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General Packet Radio Service (GPRS)

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Part IV: 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)

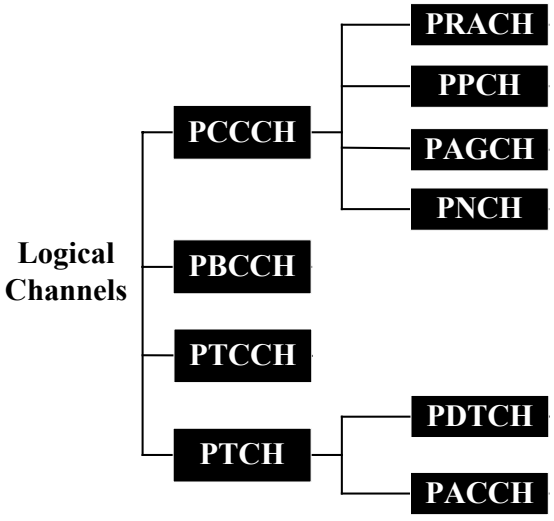
Um Interface (MS<->BSS) [gsm03.64]

- 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 via PDTCHs.**
  - **An MS currently involved in packet transfer can be paged for circuit-switched services on PACCH.**

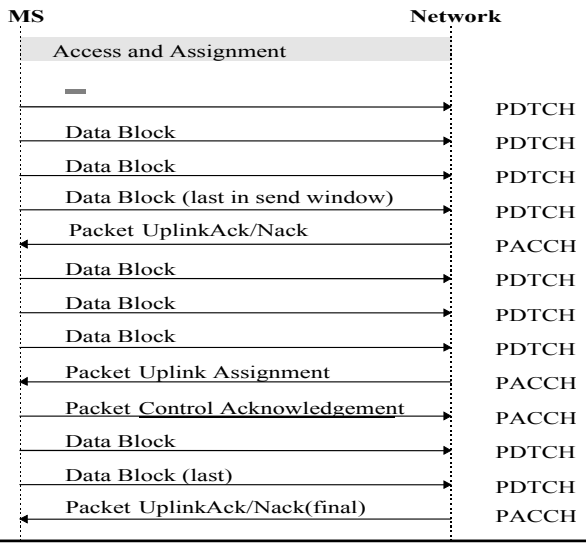
Two Concepts for GPRS Channel Management (1/2)

- Master-Slave
  - At least one PDCH, acting as a master, accommodates packet common control channels that carry all the necessary control signalling for initiating packet transfer (i.e. PCCCH).
  - whenever that signalling is not carried by the existing CCCH, as well as user data and dedicated signalling (i.e. PDTCH and PACCH).
  - Other PDCHs, acting as slaves, are used for user data transfer and for dedicated signalling.

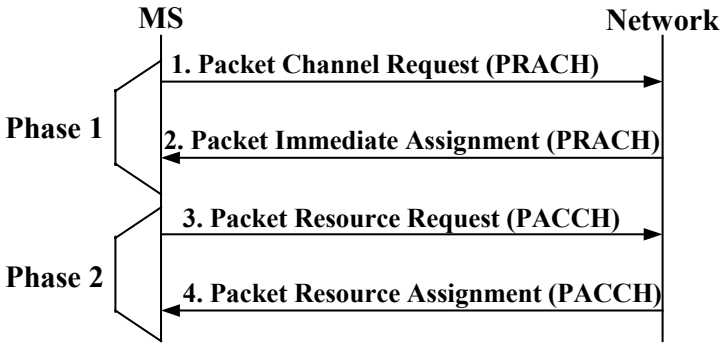
Two Concepts for GPRS Channel Management (2/2)

- Capacity on Demand
  - The GPRS does not require permanently allocated PDCHs.
  - The Allocation of capacity for GPRS can be based on the needs for actual packet transfers.
  - The operator can, as well, decide to dedicate permanently or temporarily some physical resources (i.e. PDCHs) for the GPRS traffic.
  - The existence of PDCH(s) does not imply the existence of PCCCH.
  - When no PCCCH is allocated in a cell, all GPRS attached MSs camp on the CCCH.

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 throtugh 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, which can be used to request limited resources or Two-Phase Access.

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**

Gb Link Layer 2 and NS

- The Gb Link Layer Layer 2 establishes frame relay virtual circuits (BSS<->SGSN).
- On these virtual circuits, the NS transport BSSGP Packet Data Units (PDUs) (BSS<->SGSN)
- On the BSS side, the Relay function is required to provide buffering and parameter mapping between RLC/MAC and BSSGP.

