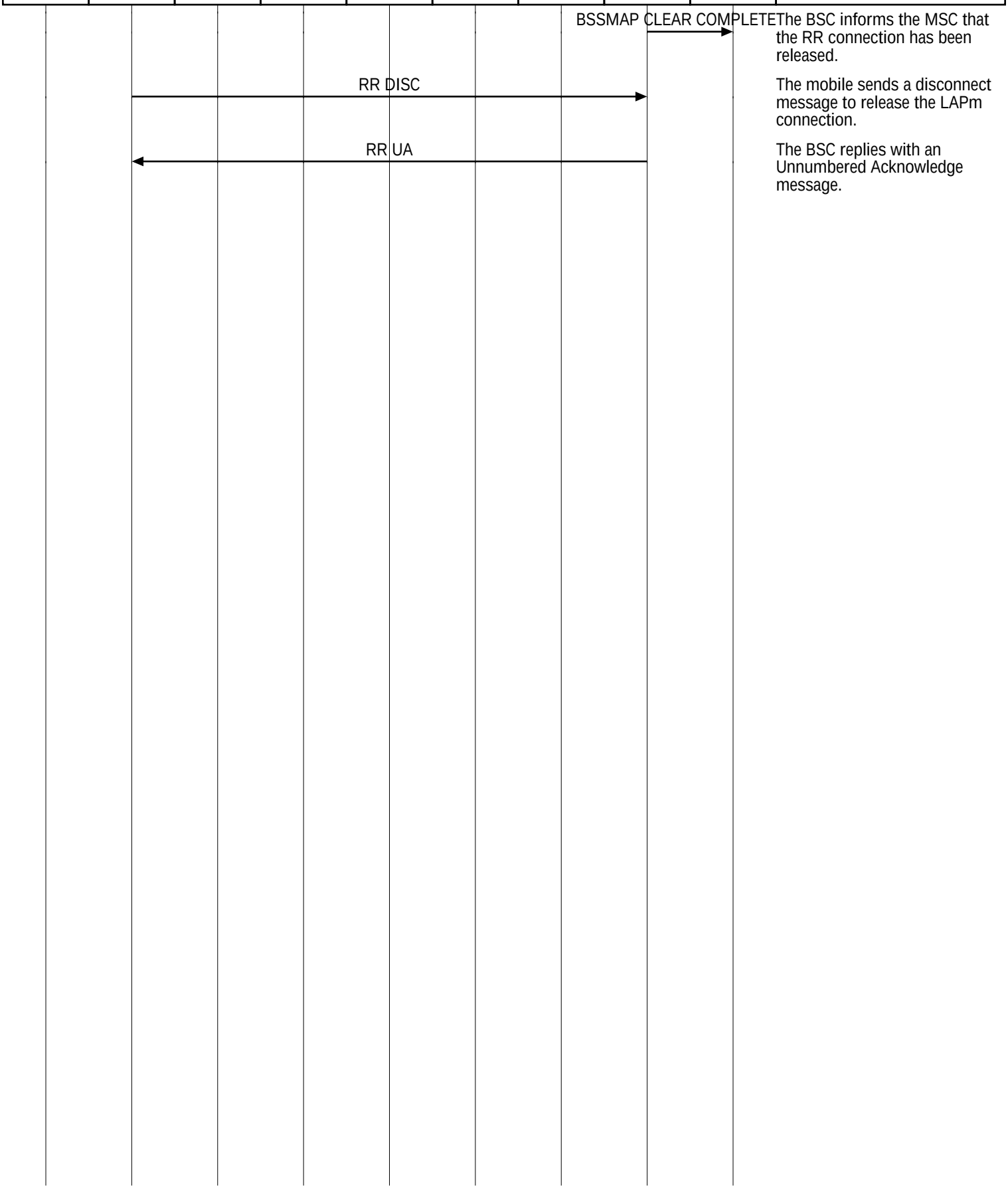
RR Connection Release

BSSMAP CLEAR COMMAND

The RR connection is released by the MSC.

RR CHANNEL RELEASE

The BSC initiates RR release with the mobile.


BSSMAP CLEAR COMPLETE
The BSC informs the MSC that the RR connection has been released.
RR DISC
The mobile sends a disconnect message to release the LAPm connection.
RR UA
The BSC replies with an Unnumbered Acknowledge message.