2.5 G Systems: GPRS

- GPRS Services
- Reference Architecture
- Mobility and Location Management
- Channels
- Protocols
- Data Transfer, Coding

Review

- GSM Architecture
- GSM Structure
- GSM Channels
- GSM Handover
- SMS in GSM

General Packet Radio Services - GPRS

- GPRS uses exactly the same physical radio channels as GSM
  - only new logical GPRS radio channels are defined
- Allocation:
  - from one to eight radio interface timeslots can be allocated per TDMA frame.
  - active users share timeslots
  - uplink and downlink are allocated separately
  - Physical channels are taken from the common pool of the cell
  - GSM and GPRS channels are dynamically allocated according to a “capacity on demand” principle
- GPRS does not require permanently allocated physical channels
- GPRS offers permanent connections to the Internet with volume based charging that enables a user to obtain a less expensive connection to the Internet

General Packet Radio Services - GPRS

- The GPRS MSs (terminals) are of three types:
- Class A terminals
  - operate GPRS and other GSM services simultaneously
- Class B terminals
  - can monitor all services, but operate either GPRS or another service, such as GSM, one at a time
- Class C terminals
  - operate only GPRS service
- GPRS has some limitations
  - Transmission speeds much lower in reality
  - There is no store and forward service in case the MS is not available, as in SMS
- The adaptation of GPRS to the IS-136 TDMA cellular standard is called GPRS-136
  - It is very similar to GPRS except that it uses 30 kHz physical channels

GPRS Services [PK 02]

- PTM-M (point-to-multipoint)
  - a multicast service to all subscribers in a given area
- PTM-G
  - a multicast service to predetermined group that may be dispersed over a geographic area
- PTP (point-to-point)
  - packet data transfer, two types:
    - connectionless based on IP and CLNP (Connectionless Network Protocol) called PTP CLNS (Connectionless Network Service)
    - connection-oriented based on X.25 (PTP-CONS) (Connection-Oriented Network Service)
- GPRS also provides a bearer service for GSM's SMS
- There is also an anonymous access for MS at no charge
  - Ex. similar to an 800 number service

GPRS Services [Schiller 03]

- GPRS has parameters that specify a QoS based on:
- service precedence (high, normal, and low) class
- Delay class (4)
  - delay is defined as the end-to-end delay between two MSs or between an MS and the interface to the network external to GPRS
- Reliability class (3)
  - Probability of data loss
  - Probability of data delivered out of sequence
  - Probability of duplicate data delivery
  - Probability of corrupted data
- Throughput class
  - The maximum bit rate value can be between 8 kbps and 11 Mbps
  - The mean bit rate value is 0.22 bps to 111 kbps

