G 364: Mobile and Wireless Networking

CLASS 22, Wed. Mar. 31 2004
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Spring 2004
M-W, 11:40am-1:20pm, 109 Rob
Logical vs. Physical Channels

<table>
<thead>
<tr>
<th>Logical channels</th>
<th>Physical channels</th>
</tr>
</thead>
<tbody>
<tr>
<td>(traffic channels, signaling (=control) channels)</td>
<td>(FDMA/TDMA)</td>
</tr>
</tbody>
</table>

- **Physical channels**
  - Time slots @ given frequencies
  - Issues: modulation, slot synchronization, multiple access techniques, duplexing, frequency hopping, etc

- **Logical channels**
  - Built on top of physical channels
  - Issue: which information is exchanged between MS and BSS
# GSM Logical Channels

<table>
<thead>
<tr>
<th>Channel Type</th>
<th>Name</th>
<th>Function</th>
<th>Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic channel (TCH)</td>
<td>TCH/F</td>
<td>TCH full rate</td>
<td>MS↔BSS</td>
</tr>
<tr>
<td></td>
<td>TCH/H</td>
<td>TCH half Rate</td>
<td>MS↔BSS</td>
</tr>
<tr>
<td>Broadcast channel</td>
<td>BCCH</td>
<td>Broadcast control</td>
<td>BSS→MS</td>
</tr>
<tr>
<td>(same information to all MS in a cell)</td>
<td>FCCH</td>
<td>Frequency Correction</td>
<td>BSS→MS</td>
</tr>
<tr>
<td></td>
<td>SCH</td>
<td>Synchronization</td>
<td>BSS→MS</td>
</tr>
<tr>
<td>Common Control channel (CCCH)</td>
<td>RACH</td>
<td>Random Access</td>
<td>MS→BSS</td>
</tr>
<tr>
<td>(point to multipoint channels)</td>
<td>AGCH</td>
<td>Access Grant</td>
<td>BSS→MS</td>
</tr>
<tr>
<td>(used for access management)</td>
<td>PCH</td>
<td>Paging</td>
<td>BSS→MS</td>
</tr>
<tr>
<td>Dedicated Control channel (DCCH)</td>
<td>SDCCH</td>
<td>Stand-alone Dedicated control</td>
<td>MS↔BSS</td>
</tr>
<tr>
<td>(point-to-point signalling channels)</td>
<td>SACCH</td>
<td>Slow associated control</td>
<td>MS↔BSS</td>
</tr>
<tr>
<td>(dedicated to a specific MS)</td>
<td>FACCH</td>
<td>Fast associated control</td>
<td>MS↔BSS</td>
</tr>
</tbody>
</table>
Power Control

- MS has ability to reduce/increase power
  - Up to its power class maximum
- Maximum one 2dB step every 60ms
- Uplink power measures taken by BTS
- Notified back to MS
  - Power level values: 0-15
    - 0 = 43 dBm (20 W)
    - 15 = 13 dBm (20 mW)

Algorithm: manufacturer specific
MS Powering Up

First operation when MS turned ON: spectrum analysis
(either on list of up to 32 Radio Frequency Channel Numbers of current network)
(or on whole 124 carriers spectrum)
Tuning

- MS listens on strongest beacon for a pure sine wave (FCCH)
  - Coarse bit synchronization
  - Fine tuning of oscillator
- Immediately follows SCH burst
  - Fine tuning of synchronization (64 bits training sequence)
  - Read burst content for synchronization data
- Finally, MS can read BCCH (Broadcast Control CHannel)
Paging, 1

- Paging
  - Needed to wake-up MS from IDLE state when incoming call arrives to MS

- MS asks for a channel

Ms asks for a channel

1) paging

2) Random access

3) Channel assignment

Paging channel: PCH
Access Grant Channel: AGCH
Random Access Channel: RACH

CCCH
Common Control Channel

PAGCH

Paging, 2

- Paging message generated by MSC (receives incoming call)
- Transferred to subset of BSC
  - Paging limited to user’s location area
  - Paging message contains:
    - List of cells where paging should be performed
    - Identity of paged user
- Paging message coded in 4 consecutive bursts over the air interface
- Paging for more MSs may be joined in one unique paging message
Access Signaling, 1

Channel_request

Channel_required
rn&frame number, Delay (TA estimate)

Channel_activation

Ch_activation_ack

r&frame number, channel description, Initial TA, initial max power

Immediate_assignment

3/31/04
Access Signaling, 2

- **Immediate_assignment**
  - Initial_message
    - MS ID (IMSI or TMSI), MS capabilities (=classmark), establishment cause
  - Initial_message_ack (UA)
    - Copy of Initial message (including MS ID)

- Establishment_indication

- Further signaling: MSC to MS
GSM Mobility Management

- Major task: Update the location of a MS (for delivering incoming calls)
- A mobile service area is partitioned in Location Areas (LAs)
- LA is a group of Base Transceiver Stations (BTSs)
- Mobility management = location tracking/update of the MS from an LA to another
GSM System Hierarchy

