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Hans-Jörg Vögel and Christian Bettstetter
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GSM

Switching, Services and Protocols Second Edition

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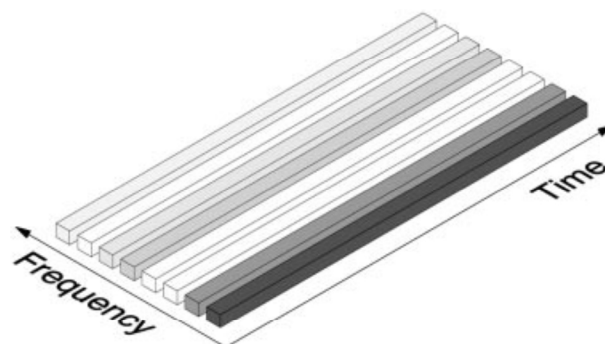


Figure 2.6: Channels of an FDMA system (schematic)

2.3.2 Time Division Multiple Access (TDMA)

Time Division Multiple Access (TDMA) is a more expensive technique, for it needs a highly accurate synchronization between transmitter and receiver. The TDMA technique is used in digital mobile radio systems. The individual mobile stations are cyclically assigned a frequency for exclusive use only for the duration of a time slot. Furthermore, in most cases the whole system bandwidth for a time slot is not assigned to one station, but the system frequency range is subdivided into subbands, and TDMA is used for multiple access to each subband. The subbands are known as carrier frequencies, and the mobile systems using this technique are designated as multicarrier systems (not to be confused with multicarrier modulation). The pan-European digital system GSM employs such a combination of FDMA and TDMA; it is a multicarrier TDMA system. A frequency range of 25 MHz holds 124 single channels (carrier frequencies) of 200 kHz bandwidth each, with each of these frequency channels containing again 8 TDMA conversation channels.

Thus the sequence of time slots assigned to a mobile station represents the physical channels of a TDMA system. In each time slot, the mobile station transmits a data burst. The period assigned to a time slot for a mobile station thus also determines the number of TDMA channels on a carrier frequency. The time slots of one period are combined into a so-called TDMA frame. Figure 2.7 shows five channels in a TDMA system with a period of four time slots and three carrier frequencies.

The TDMA signal transmitted on a carrier frequency in general requires more bandwidth than an FDMA signal, since because of multiple time use, the gross data rate has to be correspondingly higher. For example, GSM systems employ a gross data rate (modulation data rate) of 271 kbit/s on a subband of 200 kHz, which amounts to 33.9 kbit/s for each of the eight time slots.

Especially narrowband systems suffer from time- and frequency-selective fading (Figures 2.2 and 2.3) as already mentioned. In addition, there are also frequency-selective co-channel interferences, which can contribute to the deterioration of the transmission quality. In a TDMA system, this leads to the phenomenon that the channel can be very good during one time slot, and very bad during the next time slot when some bursts are strongly interfered with. On the other hand, a TDMA system offers very good opportunities to

the carried service (e.g. telephony). For the packet-switched mode, the TCH carries user data of OSI Layers 2 and 3 according to the recommendations of the X.25 standard or similar standard packet protocols.

A TCH may either be fully used (full-rate TCH, TCH/F) or be split into two half-rate channels (half-rate TCH, TCH/H), which can be allocated to different subscribers. Following ISDN terminology, the GSM traffic channels are also designated as Bm channel (mobile B channel) or Lm channel (lower-rate mobile channel, with half the bit rate). A Bm channel is a TCH for the transmission of bit streams of either 13 kbit/s of digitally coded speech or of data streams at 14.5, 12, 6, or 3.6 kbit/s. Lm channels are TCH channels with less transmission bandwidth than Bm channels and transport speech signals of half the bit rate (TCH/H) or bit streams for data services with 6 or 3.6 kbit/s.

Table 5.1: Classification of logical channels in GSM

Group		Channel	Function	Direction
Traffic channel	Traffic channel (TCH)	TCH/F, Bm	Full rate TCH	MS ↔ BSS
		TCH/H, Lm	Half rate TCH	MS ↔ BSS
Signaling channels (Dm)	Broadcast channel	BCCH	Broadcast control	MS ← BSS
		FCCH	Frequency correction	MS ← BSS
		SCH	Synchronization	MS ← BSS
		RACH	Random access	MS → BSS
	Common control channel (CCCH)	AGCH	Access grant	MS ← BSS
		PCH	Paging	MS ← BSS
		NCH	Notification	MS ← BSS
		SDCCH	Stand-alone dedicated control	MS ↔ BSS
	Dedicated control channel (DCCH)	SACCH	Slow associated control	MS ↔ BSS
		FACCH	Fast associated control	MS ↔ BSS

5.1.2 Signalling Channels

The control and management of a cellular network demands a very high signaling effort. Even when there is no active connection, signaling information (for example location update information) is permanently transmitted over the air interface. The GSM signaling channels offer a continuous, packet-oriented signaling service to MSs in order to enable them to send and receive messages at any time over the air interface to the BTS. Following ISDN terminology, the GSM signaling channels are also called Dm channels (mobile D channel). They are further divided into: *Broadcast Channel* (BCH), *Common Control Channel* (CCCH), and *Dedicated Control Channel* (DCCH) (see Table 5.1).

