General Packet Radio Service (GPRS)

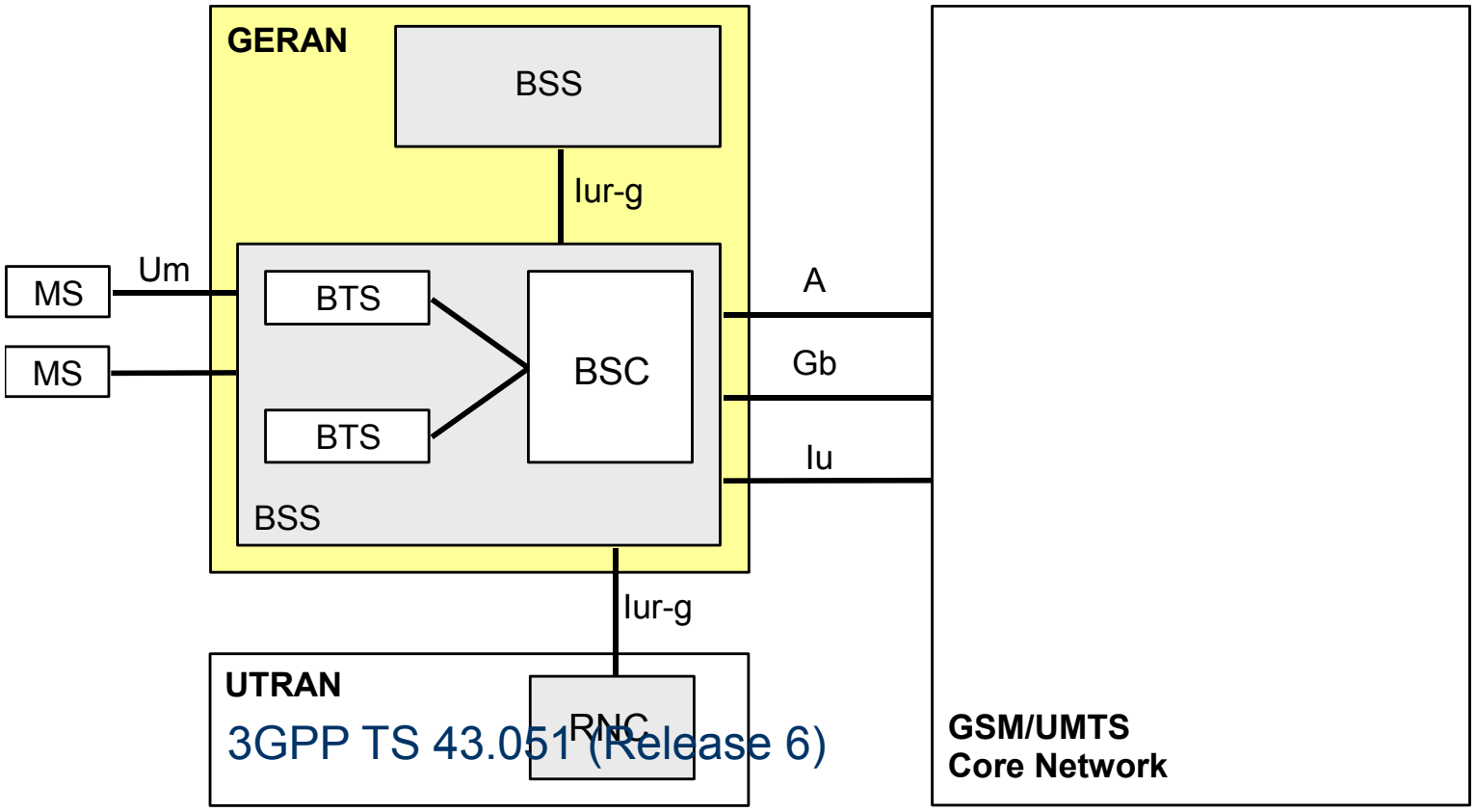
Introduction

- Packet switched data on top of GSM network
- Goals of GPRS:
  - Efficient bandwidth usage for bursty data traffic (e.g. Internet)
  - Higher data rates
  - New charging models
- Initially specified by ETSI
- Specifications handed over to 3GPP

GPRS Release 5/6

- Two modes determined by generation of core network:
  - 2G core => A/Gb
  - 3G core => Iu
- Iu interface added in rel. 5 to align with UMTS

GERAN Reference Architecture



3GPP TS 43.051 (Release 6)

