Adama Science and Technology University

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Wireless Mobile Networks-CSE5309:

Assignment - I

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1. Explain in brief cellular system, how it differ from wireless communication. What is cell splitting in cellular network explain with example?

A cellular system comprises a core network that connects to base stations with antennas on towers that span up to 20 miles in diameter. GSM and CDMA are the two major cellular technologies. See cellphone, cellular generations, GSM, CDMA and microcell.

The cellular system employs a different design approach than most commercial radio and television systems use. Radio and television systems typically operate at maximum power and with the tallest antennas allowed by the regulatory agency of the country. In the cellular system, the service area is divided into cells. A transmitter is designed to serve an individual cell. The system seeks to make efficient use of available channels by using low-power transmitters to allow frequency reuse at much smaller distances. Maximizing the number of times each channel can be reused in a given geographic area is the key to an efficient cellular system design.

During the past three decades, the world has seen significant changes in the telecommunications industry. There have been some remarkable aspects to the rapid growth in wireless communications, as seen by the large expansion in mobile systems. Wireless systems consist of wireless wide-area networks (WWAN) [i.e., cellular systems], wireless local area networks (WLAN), and wireless personal area networks (WPAN). The handsets used in all of these systems possess complex functionality, yet they have become small, low-power consuming devices that are mass produced at a low cost, which has in turn accelerated their widespread use. The recent advancements in Internet technology have increased network traffic considerably, resulting in a rapid growth of data rates. This phenomenon has also had an impact on mobile systems, resulting in the extraordinary growth of the mobile Internet.

