Telecommunication Networks and Services

Signalling 2 (GSM)

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Signalling

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GSM signalling

- Signalling of GSM is based on the ISDN signalling systems
  - SS7/DSS1
- But, because of mobility, roaming, radio access a lot of new problems to be solved, e.g.:
  - Authentication of subscribers, encryption of signals/voice transmission (ciphering)
  - Management of query/response transactions
    - e.g.: data base query between the MSC and HLR to learn the location of a called mobile subscriber
  - Establishment of a signalling connection between different signalling networks
    - in case of roaming

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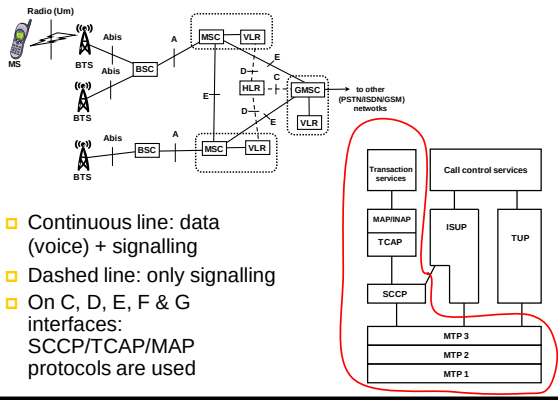
GSM interfaces in CS domain



- Continuous line: data (voice) + signalling
- Dashed line: only signalling
- On C, D, E, F & G interfaces: SCCP/TCAP/MAP protocols are used

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SCCP

- SCCP: Signalling Connection Control Part
- Main problem: 14 bits long Point Codes used in MTP-3 are not suitable for every SP to have a globally unique address
  - not a problem in ISDN, because there trunk lines are to be controlled, and two ends of every trunk line belong always to the same network,
  - ISDN: if in a call more than one trunks are used: several, independent signalling connections
  - a signalling connection may be:
    - international
    - in between different operators of the same country (national interconnecting)
    - inside the network of an operator (national – for historical reasons)
  - But in GSM in case of roaming there is a need of a direct signal exchange between network elements of different operators, e.g.:
    - SMSC – MSC
    - HLR – MSC (VLR)

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SCCP

- Solution: Global Titles (global, not SS7-related addresses)
  - Most typically: telephone number
  - A telephone number is assigned to every network element, that may be reached from an other network
- SCCP translates between the global (tel. number) and local (MTP-3 SPC) addresses
- 3 different services (SCCP „classes”):
  - connectionless, every signal sent independently (maybe on different route)
  - connectionless, every signal between two particular network elements sent always on the same route (sequence of signals is kept)
  - connection-oriented: connection establishment, usage, clearing phases
    - used at A interface in call control

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TCAP

- TCAP: Transaction Capabilities Application Part
  - SCCP provides only the transparent signal transfer
- TCAP supports the query-response data base transactions
  - e.g.: matches the response with the query
  - a transaction may contain several operations – management of operations within a transaction

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MAP/INAP

- MAP: Mobile Application Part
- INAP: Intelligent Network Application Part
  - e.g.: green/blue or premium rate number translation
- MAP: management of the communication between the network elements at C, D, E, F, G interfaces of GSM

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Identifiers in GSM

- **MSISDN**: Mobile Station ISDN Number
  - telephony number
  - unique worldwide
  - MSISDN = Country Code (Hungary: 36) + Network Identifier („area code") (Hungary:20/30/70) + Subscriber Number
- **IMSI**: International Mobile Subscriber Identity,
  - in GSM network this identifies the subscribers
    - in data bases (HLR, VLR - index)
  - assigned to SIM cards
  - unique worldwide
  - IMSI = Mobile Country Code (Hungary: 216) + Mobile Network Code (Hungary:01/30/70) + Mobile Subscriber Identifier (10 digits)
  - at operator change: MSISDN may be kept (number portability) but SIM card and so the IMSI must be changed

