General Packet Radio Service (GPRS)

Outline

- Introduction
- GPRS Architecture
- GPRS Interfaces
- GPRS Procedures
- Summary

Introduction (1/2)

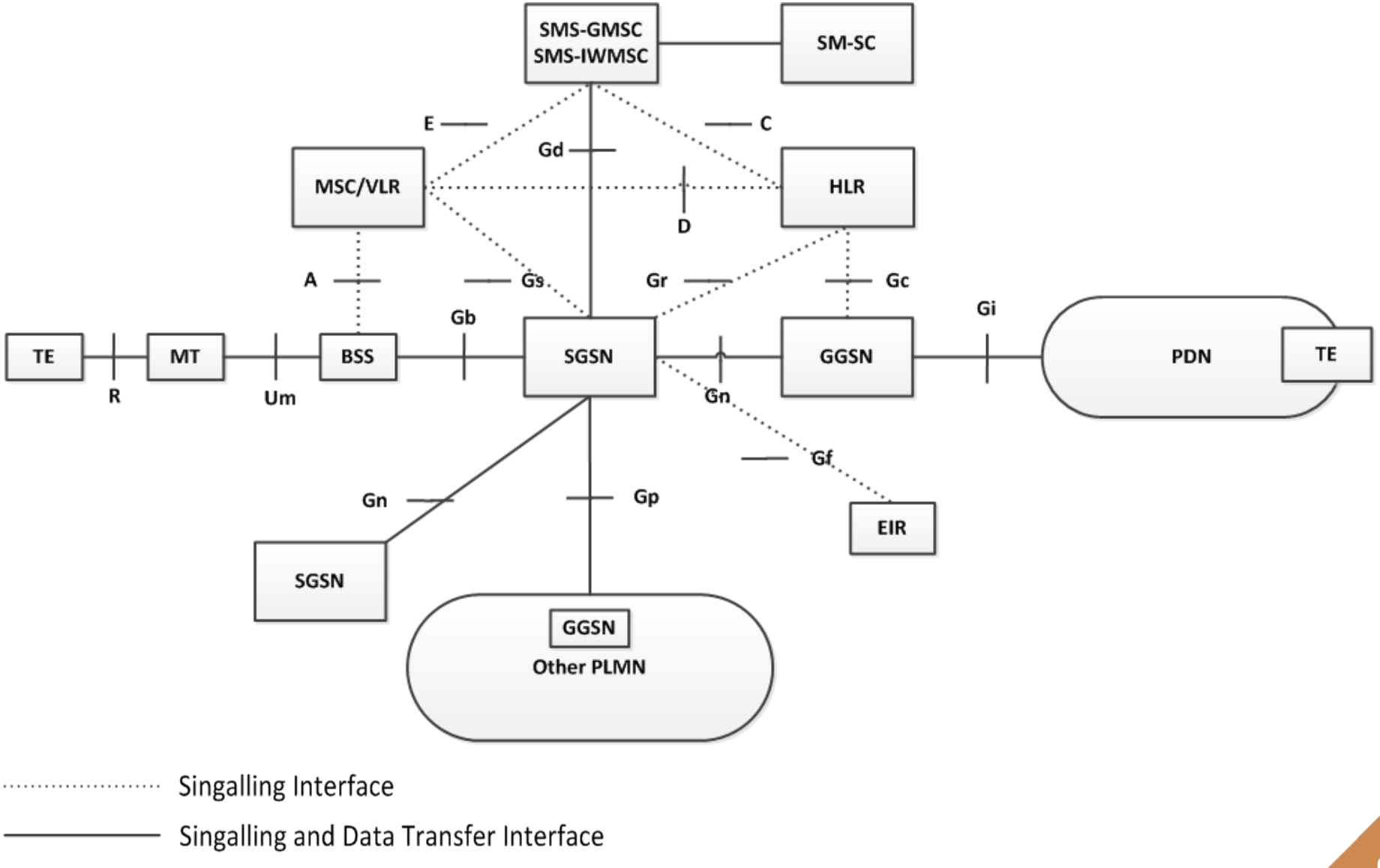
- GPRS reuses the existing GSM infrastructure to provide **end-to-end packet-switched** services.
- GPRS standard was initialized by ETSI/SMG in 1994.
- The main set of GPRS specifications was approved by SMG#25 in 1997, and was completed in 1999.
- GPRS core network has also been developed for **IS-136**, and is anticipated to evolve as the core network for the third-generation mobile system as well.

Introduction (2/2)

- To accommodate GPRS, new radio channels are defined.
- The allocation of these channels is flexible.
  - One to eight time slots can be allocated to a user, or several active users can share a single time slot, where the uplinks and the downlinks are allocated separately.
  - Various radio channel coding schemes are specified to allow bit rates from 9 Kbps to 150 Kbps.
  - GPRS fast reservation is designed to start packet transmission within 0.5 to 1 seconds.
- GPRS security functionality is equivalent to the existing GSM security.
  - A Ciphering algorithm is optimized for packet data transmission.

Part I: GPRS Architecture

GPRS Architecture (1/2)



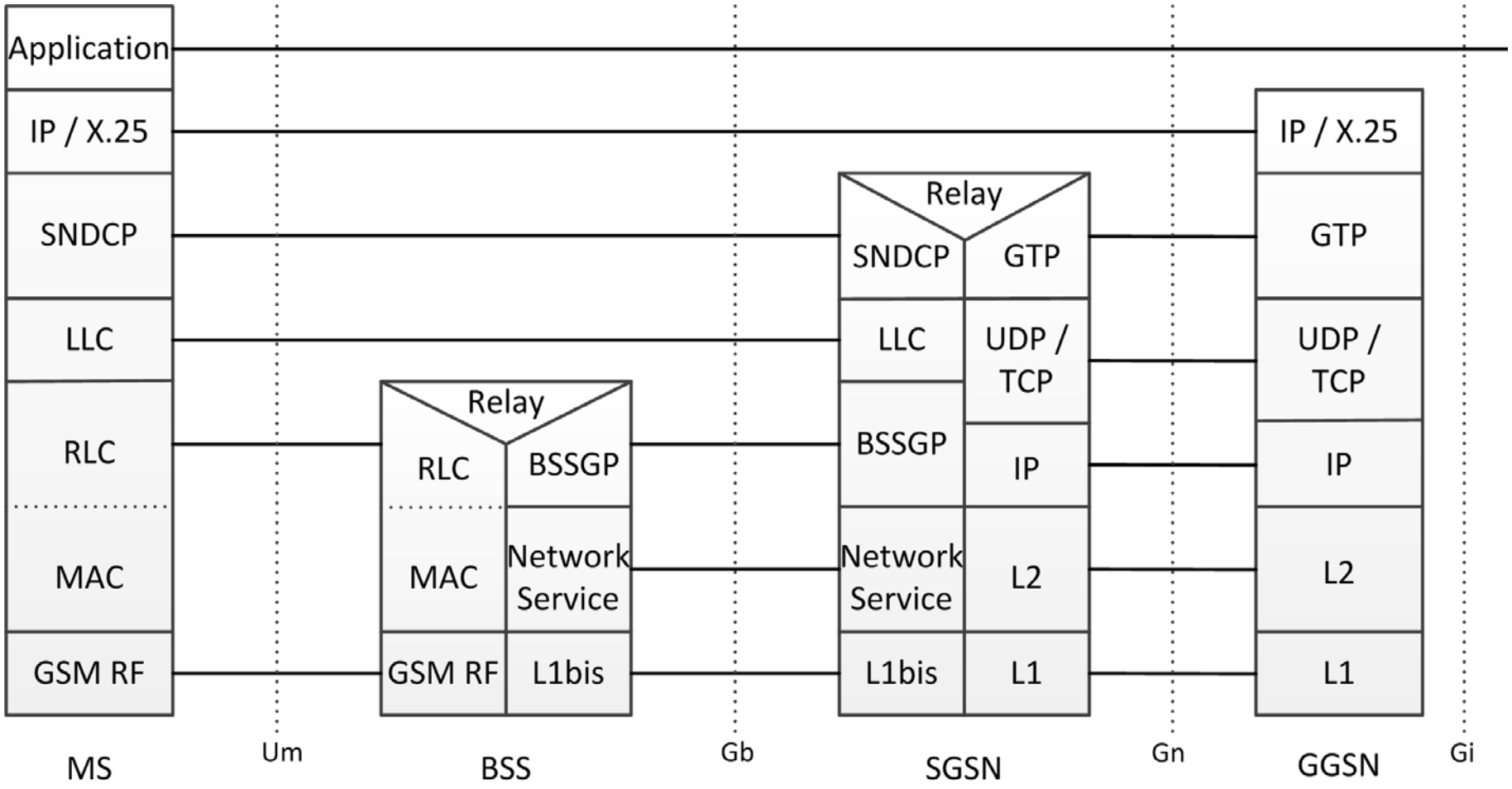
GPRS Architecture (2/2)

- MS, BSS, MSC/VLR, and HLR in the existing GSM network are modified.
  - E.g., the HLR is enhanced with GPRS subscriber information.
- Two new network nodes are introduced in GPRS.
  - The Serving GPRS Support (SGSN) node is GPRS equivalent to the MSC.
    - At GPRS attach, the SGSN establishes a mobility management context (related to mobility and security for the MS).
    - At PDP context activation, the SGSN established a PDP context, to be used for routing purpose.
  - The Gateway GPRS Support (GGSN) node provides interworking with external packet-switched networks, and is connects with SGSN via an IP-based GPRS backbone network.

Mapping of Functions to General Logical Architecture

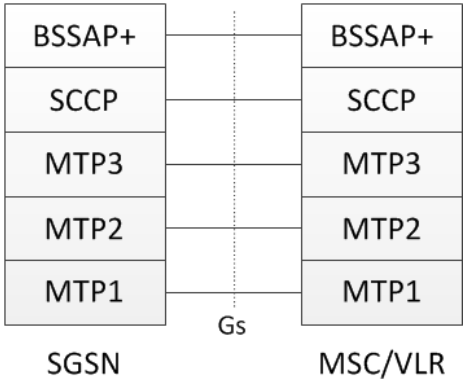
Function	MS	BSS	SGSN	GGSN	HLR
Network Access Control:					
Registration					X
Authentication and Authorisation	X		X		X
Admission Control	X	X	X		
Message Screening				X	
Packet Terminal Adaptation	X				
Charging Data Collection			X	X	
Packet Routeing & Transfer:					
Relay	X	X	X	X	
Routeing	X	X	X	X	
Address Translation and Mapping	X		X	X	
Encapsulation	X		X	X	
Tunnelling			X	X	
Compression	X		X		
Ciphering	X		X		X
Mobility Management:	X		X	X	X
Logical Link Management:					
Logical Link Establishment	X		X		
Logical Link Maintenance	X		X		
Logical Link Release	X		X		
Radio Resource Management:					
Um Management	X	X			
Cell Selection	X	X			
Um-Tranx	X	X			
Path Management		X	X		

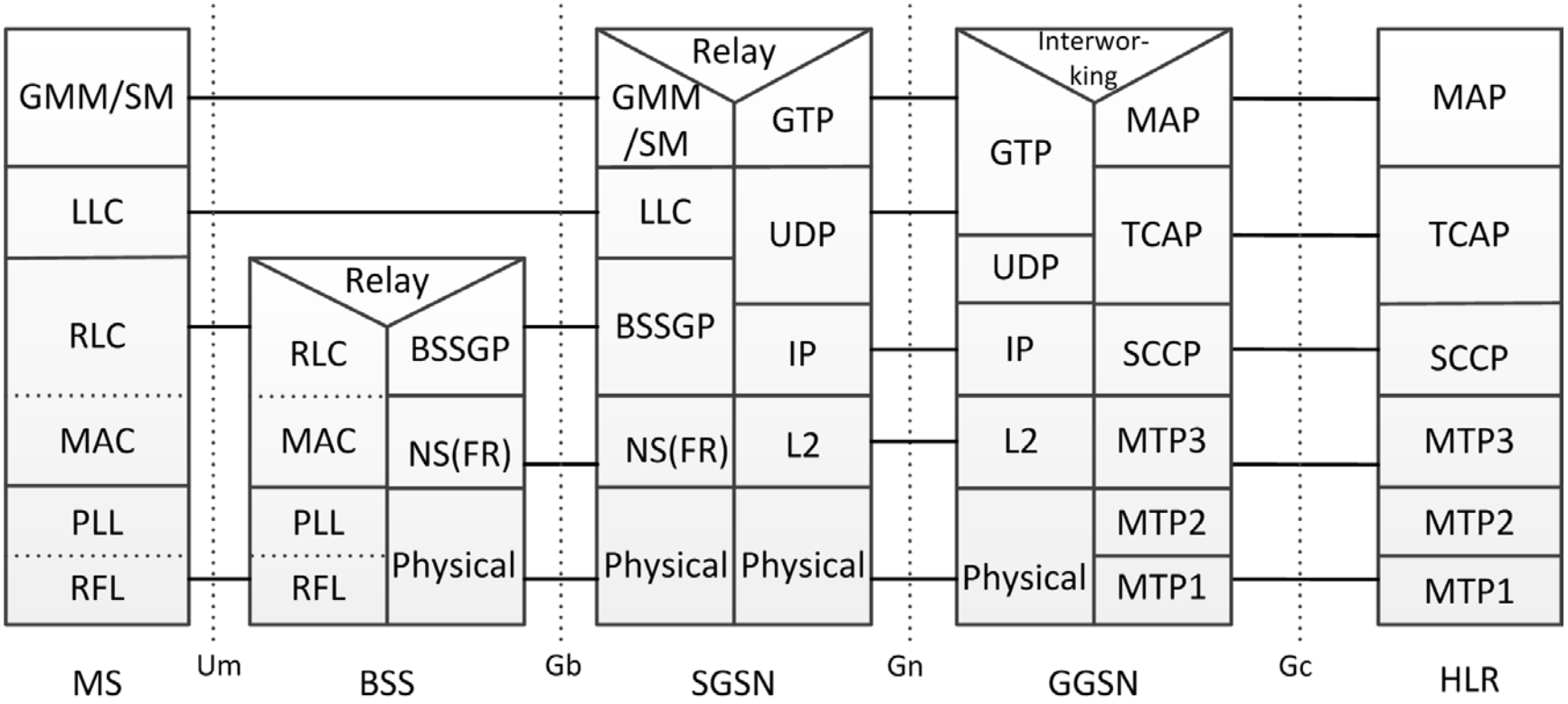
GPRS Transmission Plane



GPRS Signaling Plane

BSS AP+: Base Station System Application Part+
GMM: GPRS Mobility Management
MAP: Mobile Application Part
MTP: Message Transfer Part
SCCP: Signaling Connection Control Part
SM: Session Management
TCAP: Transaction Capabilities Application Part





GPRS Transmission & Signaling Planes

- **The GPRS Transmission Plane** consists of a layered protocol structure for user information transfer and the associated control procedures
  - e.g., flow control, error detection, error correction, and error recovery.
- **The GPRS Signaling Plane** consists of protocols for control and support of the transmission plane functions.

