18MCA33C Mobile Computing

UNIT II

Cellular Concept

FACULTY

Dr. K. ARTHI MCA, M.Phil., Ph.D.,

Assistant Professor,

Postgraduate Department of Computer Applications,

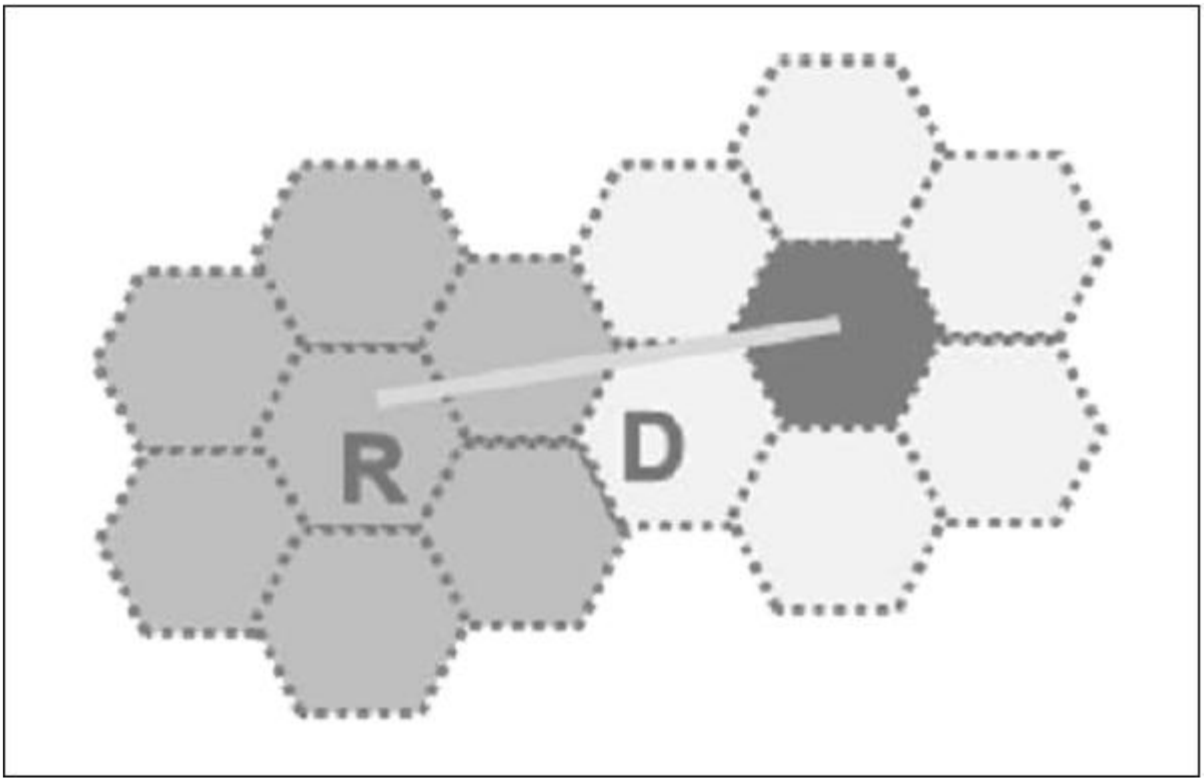
Government Arts College (Autonomous),

Coimbatore-641018.

Cellular Concept:

With limited frequency resource, cellular principle can serve thousands of subscribers at an affordable cost. In a cellular network, total area is subdivided into smaller areas called "cells". Each cell can cover a limited number of mobile subscribers within its boundaries. Each cell can have a base station with a number of RF channels.

Frequencies used in a given cell area will be simultaneously reused at a different cell which is geographically separated. For example, a typical seven-cell pattern can be considered.



Total available frequency resources are divided into seven parts, each part consisting of a number of radio channels and allocated to a cell site. In a group of 7 cells, available frequency spectrum is consumed totally. The same seven sets of frequency can be used after certain distance.

The group of cells where the available frequency spectrum is totally consumed is called a cluster of cells.

Two cells having the same number in the adjacent cluster, use the same set of RF channels and hence are termed as "Co-channel cells". The distance between the cells using the same frequency should be sufficient to keep the co-channel (co-chl) interference to an acceptable level. Hence, the cellular systems are limited by Co-channel interference.

Hence a cellular principle enables the following.

- More efficient usage of available limited RF source.
- Manufacturing of every piece of subscriber's terminal within a region with the same set of channels so that any mobile can be used anywhere within the region.

Shape of Cells

For analytical purposes a “Hexagon” cell is preferred to other shapes on paper due to the following reasons.

- A hexagon layout requires fewer cells to cover a given area. Hence, it envisages fewer base stations and minimum capital investment.
- Other geometrical shapes cannot effectively do this. For example, if circular shaped cells are there, then there will be overlapping of cells.
- Also for a given area, among square, triangle and hexagon, radius of a hexagon will be the maximum which is needed for weaker mobiles.

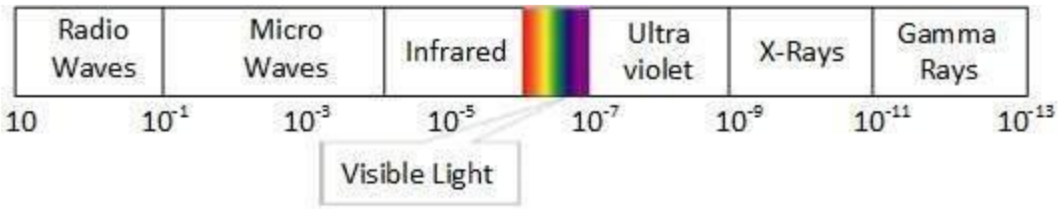
In reality cells are not hexagonal but irregular in shape, determined by factors like propagation of radio waves over the terrain, obstacles, and other geographical constraints. Complex computer programs are required to divide an area into cells. One such program is “Tornado” from Siemens.

Wireless transmission

Wireless transmission is a form of unguided media. Wireless communication involves no physical link established between two or more devices, communicating wirelessly. Wireless signals are spread over in the air and are received and interpreted by appropriate antennas.

When an antenna is attached to electrical circuit of a computer or wireless device, it converts the digital data into wireless signals and spread all over within its frequency range. The receptor on the other end receives these signals and converts them back to digital data.

A little part of electromagnetic spectrum can be used for wireless transmission.

