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Mobile Communications

6 Mobility Management

Handover Management
Location Management
GSM Location Management
GPRS Location Management
UMTS Location Management

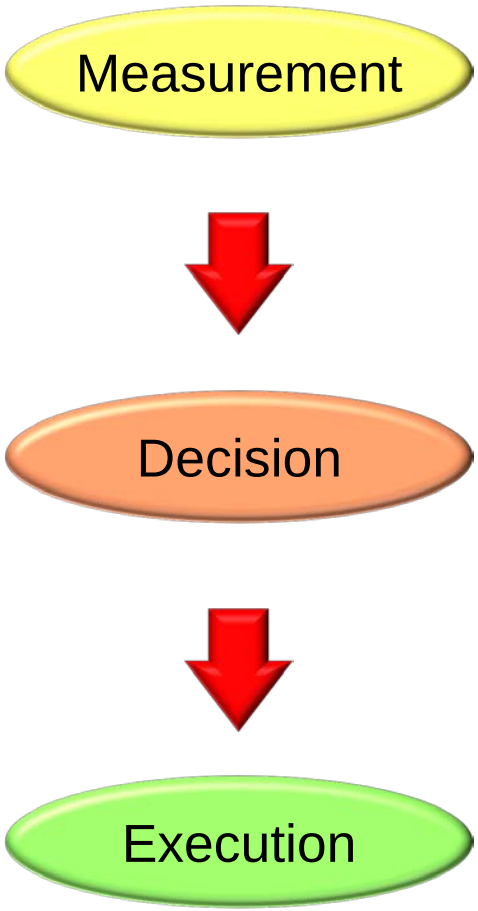
Handover Management

- Maintaining the traffic connection with a moving user when crossing cell boundaries
- Occurs when the quality or the strength of the radio signal falls below certain parameters (signal quality reason)
- Occurs when the traffic capacity of a cell has reached its maximum or is approaching (traffic reason)
- GSM standard identifies about 40 reasons for a handover
- Handover is initialized by the mobile or by the base station
- Other term: handoff (primarily used in the U.S.)

Location Management

- Mechanisms to localize users in case of incoming calls, short messages, or data
- Requires to partition an operator's coverage area into location areas in order to efficiently perform location management
- Two basic operations: Location update and Paging
- Location Update (LU)
  - Operation initialized by the terminal to inform the network about the user's location
- Paging
  - Broadcast message initialized by the network to locate the current cell of a user

Overview of the Handover Process



Measurement

- Measurement criteria: signal strength (between mobile and current base station as well as between mobile and neighboring base stations), distance, quality (e.g., in terms of error rates), traffic volume,....
- Measurement reports exchanged between mobile and base station

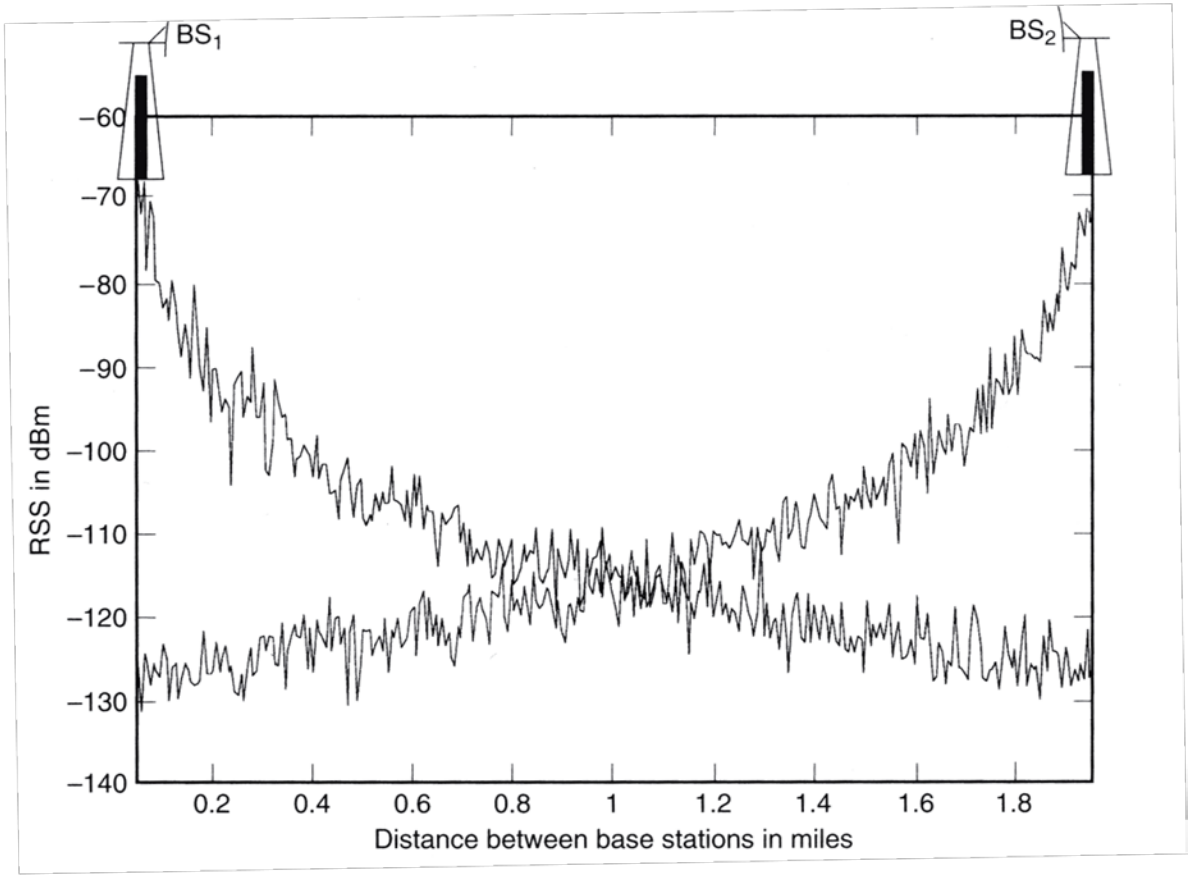
Decision

- Decision parameters: thresholds and hysteresis margin
- Network-controlled, mobile-assisted, mobile-controlled handover

Execution

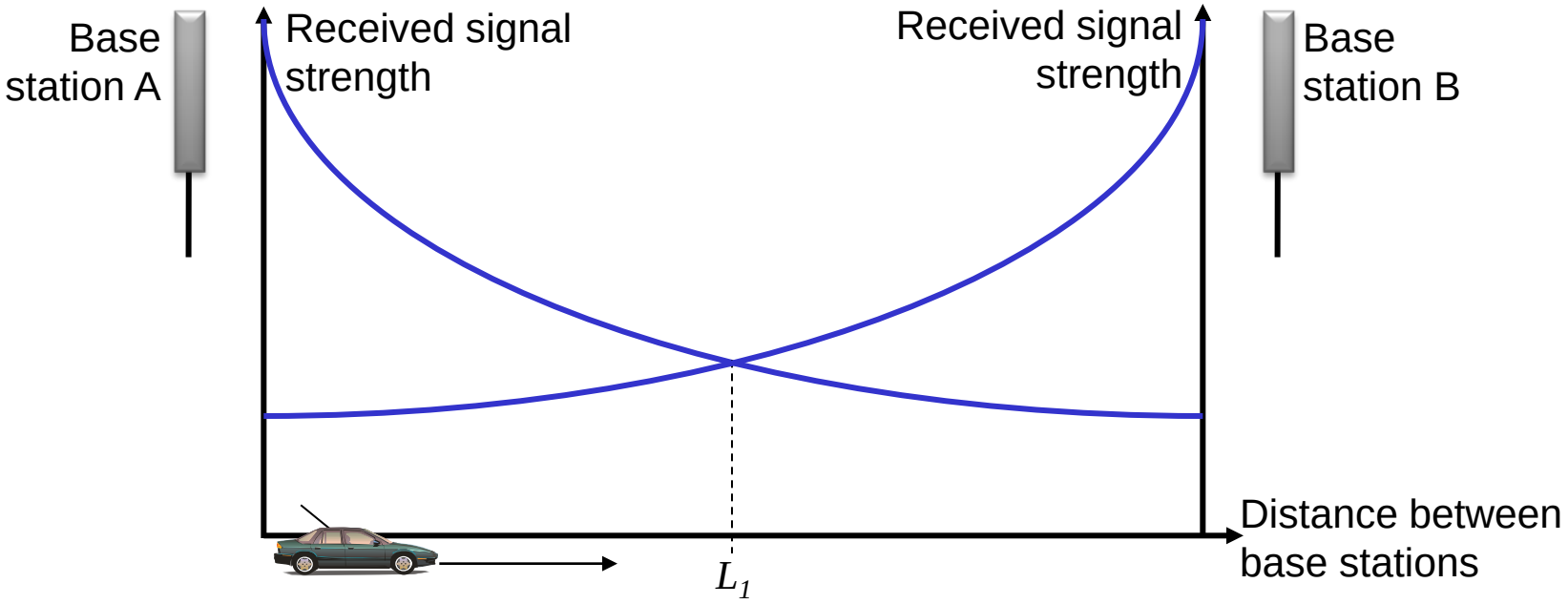
- Handover signaling
- Radio resource allocation
- Re-establishing connections in core and access networks
- Hard and soft handover
- Inter-cell and intra-cell handover
- Inter-frequency and intra-frequency handover
- Inter-system and intra-system handover

7.1 Handover Management
Overview of the Handover Process



- Primarily, RSS (relative signal strength) measurements from the serving point of attachment and neighboring points of attachment are used
- Alternatively, or in conjunction, path loss, carrier-to-interference ratio, bit error rates, block error rates, symbol error rates, utilization have been employed as metrics in certain types of networks

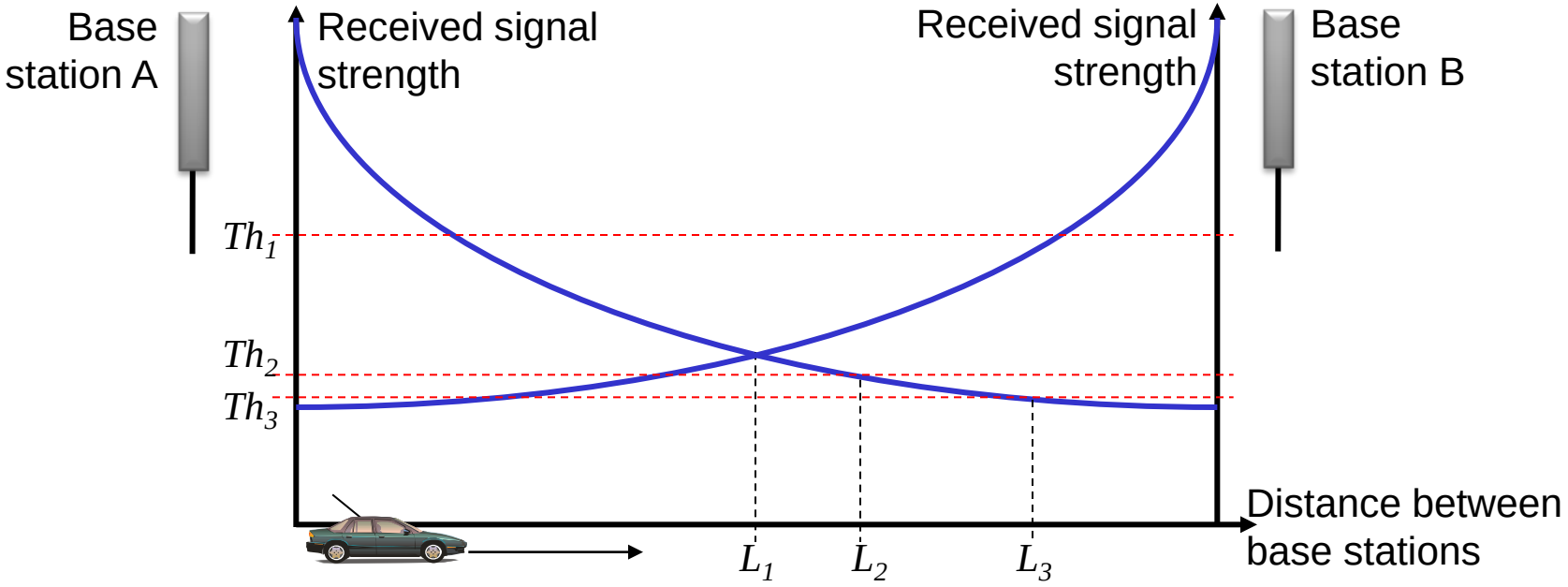
Decision: Relative Signal Strength



- Mobile terminal is handed off from BS A to BS B when the signal strength at B first exceeds that at A
- If the signal strength at B first exceeds that at A, the mobile unit is handed back to A
- In this figure, handover occurs at point L_1

Because signal strength fluctuates due to multipath propagation effects, this method can lead to a **ping-pong effect** in which the unit is repeatedly passed back and forth between two base stations

Decision: Relative Signal Strength with Threshold

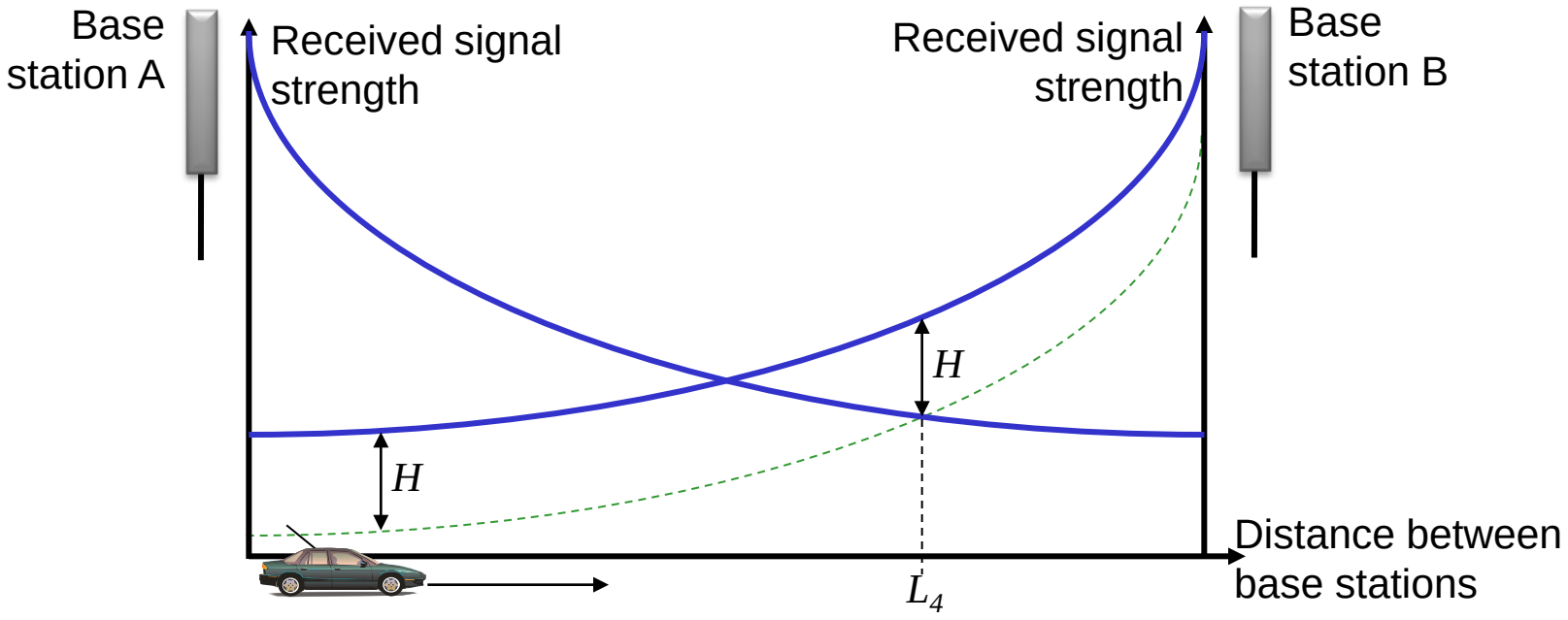


- Handover only occurs **if**
  - the signal at the current BS is less than a predefined threshold, **and**
  - the signal from a neighboring base station is stronger
- Handover is avoided as long as the signal from the serving base station is strong enough

- For a high threshold (e.g., Th_1), this scheme performs the same as the relative signal strength scheme
- If the threshold is set quite low (e.g., Th_3), the mobile may move far into the new cell

