Mobility management

From GPRS to UMTS

Introduction

Hira Shaukat   2010131

EVOLUTION PATH

GSM	GPRS	UMTS

- UMTS – 3rd generation mobile system network
- GPRS – 2.5G mobile system network
- GSM – 2nd generation mobile system network
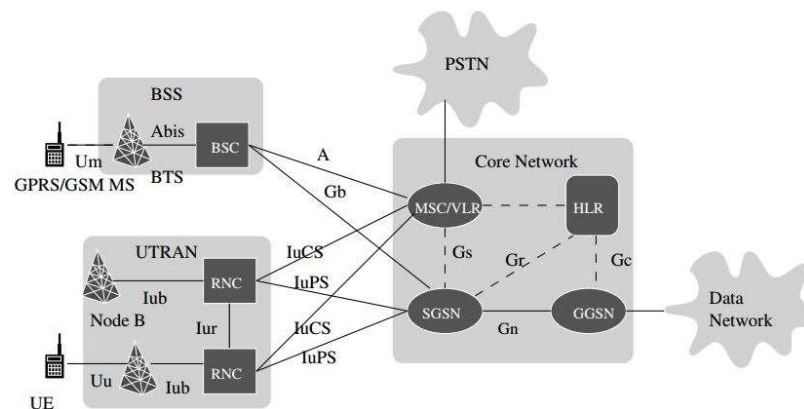- Analog Cellular systems – 1st Generation mobile system network

Fig. 1. GSM/GPRS/UMTS network architectures. BSS: base station subsystem; BTS: base transceiver station; HLR: home location register; GGSN: gateway GPRS support node; MS: mobile station; MSC: mobile switching center; Node B: base station; PSTN: public switched telephone network; RNC: radio network controller; SGSN: serving GPRS support node; UE: user equipment; UTRAN: UMTS terrestrial radio access network; VLR: visitor location register.

GSM

•GSM is a digital cellular technology that is used worldwide, predominantly in Europe and Asia
•GSM is the world's leading standard in digital wireless communications

| GSM | GPRS | UMTS |

GPRS

| GSM | GPRS | UMTS |

- GPRS is a 2.5G mobile communications technology that enables mobile wireless service providers to offer their mobile subscribers packet-based data services over GSM networks
- Common applications of GPRS:
  - Internet access
  - Intranet/corporate access
  - Instant messaging
  - Multimedia messaging
- GPRS was standardized by the European Telecommunications Standards Institute (ETSI), but today is standardized by the Third Generation Partnership Program (3GPP)

UMTS

•UMTS is a 3G mobile communications technology that provides wideband code division multiple access (W-CDMA) radio technology

•CDMA technology offers:
- •higher throughput
- •real-time services
- •end-to-end quality of service (QoS)
- •delivers pictures, graphics, video communications, and other multimedia information
- •voice and data transmission

•UMTS is standardized by the 3GPP

| GSM | GPRS | UMTS |

MOBILITY

*"**Mobility management** is one of the major functions of a GSM or a UMTS network that allows mobile phones to work. The aim of mobility management is to track where the subscribers are, allowing calls, SMS and other mobile phone services to be delivered to them"*

MOBILITY

- Mobility Scenarios
  - Service mobility
  - Network mobility
  - Personal mobility
    - Personal communication
    - Personalizing operating environment
  - Device mobility

Mobility Management (MM)

Functions of MM

- ◉ Registration
  - • Informs network which device is used and that it is ready to receive request
  - • Normally combined with authentication
- ◉ Paging
  - • In power saving mode only the area a device is located in is known by the network
 - • Paging is used to find the cell a device is located in
- ◉ Location Update
  - • Informs the network of new locations of the device.
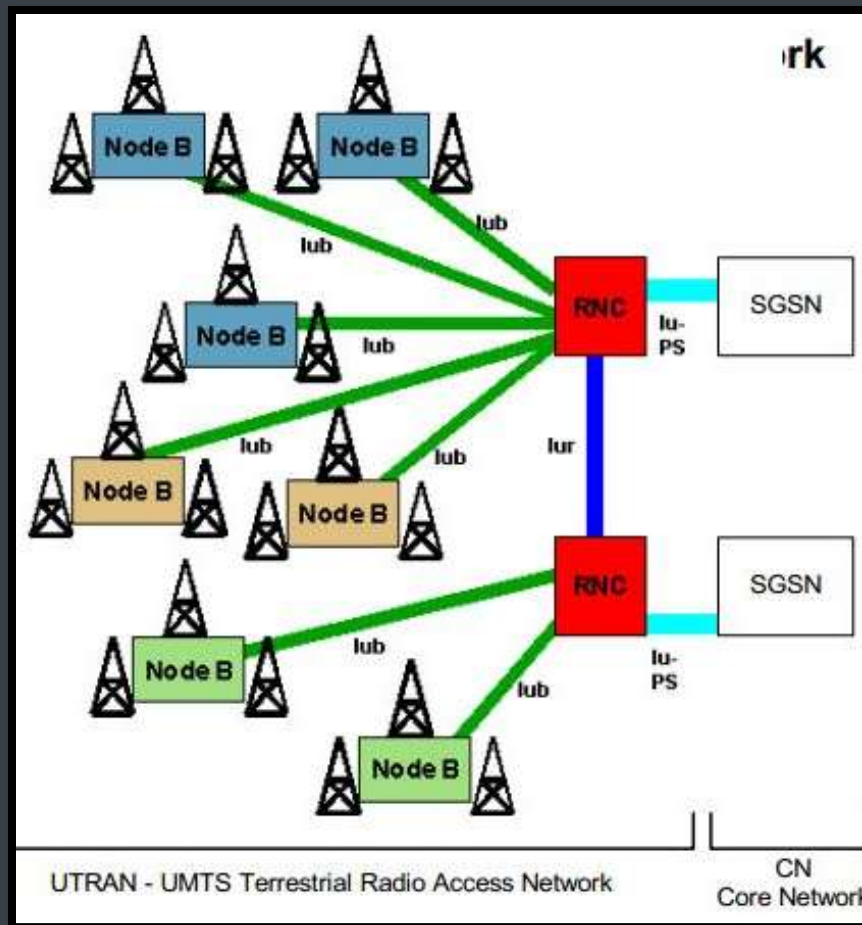 - • Triggered by movement or timer.
- ◉ Handover
  - • Keeps link while moving by switching the link from one access point to another.
- ◉ Rerouting
  - • Optimizes the traffic path by redefining routes after handovers.

