Cellular Wireless Networks

A cellular network is a radio network distributed over land through cells where each cell includes a fixed location transceiver known as base station. These cells together provide radio coverage over larger geographical areas. Cellular networks use lower power, shorter range and more transmitters for data transmission.

- Each service area is divided into small ranges called cells
- Moving units like cell phone, are called Mobile Stations
- Network station in a cell, containing antenna, is called Base station
- Base station is controlled by a switching center which is Mobile Switching Center
- Cell size is not fixed.
- Capacity of system can be increased by using Lower Power System & less Radius
- A typical system would support about 25 channels with an effective radius of about 80 km

Features of Cellular Systems

Wireless Cellular Systems solves the problem of spectral congestion and increases user capacity. The features of cellular systems are as follows

- ✓ Offer very high capacity in a limited spectrum.
- ✓ Reuse of radio channel in different cells.
- ✓ Enable a fixed number of channels to serve an arbitrarily large number of users by reusing the channel throughout the coverage region.
- ✓ Communication is always between mobile and base station (not directly between mobiles)
- ✓ Each cellular base station is allocated a group of radio channels within a small geographic area called a cell.
- ✓ Neighboring cells are assigned different channel groups.
- ✓ By limiting the coverage area to within the boundary of the cell, the channel groups may be reused to cover different cells.
- ✓ Keep interference levels within tolerable limits.
- ✓ Frequency reuse or frequency planning.
- ✓ Organization of Wireless Cellular Network.

Shape of Cells

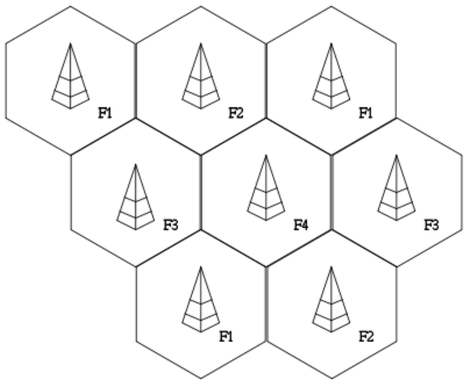
The coverage area of cellular networks are divided into cells, each cell having its own antenna for transmitting the signals. Each cell has its own frequencies. Data communication in cellular networks is served by its base station transmitter, receiver and its control unit.

The shape of cells can be either square or hexagon.

Hexagon

A hexagon cell shape is highly recommended for its easy coverage and calculations. It offers the following advantages:

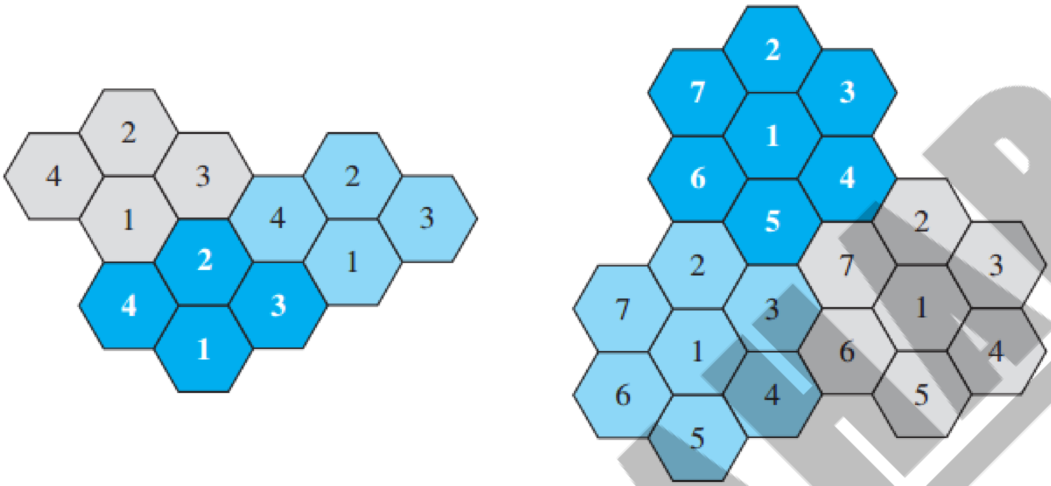
- ✓ Provides equidistant antennas
- ✓ Distance from center to vertex equals length of side