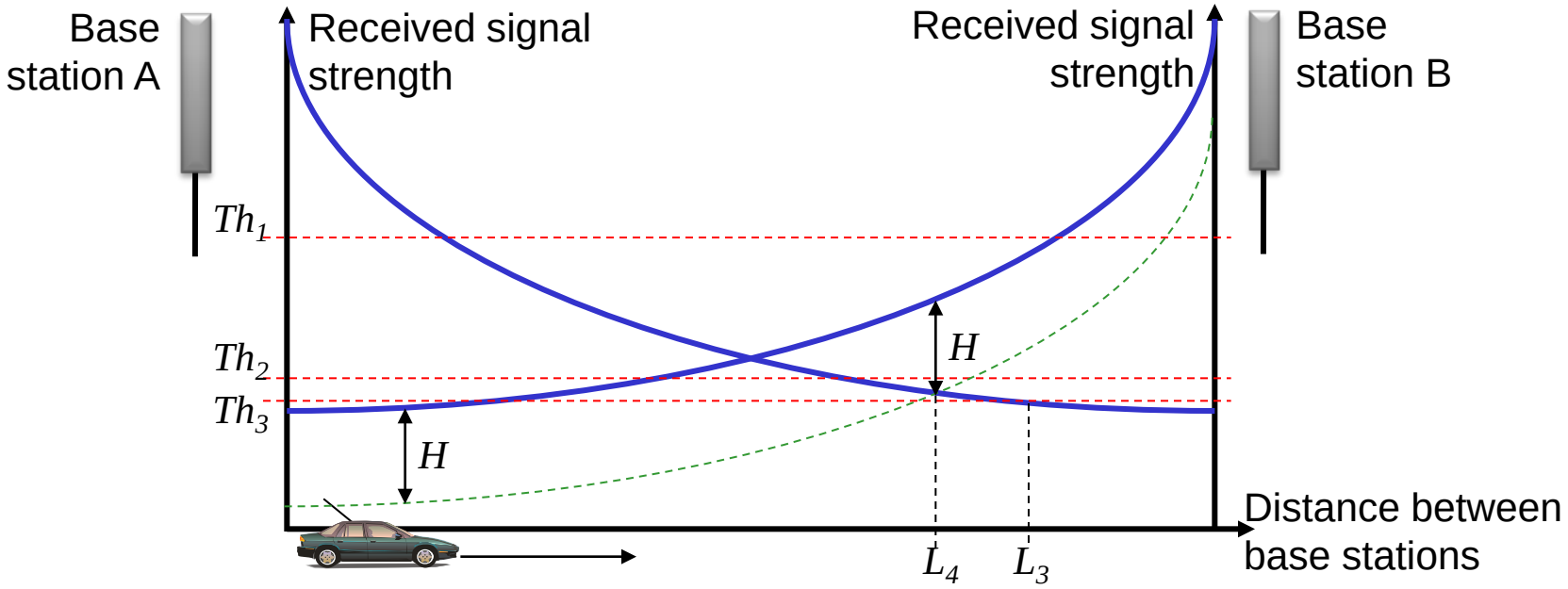
⇒ Threshold should not be used alone because its effectiveness depends on prior knowledge of the crossover signal strength between the current and the candidate base stations

Decision: Relative Signal Strength with Hysteresis



- Handover occurs only if the new base station is sufficiently stronger (by a margin H) than the current one
- While the mobile is assigned to base station A, the scheme will generate a handover when the relative signal strength reaches or exceeds H
- Once the mobile is assigned to B, it remains so until the relative signal strength falls below $-H$, at which point it is handed back to A
- Prevents the ping-pong effect
- Disadvantage: the first handover may still be unnecessary if base station A still has sufficient signal strength

Decision: Relative Signal Strength with Threshold and Hysteresis



- Handover occurs only **if**
  - the current signal level drops below a threshold, **and**
  - the target base station is stronger than the current one by a hysteresis margin H

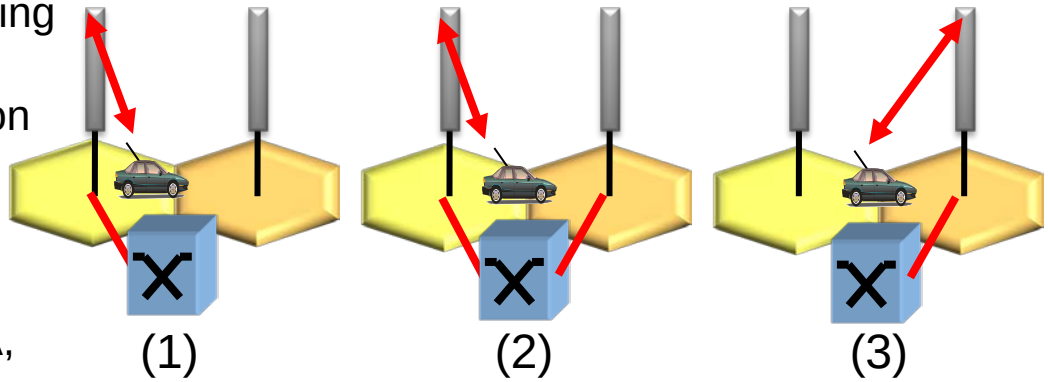
- Handover occurs at L_4, if the threshold is either Th_1 or Th_2
- Handover occurs at L_3 if the threshold is at Th_3

⇒ Scheme avoids the ping-pong effect and execution of handover if signal from the serving base station is still strong enough

Slides: courtesy of Axel Küpper

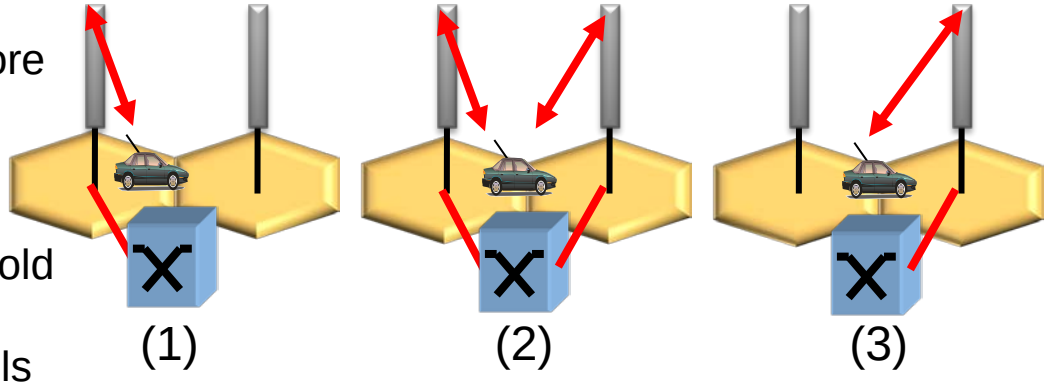
Hard handover

- **“Break before make”**
- Connection is released before making the new connection
- Causes a short cut in the connection
- The terminal is linked to no more than one base station at any given time
- Primarily used in FDMA and TDMA, where different frequency ranges are used in adjacent cells



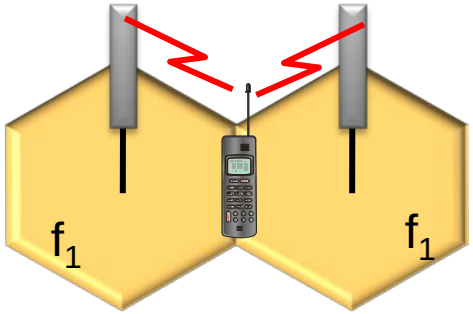
Soft handover

- **“Make before break”**
- New connection is established before the old connection is released, avoiding a cut in the connection during handover
- After the successful handover, the old connection is released
- Used in CDMA, where adjacent cells use the same frequency range



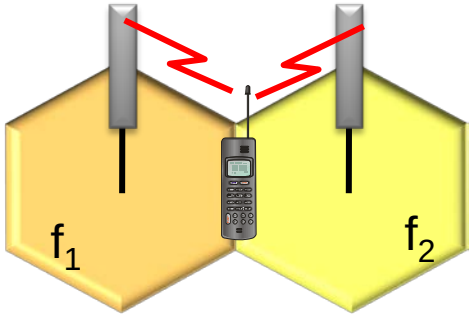
Intra-frequency handover

- The new carrier frequency is the same as the previous carrier frequency
- Deployment: CDMA (as neighboring cells usually use the same frequency range)



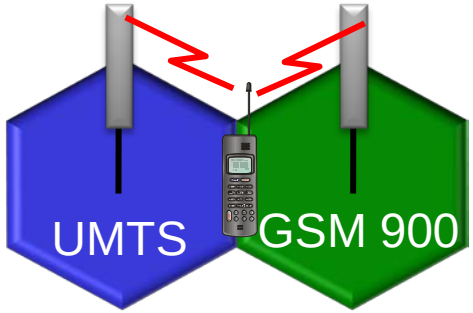
Inter-frequency handover

- Carrier frequency of the new radio access is different from the old carrier frequency
- Deployment: GSM, handover between different UMTS operators



Inter-system handover

- Happens between two different radio access networks (e.g., GSM and UMTS)
- Special kind of inter-frequency handover
- Deployment: areas where GSM and UMTS coexist and overlay networks



Network-controlled Handover (NCHO)

- Network measures the transmission quality via base stations and decides when handover should be executed
- Mobile terminal makes no measurements
- Intense signaling between the base stations and the node that decides on handover
- No handover signaling at the air interface
- Handover process (including data transmission, channel and network switching) takes 100-200ms

Mobile-assisted Handover (MAHO)

- Mobile terminal continuously measures signal strength from serving and neighboring base stations and sends the recorded values to the serving base station
- On the basis of these values, the network decides when handover should take place
- Unlike NCHO, the terminal's situation is taken into account, as the terminal itself does the measuring
- Handover time between handover decision and execution is approximately 1 second
- Increased signaling across the air interface

Mobile-controlled Handover (MCHO)

- Mobile terminal is completely in control of the handover process, i.e., it measures signal strength and decides on handover
- Very short reaction time (on the order of 0.1 seconds)

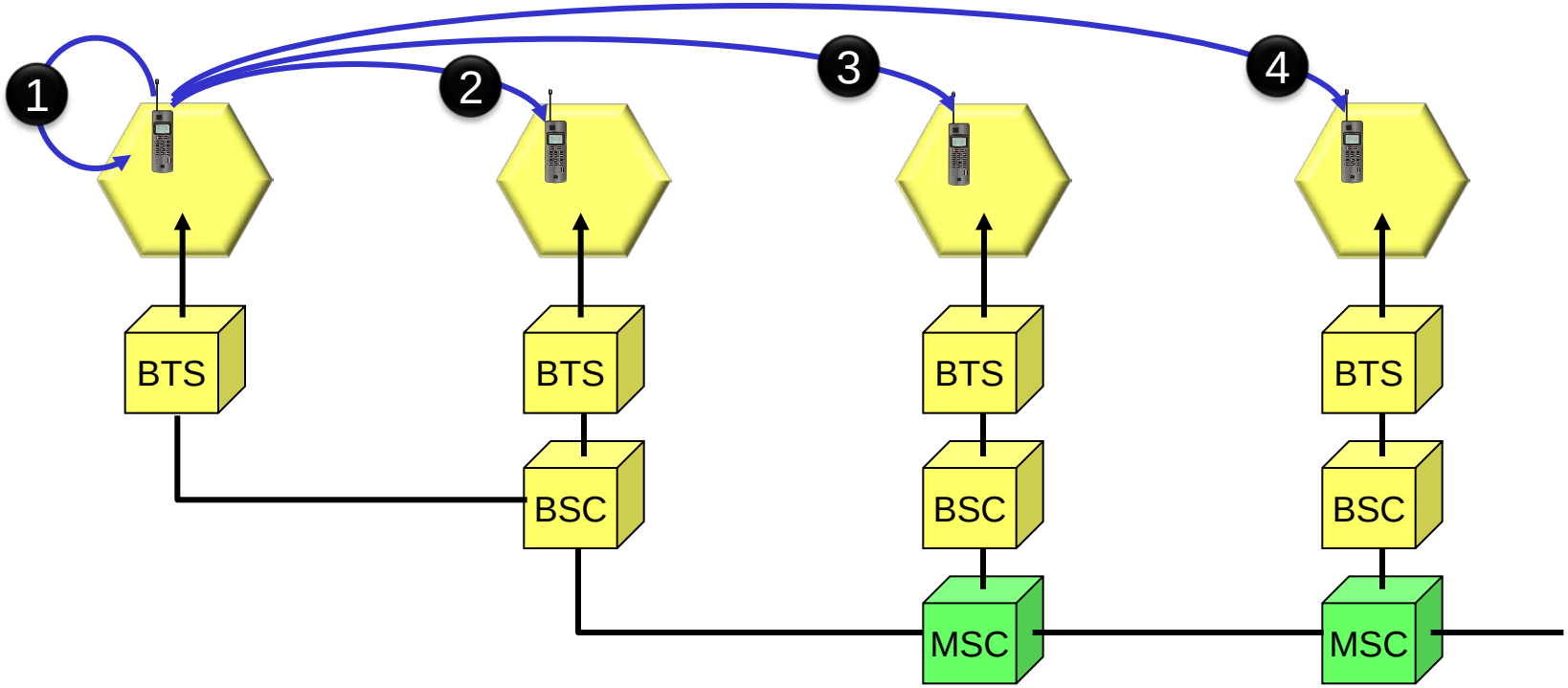
Overview

Method	Measurem.	Decision	Systems
Network-controlled handover (NCHO)	Network	Network	Analog systems
Mobile-assisted handover (MAHO)	Network and mobile	Network	GSM, UMTS
Mobile-controlled handover (MAHO)	Mobile	Mobile	DECT, 802.11

GSM Handover- Overview

- Inter-frequency hard handover: adjacent cells always use different frequency ranges
- Mobile-assisted handover: mobile station measures signal level of up to 16 neighboring base stations and reports the results of the strongest six base stations every 480 ms to the BSS
- Algorithm for handover decision is not standardized, but network operators can develop and deploy their own algorithms which are optimally tuned for their networks
- Software of mobile stations need not be changed when the handover strategy is changed
- Generally, handover between BSS of different operators (inter-operator handover) is not standardized
- However, sometimes different operators (competing in the same geographical region) enter into agreements to use one another's system (e.g., O_2 and T-Mobile in Germany)

Handover Types in GSM



(1)

Intra-cell handover

- Executed, if fading makes transmission at a certain frequency impossible

(2)

Inter-cell, intra BSC

- Terminal moves from one cell to another, but stays within control of the same BSC
- Typical handover scenario

(3)

Inter-BSC, intra-MSC

- Handover between cells controlled by different BSCs, but within the coverage area of one MSC