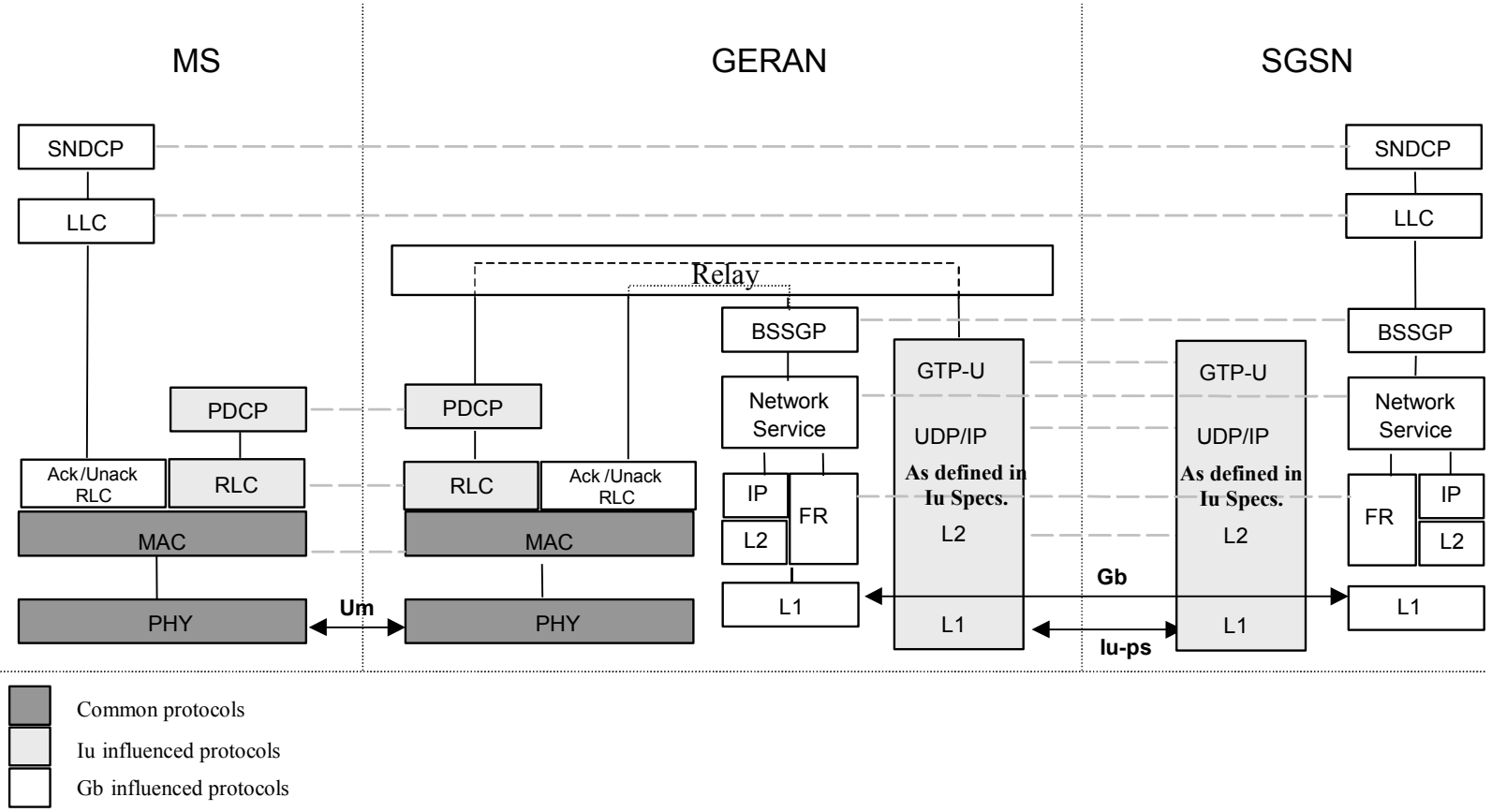
A/Gb mode

- Class A: MS can operate simultaneous packet switched and circuit switched services
- Class B: MS can operate either one at one time
  - Most common for handsets today
- Class C: MS can operate only packet switched services
  - E.g. expansion cards for laptops