Principles of cellular wireless networks

1. Frequency Reuse Principle

Each cell has its own set of frequency, adjacent cells cannot use same frequency. If they use same frequency of adjacent cell it may cause communication loss. But neighboring cells at some distance can reuse those frequencies. A frequency reuse pattern is a configuration of N cells, N being the reuse factor, in which each cell uses a unique set of frequencies. When the pattern is repeated, the frequencies can be reused.



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

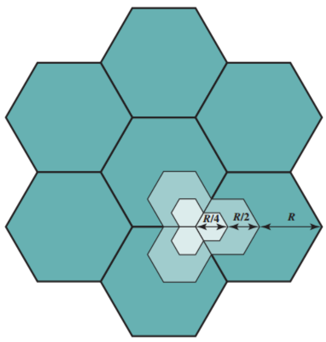
Frequency reuse offers the following benefits

- ✓ Allows communications within cell on a given frequency
- ✓ Limits escaping power to adjacent cells
- ✓ Allows re-use of frequencies in nearby cells
- ✓ Uses same frequency for multiple conversations
- ✓ 10 to 50 frequencies per cell

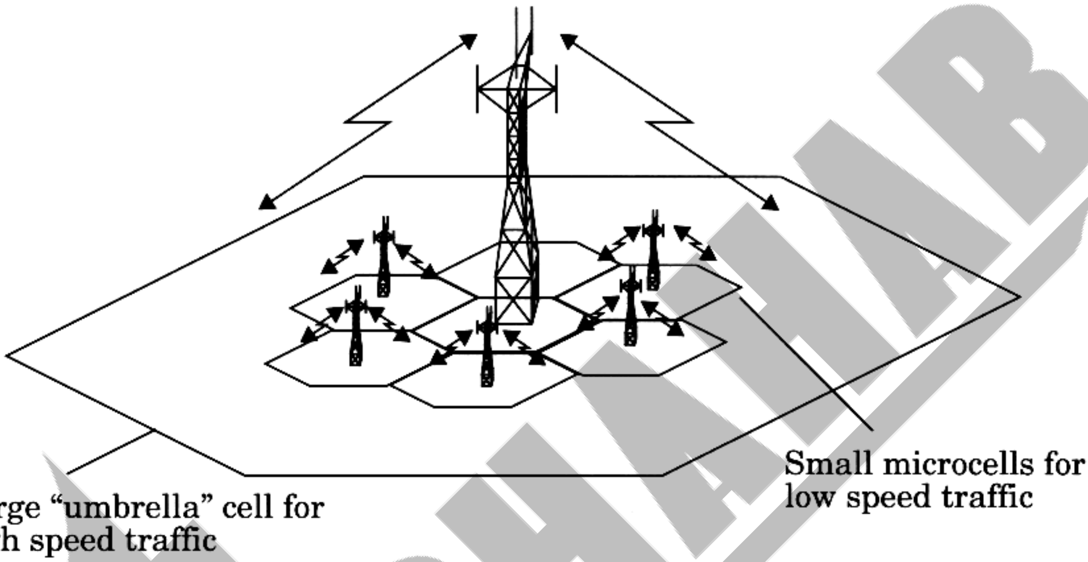
2. Increasing Capacity Principle

In time, as more customers use the system, traffic may build up so that there are not enough frequencies assigned to a cell to handle its calls. A number of approaches have been used to cope with this situation, including the following:

- ➢ **Adding new channels:** Typically, when a system is set up in a region, not all of the channels are used, and growth and expansion can be managed in an orderly fashion by adding new channels.
- ➢ **Frequency borrowing:** In the simplest case, frequencies are taken from adjacent cells by congested cells. The frequencies can also be assigned to cells dynamically.
- ➢ **Cell splitting:** In practice, the distribution of traffic and topographic features is not uniform, and this presents opportunities for capacity increase. Cells in areas of high usage can be split into smaller cells. To use a smaller cell, the power level used must be reduced to keep the signal within the cell.