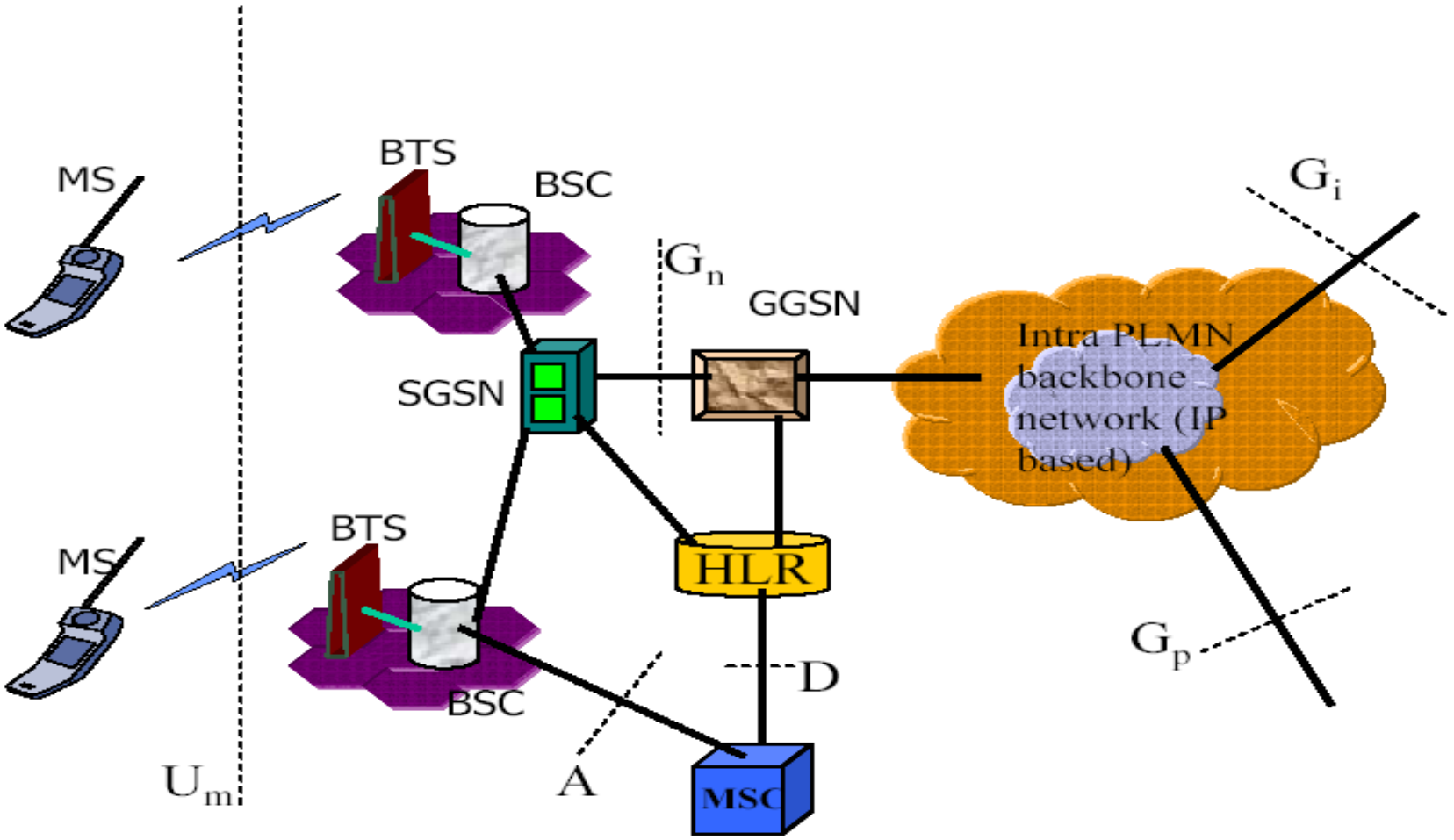
Example of QoS Requirements

Table 1. QoS requirements for different applications

Application	Data Rate (kbit/s)	End-to-end One-Way Delay	Delay Variation
Audio Streaming	5-128	< 10s	< 2s
E-mail	-	Best effort	-
File Transfer (FTP)	< 384	< 10s	-
Telnet	< 1	< 250 ms	-
Video One-way	20-384	< 10s	< 2s
Voice Messaging	4-13	< 1s	< 1 ms

Based on ETSI (1998)

GPRS Reference Architecture [PK 02]



GPRS Reference Architecture

- GPRS reuses the GSM architecture, the new entities are called GPRS support nodes (GSN)
- Serving GPRS Support Node (SGSN)
  - It controls access to MSs that may be attached to a group of BSCs (routing area - RA or service area of the SGSN)
  - It is a router, responsible for delivery of packets to the MS in its service area and from the MS to the Internet
  - It also performs the logical link management, authentication, and charging functions
- Gateway GPRS Support Node (GGSN)
  - It acts as a logical interface to the Internet
  - It maintains routing information related to a MS to be able to route packets to the SGSN servicing the MS
  - It analyses the PDN (Public Data Network) address of the MS and converts it to the corresponding IMSI