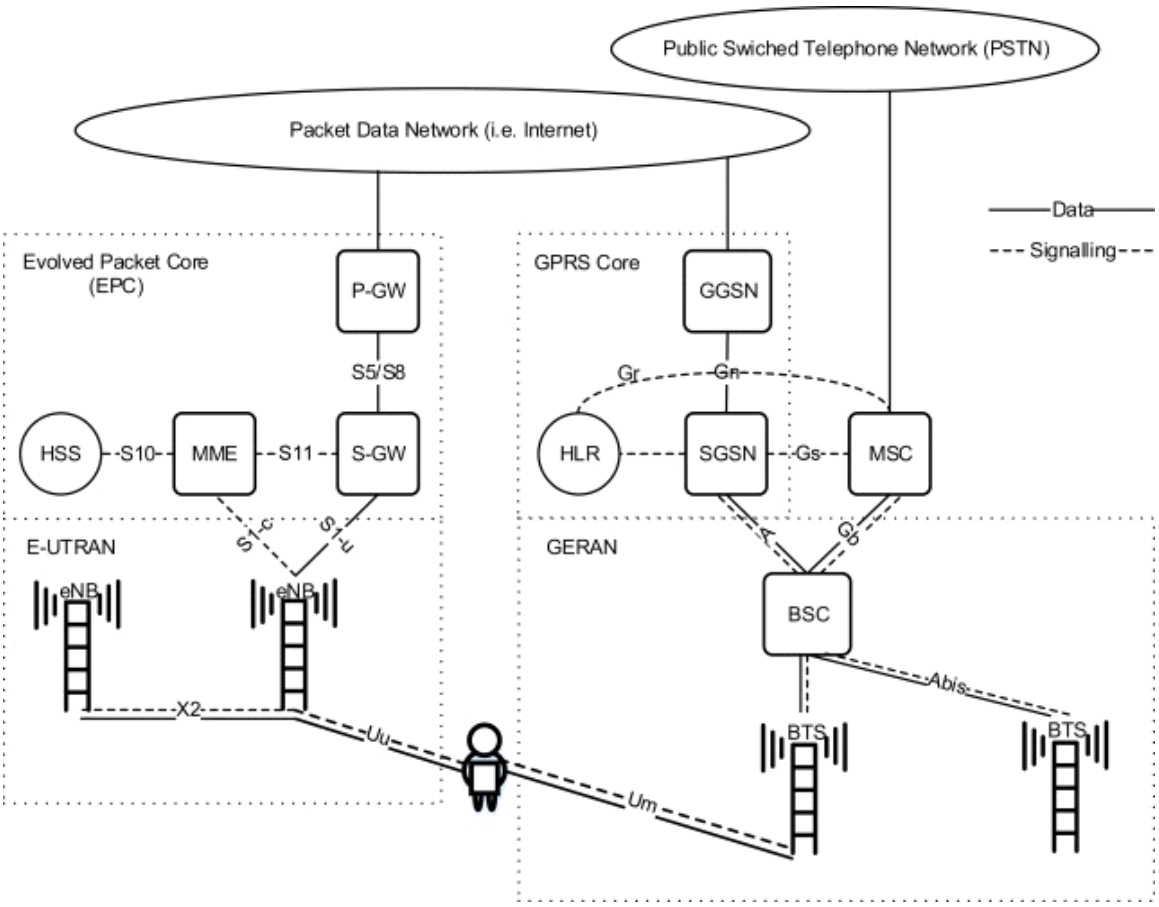


Figure 1. Cellular System Architecture

How it does it differ from wireless communication?

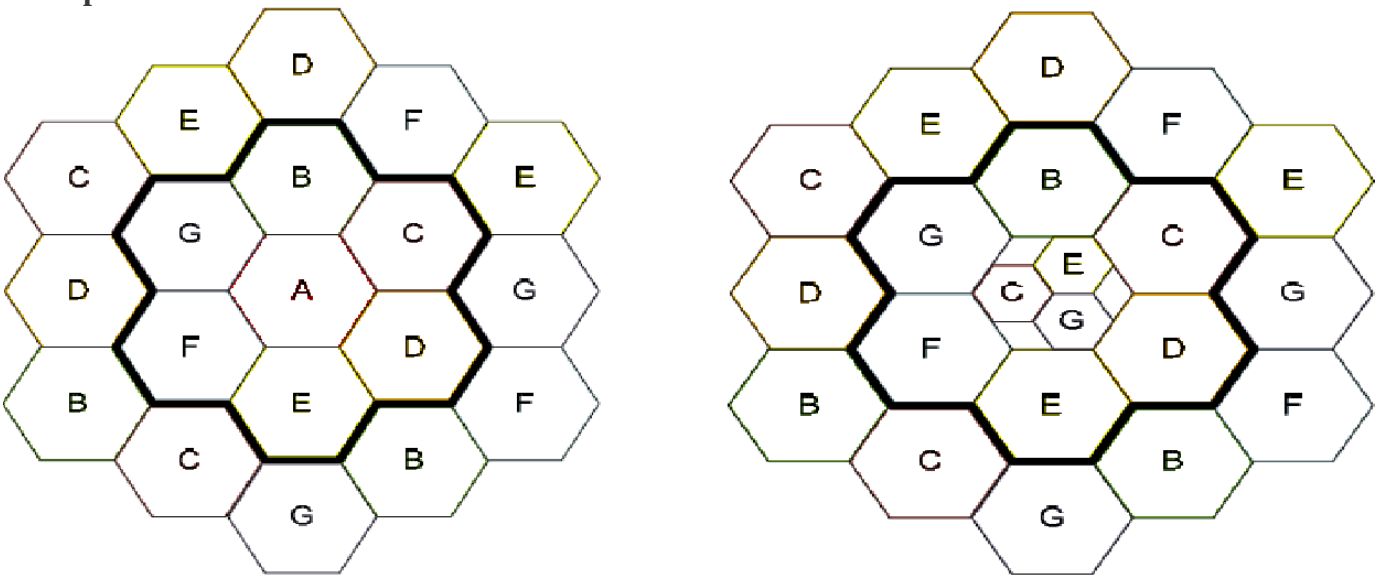
No.	Key	Cellular System	Wireless Communication
1	Internet access	Cellular systems are based on mobile phones/devices using cellular signals to connect to the internet.	Wireless communication uses radiofrequency waves to provide high-speed internet access to connected devices.
2	Standard	Cellular networks are based on mobile phones and use networks spread over a wide area.	Wireless communication is a wireless network technology following IEEE 802.11 standards.
3	Range	Cellular networks are dependent on network range availability.	Wireless communication has a limited range.
4	Data plans	Mobile phones have a plan up to which data can be consumed.	Wireless communication has no such limits or plans up to which data can be consumed.
5	Speed	Mobile phone network access speed is generally slow as compared to	Wireless communication is quite faster as compared to a cellular network.

		wireless communication.	
6	Way of connection	Connects to the internet through cellular towers.	Connects to the internet through routers.

What is cell splitting in cellular network explain with example?