Mobility Management (MM) Context (1/2)

- **MM context stored in MS and SGSN** contains
  - MM state and
  - MM-related information
- **MM states** specify the **MM activities of an MS**
  - MM State = IDLE (if the MS is not attached to the GPRS mobility management)
  - MM State = STANDBY (if the MS is attached to GPRS mobility management but has not obtained detailed location information)
  - MM State = READY (if the location information for the MS has been identified on cell level)
- **Note that** a GPRS MS can be **IMSI-** and/or **GPRS-attached**.

Mobility Management (MM) Context (2/2)

- The **IMSI attach** is the same as that for a GSM MS.
- In GPRS attach procedure,
  - Step 1. Both the MM states in MS and the SGSN are moved to the READY state.
  - Step 2. An MM context is created in each of MS and SGSN.
  - Step 3. Authentication/Ciphering may be performed.
  - Step 4. A logical link is established between MS and SGSN.

Packet Data Protocol (PDP) Context (1/2)

- The PDP contexts stored in **MS, HLR, SGSN, and GGSN** contains
  - Mapping and routing information for packet transmission between (MS<->GGSN).
- For each GPRS communication of an MS, a PDP context is created to characterize the session.
  - After the PDP context activation, the MS is known to the GGSN, and communication to external networks is possible.
  - An MS may have several activated PDP contexts if the terminal supports several IP addresses.
  - When the MS is detached from GPRS, all PDP contexts are deactivated.
  - A PDP context can be in one of the two PDP states:

    ACTIVE or INACTIVE

Packet Data Protocol (PDP) Context (2/2)

- An MS in STANDBY or READY MM state may activate a PDP context, and moves its PDP state from INACTIVE to ACTIVE.
- The ACTIVE PDP context becomes INACTIVE when the PDP context is deactivated.

QoS Profile (1/2)

- A QoS profile is maintained in the PDP context to indicate radio and network resources required for data transmission. The QoS attributes include
  - Presence class
    - specifies 3 transmission levels (during congestion, the packets with lower priorities are discarded).
  - Delay class
    - specifies 4 delay levels. In 128-octet transfer, the expected transfer time for each class may be
    - Class 1 (less than 0.5 sec)
    - Class 2 (less than 5 sec)
    - Class 3 (less than 50 sec)
    - Class 4 (best-effort transmission without specifying the transfer constraints)

QoS Profile (2/3)

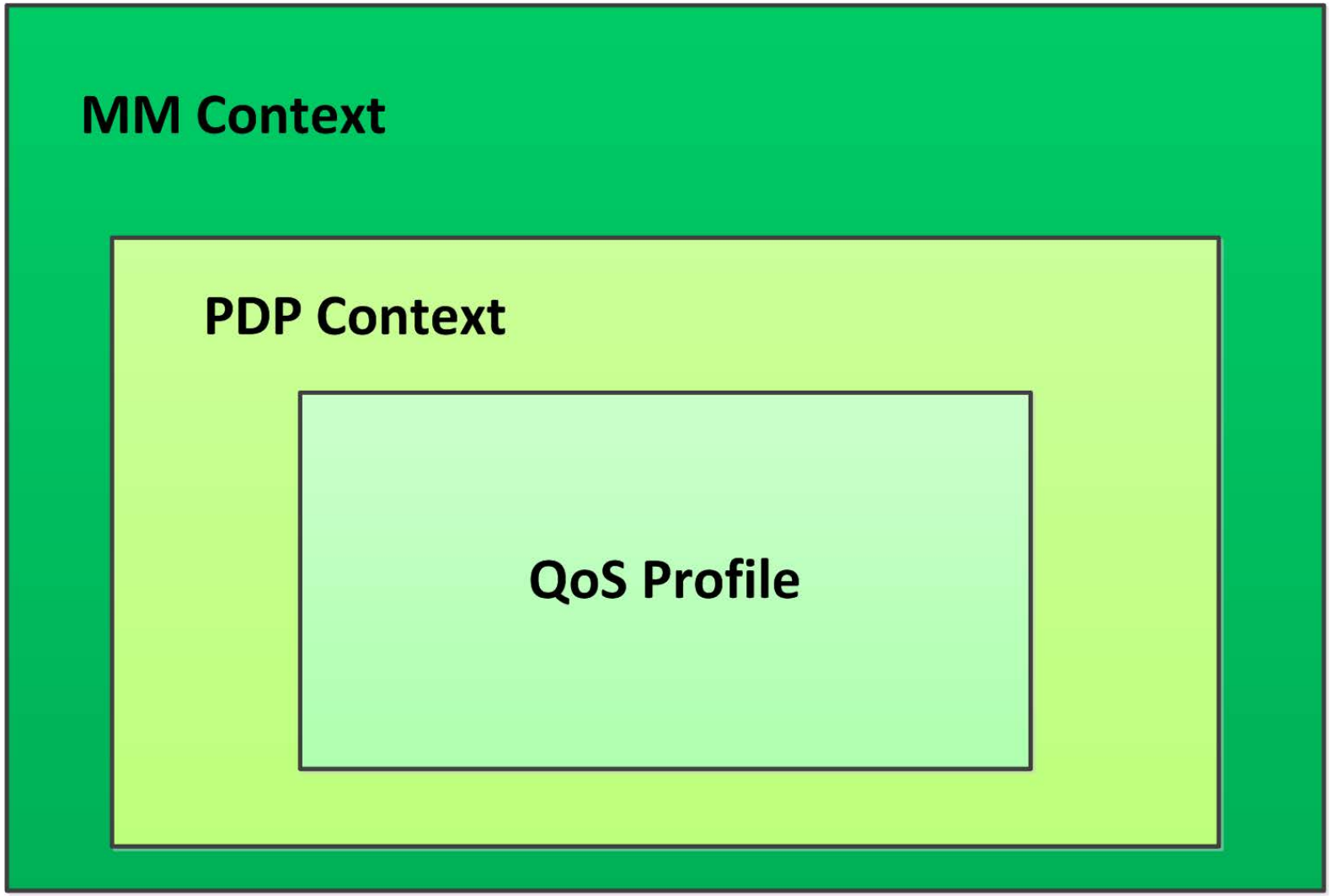
- Reliability class defines error rate (i.e., probability) for data loss, out-of-sequence delivery, and corrupted data. Five Reliability classes

Reliability Class	GTP Mode	LLC Frame Mode	LLC Data Protection	RLC Block Mode	Traffic Type
1	Ack	Ack	Protected	Ack	Non real-time traffic, error-sensitive application (cannot cope with data loss)
2	Unack	Ack	Protected	Ack	Non real-time traffic, error-sensitive application (cope with infrequent data loss).
3	Unack	Unack	Protected	Ack	Non real-time traffic, error-sensitive application that can cope with data loss, GMM/SM, and SMS.
4	Unack	Unack	Protected	Unack	Real-time traffic, error-sensitive application that can cope with data loss.
5	Unack	Unack	Unprotected	Unack	Real-time traffic, error non-sensitive application that can cope with data loss.

QoS Profile (3/3)

- Peak Throughput Class specifies the expected maximum data transmission rate. 9 classes are defined (from 8 Kbps to 2,048 Kbps).
- Mean throughput class specifies the average data transmission rate. 19 classes are defined (from best-effort to 111 Kbps).

Relationship between MM Context, PDP Context, and QoS Profile



Part II: GPRS Interfaces

The Interfaces

- Um (BSS<->MS)
- Gb (BSS<->SGSN)
- Gn (SGSN<->GGSN)
- Gp (SGSN<->GGSN in Other GPRS Network)
- Gs (SGSN<->MSC/VLR)
- Gi (GGSN<->PDN)

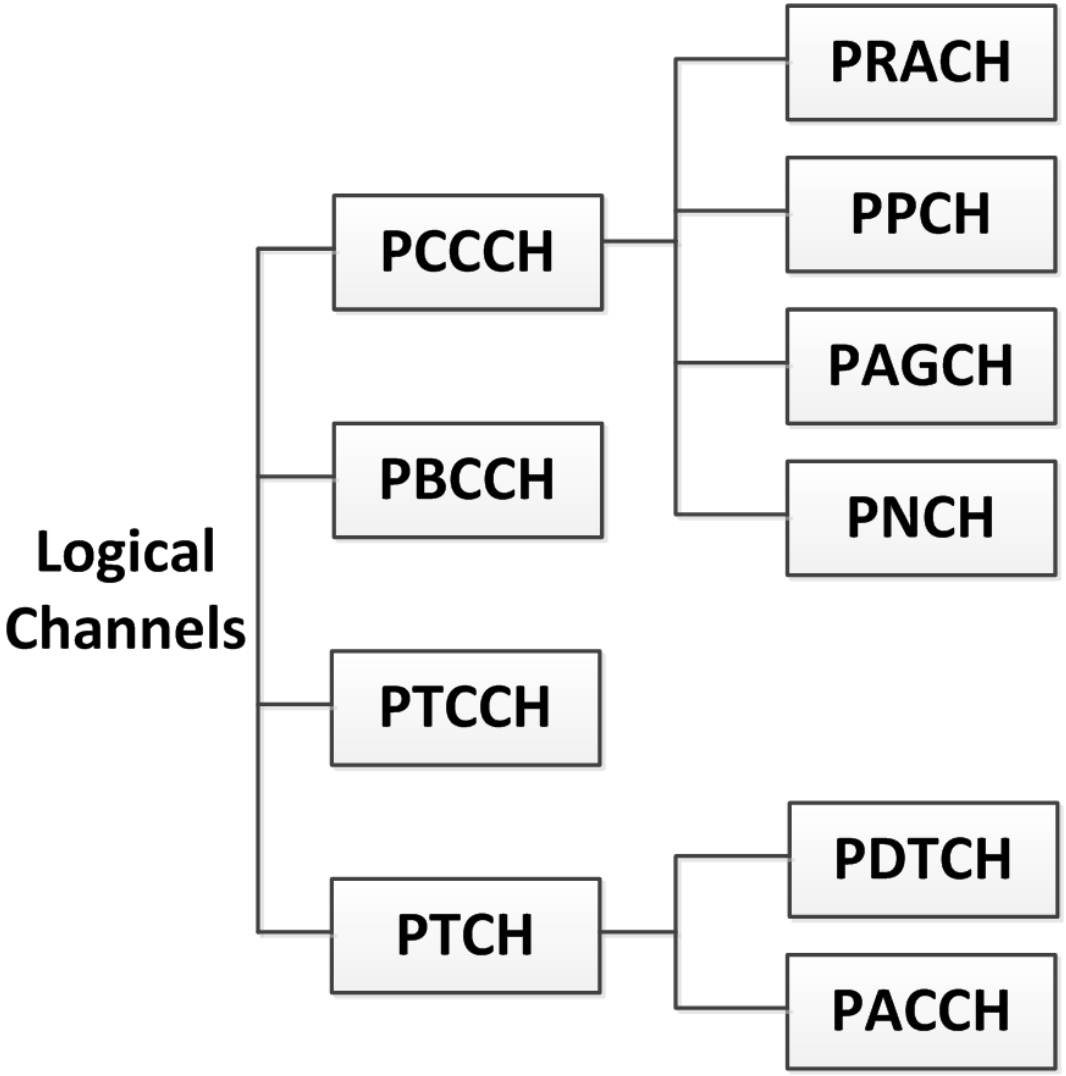
Um Interface (MS<->BSS) [gsm03.64]

- Um describes the radio interface between the MS and the BTS.
- GPRS radio technology is based on the GSM radio architecture, which introduce new logical channel structure to control signaling and traffic flow over the Um radio interface.