GPRS Reference Architecture

- A database called the GPRS Register (GR)
  - Located with the HLR
  - It stores routing information and maps the IMSI to a PDN address (ex. IP address)
- The interface between the BSS and the SGSN is called the Gb interface
- The interface between the SGSN and the GGSN is called the Gn interface

GPRS – Mobility Support

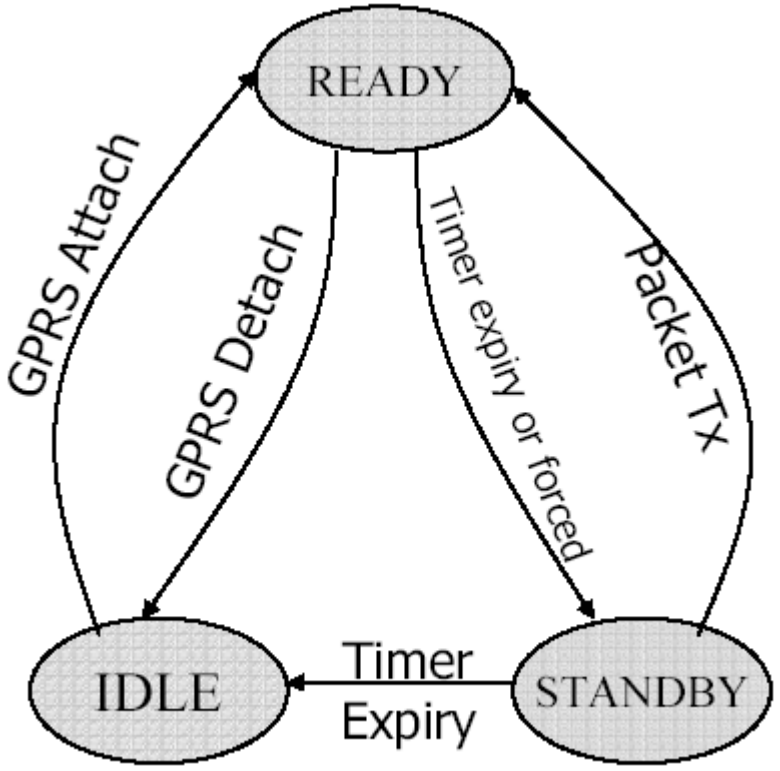
- Firstly the MS must register with the GPRS network
- The MS performs an attachment procedure with an SGSN
  - Authentication - by checking with the GR
  - Allocation of a temporary logical link identity (TLLI) to the MS
  - Creation of a PDP (packet data protocol) context for the MS
- The PDP context
  - set of parameters created for each session and contains:
    - the PDP type (ex. IPv4)
    - the PDP address assigned to the MS
    - the requested QoS parameters
    - the GGSN address that serves the point of access to the PDN
  - The PDP context is stored in the MS, the SGSN, and the GGSN
  - A user may have several PDP contexts enabled at a time
  - PDP address may be statically (common situation) or dynamically allocated
  - The PDP context is used to route packets accordingly

GPRS – Mobility and Location Management

- The location and mobility management procedures in GPRS are based on keeping track of the MSs location and having the ability to route packets to it accordingly
- Location management depends on three states in which the MS can be:
- IDLE state
  - the MS is not reachable, only capable of receiving PTM-M data
  - all PDP contexts are deleted, user is not attached to the mobility management
- STANDBY state
  - User is attached to the mobility management,
  - The location of the MS is known on a routing area level
  - MS is capable of receiving PTM and pages for PTP data
  - PDP context activated
  - If the MS sends data, the MS moves to READY state
  - MS (expiry timer) or network can initiate a *detach procedure*
  - The MS can use discontinuous reception (DRX) to save battery

GPRS – Mobility and Location Management [PK 02]