Mobility in UMTS

UTRAN - UMTS Terrestrial Radio Access Network
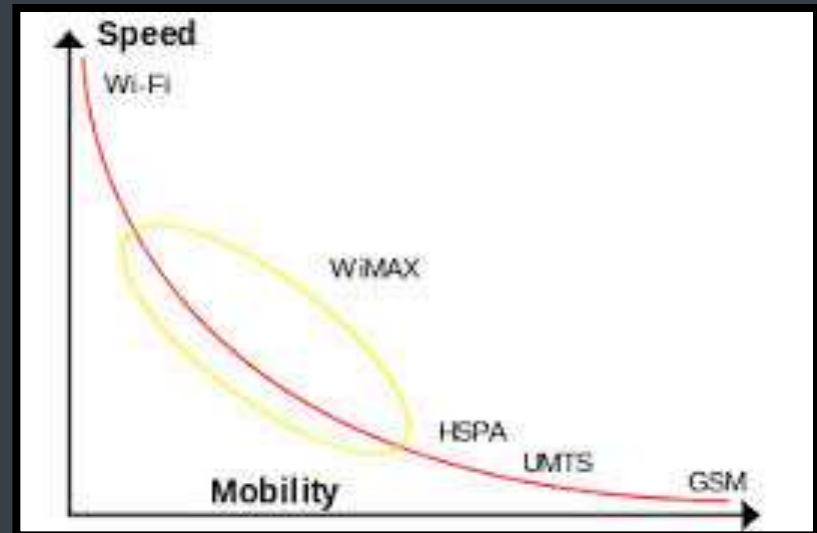
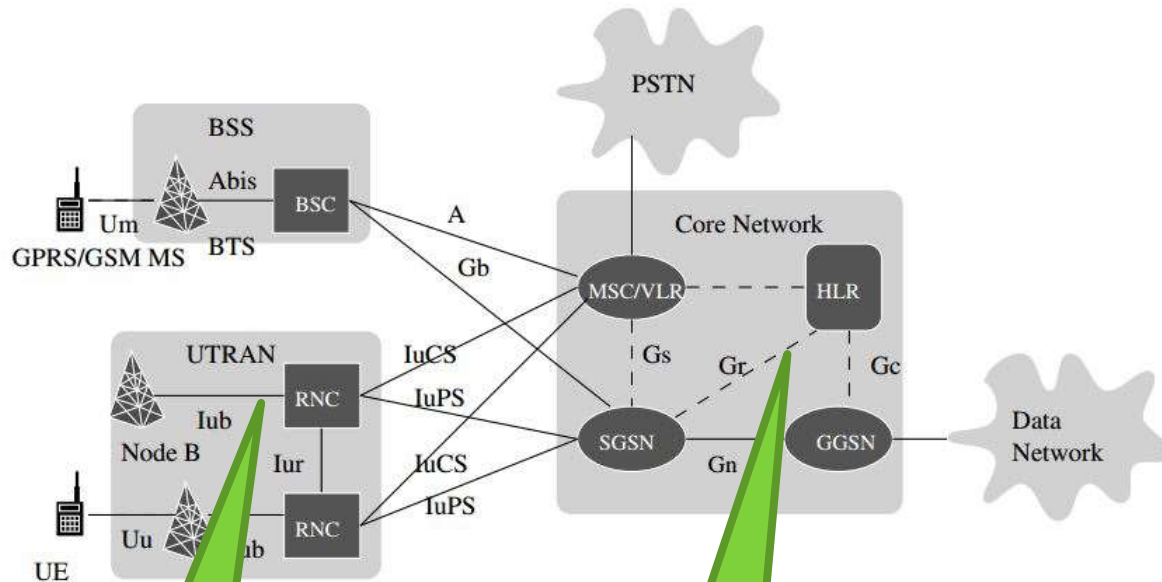|	
UE:	User Equipment
RNC:	Radio Network Controller
RNS:	Radio Network Subsystem (RNC with all connected Node Bs)
Iub:	RNC to Node B interface
Iur:	RNC to RNC interface
Iu-PS:	RNC to CN interface for packet-switched data
UTRAN:	UMTS Terrestrial Radio Access Network
CN:	Core Network
SGSN:	Serving GPRS Support Node
GGSN:	Gateway GPRS Support Node

Network architecture

Fig. 1. GSM/GPRS/UMTS network architectures. BSS: base station subsystem; BTS: base transceiver station; HLR: home location register; GGSN: gateway GPRS support node; MS: mobile station; MSC: mobile switching center; Node B: base station; PSTN: public switched telephone network; RNC: radio network controller; SGSN: serving GPRS support node; UE: user equipment; UTRAN: UMTS terrestrial radio access network; VLR: visitor location register.