Radio Channel Structure

- The physical channel dedicated to packet data traffic is called a *packet data channel (PDCH*).
- Different logical channels can occur on the same PDCH.

Logical Channel Map



Logical Channels (PCCCH) (1/2)

- Packet Common Control Channel (PCCCH)
  - At a given time, the logical channels of the PCCCH are mapped on different physical resources than the logical channels of the CCCH.
  - The PCCCH does not have to be allocated permanently in the cell. Whenever the PCCCH is not allocated, the CCCH shall be used to initiate a packet transfer.
- Packet Random Access Channel (PRACH) (MS->BTS)
  - It is sent from the MS to BTS to initiate uplink transfer for data or signaling.
- Packet Paging Channel (PPCH) (BTS->MS)
  - Pages an MS for both circuit-switched and packet data services.

Logical Channels (PCCCH) (2/2)

- Packet Access Grant Channel (PAGCH) (BTS->MS)
  - Used in the packet transfer establishment phase for resource assignment.
- Packet Notification Channel (PNCH) (BTS->MS)
  - Used to send a Point-To-Multipoint Multicast (PTM-M) notification for resource assignement.

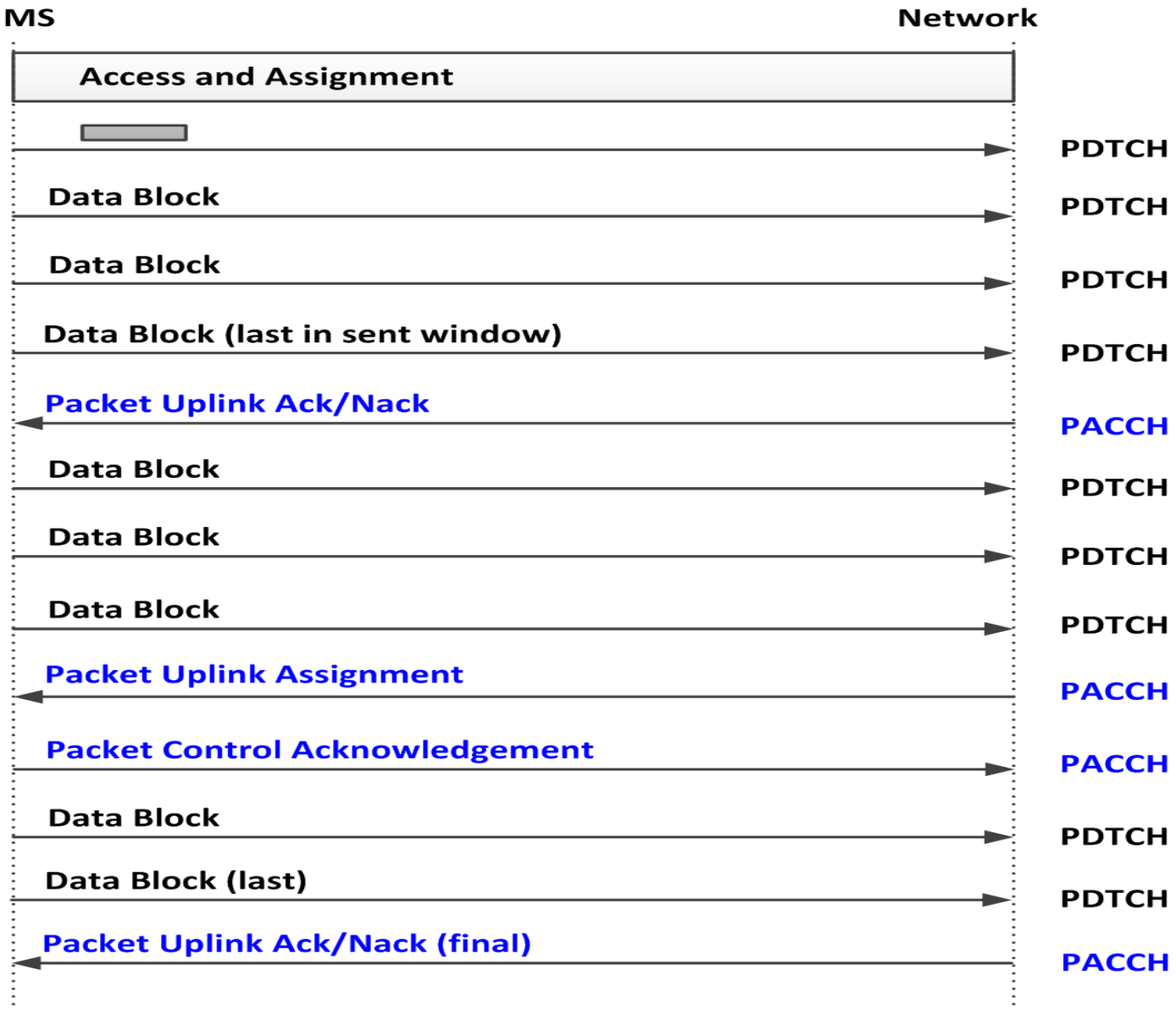
Logical Channels

- Packet Broadcast Control Channel (PBCCH)
  - Broadcasts system information specific for packet data.
  - If PBCCH is not allocated, the packet data specific system information is broadcast on the existing GSM BCCH channel.
- Packet Timing Advance Control Channel (PTCCH)
  - PTCCH/U: Used by an MS to transmit a random burst. With this information, the BSS estimates timing advance.
  - PTCCH/D: Used by BSS to transmit timing advance information updates to several MSs.

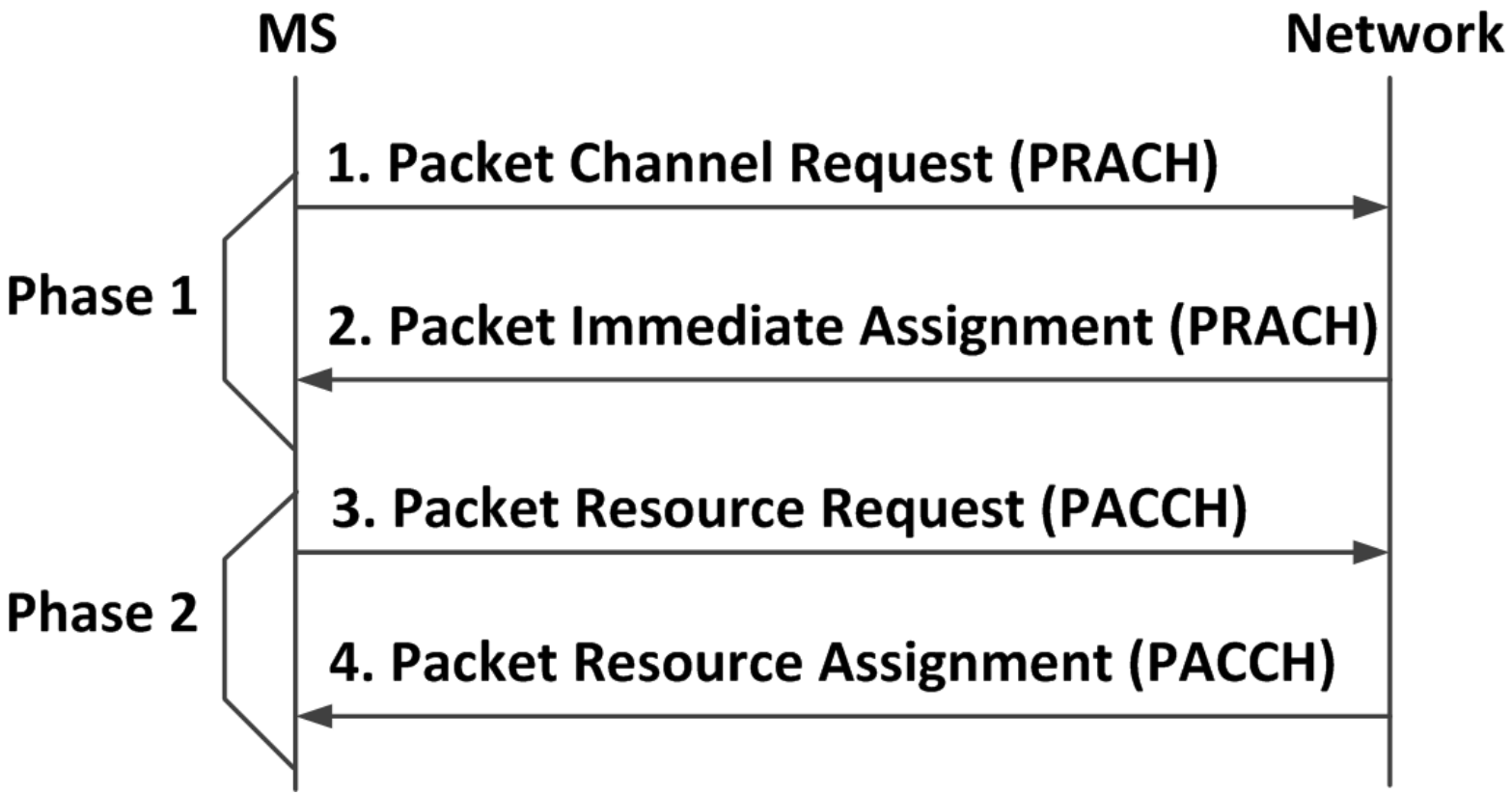
Packet Traffic Channels (PTCH)

- Packet Data Traffic Channel (PDTCH)
  - One PDTCH is mapped onto one physical channel.
  - Up to eight PDTCHs, with different timeslots but with the same frequency parameters, may be allocated to one MS at the same time.
- Packet Associated Control Channel (PACCH)
  - Conveys signaling information, such as power control, resource assignment, and reassignment information.
  - The PACCH shares resources with PDTCHs.
  - An MS currently involved in packet transfer can be paged for circuit-switched services on PACCH.

GPRS Uplink Packet Transfer



Access and Assignment Phase (1/3)



Access and Assignment Phase (2/3)

- One-Phase Approach
  - The network assigns an uplink packet channel for a number of radio blocks to be transferred.
  - The network informs the MS of this assignment through PAGCH.
  - One or more PDCHs can be assigned based on the requested resources indicated in PRACH.
  - Alternatively, the MS may use RACH for a packet channel request

Access and Assignment Phase (3/3)

- Two-Phase Access Approach
  - If the network needs more information for resource reservation, it indicates the need for two-phase access in the PAGCH (message 2).
  - The PAGCH allocates the uplink resources of PACCH (message 3) for MS to transmit the complete resource information.
  - By exchanging the uplink and downlink PACCHs (messages 3 and 4), the network obtains sufficient information for resource allocation.

Um Protocol Layers

- **RF Layer (RFL).**
  - Performs modulation/demodulation received from or sent to the PLL.
- **Physical Link Layer (PLL).**
  - Provides services for information transfer over a physical channel (including data unit framing, data coding, and the detection and correction of physical medium transmission errors).
- **Radio Link Control/Medium Access Control (RLC/MAC).**
  - Backward Error Correction Procedures (enabled by the selective retransmission of erroneous blocks)
  - RLC is responsible for block segmentation and reassembly, buffering, and retransmission with backward error correction.
  - MAC is responsible for channel access (scheduling, queuing, contention resolution), PDCH multiplexing, and Power Control.

Four GPRS Coding Schemes

- CS1.
  - User Data Rate: 9.05 Kbps; Correction Capability: Highest; Max Cell Range: 450 m
- CS2.
  - User Data Rate: 13.4 Kbps; Max Cell Range: 390 m;
- CS3.
  - User Date Rate: 15.6 Kbps; Max Cell Range: 350 m;
- CS4.
  - User Date Rate: 21.4 Kbps; Max Cell Range: 290 m; Correction Capability None.