- READY state
  - User is attached to the mobility management,
  - The location of the MS is known on a cell level
  - MS is capable of receiving PTM and PTP data
  - PDP context activated
  - MS sends data anytime, SGSN can send data to MS without paging
  - IF READY timer expires, MS goes to STANDBY state
  - If MS performs a *detach procedure* goes to IDLE state
  - The MS can use DRX to save battery



GPRS Logical Channels [HMR 03]

- The packet data logical channels are mapped onto the physical channels (that are dedicated to packet data and are called packet data channels (PDCH))
- Packet data logical channels categories: packet common control channels, packet broadcast control channels, packet traffic channels and packet dedicated control channels
  - new set of control channels (parallel to GSM control channels)
    - Reason: to be able to allocate more signalling capacity for the packet data traffic without sacrificing the quality of the speech traffic

GPRS Logical Channels [HMR 03]

- *Packet Common Control Channel (PCCCH):*
- Packet random access channel (PRACH) - uplink only
  - used by the MS to initiate uplink transfer to send data or signalling information
- Packet paging channel (PPCH) - downlink only
  - used to page an MS prior to downlink packet transfer
- Packet access grant channel (PAGCH) - downlink only
  - used in the packet transfer establishment phase to send resource assignment to an MS prior to packet transfer
- Packet notification channel (PNCH) - downlink only
  - used to send a PTM-M (point to multipoint—multicast) notification to a group of MSs prior to a PTM-M packet transfer

GPRS Logical Channels [HMR 03]

- *Packet Broadcast Control Channel (PBCCH)* - downlink only
  - broadcasts packet data specific system information
  - If PBCCH is not allocated, the packet data specific system information is broadcast on BCCH
- *Packet DataTraffic Channel (PDTCH)*
  - A channel allocated for data transfer temporarily dedicated to one MS
  - One MS may use multiple PDTCHs in parallel for individual packet transfer (Multislot operation)
  - All packet data traffic channels are uni-directional either:
    - uplink (PDTCH/U), for a mobile-originated packet transfer
    - downlink (PDTCH/D), for a mobile terminated packet transfer

GPRS Logical Channels [HMR 03]

- *Packet Dedicated Control Channels:*
- Packet associated control channel (PACCH)
  - conveys signalling information related to a given MS (e.g. acknowledgements, power control information, resource assignment and reassignment messages and further occurrences of PACCH)
  - The PACCH shares resources with PDTCHs, which are currently assigned to one MS
  - An MS that is currently involved in packet transfer can be paged for circuit-switched services on PACCH
- Packet timing advance control channel, uplink (PTCCH/U)
  - used to transmit random access bursts to allow estimation of the timing advance for one MS in packet transfer mode
- Packet timing advance control channel, downlink (PTCCH/D)
  - used to transmit timing advance information updates to several MSs. One PTCCH/D is paired with several PTCCH/Us

GPRS Protocol Layers [PK 02]