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Identifiers in GSM

- **IMEI**: International Mobile Equipment Identity
  - identifier of the mobile terminal
  - unique worldwide
  - IMEI = <equipment type+producer id> (8 digits) + <serial number> (6 digits) + <control digit> (1 digit) (+<software version id> (1 digit))
  - To query: *#06#
    - works on every GSM terminal
    - written under the battery, too
    - if they are different (or the latter is not present): the mobile is probably stolen!
      - exception: the SW version number is not always displayed by *#06# or it is not written under the battery

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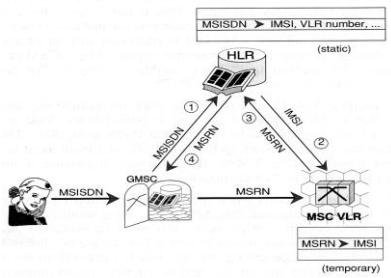
Identifiers in GSM

- **MSRN**: Mobile Station Roaming Number
  - used when a MS is called
  - assigned to MSC(VLR)



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User Confidentiality

- Authentication
  - Verification of the identity of the subscriber
- Ciphering
  - Encryption of user speech and signal transmission in the Air interface
- IMEI check
  - verification of the Mobile Equipment by checking the validity of the International Mobile Equipment Identity (IMEI)
- User Confidentiality
  - Tariff structure
    - - called: right to hide location, not to be discovered even implicitly
    - - caller: to know in advance how expensive the call will be
  - Avoidance of the broadcast of user's IMSI in the air interface – TMSI

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Authentication

- Problem: On the Radio Interface anyone can call in the name of anyone else by using a public identifier
  - And the cheated pays…
- Therefore the network must check the identity - authentication
- Private identifier needed
- But this must NEVER be transmitted through the radio interface
- But, then how ????

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Authentication

- Producer: Generates a 128 (in UMTS: 256) bit long private key (long enough) to each SIM card
  - K_i – Individual Subscriber Key
  - Off-line presents (paper, CD, …) to the service provider buying the SIM
  - Stores in Authentication Centre (AuC):
    - IMSI – K_i assignment

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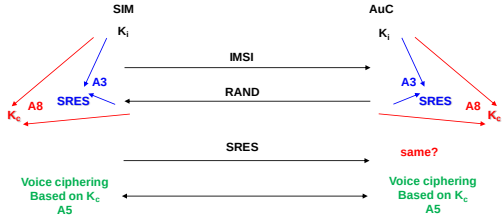
Authentication – theory



RAND: Random Number
SRES: Signed Result
Kc: Ciphering Key

REQUIRES TOO LARGE SIGNALLING TRAFFIC
LET US INVOLVE THE SERVING MSC!

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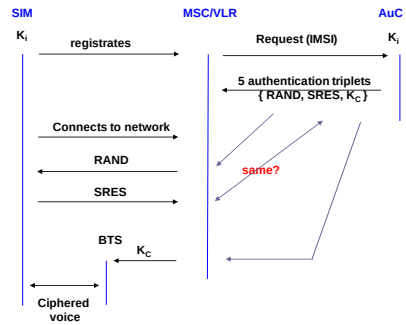
Authentication – practical implementation



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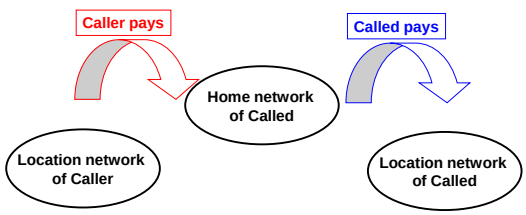
User Confidentiality – Tariff

- Tariff structure
  - - called: right to hide location, not to be discovered even implicitly (through price of the call)
  - - caller: to know in advance how expensive the call will be



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Usage of TMSI instead of IMSI

- Do not send „sensitive” identifier through radio IF
- At very first connection (LU): IMSI
- MSC gives a „random” identifier (this is the TMSI)
- At next connection – use TMSI instead of IMSI
- But how can the MSC whether the TMSI was assigned by itself or by an other MSC?
- MS sends not only the TMSI, but the LAI where it got the TMSI
- If LAI not own, MSC asks the „old” MSC