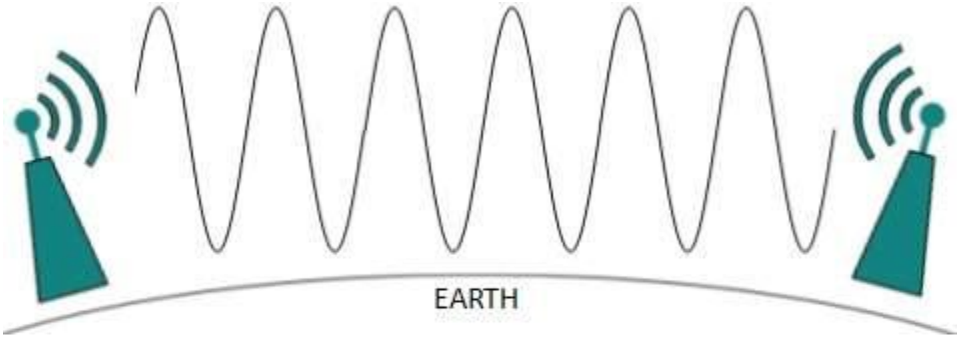


Radio Transmission

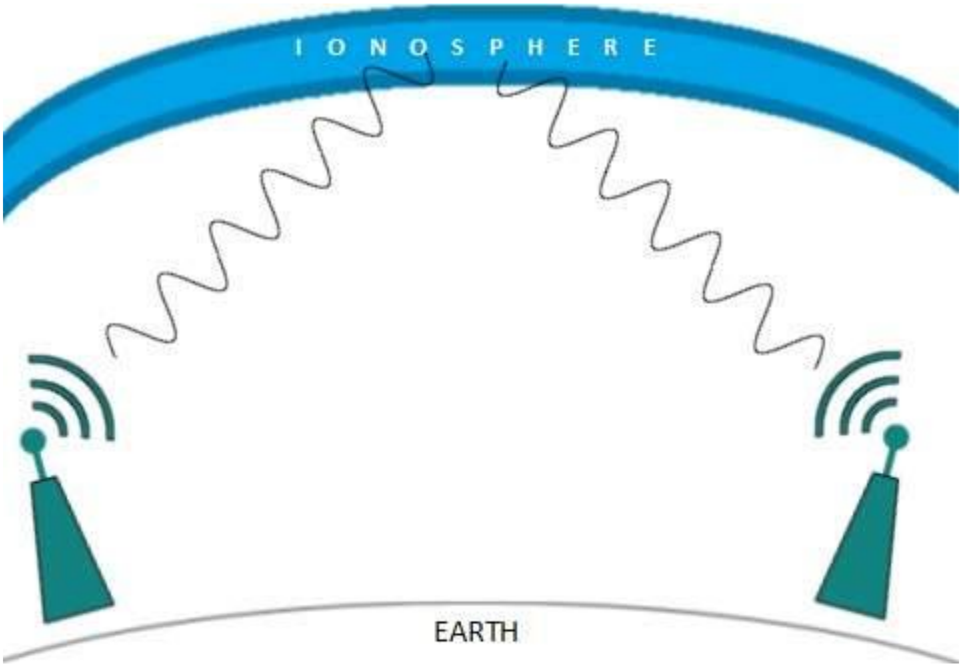
Radio frequency is easier to generate and because of its large wavelength it can penetrate through walls and structures alike.Radio waves can have wavelength from 1 mm – 100,000 km and have frequency ranging from 3 Hz (Extremely Low Frequency) to 300 GHz (Extremely High Frequency). Radio frequencies are sub-divided into six bands.

Radio waves at lower frequencies can travel through walls whereas higher RF can travel in straight line and bounce back.The power of low frequency waves decreases sharply as they cover long distance. High frequency radio waves have more power.

Lower frequencies such as VLF, LF, MF bands can travel on the ground up to 1000 kilometers, over the earth’s surface.



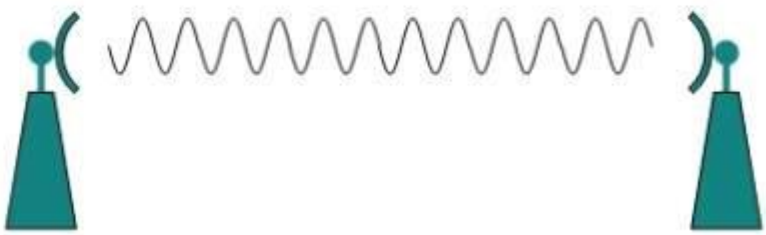
Radio waves of high frequencies are prone to be absorbed by rain and other obstacles. They use Ionosphere of earth atmosphere. High frequency radio waves such as HF and VHF bands are spread upwards. When they reach Ionosphere, they are refracted back to the earth.



Microwave Transmission

Electromagnetic waves above 100 MHz tend to travel in a straight line and signals over them can be sent by beaming those waves towards one particular station. Because Microwaves travels in straight lines, both sender and receiver must be aligned to be strictly in line-of-sight.

Microwaves can have wavelength ranging from 1 mm – 1 meter and frequency ranging from 300 MHz to 300 GHz.



Microwave antennas concentrate the waves making a beam of it. As shown in picture above, multiple antennas can be aligned to reach farther. Microwaves have higher frequencies and do not penetrate wall like obstacles.

Microwave transmission depends highly upon the weather conditions and the frequency it is using.