First of all, **a cell** is a geographical area covered by the frequency emitted by a base station in a cellular network. The elements that transmit this frequency is called a cell site. The cell provided by a cell site can range from a few kilometers to thousands of kilometers in diameter, depending on the terrain, the technology being deployed and the transmission power of the cell site. A host of cell sites form a cell system.

As the number of users increases, so does the interference, thereby affecting the capacity of the cellular system. One immediate solution to this problem is to subdivide a cell into two or more smaller cells. This method is *called* **cell splitting**. So, it is **a process by which an area of a cell or an independent coverage area of a cellular system is divided into more cell areas**, while each cell has its own base station and a subsequent cutback in antenna height and transmitter power.
What it basically does is – it split the cells in areas of high usage into multiple smaller cells called microcells. So, it would require additional BSs to be established at the site of each new cell that has been installed in order to increase the capacity in congested areas.
Example:



(a) Original cell distribution (b) After splitting cell A

Figure 1.5: Example of cell splitting

2. Briefly explain how traffic routing in wireless mobile network can be done?

The amount of traffic capacity required in a wireless network is highly dependent upon the type of traffic carried. Some traffic may have an urgent delivery schedule while some may have no need to be sent in real-time. The type of traffic carried by a network determines the routing services, protocols, and call handling techniques which must be employed.

Traffic Routing is the process of selecting a path for traffic in a network or between or across multiple networks.

How is it done in mobile networks?

When a packet has reached a router, the source and destination address of the packet are used in conjunction with a routing table (list that contains the routes to a certain network) to determine the next hop address. ... As a result, each packet can be sent through a different route to the destination if necessary.

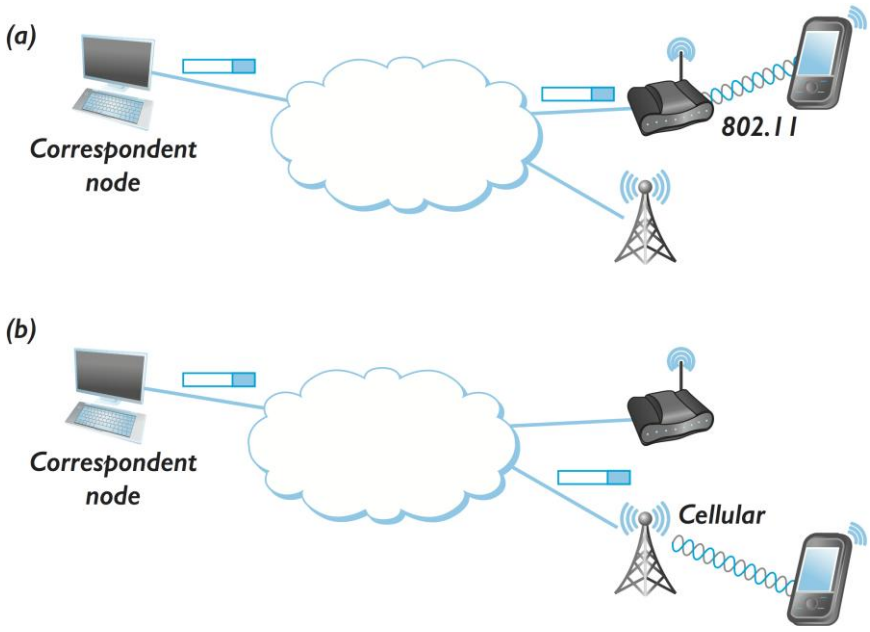


Figure 2. Traffic Routing

Two general routing services are provided by networks

1. Connection oriented services (virtual circuit routing)
2. Connectionless services (datagram services)

Connection-Oriented Routing

- In connection-oriented routing, the communications path between the message source and destination is fixed for the entire duration of the message, and a call set-up procedure is required to dedicate network resources to both the called and calling parties.

- Since the path through the network is fixed, the traffic in connection-oriented routing arrives at the receiver in the exact order it was transmitted.
- Connection-oriented service relies heavily on error control coding to provide data protection in case the network connection becomes noisy.
- If coding is not sufficient to protect the traffic, the call is broken, and the entire message must be retransmitted from the beginning.