Logical Link Control (1/3)

- To convey information between Layer 3 entities in the MS and SGSN.
- To provide one or more logical link connections with
  - **Sequence control (to maintain the sequential order of frames across a logical link connection)**
  - **Flow control**
  - **Detection of transmission**
  - **Format and operational errors on logical link connection**
  - **Recovery form (1) detected transmission error, (2) format error, and (3) operational error.**

Logical Link Control (2/3)

- LLC maintains a ciphered data link (MS<->SGSN) independent of the underlying radio interface protocols.
  - **This connection is maintained as the MS moves between cells served by the same SGSN. (New SGSN needs new LLC link).**
- The LLC layer supports several QoS delay classes with different transfer delay characters.
- The LLC layer supports transmission with both ack and unack modes.

Logical Link Control (3/3)

- In the signaling plane,
  - **LLC provides service to GPRS Mobility Management (GMM) protocol.**
  - **GMM includes functions (e.g., Attach, Authentication, and Transport of Session Management Messages).**
- In the transmission plane,
  - **The SNDCP above the LLC performs multiplexing of data coming from the different sources to be sent across LLC.**

Network Service (NS) (1/2)

- The NS layer delivers encapsulated packets (SGSN<->BSS)
  - **BBS and SGSN may be directly connected by a frame relay link.**
  - **Or indirectly through cascading links in a frame relay network.**
- Each frame relay link supports one or more Network Service Virtual Links (NS-VLs).
  - **The NS-VLs are connected to construct an end-to-end virtual path (BSS<->SGSN). This path is called Network Service Virtual Connection (NS-VC).**

Network Service (NS) (2/2)

- The NS manages NS-VCs with operations, e.g.,
  - **Blocking (when a NS-VC is not available)**
  - **Unblocking (when a NS-VC becomes available again)**
  - **Resetting (e.g., when a new NS-VC is set up)**
  - **Testing, to check that an end-to-end communication exists (peer NS entities on given NS-VC)**
- The NS also performs load sharing to distribute the packet traffic among the unblocked NS-VCs of the same BVC (BSSGP Virtual Connection).

BSSGP Virtual Connection (BVC)

- BVC (used to transport packets between NS users) is supported by a group of NS-VCs.
- BVCs provide communication paths between BSSGP entities.
- Each BVC is used to transport BSSGP PDUs between peer P-T-P functional entities, peer P-T-MP functional entities, or peer-signaling functional entities.
- For every BVC, a QoS profile and the MS ID are used to create queues and contexts in both the SGSN and the BSS.

BSS GPRS Protocol

- BSSGP provides the radio-related QoS and Routing Information required to transmit user data (BSS <-> SGSN).
- Also enables the SGSN and BSS to operate Node Management Control Functions.
  - **If an SGSN simultaneously communicates with multiple BSSs, there is one BSSGP protocol machine in the SGSN corresponding to each of the BSSs,**
  - **Three service models are supported by BSSGP: (1) BSSGP/RL service model; (2) GMM Model; (3) NM Model**

BSSGP/RL Service Mode (1/2)

- The BSSGP Service Mode controls the transfer of LLC frames across the Gb interface.
- The RL Service Mode controls the transfer of LLC frames (RLC/MAC function<->BSSGP).
- Examples of RL/BSSGP service primitives provided by the BSSGP are
  - **DL-UNITDATA: A UL-UNITDATA PDU (BSS->SGSN)**
  - **UL-UNITDATA: A DL-UNITDATA PDU (SGSN->BSS)**
- The PDU contains (1) user information (an LLC packet), (2) RLC/MAC-related info (e.g., MS radio access capability, a QoS profile, and the PDU lifetime)

BSSGP/RL Service Mode (2/2)

- If the PDU is queued in the BSS for a period > PDU lifetime, BSS discarded it.
- Based on the QoS profile, a layer 3 signaling PDU may be transmitted over the Um interface with higher protection than a data PDU.
- The PDU is either acknowledged (using RLC/MAC ARQ functionality) or unacknowledged (using RLC/MAC UNITDATA) functionality.

