UMTS Addresses and Identities
Mobility and Session Management

- Numbering, addressing and location identities
- UE modes
- Mobility management
- Session management and QoS
Numbering, Addressing and Location Identities

Unique subscriber identity:
- IMSI

Security: temporary subscriber identity
- TMSI
- P-TMSI

Service address and service separation:
- CS: MSI SDN (phone/voice or FAX number)
- PS: PDP context address (IP address)

Routing:
- MSRN (same format as MSI SDN)

References:
- Kaaranen, Ahtiainen, Laitinen, Naghian, Niemi: UMTS Networks – Architecture, Mobility and Services. Wiley 2001, Ch. 5.2
- 3GPP TS 23.003: Numbering, Addressing and Identification
- 3GPP TS 23.002: Network Architecture (including location area definitions)
User Identity: 
International Mobile Subscriber Identity (IMSI)

IMSI is the unique identity for the mobile subscriber

IMSI consists of 3 parts:

• **Mobile Country Code (MCC)** identifies uniquely the country of domicile of the mobile subscriber (three digits)

• **Mobile Network Code (MNC)** identifies the home PLMN of the mobile subscriber (two or three digits)

• **Mobile Subscriber Identification Number (MSIN)** identifies the mobile subscriber within a PLMN (9-10 digits)

IMSI serves as unique **search key** in the HLR, VLR, AuC and SGSN

IMSI follows the ITU-T E.214 numbering plan

IMSI is stored in the SIM card (USIM)
Service Address and Service Separation: Mobile Subscriber ISDN Number (MSISDN)

MSISDN is used for service separation
e.g. to separate numbers for voice and FAX

MSISDN consists of:

- **Country Code (CC)**
  1-3 digits

- **National Destination Code (NDC)**
  1-3 digits

- **Subscriber Number (SN)**

MSISDN is the directory number or subscriber number

MSISDN numbers are allocated from the ITU-T E.164 numbering plan

**Packet Data Protocol (PDP) context address** is the counterpart of the MSISDN in the PS domain, e.g. an (static or dynamic) IP address
Subscriber Identities

- IMSI
- MSISDN
- PDP context address
- ...

Base station
Base station controller
MSC
SGSN
TMSI
MSISDN
ISDN
HLR
AuC
EIR
GMSC
Internet
Node B
Radio network controller
P-TMSI
GGSN
PDP context address

Cellular Communication Systems
Andreas Mitschele-Thiel, Jens Mückenheim
Nov-16
Security: Temporary Mobile Subscriber Identity Number (TMSI)

For security reasons, the IMSI should be transferred in non-ciphered mode as seldom as possible

⇒ TMSI is used in CS mode instead of the original IMSI
⇒ P-TMSI (Packet TMSI) is used in PS mode

TMSI and P-TMSI are random numbers with limited validity time and validity area

• TMSI is allocated by the VLR (changed with each UE transaction)
• P-TMSI is allocated by the SGSN and valid in the SGSN area (changed when UE performs a RA update)
Routing:
Mobile Subscriber Roaming Number (MSRN)

- Used for routing purposes
- Follows E.164 specification (similar to MSISDN number)
  specifies country code (CC), network (NDC), network element and subscriber number (SN)

Equipment:
International Mobile Equipment Identity (IMEI)

- Unique identification of the terminal hardware
- IMEI is provided by UE with transaction establishment request
- Use of IMEI by EIR is optional
Location-related Areas

Location Area (LA)
- area in which a mobile station may move freely without updating the VLR

Routing Area (RA)
- area in which a mobile station, in PS mode, may move freely without updating the SGSN
- a RA is always contained within a location area

Source: 3GPP 23.002-5.5.0
Summary: Location Registers in UMTS CN

Home Location Register (HLR)
location register to which a mobile subscriber is assigned for record purposes such as subscriber information

Visitor Location Register (VLR)
location register for Circuit Switched (CS) services, other than the HLR, used by an MSC to retrieve information, e.g. to handle calls to or from a roaming mobile station currently located in the VLR area

Location register function in the SGSN
stores subscription information and location information for Packet Switched (PS) services for each subscriber registered in the SGSN (similar to VLR for CS domain)