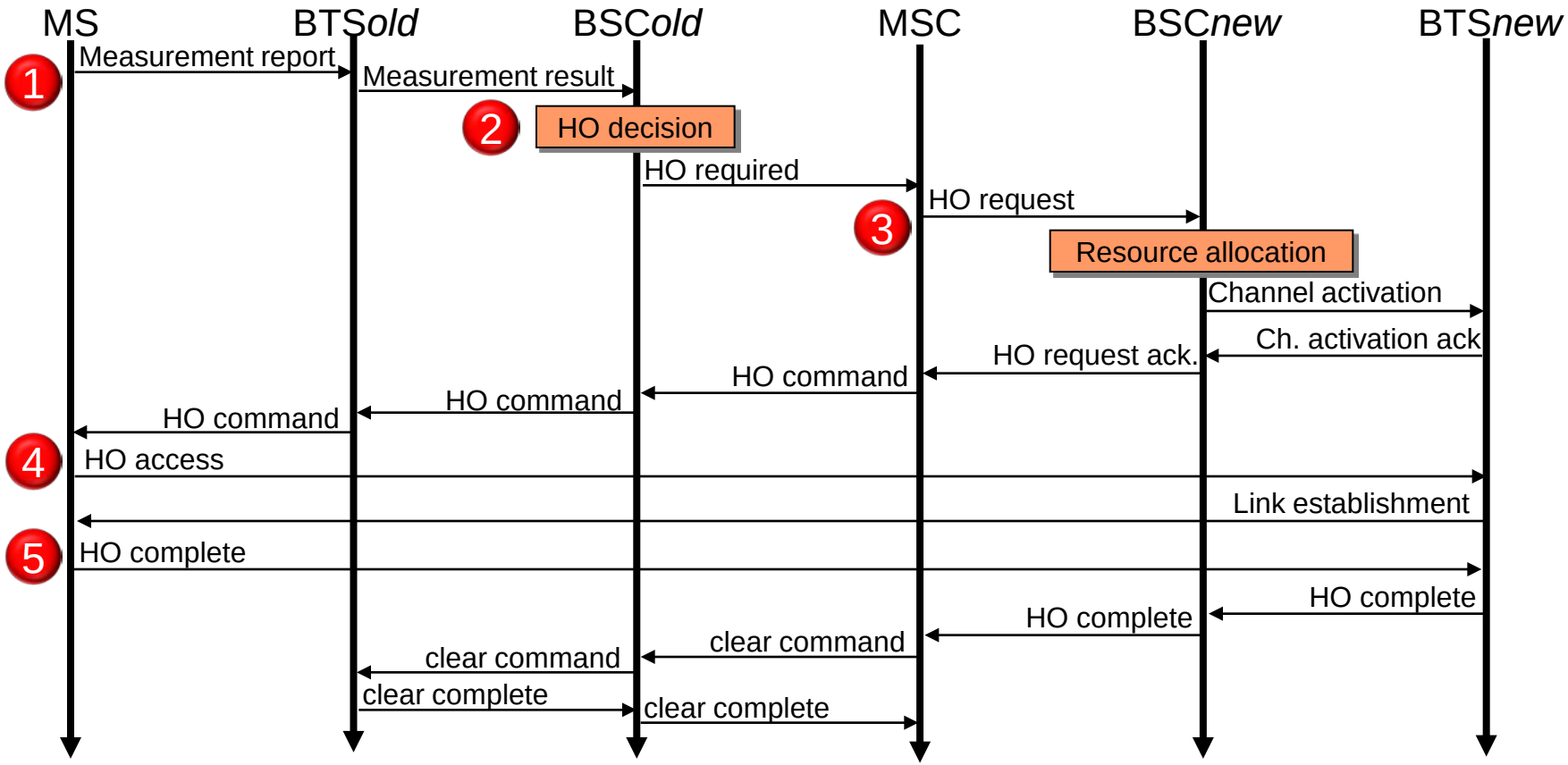
(4)

Inter-MSC handover

- Handover between two cells that belong to different MSCs

7.1 Handover Management

Principal Signaling Sequence for an Inter-BSC/Intra-MSC Handover



1. Mobile continually transmits measurement reports
2. BSS decides when to perform handover and request handover from the MSC
3. MSC causes the new BSS to prepare a channel for the handover, and frees handover to the mobile as soon as this channel is acknowledged
4. Mobile station accesses new BSS and receives information about the new air interface (timing advance value, transmitter power level)
5. Once the mobile can occupy the new channel, resources of the old BSS are released

Soft (softer, soft-softer) handover*

- Adjacent cells as well as sectors of a cell use the same 5-MHz frequency range
- Cell separation by spreading codes
- Majority of handovers are intra-frequency soft handovers

Hard handover...

- ...if old and new cell use different frequency ranges (inter-frequency handover)
- ...if RNCs participating in the handover are not connected
- ...if old and new cell use different UTRAN modes (FDD↔TDD)
- ...if old and new cell belong to different systems (e.g., UMTS→GSM)

Summary of UMTS handover types

- Intra-BS/inter-cell handover (softer handover)
- Inter-BS handover, including hard and soft handovers
- Inter-RNC handover, including hard, soft, and soft-softer handovers
- Inter-MSC handover
- Inter-Serving GPRS Support Node handover
- Inter-system handover

*) **Softer handover**

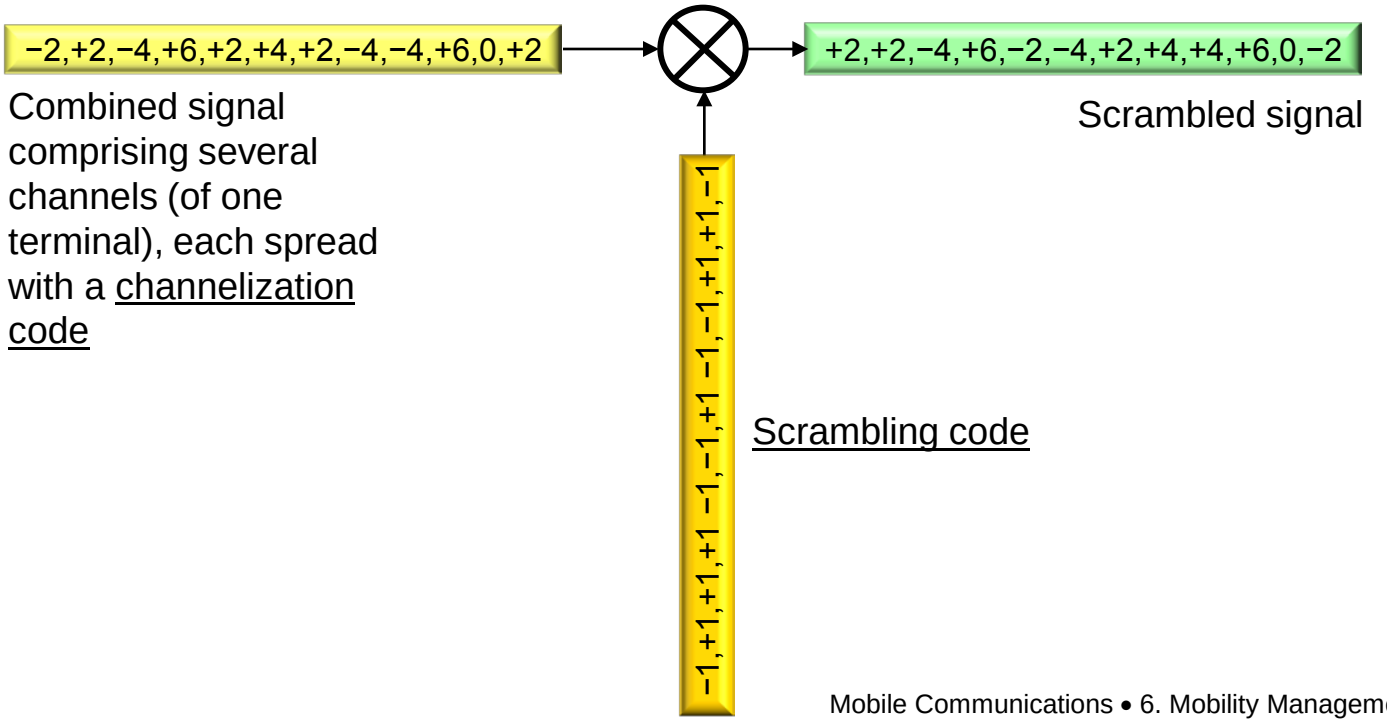
- Active set comprises different cell sectors served by the same node-B

Soft-softer handover

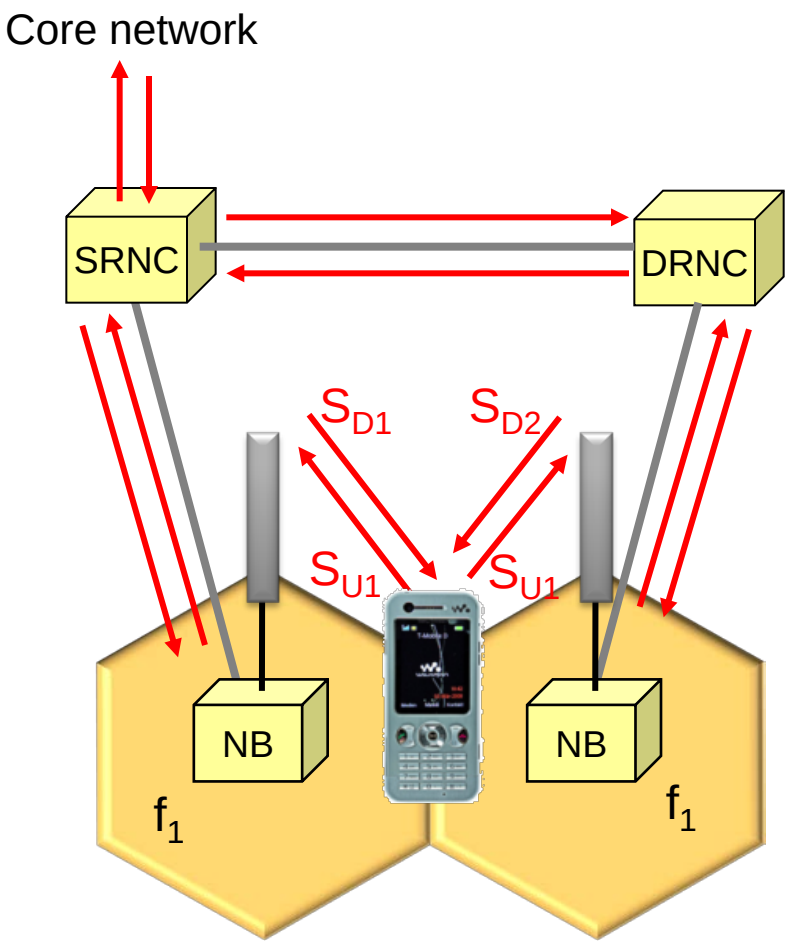
- Active set comprises cell sectors of the same cell as well as sectors from other cells

Two types of codes in UMTS: channelization codes and scrambling codes

Code	Uplink direction	Downlink direction
Scrambling codes	User separation	Cell separation
Channelization codes	Data and control channels from the same terminal	Users within one cell
Spreading code	Channelization code × scrambling code	Channelization code × scrambling code



- Soft handover enables simultaneous connection of the terminal to several Node-Bs
- List of Node-Bs connected to the terminal is called the **Active Set**
- Uplink: signal spread with the scrambling code S_{U1} is received by different neighboring Node-Bs
- Downlink: Node-Bs participating in soft handover send the same user data to the terminal, but spread with different scrambling codes (here: S_{D1} and S_{D2})
- Serving Radio Network Controller (SRNC): initial RNC that controls the soft handover and decides which signal to forward into the core network
- Drift Radio Network Controller (DRNC): RNC belonging to the new cell that forwards user data to the SRNC

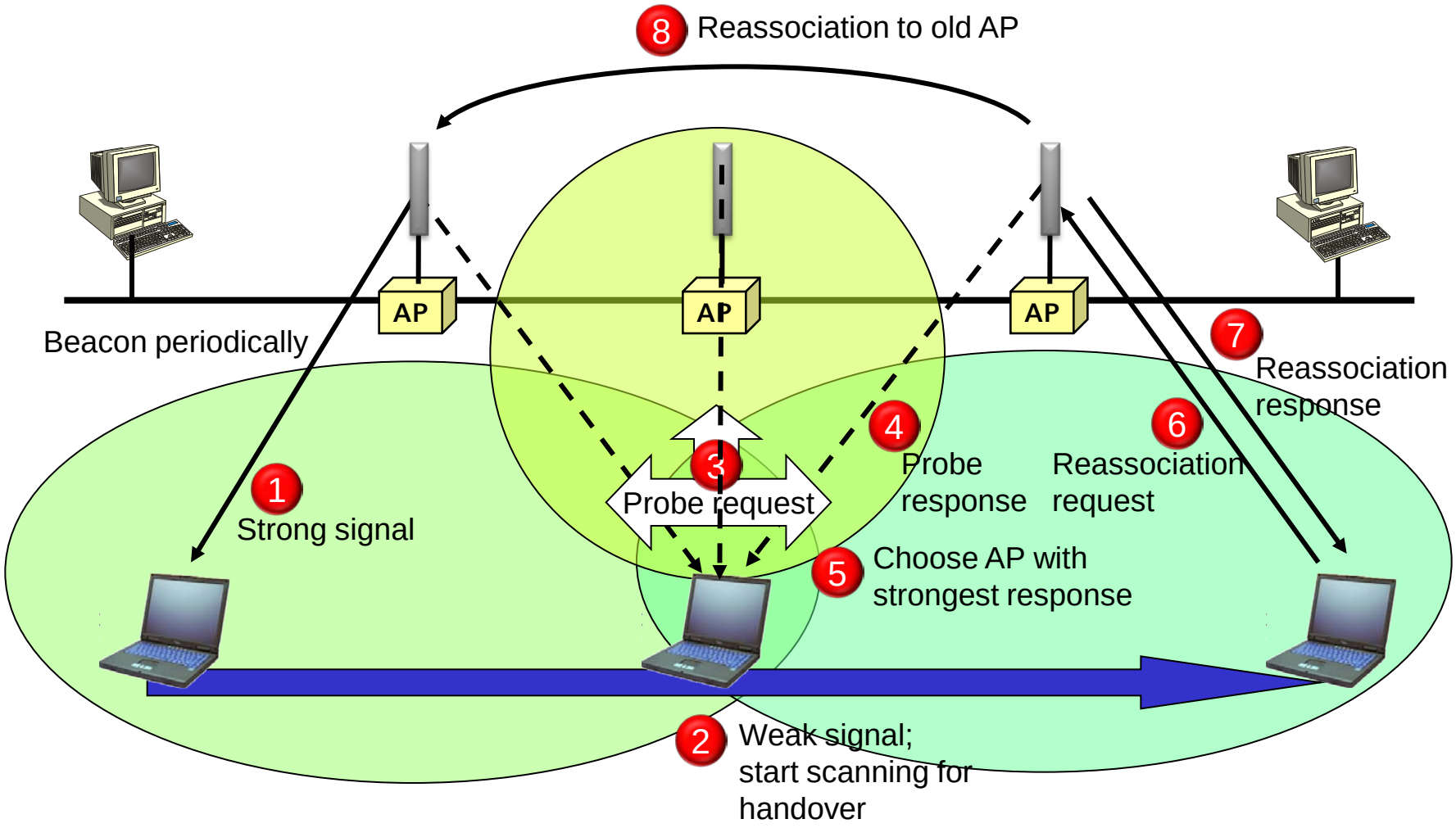


Handover in IEEE 802.11 (I)

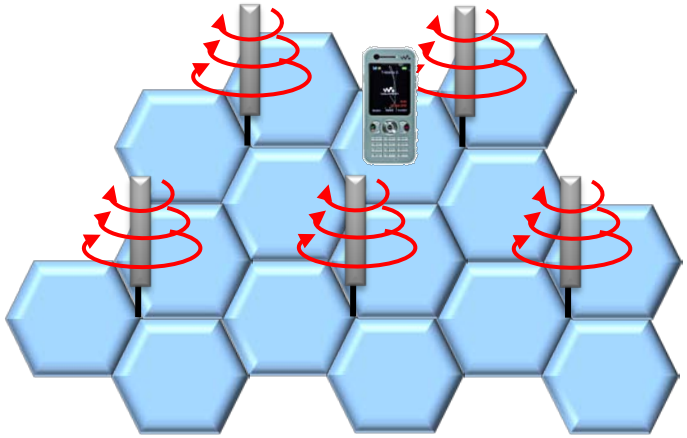
- Mobile-controlled handover
- No handover
  - Terminal is static or moves within an BSS
- BSS handover
  - Terminal moves from one BSS to another within the same ESS
- ESS handover
  - Terminal moves from one BSS to another BSS that is part of a new ESS
  - Upper layer connections may break
  - Handover must be supported by Mobile IP or Cellular IP for continuous connection

Sequence for an IEEE 802.11 Handover (see next slide)

1. AP broadcasts a beacon signal every 100ms
2. Terminal scans beacons and associates itself with the AP with the strongest beacon
   - When the beacon becomes weak, it starts to scan for stronger beacons
   - Passive scanning: the terminal simply listens to available beacons
3. Active scanning: the terminal sends a probe request and waits for receiving probes
4. Each AP that receives the probe responds with a probe response
5. Terminal chooses the AP with the strongest beacon
6. Terminal sends a reassociation request to the selected AP, containing information about the terminal and the old AP
7. New AP answers with reassociation response containing station identifier, supported bit rates,....
8. Old AP is not informed by the terminal, but by the new AP about the handover procedure

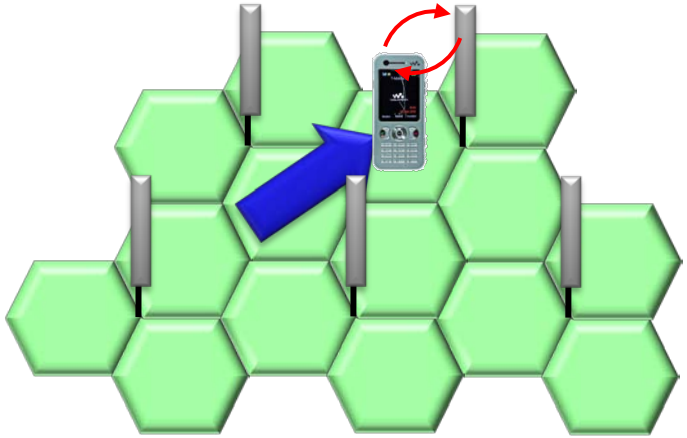

8 Reassociation to old AP
AP
AP
AP
Beacon periodically
1 Strong signal
3 Probe request
4 Probe response
5 Choose AP with strongest response
6 Reassociation request
7 Reassociation response
2 Weak signal; start scanning for handover