GPRS Mobility Management (GMM) Service Model (1/2)

- GMM service model performs mobility management functions (SGSN<->BSS).
- Examples of GMM service primitives provided by BSSGP are
  - **PAGING**
  - **SUSPEND**
  - **RESUME**
- The PAGING procedure is invoked by SGSN to inform the BSS of
  - **packet-switched transmission (if initiated by SGSN)**
  - **Circuit-switched transmission (if initiated by an MSC/VLR).**
  - **In this procedure, the SGSN will instruct the BSS to page one or more cell.**

GPRS Mobility Management (GMM) Service Model (2/2)

- To suspend a GPRS service, an MS initiates the SUSPEND procedure by requesting the BSS to send a SUSPEND PDU to the SGSN.
- When an MS resumes its GPRS service, the BSS instructs the MS to update the routing area.
- Alternatively, the BSS may send a RESUME PDU to the SGSN to indicate the MS should be resumed for the GPRS service.

The Network Management (NM) Service Model (1/2)

- The NM service model handles functions related to
  - **the Gb interfaces and**
  - **BSS/SGSN node management**
- Examples of BSSGP-supported NM service primitives are
  - **FLOW-CONTROL-BVC (to control downlink loading of the BBS per BVC)**
  - **FLOW-CONTROL-MS (to control downlink loading of the BSS per MS)**
  - **No flow control is performed in the uplink direction is performed in the uplink direction.**
  - **There is a downlink buffer for each BVC.**

The Network Management (NM) Service Model (2/2)

- If a PDU in the downlink is not transferred to the MS before its lifetime expires, the PDU is deleted from the BVC downlink buffer (this action is reported to SGSN).
- To control downlink transmission at the SGSN, a flow control message FLOW-CONTROL-BVC (FLOW-CONTROL-MS) with parameters (e.g., the buffer size and the bucket leak rate for a given BVC (MS)) are sent from the BSS to the SGSN.

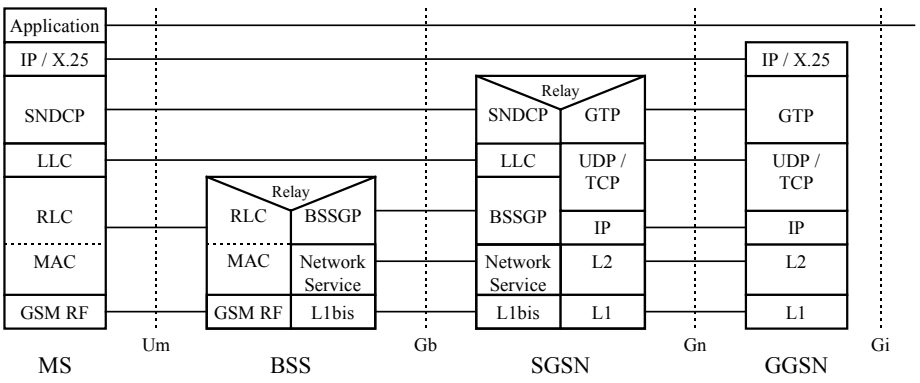
Gn (SGSN<->GGSN) & Gp (SGSN<->External GGSN) interfaces (1/3)

- 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.**

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

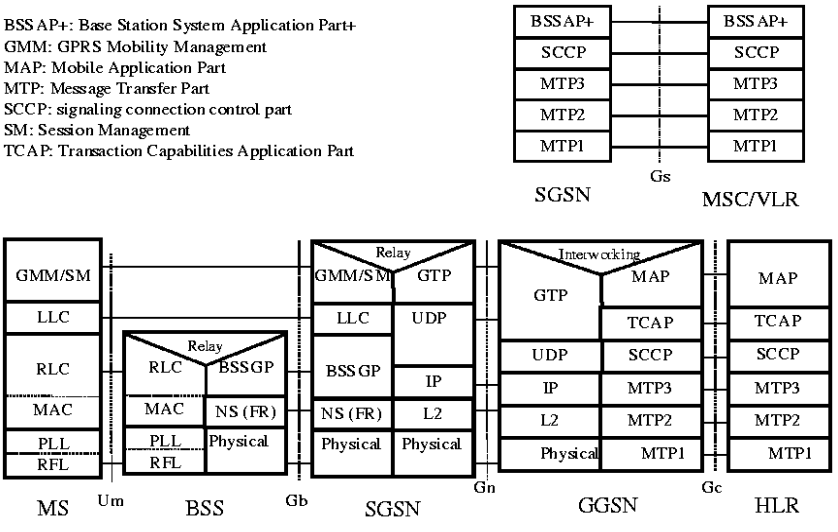


Gn (SGSN<->GGSN) & Gp (SGSN<->External GGSN) interfaces (3/3)