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Wirel. Commun. Mob. Comput. 2001; **1**:339−359

Data & Signaling Links

Signaling Links

Core Network (CN)

- CS service domain
  - PSTN/ ISDN
  - MS is identified by IMSI and TMSI
- PS service domain
  - IP
  - MS is identified by IMSI and P-TMSI
- GPRS
  - Evolved from GSM network by introducing 2 new core networks nodes
    - Serving GPRS Support Node (SGSN)
    - Gateway GPRS Support Node (GGSN)
  - Existing GSM nodes (BSS, MSC/VLR, and HLR) are upgraded
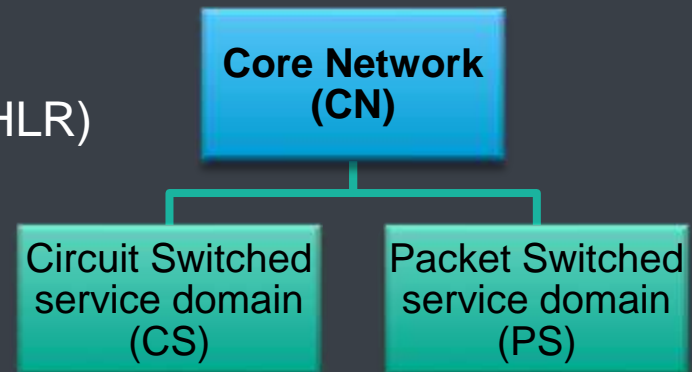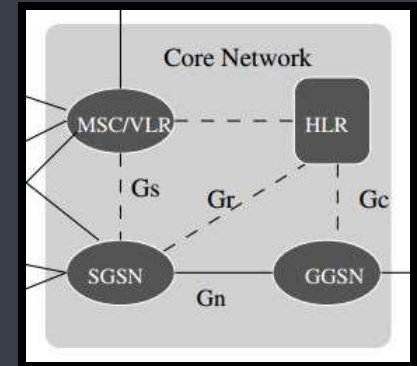
GPRS BSS

- GPRS BSS consists of
    - Base Transceiver Station(BTS) and
    - Base Station Controller (BSC)
- BSC is connected to the SGSN through frame relay link
- BTS communicates with the MS through the radio interface Um based on the TDMA technology
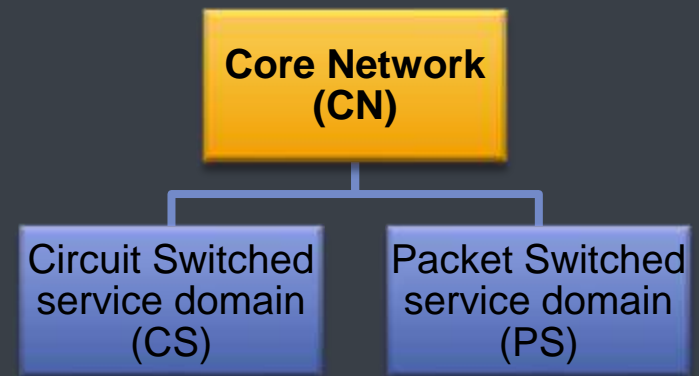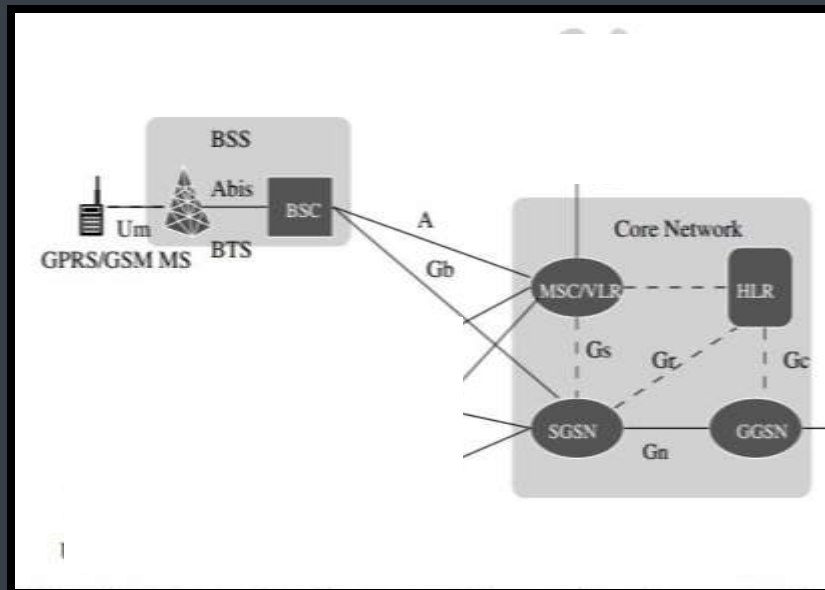
GPRS MS

•Three operation modes are defined for GPRS MS:
  •Class A MS
      allows simultaneous CS and PS connections
  •Class B MS
      provides automatic choice of CS or PS
      connection, but only one at a time
  •Class C MS
      only supports PS connection


```
Operation
Modes of
GPRS MS
```