Mobility Management based on *pure Paging:*



- If a call arrives, terminal is paged in all cells of the mobile network
- Location update is not required
- As paging must be executed in all cells of the network for each arriving call/SMS/data-packet
  - high signaling overhead
  - high delay in call/SMS/data-packet delivery

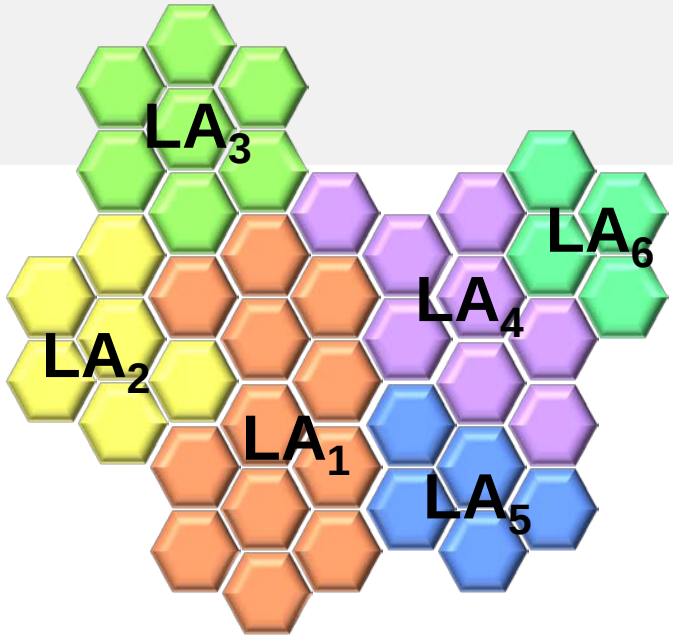
Mobility Management based on *pure Location Update:*



- Each time the user crosses cell boundaries a location update is triggered
- Paging is not required
- As location updates must be initialized whenever crossing cell boundaries
  - high signaling and database update overhead
  - high power consumption in the terminals

Location Areas

- Several cells are combined to a location area (LA)
- Subscriber location is known if the system knows the LA in which the subscriber is located
- When the system must establish a communication with the mobile, the paging only occurs in the current LA where called user resides
- Resource consumption is limited to the respective LA: paging messages are only transmitted in the cells of this particular LA
- Location information are stored in databases (generally, a home database and several visitor location databases are included in the network architecture)



Design of Location Areas

- Size of LAs is determined in dependence on
  - the cell radius
  - the mean mobile velocity
  - the cost of LUs (in terms of the number of LU messages required to update the location of a mobile)
  - the cost of paging (in terms of the number of paging messages required to find a mobile)
- Goal: minimizing location management cost (LU+paging traffic and processing)

Periodic Location Updating

- Mobile periodically transmits its identity to the network
- Resource consumption is user-independent and can be unnecessary if the user does not move from a LA for a long time

Location Updating on LA Crossing

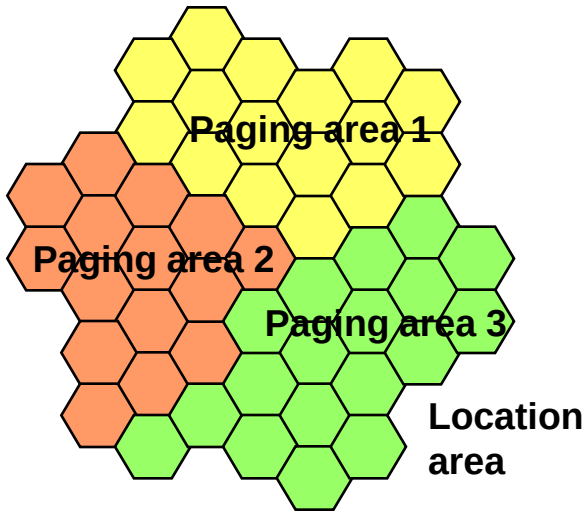
- BS periodically broadcasts the identity of its LA (Location Area Identifier, LAI)
- Mobile permanently listens to the broadcast and stores the current LAI
- If the received LAI differs from the stored one, a location update is triggered by the mobile
- Advantage: a highly mobile user generates a lot of LUs; a low mobility user only triggers a few

Hybrid Location Updating

- Combination of Periodic and Location Updating on LA Crossing
- Mobile generates its LUs each time it detects an LA crossing
- If no communication (related to an LU or a call) has occurred between mobile and network for a fixed period, the mobile generates a periodic LU
- Advantage: User location can be recovered in case of database failures

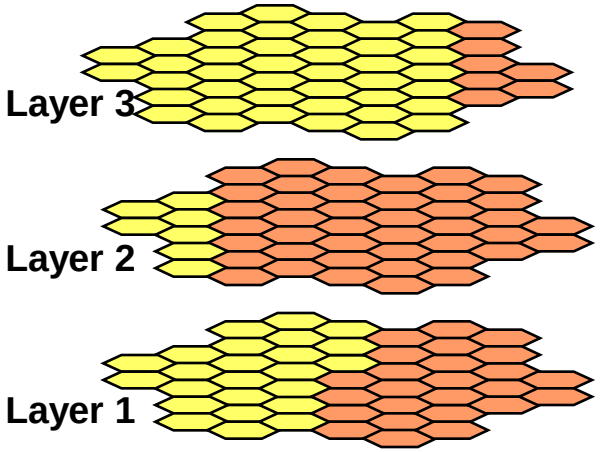
LA-Splitting in Paging Areas

- Mobile registers only when entering the LA; it does not register when moving between PAs of one LA
- For an incoming call, paging messages are broadcast in the PAs according to a sequence determined by different strategies
- Example: Start paging in the PA where the terminal was last detected by the network



Multilayer Location Areas

- Problem: LU traffic is mainly concentrated in the cells of the LA border
- Introduction of multilayer LAs
- Each mobile is assigned to a given group, and each group is assigned one or several layers of LAs
- LU traffic load is distributed over all the cells



- Different location management schemes for GSM circuit-switched and GPRS
- GSM circuit-switched: Hybrid location updating
- GPRS: introduction of new (smaller) location areas with adaptive paging/location update strategies

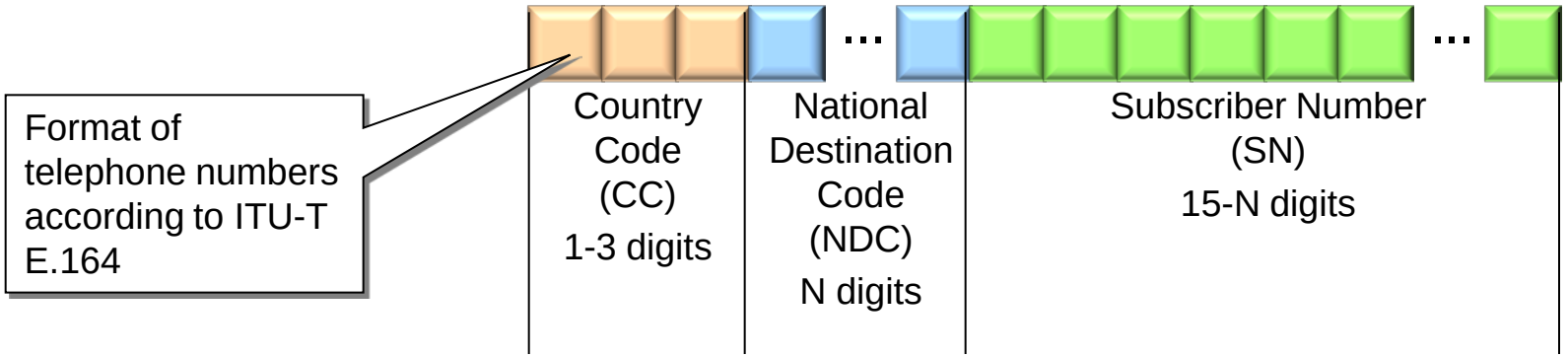
Hybrid location updating

- Periodic execution
  - Executed by the terminal if a timer has expired
  - Timer value is determined by operator:

Operator	Country	Periodic LU time constant	Storage time
D1	Germany	6 hours	-
D2	Germany	4 hours	2 days
Eplus	Germany	12 hours	2 days
Itineris	France	6 minutes	-
Swisscom	Switzerland	2 hours	7 days

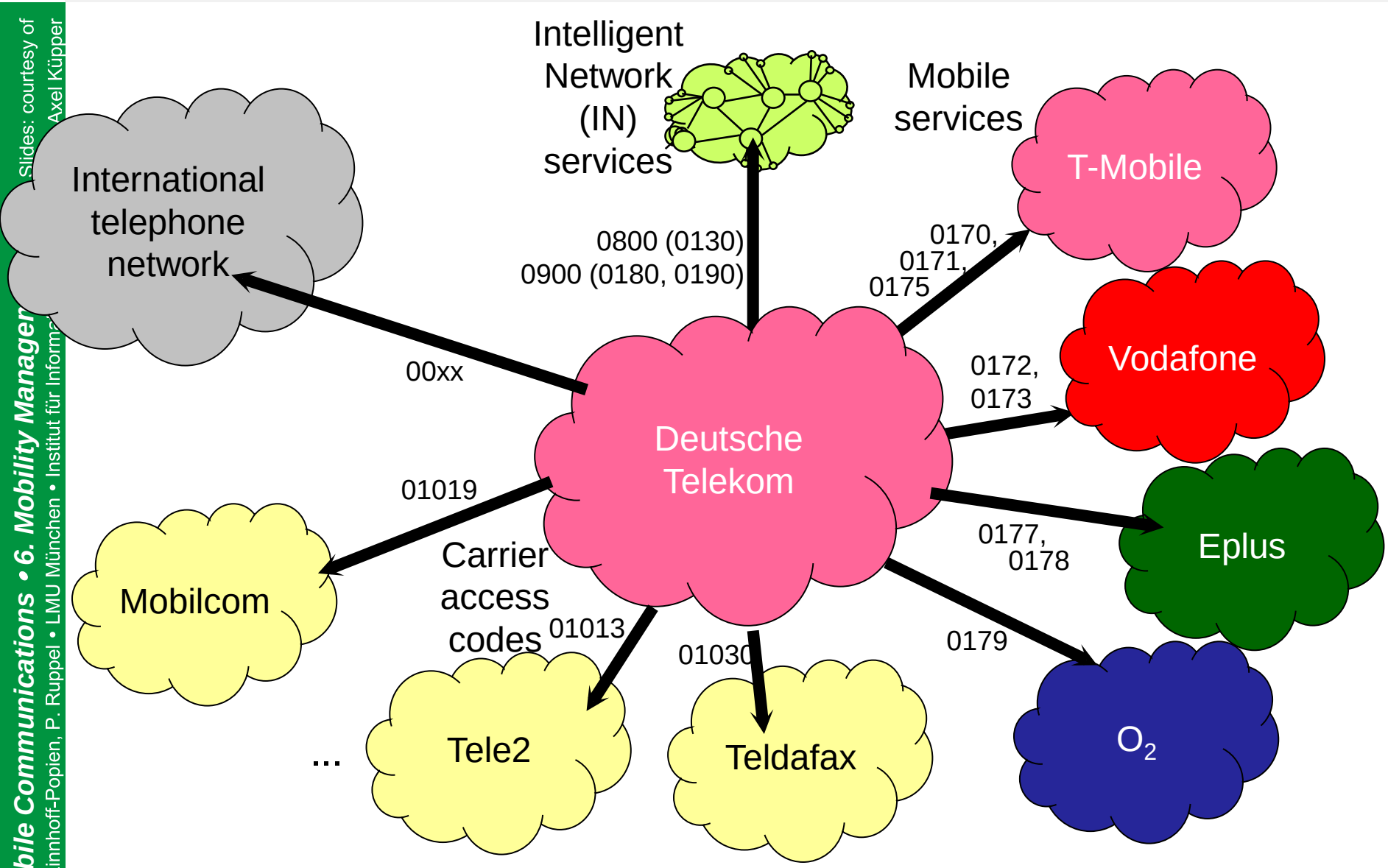
- Execution on location area crossing
  - Mobile station recognizes new location area by reading the LAI broadcast
  - If new location area is recognized, location update is triggered

7.3 GSM Location Management
Numbering Schemes in ISDN/PSTN



- **International numbering plan** enables that customers from different countries can call each other in a similar way, i.e., to use the same country code to make a call to a specific country
- Every country belonging to one of 9 different world areas starts with the same digit (e.g. Europe (3 or 4), Central and South America (5),...)
- International numbering plan is specified in the ITU-T recommendation E.164

- **National numbering plans** contains the rules of a specific country to follow when issuing telephone number
- Each country has autonomy about its numbering plan, but some countries use the same national numbering plan (e.g., USA and Canada)
- In Germany, the national numbering plan specifies the scheme for local numbers, carrier access numbers, service numbers,....

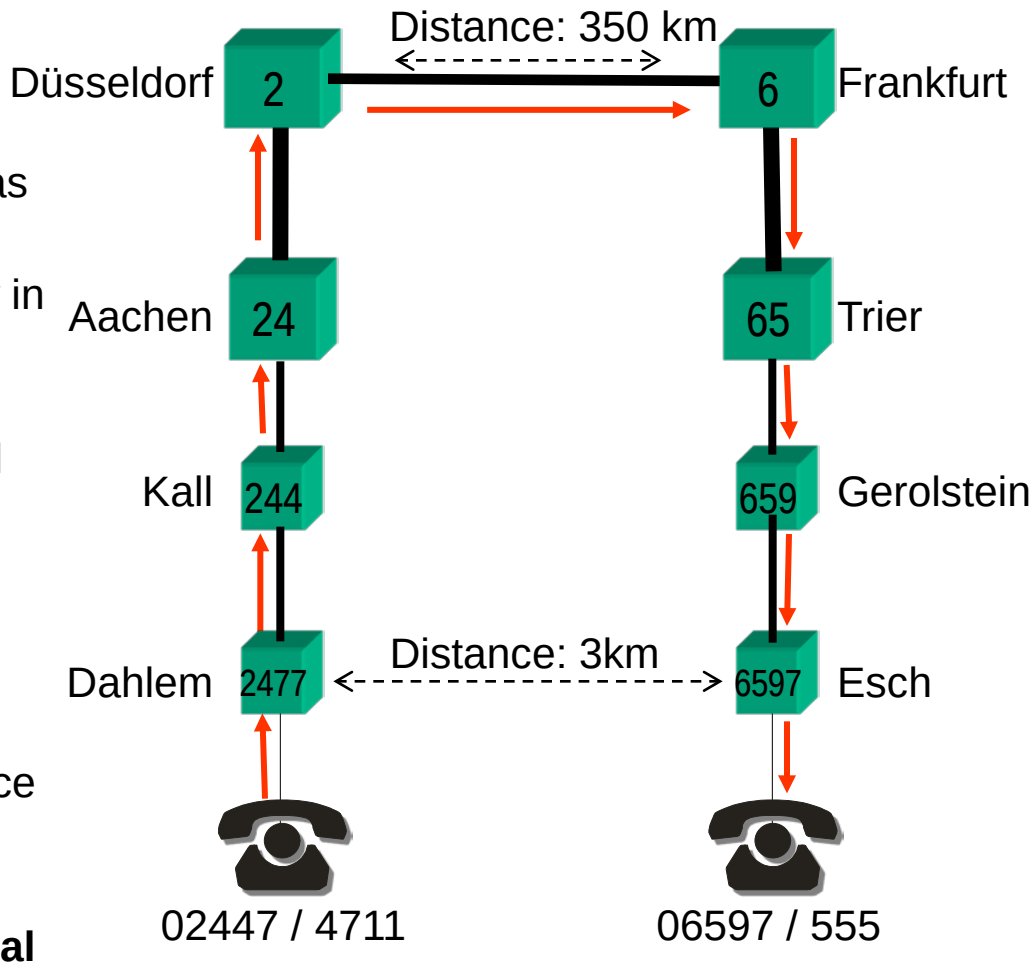

Intelligent Network (IN) services
Mobile services
International telephone network
T-Mobile
0800 (0130)
0900 (0180, 0190)
0170,
0171,
0175
Vodafone
00xx
0172,
0173
Deutsche Telekom
01019
Eplus
0177,
0178
Mobilcom
Carrier access codes
01013
01030
0179
...
Tele2
Teldafax
O2

Telephone numbers in the PSTN/ISDN...