Infrared Transmission

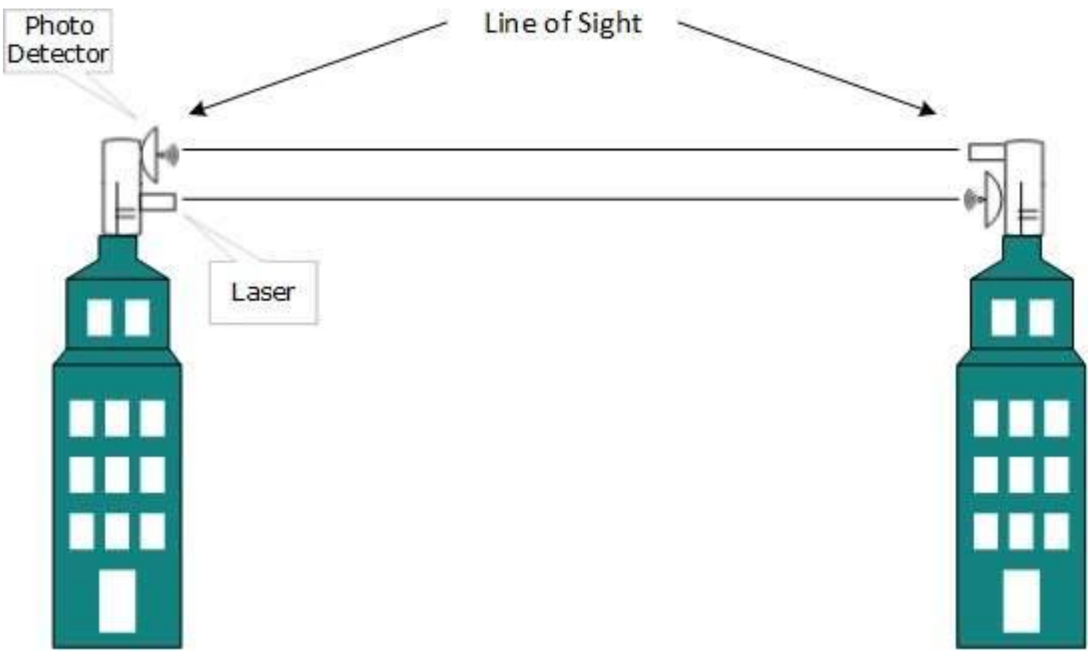
Infrared wave lies in between visible light spectrum and microwaves. It has wavelength of 700-nm to 1-mm and frequency ranges from 300-GHz to 430-THz.

Infrared wave is used for very short range communication purposes such as television and it's remote. Infrared travels in a straight line hence it is directional by nature. Because of high frequency range, Infrared cannot cross wall-like obstacles.

Light Transmission

Highest most electromagnetic spectrum which can be used for data transmission is light or optical signaling. This is achieved by means of LASER.

Because of frequency light uses, it tends to travel strictly in straight line.Hence the sender and receiver must be in the line-of-sight. Because laser transmission is unidirectional, at both ends of communication the laser and the photo-detector needs to be installed. Laser beam is generally 1mm wide hence it is a work of precision to align two far receptors each pointing to lasers source.



Laser works as Tx (transmitter) and photo-detectors works as Rx (receiver).

Lasers cannot penetrate obstacles such as walls, rain, and thick fog. Additionally, laser beam is distorted by wind, atmosphere temperature, or variation in temperature in the path.

Laser is safe for data transmission as it is very difficult to tap 1mm wide laser without interrupting the communication channel.

Frequencies for radio transmission

In the electromagnetic spectrum, all omnidirectional waves in the frequencies 3KHz to 1GHz are called radio waves. They are widely used for communications since they are easy to generate, can travel long distances and can penetrate buildings. Radio waves have omnidirectional antennas, i.e. antennas that can send signals in all directions.

The properties of radios waves vary according to their frequencies. However, radio waves at all frequencies are prone to interference from electrical equipments like motors etc.

Low and Medium Frequency Radio Waves

Low and medium frequency radio waves can pass through obstacles and have ground propagation. However, the power diminishes rapidly depending upon the distance from the source. This attenuation in power is called the path loss. AM radio uses LF and MF bands.

High Frequency Radio Waves

High frequency radio waves travel in straight lines and have sky propagation. However, they are affected by interferences and are affected by rains. The military communicates in the HF and VHF bands. They are also used for long distance broadcasting and FM radio.

Applications

Some of the areas of applications of radio waves are −

- Broadcasting and multicasting
- Fixed and mobile radio communications
- AM and FM radio
- Television
- Marine communication
- Wireless computer networks
- Cordless phones

Regulations - Signals, Signal propagation, Path loss of radio signals, Additional signal propagation effects

Radio path loss is key factor in the design of any radio communications system or wireless communication system.

It is a fact that any radio signal will suffer attenuation when it travels from the transmitter to the receiver. A variety of different phenomena give rise to this radio path loss.

Understanding what causes radio path loss enables any system to be designed to perform to its best despite the various issues affecting it.

How does radio path loss affect systems

The radio signal path loss will determine many elements of the radio communications system or wireless communication system in particular the transmitter power, and the antennas, especially their gain, height and general location. This is true for whatever frequency is used.

To be able to plan the system, it is necessary to understand the reasons for radio path loss, and to be able to determine the levels of the signal loss for a given radio path.

The radio path loss can often be determined mathematically and these calculations are often undertaken when preparing coverage or system design activities. These depend on a knowledge of the signal propagation properties.

Accordingly, radio path loss calculations are used in many radio and wireless survey tools for determining signal strength at various locations. These wireless survey tools are being increasingly used to help determine what radio signal strengths will be, before installing the equipment. For cellular operators radio coverage surveys are important because the investment in a macrocell base station is high. Also, wireless survey tools provide a very valuable service for applications such as installing wireless LAN systems in large offices and other centres because they enable problems to be solved before installation, enabling costs to be considerably reduced. Accordingly there is an increasing importance being placed onto wireless survey tools and software.

Radio path loss basics

The signal path loss is essentially the reduction in power density of an electromagnetic wave or signal as it propagates through the environment in which it is travelling. This affects all radio communication, broadcast and wireless communiction systems

There are many reasons for the radio path loss that may occur:

- ***Free space loss:*** The free space loss occurs as the signal travels through space without any other effects attenuating the signal it will still diminish as it spreads out. This can be thought of as the radio communications signal spreading out as an ever increasing sphere. As the signal has to cover a wider area, conservation of energy tells us that the energy in any given area will reduce as the area covered becomes larger.
- ***Diffraction:*** radio signal path loss due diffraction occurs when an object appears in the path. The signal can diffract around the object, but losses occur. The loss is higher the more rounded the object. Radio signals tend to diffract better around sharp edges, i.e. edges that are sharp with respect to the wavelength.
- ***Multipath:*** In a real terrestrial environment, signals will be reflected and they will reach the receiver via a number of different paths. These signals may add or subtract from each other depending upon the relative phases of the signals. If the receiver is moved the scenario will change and the overall received signal will be found vary with position. Mobile receivers (e.g. cellular telecommunications phones) will be subject to this effect which is known as Rayleigh fading.
- ***Absorption losses:*** Absorption losses occur if the radio signal passes into a medium which is not totally transparent to radio signals. There are many reasons for this which include:

- *Buildings, walls, etc:* When radio signals pass through dense materials such was walls, buildings or even furniture within a building, they suffer attenuation. It is particularly applicable to cellular communications – in buildings, houses, etc signals are considerably reduced. The radio signal attenuation is more pronounced for the higher frequency mobile bands., e.g. 2.2 GHz as opposed to 800 / 900 MHz.
- *Atmospheric moisture:* At high microwave frequencies radio path loss increases as a result of precipitation or even moisture in the air. The radio signal path loss may vary according to the weather conditions. However this typically only has a noticeable effect further into the microwave region.
- *Vegetation:* In dense forest it is found that signals even at lower frequencies are considerably reduced. This illustrates that vegetation can introduce considerable levels of radio path loss. Trees and foliage can attenuate radio signals, particularly when wet.