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Mobility Management (MM)

- The network must know the location of a MS to be able to connect a call, or deliver an SMS to it
  - If the world were just one area
    - No need for location management
    - But Paging in every cell of the world ☹
  - Divide the world to smaller areas – to Page an MS only in a limited part of the world
    - Location Area – LA
    - Often LA = Area served by an MSC, but at heavy traffic areas it is divided logically into more LAs
  - But then the network must keep track the movement of MSs
    - Additional signalling need
    - Additional network elements, processes
    - Still worth

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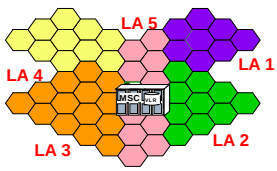
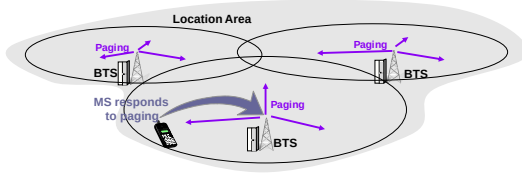
Location Areas



- Area served by an MSC/VLR can be divided into smaller units: **Location Area**
- The maximum size of LA can be one MSC area and the minimum size is one cell
- A subscriber can move within this area without having to make a normal location update
- Paging is done in all cells of the LA where the subscriber is currently located



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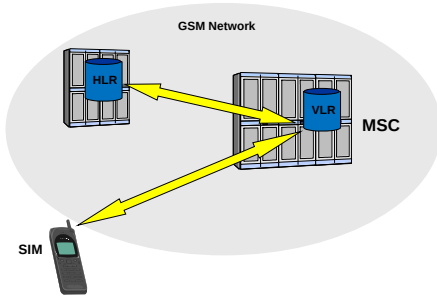
Databases involved in MM in a GSM Network



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Location update

- The Mobile Station monitors the information broadcast by the network (BTS).
- The Mobile Station stores the current location area identity (LAI) in the SIM card.
- The Mobile Station continues to monitor the broadcast information.
- If the location area identity being broadcast by the network is other than the one stored in SIM, the Mobile Station starts the location update (LU) procedure.

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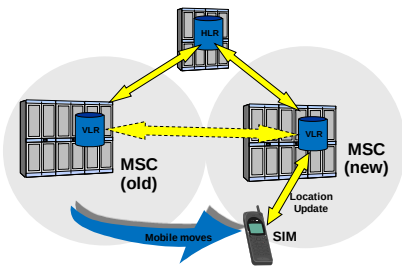
Elements Involved in a Location Update



1. „New" MSC/VLR acquires:
   - IMSI,
   - User Profile (MSISDN),
   - Authentication triplets
2. Inform HLR about new MSC area
3. Inform „Old" MSC/VLR that MS has moved – can clear

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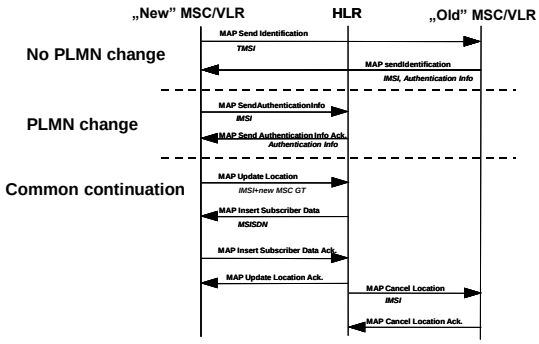
Location Update



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LU variants

- „Normal" (Generic LU)
- Periodic

- Switch on (IMSI Attach)
- Switch off (IMSI Detach)

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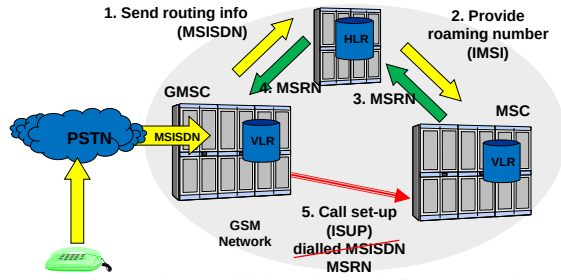
Routing the call inside the GSM network



