Chapter 2

MOBILE COMPUTING

1. Cellular Networks:

Cellular communication has experienced explosive growth in the past two decades. Today millions of people around the world use cellular phones. Cellular phones allow a person to make or receive a call from almost anywhere. Likwise, a person is allowed to continue the phone conversation while on the move. Cellular communications is supported by an infrastructure called a cellular phones into the public switched telephone network.

The cellular network has gone through three generations. The first generation of cellular networks is analog in nature. To accommodate more cellular phone substribers, digital TDMA (time division multiple access) and CDMA (Code Division Multiple Access) technologies are used in the second generation (2G) to increase the network capacity. With digital technologies, digitized voice can be coded and encrypted. Therefore, the 2G cellular network is also more secure. The third generation (3G) integrates cellular phones into the internet world by providing highspeed packet-switching data transmission in addition to circuit-switching voice transmission. The 3G cellular networks have been deployed in some parts of Asia, Europe, and the United States since 2002 and will be widely deployed in the coming years.

Basic Concepts:

A cellular network provides cell phones or mobile stations (MSs), to use a more general term, with wireless access to the public switched telephone network (PSTN). The service coverage area of a cellular network is divided into many smaller areas, referred to as cells, each of which is served by a base station (BS). The BS is fixed, and it is connected to the mobile telephone switching office (MTSO), also known as the mobile switching center. An MTSO is in charge of a cluster of BSs and it is, in turn, connected to the PSTN. With the wireless link between the BS and MS, MSs such as cell phones are able to BSs and MSs are equipped with a tarnsceiver. Figure 1 illustrated a typical cellular network, in which a cell is represented by a hexagon and a BS is represented by a triangle.

The frequency spectrum allocated for cellular communications is very limited. The success of today's cellular communications is very limited. The success of today's cellular network is mainly due to the frequency reuse concept. This is why the coverage area is divided into cells, each of which is served by a BS, Each BS (or cell) is assigned a group of frequency bands or channels. To avoid radio co-channel interface, the group of channels assigned to one cell must be different from the group of channels interference, the group of channels can be asigned to the two cells taht are far enough apart such that the radio cochannel interference between them is within a tolerable limit. Typically, seven neighbouring cells are grouped together to form a cluster, as shown in figure 2. The total available channels are divided into seven groups, each of which is assigned to a cell. In figure 2, the cells marked with the same number have the same group of channels assigned to them. Furthermore, the cells marked with different numbers must be assigned different groups of channels.

If there are a total of M channels allocated for cellular communications and if the coverage area consists of N cells, there are a total of MN/7 channels available in the coverage area for concurrent use based on the seven cell reuse pattern. That is the network capacity of this coverage area. Because of explosive growth of mobile phone subscribers, the current network capacity may not be enough. Cell splitting is one technique that used to increase the network capacity without new frequency spectrum allocation. In this technique, the cell size is reduced by lowering antenna.

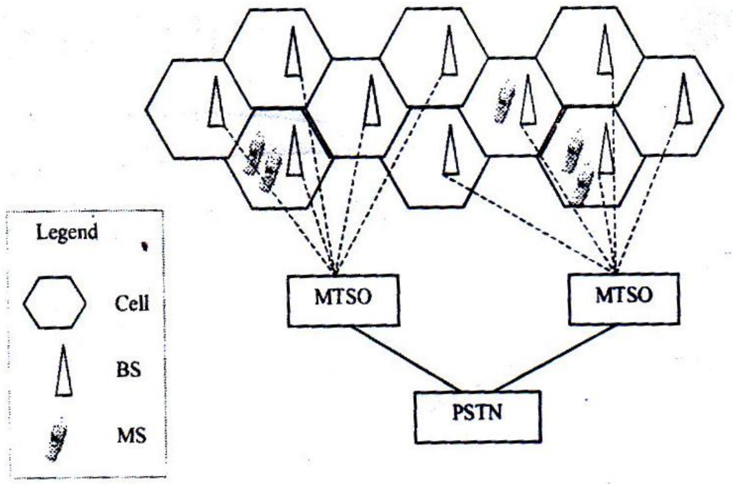


Figure 1: Typical cellular network.

height and transmitter power. Specifically, an original cell is divided into four smaller cells. After cell-splitting, the coverage area with N cells originally will be covered by 4N smaller cells. Therefore, the new network capacity is 4MN/7, which is four times the original network capacity. In reality bigger cells are not completely replaced by smaller cells. Therefore, cells of different sizes (e.g. pico, micro, and macro cells) may coexist in one area. This allows high-speed subscribers to use bigger cells, which reduces the number of hand-offs (to be explained later).

Sectoring is another technique to increase the network capacity . In sectoring, the cell size remains the same, but a cell is divided into several sectors by using several directional antennas at the BS instead of a single omnidirectional antenna. Typically, a cell is divided into three 120 sectors or six 60 sectors. The radio co-channel interference will be reduced by dividing a cell into sectors, which reduces the number of cells in a cluster. Therefore, the network capacity is increased.