Terrain: The terrain over which signals travel will have a significant effect on the signal. Obviously hills which obstruct the path will considerably attenuate the signal, often making reception impossible. Additionally at low frequencies the composition of the earth will have a marked effect. For example on the Long Wave band, it is found that signals travel best over more conductive terrain, e.g. sea paths or over areas that are marshy or damp. Dry sandy terrain gives higher levels of attenuation.

Atmosphere: The atmosphere can affect radio signal paths.

- *Ionosphere:* At lower frequencies, especially below 30 - 50MHz, the ionosphere has a significant effect, reflecting (or more correctly refracting) them back to Earth. However when passing through some regions, especially the D region and to a lesser extent the E region, signals can suffer attenuation rather than reflection / refraction. This can introduce a significant radio path loss.
- *Troposphere:* At frequencies above 50 MHz and more the troposphere has a major effect, refracting the signals back to earth as a result of changing refractive index. For UHF broadcast this can extend coverage to approximately a third beyond the horizon. The refraction can sometimes mean that signal that would normally reach a certain area may be refracted away from it.

Multi-path propagation

A radio signal spreads out in different directions as it radiates away from the broadcast antenna. Parts of the spreading wave will encounter reflecting surfaces, and the wave will scatter off these objects. In an urban environment, the wave might reflect off buildings, moving trains, or airplanes. Multipath occurs when a signal takes two or more paths from the transmitting antenna to the receiving antenna. We'll assume that one signal, the direct ray, travels directly from the transmitter to the receiver. The direct ray is usually (but not always) the strongest signal present in the receiving antenna. The other signals (or rays) arrive at the receiving antenna via more roundabout paths. These reflected signals eventually find their way to the receiving antenna. In our analysis, we'll assume these indirect rays arrive after the direct ray and that the indirect rays are weaker in power than the direct rays.

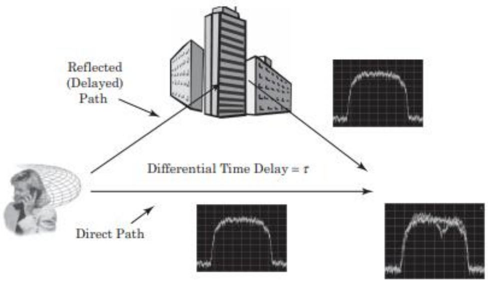


FIGURE 3-11 ■ In a severe multipath environment, a signal might bounce off several different reflectors before it arrives at a receiver. The result can be severe distortion.

Propagation Mechanisms

Wireless transmissions propagate in three modes. They are −

- Ground-wave propagation
- Sky-wave propagation
- Line-of-sight propagation

Ground wave propagation follows the contour of the earth, while **sky wave propagation** uses reflection by both earth and ionosphere.

Line of sight propagation requires the transmitting and receiving antennas to be within the line of sight of each other. Depending upon the frequency of the underlying signal, the particular mode of propagation is followed.

Examples of ground wave and sky wave communication are **AM radio** and **international broadcasts** such as BBC. Above 30 MHz, neither ground wave nor sky wave propagation operates and the communication is through line of sight.

Transmission Limitations

In this section, we will discuss the various limitations that affect electromagnetic wave transmissions. Let us start with attenuation.

Attenuation

The strength of signal falls with distance over transmission medium. The extent of attenuation is a function of distance, transmission medium, as well as the frequency of the underlying transmission.

Distortion

Since signals at different frequencies attenuate to different extents, a signal comprising of components over a range of frequencies gets distorted, i.e., the shape of the received signal changes.

A standard method of resolving this problem (and recovering the original shape) is to amplify higher frequencies and thus equalize attenuation over a band of frequencies.

Dispersion

Dispersion is the phenomenon of spreading of a burst of electromagnetic energy during propagation. Bursts of data sent in rapid succession tend to merge due to dispersion.

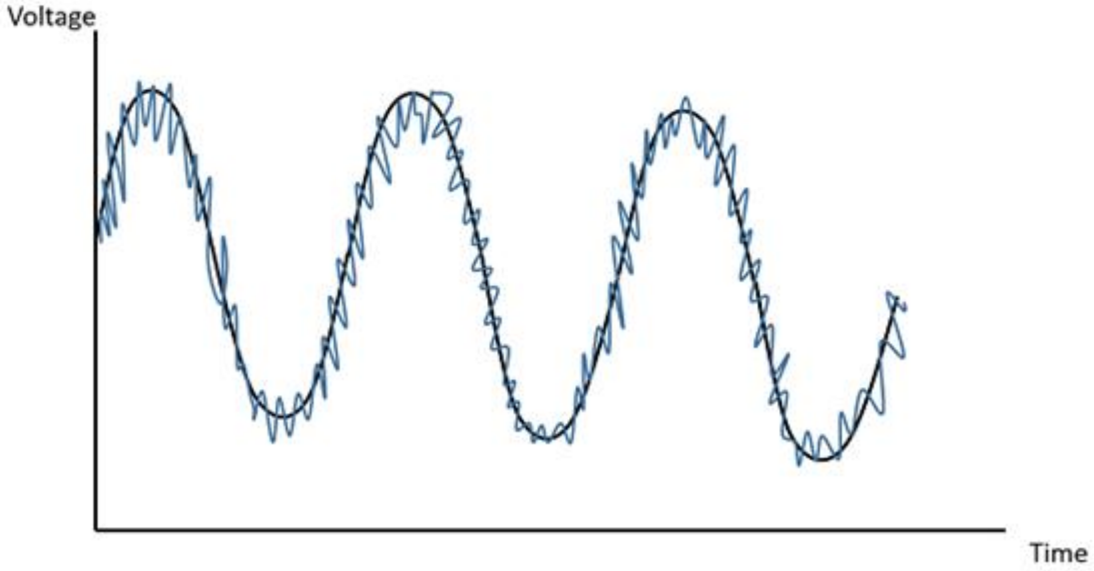
Noise

The most pervasive form of noise is thermal noise, which is often modeled using an additive Gaussian model. Thermal noise is due to thermal agitation of electrons and is uniformly distributed across the frequency spectrum.

