Technische Universität Braunschweig
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Fundamentals of Mobile Radio Communications

Exercise 9: GSM - Global System for Mobile Communications

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1 Basics

1.1 Why was the GSM standard developed? What were the main services offered by network operators at the time?

GSM (Global System for Mobile Communications) was created as a specification for a mobile communications standard to harmonize the large number of incompatible mobile communications systems in Europe. Voice and SMS were the main services at the time.

1.2 What multiplexing and duplexing methods are used in GSM?

GSM uses a combination of frequency and time division multiplexing (FDM and TDM) as the multiplexing method. GSM uses Frequency Division Duplexing (FDD) as the duplexing method with a time offset of 3 time slots between UL and DL.

1.3 Which carrier frequencies are used in GSM900 for downlink and uplink? What is the frequency duplex spacing of this system?

2 Frame and Channel Structure

2.1 What is a TDMA frame? How is a "normal burst" organized? What other burst types does GSM support?

In GSM, the time is divided in time slots (called "bursts"), each about 577 µs long. Eight of these bursts are combined into a frame, lasting about 4.6 ms.

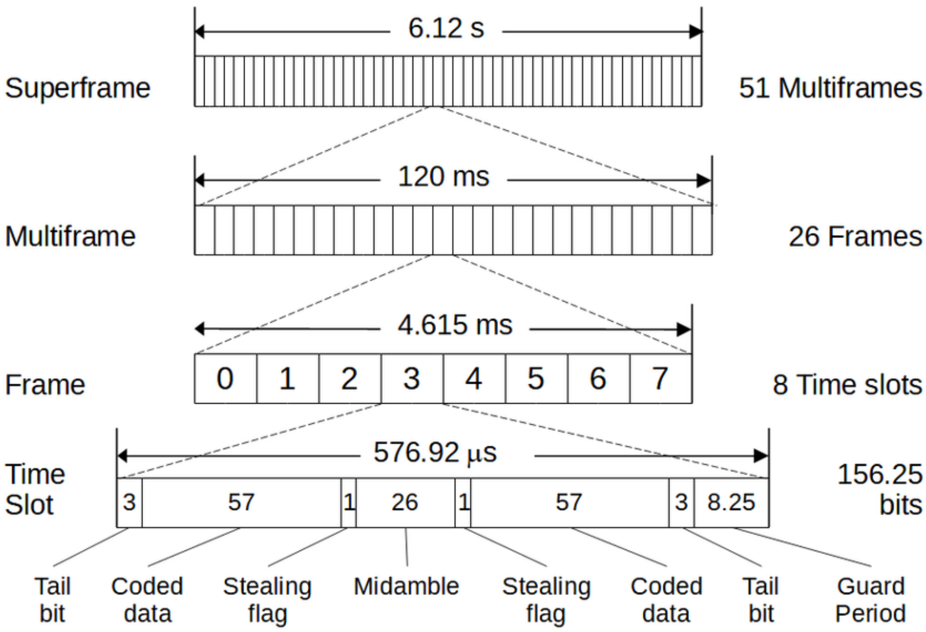

Figure 1: GSM Frame Structure

26 frames, from which 24 are used to transport data, are further organized into a multiframe that lasts for 120 ms. The remaining two bursts are used for control information. This results in the following key values:

Parameter	Value
T_{burst}	577 µs
T_{frame}	4.6 ms
$T_{\text{multiframe}}$	120 ms
bits per burst	156.25 bit
avg. data bits per burst	105 bit (117 data bits * 24/26)
bit rate per channel	$\frac{105\,\text{bit}}{4.6\,\text{ms}} = 22.8\,\text{kbit/s}$

Table 1: Key values for GSM timing

The possible burst types are:

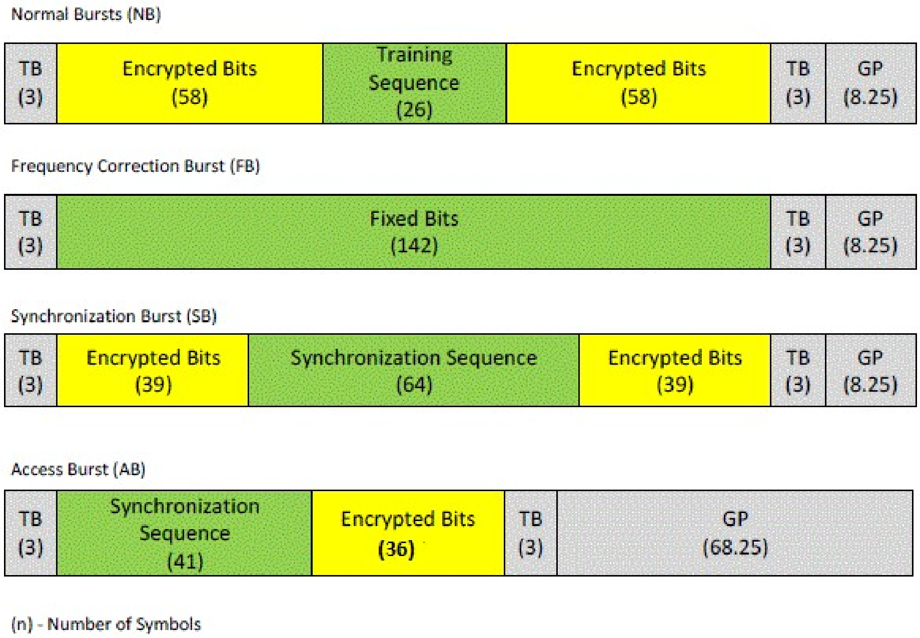

Figure 2: GSM Burst Types

2.2 What are physical and logical channels?

The GSM standard divides communication into physical and logical channels. This ensures structured communication and control within the mobile network.