Digital technlogy can also be used to increase the network capacity. Transmission of digitized voice goes through three steps before the actual transmission: speech

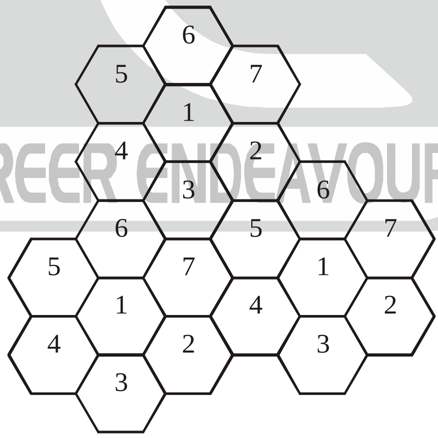


Figure 2 : Frequency reuse

coding, channel coding, and modulation. Speech coding is to compress voice. For example, a short voice segment can be analyzed and represented by a few parameter values. These values cannot be transmitted directly because wireless transmission is error prone, and a small change in these values may translate into a big change in voice. Therefore, data representing compressed voice should be arranged carefully, and redudancy should be introduced such that a transmission error can be corrected or at least detected. This process is called channel coding. Finally, the output data from channel coding are modulated for transmission. A good speech-coding scheme combined with a good channel coding scheme will greatly reduce the amount of bandwidht needed by each phone user and therefore increase the network capacity while keeping the quality of voice unchanged.

The channel assigned to a cell are used either for voice or for control. A voice channel is used for an actual conversation. Both voice and control channels are further divided into forwared (or downlink) and reverse (or uplink). A forward channel is used to carry traffic from the BS to the MS, and a reverse channel is used to carry traffic from the MS, and a reverse channel is used to carry traffic the MS to the BS. The channels assigned to a cell are shared by MSs located in the cell. Multiple access methods are used to share the the channels in a cel.

Each MS has a home MTSO, which is the MTSO where the mobile user originally subscribed for wireless services. If an MS moves out of the home MTSO area, it is roaming. A roaming MS needs to register in the visited MTSO. An MS needs to be authenticated against the information kept in its home MTSO before any service can be rendered by the network. The services include making a call, receivices are possible because of a widely used global, common channel-signaling standard named SS7 (Signaling System No 7).

To make a call from an MS the MS first needs to make a request using a reverse contro channel in the current cell.

If the request is granted by MTSO, a pair of voice channels (one for transmitting and the other for receiving) is assigned for the call. Making a call to an MS is more complicated. The call is first routed to it is roaming. The MTSO needs to know the cell in which the MS is currently located. Finding the residing cell of an MS is the subject of location management. Once the MTSO knows the residing cell of the MS, a pair of voice channels is assigned the residing in the cell for the call.

If a call is in progress when the MS moves into neighbouring cell. The MS needs to get a new pair of voice channels from the BS of the neighbouring cell so the call can continue. This process is called hand-off. A BS usually adopts a channel assignment cells over the new calls initiated in the current cell.

Multiple Access Methods:

Within a cel covered by a BS, there are multiple MSs that need to communicate with the BS. Those mobile stations must share the air interface in an orderly manner so that no MSs to share the air interface in an orderly manner are reffered to as multiple access methods. The popular multiple access methods include (frequency division multiple access) FDMA, TDMA, and CDMA.

FDMA divides the frequency spectrum assigned to the BS into several frequency bands, as known as channels, as shown in figure 3. These channels are well separated and do not interfere with each other. An MS can use the assigned channel(s) exclusively. FDMA is used in the Advanced Mobile Phone Systems(AMPS) AMPS uses a total of 40 MHz in the 800-MHz spectrum. 825-845 MHz and 870-890 MHz to be exact. (For ease of clarification, the additional 10 MHz added later is not considered here). In AMPS, each channel has a bandwidth of 30 KHz, and the 40-MHz bandwidth translates into about 1332 channels. In the United States, it is required that two cellular communication providers be present in every market to encourage competition. Therefore, each

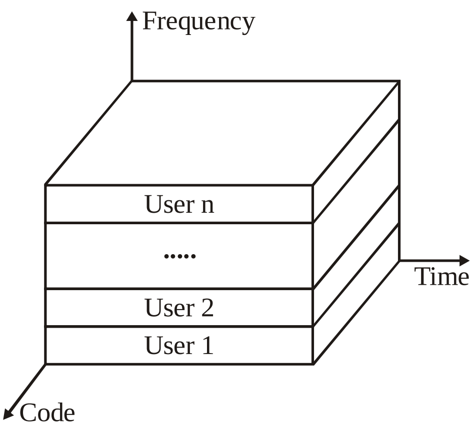


Figure 3: FDMA (frequency division multiple access)

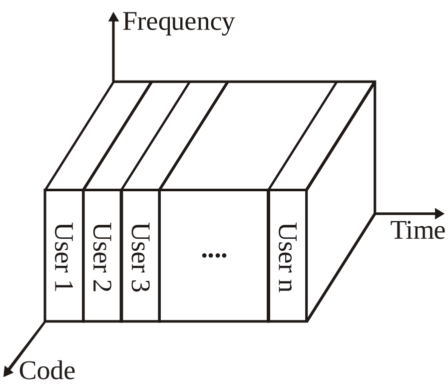


Figure 4: TDMA (time division multiple access)

cellular communication has 666 channels. AMPS uses FDD (frequency division multiplexing). That is, 333 channels are for communication from mobile stations to the base station. Among these 333 channels, only 312 channels are for voice traffic because 21 of them need to be used for control. Based on the seven-cell reuse pattern, only about 45 MSs within a cell can comunicate with the BS simultaneously.

TDMA usually builds on FDMA and allows multiple MSs to share the same channel. In TDMA, time is slotted. In each time slot, only one MS is allowed to use the shared channel to transmit or receive. MSs is allowed to use the shared channel to transmitting or receiving in their allocated slots in a roundrobin fashion. Although the channel is shared, no interference can arise among those sharing MSs because only one MS can use the channel at one time. Figure 4 illustrates the concept of TDMA

Because an MS is not able to use the channel all the time, it is callenging to deliver voice, which is supposed to be continuous. Fortunately, an ordinary human can tolerate a delay of 20 millisseconds (ms). In D-AMPS (D for digital), a speech segment consists of 20-ms durations of speech. The speech segment is first digitized and then compared with the VSELP (vector sum excited linear predictive) Cookbook (Black, 1999). The index to the digitized voice is transmited instead of the digitzed voice. The index is 159 bits long. At the receiving end, the digitized voice that is very close to the original voice can be retrieved based based on the 159-bit index. In D-AMPS, which uses the same 30-kHz channel as AMPS, 159 bits (along with overhead bits for a total of 260 bits) can be transmitted in two of six time slots in a frame. TDMA can operate in either the 800-MHz cellular spectrum (IS-54/D-AMPS; EIA/TIA, 1990) or the 1900-MHz PCS spectrum (IS-136; EIA/TIA, 1995).