Connectionless Routing

Connectionless routing, on the other hand, does not establish a firm connection for the traffic, and instead relies on packet-based transmissions

- Packets sent using connectionless routing do not necessarily arrive in the order of transmission and must to be reordered at the receiver. Several packets form a message, and each individual packet in a connectionless service is routed separately
- Because packets take different routes in a connectionless service, some packets may be lost due to network or link failure; however others may get through with sufficient redundancy to enable the entire, message to be recreated at the receiver. Thus, connectionless routing often avoids having to retransmit an entire message, but requires more overhead information for each packet
- In a connectionless service, a call set-up procedure is not required at the beginning of a call, and each message burst is treated independently by the network

3. What is ISDN? Explain its architecture, data transfer mechanism and applications.

Integrated Services Digital Network (ISDN) is a set of communication standards for simultaneous digital transmission of voice, video, data, and other network services over the digitalized circuits of the public switched telephone network.

Integrated services refers to ISDN's ability to deliver at minimum two simultaneous connections, in any combination of data, voice, video, and fax, over a single line. Multiple devices can be attached to the line, and used as needed. That means an ISDN line can take care of what were expected to be most people’s complete communications needs (apart from broadband Internet access and entertainment television) at a much higher transmission rate, without forcing the purchase of multiple analog phone lines. It also refers to integrated switching and transmission in that telephone switching and carrier wave transmission are integrated rather than separate as in earlier technology.

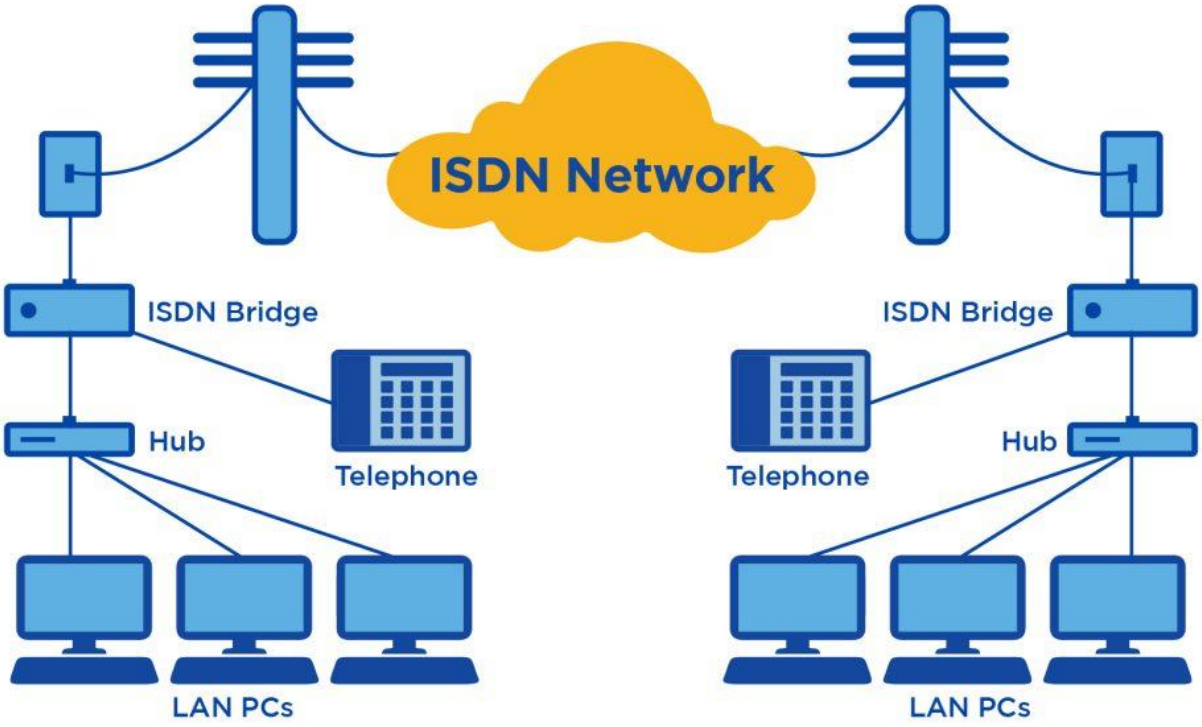


Figure 3. ISDN Architecture

Data transfer mechanism in ISDN

ISDN or Integrated Services Digital Network uses a **circuit-switched telephone network system** that transmits both data and voice over a digital line. You can also think of it as a set of communication standards to transmit data, voice, and signaling.