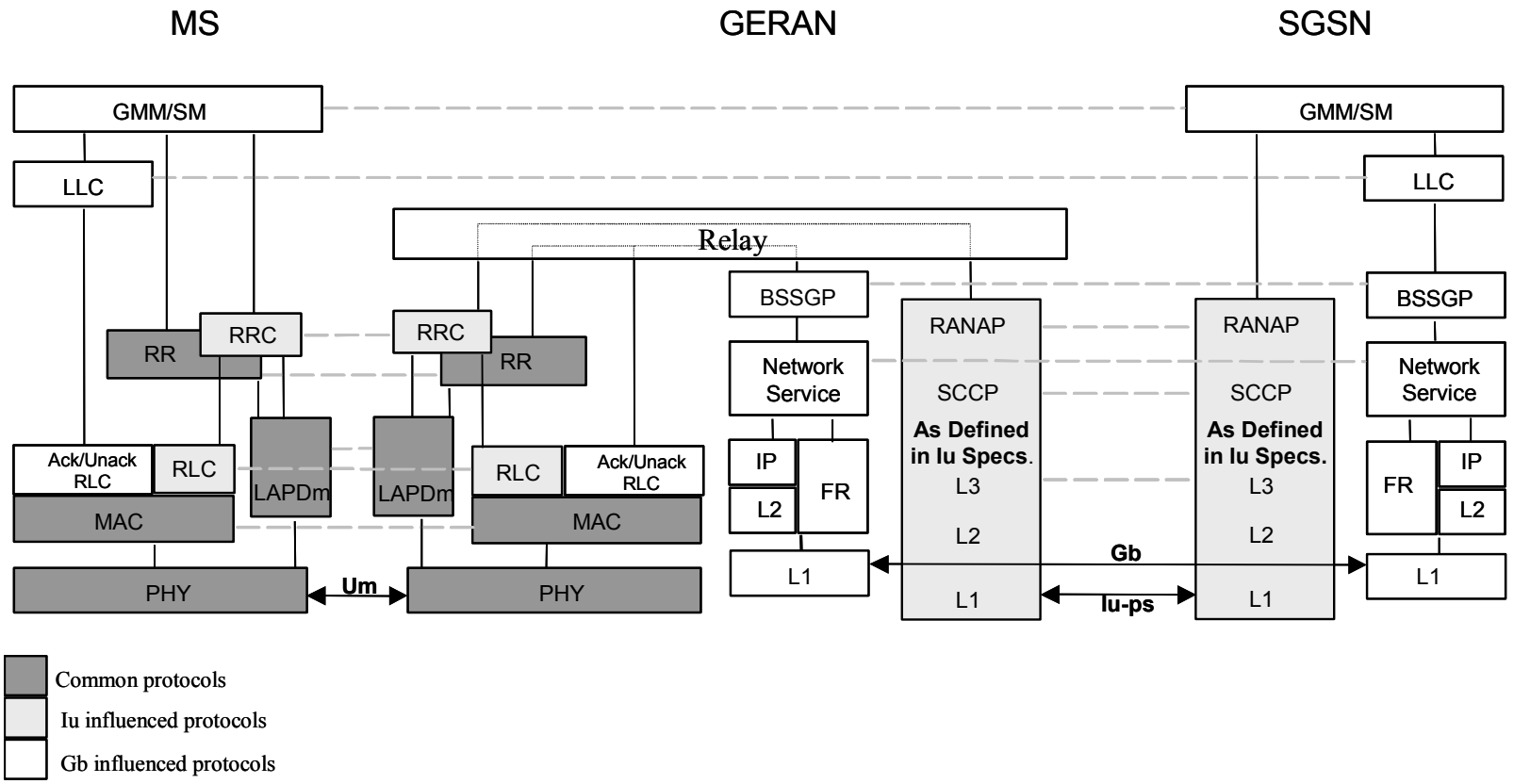
Iu mode

- CS/PS mode: Same as Class A in A/Gb mode
- PS mode: MS can only operate packet switched services
- CS mode: MS can only operate circuit switched services

User Plane Protocol Architecture



Control Plane Protocol Architecture



Service Types

- Point-to-Point
  - Internet access by user
- Point-to-Multipoint
  - Delivery of information (e.g. news) to multiple locations or interactive conference applications

Internet (IP) Multimedia Subsystem

- New in Release 5
- Simultaneous access to multiple different types of real-time and non-real-time traffic
- IMS provides synchronization between such components

Radio Interface Protocols

- User plane and Control Plane
- Three layers
  - Layer 1; Physical (PHY)
  - Layer 2; Data Link, Media Access Control (MAC), Radio Link Control (RLC) and Packet Data Convergence Protocol (PDCP)
  - Layer 3; Radio Resource Control (RRC) for Iu mode and Radio Resource (RR) for A/Gb mode

Physical Layer

- Combined Frequency Division Multiple Access (FDMA) and Time Division Multiple Access (TDMA) (GSM)
- Channel separation: 200 kHz
- Power output control; find minimum acceptable level
- Synchronization with base station
- Handover
- Quality monitoring

Release 5 Protocol Arch.