CDMA takes an entirely different appraoch from TDMA. In CDMA, mutiple MSs share the same wideband of spectrum. Instead of being assigned to time slots as in TDMA, each MS is assigned a unique sequence a unique sequence code. Each

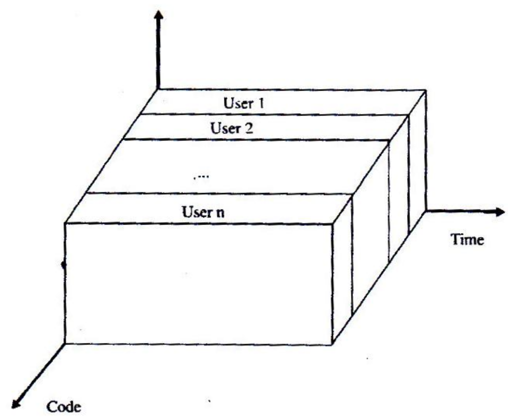


Figure 5: CDMA (code division multiple access).

MS's signal is spread over the entire bandwidth by the unique sequence code. At the receiver, that same unique code is used to recover the signal. Although the radio spectrum is shared, no interference can arise because the sequence codes used by the sharing MSs are basically orthogonal. Figure 5 illustrates the concept of CDMA.

Cellular telephony is designed to provide communications between two moving units, called mobile stations (MSs), or between one mobile unit and one stationary unit, often called a land unit. A service provider must be able to locate and track a caller, assign a channel to the call, and transfer the channel from base station to base station as the caller moves out of range.

To make this tracking possible, each cellular service area is divided into small regions called cells. Each cell contains an antenna and is connected by a solar or AC powered network station, called the Base Station (BS). Each base station, in turn, is controlled by a switching office, called a **Mobile Switching Center (MSC).** The MSC coordinates communication between all the base stations and the telephone central office. It is a comupterized center that is responsible for connecting calls, recording call information, and billing.

Cell size is not fixed and can be increased or decreased depending on the population of the area. The typical radius of a cell is 1 to 12 mi. High density areas require more, geographically smaller cells to meet traffic demands than do low-density areas. Once determined, cell size is optimized to prevent the interference of adjacent cell signals. The transmission power of each cell is kept to prevent its signal from interfering with those of other cells.

Frequency-Reuse Principle:

In general, neigbouring cells cannot use the same set of frequencies for communication because it may create interference for the users located near the cell boundaries. However, the set of frequencies available is limited, and frequencies need to be reused. A frequency resue pattern is a configuration of N cells, N being the reuse

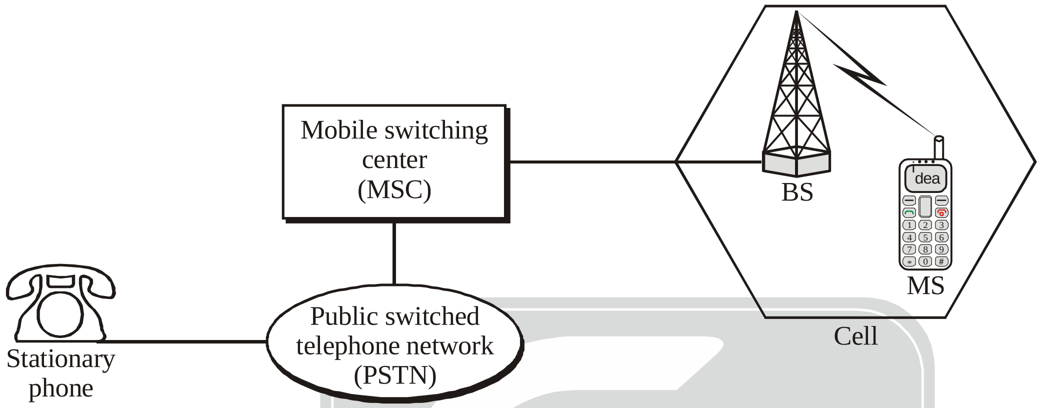
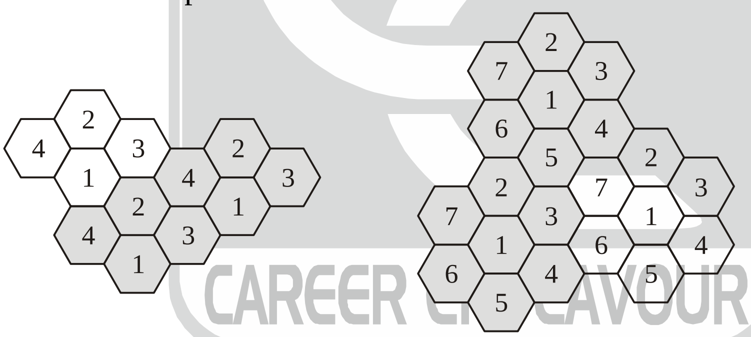


Figure: Cellular System

factor, in which each cell uses a unique set of frequencies. When the pattern is repeated, the frequencies can be reused. There are several different patterns.



a. Reuse factor of 4 **b. Reuse factor of 7**

Figure: Frequency reuse patterns.

