GSM Radio Network Concepts

Overview of the GSM Interfaces

For the connection of the different nodes in the GSM network, different interfaces are defined in the GSM specifications. The GSM interfaces discussed in this lesson are:

Air interface or Um –interface

The Air Interface is the interface between the BTS (Base Transceiver Station) and the MS (Mobile Station). The air interface is required for supporting:

— Universal use of any compatible mobile station in a GSM network

— A maximum spectral efficiency

A bis –interface

The A bis -interface is the interface between the BSC (Base Station Controller) and the BTS. The interface comprises traffic and control channels. Functions implemented at the A bis -interfaces are:

— Voice-data traffic exchange

— Signaling exchange between the BSC and the BTS

— Transporting synchronization information from the BSC to the BTS

A-interface

The A-interface is the interface between the BSC and the MSC.

The U m –interface

One of the most important interfaces is the U m or Air interface. This interface is thoroughly specified to achieve a full compatibility between mobile stations of various manufacturers and networks of different operators.

FDMA and TDMA methods

To achieve a high spectral efficiency in the cellular network a combination of FDMA (Frequency Division Multiple Access) and TDMA (Time Division Multiple Access) is used. The FDMA part involves the division by frequency of the 25 MHz bandwidth into 124 carrier frequencies spaced 200 KHz for GSM-900. For GSM-1800 the frequency spectrum of the 75 MHz bandwidth is divided into 374 carrier frequencies spaced 200 KHz. One or more frequencies are assigned to each BTS. Each of these carrier frequencies is then divided in time, using a TDMA scheme to increase the number of channels per carrier frequency.

Each carrier frequency channel carries eight time-division multiplexed physical channels. A physical channel is determined by the carrier frequency (or a number of carrier frequencies and a defined hopping sequence) and the timeslot number. A mobile station can transmit speech data only during its assigned timeslot.

Uplink and downlink

In the frequency range specified for the GSM-900 mobile radio networks, 124 frequency channels with a bandwidth of 200 KHz are available for both the uplink and downlink direction. The uplink (mobile station to BTS) uses the frequencies between 890 MHz and 915 MHz and the downlink (BTS to mobile station) uses the frequencies between 935 MHz and 960 MHz. The duplex spacing, the spacing between the uplink and downlink channel, is 45 MHz.

GSM-1800 uses a similar scheme. The difference is that for GSM-1800 the uplink uses the frequencies between 1710 MHz and 1785 MHz and the downlink the frequencies between 1805 MHz and 1880 MHz. The duplex spacing is 95 MHz.

Types of Logical Channels:

1. Traffic channel
   - TCH / F
   - TCH / H
2. Control Channel
   - Broadcast channels
   - Common control channels
   - Dedicated control channels

Logical Channels on the U m –interface

One or more logical channels can be transmitted on a physical channel. There are different types of logical channels. The type of logical channel is determined by the function of the information transmitted over it.

The following types of logical channels are defined:

- Traffic channels
- Broadcast channels
- Common control channels
- Dedicated control channels

Note that the first channel type carries speech and data, and the other types control information (signaling).

Traffic Channels:

The traffic channels are used to send speech or data services. There are two types of traffic channels. They are distinguished by their transmission rates.

The following traffic channels are provided:

- TCH/F (Traffic CHannel Full rate)

  The TCH/F carries information at a gross bit rate of 22.8 kbit/s (after channel coding). The net (or effective) bit rate at the TCH/F is for speech 13 kbit/s and for data 12, 6 or 3.6 kbit/s (before channel coding). The transmission rates of the data services allow services which are compatible to the existing, respectively, 9.6, 4.8 and 2.4 kbit/s PSTN and ISDN services.

- TCH/H (Traffic CHannel Half rate)

  The TCH/H carries information at a gross bit rate of11.4 kbit/s. The net bit rate at the TCH/H is for speech 5.6 kbit/s and for data 6 or 3.6 kbit/s.

A TCH/F or a TCH/H may also be used to send signaling information (for example call forwarding and short messages). In that case a small portion of the time slot is used.

A. Broadcast Channels:

- BCCH
- FCCH
- SCH
- CBCH

B. Common Control Channels:

- PCH
- AGCH
- RACH

C. Dedicated Control Channels:

- SACCH
- FACCH
- SDCCH

Broadcast Channels:

The information distributed over the broadcast channels helps the mobile stations to orient themselves in the mobile radio network.

The broadcast channels are point-to-multipoint channels which are only defined for the downlink direction (BTS to the mobile station). They are divided into:

- BCCH (Broadcast Control CHannel)

Via the BCCH the mobile station is informed about the system configuration parameters (for example Local Area Identification, Cell Identity and Neighbor Cells). Using this information the mobile stations can choose the best cell to attach to.

The BCCH is also known as beacon.

- FCCH (Frequency Correction CHannel)

To communicate with the BTS the mobile station must tune to the BTS. The FCCH transmits a constant frequency shift of the radio frequency carrier that can be used by the mobile station for frequency correction.

- SCH (Synchronization CHannel)

The SCH is used to time synchronize the mobile stations. The data on this channel carries the TDMA frame number and the BSIC (Base Station Identity Code).