- **Cell sectoring:** With cell sectoring, a cell is divided into a number of wedge shaped sectors, each with its own set of channels, typically three or six sectors per cell. Each sector is assigned a separate subset of the cell's channels, and directional antennas at the base station are used to focus on each sector.
- **Microcells:** As cells become smaller, antennas move from the tops of tall buildings or hills to the tops of small buildings or the sides of large buildings, and finally to lamp posts, where they form microcells. Each decrease in cell size is accompanied by a reduction in the radiated power levels from the base stations and the mobile units. Microcells are useful in city streets in congested areas, along highways, and inside large public buildings.



Operations on Cellular System

1. Transmitting Calls / Outgoing Calls

To place a call

- The caller enters the phone number of receiver & press the call/send button
- The mobile station (cell phone) scans and select the channel of strong signals
- Then mobile station sends the phone number of receiver to the nearest base station
- Base station sends the data to Mobile Switching Centre (MSC)
- MSC sends that data to the central office
- If The receiver is available, MSC assigns the unused voice channel & connection is made
- Mobile station automatically adjusts its tuning to new channel

2. Receiving Calls / Incoming Calls

When a Mobile phone is called:

- Telephone Central Office sends the receiving mobile number to MSC
- MSC sends the query signals to each cell to find the location of receiving mobile station, it is called paging.
- When mobile station/phone is located, MSC transmits the ringing signals to the receiving phone
- If the receiver answers the call, a voice channel is assigned to the mobile phone

3. Handoff

If a mobile unit moves out of range of one cell and into the range of another during a connection, the traffic channel has to change to one assigned to the BS in the new cell. The system makes this change without either interrupting the call or alerting the user. This process is called Handoff. There are two types of Handoff.

- **Soft Handoff**

In Soft Handoff, Mobile station can connect to two base stations at a time. Connection with the new base station has to establish before connecting to new one.

- **Soft Handoff**

In Hard Handoff, Mobile station communicates only with one base station at a time. When mobile station moves from one cell to another, communication with old base station is broken before connecting to new cell's base station.

- **Call drop**

During a connection, because of interference or weak signal spots in certain areas, if the BS cannot maintain the minimum required signal strength for a certain period of time, the traffic channel to the user is dropped and the MTSO (Mobile Telephone Switching Office) is informed.

- **Roaming**

One feature of cellular telephony is called roaming. Roaming means, in principle, that a user can have access to communication or can be reached where there is coverage. A service provider usually has limited coverage. Neighbouring service providers can provide extended coverage through a roaming contract. The roaming charges is based upon the roaming contract between those service providers.

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Cellular Wireless Network Generations

1G

1G refers to the first generation of wireless telephone technology (mobile telecommunications). These are the analog telecommunications standards that were introduced in 1980s and continued until being replaced by 2G digital telecommunications. The main difference between the two mobile telephone systems (1G and 2G), is that the radio signals used by 1G network are analog, while 2G networks are digital. 1G was not able to support Internet, Roaming, SMS (Short Message Service), MMS (Multimedia Message Service) and Digitized Voice.

The first generation was designed for voice communication using analog signals. The most widely deployed 1G system was the **Advanced Mobile Phone Service (AMPS)**, developed by AT&T. 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.

2G

Second-generation systems (2G) were developed to provide higher-quality signals, higher data rates for support of digital services, and greater capacity. 2G technologies enable the various mobile phone networks to provide the services such as text messages, picture messages and MMS (Multimedia Message Service). Key differences between 1G and 2G networks include:

Digital traffic channels: The most notable difference between the two generations is that 1G systems are almost purely analog, whereas 2G systems are digital. 2G systems provide digital traffic channels. These systems readily support digital data; voice traffic is first encoded in digital form before transmitting.