| Class A MS | Class B MS | Class C MS |
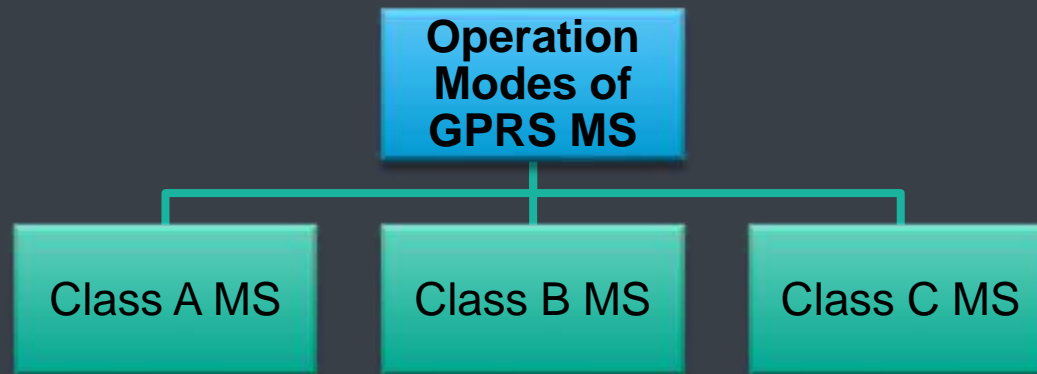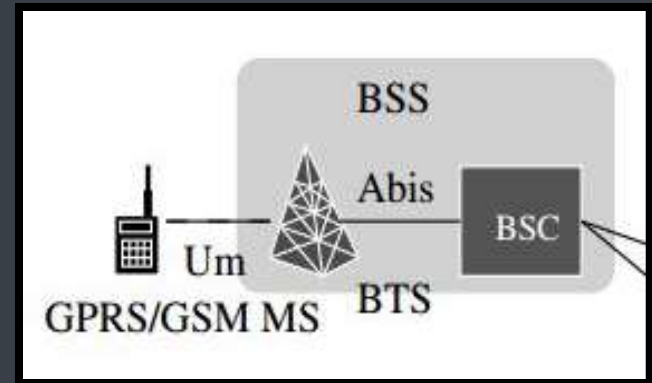
Mobility in GPRS

- **IDLE STATE**
  - MS is yet to be attached to the GPRS MM
  - MS location not known
  - Subscriber is not reachable by the GPRS NW
- **READY State**
  - MS is attached to the GPRS MM
  - Known in accuracy of cell
  - MS is transmitting or has just been transmitting
  - Capable of receiving Point-to-Point data and Point-to-Multipoint data.
- **STANDBY state**
  - When ready timer expires
  - MS is attached to GPRS MM
  - MS location known to SGSN/RA
  - Capable of receiving Point-to-Multi point data and being paged for Point-to-Point data

Idle

MS Mobility Management States

Standby

Ready
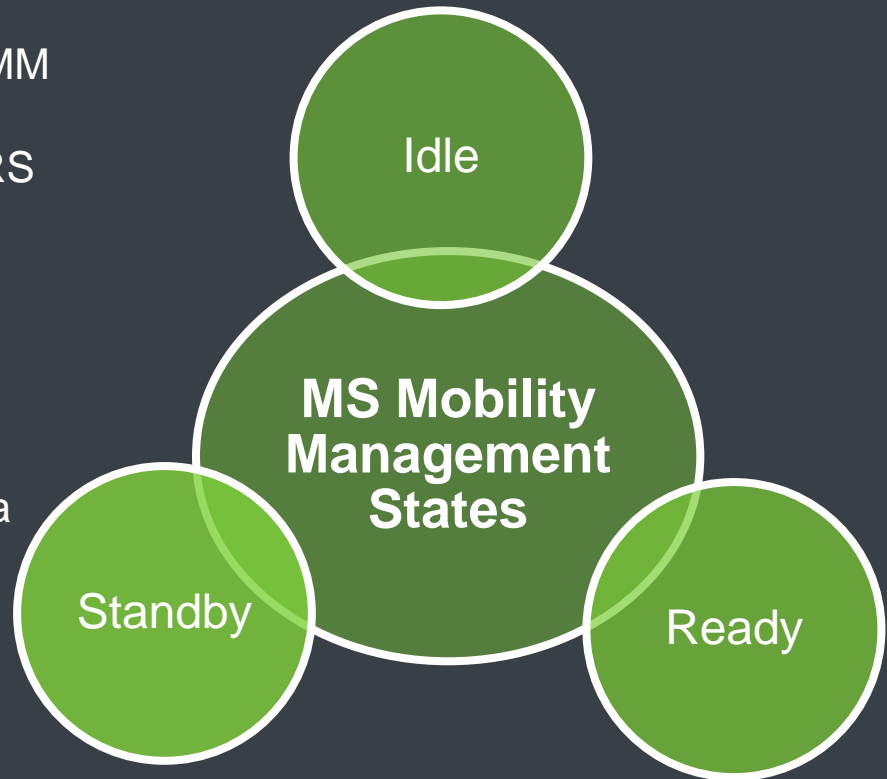
From GPRS to UMTS

•UMTS is evolved from GPRS by replacing the radio access network

•The UMTS Terrestrial Radio Access Network (UTRAN) consists of
  •Node Bs (the 3G term for BTS)
  •Radio Network Controllers (RNCs)
  •connected by an ATM network

•The RNC and the Node B serving an MS are called the Serving Radio Network System(SRNS)

•The User Equipment (UE; the 3G term for MS) connects with Node Bs through the radio interface Uu based on the WCDMA (Wideband CDMA) technology operation modes are defined for UMTS UE

•Three PS/CS mode UE is equivalent to GPRS Class A MS
  •PS mode UE is equivalent to GPRS Class C MS
  •CS mode UE can only attach to the CS domain

Mobility Management States

Yamna Anwar   2010386

Mobility Management States

A sequence of states executed under specific circumstances that characterize the mobility management activities for the MS

States in MM state machine

The characterization of the mobility management activities in both GPRS and UMTS systems is achieved by executing a finite state machine in both the MS and the SGSN.