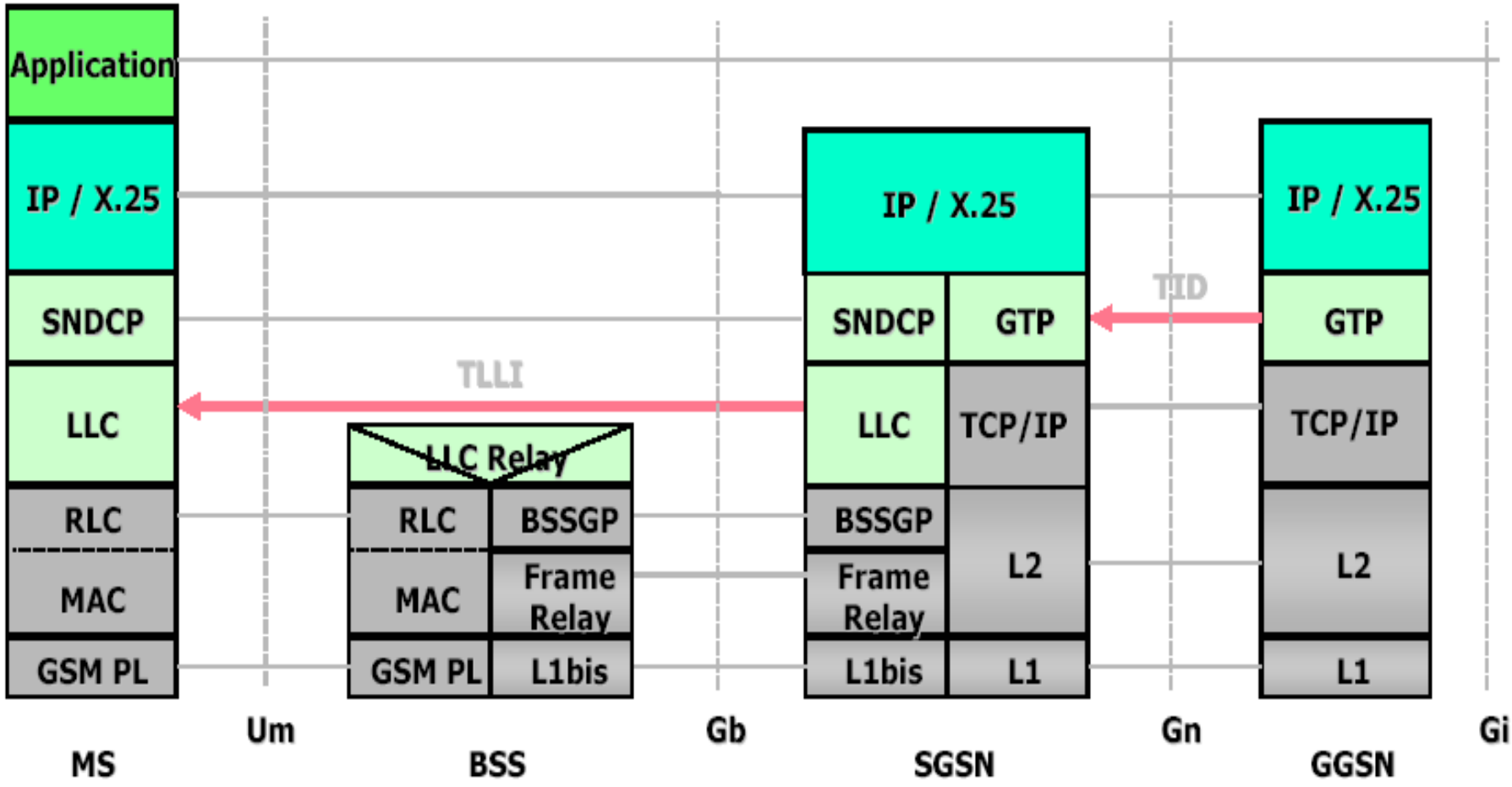


Figure 9.13 GPRS transport plane [PK02]