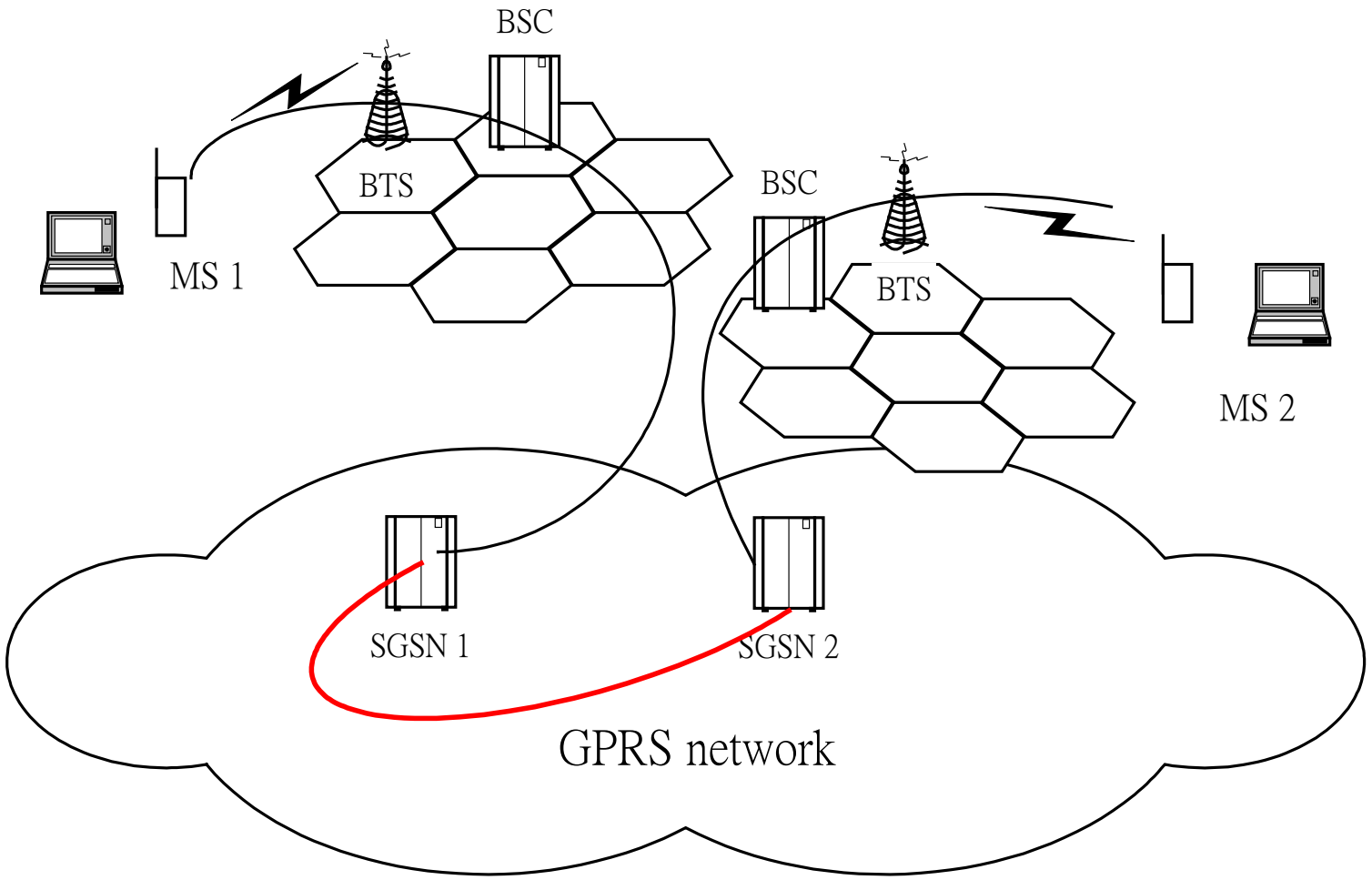
Gb Interface (BSS<->SGSN)

- The Gb interface allows many users to be multiplexed over the same physical resource.
  - Unlike GSM, A interface (where the resources of a circuit-switched connection are dedicated to a user) through the whole session.
- The Gb interface includes
  - SNDCP (SubNetwork Dependent Convergence Protocol)
  - LLC (Logical Link Control)
  - BSSGP (Base Station System GPRS Protocol)
  - NS (Network Service; Frame Relay)
  - Link Layer 2
  - Physical Layer

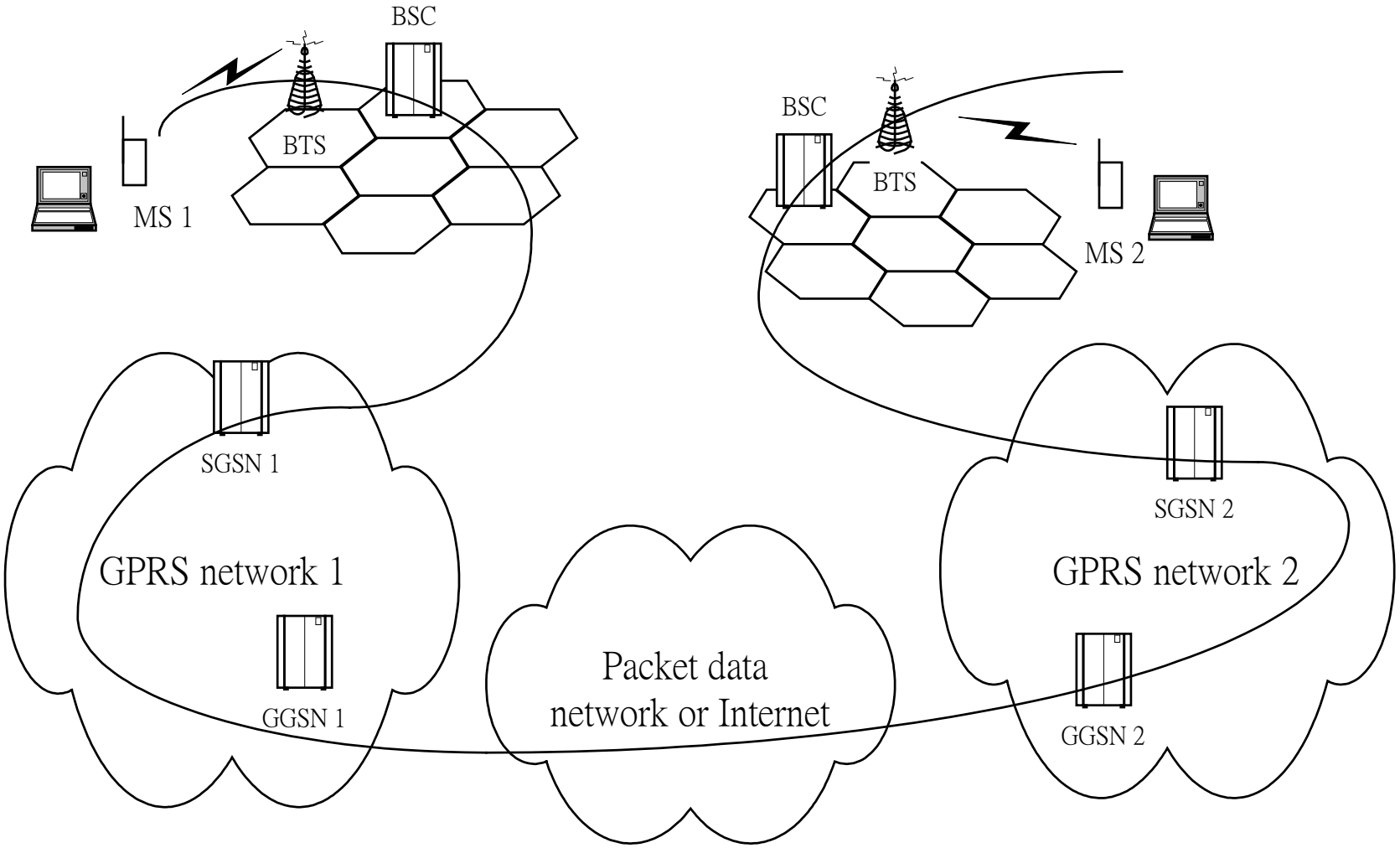
Gn (SGSN<->GGSN) & Gp (SGSN<->External GGSN) interfaces (1/3)

- Both Gn and Gp interfaces utilizes the GPRS Tunneling Protocol (GTP).
  - GTP tunnels user data and signaling message between GSNs.
- Gp is the same as Gn except that extra security functionality is required for internetwork communications over the Gp interface.
  - These security functionality is based on mutual agreements between operators.
- With GTP, an SGSN may communicate with multiple GGSNs, and a GGSN may connect to many SGSNs.
  - MS, BSS, MSC/VLR, and HLR are not aware of the existence of GTP.