ISDN uses **out-channel transfer mechanism**. This out-channel signaling system enables call control to be done independently of user-information transfer. Also, most parts of the signaling procedures are the same as in the N-ISDN. The B-ISDN signaling system uses a meta-signaling channel to control the setting up and closing of signaling channel.

Applications of ISDN

- **Video Conferencing:** ISDN circuits have been very useful for video conferencing. A video conferencing session can be established with a single ISDN line (128 Kbps) and a set-top video conferencing Codec (at both ends). The video conferencing can be done at a much lower bandwidth than a packet switched network (like Internet Leased Lines or high speed broadband) because, ISDN is a circuit switched network and hence there are no packet losses and ISDN can give equal throughput for both upstream and downstream transmissions (which is so critical for sending and receiving real time video in both the ends). Apart from the rental, the payment is only for usage (duration in minutes). So, if your company doesn't conduct video conferencing sessions frequently, ISDN can still be a good choice! Moreover, the data network would be free to do what it needs to do – carry data without any congestion and delays. Multiple ISDN (Up to four, in most video conferencing systems) can be terminated simultaneously in video conferencing systems

to enable a conference at higher bandwidth (hence higher quality) or conduct a multi-party video conference. Even if you have your entire video conferencing infrastructure on IP, but have to connect one customer on ISDN, you can still do so by using certain devices that convert ISDN to IP and vice versa.

- **Making Couple of Telephone Calls Simultaneously:**

  With an ISDN line, we can do a number of things simultaneously:

  - We can dial out two telephone calls (by connecting two analog phones to the adapter)
  - We can browse the Internet (128 Kbps) and if we get a call during browsing, the call will be connected in one channel (64 Kbps) and the Internet connectivity can continue in the other channel at a lower speed (64 Kbps)
  - We can send a fax in one channel and simultaneously talk to some one in the other channel (while the fax is being transmitted)

  In some countries (like Germany), a lot of ISDN connections are used for basic voice communications (phone calls), just like how analog trunks are being used.

- **ISDN Video Phones:** There are certain video phones that connect to the ISDN network and can make a video call (voice and video) to any other similar ISDN phone connected to the ISDN network. The video phones have a bigger screen and built in camera to show the output video as well as capture the video.
- **Broadcasting Industry:** The broadcasting industry (especially the radio broadcasting stations) use ISDN network for carrying the audio signals from one station to another as well as from the covering point (sports stadium, etc) to the broadcasting point (radio station). But these days, IP networks are also popular for this application.
- **Digital PBX/ IP PBX:** There are ISDN interface cards which allow ISDN lines to be terminated on a corporate PBX (both for Digital – Mixed PBX as well as IP PBX). So, the Digital ISDN lines can be terminated on the PBX and can be used for making outgoing calls as well as receiving incoming calls from any phone in the organization. This can be especially useful for companies that want to use ISDN for video conferencing, as the ISDN lines can be used for normal voice communications (through PBX) when they are not being used for video conferencing.
- **Back-up Internet Connectivity:** The ISDN networks can be directly terminated on certain enterprise Routers that provide an automatic fail-over to the ISDN network for accessing Internet when the primary Internet Line (Internet Leased Lines, Broadband etc) is down. Sometimes, ISDN can also be the primary source of Internet connectivity for small companies in remote locations where the ADSL broadband networks are not supported.
- **Bank ATM/ Point of Sale Locations:** ISDN networks make a good choice for connecting critical yet low bandwidth consuming applications like multiple Bank ATM's (Automated Teller Machines), Point of Sale locations like an exhibition which needs network access for accepting payment through credit cards, etc.

4. Provide different steps required when a mobile originates a call in cellular system.

Steps followed when a mobile originates a call:

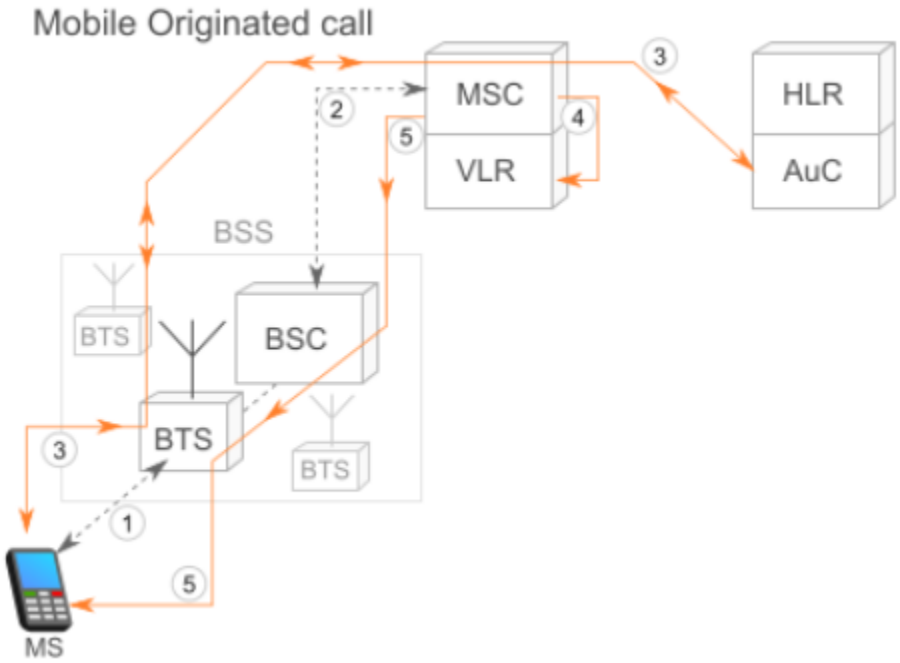


Figure 4. Mobile Originated Call Procedure

1. To initiate a call, the MS sends a request for radio resource allocation to the BSS, which mediates further connection to the Mobile Switching Center (MSC). The BSS assigns the MS a channel with a given frequency and time slot, which constitutes the communication route between the MS and the BSS.
2. Once the MS confirms the established channel, the BSS can initiate the connection to the MSC.
3. Once the MS has connected to the network, the subscriber needs to be authenticated. This can be done using the IMSI number stored in the SIM card, which allows the Authentication Center in the core network to verify the subscriber's identity. After this step, the MS and the MSC can start communicating.

   To make sure the data sent over the radio network between the BSS and MS/MSC is secure, the MSC initiates a ciphering procedure which is transmitted to the BTS, which in turn forwards the message to the MS. The MS enables ciphering towards the BTS; as the BTS starts receiving ciphered data, it will start the ciphered transmission of information, finalizing the encryption procedure.

4. In order to initiate the call setup, the MSC verifies that the requested service is allowed for the subscriber. This information is available in the Virtual Location Register, which

maintains temporary subscriber data (location, preferences, allowed services). Once the VLR confirms the service requested by the originating MS, the MSC starts the call setup.

5. For the call to take place, the MSC allocates a voice channel between the MSC and the BSS. The BSS notifies the MS about the change to voice mode, and the MS returns a confirmation message. The MSC routes the call to the dialed number. When the call is received in the PSTN, the MSC is notified that the called subscriber is being alerted, at which point the originating MS receives a ring notification.

5. From the following mobile technology concepts which one has shortest battery life?

(Before call drop) and why?

a. **Pager,**
b. **A cellular phone and**
c. **Cordless phone.**

Pagers have the longest battery life because a pager is just a radio receiver and not a radio transmitter. A cell phone or a cordless phone are both a receiver and a transmitter. A receiver uses much less battery power than a transmitter does. And because a pager's disposable alkaline battery holds more power than a cell phone or cordless phone's rechargeable battery.

6. List and discuss performance criteria of cellular mobile networks.

There are several performance criteria in which a cellular network can be evaluated. Some of them are:

- **Voice quality:** Voice quality is complicated for design engineers. A cellular network would be measured in terms of voice bit rate and noise.

Circuit Merits in respect of Voice Quality

Circuit Merit	Score	Quality Scale
CM 1	1	(Unsatisfactory) not understandable
CM 2	2	Poor (understandable, but repetitions are required)
CM 3	3	Fair (Occasional repetitions required)
CM 4	4	Good (understandable, but some noise)
CM 5	5	Excellent

- **Service quality:** the following parameters are required to judge performance in service quality
    I. ***Coverage area***- If a system serve as far as possible i.e., large area, it is said to be performing good in terms of coverage area otherwise, it's not.
    II. ***Grade of service***- The grade of service is very good if number of block calls out of 100 is two or less than that. However, the blocking probability at each cell site is different. To decrease blocking of calls we need sufficient number of radio channels as well as number of BTS.
    III. ***Number of dropped calls-*** To measure the dropped calls, there is a parameter named call drop rate. If during Q calls, Q-1 calls are completed, then the call drop rate is 1/Q, if Q-2 calls are completed, then call drop rate is 2/Q.