- In the signaling plane, GTP is supported by UDP.
  - **UDP enables the SGSN to provide GPRS network access for an MS.**
- 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

BSSAP+: 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 ot 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 (1/2)

- 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.**

Gs Interface (2/2)

- Paging Procedure
- Suspend Procedure
- Resume Procedure
- Location Update Procedure

Gs Interface: Paging Procedure (1/2)

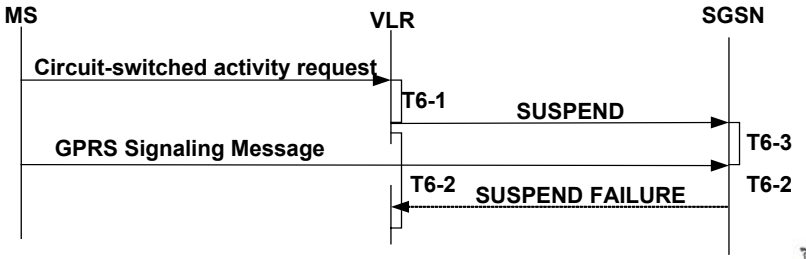
- The paging procedure for MSC/VLR-based services allows the VLR to use GPRS to page a Class A or Class B MS that is simultaneoulsy IMSI- and GPRS-Attached.
  - **By doing so, the system needs not repeat paging of an MS for both GSM and GPRS services, and**
  - **The overall paging load on the radio interface is expected to be reduced.**

Gs Interface: Paging Procedure (2/2)

- Step 1. The VLR initiates this procedure by sending the GPRS_PAGING to the SGSN.
  - **This message has a structure similar to the PAGING (delivered on the A interface).**
- Step 2. When the SGSN receives the message, it checks to see if the MS is GPRS-attached and is known by SGSN.
  - **If so, the SGSN sends the Gb PAGING to the BSS.**
- Step 3. The SGSN then forwards the paging result back to the VLR.
  - **If the MS does not respond, the VLR or BSS retransmits the paging message.**
  - **The SGSN is not responsible for retransmission of the message.**

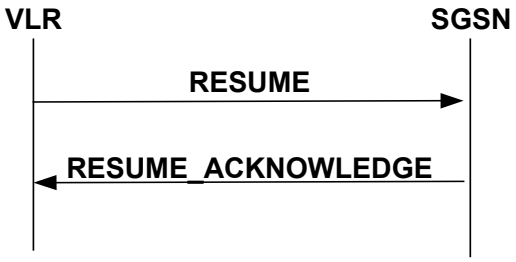
Gs Interface: Suspend Procedure

- To perform circuit-switched activity for a Class B MS (IMSI and GPRS-attached),
  - **the VLR uses the SUSPEND procedure to inform the SGSN to suspend the GPRS activities of the MS.**



Gs interface: Resume Procedure

- Upon release of the circuit-switched activity for a Class B MS (both GPRS- and IMSI-attached),
  - **The VLR sends a RESUME message to the SGSN to resume the GPRS activity of the MS.**



Gs Interface: Location Update Procedure

- Step 1. If a GPRS location update is initiated by an MS,
  - **the SGSN sends a GPRS_LOCATION_UPDATING_Request message to the VLR.**
- Step 2. The VLR Checks to determine if the IMSI is known.
  - **If not, the VLR retrieves the MM context of the MS from the HLR.**
- Step 3. If the SGSN does not hear from the VLR within a period T8-1, or if the VLR replies with a GPRS_LOCATION_UPDATING_Reject message
  - **The SGSN informs the MS that the location update failed.**
  - **If the update is successful, the VLR returns a GPRS_LOCATION_UPDATING_Accept message to the SGSN.**

Gi Interface (1/3)

- GPRS interworks with the PSDN (Public Switched Data Network) and PDN (Packet Data Network) through the Gi interface.
- In the Gi interface, GGSN serves as the access point of the GPRS network to the external data network.
- The interworking models to PSDN includes X.25 and X.75.
  - **An MS is assigned an X.121 address. This address dynamically or permanently assigned.**
- The interworking models to PDN includes IP and Point-to-point (PPP).
  - **The IP address is statically assigned or dynamically allocated when PDP context activation (performed by GGSN or DHCP server)**

Gi Interface (2/3)