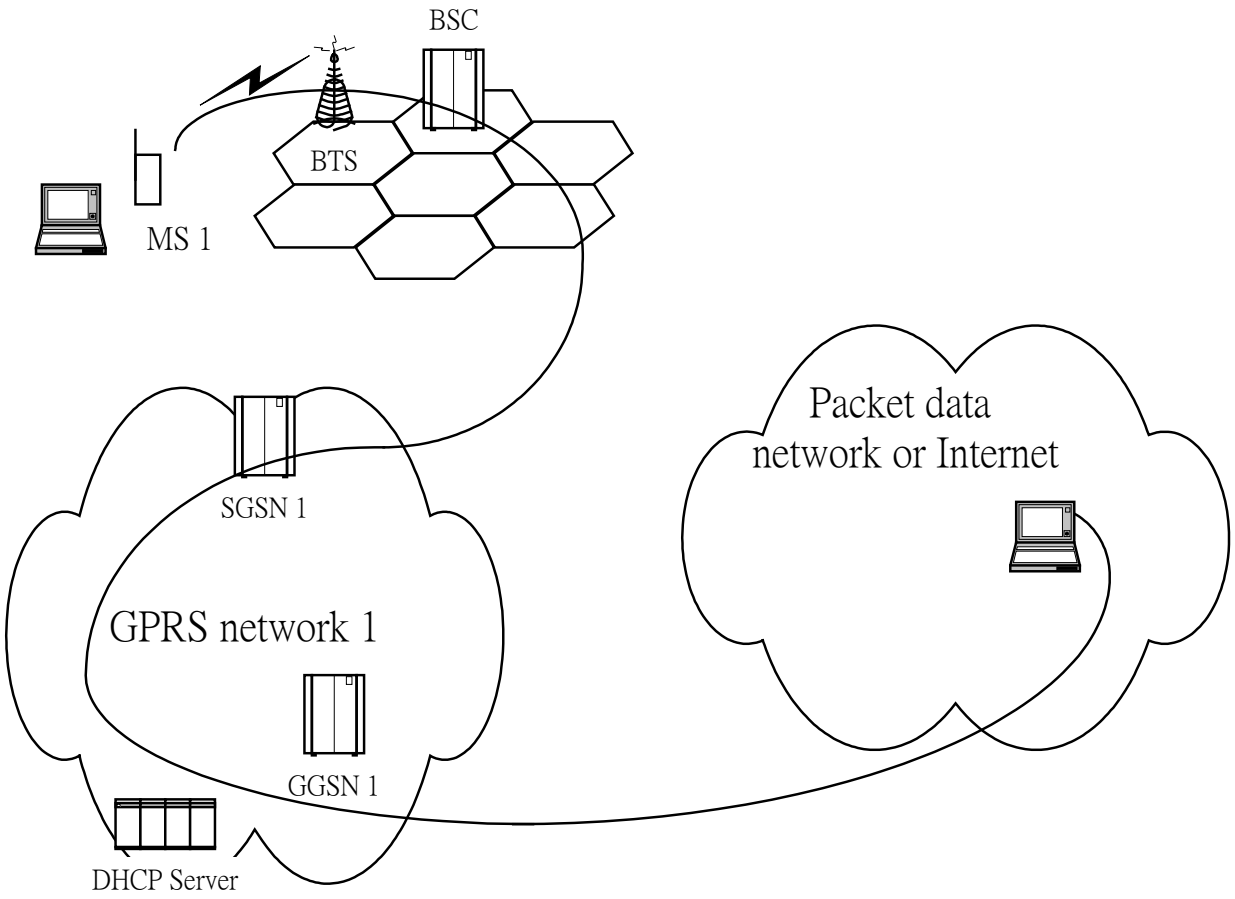
GPRS Example 1



GPRS Example 2



GPRS Example 3

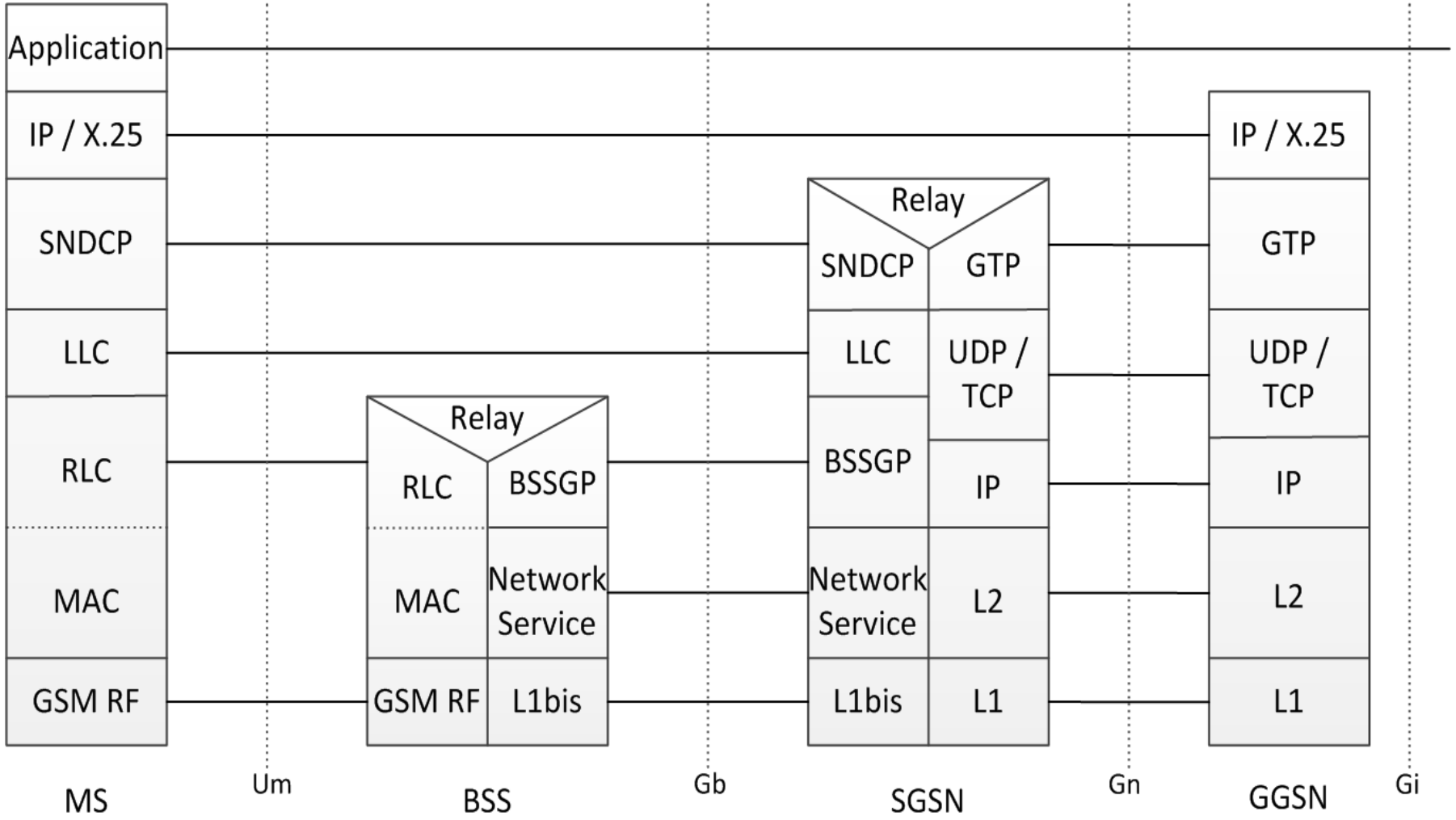


Gn (SGSN<->GGSN) & Gp (SGSN<->External GGSN) interfaces (2/3)

- In the transmission plane, GTP is supported by the
  - Transmission Control Protocol (TCP) for connection-oriented transmission,
  - User Datagram Protocol (UDP) for connectionless transmission.

- GTP transmission uses a tunneling mechanism to carry user data packets.
  - A tunnel is a two-way, point-to-point path.
  - Tunneling transfers encapsulate data between GSNs (the point of encapsulation-> the point of decapsulation).
  - GTP implements out-of-band signaling (so that signaling path is logically separated from the data tunnels).

GPRS Transmission Plane

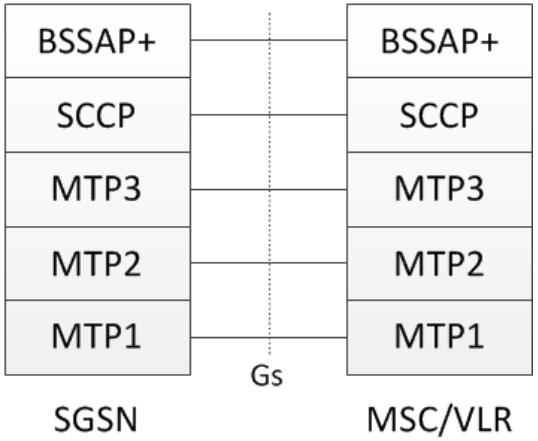


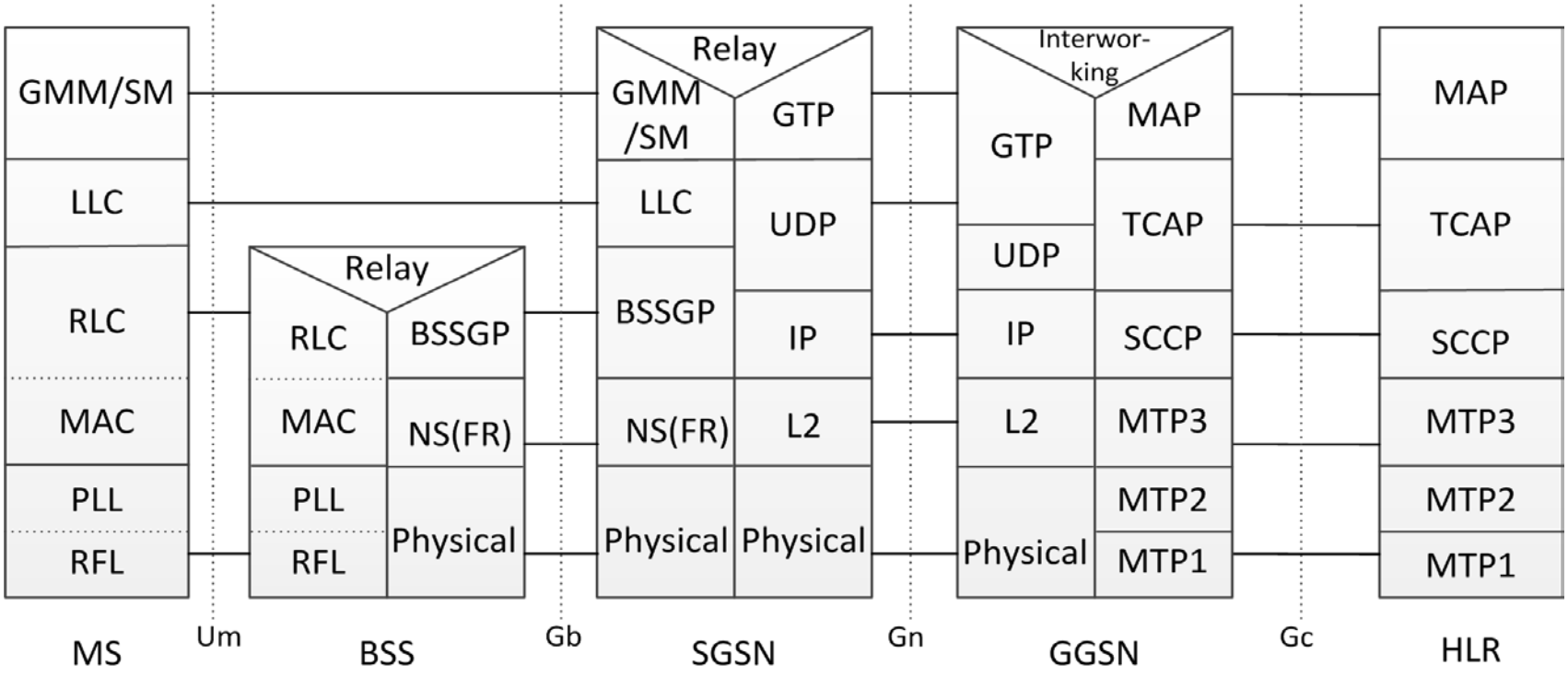
Gn (SGSN<->GGSN) & Gp (SGSN<->External GGSN) interfaces (3/3)

- In the signaling plane, GTP is supported by UDP.
- More than one path may be established between two GSNs, either in the same network or in different networks.
- A GTP tunnel is defined by the associated PDP contexts in two GSN nodes, and is identified with a tunnel ID.
- GTP performs
  - Path Management
  - Tunnel Management
  - Location Management
  - Mobility Management

GPRS Signaling Plane

BSS AP+: Base Station System Application Part+
GMM: GPRS Mobility Management
MAP: Mobile Application Part
MTP: Message Transfer Part
SCCP: Signaling Connection Control Part
SM: Session Management
TCAP: Transaction Capabilities Application Part





Path and Location Managements in GTP

- In path management, the GSNs exchange the Echo_Request and Response message pair to quickly detect failures occurring in the path.

- Location management is required if a GGSN does not support SS7 MAP for communication with an HLR.
  - In this case, the interaction (GGSN<->HLR) is done indirectly through a specific GSN that performs GTP-MAP protocol conversation (usually through SGSN).

GTP Tunnel Management

- Creating Tunnels.
- Updating Tunnels.
- Deleting Tunnels.

GTP Tunnel Management: Creating Tunnel (1/2)

- Step 1. The SGSN selects the IP address of a GGSN from a list in DNS, and sends Create_PDP_Context_Request message to that GGSN.
- Step 2. If the GGSN does not respond, the SGSN continues to send the request message to the GGSN in the DNS list.
- Step 3. Upon receipt of this message, the GGSN creates a PDP context entry for the MS, and generates a charging ID.
  - The new entry allows the GGSN to route and charge packets between the SGSN and the external PDP networks.

GTP Tunnel Management: Creating Tunnel (2/2)

- Step 4. The GGSN returns a Create_PDP_Context_Response message to the SGSN.
  - This message indicates whether TCP or UDP will be used to transport user data.
- Note that only one path is used between any given GSN pair to tunnel end-user traffic in both directions.

GTP Tunnel Management: Updating Tunnel (1/2)

- To update (1) the routing area information or (2) a PDP context, an SGSN sends the Update_PDP_Context_request message (SGSN->GGSN).
  - The message includes (new SGSN address, Tunnel ID, QoS Negotiates).

- Upon receipt of this message, GGSN may reject the update request if the QoS negotiated with the SGSN is not compatible.
  - E.g., the reliability class is insufficient to support the PDP type.
  - The GGSN may also restrict the QoS negotiated based on its capabilities and the current load.

GTP Tunnel Management: Updating Tunnel (2/2)

- If the GGSN returns a negative Update_PDP_Context_Response message, the SGSN deactivates the PDP context.
- GTP may use this message pair (Update_PDP_Context_request , negative Update_PDP_Context_Response) to redistribute PDP contexts for load balancing.

GTP Tunnel Management: Deleting Tunnel

- To detach an MS or to deactivate a PDP context, an SGSN and a GGSN exchanges the Delete_PDP_Context_Request and Response message pair.
- For GGSN to activate a PDP context,
  - Step 1. the GGSN sends the PDU_Notification_Request message to the SGSN indicated by the HLR (SGSN serving MS).
  - Step 2. SGSN requests that the MS activate the indicated PDP context.
  - Step 3. SGSN replies with a PDU_Notification_Response message to the GGSN.

GTP Mobility Management (1/2)

- GTP MM supports functions, e.g.,
  - GPRS Attach
  - GPRS Routing Area Update
  - Activation of PDP Contexts

- Step 1. When MS moves from one SGSN to another SGSN, it sends P-TMSI to the new SGSN.
  - The new SGSN then exchanges Identification_Request and Response message pair with the old SGSN to obtain the IMSI of the MS. (IMSI used for finding MS record in HLR).

GTP Mobility Management (2/2)

- Step 2. The SGSN_Context_Request message is sent from the new SGSN to the old SGSN to obtain MM and all active PDP contexts of an MS.
  - (old RA ID, old P-TMSI, new SGSN address).
- Step 3. Upon receipt of the message, the old SGSN sends the requested contexts to the new SGSN by SGSN_Context_Response.
  - (MM context, PDP contexts, LLC Ack)
- Step 4. After new SGSN receives, it acks by SGSN_Context_Acknowledge message.
  - This message implies that the new SGSN is ready to receive the packet frames for the MS.
- Step 5. The old SGSN forwards user packets to the new SGSN.