Encryption: Because all of the user traffic, as well as control traffic, is digitized in 2G systems, it is a relatively simple matter to encrypt all of the traffic to prevent eavesdropping. All 2G systems provide this capability, whereas 1G systems send user traffic in the clear, providing no security.

Error detection and correction: The digital traffic stream of 2G systems also lends itself to the use of error detection and correction techniques. The result can be very clear voice reception.

Channel access: In 1G systems, each cell supports a number of channels. At any given time a channel is allocated to only one user. 2G systems also provide multiple channels per cell, but each channel is dynamically shared by a number of users using TDMA (time-division multiple access) or CDMA (code division multiple access).

Three major systems evolved in the second generation: D-AMPS, GSM, and IS-95.

D-AMPS: It is the digital AMP (Advance Mobile Phone Service). D-AMPS was designed to be backward-compatible with AMPS. This means that in a cell, one telephone can use AMPS and another D-AMPS. D-AMPS uses the same bands and channels as AMPS. It is a digital cellular phone system 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. 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. IS-95 is a digital cellular phone system using CDMA/DSSS and FDMA.

3G

The objective of the third generation (3G) of wireless communication is to provide fairly high-speed wireless communications to support multimedia, data, and video in addition to voice. The ITU's International Mobile Telecommunications for the year 2000 (IMT-2000) initiative has defined the third-generation capabilities as follows:

- ✓ Voice quality comparable to the public switched telephone network
- ✓ 144 kbps data rate available to users in high-speed motor vehicles over large areas
- ✓ 384 kbps available to pedestrians standing or moving slowly over small areas
- ✓ Support (to be phased in) for 2.048 Mbps for office use
- ✓ Symmetrical and asymmetrical data transmission rates
- ✓ Support for both packet-switched and circuit-switched data services
- ✓ An adaptive interface to the Internet to reflect efficiently the common asymmetry between inbound and outbound traffic
- ✓ More efficient use of the available spectrum in general
- ✓ Support for a wide variety of mobile equipment
- ✓ Flexibility to allow the introduction of new services and technologies

4G

4G systems provide ultra-broadband Internet access for a variety of mobile devices including laptops, smartphones, and tablets. 4G networks support Mobile Web access and high-bandwidth applications such as high-definition mobile TV, mobile video conferencing, and gaming services. The ITU has issued directives for 4G networks. According to the ITU, an IMT-Advanced (or 4G) cellular system must fulfill a number of minimum requirements, including the following:

- ✓ Be based on an all-IP packet switched network.
- ✓ Support peak data rates of up to approximately 100 Mbps for high-mobility mobile access and up to approximately 1 Gbps for low-mobility access such as local wireless access.
- ✓ Dynamically share and use the network resources to support more simultaneous users per cell.
- ✓ Support smooth handovers across heterogeneous networks.
- ✓ Support high quality of service for next-generation multimedia applications.

To increase efficiency, capacity, and scalability, new access techniques are being considered for 4G. For example, orthogonal FDMA (**OFDMA**) and interleaved FDMA (**IFDMA**) are being considered respectively for the downlink and uplink of the next generation Universal Mobile Telecommunications System (UMTS).

LTE Advance

Two candidates emerged for 4G standardization. One is known as Long Term Evolution (LTE) and the other one is LTE Advance (LTE-A). The other effort is from the IEEE 802.16 committee, which has developed standards for high-speed fixed wireless operations known as WiMAX. The committee has specified an enhancement of WiMAX to meet 4G needs. The most important thing to know is that LTE-A promises to deliver true 4G speeds, unlike current LTE networks. You can expect the real-world speed of LTE-A to be two to three times faster than today's LTE.