- **Handoff measurement request**: A serving MSC can sometimes request an adjacent MSC for a handoff measurement. In case the response requires a handoff to be performed, the MSC informs the HLR of this handoff and the HLR updates its database to indicate this change.
- **Recovery from failure at the HLR**: This IS-41 procedure is used in the event of an HLR failure. In case of failure the HLR sends an UNRELDIR (Unreliable Roamer Data Directive INVOKE) to all the VLRs in its database. On receiving this message, all the VLRs remove all the associated data regarding this HLR and go through the registration process again.

11.4 GSM

GSM (Global System for Mobile communications or Groupe Speciale Mobile) communications, initiated by the European Commission, is the second-generation mobile cellular system aimed at developing a Europe-wide digital cellular system. GSM was created in 1982 to establish a common European mobile telephone standard that would formulate specifications for a pan-European mobile cellular radio system operating at 900 MHz. The main objective of GSM is to remove any incompatibility among the systems by allowing the roaming phenomenon for any cell phone. It also supports speech transmissions between MSs, emergency calls, and digital data transmissions.

A block diagram representation of the GSM infrastructure is given in Figure 11.8, with various interfaces clearly marked [11.2]. The radio link interface through the air is between the MS and the base transceiver station (BTS). A MS

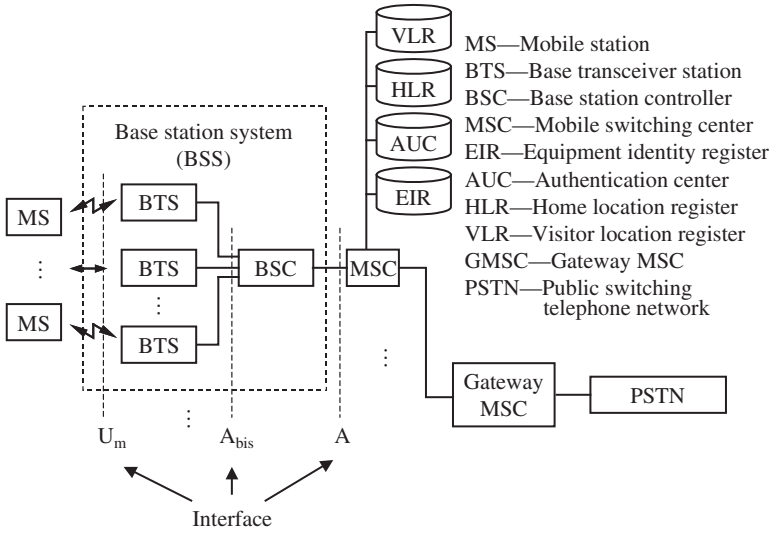

Figure 11.8
GSM infrastructure.

interfaces only with the BTS. Many BTSs are controlled by a BS controller (BSC), which in turn has an interface to a MSC. Specific functions of different constituents are as follows:

- **Base station controller (BSC)**: The main function of the BSC is to look over a certain number of BTSs to ensure proper operation. It takes care of handoff from one BTS to the other, maintains appropriate power levels of the signal, and administers frequency among BTSs.
- **Mobile switching center (MSC)**: The MSC basically performs the switching functions of the system by controlling calls to and from other telephone and data systems. It also does functions such as network interfacing and common channel signaling. If the MSC has an interface to the PSTN, then it is called a gateway MSC. GSM uses two important databases called HLR and VLR, to keep track of the current location of a MS.
- **Authentication center (AUC)**: AUC unit provides authentication and encryption parameters that verify the user's identity and ensure the confidentiality of each call. The AUC protects network operators from different types of frauds and spoofing found in today's cellular world.
- **Equipment identity register (EIR)**: EIR is a database that contains information about the identity of mobile equipment that prevents calls from being stolen and prevents unauthorized or defective MSs. Both AUC and EIR can be implemented as individual stand-alone nodes or as a combined AUC/EIR node.

11.4.1 Frequency Bands and Channels

GSM has been allocated an operational frequency from 890 MHz to 960 MHz. To reduce possible interference, the MS and the BS use different frequency ranges (i.e., MSs employ 890 MHz to 915 MHz and BS operates in 935 MHz to 960 MHz). GSM follows FDMA and allows up to 124 MSs to be serviced at the same time (i.e., the frequency band of 25 MHz is divided into 124 frequency division multiplexing (FDM) channels, each of 200 kHz as shown in Figure 11.9). A guard frame

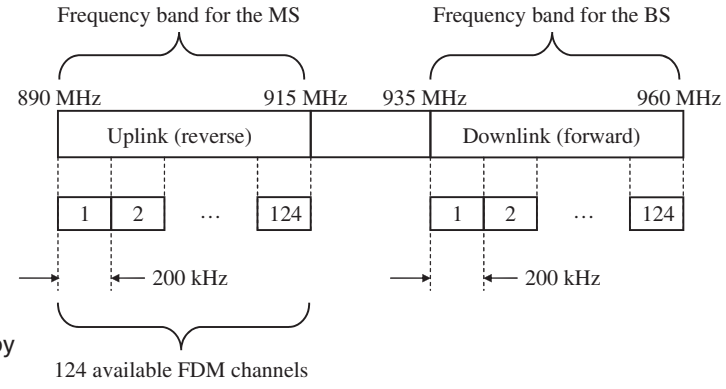

Figure 11.9
Frequency band used by GSM.

of 8.25 bits is used in between any two frames transmitted either by the BS or the MS.