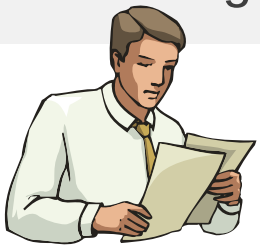
- ...initially represented a geographic area where the associated device was located
- ...have been organized hierarchically in order to reflect the network topology
- ...contain routing information used to locate the destination device of a call

For GSM, this approach is not applicable, because...

- ...users want to be called via their personal telephone number independent of the used mobile device (**personal mobility**)
- ...are only temporarily attached to a local switch (i.e, MSC) due to **terminal mobility**



Principals of Numbering in GSM



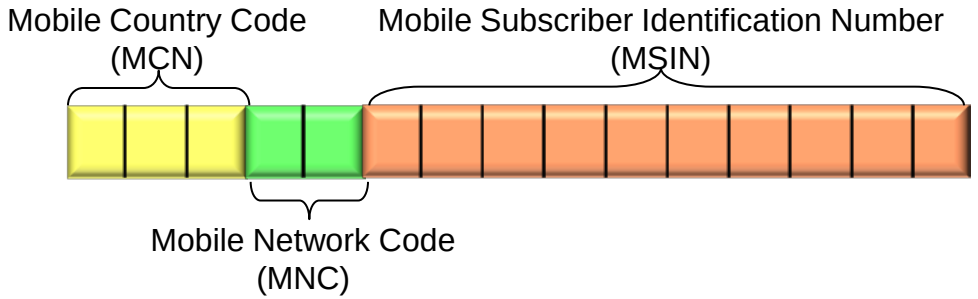
	Numbering of subscribers	Numbering of devices
Permanent numbering	▪ International Mobile Subscriber Identitiy (IMSI) ▪ Mobile Subscriber ISDN Number (MISDN)	▪ International Mobile Station Equipment Identity (IMEI)
Temporary numbering	▪ Mobile Station Roaming Number (MSRN) ▪ Temporary Mobile Subscriber Identity (TMSI) ▪ Location Area Identifier (LAI) ▪ Cell Id (CI)	

- Separation between subscriber and device numbering supports personal mobility
- Separation between permanent and temporary numbering supports mobility management

- Mapping between a user's permanent/temporary and device/subscriber numbers is stored in the HLR and VLR for each user

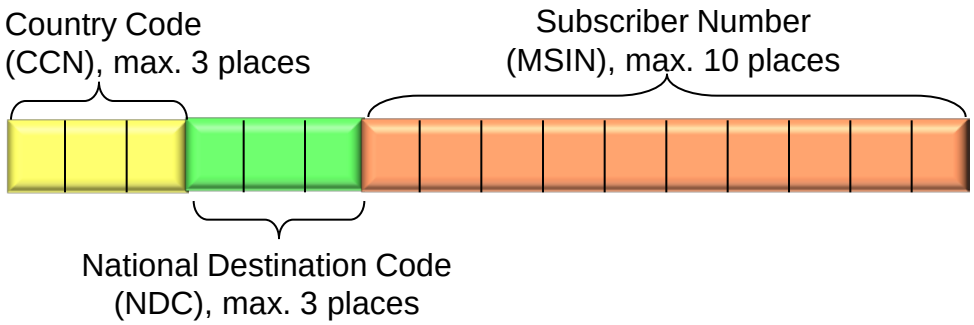
International Mobile Subscriber Identity (IMSI)

- Uniquely identifies the subscriber and is stored in the SIM, HLR, and AuC
- Hierarchical addressing (example: MCN=262 for Germany, MNC=01,02,03,07 for T-Mobile, Vodafone, Eplus, O_2)
- Used, e.g., for billing



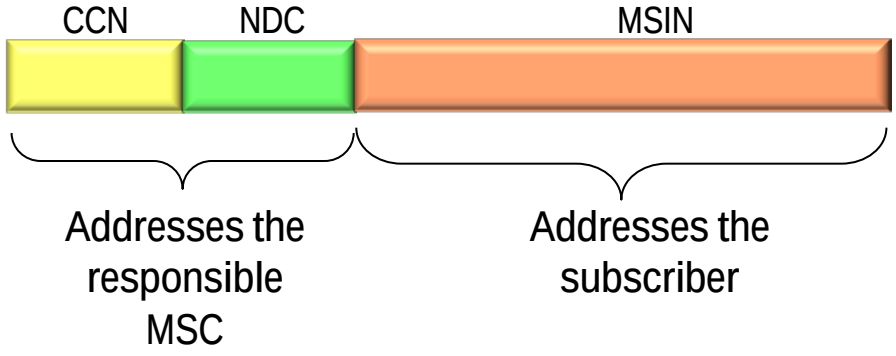
Mobile Subscriber ISDN Number (MSISDN)

- Real telephone number of a subscriber
- Subscriber can have several MSISDNs, e.g., to distinguish several services (voice, data, fax,...)
- Thus, automatic activation of service-specific resources is already possible during setup of connection
- Stored centrally in the HLR and in the SIM



Mobile Station Roaming Number (MSRN)

- Temporary location-dependent ISDN number
- Required to make routing descisions and to identify the responsible MSC
- Assigned by the locally responsible VLR to each mobile station in its area and passed to the HLR
- Generated at each registration or when the HLR requests it for call setup (on a call-by-call basis)

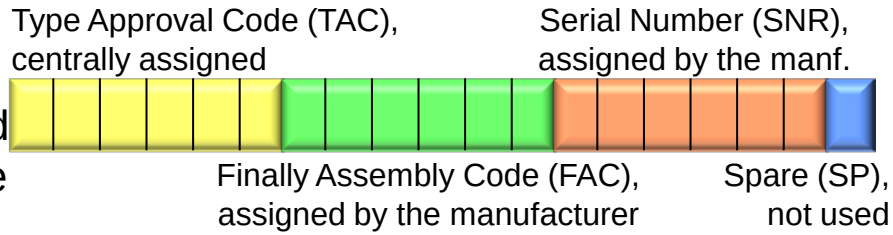


Temporary Mobile Subscriber Identity (TMSI)

- Used in place of the IMSI for the definite identification and addressing of the mobile station
- Avoids to determine the identity of the subscriber by listening to the radio channel
- Assigned during the mobile station's presence in the area of one VLR (by that VLR) and can be changed during this period (ID hopping)
- Is stored by the mobile station on the SIM card
- Is stored on the network side only in the VLR, not in the HLR
- Is assigned in an operator specific way and consists of 4x8 Bits
- Subscriber can be uniquely identified; IMSI is replaced by (TMSI, LAI)

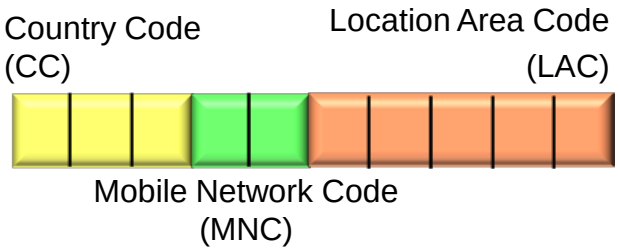
International Mobile Station Equipment Identity (IMEI)

- Uniquely identifies mobile stations internationally
- Allocated by the manufacturer, registered by the network operator and stored in the EIR
- Characterizes a mobile station and gives clues about the manufacturer and the date of manufacturing



Location Area Identifier (LAI)

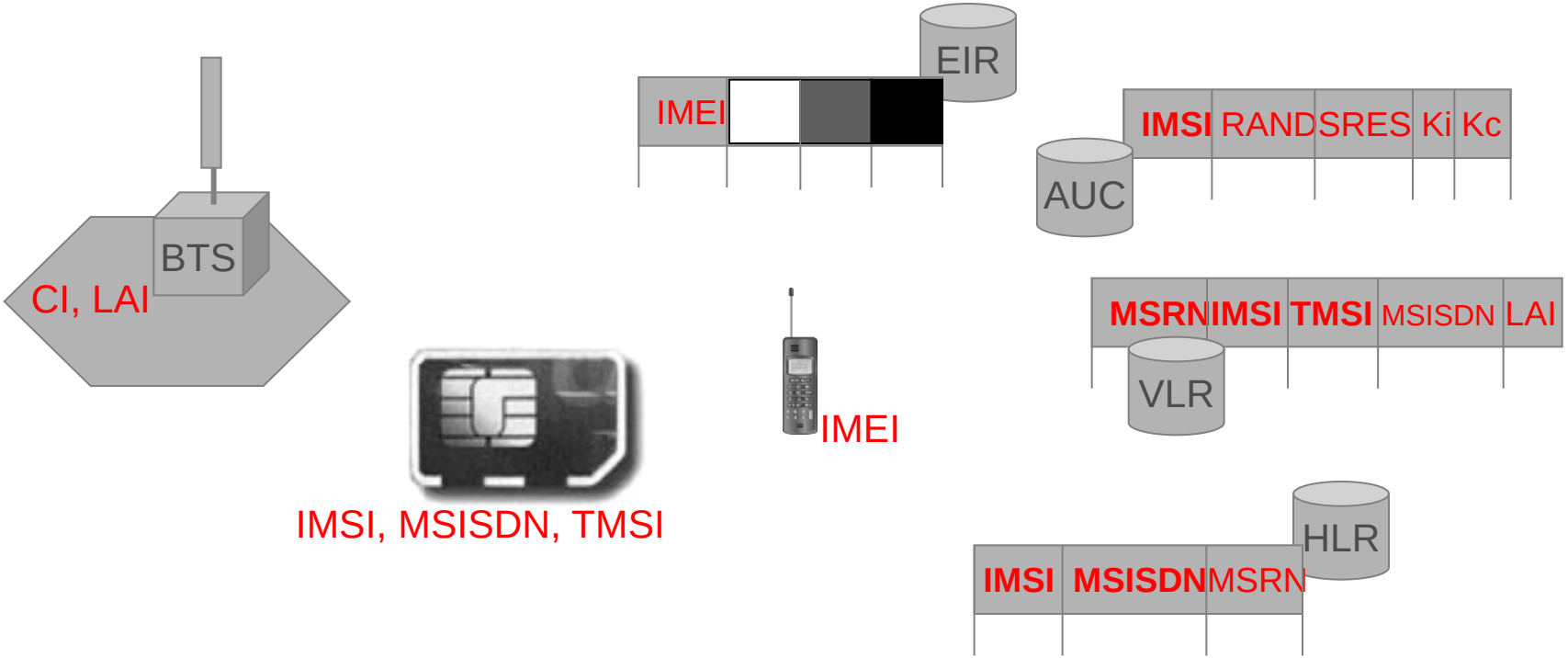
- Internationally unique identification of a location area
- Regularly broadcasted by the base station
- “Heard” by the mobile station in order to decide whether or not a new LA has been entered



Cell Identifier (CI)

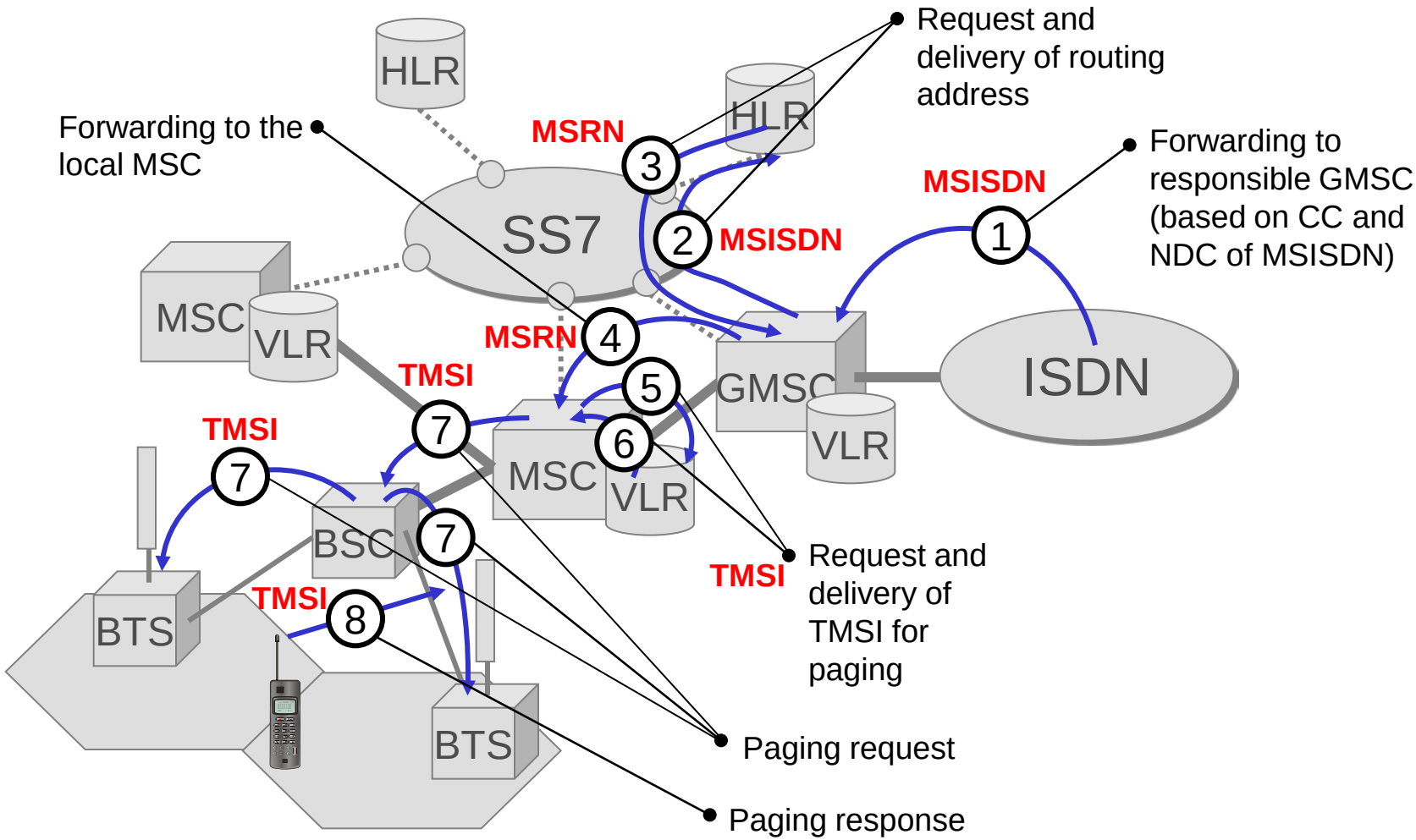
- Uniquely identification of cells within an LA
- Length of CI: 2x8 bits
- Internationally unique identification with the Global Cell Identity (LAI+CI)