States in the MM state machine are:

- **GPRS –** IDLE, STANDBY and READY
- **UMTS PS service domain –** PMM-DETACHED, PMM-IDLE and PMM-CONNECTED

The MM states for GPRS and UMTS are basically the same. These states are stored in the MM contexts which are maintained by the MS and SGSN

Characteristics of MM states

- **IDLE / PMM-DETACHED –** MS unknown; not attached to GPRS (UMTS/PS)
  - not reachable by the network
  - MS may perform attach procedure

- **STANDBY / PMM-IDLE** – MS is attached to GPRS (UMTS/PS): MS and SGSN have established MM contexts
  - MS may perform detach and location update procedures
  - SGSN may perform paging procedure
  - MS tracked by SGSN at RA level

- **READY / PMM-CONNECTED** – PDUs can only be delivered in this state
  - *GPRS* – SGSN tracks MS at cell level
  - *UMTS* – PS signaling connection is established between the MS and SGSN
  - SGSN tracks the MS at RA level accuracy
  - Serving RNC is responsible for cell-level tracking
  - Serving RNC relocation is executed in this state

Transition of MM states

- **IDLE → READY / PMM-DETACHED → PMM-CONNECTED**
- **STANDBY → IDLE / PMM-IDLE → PMM-DETACHED**
- **STANDBY → READY / PMM-IDLE → PMM-CONNECTED**
- **READY → STANDBY / PMM-CONNECTED → PMM-IDLE**
- **READY →IDLE / PMM-CONNECTED → PMM-DETACHED**

Transition of MM states

- **IDLE → READY**
(PMM-DETACHED →PMM-CONNECTED)

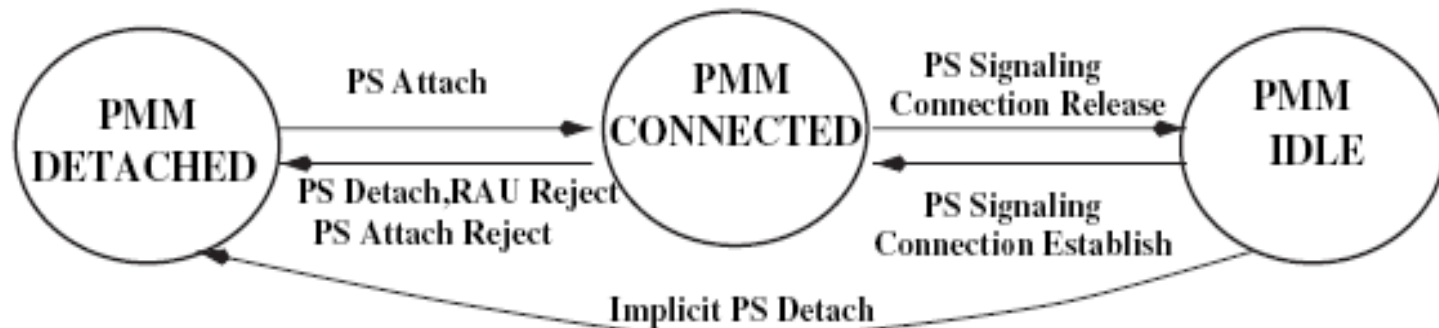This transition is triggered by the MS when the MS performs GPRS/PS attach.

- **STANDBY → IDLE**
(PMM-IDLE → PMM-DETACHED)

This transition can be triggered by the MS or the SGSN

# MS MM State Diagrams

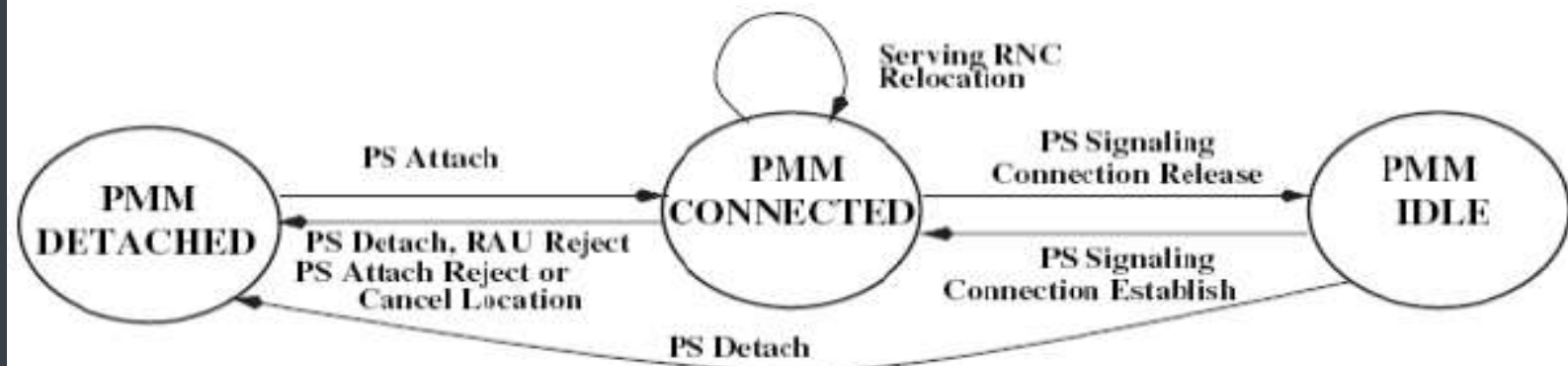
(a) MS MM States for GPRS

(b) MS MM States for UMTS

Transition of MM states

- **STANDBY → IDLE / PMM-IDLE → PMM-DETACHED** – triggered by MS or SGSN
  - *Tracking of MS is lost* – triggered by SGSN
    - SGSN performs an *implicit GPRS/PS detach*
    - *Mobile Reachable Timer* – maintained in the SGSN to monitor the periodic RA update procedure
    - MS detached – if SGSN does not receive RA update request message from the MS after the timer expires
    - Timer used only when the MM state is **STANDBY / PMM-IDLE**
  - *Cancel Location message from HLR received* – triggered by SGSN
    - The MM and the PDP contexts are already moved to the new SGSN that serves the MS
    - Contexts of the old SGSN can be deleted
    - MS will be associated with the new SGSN
  - *Implicit detach performed by the MS* – triggered by the MS
    - Due to removal for the SIM card or the battery
    - Defined for UMTS only