Other forms of noise include −

- **Inter modulation noise** (caused by signals produced at frequencies that are sums or differences of carrier frequencies)
- **Crosstalk** (interference between two signals)
- **Impulse noise** (irregular pulses of high energy caused by external electromagnetic disturbances).

While an impulse noise may not have a significant impact on analog data, it has a noticeable effect on digital data, causing **burst errors**.



The above figure clearly illustrates how the noise signal overlaps the original signal and tries to change its characteristics.

Fading

Fading refers to the variation of the signal strength with respect to time/distance and is widely prevalent in wireless transmissions. The most common causes of fading in the wireless environment are multipath propagation and mobility (of objects as well as the communicating devices).

Multipath propagation

In wireless media, signals propagate using three principles, which are reflection, scattering, and diffraction.

- **Reflection** occurs when the signal encounters a large solid surface, whose size is much larger than the wavelength of the signal, e.g., a solid wall.
- **Diffraction** occurs when the signal encounters an edge or a corner, whose size is larger than the wavelength of the signal, e.g., an edge of a wall.
- **Scattering** occurs when the signal encounters small objects of size smaller than the wavelength of the signal.

One consequence of multipath propagation is that multiple copies of a signal propagation along multiple different paths, arrive at any point at different times. So the signal received at a point is not only affected by the **inherent noise, distortion, attenuation**, and **dispersion** in the channel but also the **interaction of signals** propagated along multiple paths.

Delay spread

Suppose we transmit a probing pulse from a location and measure the received signal at the recipient location as a function of time. The signal power of the received signal spreads over time due to multipath propagation.

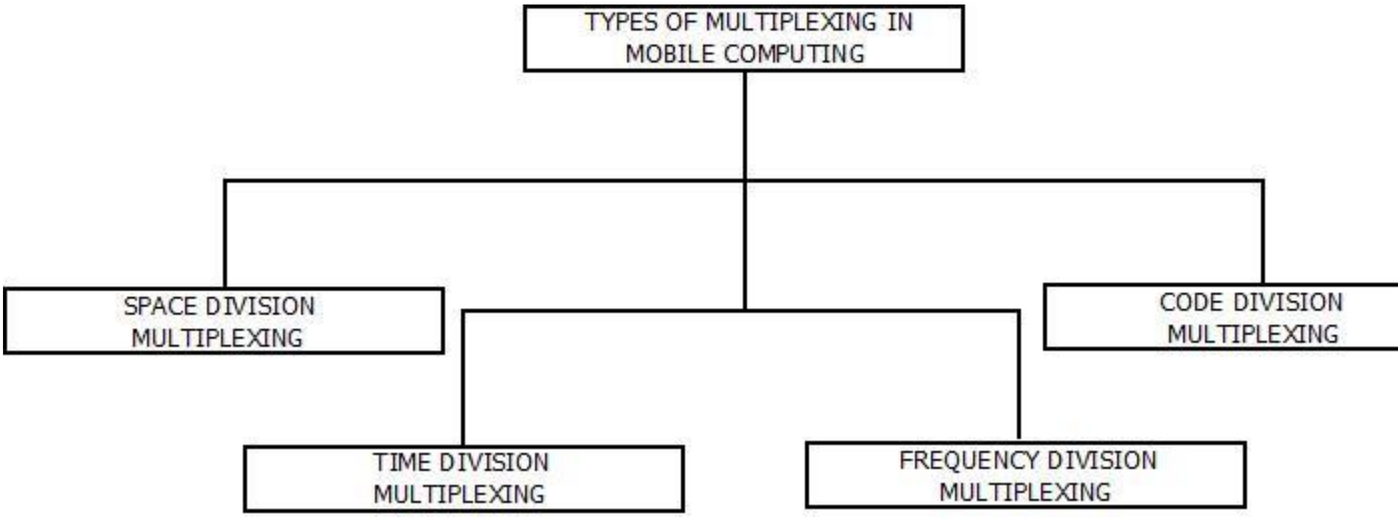
The delay spread is determined by the density function of the resulting spread of the delay over time. **Average delay spread** and **root mean square delay spread** are the two parameters that can be calculated.

Doppler spread

This is a measure of **spectral broadening** caused by the rate of change of the mobile radio channel. It is caused by either relative motion between the mobile and base station or by the movement of objects in the channel.

Multiplexing

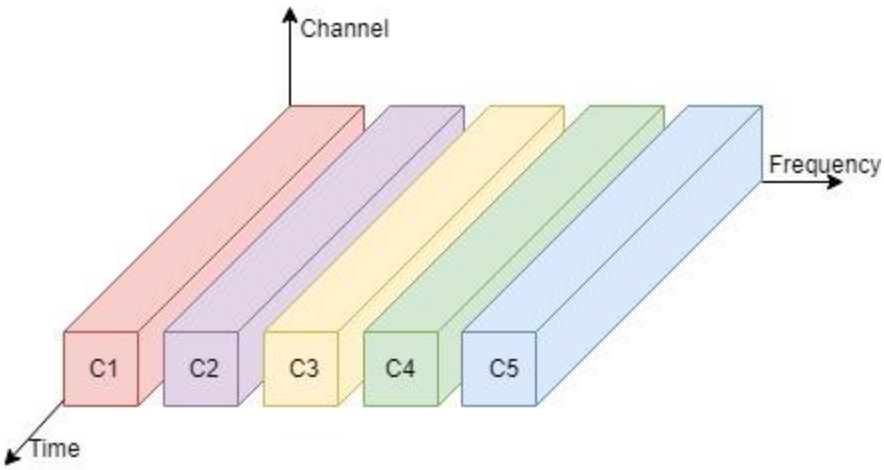
- **Multiplexing is a technique in which, multiple simultaneous analog or digital signals are transmitted across a single data link.**
- **The concept behind it is very simple: Proper Resource Sharing and its Utilization.**
- **It can be classified into four types. These are:**



Multiplexing : Mobile Computing

Multiplexing : Frequency Division Multiplexing(FDM)

