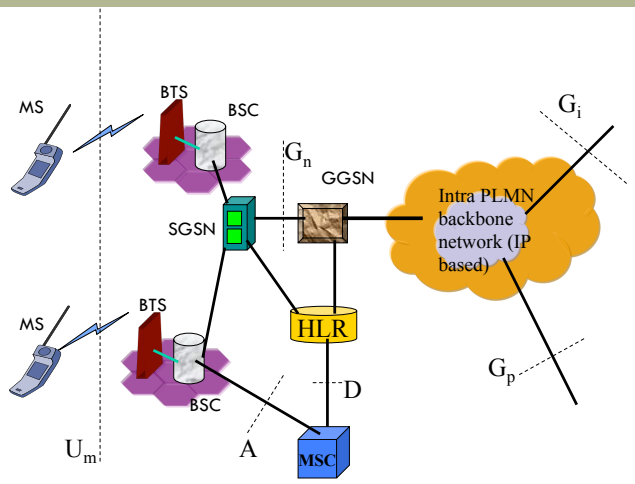
LECTURE 6

GPRS

What is GPRS?

- General Packet Radio Service is an overlay on top of GSM physical layer and network entities
- It extends data capabilities of GSM and provides connection to external packet data networks through the GSM infrastructure
- Short access time to the network for independent short packets (500 – 1000 bytes)
- No hardware changes to the BTS/BSC
- Easy to scale
- Support for both voice/data and data only terminals
- High throughput (up to 200 kbps)
- User-friendly billing ☺

GPRS System Architecture



New Network Entities

- GPRS Support Node (GSN)
  - Responsible for delivery and routing of data packets between the mobile station and external packet network
  - Two types:
    - Serving GPRS Support Node (SGSN)
    - Gateway GPRS Support Node (GGSN)
- GPRS Register (GR) co-located with the HLR
  - Stores routing information and maps IMSI to a PDN address (IP address for example)

Serving GPRS Support Node (SGSN)

5

- It controls access to MSs that may be attached to a group of BSCs
  - This is called a routing area (RA) or service area of the SGSN
- It is 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)

6

- It acts as a logical interface to the Internet
- Maintains routing information related to a MS, so that it can route packets to the SGSN servicing the MS
- It analyses the PDN address of the MS and converts it to the corresponding IMSI

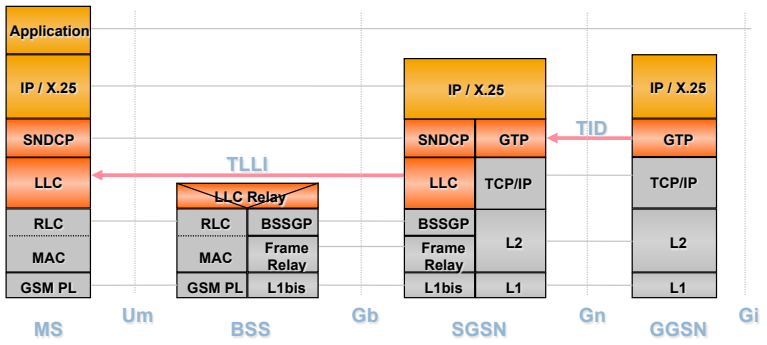
GPRS Signaling Plane

7

- GPRS employs out of band signaling in support of actual data transmission
- Signaling between SGSN, HLR, VLR, EIR is similar to GSM and extends only the GPRS related functionality
  - Based on Signaling System 7
- Between the MS and SGSN, a GPRS mobility management and session management (GMM/SM) protocol is used for signaling purposes

GPRS Transport Plane

8



SNDCP: Subnetwork Dependent Convergence Protocol
BSSGP: BSS Gateway Protocol
GTP: GPRS Tunneling Protocol

RLC/MAC and Physical Layers

9

- The physical layer is the same as GSM (uses GMSK)
- Functionalities include
  - Forward error correction and indication of uncorrectable code words
  - Interleaving of radio "blocks"
  - Synchronization
  - Monitoring of radio link signal quality
  - Other functions similar to GSM

GPRS Vs GSM

10

- GPRS allows a MS to transmit on multiple time slots of the same TDMA frame unlike GSM
- A very flexible channel allocation is possible since 1-8 time slots can be allocated per TDMA frame to a single MS
- Uplink and downlink slots can be allocated differently – asymmetric data traffic
- Some channels may be allocated for GPRS. These are called Packet Data Channels (PDCH)