- Physical Channels
- Logical, Control and Traffic Channels
- Media Access Control and Radio Link Control
- Radio Resource Control and Radio Resource

Physical Channels

- Defined by timeslot (0-7) and radio frequency channel
- Shared Basic Physical Sub Channel
  - Shared among several users (up to 8)
  - Uplink Stage Flag (USF) controls multiple access
- Dedicated Basic Physical Sub Channel
  - One user

Physical Channels

- Packet Data Channel (PDCH)
  - Dedicated to packet data traffic from logical channels (next slide)
    - Control
    - User data

Logical Channels

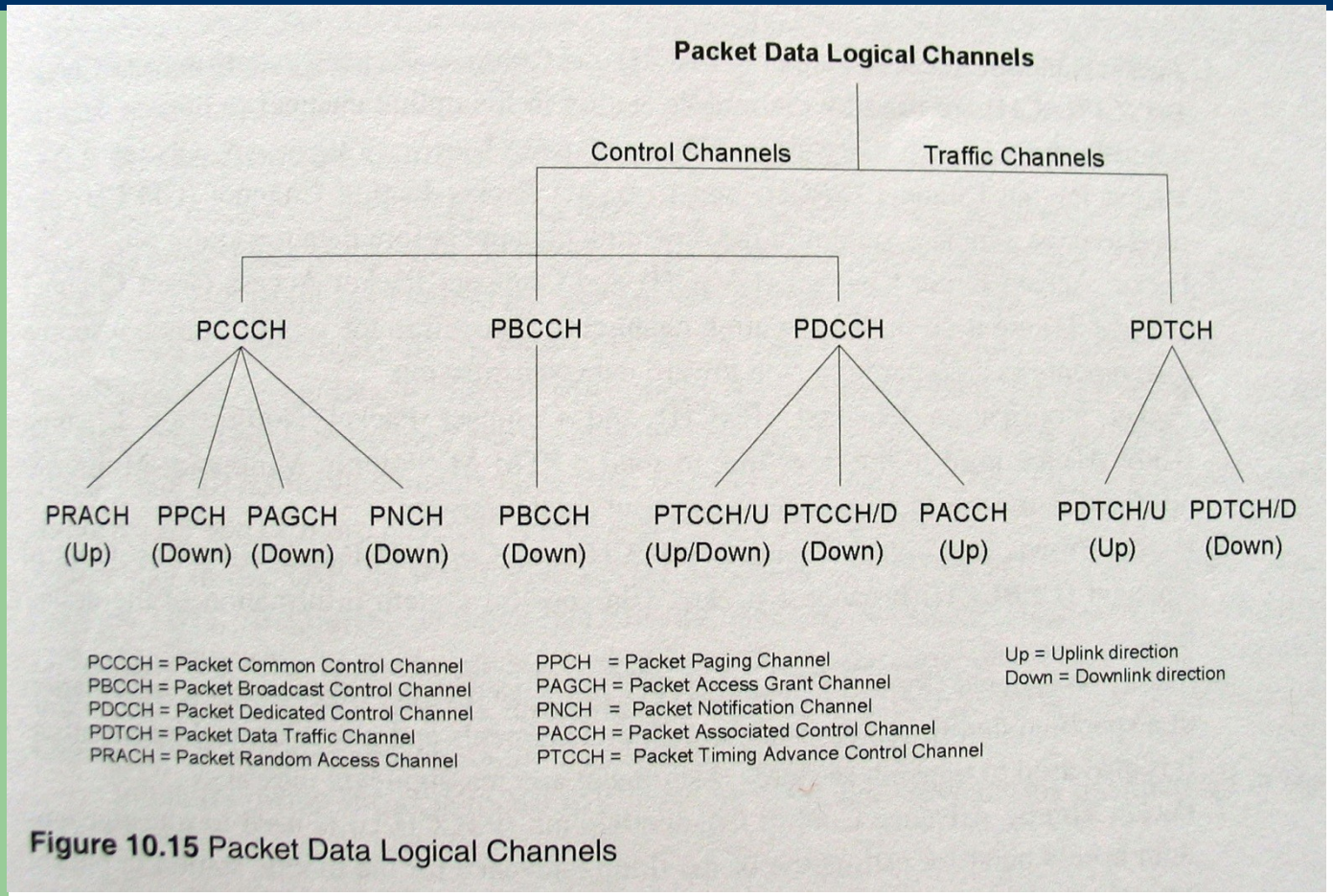


Figure 10.15 Packet Data Logical Channels

Logical Channels

- Mapped by the MAC to physical channels
- Control channels for control, synchronization and signaling
  - Common
  - Dedicated
  - Broadcast
- Packet Traffic channels
  - Encoded speech
  - Encoded data