The numbers in the cells define the pattern. The cells with the same number in a pattern can use the same set of frequencies. We call these cells the reusing cells. As figure shows in above, in a pattern with reuse factor 4, only one cell separates the cells using the same set of frequencies. In the pattern with reuse factor 7, two cells two cells separate the reusing cells.

Transmitting: To place a call from a mobile station, the caller enters a code of 7 or 10 digits (a phone number) and presses the send button. The mobile station then scans the band, seeking a setup channel with a strong signal, and sends the data (phone number) to the closest base station using that channel. The base station relays the data to the MSC. The MSC sends the data on to the telephone central office. If the called party is available, a connection is made and the result is relayed back to the MSC. At this point, the MSC assigns an unused voice channel to the call, and a connection is established. The mobile station automatically adjusts its tunning to the new channel, and communication can begin.

Receiving: When a mobile phone is called, the telephone central office sends the number to the MSC. The MSC searches for the location of the mobile station by sending query signals to each cell in a process called paging. Once the mobile station is found, the MSC transmits a ringing and, when the mobile station answers, assigns a voice channel to the call, allowing voice communication to begin.

Handoff: It may happen that, during a conversation, the mobile station moves from one cell to another. When it does, the signal may become weak. To solve this problem, the MSC monitors the level of the signal every few seconds. If the strength of the signal diminishers, the MSC seeks a new cell that can better accommodate the communication. The MSC then changes the channel carrying the cal (hands the signal off from the old channel to a new one).

Hard Handoff: New systems use a soft handoff. In this case, a mobile station only communicates with one base station. When the MS moves from one cell to another, communication must first be broken with the previous base station before communication can be established with the new one. This may create a rough transition.

Soft Handoff: New systems use a soft handoff. In this case, a mobile station can communicate with two base stations at the same time. This means that, during handoff, a mobile station may continue with the new base station breaking off from the old one.

Roaming: Cellular telephony is now in its second generation with the third on the horizon. The first generation was designed for voice communication using analog signals. We discuss one first-generation mobile system used in Norht America, AMPS.

AMPS: Advanced Mobile Phone Systems (AMPS) is one of the analog cellular systems in Norht America. It uses FDMA to separate channels in a link.

AMPS is an analog cellular phone system using FDMA.

Bands: AMPS operates in the ISM 800-MHz band. The system uses two separate analog channels, one for forward (base station to mobile station) communication and one for reverse (mobile station to base station) communication. The band between 824 and 849 MHz carries reverse communication; the band between 869 and 894 MHz carries forward communication.

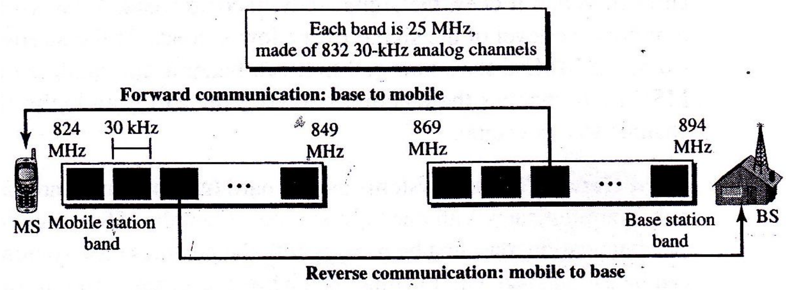


Figure : Cellular bands for AMPS

Each band is divided into 832 channels. However, two providers can share an area, which means 416 channels in each cell for each provider. Out of these 416, 21 channels are used for control, which leaves 395 channels. AMPS has a frequency reuse factor of 7; this means only one-seventh of these 395 traffic channels are actually available in a cell.

Transmission: AMPS uses FM and FSK for modulation. Figure (2) shows the transmission in the reverse direction. Voice channels are modulated using FM, and control channels use FSK to create 30-KHz analog signals. AMPS uses FDMA to divide each 25-MHz band into 30-KHz channels.

Second Generation: To provide higher-quality (less noise-prone) mobile voice communications, the second generation of the cellular phone network was developed. While the first generation was designed for analog voice communication, the second generation was mainly designed for digitized voice. Three major systems evolved in the second generation, as shown in figure(3).

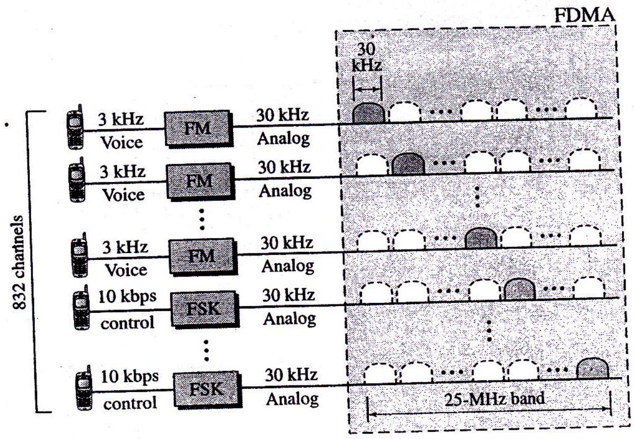


Figure (2): AMPS reverse communication band

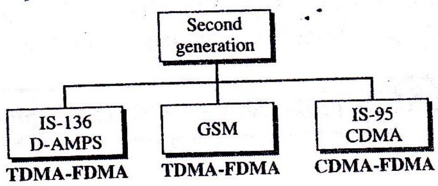


Figure (3): Second-generation cellular phone system

D-AMPS:

The product of the evolution of the analog AMPS into a digital system is digital AMPS (D-AMPS). D-AMPS was designed to be backward-compatible with AMPS. This means that in a cell, one telephone can use another D-AMPS was first denoted by IS-54 (Interim Standard 54) and later revised by IS-136.