Gs Interface

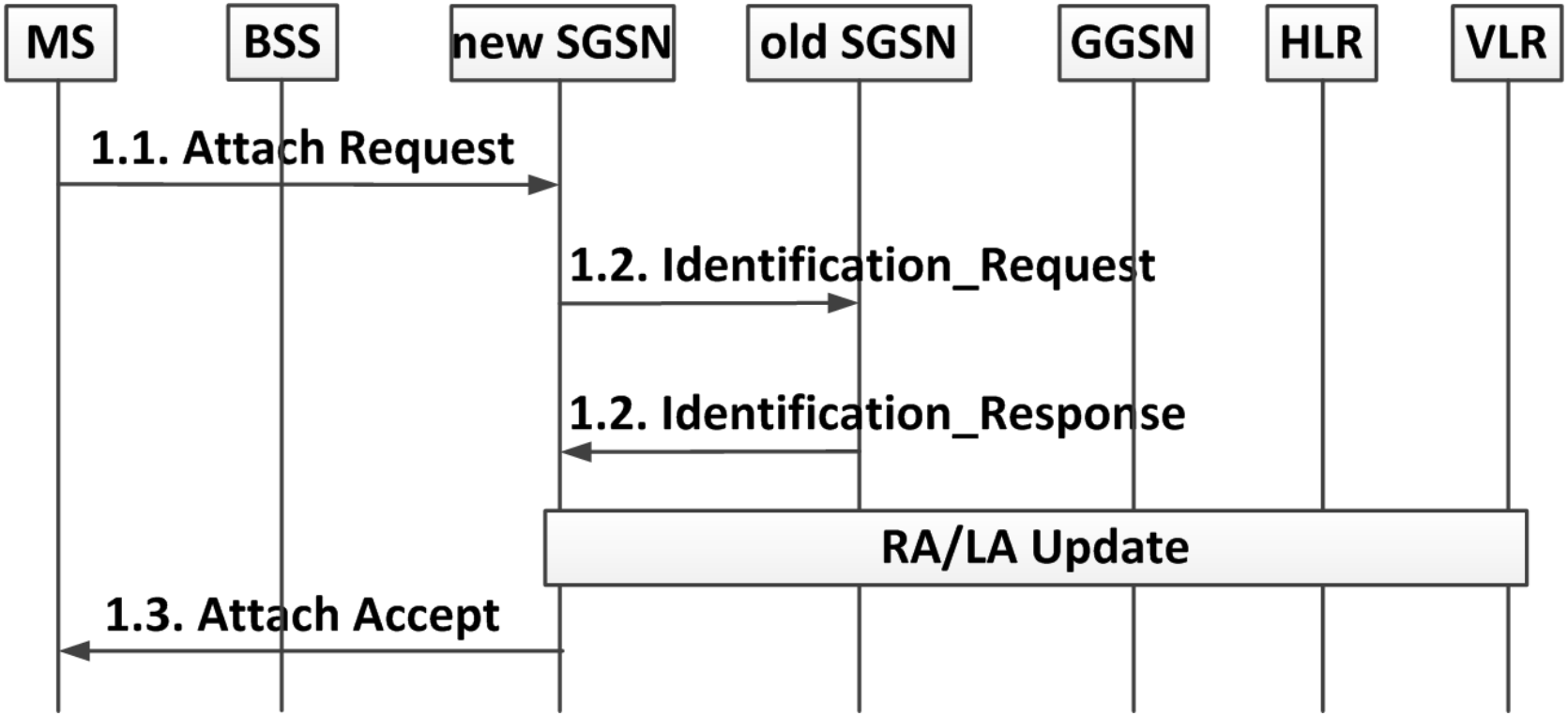
- The Gs Interface connects the database in the MSC/VLR and the SGSN,
  - Which does not involve user data transmission.
- The BSSAP+ implements the functionality for the Gs interface.
  - BSSAP+ utilizes SS7 Signaling Connection Control Part as the lower-layer protocol.
  - BSSAP+ procedures coordinate the location information of MSs (that are both IMSI- and GPRS-attached).
  - BSSAP+ is used to convey some GSM procedures via SGSN.

Part III: GPRS Procedures

GPRS Procedures

- GPRS Attach/Detach
- PDP context manipulation
- RA/LA Update

GPRS Attach Procedure: Message Flow



GPRS Attach (1/3)

- Step 1.1. (GMM/Um and Gb interfaces).
  - The MS sends an Attach Request to SGSN.
  - The Generation of this message involves the GMM layer.
  - The message indicates whether GPRS attach or GPRS/IMSI attach will be performed.

- Step 1.2. (GTP Mobility Management/Gn interface).
  - Assuming that after the last detach, the MS moved from the old SGSN to the new SGSN.
  - The new SGSN sends an Identification_Request(old P-TMSI).
  - The old SGSN uses the received P-TMSI to search for the IMSI of MS.
  - Then old SGSN returns the IMSI by sending Identification_Response(IMSI).

GPRS Attach (2/3)

- Step 1.2. (Cont.).
  - If the IMSI search fails, the old SGSN responds with an appropriate error cause.
  - In this case, the new SGSN will ask the MS to send its IMSI over the air interface.
  - After the IMSI has been obtained, the SGSN may perform security procedures for MS authentication and ciphering.
  - For the first attach, or if the SGSN number has changed since GPRS detach, the RA (and possibly the LA) update is performed.

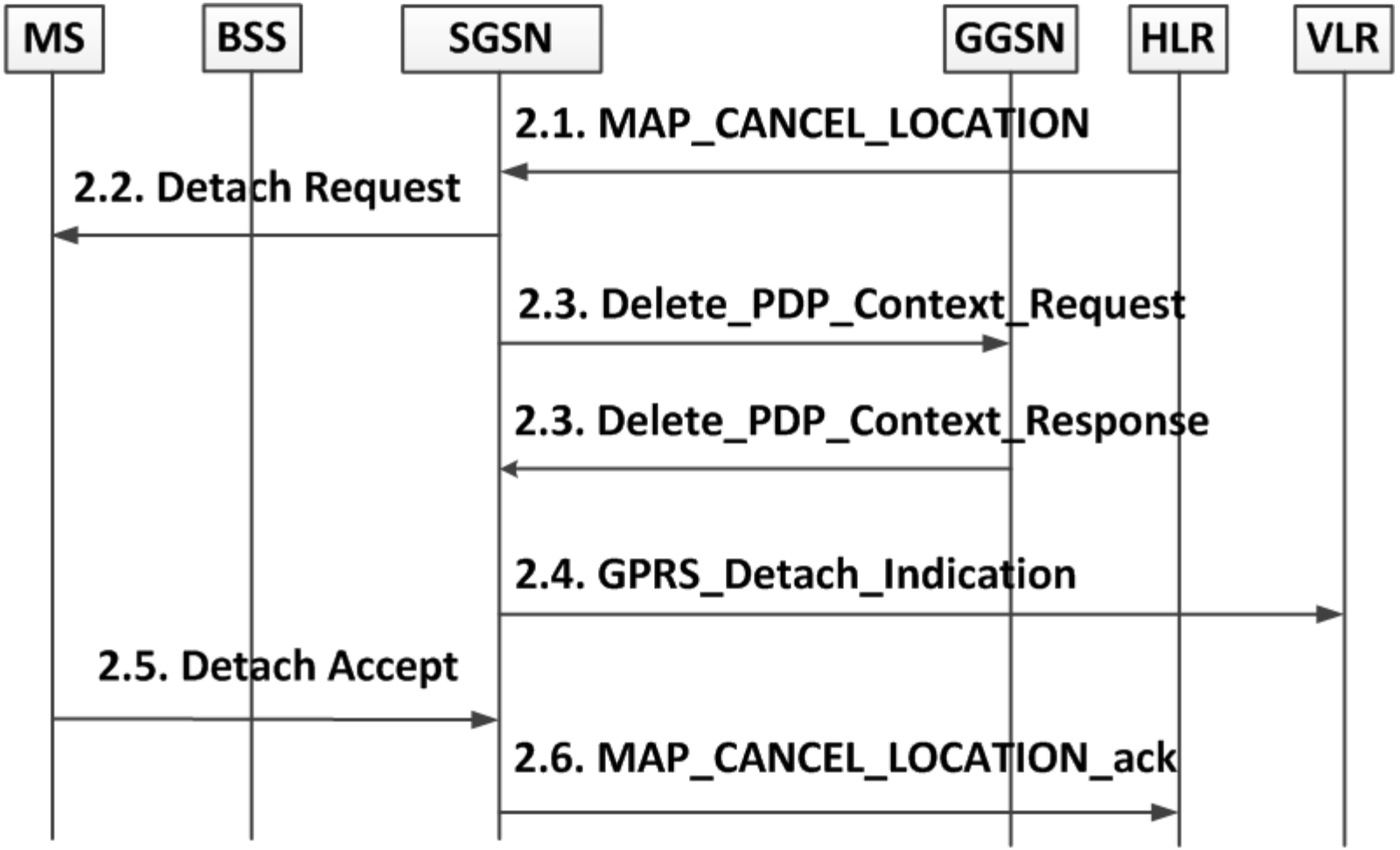
GPRS Attach (3/3)

- Step 1.3 (GMM/Um and Gb interfaces).
  - The SGSN selects the radio priority for the short message service,
  - Sends Attach Accept (P-TMSI, VLR TMSI, P-TMSI Signature, Radio Priority SMS) to the MS.
  - If a new P-TMSI is allocated to the MS, the MS sends an acknowledge to the corresponding VLR.

GPRS Detach

- GPRS detach can be initiated by MS, SGSN, or HLR.
- The different types of detach are:
  - IMSI detach;
  - GPRS detach; and
  - combined GPRS / IMSI detach (MS-initiated only).

GPRS Detach: HLR-Initiated Detach Procedure (Message Flow)



Detach message flow

GPRS Detach: HLR-Initiated Detach Procedure (1/2)

- Step 2.1 (GSM MAP/Gr interface).
  - Following the standard GSM MAP, the HLR sends the MAP_CANCEL_LOCATION(IMSI, Cancellation Type) message to the SGSN with Cancellation Type set to Subscription Withdrawn.
- Step 2.2 and 2.5 (GMM/Um and Gb interfaces).
  - The SGSN sends Detach Request to the MS. The message includes the detach type parameter to indicate that the MS should not make a new attach and PDP context activation.
  - At Step 2.5, the MS returns Detach Accept and detaches itself from the network.
  - Note that detach type parameter used depends on who initiates the detach procedure.

    (1) In SGSN-initiated detach, the SGSN may request the MS to make a new attach.

    (2) In MS-initiated detach, the detach type is specified by the MS to indicate whether the operation is for GPRS-, IMSI-, or combined GPRS and IMSI attach.

GPRS Detach: HLR-Initiated Detach Procedure (2/2)

- Step 2.3 (GTP tunnel management/Gn interface).
  - The SGSN and GGSN exchange Delete_PDP_Context_Request(TID) and Response(TID) to deactivate the MS's PDP context in the GGSN.
- Step 2.4 (BSSAP+/Gs interface).
  - If the MS was also IMSI-attached, the SGSN sends a GPRS_Detach_Indication(IMSI) to the VLR.
  - The VLR removes the association with the SGSN and handles paging and location update without going through the SGSN.
- Step 2.6 (GSM MAP/Gr Interface).
  - After the MS detach operation is performed (at Step 2.5), the SGSN sends the MAP_CANCEL_LOCATION_ack to confirm the deletion of the MM and PDP contexts.

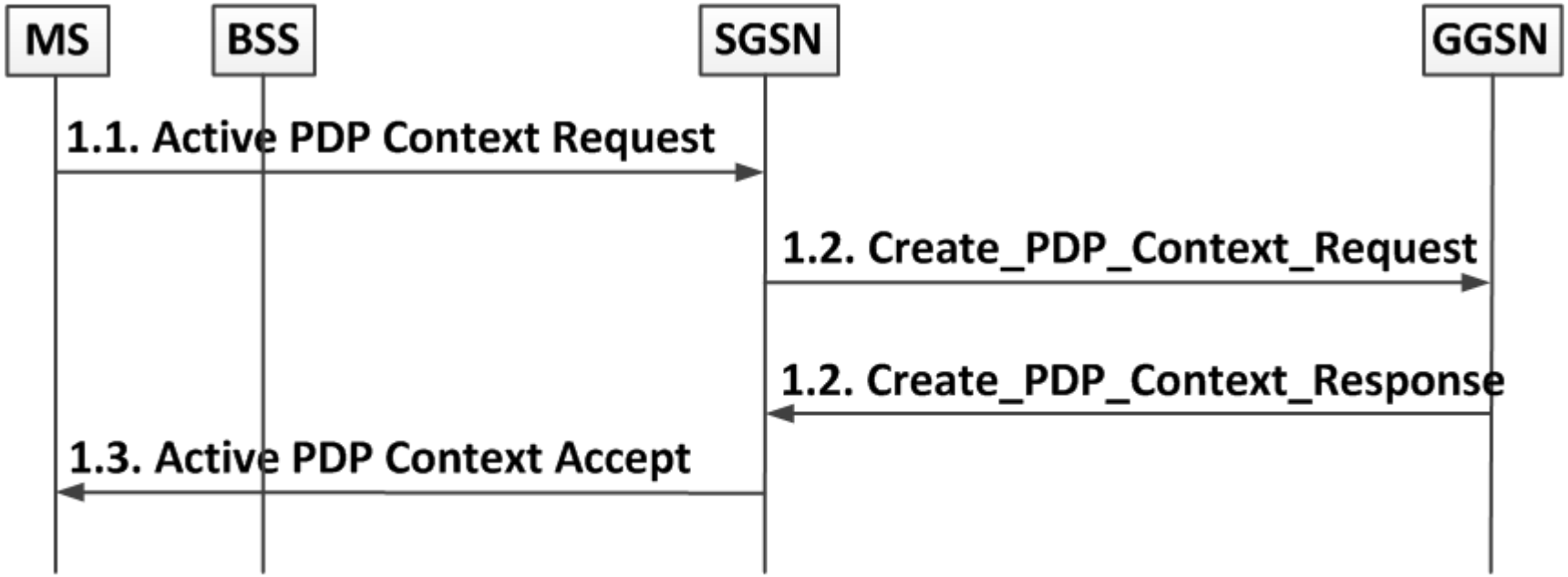
GPRS Detach: SGSN-initiated & MS-initiated

- In both SGSN-initiated and MS-initiated detach procedures, the HLR is not involved.
- The message flow for the SGSN-initiated procedure is the same as that HLR-initiated, except Steps 2.1 and 2.6 are not executed.
- The message flow for the MS-initiated procedure is similar to SGSN-initiated
  - Except that the Detach Request is sent from the MS to the SGSN and the Detach Accept message is sent from the SGSN to the MS.