The unidirectional Broadcast Channels are used by the *Base Station Subsystem* (BSS) to

broadcast the same information to all MSs in a cell. The group of Broadcast Channels consists of three channels:

- *Broadcast Control Channel (BCCH)*: On this channel, a series of information elements is broadcast to the MSs which characterize the organization of the radio network, such as radio channel configurations (of the currently used cell as well as of the neighboring cells), synchronization information (frequencies as well as frame numbering), and registration identifiers (LAI, CI, BSIC). In particular, this includes information about the structural organization (formats) of the CCCH of the local BTS. The BCCH is broadcast on the first frequency assigned to the cell (the so-called *BCCH carrier*).
- *Frequency Correction Channel (FCCH)*: On the FCCH, information about correction of the transmission frequency is broadcast to the MSs; see Section 5.2.2 (frequency correction burst).
- *Synchronization Channel (SCH)*: The SCH broadcasts information to identify a BTS, i.e. *Base Station Identity Code (BSIC)*; see Section 3.2.9. The SCH also broadcasts data for the frame synchronization of an MS, i.e. *Reduced Frame Number (RFN)* of the TDMA frame; see Section 5.3.1.

FCCH and SCH are only visible within protocol Layer 1, since they are only needed for the operation of the radio subsystem. There is no access to them from Layer 2. In spite of this fact, the SCH messages contain data which are needed by Layer 3 for the administration of radio resources. These two channels are always broadcast together with the BCCH.

The CCCH is a point-to-multipoint signaling channel to deal with access management functions. This includes the assignment of dedicated channels and paging to localize a mobile station. It comprises the following:

- *Random Access Channel (RACH)*: The RACH is the uplink portion of the CCCH. It is accessed from the mobile stations in a cell without reservation in a competitive multiple-access mode using the principle of slotted Aloha [4], to ask for a dedicated signaling channel (SDCCH) for exclusive use by one MS for one signaling transaction.
- *Access Grant Channel (AGCH)*: The AGCH is the downlink part of the CCCH. It is used to assign an SDCCH or a TCH to a mobile station.
- *Paging Channel (PCH)*: The PCH is also part of the downlink of the CCCH. It is used for paging to find specific mobile stations.
- *Notification Channel (NCH)*: The NCH is used to inform mobile stations about incoming group and broadcast calls.

The last type of signaling channel, the DCCH is a bidirectional point-to-point signaling channel. An *Associated Control Channel (ACCH)* is also a dedicated control channel, but it is assigned only in connection with a TCH or an SDCCH. The group of *Dedicated/Associated Control Channels (D/ACCH)* comprises the following:

- *Stand-alone Dedicated Control Channel (SDCCH)*: The SDCCH is a dedicated point-to-point signaling channel (DCCH) which is not tied to the existence of a TCH (“stand-alone”), i.e. it is used for signaling between an MS and the BSS when there is no active connection. The SDCCH is requested from the MS via the RACH and assigned via the AGCH. After the completion of the signaling transaction, the SDCCH is released and can be reassigned to another MS. Examples of signaling transactions

into the GSM network. Data is transmitted in the PLMN in nontransparent and synchronous mode. Access to the packet handler is the same in all PLMNs, and is also available to foreign mobile subscribers. Since packet data networks do not know roaming, only outgoing data calls are possible.

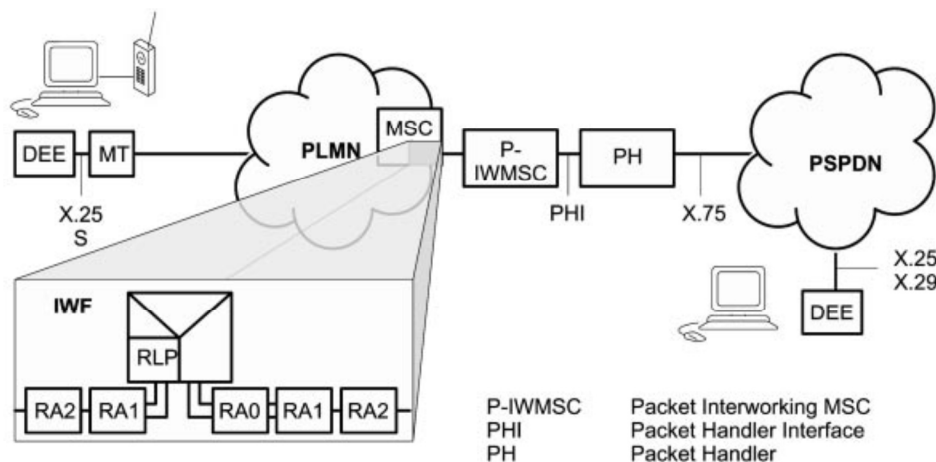


Figure 9.15: Dedicated packet mode with packet handler in GSM

9.7 Teleservices: Fax

In the following, we briefly explain the realization of the GSM fax service.

The GSM standard considers the connection of a regular Group 3 fax terminal with its two-wire interface to an appropriately equipped mobile station as the standard configuration of a mobile fax application. The GSM fax service is supposed to enable this configuration to conduct fax transmissions with standard Group 3 fax terminals over mobile connections. This requires mapping the fax protocol of the analog two-wire interface onto the digital GSM transmission, because the fax procedure defines a complete protocol stack with its own modulation, coding, user data compression, inband signaling, etc. Therefore the *Fax Adapter* (FA) has been defined for this mapping. The principle is summarized in Figure 9.16. The fax adapter of the mobile station converts the fax protocol of a standard Group 3 fax terminal on an analog two-wire line into a GSM internal fax adapter protocol. The PDUs of the adapter protocol are transmitted over the MT with the GSM data services to the fax adapter in the IWF of the MSC, and there they are again converted into the T.30 protocol on the analog line, or transmitted to the ISDN in PCM-coded format, where again a terminal adapter allows connection of a Group 3 fax terminal (not shown in Figure 9.16).

A more compact version of a mobile fax terminal is possible, if the fax adapter and the Group 3 fax terminal are integrated into a compact terminal (GSM fax, Figure 9.16). Such equipment can be connected at reference point R to an MT2. It delivers a digital signal directly. With this integration, the analog two-wire line interface becomes superfluous.