- **In Frequency Division , the frequency dimension spectrum is split into bands of smaller frequency.**
- **FDM is used because of the fact that, a number of frequency band can work simultaneously without any time constraint.**



Frequency Division

Advantages of FDM

- **This concept is applicable on both analog signals as well as digital signals.**
- **Simultaneous signal transmission feature.**

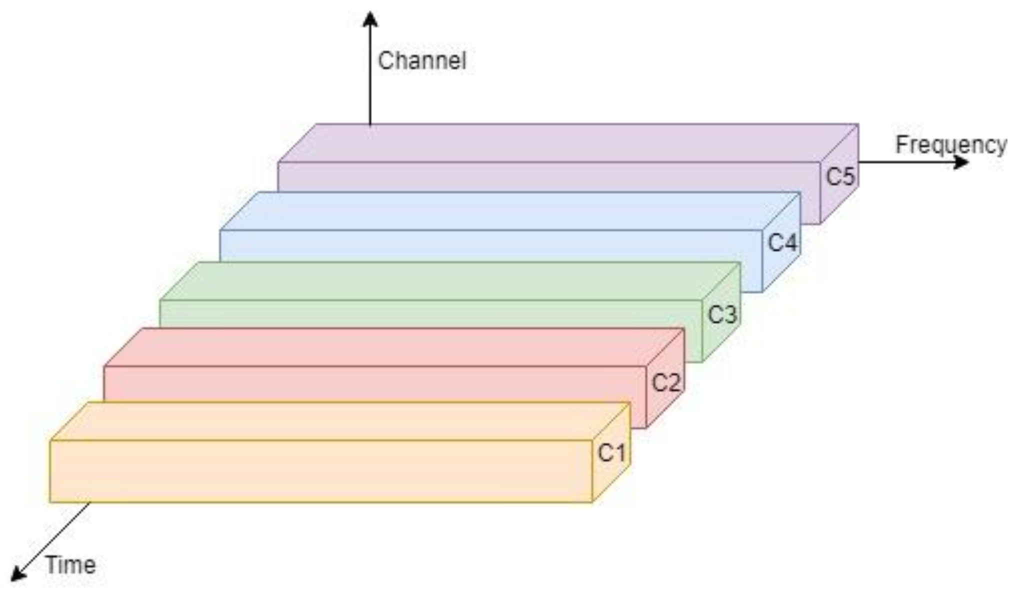
Disadvantages of FDM

- **Less Flexibility.**
- **Bandwidth wastage is high and can be an issue.**

For Example : Frequency Division Multiplexing can be used for radio station in a particular region as every radio station will have their own frequency and can work simultaneously without having any constraint of time.

Multiplexing : Time Division Multiplexing(TDM)

- **Time Division is used for a particular amount of time in which the whole spectrum is used.**
- **Time frames of same intervals are made such that the entire frequency spectrum can be accessed at that time frame.**



Time Division

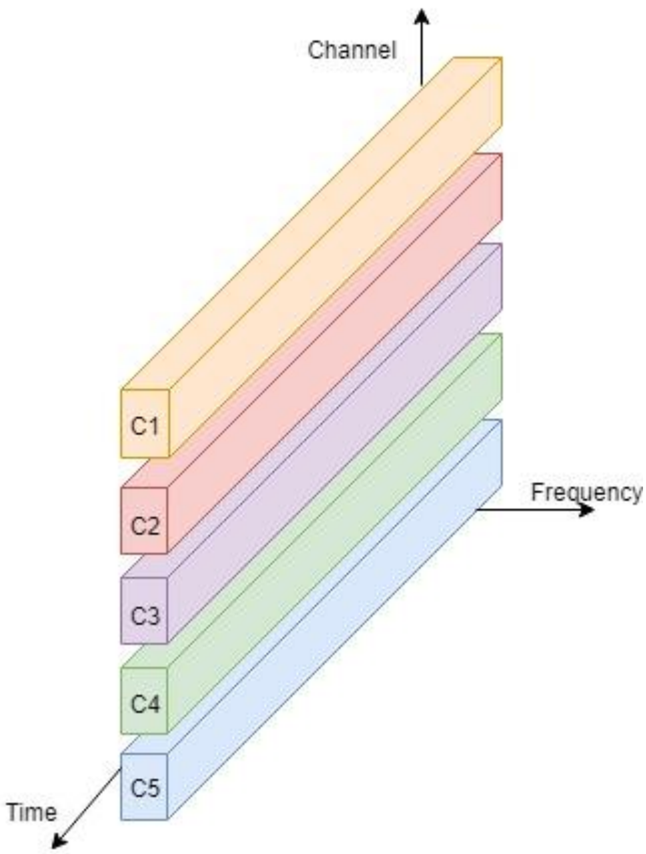
Advantages of TDM
- **Single user at a time.**
- **Less complex and more flexible architecture.**

Disadvantages of TDM
- **Difficult to implement.**

For Example : ISDN(Integrated Service for Digital Network) telephonic service.

Multiplexing : Code Division Multiplexing(CDM)

- **In Code Division Multiplexing, every channel is allotted with a unique code so that each of these channels can use the same spectrum simultaneously at same time.**



Code Division

<u>Advantages of CDM</u>

- **Highly Efficient.**
- **Less Inference.**

<u>Disadvantages of CDM</u>

- **Less data transmission rates.**
- **Complex in nature.**

For Example : Cell Phone Spectrum Technology(2G, 3G etc.).

<u>Multiplexing : Space Division Multiplexing(SDM)</u>

- **Space Division can be called as the combination of concepts of Frequency Division Multiplexing and Time Division Multiplexing.**
- **In SDM, the goal is to pass messages or data parallelly with the use of specific frequency at certain interval of time.**
- **It means, a particular channel for some amount of time will be used against a certain frequency band.**

<u>Advantages of SDM</u>

- **High Data transmission rate.**
- **Optimal Use of Time and Frequency bands.**

<u>Disadvantages of SDM</u>

- **Inference Problems.**
- **High inference losses.**

For Example : GSM(Global Service For Mobile) Technology.

Cellular Systems

Cellular network is an underlying technology for mobile phones, personal communication systems, wireless networking etc. The technology is developed for mobile radio telephone to replace high power transmitter/receiver systems. Cellular networks use lower power, shorter range and more transmitters for data transmission.

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.

Cellular network is organized into multiple low power transmitters each 100w or less.