PDP Context Procedures

- PDP Context Activation
- PDP Context Modification
- PDP Context Deactivation

PDP Context Activation: Message Flow



PDP context activation message flow

PDP Context Activation (1/3)

- Step 1.1 (GMM/Um and Gb Interfaces).
  - The MS sends an Activate PDP Context Request (NSAPI, TI, PDP Type, PDP Address, Access Point Name, QoS Requested, PDP Configuration Options) to the SGSN, to indicate whether the MS will use a static or a dynamic PDP addresses.
  - This message also specifies the external data network to be connected and the desired QoS.
  - After this message, security functions may be executed (SGSN<->MS) for authentication.
  - The SGSN checks the user subscription and QoS.

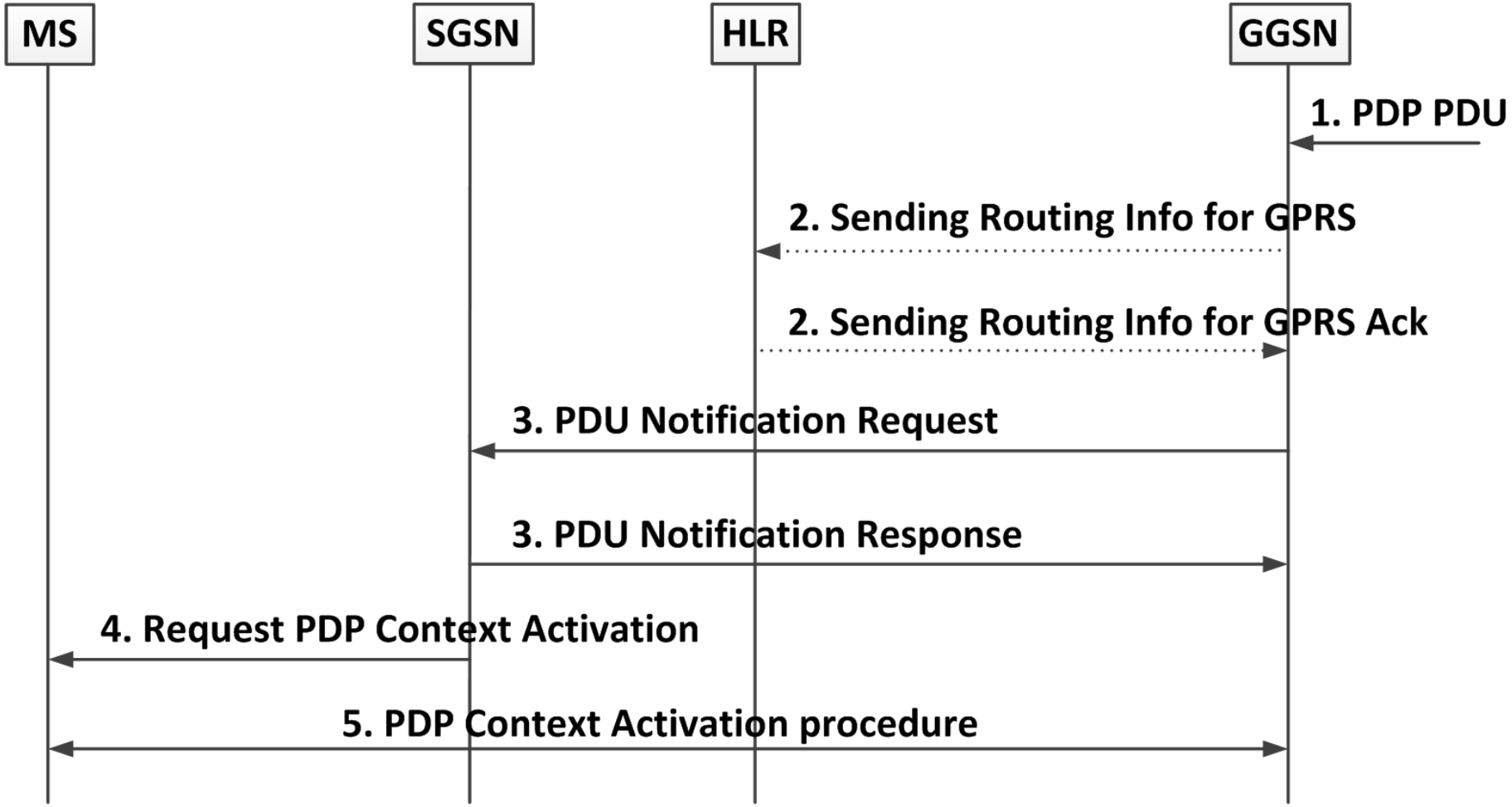
PDP Context Activation (2/3)

- Step 1.2 (GTP tunnel management/Gn interface).
  - The SGSN sends a Create_PDP_Context_Request message to GGSN.
  - The activation creates a tunnel/logical link between a PDP context in the SGSN and a PDP context in the GGSN.
  - The GGSN obtains the IP address from the external data network, and is forwarded to the MS.
  - If the GGSN replies to the SGSN with a positive Create_PDP_Context_Response message, the SGSN activates the PDP context and is ready to forward packets between the MS and the GGSN.

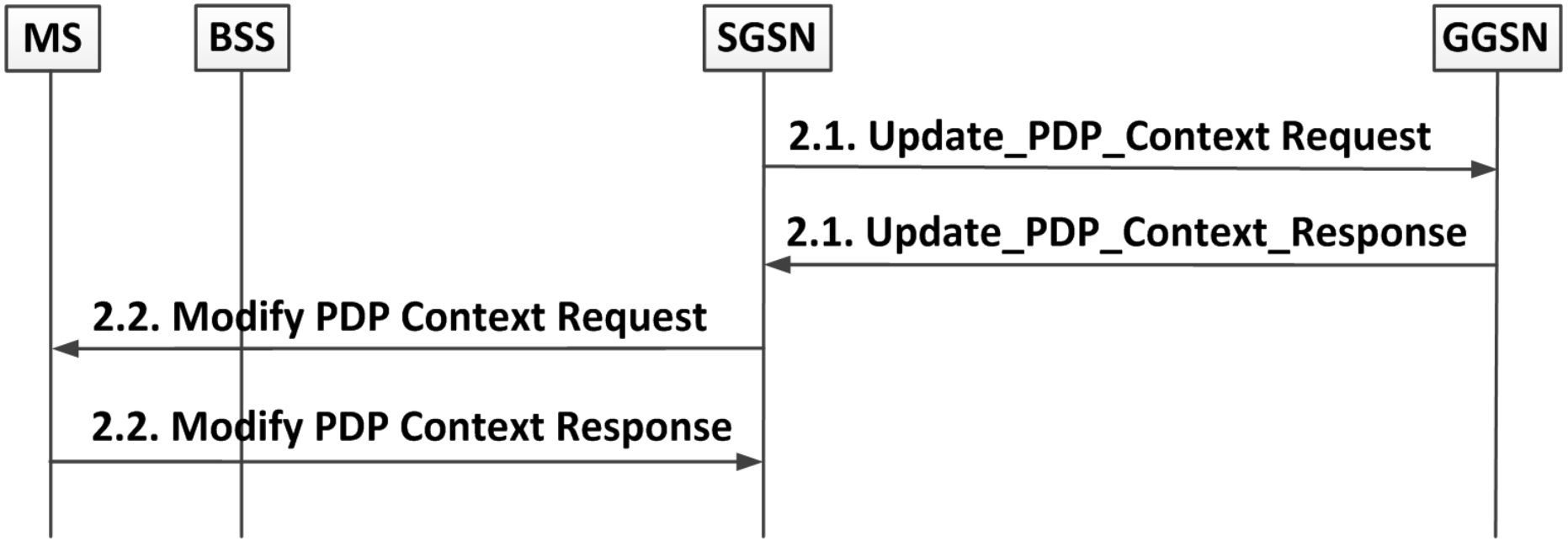
PDP Context Activation (3/3)

- Step 1.3 (GMM/Um and Gb interfaces).
  - Based on the information received from the GGSN in Step 1.2, the SGSN stores the GGSN address and the dynamic PDP address (if any) in the PDP context.
  - The SGSN selects the radio priority based on the negotiated QoS, and returns an Activate PDP Context Accept to the MS.
- After the PDP context activation, a connection between the MS and the external data network is established.
- The SGSN is ready to route and charge for packets delivered (GGSN<->MS).

Network-Requested PDP Context Activation Procedure



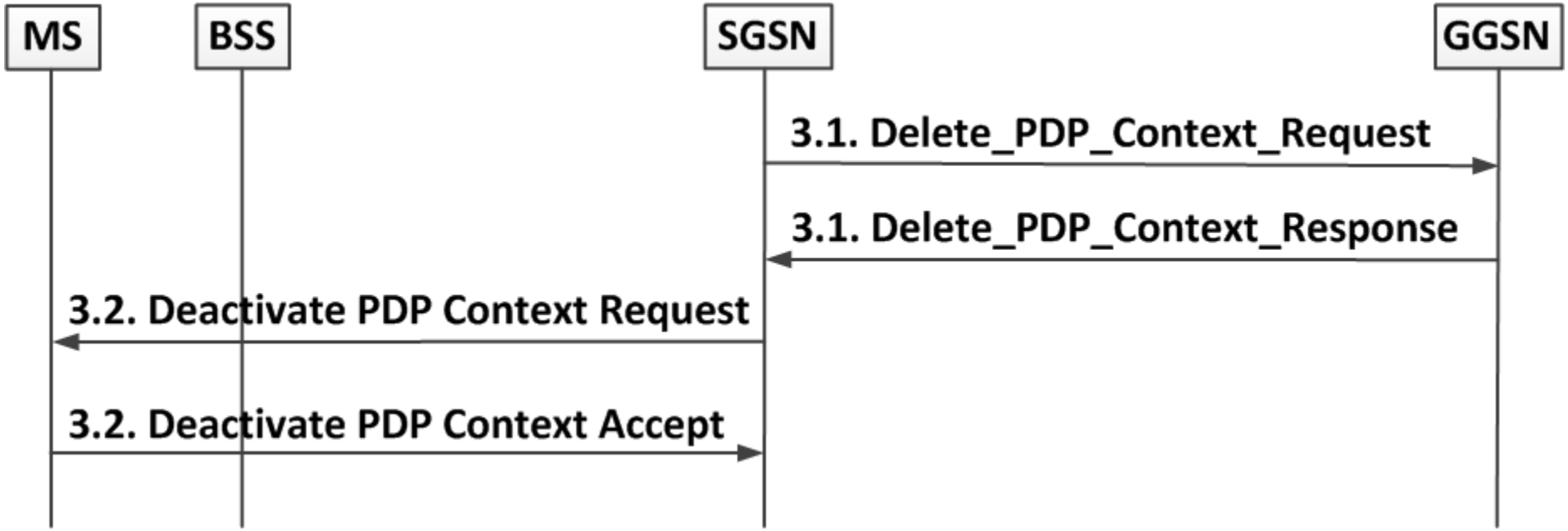
PDP Context Modification: Message Flow



PDP Context Modification

- Step 2.1 (GTP tunnel management/Gn interface).
  - The SGSN and the GGSN exchanged the Update_PDP_Context_Request and Response.
- Step 2.2 (GMM/Um and Gb interfaces).
  - The SGSN and the MS exchange the Modify PDP Context Request and Accept message pair to update the PDP context at the MS.
  - If the MS does not accept the new negotiated QoS, it deactivates the PDP context.