7.3 GSM Location Management
Overview of Addresses

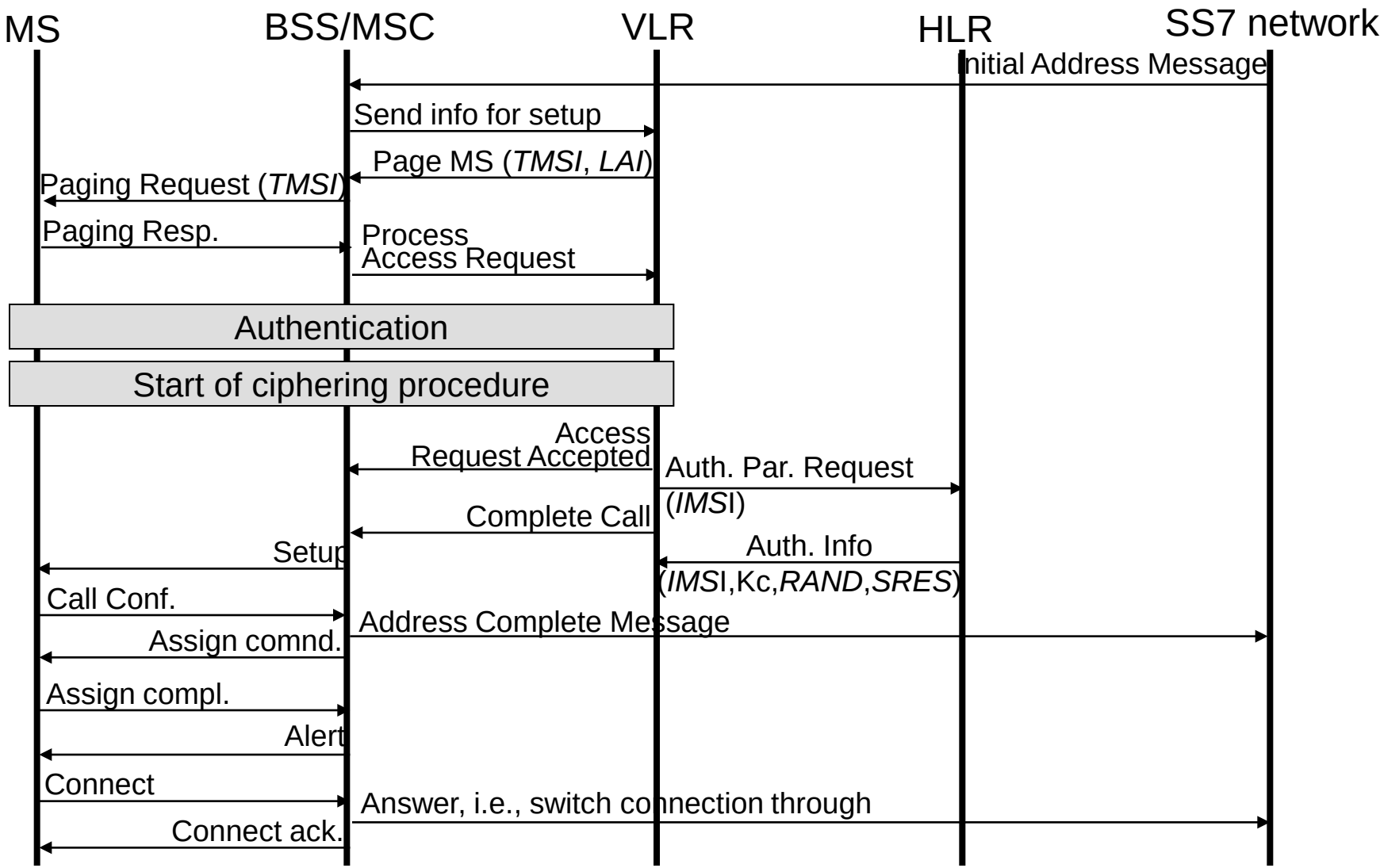


BSIC	Base Transceiver Station Identity Code
CI	Cell Identifier
IMEI	International Mobile Station Equipment Identity
IMSI	International Mobile Subscriber Identity
Kc	Cipher/Decipher Key
Ki	Subscriber Authentication Key
MSISDN	Mobile Subscriber ISDN Number

MSRN	Mobile Station Roaming Number
LAI	Location Area Identifier
RAND	Random Number
SPC	Signaling Point Code
SRES	Session Key
TMSI	Temporary Mobile Subscriber Identity


HLR
HLR
Request and delivery of routing address
Forwarding to the local MSC
MSRN
3
SS7
2
MSISDN
MSISDN
1
Forwarding to responsible GMSC (based on CC and NDC of MSISDN)
MSC
VLR
MSRN
4
TMSI
5
GMSC
ISDN
TMSI
7
6
MSC
VLR
VLR
7
BSC
7
TMSI
Request and delivery of TMSI for paging
TMSI
8
BTS
BTS
Paging request
Paging response

Detailed Sequence of Mobile Terminated Call

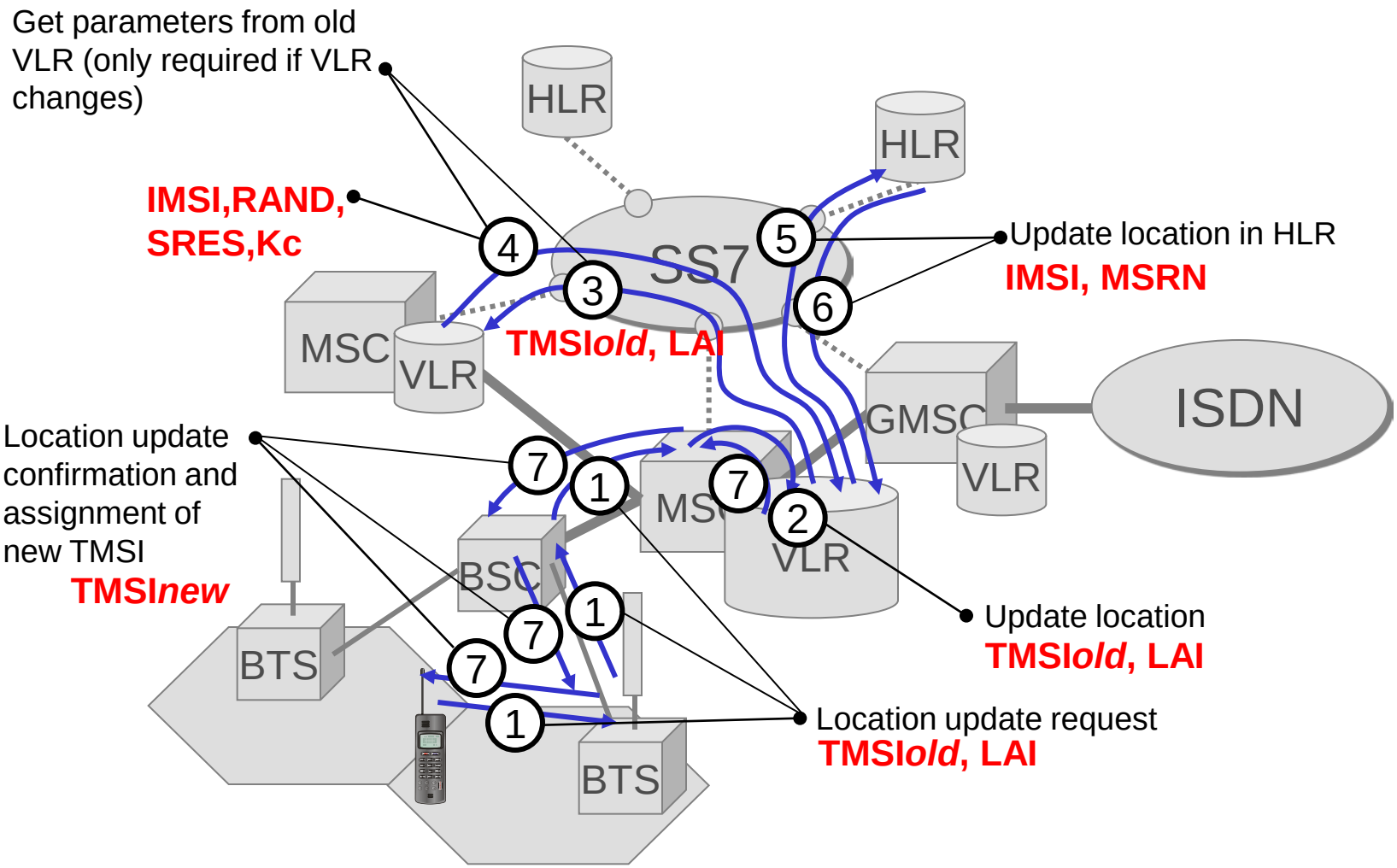


Location Registration

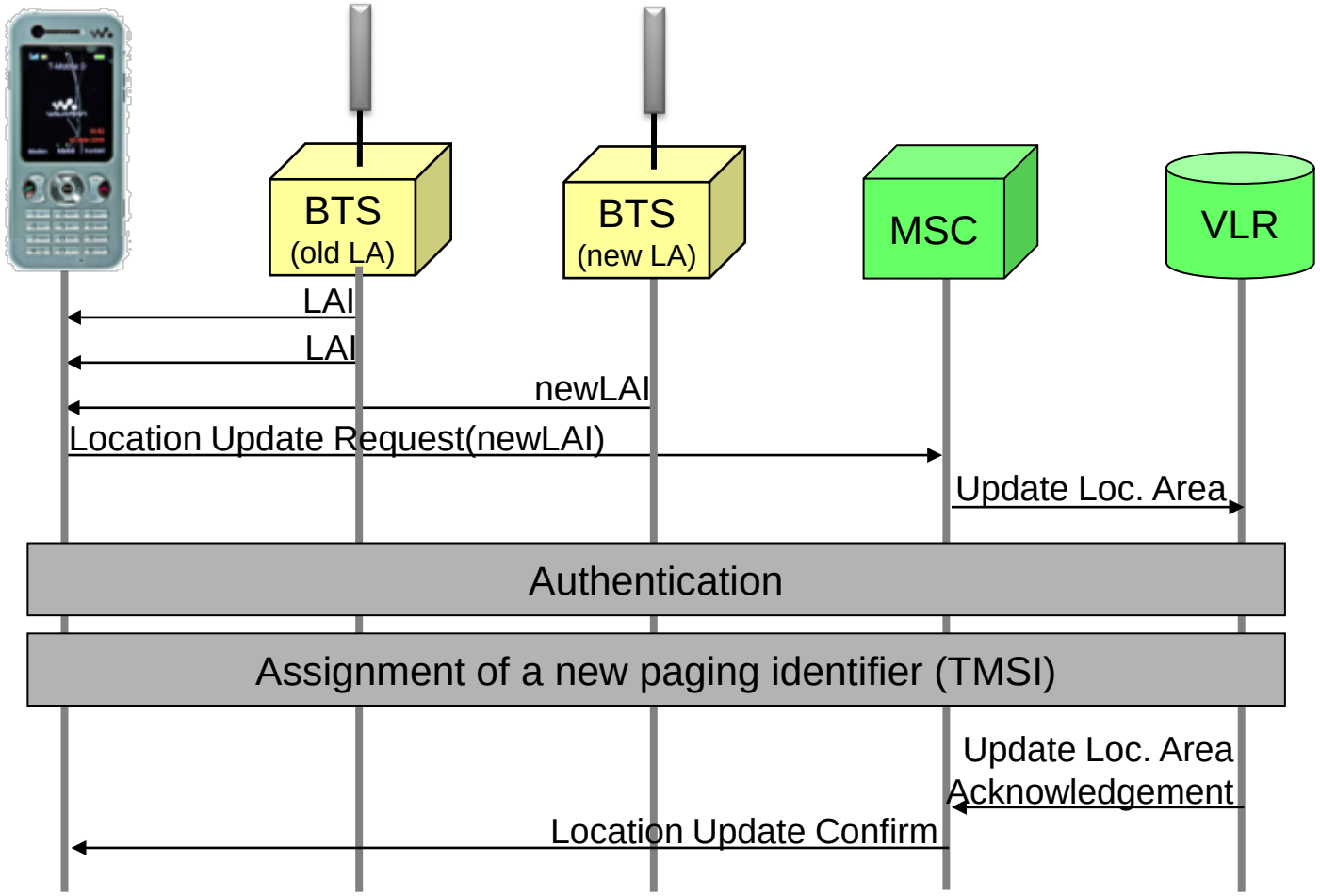
- Must be executed in order to get access to a GSM network, i.e., to receive or to initiate calls
- Registration with home network or a foreign network (roaming; provided there is a roaming agreement between home and foreign network)
- Steps:
  - Sending IMSI and LAI to the network
  - Authentication
  - Start of ciphering
  - Generation of an TMSI (stored in the associated VLR) and an MSRN (stored in the central HLR)
  - MS receives TMSI and saves it in the SIM storage

Location Update

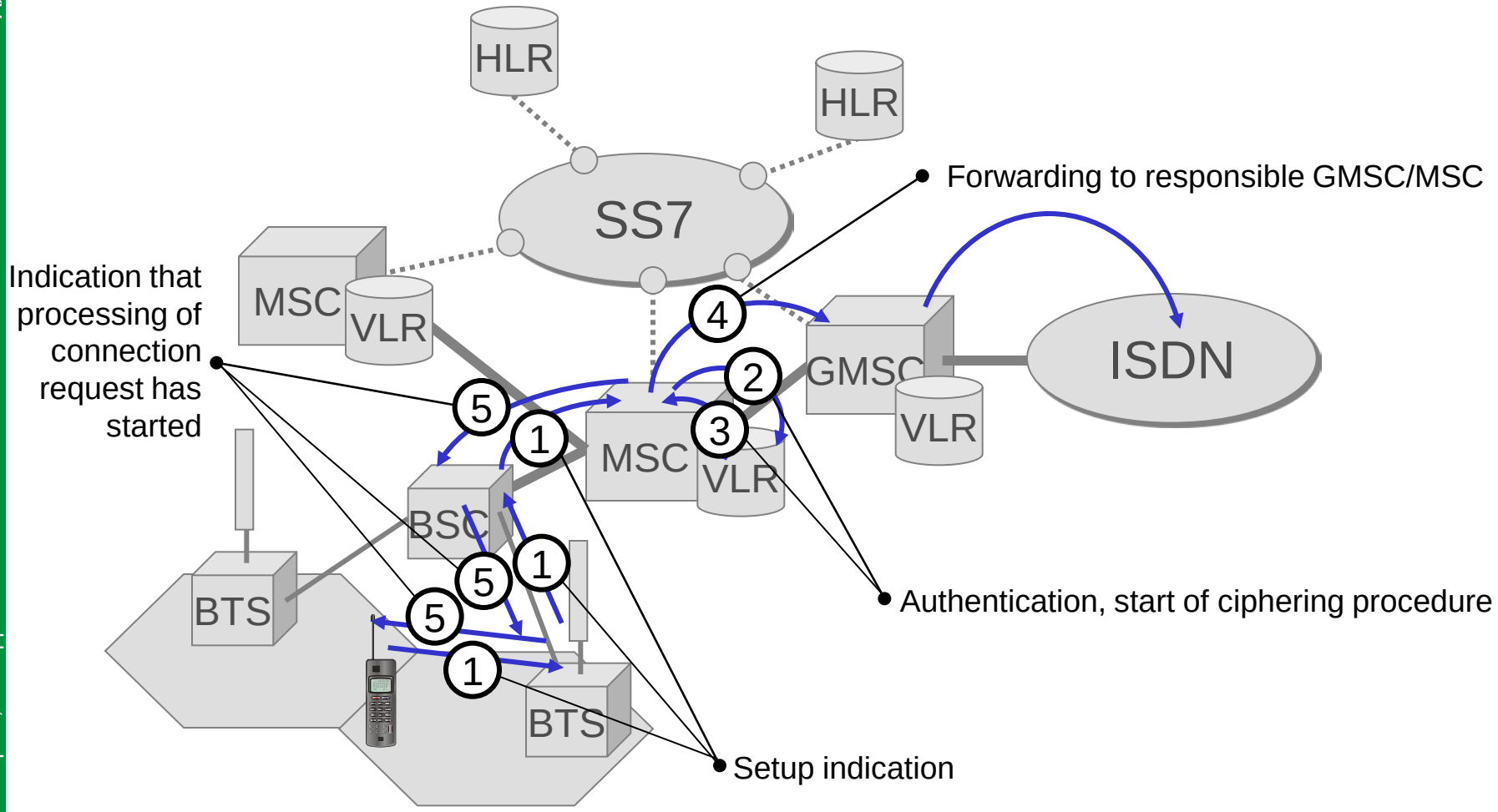
- Purpose: Tracking the mobile user in order to deliver calls or SMS
- Hybrid location updating
  - **Execution on LA crossing**: mobile station recognizes that it is in a new LA by regularly reading the LAI broadcasted in each cell
  - **Periodic execution**: Periodic execution of location updates (independent of “Execution on LA crossing”)
- Difference between location registration and location update: location update is based on TMSI (which is only unique in connection with an LAI) instead of the IMSI


Get parameters from old VLR (only required if VLR changes)
IMSI,RAND, SRES,Kc
HLR
HLR
SS7
4
3
5
6
Update location in HLR
IMSI, MSRN
MSC
VLR
TMSIold, LAI
GMSC
ISDN
VLR
Location update confirmation and assignment of new TMSI
TMSInew
7
1
7
2
BSC
VLR
Update location
TMSIold, LAI
1
7
7
BTS
1
Location update request
TMSIold, LAI
BTS