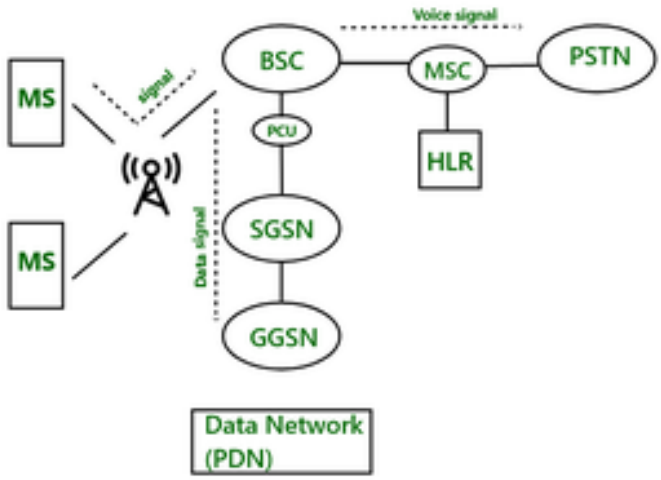
7. Brief explain the concept of GPRS and the two new network elements introduced by it.

General Packet Radio Services (GPRS) is a best-effort packet-switching protocol for wireless and cellular network communication services. It is considered best effort because all packets are given the same priority and the delivery of packets isn't guaranteed.

The 3rd Generation Partnership Project (3GPP) standardized GPRS in early 1998, but commercial cellular networks did not widely adopt the technology until 2000. It was the first technology successfully deployed in 2G mobile phone systems.

What made GPRS technology different from other cellular wireless technologies, like Global System for Mobile Communications (GSM), available at the time was the use of packet-switched data instead of the traditional circuit-switched data. When a cellphone was on circuit-switched mode, the circuit was permanently switched on to a specific user. By contrast, packet-switched data transfers occurred in bursts during short peaks, followed by breaks.

This approach was a more efficient use of available capacity because, by splitting data into packets and tags, GPRS shared overall capacity among multiple users. This was possible because everyone wasn't online at the same time often. The destination address became available when inserted into the packet, which enabled packets from multiple sources to transmit through a single link.



The two main elements in GPRS:

The GPRS standard introduces two new elements /nodes, the **serving GPRS support node (SGSN) and the gateway GPRS support node (GGSN)**. The home location register (HLR) is enhanced with GPRS subscriber data and routing information. Two types of services are provided by GPRS: Point-to-point (PTP)

8. Briefly describe the concept of frequency reuse in mobile wireless network.

Cellular phone networks use cellular frequency reuse. In the cellular reuse concept, frequencies allocated to the service are reused in a **regular pattern of areas**, called "cells", each covered by one base station. ... However in cells that are separated further away, frequencies can be reused.

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. For example, when N cells are using the same number of frequencies and K be the total number of frequencies used in systems.

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**.

In Advanced Mobile Phone Services (AMPS) when K = 395 and N = 7, then frequencies per cell on an average will be 395/7 = 56. Here, **cell frequency** is 56.

