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1.4.3 Cellular Telephone Systems

A cellular telephone system provides a wireless connection to the PSTN for any user location within the radio range of the system. Cellular systems accommodate a large number of users over a large geographic area, within a limited frequency spectrum. Cellular radio systems provide high quality service that is often comparable to that of the landline telephone systems. High capacity is achieved by limiting the coverage of each base station transmitter to a small geographic area called a *cell* so that the same radio channels may be reused by another base station located some distance away. A sophisticated switching technique called a *handoff* enables a call to proceed uninterrupted when the user moves from one cell to another.

Figure 1.5 shows a basic cellular system which consists of *mobile stations*, *base stations* and a *mobile switching center (MSC)*. The Mobile Switching Center is sometimes called a *mobile telephone switching office (MTSO)*, since it is responsible for connecting all mobiles to the PSTN in a cellular system. Each mobile communicates via radio with one of the base stations and may be handed-off to any number of base stations throughout the duration of a call. The mobile station contains a transceiver, an antenna, and control circuitry, and may be mounted in a vehicle or used as a portable hand-held unit. The base stations consist of several transmitters and receivers which simultaneously handle full duplex communications and generally have towers which support several transmitting and receiving antennas. The base station serves as a bridge between all mobile users in the cell and connects the simultaneous mobile calls via telephone lines or microwave links to the MSC. The MSC coordinates the activities of all of the base stations and connects the entire cellular system to the PSTN. A typical MSC handles 100,000 cellular subscribers and 5,000 simultaneous conversations at a time, and accommodates all billing and system maintenance functions, as well. In large cities, several MSCs are used by a single carrier.

Communication between the base station and the mobiles is defined by a standard *common air interface (CAI)* that specifies four different channels. The channels used for voice transmission from the base station to mobiles are called *forward voice channels (FVC)* and the channels used for voice transmission from mobiles to the base station are called *reverse voice channels (RVC)*. The two channels responsible for initiating mobile calls are the *forward control channels (FCC)* and *reverse control channels (RCC)*. Control channels are often called *setup channels* because they are only involved in setting up a call and moving it to an unused voice channel. Control channels transmit and receive data messages that carry call initiation and service requests, and are monitored by mobiles when they do not have a call in progress. Forward control channels also serve as beacons which continually broadcast all of the traffic requests for all mobiles in the system. As described in Chapter 10, supervisory and data mes-