- GPRS may transparently access the Internet and non-transparently access the intranet and ISP.
- In transparently access the Internet,
  - **The IP address of an MS is allocated from the GPRS operator's addressing space.**
  - **This address is used for packet forwarding (the Internet <-> the GGSN) and (among the GGSNs).**
  - **The MS need not send any authentication request at PDP context activation, and the GGSN need not be involved in user authentication and authorization.**
  - **Domain name services are provided by the GPRS in this case.**

Gi Interface (3/3)

- In nontransparent access to an intranet or ISP,
  - The IP address of an MS is allocated from the intranet/ISP address space where the address allocation server belongs to the intranet/SIP.
  - At PDP context activation, the MS must by authenticated by the intranet/ISP using a security protocol agreed upon by the GPRS operator and the intranet/ISP.
  - DN services are provided by the intranet/ISP.

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Part V: GPRS Procedures

GPRS Procedures

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

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 (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 (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.

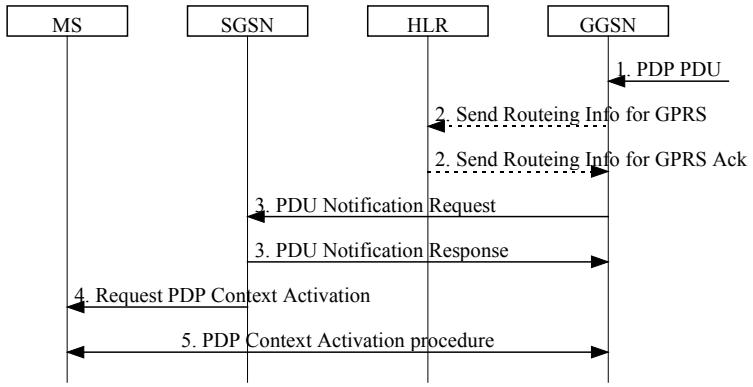
PDP Context Activation (2/3)

- 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



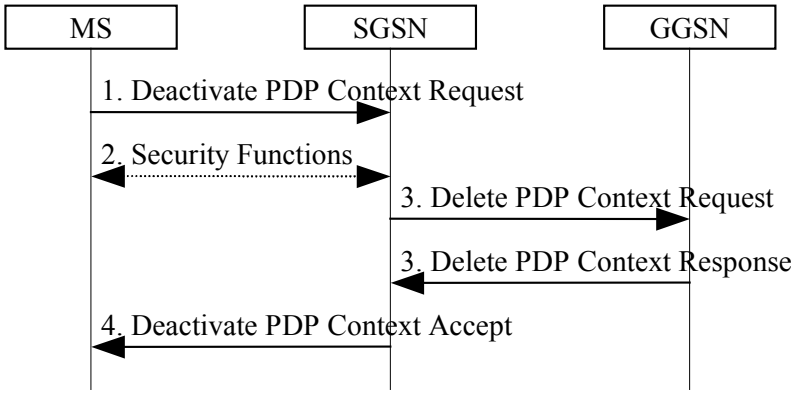
PDP Context Modification

- 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.**

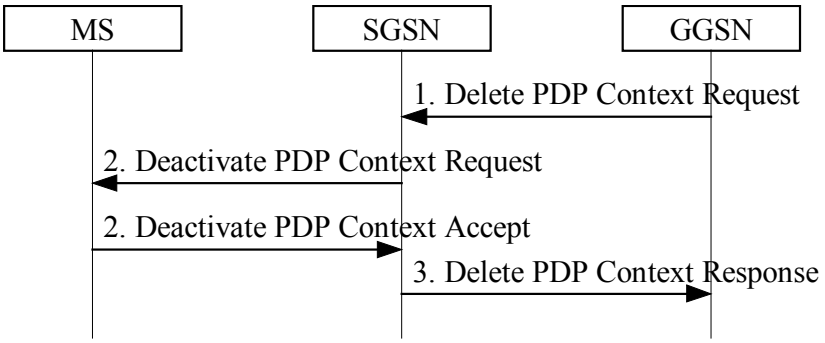
PDP Context Deactivation

- 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 (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.