- CBCH (Cell Broadcast CHannel)

The CBCH is used for the transmission of generally accessible information (Short Message Service messages) in a cell, which can be polled by the mobile station.

Common Control Channels:

Common control channels are specified as point-to-multipoint channels which only operate in one direction of transmission, either in the uplink or downlink direction. The following channels are provided:

- PCH (Paging CHannel)

The PCH is used in the downlink direction for paging the mobile stations.

- AGCH (Access Grant CHannel)

The AGCH is also used in the downlink direction. A logical channel for a connection is allocated via the AGCH if the mobile station has requested such a channel via the RACH.

- RACH (Random Access CHannel)

The RACH is used in the uplink direction by the mobile stations for requesting a channel for a connection. It is an access channel that uses the slotted Aloha access scheme.

Dedicated Control Channels:

Dedicated control channels are full-duplex, point-to-point channels. They are used for signaling between the BTS and a certain mobile station. They are divided into:

- SACCH (Slow Associated Control Channel)

The SACCH is a duplex channel which is always allocated to a TCH or SDCCH. The SACCH is used for transmission of signaling data, radio link supervision measurements, transmit power control and timing advance data. Note that the SACCH is only used for non-urgent procedures.

- FACCH (Fast Associated Control Channel)

The FACCH is used as a main signaling link for the transmission of signaling data (for example handover commands). It is also required for every call set-up and release. During the call the FACCH data is transmitted over the allocated TCH instead of traffic data; this is marked by a flag called a stealing flag. The process of stealing a TCH for FACCH data is called pre-emption.

- SDCCH (Stand-alone Dedicated Control Channel)

The SDCCH is a duplex, point-to-point channel which is used for signaling in higher layers. It carries all signaling between the BTS and the mobile station when no TCH is allocated. The SDCCHs are used for service requests (for example Short Message Service), location updates, subscriber authentication, ciphering initiation, equipment validation and assignment to a TCH. The net SDCCH bit rate is about 0.8 kbit/s.

Multiplexing Logical Channels on to Physical Channels:

Several of the above-mentioned types of logical channels can be transmitted over one single physical channel (timeslot). The GSM specifications 05.02 specify several combinations of channel types (the sequence of logical channels is fixed).

The order of the logical channels depends on the channel combination.

Channel Combinations:

The channel combinations are:

1. TCH/F + FACCH/F + SACCH/F
2. TCH/H + FACCH/H + SACCH/H
3. (TCH/F + FACCH/F + SACCH/F) or (TCH/H + FACCH/H + SACCH/H)
4. FCCH + SCH + CCCH + BCCH
5. FCCH + SCH + CCCH + BCCH + SDCCH/4 + SACCH/4
6. CCCH + BCCH
7. SDCCH/8 + SACCH/8

Definitions:

The CCCH is a channel that carries both the PCH and the AGCH on the downlink, and the RACH on the uplink.

The extensions "/4" and "/8" in the above mentioned terms mean, respectively, that four and eight logical channels are mapped onto one physical channel (timeslot).

Note that the BCCH is always transmitted in timeslot 0 on the first defined frequency.

Frame Types on the U m –interface:

The GSM specifications define several types of frames, which are:

- TDMA frame

A TDMA frame consist of eight timeslots (physical channels). The length of a timeslot is 0.577 ms. The length of a TDMA frame is therefore 4.62 ms.

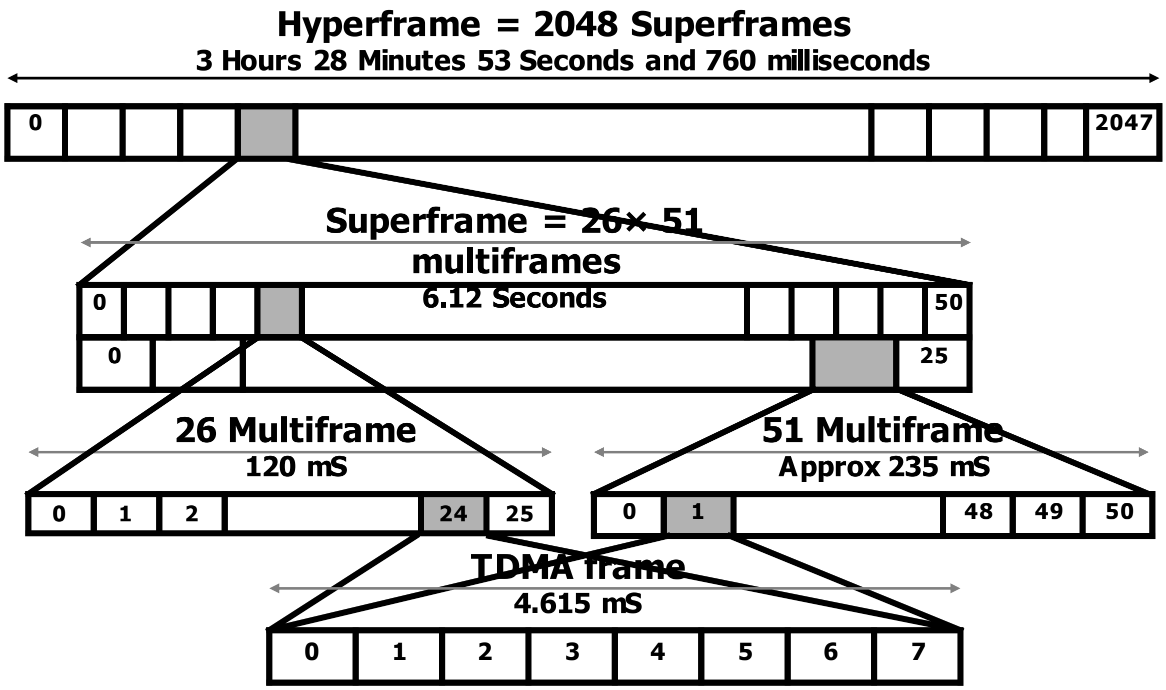
Note: because data on a timeslot is transmitted in bursts, the length of a timeslot is often expressed in BP (Burst Period); 1 BP represents the length of 1 timeslot.