Allocation of Radio Resources

11

- A cell may or may not support GPRS!!
- Radio resources are dynamically allocated between GSM and GPRS services
- GPRS information is broadcast on the CCHs
- PDCHs may be dynamically allocated or de-allocated by the network (usually the BSC)
- If a MS is unaware that the PDCH has been de-allocated, it may cause interference.
- Fast release of PDCHs is achieved by a broadcast of de-allocation message on a PACCH

Medium Access

12

- Uplink and downlink transmissions are independent
- Medium access protocol is called "Master-Slave Dynamic Rate Access" or MSDRA
- Organization of time-slot assignment is done centrally by the BSS
- A "master" PDCH includes common control channels that carry the signaling information required to initiate packet transfer
- The "slave" PDCH includes user data and dedicated signaling information

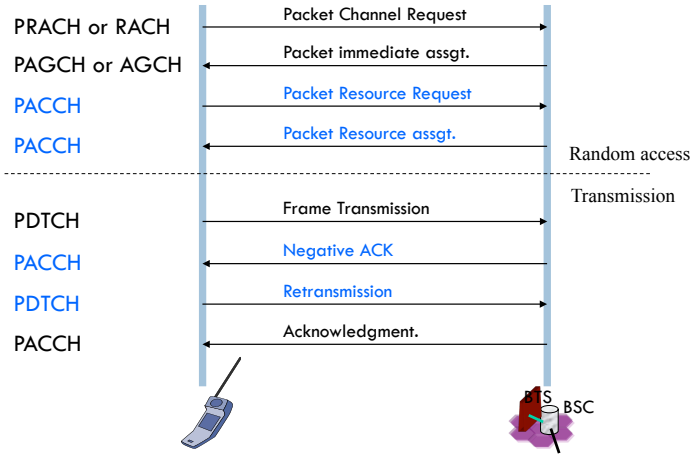
Logical GPRS Channels

13

- Analogous to GSM, GPRS has certain traffic and control channels
- PDTCH → Packet Data Traffic Channel
- PBCCH →Packet BCCH
- PNCH: Packet Notification Channel
- PRACH: Packet Random Access Control Channel
- PAGCH : Packet Access Grant Channel
- PACCH: Packet Associated Control Channel
  - Use to send ACKs for received packets
- PTCCH: Packet Timing-advance Control Channel is used for adaptive frame synchronization

Uplink Data Transfer

14



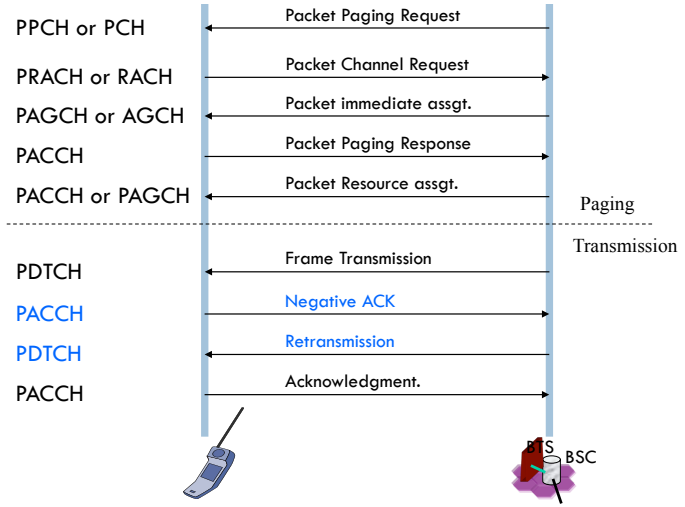
Comments on Uplink Data Transfer

15

- If a MS does not get an ACK, it will back off for a random time and try again
- The Master-Slave mechanism utilizes a 3 bit "uplink status flag" or USF on the downlink
  - A list of PDCHs and their USF are specified
  - The Packet Resource or Immediate Assignment message indicates what USF state is reserved for the mobile on a PDCH
  - Assignment can also be done so that a MS can send packets uninterrupted for a predetermined amount of time

Downlink Data Transfer

16



Comments on Downlink Data Transfer

- Data transmission to a mobile can be interrupted if a high priority message needs to be sent
- Instead of paging, a resource assignment message may be sent to the MS if it is already in a "ready" state (see later)

LLC

- The TLLI (Temporary Logical Link Identity) is used to identify a MS in the LLC header
- A logical link is created between the MS and the SGSN
- Performs sequence control, error recovery, flow control and encryption
- It has an acknowledged mode (with retransmission for network layer payloads) and an unacknowledged mode (for signaling and SMS)
- Supports various QoS classes