Control Channels

- Packet Common Control Channel (PCCCH)
  - Paging (PPCH)
  - Random Access (PRACH)
  - Grant (PAGCH)
  - Packet Notification (PNCH)

Control Channels

- Packet Dedicated Control Channel (PDCCH)
  - Operations on DBPSCH
    - Slow Associated Control Channel (SACCH)
      - Radio measurements and data
      - SMS transfer during calls
    - Fast Associated Control Channel (FACCH)
      - For one Traffic Channel (TCH)
    - Stand-alone Dedicated Control Channel (SDCCH)

Control Channels

- Packet Broadcast Control Channel (PBCCH)
  - Frequency correction channels
  - Synchronization channel (MS freq. vs. BS)
  - Broadcast control channel for general information on the base station
  - Packet broadcast channels
    - Broadcast parameters that MS needs to access network for packet transmission

Packet Traffic Channels

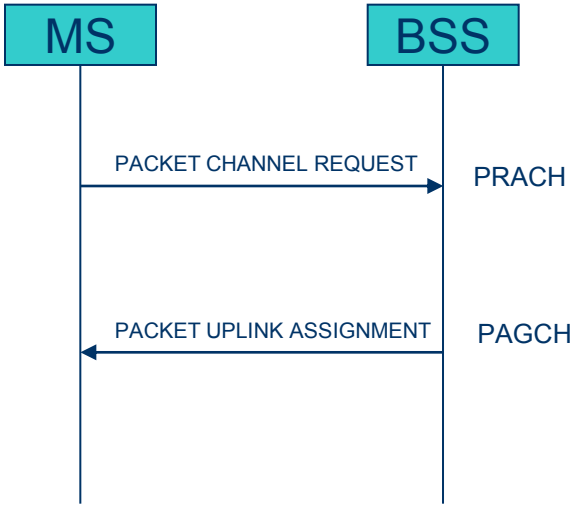
- Traffic Channels (TCH)
- Encoding of speech or user data
- Channels are either predetermined multiplexed or multiplexing determined by MAC
- Full rate/half rate
- On both SBPSCH and DBPSCH
- Modulation techniques
  - GMSK
  - 8-PSK

Media Access Control (MAC)

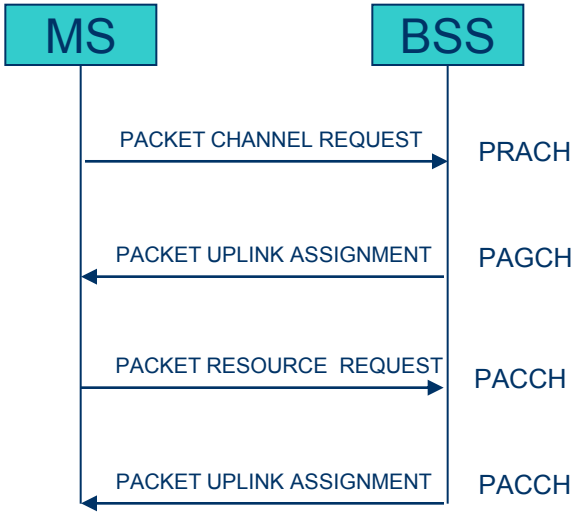
- Connection oriented
- Connections are called Temporary Block Flows (TBF)
  - Logical unidirectional connection between two MAC entities
  - Allocated resources on PDCH(s)
  - One PDCH can accomodate multiple TBFs
  - Temporary Flow Identity (TFI) is unique among concurrent TBFs in the same direction
  - Global_TFI to each station