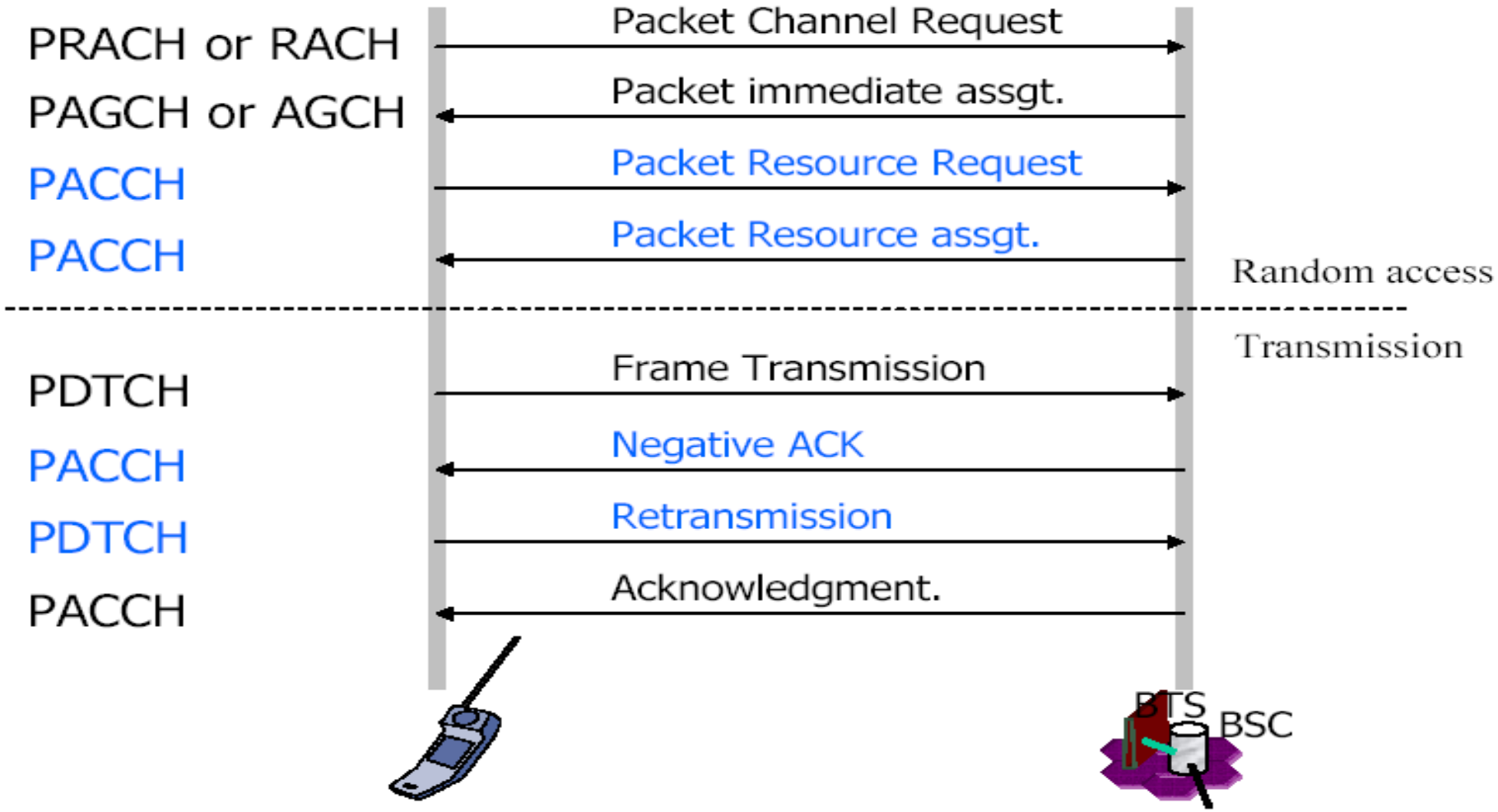
GPRS Protocol Layers [HMR 03]

- The network protocol data units (N-PDU) (full IP packets) are compressed and segmented into the sub-network protocol data units (SN-PDU) by the sub-network-dependent convergence protocol (SNDCP)
- The SN-PDUs are encapsulated into one or several Link Layer Control (LLC) frames
- LLC frames are segmented into Radio Link Control (RLC) data blocks
- At the RLC/MAC layer, a selective automatic repeat request (ARQ) protocol (including block numbering) between the MS and the network provides re-transmission of erroneous RLC data blocks
- When a complete LLC frame is successfully transferred across the RLC layer, it is forwarded to the LLC layer

GPRS – Operating Modes [HMR 03]