Hierarchy: MSC region → n x Location Areas → m x BSC → k x BTS

MSC: Mobile Switching Center
LA: Location Area
BSC: Base Station Controller
BTS: Base Transceiver Station
Location Update

Called registration

Initiated by MS:

- BTSs broadcast their LA address to the MS
- If LA AD is different from the one with the MS, MS send a registration message to the network (signaling: Chapter 10)
- Location information about the current LA of a MS is stored in HLR (permanent) and VLR (temporary)
GSM Mobility Databases

Two main issues

- Fault tolerance: Need for failure restoration procedures, especially for HLR
- Database overflow: The VLR may overflow (MSs move “en masse” to its controlled area). Causes failure of registration, i.e., the user cannot be provided service (VLR overflow)
GSM Basic Location Update

- Location update procedures handle:
  - Inter-LA movements
  - Inter-MSC movements
  - Inter-VLR movements (no overflow is considered for the moment)

- MS cannot distinguish between types of movement (same format of messages)
Inter-LA Movements

- MS moves from LA1 to LA2 (Figure 11.2)
- Nine message exchanges between MS and MSC + ten between MSC and VLR (GSM 4.08)
- Four major steps
Inter LA: Step 1

- MS requires a location update (LU) to MSC via BTS
- Message includes: current LA address, MSC and VLR (last two are the same) + MS TMSI (temporary mobile system identity)
Inter-LA: Step 2

MSC forward the LU request to VLR via a TCAP message (signaling, SS7)

TCAP includes
- Address of the MSC
- TMSI of the MS
- Previous LA identification (LAI)
- Target LAI
- +
Inter LA: Steps 3 and 4

- VLR notices that LA1 and LA2 belong to the same MSC
- VLR updates the temporary LAI entry for MS
- VLR acknowledges the MS via the MSC
Inter-MSC Movements

- The two LAs belong to two different MSCs of the same VLR (Figure 11.3)
- Six steps procedure
- Step 1 and 2: The LU request is sent by the MS to the network as for the Inter-LA movement case
Inter-MSC: Step 3

VLR notices that LA1 belongs to MSC1 and that LA2 belongs to MSC2 ≠ MSC1

VLR updates the LAI and MSC field of the MS record and derive the HLR address from its recorded IMSI

VLR sends a message to HLR that includes IMSI of MS, address of MSC2, address of VLR, +
Inter-MSC: Steps 4, 5 and 6

**Step 4**
- HLR identifies MS (via IMSI)
- MS record is updated (new MSC)
- Ack is sent to VLR

**Steps 5 and 6**
- Ack is sent to MS
Inter-VLR Movements

- The two LAs belongs to MSCs connected to different VLRs (Figure 11.4)
- Without considering authentication, we have a 8 step procedure
- Step 1: LU request is sent from MS to VLR2 (as for Inter-LA movements)
Inter-VLR: Steps 2 and 3

- VLR2 does not have an entry for MS (the IMSI of the MS is not known)
- The LU request contains the address of VLR1
- VLR2 sends a message to VLR1 with the received TSMI
- VLR1 sends IMSI of MS to VLR2 (difference with IS-41 where IMSI is sent over the air)
Inter-VLR: Steps 4 and 5

- VLR2 creates a record for MS
- Sends a registration message to HLR (step 3 of Inter-MSC case)
- HLR updates record of MS, included the entry for the new VLR
- HLR sends an ack back to VLR2
Inter-VLR: Steps 6, 7 and 8

- **Step 6**: VLR2 generates a new TMSI and sends it to the MS
  - In GSM the TMSI is changed periodically to avoid fraudulent use

- **Steps 7 and 8**: The obsolete record of the MS in VLR1 is deleted
Basic Call Origination

- Call origination is a four steps process (Figure 11.5)
- Step 1: MS sends a call origination request to MSC
- Step 2: MSC forwards the request to VLR (signaling)
- Step 3: VLR checks the “u1”s profile and messages the MSC to grant the call request
- Step 4: The MSC sets up the trunk (PSTN call setup procedure)
Basic Call Termination, CT

Call termination to a GSM subscriber is a six steps process (Figure 11.6) that requires routing information from the serving VLR.

Step 1: When the MS ISDN number (MSISDN) is dialed by a PSTN user, call is routed to a GMSC by SS7.
CT, Steps 2 and 3

- Step 2: GMSC interrogates HLR for routing information
  - Message includes MSISDN +
- Step 3: HLR asks the VLR for the MS roaming number (MSRN)
  - Message includes IMSI, MSC number +
- The MSC number is updated by the Inter-MSC and Inter-VLR procedure and it is needed for setting up the trunk
CT, Steps 4, 5 and 6

- **Step 4:** VLR creates MSRN by using the MSC number stored with the MS information
- **Step 5:** MSRN is sent to GMSC via HLR
- **Step 6:** MSRN provides address of MS’s MSC
- **SS7 message is sent by the GMSC to the MS’s MSC to set up the trunk**
Assignments

- Read chapters 10 and 11 of the textbook
- Updated information on the class web page:

  www.ece.neu.edu/courses/eceg364/2004sp