MAC: TBF Establishment

- MS initiated
  - One Phase Access, or
  - Two Phase Access



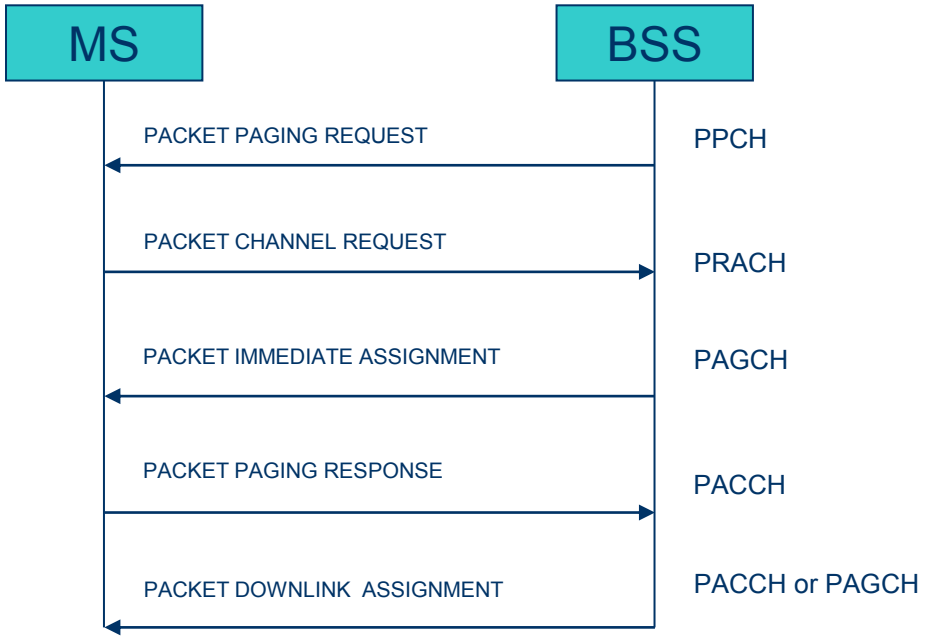
TBF Est. By MS: One Phase Access



TBF Est. By MS: Two Phase Access

MAC: TBF Establishment

- Network initiated



TBF Est. By Network

MAC: Channel Access & Resource Allocation

- Slotted Aloha
  - Used in PRACH
    - MSs send packets in uplink direction at the beginning of a slot
    - Collision: Back off -> timer (arbitrary) -> re-transmit
- Time Division Multiple Access (TDMA)
  - Predefined slots allocated by BSS
  - Contention-free channel access
  - All logical channels except PRACH

MAC: Resource Allocation Mechanisms

- Uplink State Flag (USF, 3bits) associated with an assigned PDCH (USF on each downlink Radio Block)
- USF_GRANULARITY assigned during TBF est.
- Dynamic Allocation
  1. MS finds it's USF in RLC/MAC PDU header. On the next uplink block:
  2. If USF_GRANULARITY=0, transmit one radio block
  3. If USF_GRANULARITY=1, transmit four cons. radio blocks
- Extended Dynamic Allocation
  - Same as Dynamic, except the four radio blocks are transmitted on different PDCHs
- Exclusive Allocation

Radio Link Control

- Can provide reliability for MAC transmissions
- Transparent mode
  - No functionality
- Acknowledged mode
  - Selective Repeat ARQ
  - Sender: Window
  - Receiver: Uplink ACK/NACK or Downlink ACK/NACK
- Unacknowledged mode
  - Controlled by numbering within TBF
  - No retransmissions
  - Replaces missing packets with dummy information bits

Radio Resource Control/Radio Resource

- Radio resource management
- RRC in Iu mode
  - Broadcasts system information
  - Considers QoS requirements and ensures allocation of resources
- RR in A/Gb mode
  - Maintains at least one PDCH for user data and control signaling
- Allocates new DBPSCHs
- Intracell handover of DBPSCHs

QoS Support

- End-to-end QoS may be specified by Service Level Agreements
- Assumes that IP multimedia applications are able to
  - Define their requirements
  - Negotiate their capabilities
  - Identify and select available media components
- GPRS specifies signaling that enable support for various traffic streams
  - Constant/variable bit rate
  - Connection oriented/connection less
  - Etc.

QoS Profile for GPRS Bearers

- Describes applications characteristics and QoS requirements
- 4 parameters:
  - Service precedence
    - 3 classes
  - Reliability parameter
    - 3 classes
  - Delay parameters
    - 4 classes
  - Throughput parameter
    - Maximum and mean bit rates

QoS Profile for GPRS Bearers

- QoS profile is included in Packet Data Protocol (PDP) context
- Negotiation managed through PDP procedures (activation, modification and deactivation)

Packet Classification and Scheduling

- TBF tagged with TFI
- TFI different for each TBF
- Packet scheduling algorithms are not defined by the standard; defined and implemented by GPRS network designers and carriers
- GPRS *can* enable per-flow quantitative QoS services with proper packet classification and scheduling algorithms...Hmmm.