7.3 GSM Location Management
Overview (I)

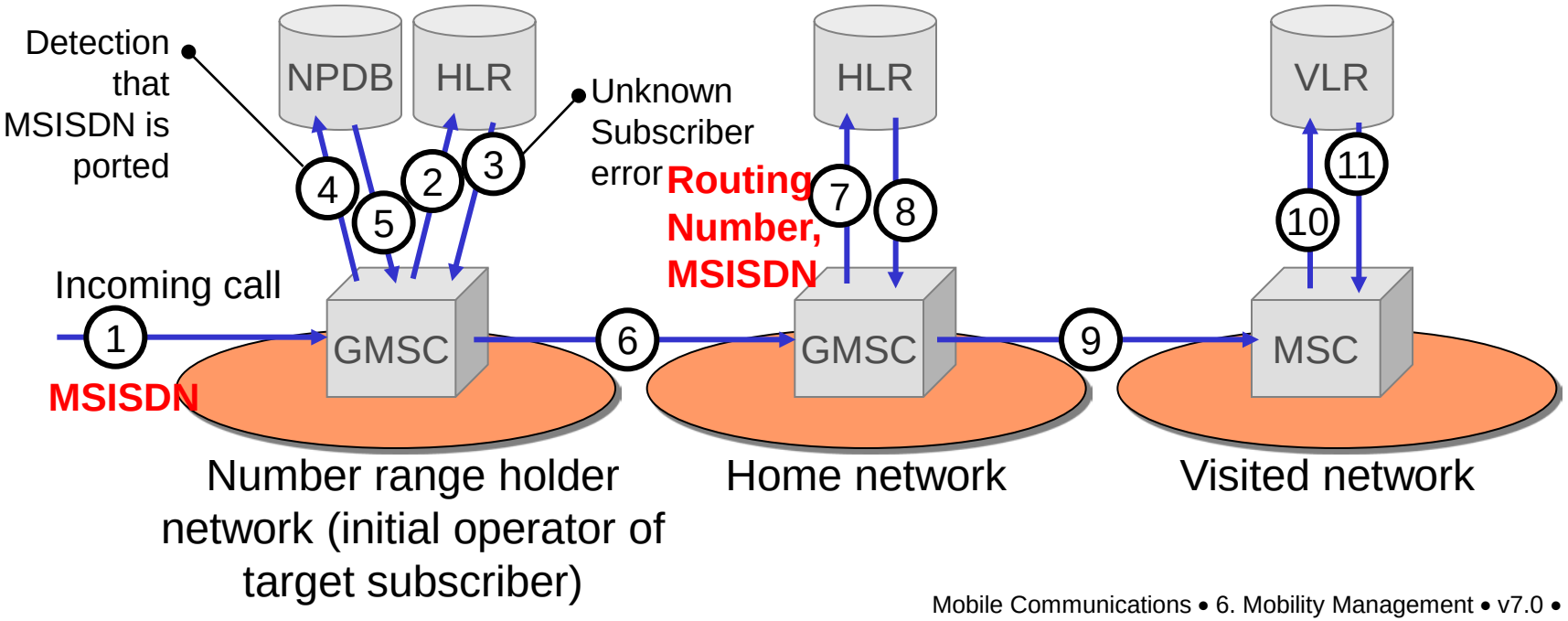


*)
- Figure shows location update sequence when roaming within a VLR area and MSC area
- If location area change incorporates change of the MSC or/and the VLR, location update procedure requires interactions with the central HLR

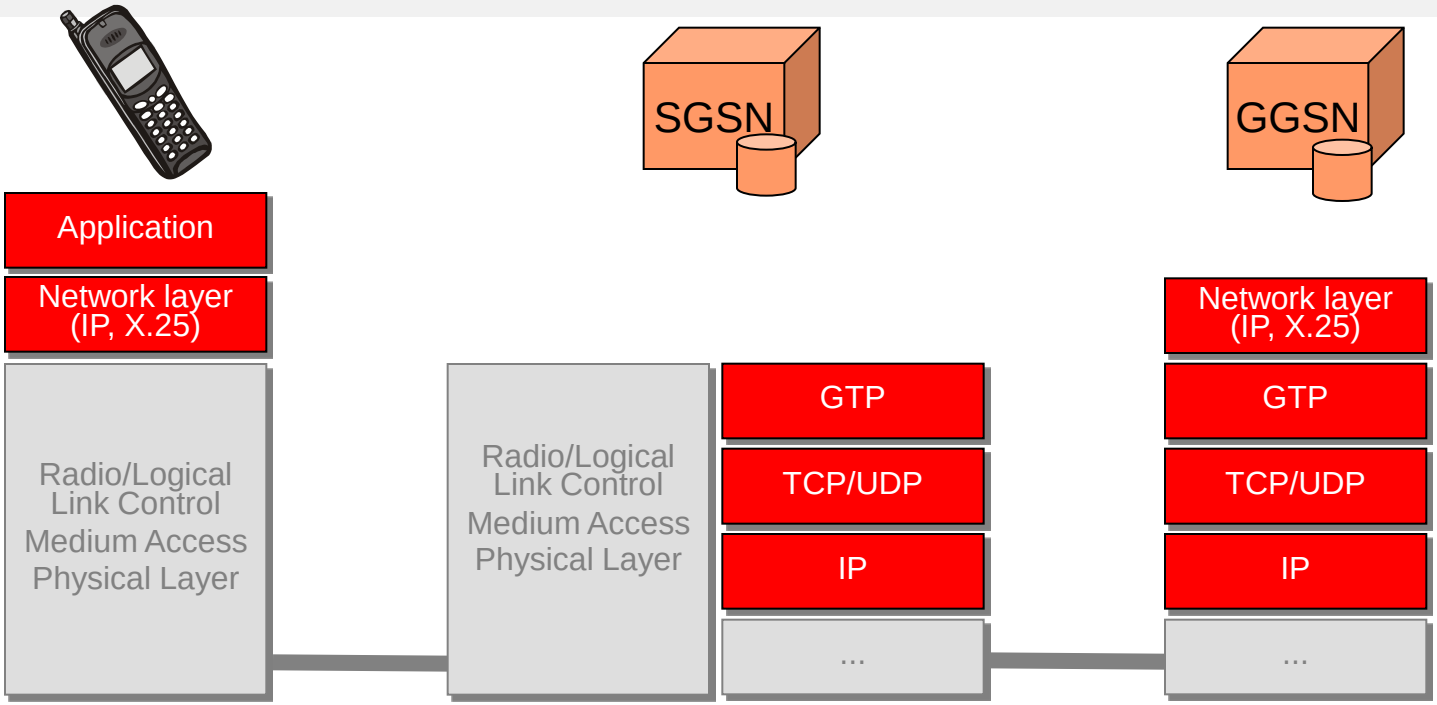

HLR
HLR
SS7
Forwarding to responsible GMSC/MSC
Indication that processing of connection request has started
MSC
VLR
4
2
GMSC
ISDN
5
1
3
MSC
VLR
VLR
BSC
5
1
BTS
5
1
BTS
Authentication, start of ciphering procedure
Setup indication

7.3 GSM Location Management
Number Portability

- MSISDNs are operator-specific and initially could not be kept by the user when changing the operator (number portability)
- Regulatory Authority for Telecommunications and Posts imposed operators to support number portability
- GSM TS 23.066: introduction of an additional Number Portability Database (NPDB)
- NPDB: operational database (used in real time at call set-up) which provides portability information

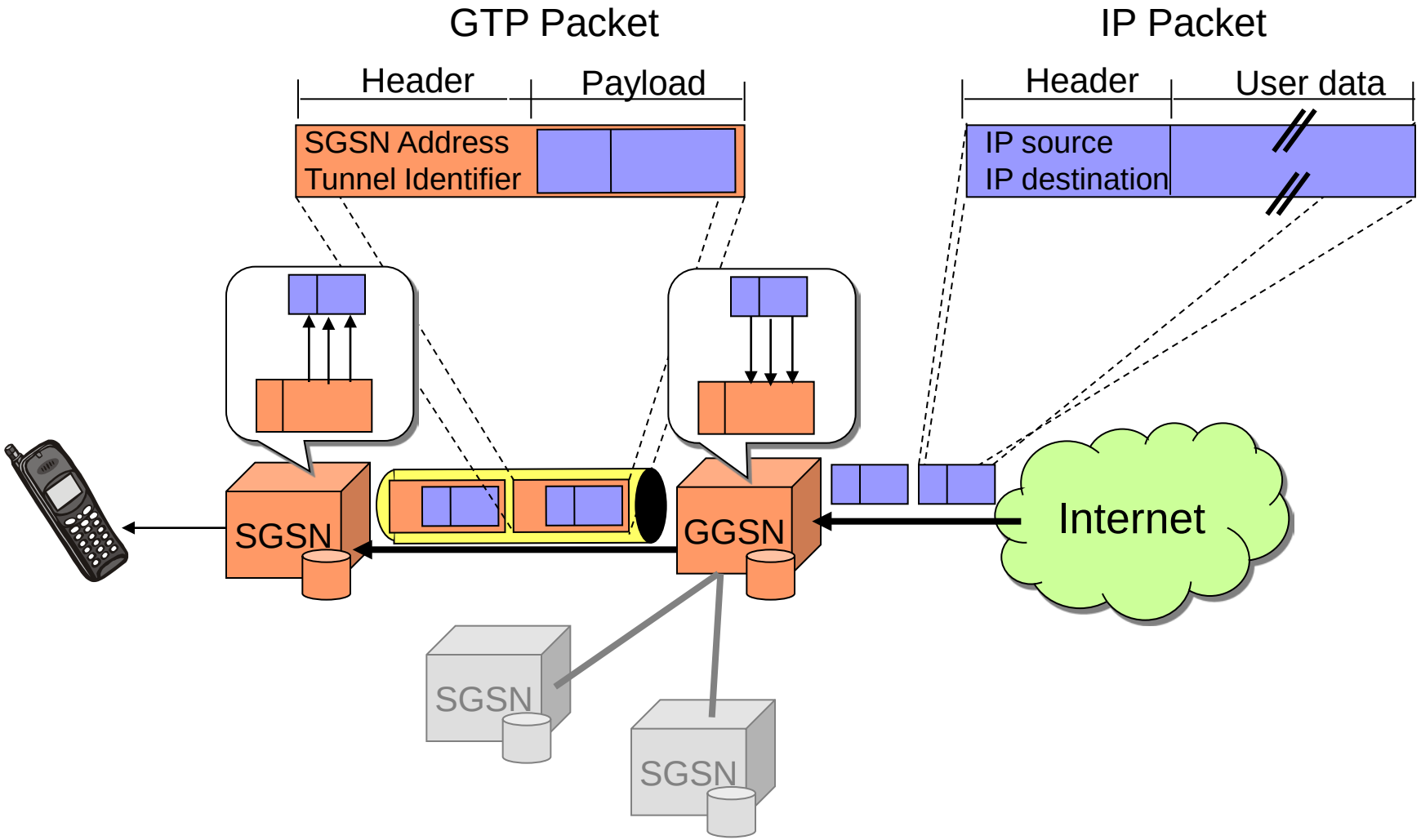


7.4 GPRS Location Management
Gateway Tunneling Protocol



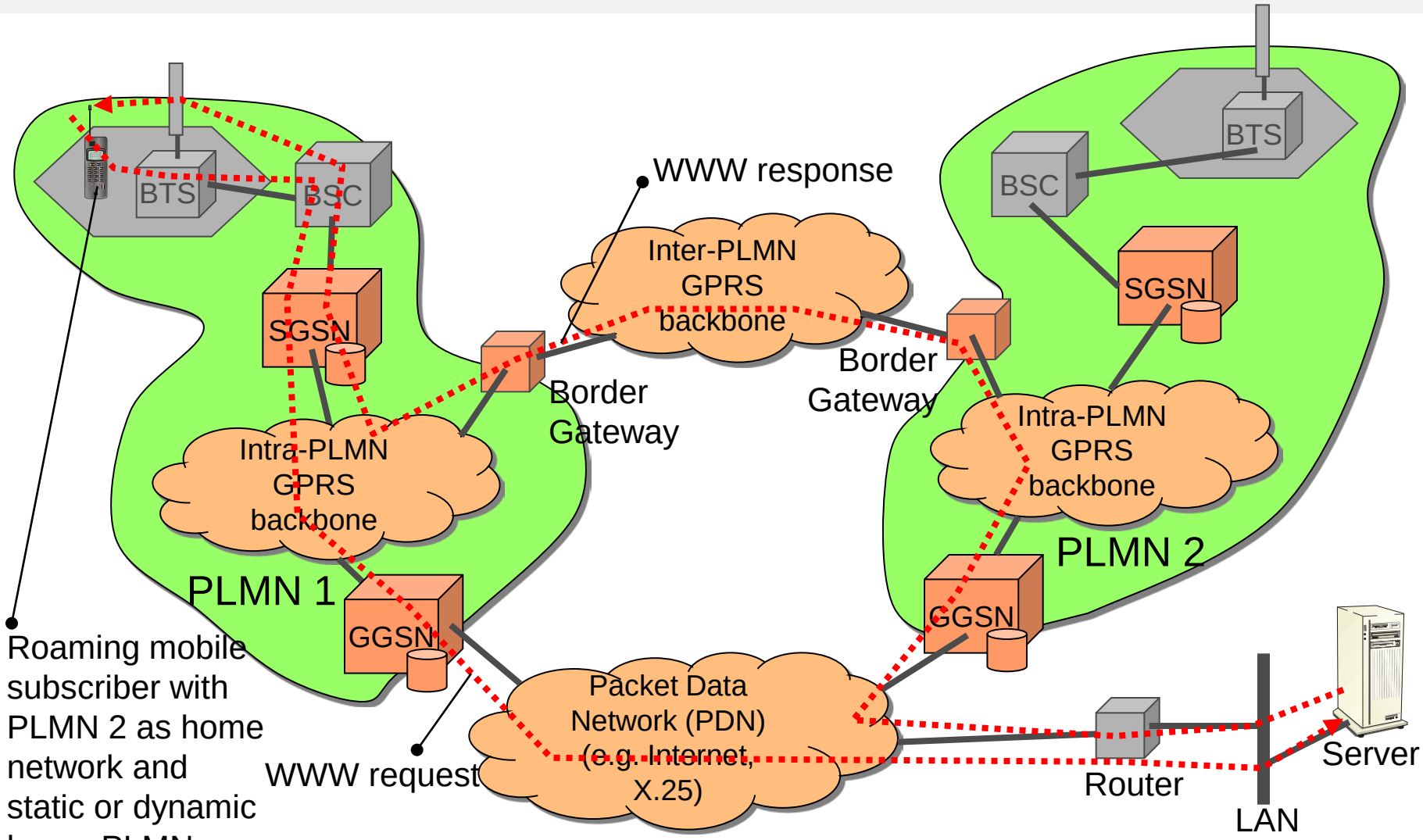
- Because IP does not support keeping the host address while moving to other points of attachment, GPRS applies **tunneling**
- Tunneling transparently transfers packets between the mobile station and external data networks
- In a tunnel, IP and X.25 packets are transmitted encapsulated within the GPRS backbone network between GGSN and SGSNs
- GPRS Tunneling Protocol (GTP) carries the user's IP or X.25 packets between GSNs within the same GSM network and between GSNs of different GSM networks
- GTP is carried over TCP/IP if X.25 is carried over GPRS and UDP/IP if IP is carried over GPRS

⇨ GPRS backbone is IP-based



Due to tunneling overhead, tunnels are terminated at an SGSN and are not continued at the air interface in GPRS

7.4 GPRS Location Management
GPRS Routing Example



Packet Data Protocol (PDP) Address

- Address of an MS in the format of the used PDP (e.g., IP address)
- Static
  - MS permanently owns a PDP address assigned by the operator of the user's home GSM network
- Dynamic
  - MS is assigned a new PDP address whenever it attaches to the network
  - Dynamic Home-PLMN Address: Dynamic address assigned by the user's home PLMN
  - Dynamic Visited-PLMN Address: dynamic address assigned by the operator of the visited PLMN
- GGSN is responsible for the allocation and deactivation of PDP addresses

Packet TMSI (P-TMSI)