Band: D-AMPS uses the same bands and channels as AMPS.

Transmission: Each voice channel is digitized using a very complex PCM and compression technique. A voice channel is digitized to 7.95 kbps. Three 7.95-kbps digital voice channels are combined using TDMA. The result is 48.6 kbps of digital data; much of this is overhead. As figure (4) shows, the system sends 25 frames per second, with 1944 bits per frame. Each frame lasts 40 ms (1/25) and is divided into six slots shared by three digital channels; each channel is allotted two slots.

Each slot holds 324 bits. However, only 159 bits comes from digitized voice; 64 bits are for control and 101 bits are error correction. In other words, each channel drops 159 bits of data into each of the two channels assigned to it. The system adds 64 control bits and 101 error-correcting bits.

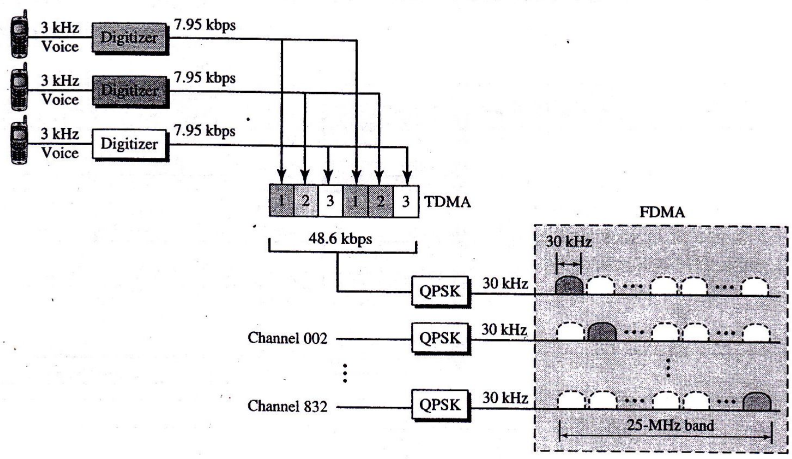


Figure (4): D-AMPS

The resulting 48.6 kbps of digital data modulates a carrier QPSK; the result is a 30-KHz analog signal. Finaly, the 30 KHz analog signals share a 25-MHz band (FDMA). D-AMPS has a frequency reuse factor of 7.

D-AMPS, or IS-136, is a digital cellular phone sytem using TDMA and FDMA.

GSM: The Global System for Mobile Communication (GSM) is a European standard that was developed to provide a common second-generation technology for all Europe. The aim was to replace a number of incompatible first-generation technologies.

Bands: GSM uses two bands for duplex communication. Each band is 25 MHz in width, shifted toward 900 MHz, as shown in figure (5). Each band is divided into 124 channels of 200 KHz separated by guard bands.

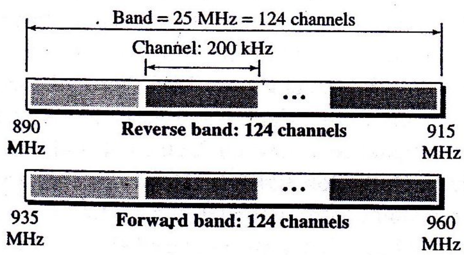


Figure (5): GSM bands.

Transmission: Figure (5) shows a GSM system. Each voice channel is digitized and compressed to a 13-kbps digital signal. Each slot carries 156.25 bits (see figure -6). Eight slots share a frame (TDMA). Twenty-six frames also share a multiframe (TDMA). We can calculate the bit rate of each channel as follows.

Channel data rate = (1/120 ms) ×26×8×156.25 = 270.8 kbps.

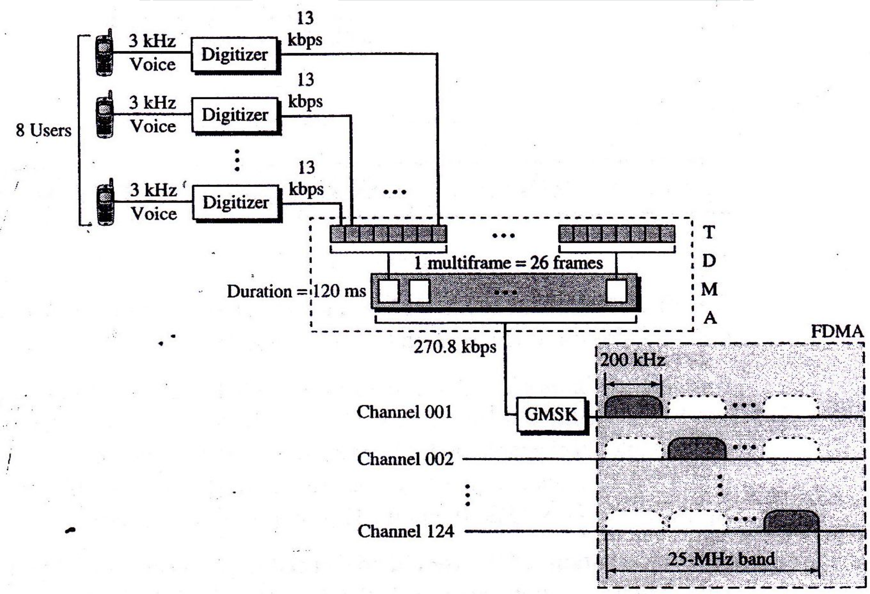


Figure-6: GSM

Each 270.8 kbps digital channel modulates a carrier using GMSK (a form of FSK used mainly in European systems); the result is a 200-KHz analog signal. Finally 124 analog channels of 200 KHz are combined using FDMA. The result is a 25-MHz band. Figure (9) shows the user data and overhead in a multiframe.