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 −

Square

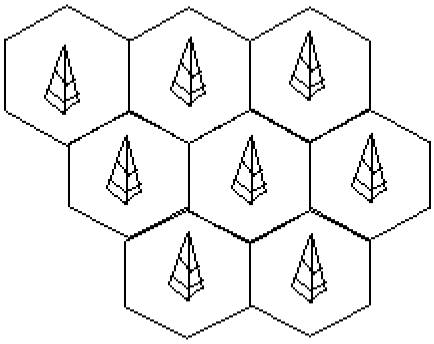
A square cell has four neighbors at distance **d** and four at distance Root **2 d**

- Better if all adjacent antennas equidistant
- Simplifies choosing and switching to new antenna

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



Frequency Reuse

Frequency reusing is the concept of using the same radio frequencies within a given area, that are separated by considerable distance, with minimal interference, to establish communication.

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

For example, when **N** cells are using the same number of frequencies and **K** be the total number of frequencies used in systems. Then each **cell frequency** is calculated by using the formulae **K/N**.

MACA

Multiple Access with Collision Avoidance (MACA) is a medium access control (MAC) layer protocol used in wireless networks, with a view to solve the hidden terminal problem. It also provides solution to the exposed terminal problem. The MAC layer protocol IEEE 802.11 RTS/CTS has been adopted from MACA.

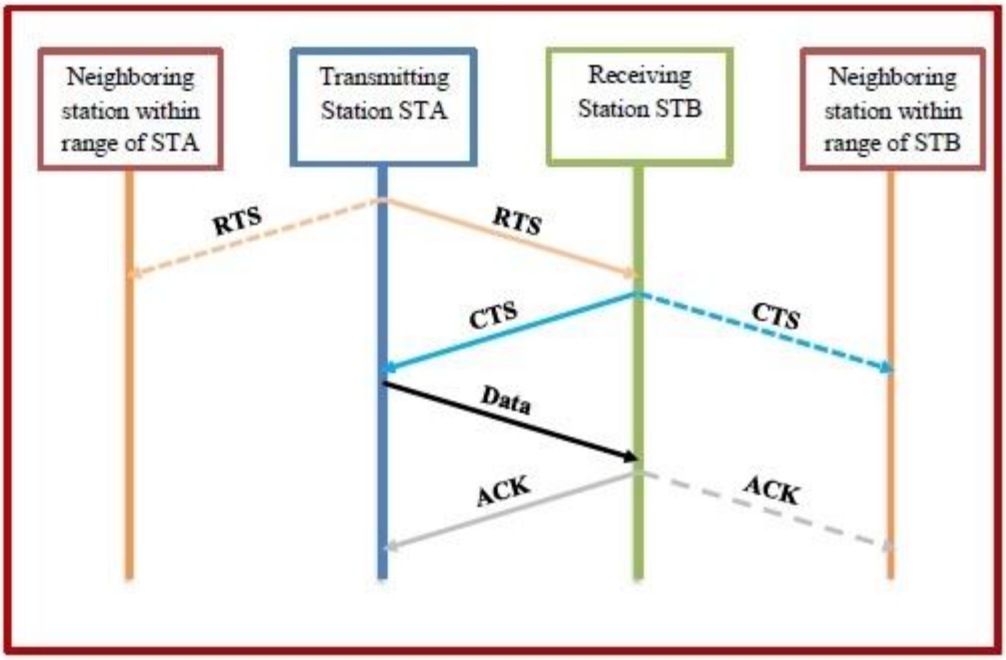
Working Principle

The MACA protocol works with the condition that the stations are synchronized and frame sizes and data speed are the same. It involves transmission of two frames called RTS and CTS prior to data transmission. RTS stands for Request to Send and CTS stands for Clear to Send.

Let us consider that a transmitting station STA has data frame to send to a receiving station STB. The operation works as follows:

- Station STA sends a RTS frame to the receiving station.
- On receiving the RTS, station STB replies by sending a CTS frame.
- On receipt of CTS frame, station STA begins transmitting its data frame.
- After successful receipt of the data frame, station STB sends an ACK frame (acknowledgement frame).

The sequence is illustrated as follows:



Any station than can hear RTS is close to the transmitting station and remains silent long enough for the CTS, or waits for a certain time period. If the RTS is not followed by a CTS, the maximum waiting time is the RTS propagation time.

Any station that can hear the CTS is close to the receiving station and remains silent during the data transmission. It attempts for transmission after hearing the ACK.

MACA is a non-persistent slotted protocol. This implies that if the medium is detected as busy, a station waits for a random time period after the beginning of a time slot and then it sends an RTS. This assures fair access to the medium.

CDMA.

Code Division Multiple Access (CDMA) is a sort of multiplexing that facilitates various signals to occupy a single transmission channel. It optimizes the use of available bandwidth. The technology is commonly used in ultra-high-frequency (UHF) cellular telephone systems, bands ranging between the 800-MHz and 1.9-GHz.

CDMA Overview

Code Division Multiple Access system is very different from time and frequency multiplexing. In this system, a user has access to the whole bandwidth for the entire duration. The basic principle is that different CDMA codes are used to distinguish among the different users.