- 26-TDMA multiframe

This multiframe is defined as a succession of 26 TDMA frames, and corresponds to the 26 x 8 BP or 120 ms cycle used in the definition of the TCH/F and TCH/H.

- 51-TDMA multiframe

This multiframe is defined as a succession of 51 TDMA frames, and corresponds to the 51 x 8 BP cycle used in the definition of the TCH/F, TCH/H and of the common channels.



GSM Radio Interface Cycles

- Superframe

The superframe is a succession of 51 x 26 TDMA frames (6.12 sec), and corresponds to the smallest cycle for which the organization of all channels is repeated.

- Hyperframe

The hyperframe is the numbering period. It is 2048 x 51 x 26 x 8 BP long, or 3 hours, 28 minutes, 53 seconds and 760 milliseconds. It is a multiple of all previously cited cycles, and determines all the cycles in the transmission of the radio path. It is in particular the smallest cycle for frequency hopping and for ciphering.

Network Attachment Process:

Network attachment is the process of selecting an appropriate cell (radio frequency) by the mobile station to provide the available services, and making its location known to the network.

The process starts when the mobile is switched on, and ends when the mobile station enter the idle mode. In idle mode the mobile station does not have a traffic channel allocated to make or receive a call, but the Public Land Mobile Network (PLMN) is aware of the existence of the mobile station within the chosen cell.

For normal service, the mobile station has to camp on a suitable call, tune to that cell's control channel. The choice of such a suitable cell for the purpose of normal service is referred to as "normal camping".

The network attachment process consists of the following tasks:-

Cell Identification

When Mobile Station is switched on, it attempts to make contact with a GSM PLMN by performing following actions.

- Measure the BCCH channel.
- Search for a suitable call.

The Mobile Station measure the signal strength of the BCCH (Broadcast Control Channel) channels received. It stores a list information about 30 of these BCCH channels, such as signal strength and the frequency corresponding.

PLMN Selection

The particular PLMN to be contacted can be selected either in one of the following modes:

Automatic mode

In automatic mode, the station will choose which PLMNs to try by itself. The automatic mode is based on the existence of the preferred list, which is stored in a non-volatile memory in the SIM. This list includes a number of PLMN identities in order of preference and is under control of the user. The most preferred is usually the home PLMN. The list is filled in by the user through a mechanism to be specified by the mobile station manufacturer. The automatic mode is normally used when the mobile station operates on its home PLMN(that is the PLMN the mobile station is subscribed to).

Manual mode

In manual mode, the user is presented a list containing all found PLMNs. The user chooses one of the PLMNs from the list.

Cell selection:

The mobile station attempts to find a suitable cell by passing through the list in descending order of received signal strength; the first BCCH channel which satisfies a set of requirements. The requirement that a cell must satisfy before a mobile station can be provide service from it, are:

1. It should be a cell of the selected PLMN.
   The mobile station checks whether the cell is part of the selected PLMN.

2. It should not be "barred".
   The PLMN operator may decide not to allow mobile stations to access certain cells. These cells may, for example, only be used for handover traffic. Barred cell information is broadcast on the BCCH to instruct mobile stations not to access these cells.

3. The radio path loss between the mobile station and the selected BTS must be below a threshold set by the PLMN operator.

4. It should not be in an LA which is in list of "forbidden LA's for roaming".

No suitable cell found

If the mobile station is unable to find a suitable cell to access, it attempts to access a cell irrespective of the PLMN identity, and enters a "limited service" state in which it can only attempt to make emergency calls.

When successfully camped on a cell the mobile station regularly looks to see if there is a better cell in terms of a cell-re-selection criterion, and if there is, the better cell is selected. Also if one of the other criteria changes (e.g the current serving cell becomes based), or there is downlink signaling failure, a new cell is selected.

References:

1. GSM 05.01 Physical layer on the radio path (general description).
2. GSM 05.02 multiplexing and multiple access on the radio path.
3. The GSM system for mobile communication-Michel Mouly and Marie-Bernadette Pautet.
4. GSM system Engineering- Asha Mehrotra (Artech House Publisher).