2.2.1 Physical channels

Physical channels represent the individual channels resulting from time and frequency multiplexing and enable transmission of information between mobile station and base station. Each physical channel can be identified using the ARFCN and the time slot number and therefore corresponds to a specific time slot on a particular frequency.

2.2.2 Logical channels

Logical channels specify the type of data transmitted and are mapped onto physical channels. These channels are categorized into two groups: Traffic Channels (TCH) and Control Channels (CCH).

Traffic Channels (TCH) are used for data transmission

Control Channels (CCH) manage network signaling and control (like cell identification, frequency correction, time synchronisation, ...)

2.3 How are the CCHs organized and what are their tasks? Give examples.

2.3.1 Broadcast Control Channels (BCCH Group)

Broadcast Control Channels are DL-only control channels and are used to broadcast information to all MSs in a cell.

Broadcast Common Control Channel (BCCH) Transmits system information such as cell parameters, frequency allocations, and access rules.

Frequency Correction Channel (FCCH) Enables mobile stations to synchronize their frequency using a *Frequency Correction Burst.*

Synchronization Channel (SCH) Provides frame synchronization and cell identification data.

2.3.2 Common Control Channels (CCCH Group)

These channels handle network access and connection establishment.

Paging Channel (PCH) Sends notifications to mobile stations about incoming calls or messages.

Access Grant Channel (AGCH) Assigns network resources to mobile stations.

Random Access Channel (RACH) Used by mobile stations to initiate a connection with the network.

2.3.3 Dedicated Control Channels (DCCH Group)

These channels manage communication between a base station (BTS) and an individual mobile station.

Standalone Dedicated Control Channel (SDCCH) Handles signaling information such as authentication, location updates and SMS point-to-point transmission.

Slow Associated Control Channel (SACCH) Supports TCH and SDCCH with periodic control information (e.g., power control).

Fast Associated Control Channel (FACCH) Temporarily replaces a TCH to transmit urgent signaling data.

3 Operating Modes and Procedures

3.1 Which operation modes do exist for mobile stations?

Idle Mode In this mode, the MS is switched on but not actively involved in communication. It monitors the network and is ready to establish a connection when needed. The key functions are:

- Cell Selection and Reselection
- Monitoring of the BCCH
- Listening for Paging Messages (PCH)
- Random Access Attempts (RACH)

Dedicated Mode When the MS establishes a connection with the network (e.g., during a call or data session), it enters Dedicated Mode. In this mode:

- A traffic channel (TCH) is allocated for voice or data transmission.
- Signaling channels manage call setup, authentication and mobility updates.
- The MS exchanges control signals with the BS for handovers, power control and quality monitoring.

3.2 For the following situations, determine whether the C1 criterion is fulfilled or not.

The C1 criterion is a path loss criterion and determines whether a MS should stay in the current cell or handover to a better one. It is calculated as follows:

$$C1 = RXLEV - RXLEV\_ACCESS\_MIN - \max(0, (MS\_TXPWR\_MAX\_CCH - P))$$

If $C1 > 0\,\text{dB}$, a connection is possible.

$$\max(0, (MS\_TXPWR\_MAX\_CCH - P))$$

is 0 (in most cases), since the maximum transmission power P of the mobile station is (usually) higher than the maximum allowed transmission power on the CCH ($MS\_TXPWR\_MAX\_CCH$). This simplifies the C1 criterion to

$$C1 = RXLEV - RXLEV\_ACCESS\_MIN$$

which is used for the following calculations.

3.2.1 $P_{\mathrm{dBm,TX,BS}} = 55\,\mathrm{dBm}$, $P_{\mathrm{dBm,RX,BS,min}} = 55\,\mathrm{dBm}$, $PL = 152\,\mathrm{dB}$, $RXLEV\_ACCESS\_MIN = -97\,\mathrm{dBm}$

3.2.2 same values, but $PL = 120\,\mathrm{dB}$

3.3 Check whether a power budget handover occurs or not.

The power budget for a neighboring cell BS_n next to the serving cell BS_s can be calculated with

$$PBGT(BS_s, BS_n) = (RXLEV(BS_n) - MS\_TXPWR\_MAX(BS_n)) - (RXLEV^*(BS_s) - MS\_TXPWR\_MAX(BS_s)),$$

where $RXLEV^*(BS_s) = RXLEV(BS_s) + PWR\_CTL$.
A handover in this case occurs when $PBGT > 0$ and greater than the HO_MARGIN. Also, C1 criterion needs to be fulfilled for neighboring cell BS_n.

3.3.1 receive level of serving cell: –100 dBm, possible power control: 10 dB, receive level of neighboring cell: –85 dBm, handover margin: 6 dB, $MS\_TXPWR\_MAX(BS_s) = MS\_TXPWR\_MAX(BS_n)$, $RXLEV\_ACCESS\_MIN = -104$ dBm

3.3.2 Why is a HO margin needed?

The handover margin reduces the occurrence of ping-pong handovers by adding hysteresis.