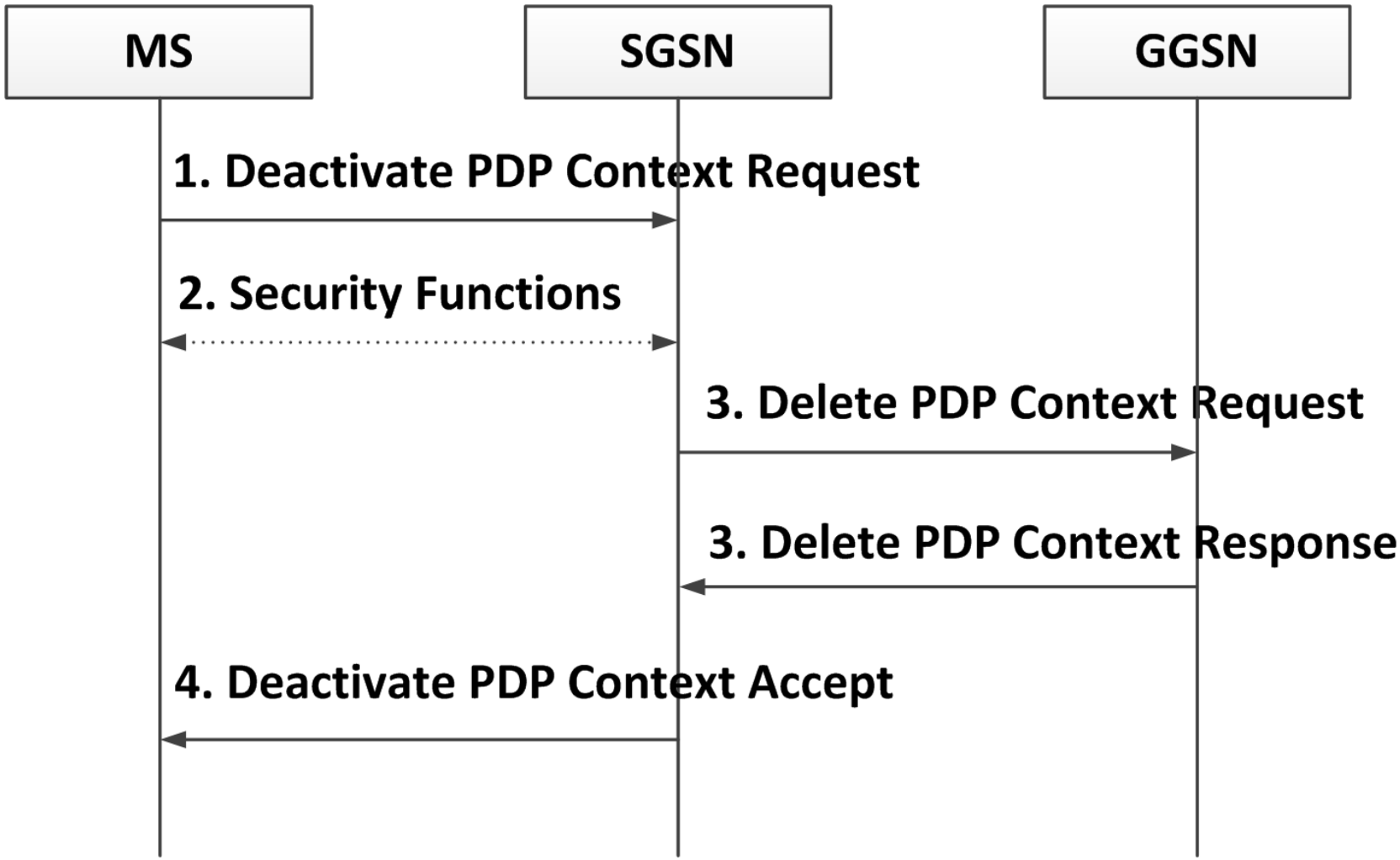
PDP Context Deactivation: Message Flow



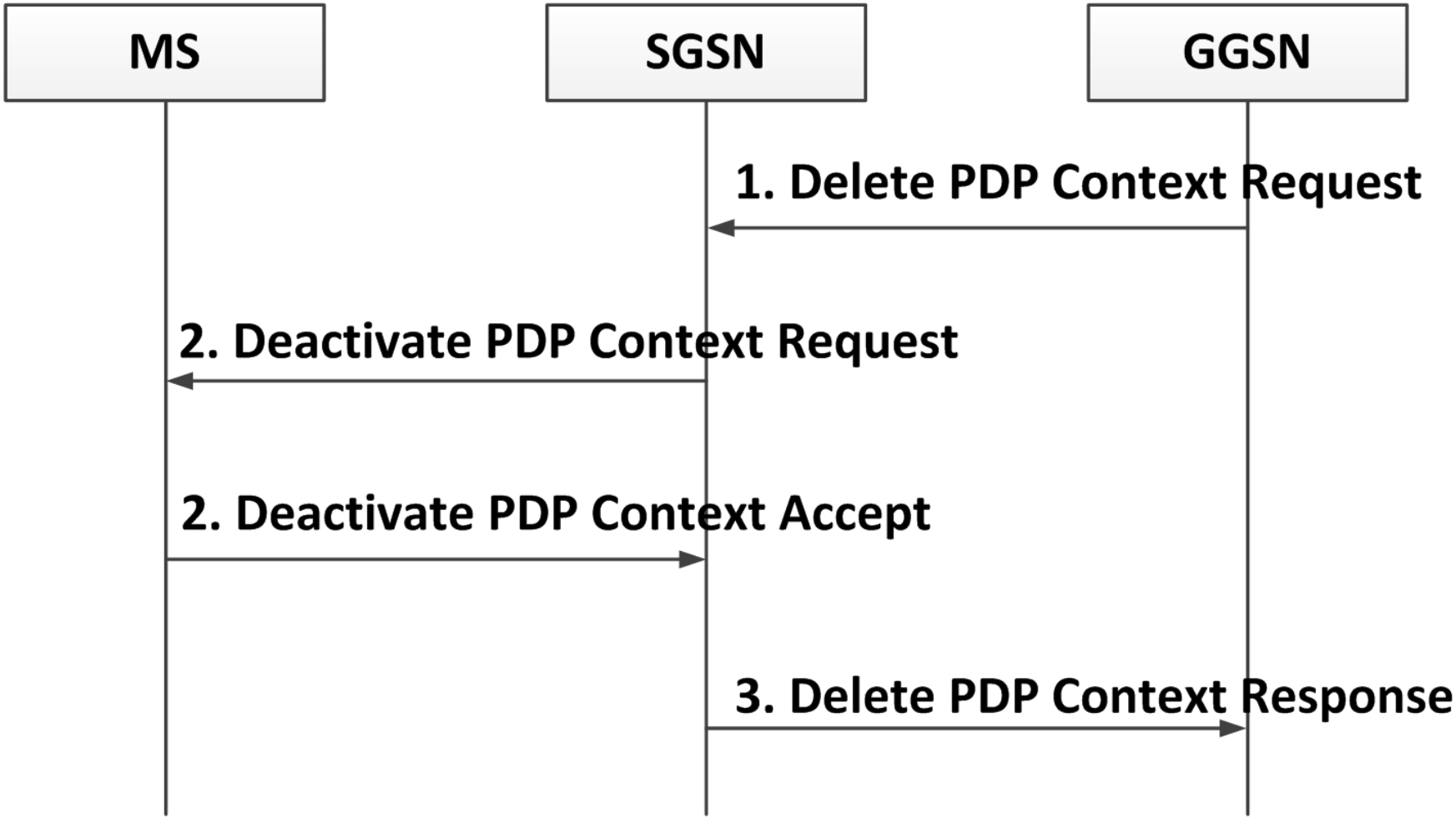
PDP Context Deactivation

- Step 3.1 (GTP tunnel management/Gn interface).
  - The SGSN and GGSN exchanges the Delete_PDP_Context_Request and Response message pair to deactivate the PDP context.
  - The GGSN removes the PDP context and reclaims dynamic PDP address.
- Step 3.2 (GMM/Um and Gb interfaces).
  - The SGSN and the MS exchange the Deactivate PDP Context Request and Accept message pair.
  - The MS removes the PDP context.

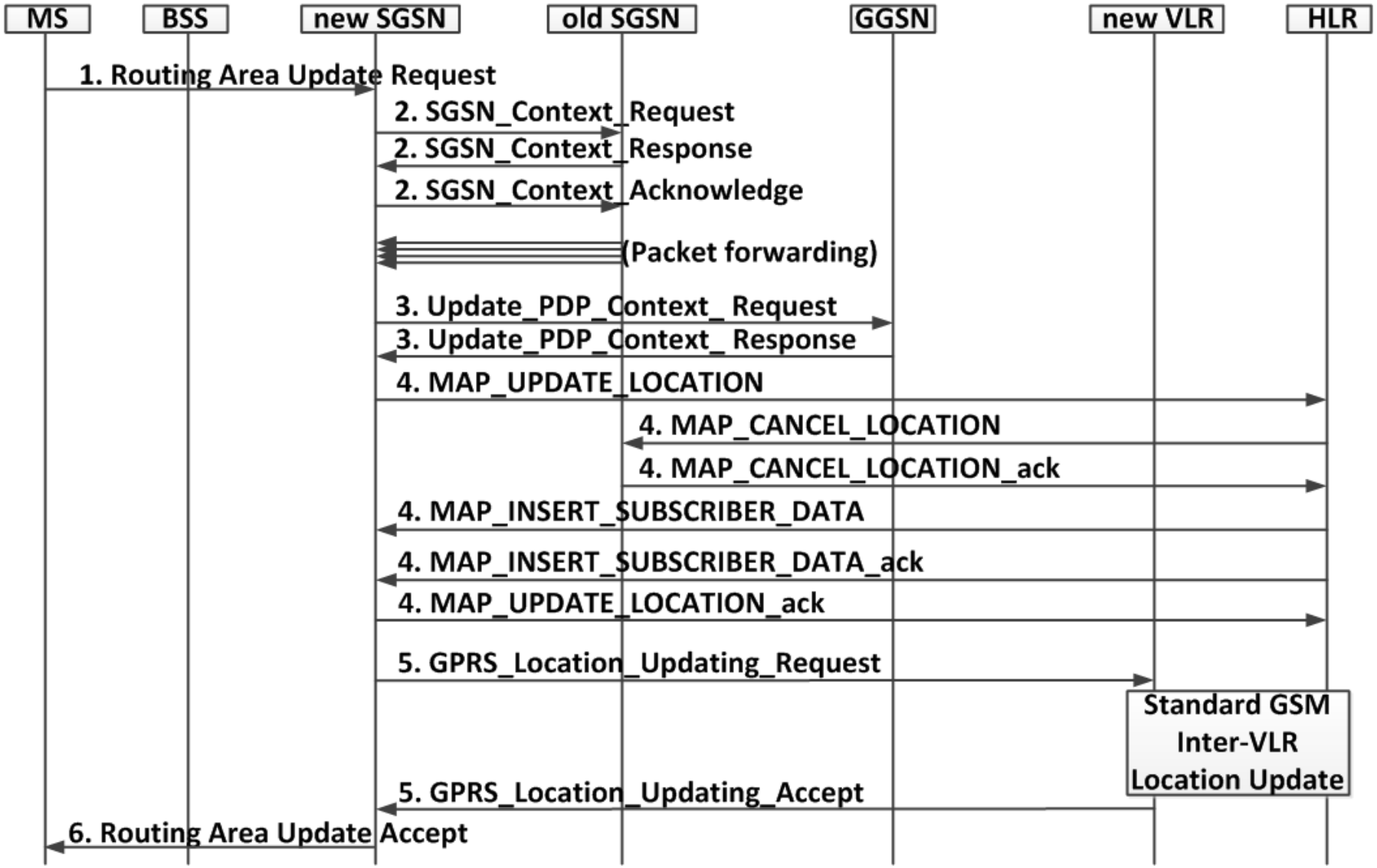
PDP Context Deactivation Initiated by MS Procedure



PDP Context Deactivation Initiated by GGSN Procedure



The Combined RA/LA Update Procedure: Message Flow



The Combined RA/LA Update Procedure (1/6)

- Step 1 (GMM/Um and Gb interfaces).
  - The MS sends a Routing Area Update Request to SGSN, which is generated from GMM layer.
  - (Old RA ID, P-TMSI, update type (RA/LA))
  - Before forwarding to SGSN, the BSS adds the global ID of the cell.

The Combined RA/LA Update Procedure (2/6)

- Step 2 (GTP Mobility Management/Gn Interfaces).
  - The new SGSN obtains the MM and PDP contexts from the old SGSN by exchanging SGSN_Context_Request and Response message pair.
  - Security functions may be performed to support ciphering mode in the new connection.
  - When the new SGSN is ready to receive data packets, it informs the old SGSN by SGSN_Context_Acknowledge.
  - The old SGSN forwards the buffered packet to the new SGSN.

The Combined RA/LA Update Procedure (3/6)

- Step 3 (GTP tunnel management/Gn interface).
  - The new SGSN exchanges the Update_PDP_Context_Request and Response message pair with all related GGSNs.
  - The GGSNs update their PDP context field.

The Combined RA/LA Update Procedure (4/6)

- Step 4 (GSM MAP/Gr interface).
  - Following the standard GSM registration procedure, the new SGSN and the HLR exchanges the MAP_UPDATE_LOCATION and acknowledgement to update SGSN number in HLR.
  - The HLR and old SGSN exchanges MAP_CANCEL_LOCATION and acknowledgement to remove the PDP and MM contexts of the MS.
  - The HLR and new SGSN exchange MAP_INSERT_SUBSCRIBER_DATA and acknowledgement to provide GPRS subscriber data.
  - Based on the subscriber data, the new SGSN determines if MS is allowed to receive service in the routing data.
    - If not, the SGSN returns the MAP_INSERT_SUBSCRIBER_DATA_Ack with an error cause "GSN Area Restricted", update fails.
    - Otherwise (all checks are successful), the SGSN constructs an MM context for the MS).

The Combined RA/LA Update Procedure (5/6)

- Step 5 (BSSAP+ and GSM MAP/Gs and D interfaces).
  - The update type is RA/LA in our example.
  - From the new RA ID, the new SGSN identifies the new VLR through table lookup, and sends a GPRS_Location_Updateing_Request to VLR.
  - This action is taken when the SGSN receives the first MAP_INSERT_SUBSCRIBER_DATA.
  - The new VLR updates the SGSN number for the MS.
  - Then the VLR performs a standard GSM location update.
  - After the LA location update, the new VLR acknowledges the new SGSN with GPRS_Location_Updating_Accept message.

The Combined RA/LA Update Procedure (6/6)

- Step 6 (GMM/Um and Gb interfaces).
  - The new SGSN sends the Routing Area Update Accept message to the MS to complete the RA/LA location update procedure.
  - If the MS receives a new TMSI in this message, it sends an acknowledge to the new VLR.
- For a combined intra-SGSN and RA/LA update,
  - Steps 2 and 3 are not performed.
- For a pure RA update,
  - Step 5 is not executed.