Location register function in the GGSN
stores subscription information and routing information (needed to tunnel packet data traffic to the SGSN where the MS is registered) for each subscriber for which the GGSN has at least one PDP context active
UE Modes, Mobility and Session Management

- UE modes
- Mobility Management
- Session Management and QoS

Focus on PS Domain
**UE Modes**

**Idle mode** (paging area is known; paging needed)
- UE is identified by non-access stratum identities such as IMSI, TMSI and P-TMSI
- UTRAN has no information about UEs in idle mode (no RRC connection)
- UTRAN can only address e.g. all UEs in a cell or all UEs monitoring a specific paging occasion

**Connected mode** (cell or URA is known; RRC connection)
- connected mode is entered when the UTRAN establishes and maintains information about the individual UE (RRC connection)
- RRC connection is established between UE and Serving RNC
- UE is assigned a radio network temporary identity (U-RNTI) to be used as **UE identity on common transport channels** (RACH, FACH, PCH)
- note that connected mode does not require assignment of physical channel resources
PS mode: Overview on Modes and States

- SM: PDP context (active, inactive)
- PMM state (connected, idle, detached)
- Signaling connection
- RRC connection

SM: Session Management
PMM: Packet Mode Mobility Management
(also GMM – GPRS Mobility Management)
Packet Mode Mobility Management (PMM) States

**MS MM States**

- **PMM-DETACHED**
  - GPRS detach
  - PS Detach
- **PMM-IDLE**
  - SM-ACTIVE or INACTIVE
  - GPRS attach
  - PS Detach
  - PS Attach
  - PS Signalling Connection Release
- **PMM-CONNECTED**
  - SM-ACTIVE or INACTIVE
  - PS Signalling Connection Establish

**3G-SGSN MM States**

- **PMM-DETACHED**
  - Detach, PS Attach Reject, RAU Reject
- **PMM-IDLE**
  - SM-ACTIVE or INACTIVE
  - PS Detach
  - PS Attach
  - PS Signalling Connection Release
- **PMM-CONNECTED**
  - SM-ACTIVE or INACTIVE
  - PS Signalling Connection Establish
  - Serving RNC relocation

**Paging only**

-no signaling connection between MS and SGSN

**Signaling connection**

-between MS and SGSN (addressing by U-RNTI)

**PS Mobility Management (PMM)** is independent of Session Management (SM), e.g. availability of IP address & traffic activity

PMM is independent of the number and state of PDP contexts for the subscriber

In both the PMM-IDLE and the PMM-CONNECTED states, session management may or may not have activated a PDP context (assigned a dynamic IP address)

Source: 3GPP 23.060-4.1.0

U-RNTI: UTRAN - Radio Network Temporary Identity
RA Update (with change of SGSN)
Cell Update (PS)

**PS mode:**
- `->` explicit cell update procedure

Reasons for cell update
- cell reselection
- periodic cell update
- uplink data transmission
- paging response
- re-entered service area
- radio link failure
- unrecoverable RLC error

**CS mode:**
continuous exchange of cell information during call (or transaction)
**Session Management (SM)**

**Fundamental differences of PS mode**

**Connection** (e.g. voice, CS data)
- clearly defined start and end
- no burstiness

**Packet session** (e.g. web surfing)
- start and end times are typically unknown to the UMTS system
- traffic is highly bursty

Differences require different solutions to
- mobility mgmt and
- communication mgmt
Session Management – PS Mode

States of SM (state of PDP contexts)
- inactive: no packet data transfer, no valid routing information
- active: packet data transfer possible, valid routing information

Dominant packet data protocol (PDP): IP

Attributes of a packet session: PDP context
- defines all parameters of the packet data session by end-to-end attributes and QoS
- one PDP context per PS services with a certain QoS, e.g. for web serving, streaming video, packet voice, etc.
Session Management: States of PDP Context

A GPRS subscription contains the subscription of one or more IP addresses.

Each IP address is described by one or more PDP contexts in the MS, SGSN, and GGSN.