- Packet transfer mode
  - the mobile station is allocated radio resource, providing a temporary block flow (TBF) on one or more physical channels
  - Continuous transfer of one or more LLC PDUs is possible
  - Concurrent TBFs may be established in opposite directions
- Packet idle mode
  - No TBF
  - Upper layers can require the transfer of a LLC PDU
    - Implicitly triggering the establishment of TBF and transition to packet transfer mode
  - The MS listens to the PBCCH and to the paging channel or BCCH if PBCCH absent
- Temporary Block Flow (TBF)
  - It is a temporal connection between the MS and the network to support the uni-directional transfer of LLC PDUs on packet data physical channels
  - temporary and maintained only for the duration of the data transfer

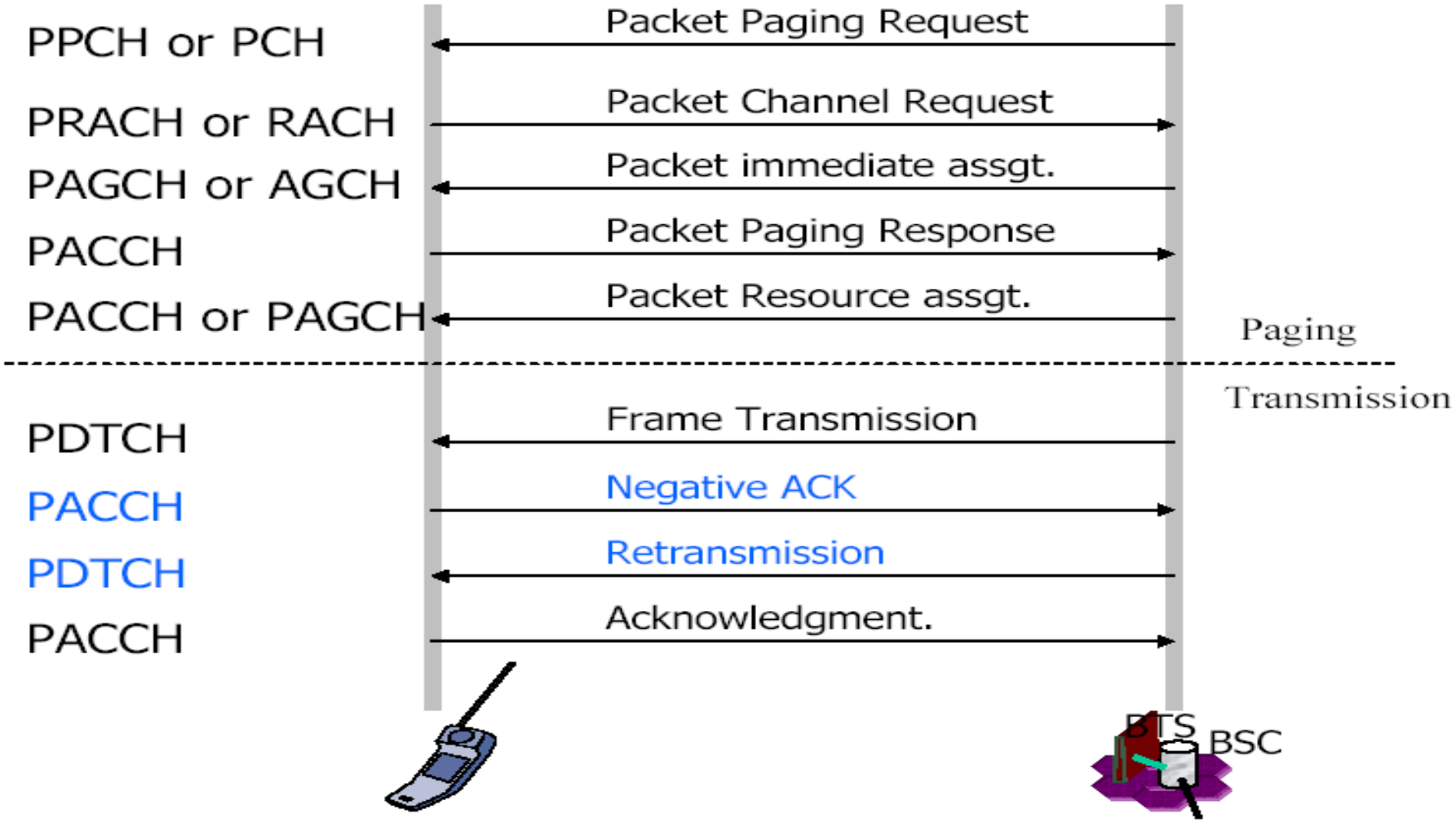
GPRS - Uplink Data Transfer (two phase) [PK02]