Attachment Procedure

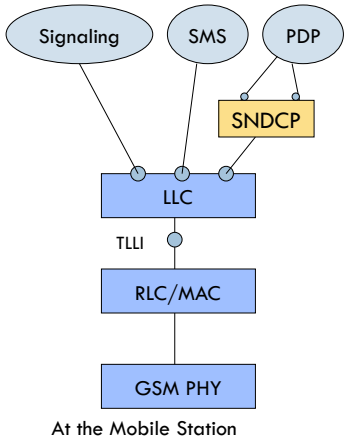
- Before accessing GPRS services, the MS must register with the GPRS network and become "known" to the PDN
- The MS performs an ***attachment procedure*** with an SGSN
  - Authentication
  - Check with GR etc.
- It is allocated a temporary logical link identity (TLLI) by the SGSN
- ***A PDP*** (packet data protocol) ***Context*** is created for the MS

PDP Context

- For each session, a PDP context is created
  - PDP Type: (e.g. IPv4)
  - The PDP address assigned to the MS
  - The requested QoS
  - The GGSN address that serves the point of access to the PDN
- PDP context is stored in the MS, the SGSN, and the GGSN
- A user may have several PDP contexts enabled at a time
- The PDP address may be statically or dynamically assigned (static address is the common situation)

SNDCP:Sub-Network Dependent Convergence Protocol

21

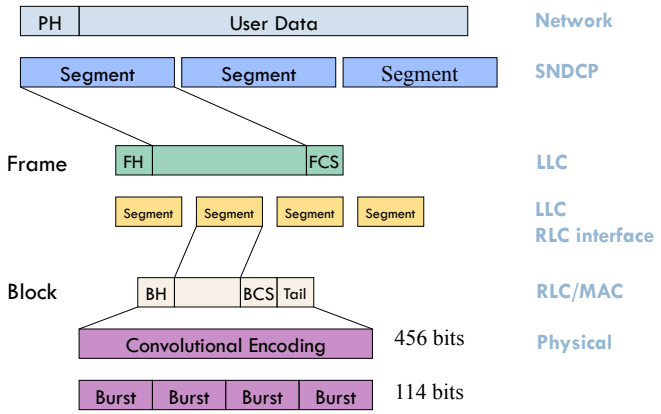


At the Mobile Station

- Supports a variety of network protocols (IP, X. 25, CLNP etc.)
- All network layer packets share the same SNDCP
- It multiplexes and de-multiplexes the network layer payload
- It forms the interface between the LLC and the network layer
- Handles packets based on QoS

Packet Transformation Data Flow

22



BSS Gateway Protocol BSSGP

23

- Primary function is to relay radio related, QoS, and routing information between the BSS and SGSN
  - Paging requests from SGSN
  - Support flushing of old messages from BSS
- Also carries the LLC frame from the MS to the SGSN
- Many MS LLCs can be multiplexed over one BSSGP
  - Gb interface is different from A interface
- Data transfer is unconfirmed between BSS and SGSN

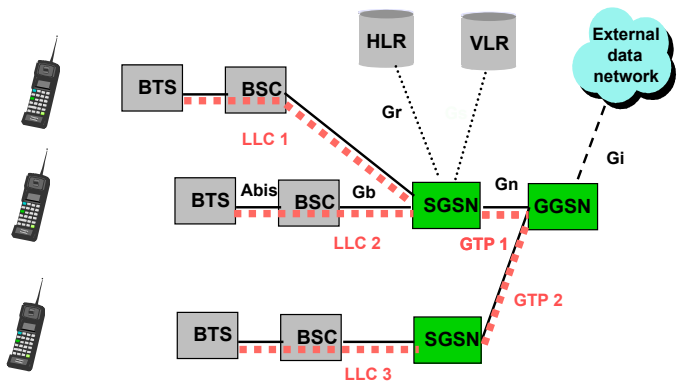
GPRS Tunneling Protocol (GTP)

24

- Why GTP?
- Allows multi-protocol packets to be tunneled through the GPRS backbone
- A Tunnel ID (TID) is created using signaling plane that tracks the PDP context
  - Multiplexing different payloads
  - Use in mobility management

Mobility and Tunnel Management

25

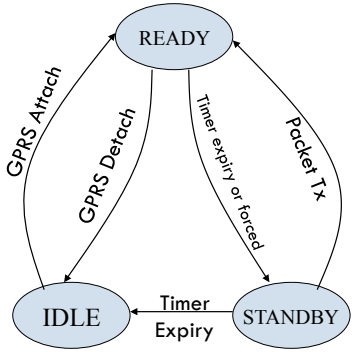


The two-level tunneling mechanism corresponds to a two level Mobility Management: LLC "tunnels" (or virtual circuits) correspond to small area mobility, while GTP tunnels correspond to wide area mobility.