Each PDP context is associated with:
- A QoS profile
- A traffic flow template (TFT) to discriminate flows sharing the same PDP address.

Every PDP context exists independently in one of two PDP states (active, inactive).

The PDP state indicates whether data transfer is enabled for that PDP address and TFT or not.

Reference: 3G 23.060, ch 9
Session Management: States of PDP Context

**Inactive state:**
- no valid routing or mapping information to process data related to PDP address
- no data transfer
- no updates due to location changes (even in GPRS-attached states)

**PDP context activation:**
- MS-initiated or
- network-requested

Reference: 3G 23.060, ch 9
Session Management: States of PDP Context

**Active state:**
- valid routing or mapping information to process data related to PDP address (MS, SGSN, GGSN)
- requires MM state PMM-idle or PMM-connected
- data transfer possible
- updates due to location changes

PDP context deactivation:
- PDP context deactivation procedure
- due to PMM-detached

PDP context modification, e.g. to modify QoS profile

Reference: 3G 23.060, ch 9
Relation between PDP Context and MM

GPRS subscription

PDP address

PDP context

PDP context

PDP context

PDP state active

PDP state inactive

Single MM context

Relation between MM and PDP states:

• All PDP contexts of a subscriber are associated with the same MM context for the IMSI of that subscriber.

• The MM state is independent of the number and state of PDP contexts for the subscriber.

• In both the PMM-IDLE and the PMM-CONNECTED states, session management may or may not have activated a PDP context.
QoS: User Plane Bearer Services – Overview

For each bearer:
- specific attributes (delay, bandwidth, guarantees, etc.)
- specific reservation mechanism
QoS Management – Control Plan Functions

- TE
- MT
- RAN
- CN EDGE
- Gateway

Local Service Control

protocol interface

service primitive interface
QoS User Plane – User Plane Functions

Data flow with indication of direction
<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMSI</td>
<td>International Mobile Subscriber Identity</td>
</tr>
<tr>
<td>NSAPI</td>
<td>Network layer Service Access Point Identifier</td>
</tr>
<tr>
<td>MSISDN</td>
<td>The basic MSISDN of the MS</td>
</tr>
<tr>
<td>PDP Type</td>
<td>PDP type; e.g. PPP or IP</td>
</tr>
<tr>
<td>PDP Address</td>
<td>PDP address; e.g. an IP address</td>
</tr>
<tr>
<td>Dynamic Address</td>
<td>Indicates whether PDP Address is static or dynamic</td>
</tr>
<tr>
<td>APN in Use</td>
<td>Access Point Name, i.e. GGSN currently used</td>
</tr>
<tr>
<td>TEID</td>
<td>Tunnel Endpoint Identifier (identification of UMTS bearer)</td>
</tr>
<tr>
<td>TFT</td>
<td>Traffic flow template (for UMTS bearer)</td>
</tr>
<tr>
<td>QoS Profile Negotiated</td>
<td>QoS specification negotiated</td>
</tr>
<tr>
<td>SGSN Address</td>
<td>IP address of SGSN currently serving this MS</td>
</tr>
<tr>
<td>GTP-SND</td>
<td>GTP-U sequence number of the next downlink N-PDU to be sent to the SGSN</td>
</tr>
<tr>
<td>GTP-SNU</td>
<td>GTP-U sequence number of the next uplink N-PDU to be received from the SGSN</td>
</tr>
</tbody>
</table>
Relations between CM/SM, MM/PMM, RRC States and UE modes

- **Core Network**
  - CM/SM state(s) (UE-SGSN-GGSN)
  - MM/PMM state (UE, SGSN, HLR)

- **UTRAN**
  - Signaling connection (UE-SGSN)
  - RRC state (UE-RNC)

- **UE**
  - UE mode

**Subscription**
- inactive
- active

**PDP address**
- detached
- idle
- connected

**UTRAN**
- signaling connection
- connected

**UE**
- UE mode

**Addressing**
- Paging using TMSI/P-TMSI
- Addressing using RNTI
Example of States During Packet Flow

For details see Kaaranen, ch 5.3.2
Instead of cell_DCH, cell_FACH may be used for small messages.