GPRS - Uplink Data Transfer

- MS initiates a packet transfer by making a packet channel request on PRACH or RACH
- The network responds on PAGCH or (AGCH)
- In the one-phase access
  - The network will respond to the packet channel request by sending a **packet uplink assignment message** and reserving the resources on PDCH(s) for uplink transfer of a number of radio blocks
    - Reservation done according to the requested resources in the packet channel request
- In the two-phase access
  - The packet channel request is responded to with the **packet uplink assignment**, which reserves the uplink resources for transmitting the packet resource request
  - The **packet resource request message** carries the complete description of the requested resources for the uplink transfer
  - The network responds with the packet uplink assignment, reserving resources for the uplink transfer and defining the actual parameters for data transfer
  - If there is no response to the packet channel request within the pre-defined time period, the MS makes a retry after a random time

GPRS - Downlink Data Transfer



GPRS - Downlink Data Transfer

- The network initiates a packet transfer to an MS that is in the **standby state** by sending one or more packet paging request messages on the downlink (PPCH or PCH)
- The MS responds with a **packet paging response message** on PRACH or on RACH
- After the packet paging response, the MS is **ready state**
- The network uses a packet downlink assignment message to start the downlink transfer
  - In case there is an uplink packet transfer in progress, the packet downlink assignment message is transmitted on PACCH. Otherwise, it is transmitted in the PCCCH or CCCH
  - The packet downlink assignment message includes the list of PDCH(s) that will be used for downlink transfer
- The network sends the RLC/MAC blocks belonging to one TBF on downlink on the assigned downlink channels (PDTCHs)
- The sending of the packet downlink Ack/Nack message is obtained through the periodical network-initiated polling of the MS
  - The MS sends the packet downlink Ack/Nack message in a reserved radio block, which is allocated together with polling

GPRS - Channel Coding [HMR03]

- Four coding schemes are defined in GPRS
- Different coding schemes are used to cope with differences in link quality between the Base Station and the Mobile Station
- The selection of the coding scheme depends on the quality of the link
  - A link with poor quality needs better error control; a coding scheme with greater number of correction bits is used, consequently the user data rate is smaller
  - When the link quality is good a code scheme with less error control is used, consequently a higher user data rate is achieved.
- Channel Coding
  - The first step of the coding procedure is to add a BCS (Block Check Sequence) for error detection
  - For the CS-1 to CS-3, the second step consists of pre-coding Uplink State Flag (USF) (except for CS-1), adding 4 tail bits and a 1/2 convolutional coding for error correction that is punctured to give the desired coding rate
  - For the CS-4, there is no coding for error correction

GPRS user data rates in kbit/s [Schiller 03]

Coding scheme	1 slot	2 slots	3 slots	4 slots	5 slots	6 slots	7 slots	8 slots
CS-1	9.05	18.2	27.15	36.2	45.25	54.3	63.35	72.4
CS-2	13.4	26.8	40.2	53.6	67	80.4	93.8	107.2
CS-3	15.6	31.2	46.8	62.4	78	93.6	109.2	124.8
CS-4	21.4	42.8	64.2	85.6	107	128.4	149.8	171.2

Table 4.3 GPRS data rates in kbps

Class Quiz

- What are two key nodes in GPRS architecture?
- How is the mobility supported in GPRS?
- How is the channel coding implemented in GPRS?

References

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