SGSN MM State Diagrams
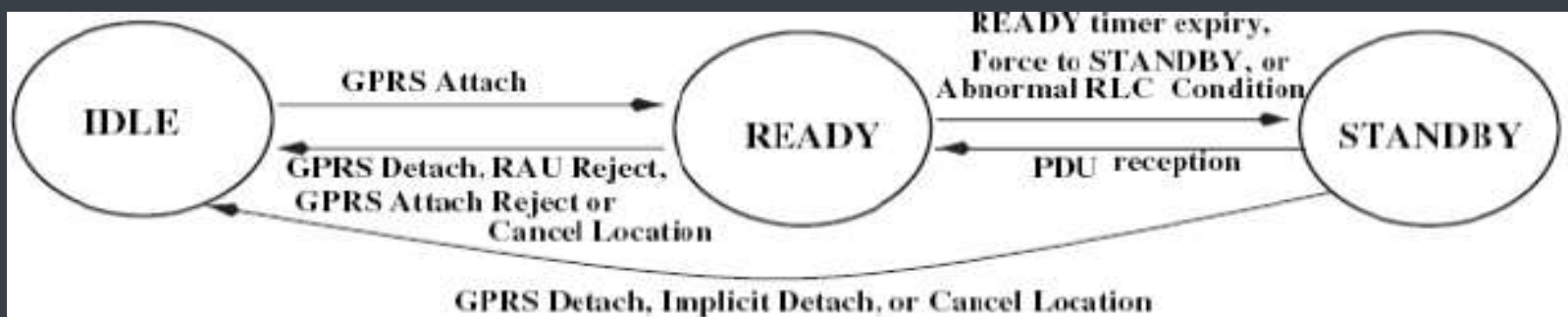
(c) SGSN MM States for GPRS

(d) SGSN MM States for UMTS

Transition of MM states

- **STANDBY → READY / PMM-IDLE → PMM-CONNECTED** – triggered by the MS
  - *GPRS* – MS sends an LLC PDU to the SGSN
    - possibly in response to a page from the SGSN
  - *UMTS* – transition occurs when the service request procedure is executed
    - Possibly in response of a page from the SGSN
    - Establishes a signaling connection between the SGSN and the MS

- **READY → STANDBY / PMM-CONNECTED → PMM-IDLE** – triggered by either MS or SGSN
  - *GPRS* – a **READY** timer is maintained in the MS and the SGSN
    - length of the ready timer can only be changed by the SGSN
    - MS informed of the ready timer value change by messages like Attach Accept and Routing Area Update Accept
    - Transition occurs when
      - No LLC PDU transmitted before the timer expires
      - SGSN forces the transition
      - Abnormal RLC conditions detected during radio transmission
  - *UMTS* – transition occurs when
    - PS signaling connection is broken or released (e.g., RRC connection failure), or
    - URA update timer at RRC expires

Transition of MM states

- **READY →IDLE / PMM-CONNECTED → PMM-DETACHED** – triggered by MS or SGSN

  - *Transition triggered by MS or SGSN* – the MS or network initiated GPRS/PS detach is performed
  - *Transition triggered by SGSN* –
    - When SGSN receives a Cancel Location message from the HLR
    - When SGSN rejects a RA update or attach request from the MS
  - *GPRS* – LLC linked removed after this transition
  - *UMTS* – PS signaling connection is released after this transition
    - Both RRC and SCCP connections are released

MM & PDP CONTEXT

Amna Gul   2010056

MM and PDP Contexts

- ***Mobility Management (MM) context*** – provides mobility information of an MS
- ***Packet Data Protocol (PDP) context*** – provides information to support packet data delivery between an MS and the network
  - MS may be associated with several PDPs, but supports only one MM context, which is maintained in the MS and SGSN.
  - PDP contexts are maintained in MS, SGSN and GGSN

MM Contexts in SGSN

In addition to the context fields related to
- subscriber's identity,
- location security and
- authentication

which are commonly maintained by the SGSNs of both GPRS and UMTS, other contexts like
- MM states
- subscribed charging characteristics and
- several flags

are also maintained.

MM Contexts in SGSN

The following context fields are different in GPRS SGSN and UMTS SGSN:

1. **Location Information**
2. **Security Information**
3. **Radio Resource Information**

MM Contexts in SGSN
Location Information

- **GPRS** – There is no concept of SAC as in UMTS. The cell tracking information maintained by SGSN is:
  - **Cell identity** – current cell in READY state or last known cell in STANDBY or IDLE state
  - **Cell identity age** – time elapsed since last LLC PDU was received from the MS
- **UMTS** – cell tracking is performed by the serving RNC. The fields maintained by the UMTS SGSN are:
  - **Service Area Code (SAC)** – The SAC is used to uniquely identify an area consisting of one or more cells belonging to the same LA. SAC is used for *location service* (LCS) and other services such as emergency calls
  - **Time elapsed since last SAC was received**

MM Contexts in SGSN
Security Information

- *GPRS* – the SGSN maintains **CKSN** (ciphering key sequence no. of Kc)
- *UMTS* – UMTS systems boast enhanced security functions over GPRS, thus extra security parameters need to be maintained by a UMTS SGSN. These include
  - Currently used ciphering key (**CK**)
  - Currently used integrity key (**IK**)
  - Key set identifier (**KSI**)

MM Contexts in SGSN
Radio Resource Information

- **GPRS** – the fields maintained by the SGSN are
  - **Radio access capability**
  - **Discontinuous Reception** (**DRX**) –allows discontinuous radio transmission to save power consumption of the MS
  - **Radio priority SMS** – RLC/MAC radio priority level for uplink SMS transmission
- **UMTS** – since the radio resources are controlled by the UTRAN, so the radio resource fields are not known to the UMTS SGSN

PDP Contexts in SGSN

The PDP fields common to both GPRS and UMTS SGSNs include

- PDP Route information,
- Access Point Name
- QoS information
- Subscribed Charging Characteristics
- charging information and other routing information

PDP Contexts in SGSN

The following context fields are different in the GPRS and UMTS SGSNs.