HLR and serving MSC (VMSC – Visited MSC) may be in different networks – SCCP Global Title

GMSC and serving MSC (VMSC – Visited MSC) may be in different networks – (international) transit switches

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GSM protocols

- Previously discussed: Protocos among MSC, VLR, HLR, EIR (C, D, E, F, G interfaces): SCCP/TCAP/MAP
- Let us have a look at the protocols between the MSC and MS (A, Abis, Um (radio) interfaces) -- simplified
  - Lower layers:
    - A interface: MTP + SCCP
    - Abis interface: LAPD (old friend...)
    - Radio (Um) interface: LAPDm: modified LAPD (optimized for radio channels – e.g. shorter messages, etc.)
  - Two special protocols above them:
    - MM – Mobility Management
    - CC – Call Control (~DSS1)

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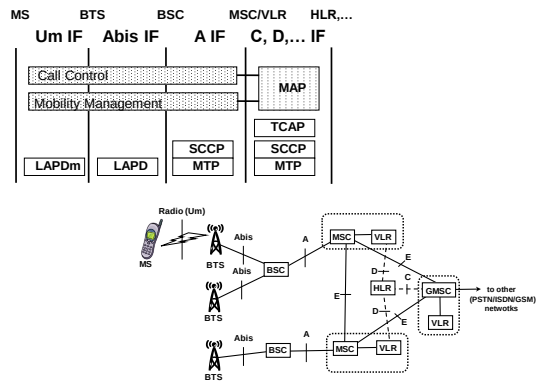
GSM protocols



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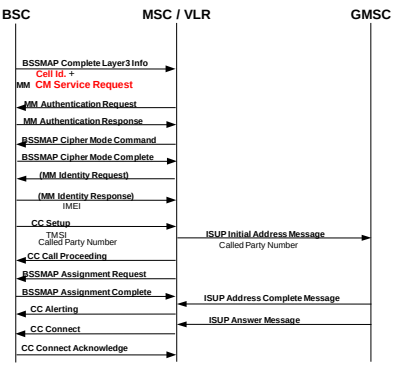
Mobile Originated (MO) Call

- Connection indication
- Authentication
- Ciphering
- IMEI check (optional)
- Call setup – as in DSS1
- The exception: radio channel assignment



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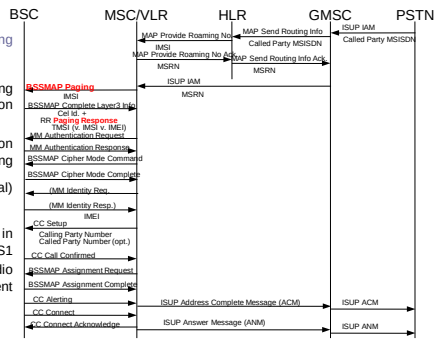
Mobile Terminated (MT) Call

- MSRN acquiring
- Paging
- Conn. indication
- Authentication
- Ciphering
- IMEI check (optional)
- Call setup – as in DSS1
- The exception: radio channel assignment



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Short Message Service

- Signalling service, no voice lines involved
- Datagram service
  - Not requiring the end-to-end establishment of a traffic path between sender and receiver
  - Sender sends SM to SMSC of its home PLMN
  - SMSC delivers it to receiver
- Not guaranteed service
- Asymmetric: Mobile Originating Short Message transmission is considered as a different service from Mobile Terminating Short Message transmission

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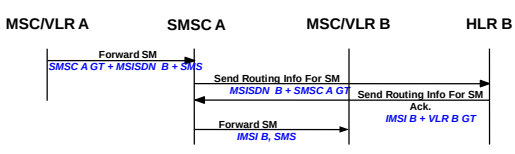
Successful SMS transmission

A: sender
B: receiver



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