Mobility Management

- Two procedures:
  - GPRS Attach/Detach (towards SGSN/HLR)
    - Makes MS available for SMS over GPRS
    - Paging via SGSN
    - Notification of incoming packet
  - PDP Context Activation/Deactivation
    - Associate with a GGSN
    - Obtain PDP address (e.g. IP)

GPRS Mobile “Station” States

- GPRS protocol stack (MS) can take on 3 different states
  - IDLE
  - STANDBY
  - ACTIVE/READY
- Data can only be transmitted in the ACTIVE state

Routing to MS

- IDLE state
  - No logical PDP context activated
  - No network address (IP) registered for the terminal
  - No routing of external data possible
  - Only multicast messages to all GPRS handsets available

Routing to MS

- STANDBY state
  - Only routing area is known
    - RA is defined by operator => allows individual optimizations
  - When downlink data is available, packet paging message is sent to routing area
  - Upon reception, MS sends it's cell location to the SGSN and enters the ACTIVE state

Routing to MS

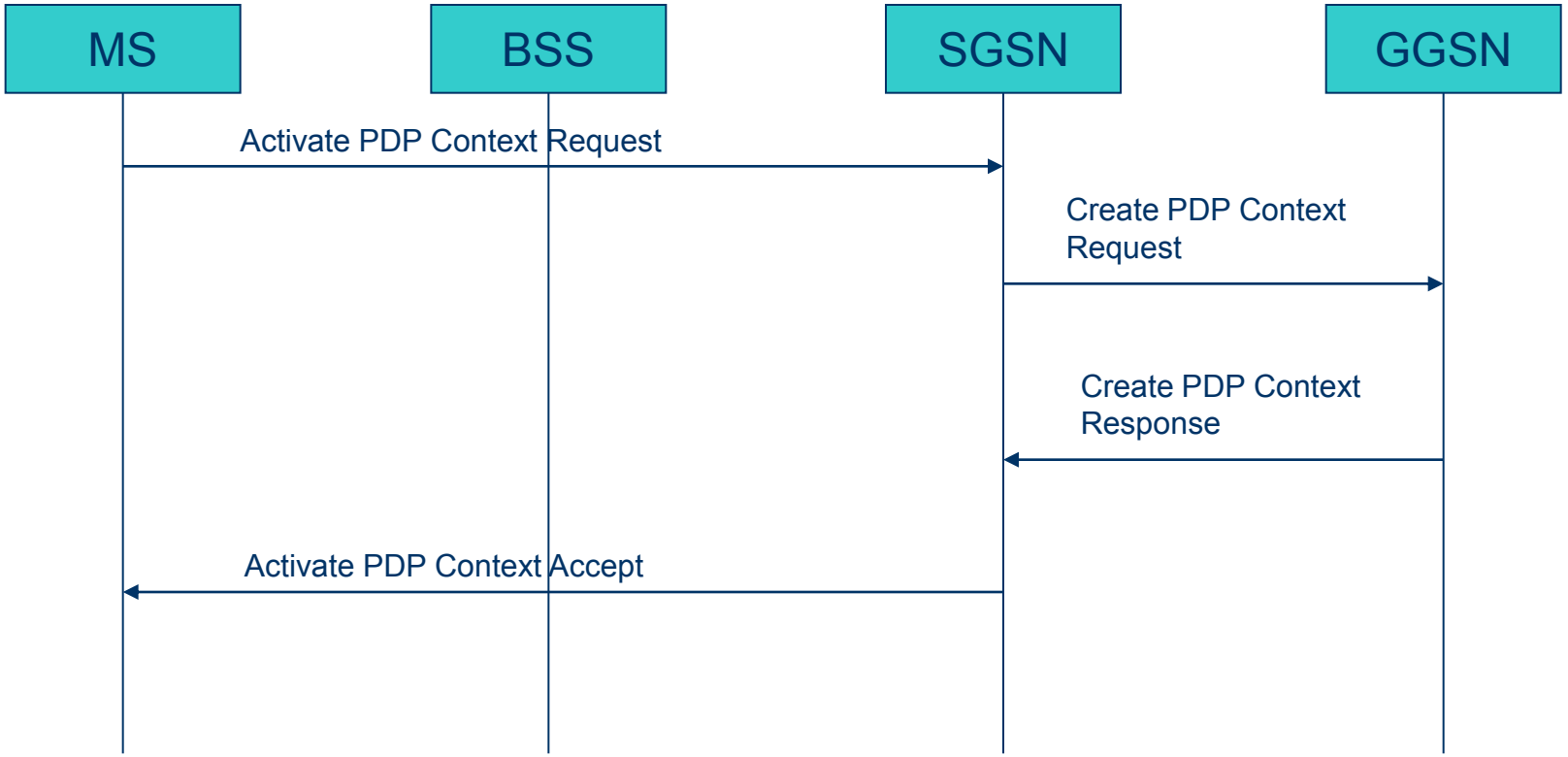
- ACTIVE state
  - SGSN knows the cell of the MS
  - PDP contexts can be activated/deactivated
  - Can remain in this state even if not data is transmitted (controlled by timer)