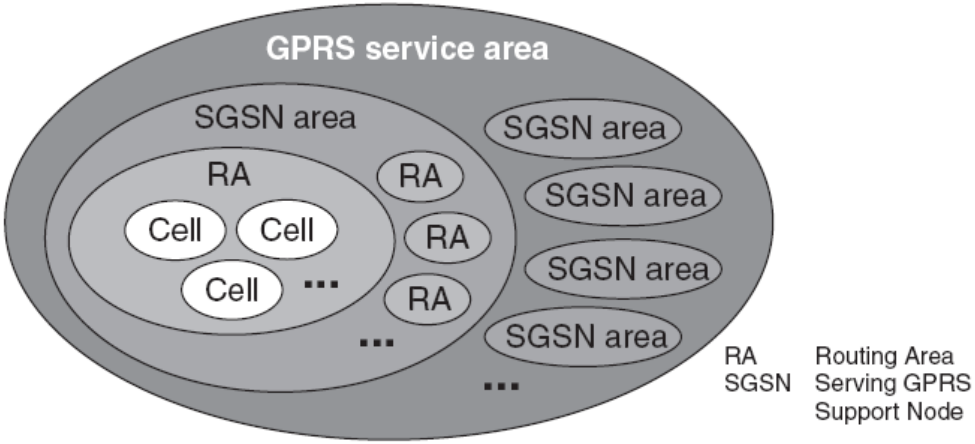
- Assigned during an GPRS attach procedure and after a location update
- Used to page the MS when packets have to be delivered
- Mapping between PDP address and P-TMSI by the SGSN makes the transmission of packets between GGSN and MS possible

Routing Area Identifier (RAI)

- In order to optimize location management, GSM location areas are subdivided into several routing areas
- RAI is transmitted from the MS to the network instead of the LAI

7.4 GPRS Location Management
Routing Areas

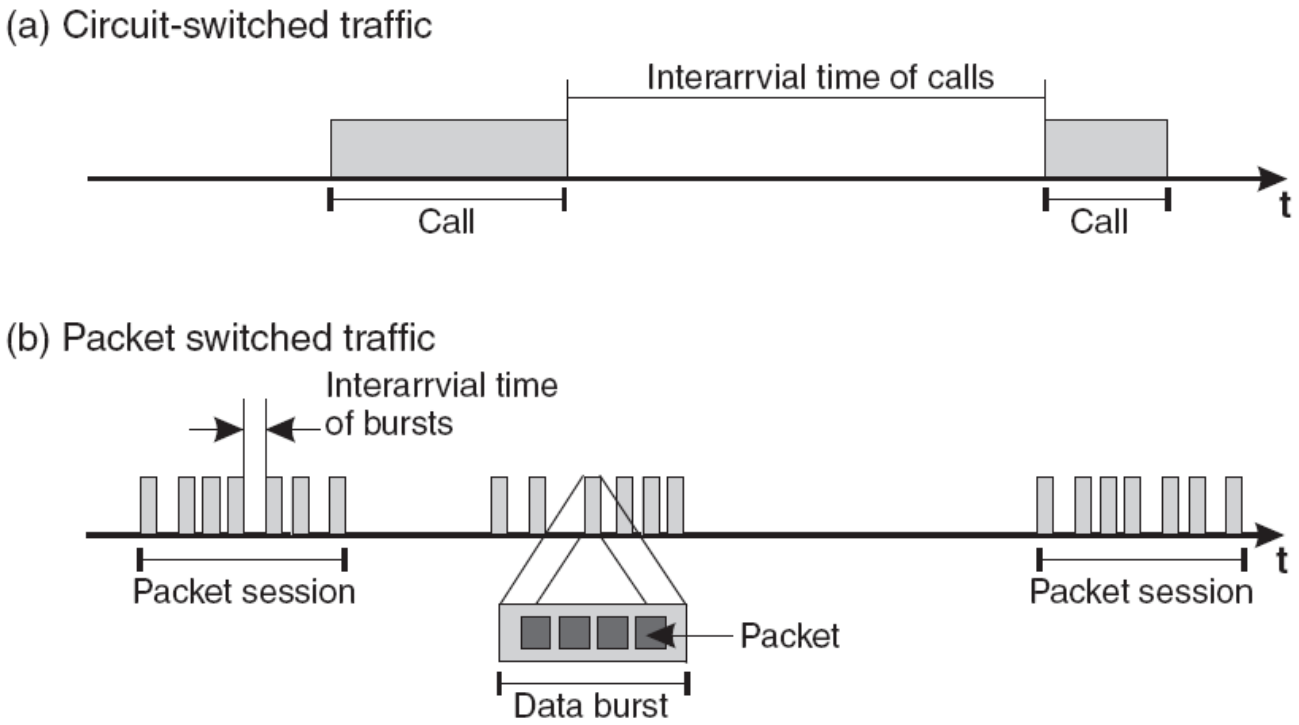
- Like terminals must be located for incoming calls in circuit-switched GSM, in GPRS localization is necessary for the delivery of data packets in the downlink
- Paging of the terminal for every downlink packet (or at least for every data burst) in all cells of the user's location area:
  - High overhead, which may exceed amount of user data to be transferred
  - High delay for packet delivery
  - **Not used**
- **Instead**: Introduction of
  - Routing areas and
  - State model for adaptive location management



Routing Areas

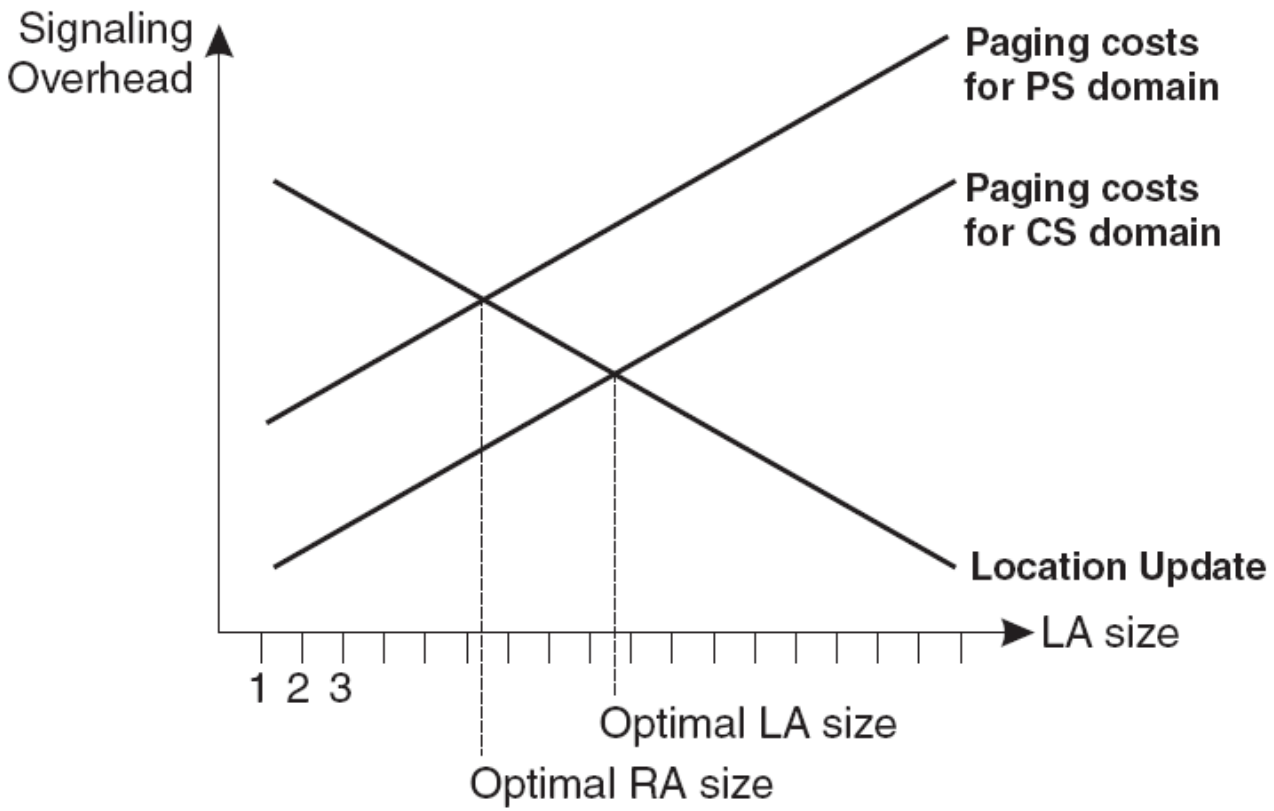
- A routing area comprises several cells
- Routing areas are significantly smaller than location areas
- Depending on the GPRS state model, location updates and paging are related
  - to routing instead of location areas or
  - to cells

Characteristics of Circuit and Packet Switched Traffic



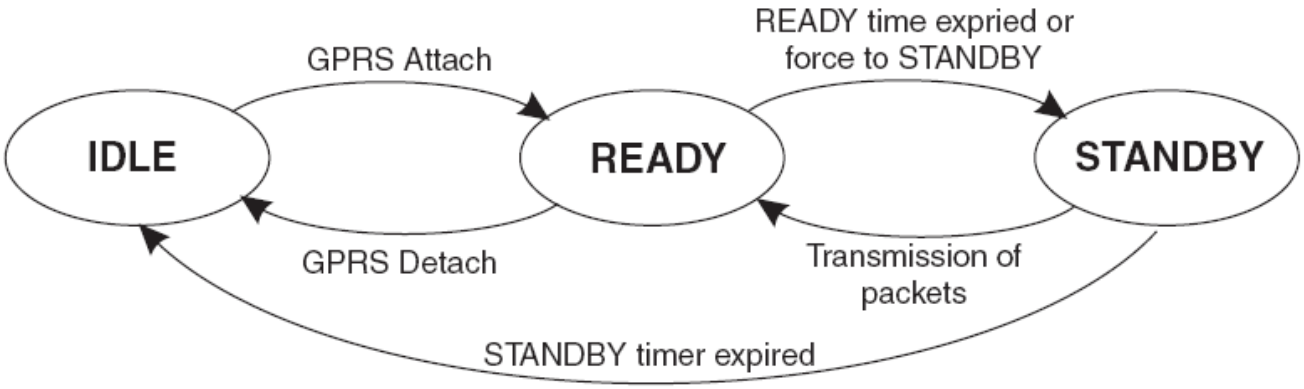
- Frequency of data bursts (i.e., packets) exchanged in the packet-switched mode may be much higher than that of calls in the circuit-switched mode
- Interarrival-time of data bursts is on average much smaller than the inter-arrival time of calls
- Packet switched traffic may result in an increased number of paging requests, i.e., each time a data burst is to be transferred in the downlink

7.4 GPRS Location Management
Signaling Overhead of Location Update and Paging Costs



- Optimal LA/RA size is determined in dependence on the margin between location update and paging costs
- As paging costs are much higher for packet-switched traffic, routing areas have a smaller number of cells than location areas

GPRS State Model



- **States**: IDLE, READY, STANDBY
- **Timers**: READY, STANDBY
- State transitions are executed by timers, data packet transfer, or user activity
- No paging and low delay of packet delivery in the READY state, but increased location-update overhead
- Decreased location-update overhead and power consumption in the STANDBY state, but increased paging overhead if downlink transmission starts
- Timers are operator-specific and are broadcasted on a dedicated signaling channel to the terminals

IDLE

- Terminal is not reachable in GPRS mode
- Location management according to GSM circuit-switched

READY

- Terminal performs location updates whenever entering a new **cell**

STANDBY

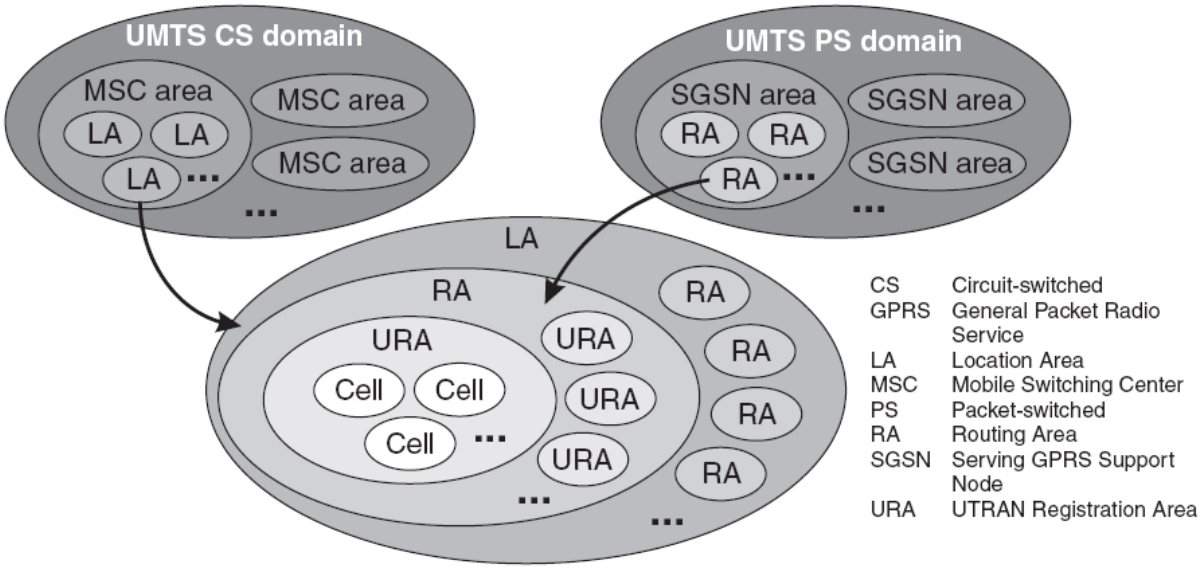
- Terminal performs location updates whenever entering a new **routing area**

Experiences from GPRS

- Location management is exclusively controlled in the core network (e.g., by SGSNs)
- Procedures (paging and location/cell updates) must pass the interface between access and core network
- High load and large delays

New approach for UMTS PS domain

- Track subscribers on the basis of routing areas in the core network
- Track subscribers on the basis of **UTRAN Registration Areas** (URAs) and cells in the access networks



7.5 UMTS Location Management
State Models

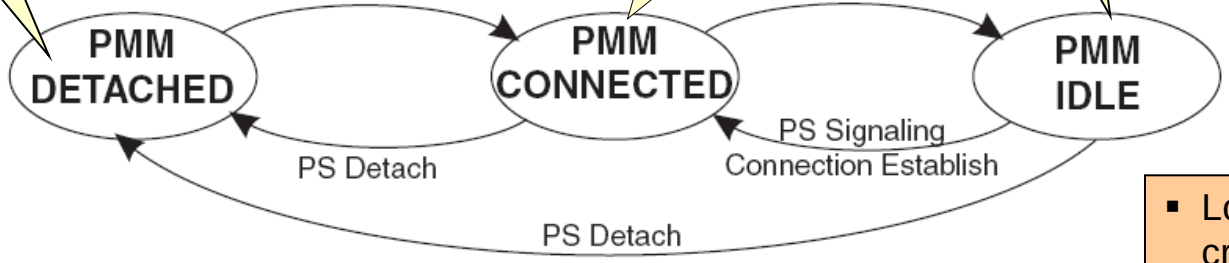
- No location management in the PS domain

- Location updates on crossing of routing areas
- Corresponds to CELL CONNECTED or URA CONNECTED state in the access network

- Location updates on crossing of routing areas

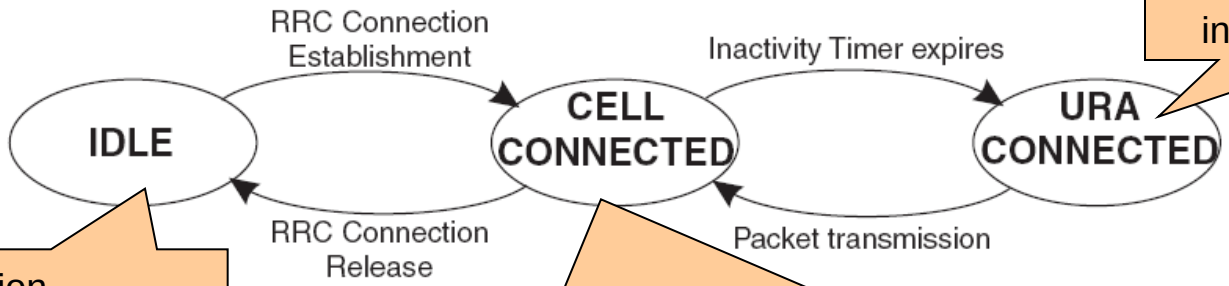
PMM Packet Mobility Management
RRC Radio Resource Control
PS Packet switched

(a) State model for the core network



- Location updates on crossing of URAs
- Corresponds to PMM CONNECTED state in the core network

(b) State model for the access network



- No location management in the access network

- Location updates on crossing of cells
- Corresponds to PMM CONNECTED state in the core network

7.5 UMTS Location Management
Areas tracked by Network Nodes

	MSC/VLR			SGSN		UTRAN
	GSM	GPRS	UMTS	GPRS	UMTS	UMTS
Cell	no	no	no	yes	no	yes
URA	—	—	no	—	no	yes
Routing area	—	no	no	yes	yes	no
Location area	yes	yes	yes	no	no	no