Part VI: GPRS Billing

GPRS Charging Nodes

- In GPRS, the Charging information is collected by SGSNs and GGSNs.
- The SGSN collects charging information for radio resource usage by an MS.
- Depending on the agreement (GPRS operator<->external packet data network), network usage may be collected in the external/internal GGSNs.
  - **If the visited GPRS network assigns a dynamic address to an MS, the charging of the GPRS is gathered and sent to the home GPRS network.**

The Charging Info in SGSN

- Location information indicates if the MS is in its home network or a visited network, the cell location, and so on.
- The amount of data transmitted through the radio interface for MO and MT calls specified with QoS profiles and user protocols.
- The amount of time an MS occupies the PDP context.
- The amount of GPRS-related network resources..
- The GPRS activity (e.g., MM) dedicated to the MS.
- Note that the data volume counted is at SNDCP level in SGSN.

The Charging Info in GGSN

- The addresses of the destination and source defined by the GPRS operator.
- The amount of data delivered (MS<->external data network).
- The period that the MS has used the PDP addresses.
- Note that the data volume counted is at the GTP level in GGSN.

Types of Call Detailed Records (CDRs)

- S-CDR for the radio usage by SGSN
- G-CDR for external data network usage by GGSN
- M-CDR for Mobility Management activity by SGSN

Fields in S-CDR

- MO data volume
- MT data volume
- Location Information
- SMS MO
- SMS MT
- Associated QoS
- Record Duration

Fields in GGSN

- Destination Address
- Source Address
- Data Received
- Data Sent
- Associated QoS
- Record Duration

The Generation of CDRs (1/2)

- Every CDR is associated with a subscriber's active PDP context.
  - **A PDP context may generate several S-CDRs and G-CDRs.**
- A CDR is initiated based on PDP context activation, and generated by the following criteria
  - **End-of-Call Accounting Schedule**
  - **Time-of-Data Accounting Schedule**
  - **Inter-SGSN routing area update**
- If an MS moves during a communication session, several CDRs may be generated from various GSNs and the external data networks.
  - **These CDRs are merged into one complete CDR.**
  - **Charging Gateway Function is implemented in GSNs.**

The Generation of CDRs (2/2)

- In GPRS, several users share the resources.
  - **Especially, if a PDP context activated for a long time involves only occasional packet transmissions.**
- Charging for packet-switched is more difficult.
  - **Possible that the cost of measuring packet is greater than their values and the existing GSM billing system may not able to handle GPRS real time CDR information.**
  - **A charging gateway is typically introduced to perform billing mediation based on the information from the SGSNs/GGSNs.**

Part VII: Evolving from GSM to GPRS

GSM Network Elements Impact by GPRS

ELEMENT	SOFTWARE	HARDWARE
MS	Upgrate	Upgrate
BTS	Upgrate	No Change
BSC	Upgrate	PCU Interface
TRAU	No Change	No Change
MSC/VLR	Upgrate	No Change
HLR	Upgrate	No Change
SGSN	New	New
GGSN	New	New

GPRS Implementation

- By using GSM infrastructure, most GPRS implementation costs in existing GSM nodes are software-related.
- In many vendor solutions, GPRS software can be remotely downloaded to BTSs,
  - **No site visits are needed.**
- In the MS development, a major challenge is to resolve the power consumption issue.
  - **Multiple time-slot transmission (much more power)**
- GPRS Protocol can be implemented by general computer language.
  - **Trillium GPRS protocol software in standard C.**
  - **Lucent/Optimary GmbH provides with a man-machine interface**

GPRS Phase 1 Implementation

- Standard Packet Services Delivery (PTP packet bearer service)
- CS-1 and CS-2 Channel Coding Scheme
- Gn, Gb, Gp, Gs interfaces
- Flexible Radio Resource Allocation
- Classes B and C MSs
- GPRS Charging (e.g., Packet-based and QoS-based)
- IP and X.25 interfaces to packet data network
- Static and dynamic IP Address Allocation
- Anonymous Access
- Security

GPRS Phase 2 Implementation

- Enhanced QoS support in GPRS
- Unstructured octet stream GPRS PDP type
- Access to ISPs and Intranets
- GPRS Prepaid
- GPRS Advice of Charge
- Group Call
- Point-to-multipoint services

Applications in GPRS

- Specific Data Communication Requirement of Companies:
  - **Traffic Management** **(Fleet Management, Vehicle Tracking, Vehicle Control, Guidance)**
  - **Monitoring Automation** **(Telemetry and Security)**
- Applications for Individual Users
  - **Entertainment** **(Games and Music)**
  - **Location Information** **(Restaurants, Cinema, Hotels, Parking)**
  - **Commerce Transactions** **(Banking, Airlines, trains, Online Shopping,)**