- **Core Network to Radio Access Connection**
  - *GPRS* – SGSN does not maintain this field
  - *UMTS*—the SGSN maintains the following.
    - **TE ID** for the Iu interface
    - IP address of the RNC currently used
- **Radio Resource Information**
  - *GPRS* – SGSN maintains radio priority for uplink radio transmission
  - *UMTS* – radio resources are controlled by the UTRAN, so these fields are not kept by the SGSN
- **PDU Information**

MM Contexts in MS

The fields common in both GPRS and UMTS MS are:

- IMSI
- MM state
- P-TMSI
- P-TMSI signature
- routing area
- MS network access capacity
- CKSN/KSI
- ciphering algorithm and
- the DRX parameters

MM Contexts in MS

The context fields different in the GPRS and UMTS MS are the following.

1. **Location Information**
   - *GPRS* – MS maintains cell identity
   - *UMTS* – the cell identity is not maintained in the MM context of the MS, but is rather between the MS and the UTRAN. This is because cell tracking is not done between the mobility management layer between the MS and SGSN.
2. **Security Information**
   - *GPRS*– no parameters other than CKSN are maintained
   - *UMTS* – MS maintains an extra parameter, CK next
3. **Radio Resource Information**
   - *GPRS* – MS maintains
     - radio priority SMS
     - radio access capability
   - *UMTS*–the SMS as well as signaling are delivered through dedicated control channels, therefore radio SMS priority is not maintained. However, UE capability is maintained.

PDP Contexts in MS

The following PDP context fields are different in GPRS and PDP MS.

1. **Radio Resource Information**
   - *GPRS* – MS maintains radio priority.
   - *UMTS* – radio priority is not kept separately but is rather determined by the QoS profile
2. **PDU Delivery Information**
   - *GPRS* – MS maintains BSS packet flow identifier, Send N-PDU number and Receive N-PDU number.
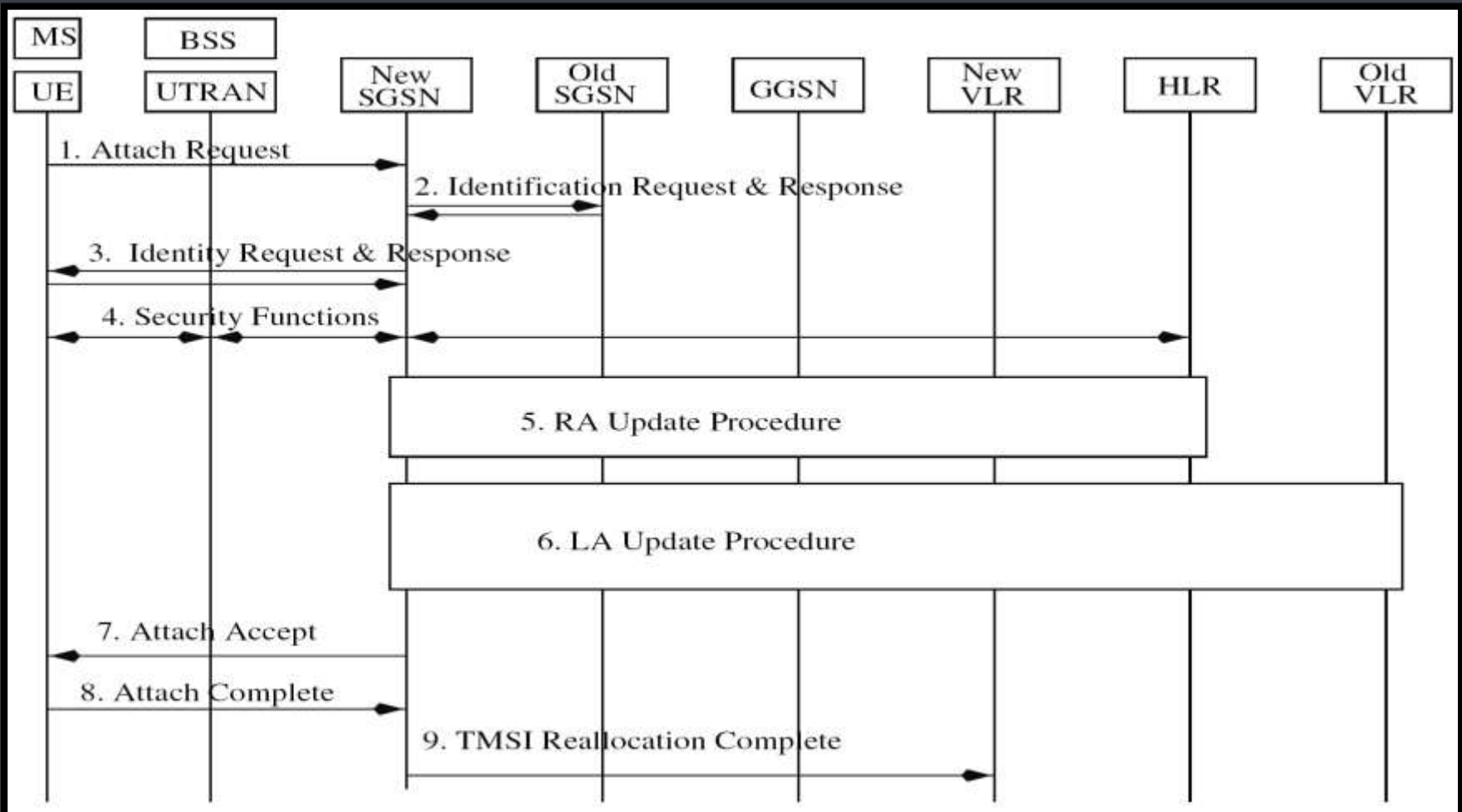   - *UMTS* – MS maintains PDCP-SND and PDCP-SNU