The reader may have noticed the large amount of overhead in TDMA. The user data are only 65 bits per slot. The system adds extra bits for error correction to make it 114 bits per slot. To this, control bits are added to bring it up to 156.25 bits per slot. Eight slots are encapsulated in a frame. Twenty-four traffic frames and two additional control frames make a multiframe. A multiframe has a duration of 120 ms.

Reuse Factor: Because of the complex error correction mechanism, GSM allows a reuse factor as low as 3.

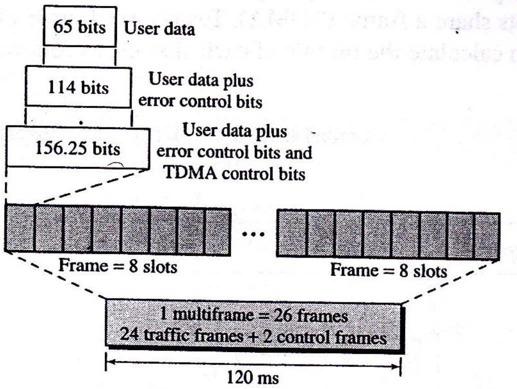


Figure-7: Multiframe components

GSM is a digital cellular phone system using TDMA and FDMA.

IS-95: One of the dominant second-generation standards in North America is **Interim Standard 95(IS-95).** It is based on CDMA and DSSS.

Bands and Channels: IS-95 uses two bands for duplex communication. The bands can be teh traditional ISM 800-MHz band or the ISM 1900-MHz band. Each band is divided into 20 channels of 1.28 MHz separated by guard bands. Each service provider is allotted 10 channels. IS-5 can be used in parallel with AMPS. Each IS-95 channel is equivalent to 41 AMPS channels (41×30 KHz = 1.33 MHz).

Synchronization: All base channels need to be synchronized to use CDMA. To provide synchronization, bases use the services of GPS (Global Positioning System).

Forwarded Transmission: IS-95 has two different transmission techniques: one for use in the forward (base to mobile) direction and another for use in the reverse (mobile to base) direction. In the forward direction, communications between the base and all mobiles are synchornized; the base sends synchronized data to all mobiles. Figure (8) shows a simplified diagram for the forward directon.

Each voice channel is digitized, producing data at a basic rate of 9.6 kbps. After adding error-correcting and repeating bits, and interleaving, the result is a signal of 19.2 ksps (kilosignals per second). This output is now scrambled using a 19.2 ksps signal. The scrambling signal is produced from a long code generator that uses the electronic serial number (ESN) of the mobile station and generats 2^{42} pseudorandom chips, each chip having 42 bits. Note that the chips are generated pseudorandomly, not randomly, because the pattern repeats itself. The output of the long code generator is fed to a decimator, which chooses 1 bit out of 64 bits. The output of the decimator is used for scrambling. The scrambling is used to create privacy; the ESNM is unique for each station.

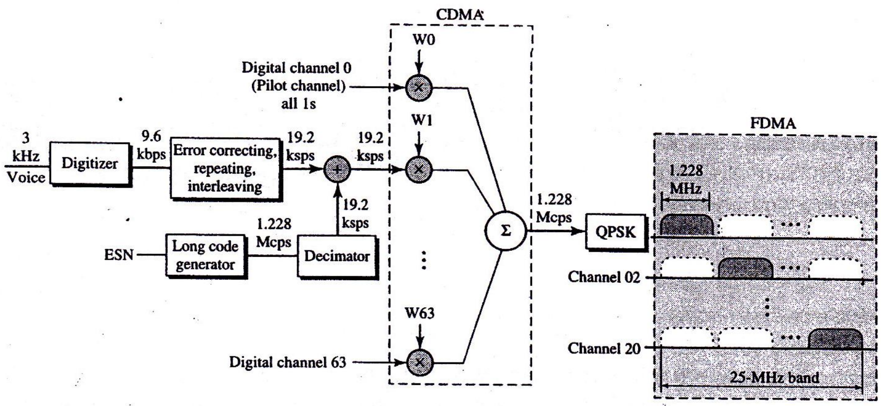


Figure-8: IS-95 forward transmission

The result of the scrambler is combined using CDMA. For each traffic channel, oen Walsh 64×64 row chip is selected. The result is a signal of 1.228 Mcps (megachips per second).

19.2 ksps ×64 cps = 1.228 Mcps

The signal is fed into a QPSK modulator to produce a signal of 1.228 MHz. The resulting bandwidth is shifted appropriately, using FDMA. An analog channel creates 64 digital channels, of which 55 channels are traffic channels (carrying digitized voice). Nine channels are used for control and synchronization:

- Channel 0 is a pilot channel. This channel sends a continuous stream of 1s to mobile stations. The stream provides bit synchronization, serves as a phase reference for demodulation, and allows the mobile station to compare the signal strength of neighbouring bases for handoff decisions.
- Channel 32 gives information about the system to the mobile station.
- Channels 1 to 7 are used for paging, to send messages to one or more mobile stations.
- Channels 8 to 31 and 33 to 63 are traffic channels carrying digitized voice from the base station to the corresponding mobile station.

Reverse Transmission: The use of CDMA in the forward direction is possible because the pilot channel sends a continuous sequence of 1s to synchornize transmission. The synchronization is not used in the reverse direction because we need an entity to do that, which is not feasible. Instead of CDMA, the reverse channels use DSSS (direct sequence spread spectrum). **Figure -9** shows a simplified diagaram for reverse transmission.