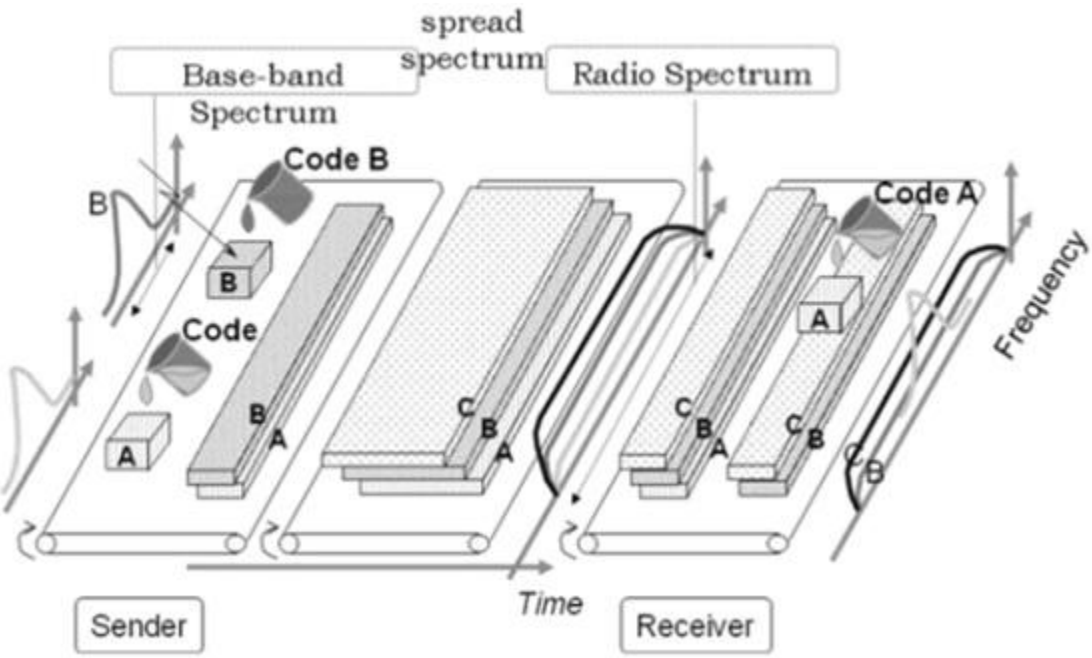
Techniques generally used are direct sequence spread spectrum modulation (DS-CDMA), frequency hopping or mixed CDMA detection (JDCDMA). Here, a signal is generated which extends over a wide bandwidth. A code called **spreading code** is used to perform this action. Using a group of codes, which are orthogonal to each other, it is possible to select a signal with a given code in the presence of many other signals with different orthogonal codes.

How Does CDMA Work?

CDMA allows up to 61 concurrent users in a 1.2288 MHz channel by processing each voice packet with two PN codes. There are 64 Walsh codes available to differentiate between calls and theoretical limits. Operational limits and quality issues will reduce the maximum number of calls somewhat lower than this value.

In fact, many different "signals" baseband with different spreading codes can be modulated on the same carrier to allow many different users to be supported. Using different orthogonal codes, interference between the signals is minimal. Conversely, when signals are received from several mobile stations, the base station is capable of isolating each as they have different orthogonal spreading codes.

The following figure shows the technicality of the CDMA system. During the propagation, we mixed the signals of all users, but by that you use the same code as the code that was used at the time of sending the receiving side. You can take out only the signal of each user.



CDMA Capacity

The factors deciding the CDMA capacity are −

- Processing Gain
- Signal to Noise Ratio
- Voice Activity Factor
- Frequency Reuse Efficiency

Capacity in CDMA is soft, CDMA has all users on each frequency and users are separated by code. This means, CDMA operates in the presence of noise and interference.

In addition, neighboring cells use the same frequencies, which means no re-use. So, CDMA capacity calculations should be very simple. No code channel in a cell, multiplied by no cell. But it is not that simple. Although not available code channels are 64, it may not be possible to use a single time, since the CDMA frequency is the same.

Centralized Methods

- The band used in CDMA is 824 MHz to 894 MHz (50 MHz + 20 MHz separation).
- Frequency channel is divided into code channels.
- 1.25 MHz of FDMA channel is divided into 64 code channels.

Processing Gain

CDMA is a spread spectrum technique. Each data bit is spread by a code sequence. This means, energy per bit is also increased. This means that we get a gain of this.

P (gain) = 10log (W/R)

W is Spread Rate

R is Data Rate

For CDMA P (gain) = 10 log (1228800/9600) = 21dB

This is a gain factor and the actual data propagation rate. On an average, a typical transmission condition requires a signal to the noise ratio of 7 dB for the adequate quality of voice.

Translated into a ratio, signal must be five times stronger than noise.

Actual processing gain = P (gain) - SNR

= 21 – 7 = 14dB

CDMA uses variable rate coder

The Voice Activity Factor of 0.4 is considered = -4dB.

Hence, CDMA has 100% frequency reuse. Use of same frequency in surrounding cells causes some additional interference.

In CDMA frequency, reuse efficiency is 0.67 (70% eff.) = -1.73dB

Advantages of CDMA

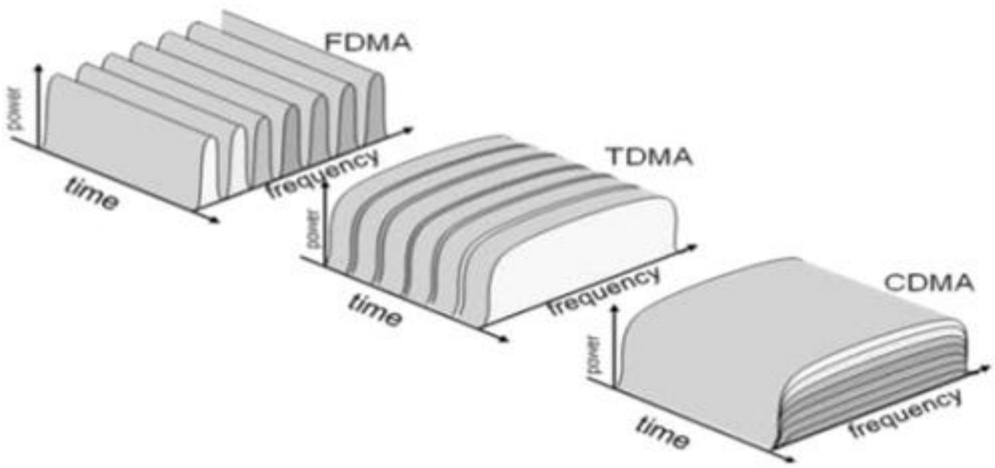
CDMA has a soft capacity. The greater the number of codes, the more the number of users. It has the following advantages −

- CDMA requires a tight power control, as it suffers from near-far effect. In other words, a user near the base station transmitting with the same power will drown the signal latter. All signals must have more or less equal power at the receiver
- Rake receivers can be used to improve signal reception. Delayed versions of time (a chip or later) of the signal (multipath signals) can be collected and used to make decisions at the bit level.
- Flexible transfer may be used. Mobile base stations can switch without changing operator. Two base stations receive mobile signal and the mobile receives signals from the two base stations.
- Transmission Burst − reduces interference.

Disadvantages of CDMA

The disadvantages of using CDMA are as follows −

- The code length must be carefully selected. A large code length can induce delay or may cause interference.
- Time synchronization is required.
- Gradual transfer increases the use of radio resources and may reduce capacity.
- As the sum of the power received and transmitted from a base station needs constant tight power control. This can result in several handovers.



THANK YOU

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