Location Management

26

- MS can be in three states
- In the IDLE state the MS is not reachable
  - All PDP contexts are deleted
- In the STANDBY state, movement across routing areas are updated to the SGSN but not across cells
- In the READY state, every movement of the MS is indicated to the SGSN



Why three states?

27

- If the MS updates its location too often, it consumes battery power and wastes the air-interface resources
- If it updates too infrequently, a system-wide paging is needed; this is also a waste of resources
- A standby state focuses the area
  - Chance of packets reaching are medium
- A ready state pinpoints the area
  - Chances of packets reaching are high

Routing Area Updates

28

- Intra-SGSN RA Update
  - The SGSN already has the user profile
  - A new temporary mobile subscriber identity is issued as part of routing area update "accept"
  - The Home GGSN and GR(HLR) need not be updated
- Inter-SGSN RA Update
  - The new RA is serviced by a new SGSN
  - The new SGSN requests the old SGSN to send the PDP contexts of the MS
  - The new SGSN informs the home GGSN, the GR, and other GGSNs about the user's new routing context

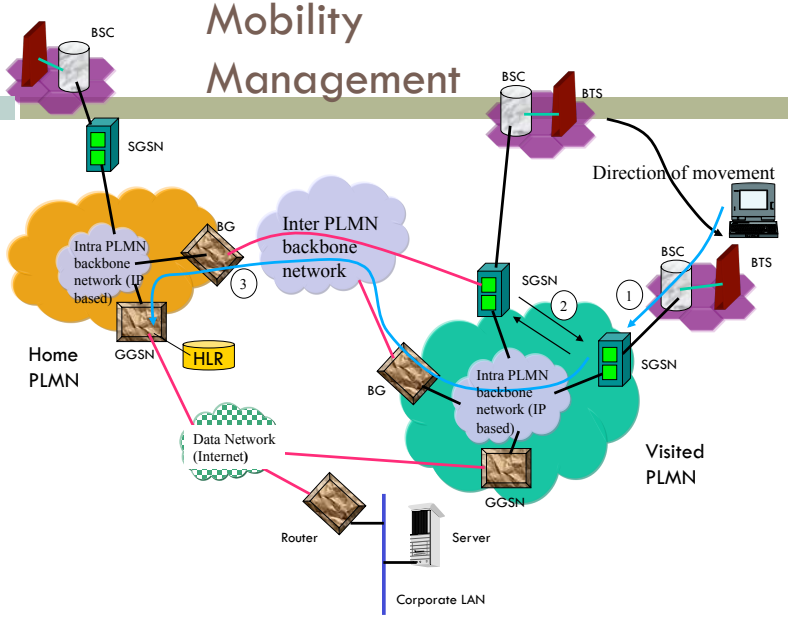
Mobility Management in GPRS

29

- Handoff Initiation
  - The MS listens to the BCCH and decides which cell it has to select
  - Proprietary algorithms are employed that use RSS, Cell ranking, Path loss, Power Budget, etc.
  - An option exists where the network can ask the MS to report its measurements and ask it to make a handoff (as in GSM)
- Handoff Procedure
  - Very similar to Mobile IP

Mobility Management

30



Steps in Mobility Management

31

- 1. RA Update to new SGSN
- 2. Communication between new and old SGSN
- 3. Communication between new SGSN and Home-GGSN/HLR
- The Home GGSN "tunnels" packets to the new SGSN
- The HLR deletes old SGSN information and includes the new SGSN information in the database
- The new SGSN decapsulates packets and forwards them to the MS

Limitations of GPRS

32

- Limited cell capacity for all users
- Speeds much lower in reality
- Sub-optimal modulation
- Transit delays
- No store and forward
  - Popular SMS does have it

GPRS-136: GPRS and IS-136

33

- Adaptation of GPRS to the IS-136 TDMA cellular standard
- Very similar to GPRS
  - 30 kHz physical channels instead of 200 kHz physical channels
  - Can use coherent 8-PSK in addition to $\pi/4$ – DQPSK to increase throughput over a limited area => EDGE
  - Hooks in the standard allow the possibility of 16-QAM, 16-PSK, or 16-DQPSK in the future

High Speed Circuit Switched Data (HSCSD)

34

- Use multiple circuit switched connections to transfer data!
- Slow and expensive
- Inefficient use of radio resources
- Migration path to full fledged third generation (3G) packet data services
  - Customer base development

EDGE

35

- Enhanced Data rates for GSM Evolution
- Data throughput speeds of up to 384 kb/s using existing GSM infrastructure.
- Idea: Use higher level modulation schemes like 8-PSK
- Disadvantage: Coverage is reduced
  - Adaptive bit rates