Attach & Detach

Faryal Aftab Khan   2010105

Attach and Detach

- PS/CS (GPRS/IMSI) Attach Procedure

Location Update

Attiya Rehman   2010079

Location Update

The MS informs the network of its location through RA and LA update procedures

- Update procedures are executed in two situations:
  - *Normal Location Update*
    Performed when location change has been detected
  - *Periodic Location Update*
    MS periodically reports its presence to the network

Location Update

The MS informs the network of its location through RA and LA update procedures

Periodic Location Updates

- Allows network to detect if an MS is still connected to the network
- *Periodic RA update Timer* – maintained by both MS and SGSN
- MS perform RA update after every timer expiry
- Timer value is set by SGSN
  - RA update Accept or Attach Accept

- **RA update** is periodically performed for a PS attached MS that is not CS attached
- Conversely, **LA update** is periodically performed for a CS-attached MS that is not PS-attached.
- For a PS/CS attached MS, two cases are considered:
  - **The MS is not engaged in a CS connection**
  - **The MS is engaged in a CS connection.**

- Mode 1: simultaneous PS/CS attach
- Periodic RA update performed
- SGSN receives periodic RA updates
- If MS is lost
  - SGSN detaches MS
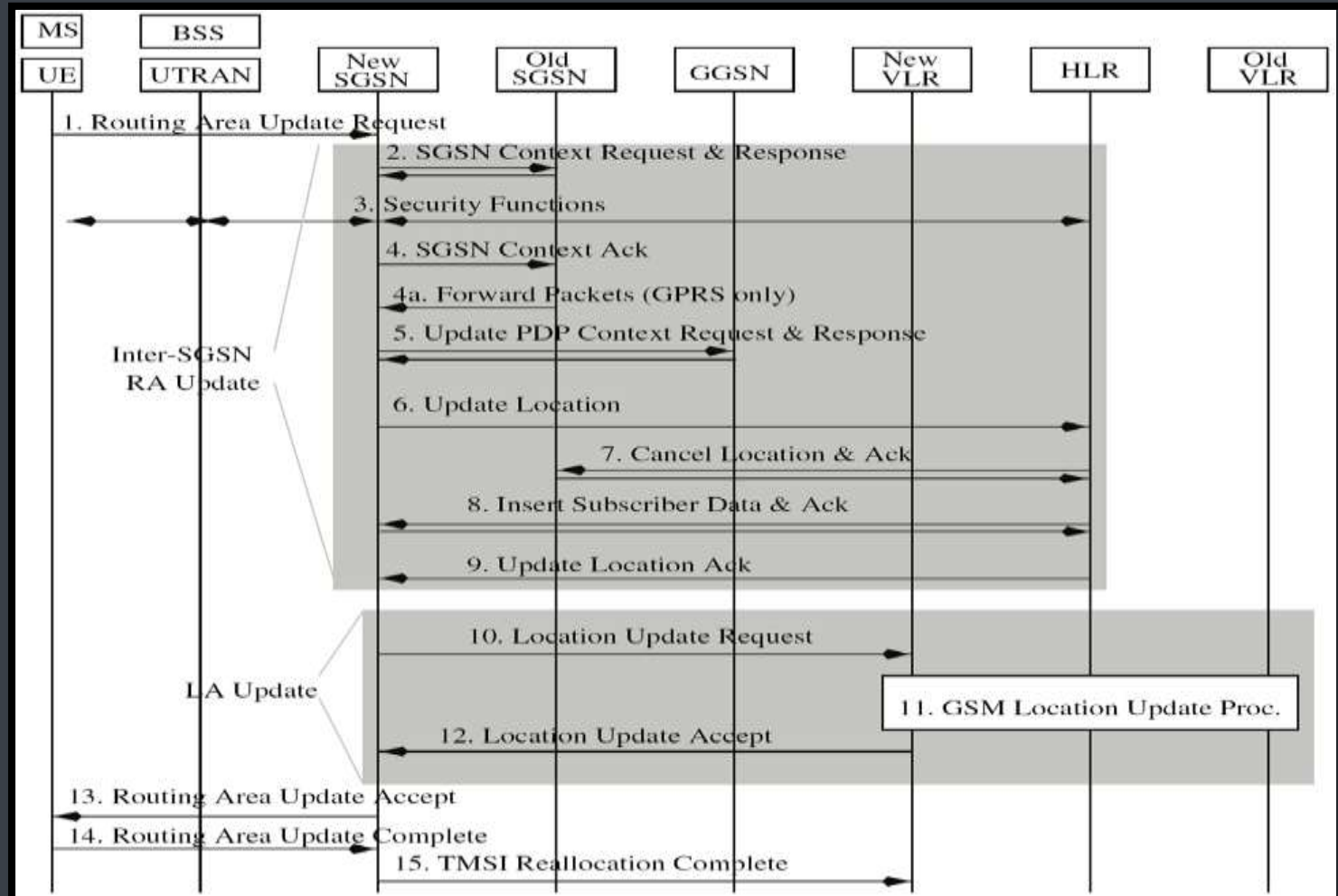 - Notifies VLR of detach by IMSI Detach Indication Message

MS not engaged in a CS connection

- Mode 2: simultaneous PS/CS attach
- RA update to SGSN
- LA update to the VLR
- LA update performed before RA update

MS engaged in a CS connection

- Network knows that the CS is attached
- No periodic location update performed
- Two classes
  - Class A MS (GPRS) or PS/CS MS (UMTS)
    - RA update performed
    - LA update is not performed
  - Class B MS (GPRS only)
    - During CS operation no RA/LA updates performed

Combined RA/LA Update

The End