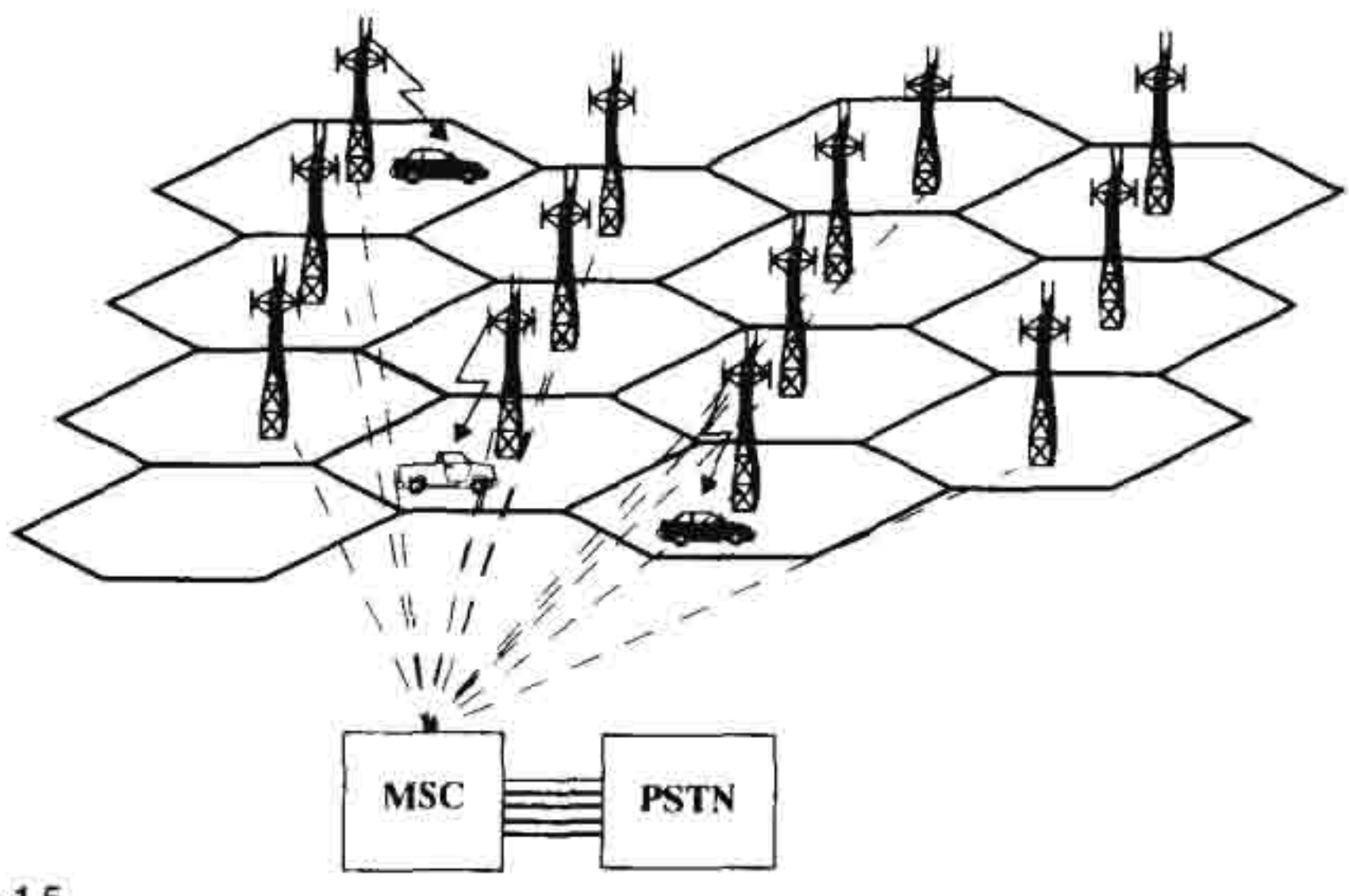


Figure 1.5
 An illustration of a cellular system. The towers represent base stations which provide radio access between mobile users and the Mobile Switching Center (MSC).

sages are sent in a number of ways to facilitate automatic channel changes and handoff instructions for the mobiles before and during a call.

Example 1.2

Cellular systems rely on the frequency reuse concept, which requires that the forward control channels (FCCs) in neighboring cells be different. By defining a relatively small number of FCCs as part of the common air interface, cellular phones can be manufactured by many companies which can rapidly scan all of the possible FCCs to determine the strongest channel at any time. Once finding the strongest signal the cellular phone receiver stays "camped" to the particular FCC. By broadcasting the same setup data on all FCCs at the same time, the MSC is able to signal all subscribers within the cellular system and can be certain that any mobile will be signaled when it receives a call via the PSTN.

1.4.3.1 How a Cellular Telephone Call is Made

When a cellular phone is turned on, but is not yet engaged in a call, it first scans the group of forward control channels to determine the one with the strongest signal, and then monitors that control channel until the signal drops below a usable level. At this point it again scans the control channels in search of the strongest base station signal. For each cellular system described in Table 1.1 through Table 1.3, the control channels are defined and standardized over the entire geographic area covered and typically make up about 5% of the total num-

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accomplished over the FCC, since each roamer is camped on to a FCC at all times. Every several minutes, the MSC issues a global command over each FCC in the system, asking for all mobiles which are previously unregistered to report their MIN and ESN over the RCC. New unregistered mobiles in the system periodically report back their subscriber information upon receiving the registration request, and the MSC then uses the MIN/ESN data to request billing status from the home location register (HLR) for each roaming mobile. If a particular roamer has roaming authorization for billing purposes, the MSC registers the subscriber as a valid roamer. Once registered, roaming mobiles are allowed to receive and place calls from that area, and billing is routed automatically to the subscriber's home service provider. The networking concepts used to implement roaming are covered in Chapter 9.

1.4.4 Comparison of Common Mobile Radio Systems

Table 1.5 and Table 1.6 illustrate the types of service, level of infrastructure, cost, and complexity required for the subscriber segment and base station segment of each of the five mobile or portable radio systems discussed earlier in this chapter. For comparison purposes, common household wireless remote devices are shown in the table. It is important to note that each of the five mobile radio systems given in Table 1.5 and Table 1.6 use a fixed base station, and for good reason. Virtually all mobile radio communication systems strive to connect a moving terminal to a fixed distribution system of some sort and attempt to look invisible to the distribution system. For example, the receiver in the garage door opener converts the received signal into a simple binary signal which is sent to the switching center of the garage motor. Cordless telephones use fixed base stations so they may be plugged into the telephone line supplied by the phone company – the radio link between the cordless phone base station and the portable handset is designed to behave identically to the coiled cord connecting a traditional wired telephone handset to the telephone carriage.

Notice that the expectations vary widely among the services, and the infrastructure costs are dependent upon the required coverage area. For the case of low power, hand-held cellular phones, a large number of base stations are required to insure that any phone is in close range to a base station within a city. If base stations were not within close range, a great deal of transmitter power would be required of the phone, thus limiting the battery life and rendering the service useless for hand-held users.

Because of the extensive telecommunications infrastructure of copper wires, microwave line-of-sight links, and fiber optic cables — all of which are fixed — it is highly likely that future land-based mobile communication systems will continue to rely on fixed base stations which are connected to some type of fixed distribution system. However, emerging mobile satellite networks will require orbiting base stations.

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MSC		Receives call from PSTN. Sends the requested MIN to all base stations		Verifies that the mobile has a valid MIN, ESN pair.	Requests BS to move mobile to unused voice channel pair.		Connects the mobile with the calling party on the PSTN.
	FCC		Transmits page (MIN) for specified user.			Transmits data messages for mobile to move to specific voice channel.	
Base Station	RCC			Receives MIN, ESN, Station Class Mark and passes to MSC.			
	FVC						Begin voice transmission.
Mobile	RVC						Begin voice reception.
	FCC		Receives page and matches the MIN with its own MIN.			Receives data messages to move to specified voice channel.	
	RCC			Acknowledges receipt of MIN and sends ESN and Station Class Mark.			
	FVC						Begin voice reception.
	RVC						Begin voice transmission.

time →

Figure 1.6 Timing diagram illustrating how a call to a mobile user initiated by a landline subscriber is established