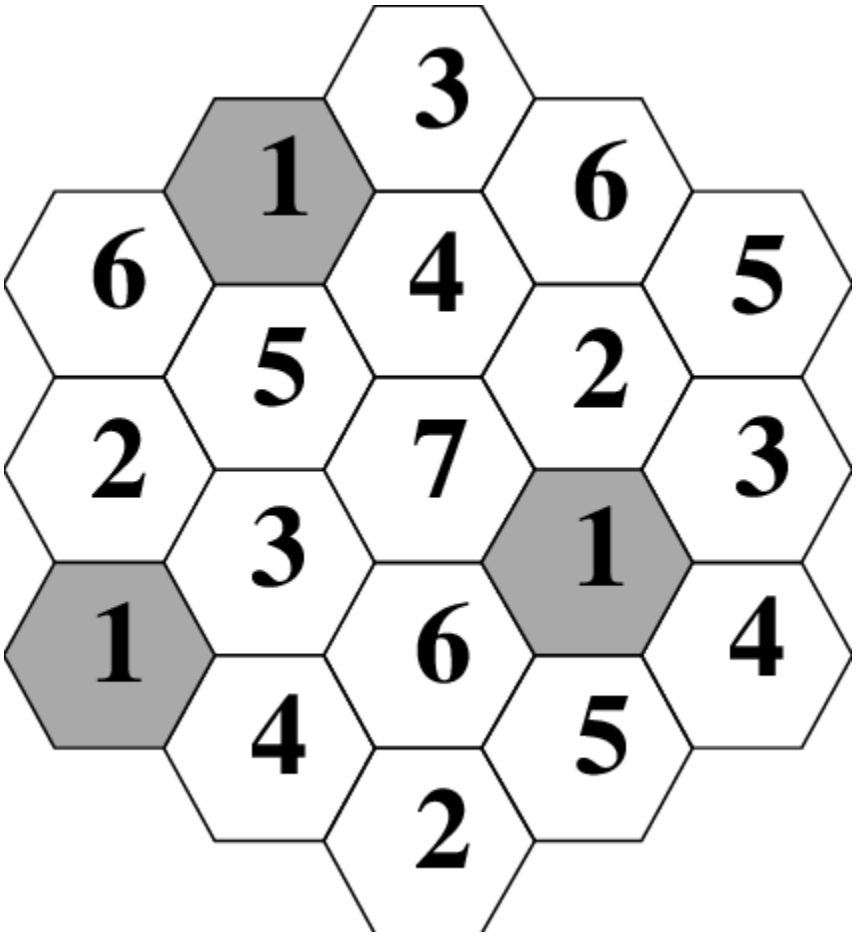


Figure 5. Frequency Reuse in wireless networks

9. Discuss the Basic Methods of signal propagation in a mobile communication system, and which propagation method is preferable in today's technology?

Wireless communications systems are composed of one or more "Antenna Sites", "Tower Sites", or "Cell Sites". Antennas mounted on these structures pump out wireless communications signals to devices in the field via electromagnetic waves. In addition to receiving these signals from the sites, user devices transmit similar types of signals back to the sites. This creates two-way communication.

Wireless signal propagation is the movement of these radio waves (which move at the speed of light) to and from these sites and devices.

Mechanisms of Propagation

In a wireless communication system, a transmitted signal can reach the receiver via a number of propagation mechanisms. In this section, we review at a high level these key mechanisms, each potentially associated with a different propagation path.

The mechanisms of propagation in the context of an indoor wireless local area network. The LOS path is unobstructed between the access point and client 1. That client also receives weaker signals as a result of a reflection off of a wall. The LOS path is obstructed for client 2, who instead receives signals through diffraction in the doorway and also scattering off of a rough wall.

When a signal reaches the receiver from the transmitter in a single path, without suffering any reflections, diffractions, or scattering, this is known as propagation along the *line-of-sight* (LOS) path. An LOS component has the shortest time delay among all the received signals and is usually the strongest signal received. The exact classification of a path being LOS requires that any obstructions be sufficiently far away from the path, which is quantified by the idea of the Fresnel zone.

In *non-line-of-sight* (NLOS) propagation, a signal transmitted into a wireless medium reaches the receiver via one or more indirect paths, each having different attenuations and delays. When a transmitted signal travels through communication paths other than the LOS path to reach the receiver, it is said to have undergone NLOS propagation. NLOS propagation is responsible for coverage behind buildings and other obstructions. The main NLOS propagation mechanisms are reflection, scattering, and diffraction.

Reflection occurs when a wave impinges on an object that is smooth, which means that any protrusions have dimensions much larger than a wavelength. Reflection is accompanied by refraction (transmission of the wave through the object). The strengths of the reflected and refracted waves depend on the type of material. The angles and indices of reflection and refraction are given by Snell's law.

Scattering is what happens when a wave impinges on an object that is rough or has irregularities with dimensions on the order of the wavelength. It is similar to reflection but results in a smearing of the signal around the angle of reflection. This leads to a larger loss of energy as the signal is spread over a wider area. It also results in multiple paths arriving at the receiver from a similar location with slight differences in delay.

Diffraction is the "bending" of waves around sharp corners. Important examples of diffraction include waves bending over the tops of buildings, around street corners, and through doorways. Diffraction is one of the main ways that it is possible to provide cellular coverage in cities and is one reason why lower frequencies, say less than 3GHz, are considered beachfront property in the world of cellular spectrum.