PDP Contexts

- Packet Data Protocol (PDP)
  - Session
  - Logical tunnel between MS and GGSN
  - Anchored GGSN for session
- PDP activities
  - Activation
  - Modification
  - Deactivation

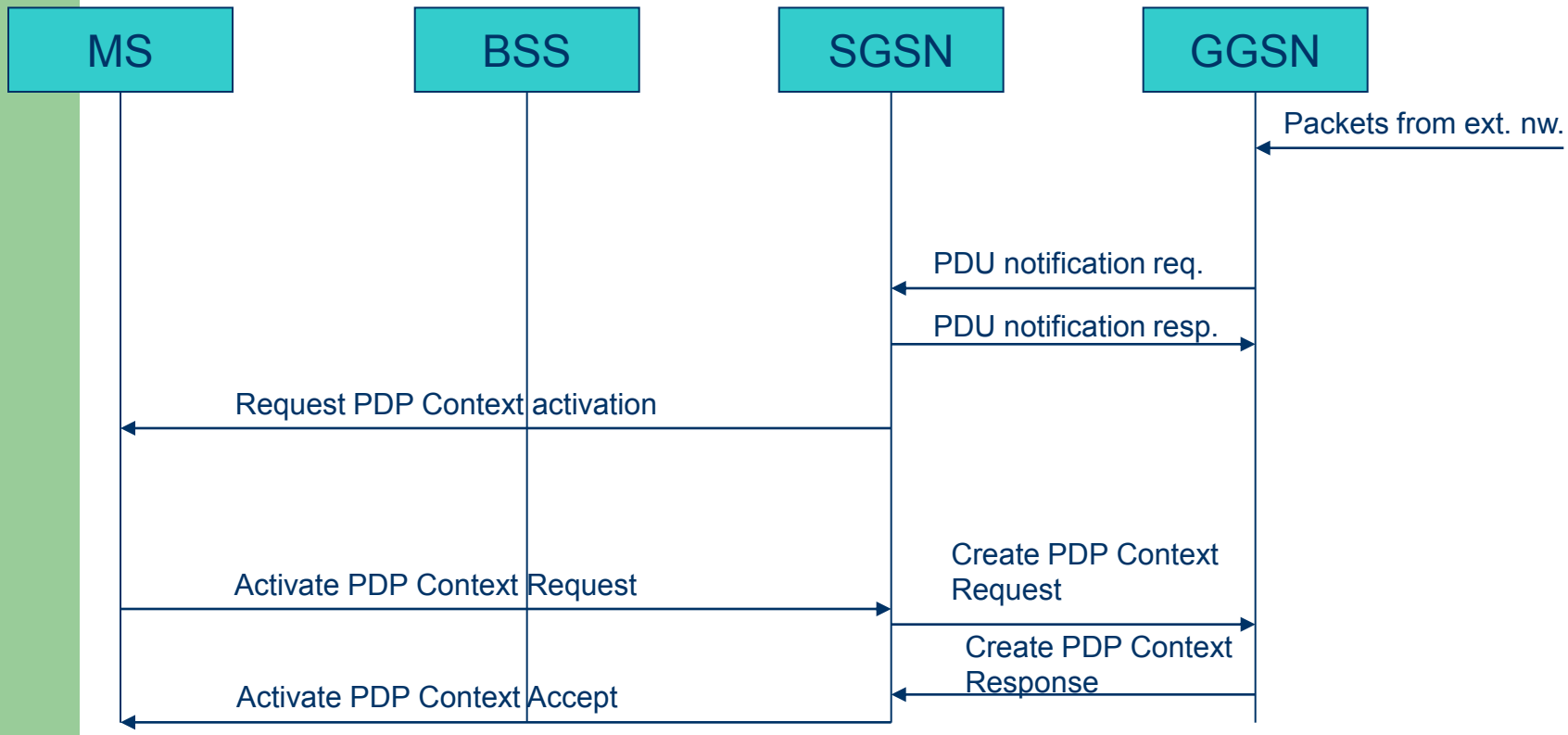
PDP Context Procedures

- MS initiated



PDP Context Procedures

- GGSN initiated



Secondary PDP Contexts

- Used when the QoS requirements differ from Primary PDP Context
  - Same IP address
  - Same APN
- E.g., for IMS; signaling on primary PDP context and user data on secondary PDP context

The End...