GSM uses a variety of multiplexing techniques to create a collection of logical channels. The channels used by a GSM system are shown in Table 11.3.

Table 11.3: ▶
Channels in GSM

Channel	Group	Channel	Direction
Control channel	BCCH (Broadcast control channel)	BCCH (Broadcast control channel)	BS →MS
		FCCH (Frequency correction channel)	BS →MS
		SCH (Synchronization channel)	BS →MS
	CCCH (Common control channel)	PCH (Paging channel)	BS →MS
		RACH (Random access channel)	BS ← MS
		AGCH (Access grant channel)	BS →MS
	DCCH (Dedicated control channel)	SDCCH (Stand-alone dedicated control channel)	BS ↔ MS
		SACCH (Slow associated control channel)	BS ↔ MS
		FACCH (Fast associated control channel)	BS ↔ MS
Traffic channel	TCH (Traffic channel)	TCH/f (Full-rate traffic channel)	BS ↔ MS
		TCH/s (Half-rate traffic channel)	BS ↔ MS

The GSM system uses a variety of control channels to ensure uninterrupted communication between MSs and the BS. Three control channels are used for broadcasting some information to all MSs:

- **Broadcast control channel (BCCH)**: Used for transmitting system parameters, (e.g., the frequency of operation in the cell, operator identifiers) to all the MSs.
- **Frequency correction channel (FCCH)**: Used for transmission of frequency references and frequency correction burst of 148 bits length.
- **Synchronization channel (SCH)**: Used to provide the synchronization training sequences burst of 64 bits length to the MSs.

Three common control channels are used for establishing links between the MS and the BS, as well as for any ongoing call management:

- **Random-access channel (RACH)**: Used by the MS to transmit information regarding the requested dedicated channel from GSM.
- **Paging channel**: Used by the BS to communicate with individual MS in the cell.
- **Access-grant channel**: Used by the BS to send information about timing and synchronization.

Two dedicated control channels are used along with traffic channels to serve for any control information transmission during actual communication:

- **Slow associated control channel (SACCH)**: Allocated along with a user channel, for transmission of control information during the actual transmission.
- **Stand-alone dedicated control channel (SDCCH)**: Allocated with SACCH; used for transfer of signaling information between the BS and the MS.
- **Fast associated control channel (FACCH)**: FACCH is not a dedicated channel but carries the same information as SDCCH. However, FACCH is a part of the traffic channel, while SDCCH is a part of the control channel. To facilitate FACCH to steal certain bursts from the traffic channel, there are 2 bits, called the flag bits in the message.

11.4.2 Frames in GSM

The GSM system uses the TDMA scheme shown in Figure 11.10 with a 4.615 ms–long frame, divided into eight time slots each of 0.557 ms. Each frame measured in terms of time is 156.25 bits long, of which 8.25 period bits are guard bits for protection. The 148 bits are used to transmit the information. Delimited by tail bits (consisting of 0s), the frame contains 26 training bits sandwiched between two bursts of data bits. These training bits allow the receiver to synchronize itself. Many such frames are combined to constitute multiframe, superframe, and hyperframes.

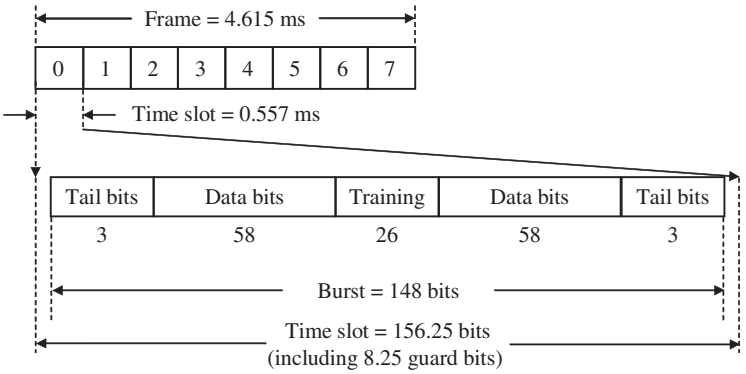

Figure 11.10
Frame structure in TDMA.

11.4.3 Identity Numbers Used by a GSM System

Several identity numbers are associated with a GSM system, as follows:

- **International mobile subscriber identity (IMSI)**: When a cell phone attempts a call, it needs to contact a BS. The BS can offer its service only if it identifies the cell phone (MS) as a valid subscriber. For this, the MS needs to store certain values uniquely defined for the MS, like the country of subscription, network type, and subscriber ID, and so on. These values are called the international mobile subscriber identity (IMSI). This number is usually 15 digits or less. The structure