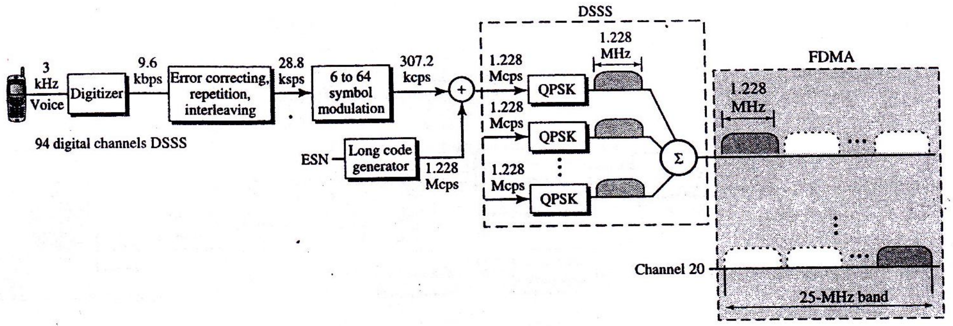


Figure-9: IS-95 reverse transmission

Each voice channel is digitzed, producing data at a rate of 9.6 kbps. However, after adding error-correcting and repeating bits, plus interleaving the result is a signal of 28.8 ksps. The output is now passed through a 6/64 symbol modulator. The symbols are divided into six-symbol chunks, and each chunk is interpreted as a binary number (from 0 to 63). The binary number is used as the index to to a 64×64 Walsh matrix for selection of a new of chips. Note that this procedure is not CDMA; each bit is not multiplied by the chips in a row. Each six-symbol chunk is replaced by a 64-chip code. This is done to provide a kind of orthogonality; it differentiates the streams of chips from the different mobile stations. The result creates a signal of 3072 kcps or (28.8/6) × 64.

Spreading is the next step; each chip is spread into 4. Again the ESN of the mobile station creates a long code of 42 bits at a rate of 1.228 Mcps, which is 4 times 307. 2. After spreading, each signal is modulated using QPSK, which is slightly different from the one used in the forward direction; we do not go into details here. Note that there is no multiple - access mechanism herel; all reverse channels send their analog signal into the air, but the correct chips will be received by the base station due to spreading.

Although we can create $2^{42}-1$ digital channels in the reverse direction(because of the long code generator), normally 94 channels in the reverse direction (because of the long code generator), normally 94 channels are used; 62 are traffic channels, and 32 are channels used to gain access to the base station.

IS-95 is a digital cellular phone system using CDMA/DSSS and FDMA.

Two data Rate Sets: IS-95 defines two data rate sets, with four different rates in each set. The first defines 9600, 4800 2400, and 1200 bps. If, for eaxmple, the selected rate is 1200 bps, each bit is repeated 8 times to provide a rate of 9600 bps. The second set defines 14, 400, 7200, 3600 and 1800 bps. This is possible by reducing the number of bits used for error correction. The bit rates in a set are related to the activity of the channel. If the channel is silent, only 1200 bits can be transferred, which improves the spreading by repeating each bit 8 times.

Frequency-Reuse Factor: In an IS-95 system, the frequency-reuse factor is normally 1 becayse the interference from neighboring cells cannot affect CDMA or DSSS transmission.

Soft Handoff: Every base station continuously broadcasts signals using its pilot channel. This means a mobile station can detect the pilot signal from its cell and neighbouring cells. This enables a mobile station to do a soft contrast to a hard handoff.

PCS: Before we leave the discussion of second generation cellular telephones, let us explain a term generally heard in relation to this generation. PCS. **Personal Communications System (PCS)** does not refer to a single technology such as GSM, IS-136, or IS-95. It is a generic name for a commercial system that offers several kinds of communication services. Common features of these can be summarized.

1. They may use any second-generation technology (GSM, IS-136, or IS-95).
2. They use the 1900-MHz band, which means that a mobile station needs more power because higher frequencies have a shorter range than lower ones. However, since a stations power is limited by the FCC, the base station and the mobile station need to be close to each other (smaller cells).
3. They offer communication services such as short message service (SMS) and limited Internet access.

Third Generation: The third generation of cellular telephony refers to a combination of technologies that provide a variety of services. Ideally, when it matures, the third generation can provide both digital data and voice communication. Using a small portable device, a person should be able to talk to anyone else in the world with a voice quality similar to that of the existing fixed telephone network. A person can download and watch a movie, can download and listen to music, can surf the internet or play games, can have a video conference, and can do much more. One of the interesting characteristics of a third-generation system is that the portable device is always connected; you do not need to dial a number to connect to the internet.

The third-generation concept started in 1992, when ITU issued a blueprint called the **Internet Mobile Communication 2000 (IMT-2000).** The blueprint defines some criteria for third-generation technology as outlined below:

- Voice quality comparable to that of existing public telephone network.
- Data rate of 144 kbps for access in a moving vehicle (car), 384 kbps for access as the user walks (Pedestrians), and 2 Mbps for the stationary user (office or home).
- Support for packet-switched and circuit-switched data services.
- A band of 2 GHz
- Bandwidths of 2 MHz.
- Interface to the Internet.

The main goal of third-generation cellular telephony is to provide universal personal communication.

IMT-2000 Radio Interface: Figure (10) shows the radio interfaces (wireless standards) adopted by IMT-2000. All five are developed from second-generation technologies. The first two evolve from CDMA technology. The third evolves from a combination of CDMA and TDMA. The fourth evolves from TDMA, and the last evolves from both FDMA andTDMA.

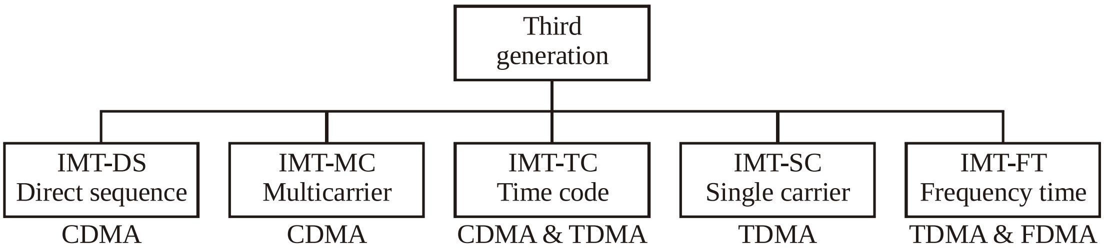


Figure-10: IMT-2000 radio interface.

IMT-DS: This approach uses a version of CDMA called wideband CDMA or W-CDMA. W-CDMA uses a 5-MHz bandwidth. It was developed in Europe, and it is compatible with CDMA used in IS-95.

IMT-MC: This approach was developed in North America and is known as CDMA 2000. It is an evolution of CDMA technology used in IS-95 channels. It combines the new wideband (15-MHz) spread spectrum with the narrowband (1.25-MHz) CDMA of IS-95. It is backward-compatible with IS-95. It allows communication on multiple 1.25-MHz channels (1, 3, 6, 9, 12 times), up to 15 MHz. The use of the wider channels allows it to reach the 2-Mbps data rate defined for the third generation.

IMT-TC: This standard uses a combination of W-CDMA and TDMA. The standard tries to reach the IMT-2000 goals by adding TDMA multiplexing to W-CDMA.
IMT-SC: This standard only uses TDMA.
IMT-FT: This standard uses a combination of FDMA and TDMA.

PROBLEMS

1. In a frame transmission, CRC stands for
(a) Code Renewable Check (b) Cyclic Redundancy Check
(c) Control and Refresh Code (d) Cyclic Refreshing of CPU

2. In a LAN network every system is identified by
(a) Name (b) MAC address
(c) IP Address (d) Serial number given by manufacturer

3. An off-hook signal will repeat for a/an .... duration.
(a) finite (b) infinite
(c) duration of 40 seconds (d) duration of 80 seconds

4. Typical human voice is centered around .... Hz.
(a) 200 – 400 (b) 280 – 3000 (c) 400 – 600 (d) 1400 – 1800

5. Using .... each connected device is assigned a time slot whether or not the device has any thing to send.
(a) WDM (b) FDM (c) TDM (d) STDM

6. When a switch capacity is full, calls coming into that switch are said to be ....
(a) open (b) shorted (c) blocked (d) shunted

7. Using .... ARQ, a sending modem must wait for a return ACK for each sent block before sending the next block.
(a) discrete (b) efficient (c) continuous (d) delivered

8. A/An .... network is typically a company network that connects multiple company locations into a single network.
(a) local area (b) enterprise (c) campus wide (d) protocol

9. Ethernet 10 Base 2 is an example of .... network topology.
(a) Bus (b) Ring (c) Star (d) Mesh

10. The .... electro mechanical switch (developed in 1938) had fewer moving parts than earlier switches.
(a) No. 1ESS (b) Strowger (c) Step-by-step (d) Crossbar

11. Side tone is the speech heard by
(a) the receiving subscriber (b) both the receiving and calling subscriber
(c) by on looker (d) by calling subscriber

12. Busy hour traffic is the
(a) maximum average simultaneous traffic (b) traffic during peak hour
(c) traffic when all subscribers are engaged (d) the duration of maximum calls

13. The final selector is connected to the
(a) calling subscriber (b) switching network (c) called subscriber (d) line finder

14. In a DTMF phone a dialing of 8 generates
(a) 1336 Hz-770 Hz (b) 1209 Hz-1477 Hz (c) 1209 Hz-941 Hz (d) 1336 Hz-852 Hz

15. SPC stands
(a) Standard Protocol Control (b) Stored Program Control
(c) Signaling and switching Center (d) Signaling Process Center

16. For two stage network the switching elements for M inlets with r blocks and N outlets with s blocks is given by
(a) Ms + Nr (b) Mr + Ns (c) (M + N) (r + s) (d) (M + N) rs

17. As per Nyquist criterion the sampling rate is
(a) 2fs (b) (1/2) fs (c) (1/2 fs) (d) (2/fs)
Where fs is the signal frequency

18. Common channel signaling in SS7 is
(a) out band control channel (b) in band control channel
(c) speech control channel (d) none of these

19. Broad Band ISDN handles data rate of about
(a) 64 kbps (b) 100 mbps (c) 5.4 mbps (d) 2.048 mbps

20. MAC address helps in
(a) multimedia access control (b) media access control
(c) mobile access point control (d) master access point control

21. Telex is a
(a) Telephone Service between various subscribers
(b) Tele printer Service between various subscribers
(c) Television Service between various subscribers
(d) Telegraph Service between various subscribers

22. The bandwidth requirement of a telephone channel is
(a) 3 KHz (b) 15 KHz (c) 5 KHz (d) 25 KHz

23. Distortion caused on telephone line by an adjacent one is called
(a) Cross Fire (b) Inductive Disturbance
(c) Cross Talk (d) None of these

ANSWER KEY

1. (b)	**2. (c)**	**3. (a)**	**4. (b)**	**5. (c)**
6. (c)	**7. (a)**	**8. (b)**	**9. (a)**	**10. (d)**
11. (d)	**12. (b)**	**13. (c)**	**14. (d)**	**15. (b)**
16. (a)	**17. (a)**	**18. (b)**	**19. (a)**	**20. (b)**
21. (b)	**22. (a)**	**23. (c)**		