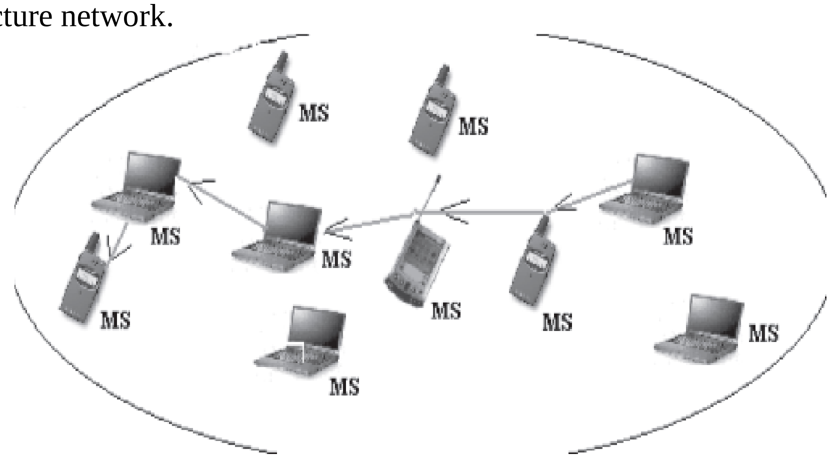
Q.2 a. What do you mean by ad hoc networks? How is an ad hoc network different from cellular network?

Answer:

An ad hoc (also written ad-hoc or adhoc) network is a local network with wireless or temporary plug-in connection, in which mobile or portable devices are part of the network only while they are in close proximity.

A mobile ad hoc network (MANET) is an autonomous system of mobile nodes, mobile hosts (MHs), or MSs (also serving as routers) connected by wireless links, the union of which forms a network modeled in the form of an arbitrary communication graph. The routers are free to move at any speed in any direction and organize themselves randomly. Thus, the network's wireless topology may dynamically change in an unpredictable manner. There is no fixed infrastructure, and information is forwarded in peer-to-peer (p2p) mode using multihop routing. MANETs are basically peer-to-peer (p2p) multihop mobile wireless networks where information packets are transmitted in a store-and-forward method from source to destination, via intermediate nodes, as shown in Figure. As the nodes move, the resulting change in network topology must be made known to the other nodes so that prior topology information can be updated. Such a network may operate in a stand-alone fashion, or with just a few selected routers communicating with an infrastructure network.



b. Draw and explain the block diagram of satellite communication system

Answer: Page no 21 of Text Book

Q.3 a. Explain free space propagation model.

Answer:

This model is used to predict the received signal strength, when there is unobstructed line-of-sight between the transmitter and receiver. The free space power received by the receiving antenna which is separated from a radiating transmitter antenna by a distance d is given by

$$P_r(d) = \frac{P_t G_t G_r \lambda^2}{(4\pi)^2 d^2 L}$$

where Pr(d) is the received power, Pt is the transmitted power, Gt is the transmitter antenna gain, Gr is the receiver antenna gain, L is the loss factor and λ is wavelength in meters.

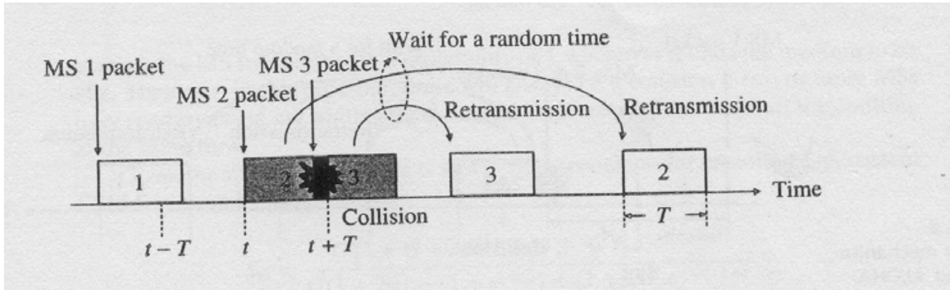
b. Explain in detail the fading effects in wireless channel.

Answer:
In wireless communications, fading is deviation of the attenuation that a carrier modulated telecommunication signal experiences over certain propagation media. The fading may vary with time, geographical position and/or radio frequency, and is often modelled as a random process. A fading channel is a communication channel that experiences fading. In wireless systems, fading may either be due to multipath propagation, referred to as multipath induced fading, or due to shadowing from obstacles affecting the wave propagation, sometimes referred to as shadow fading. The terms *slow* and *fast* fading refer to the rate at which the magnitude and phase change imposed by the channel on the signal changes. The coherence time is a measure of the minimum time required for the magnitude change of the channel to become uncorrelated from its previous value.
Slow fading arises when the coherence time of the channel is large relative to the delay constraint of the channel. In this regime, the amplitude and phase change imposed by the channel can be considered roughly constant over the period of use. Slow fading can be caused by events such as shadowing, where a large obstruction such as a hill or large building obscures the main signal path between the transmitter and the receiver. The amplitude change caused by shadowing is often modelled using a lognormal distribution with a standard deviation according to the log-distance path loss model.
Fast fading occurs when the coherence time of the channel is small relative to the delay constraint of the channel. In this regime, the amplitude and phase change imposed by the channel varies considerably over the period of use.

Q.4 a. Explain in detail the ALOHA random access protocols used in wireless systems. Derive expression of its throughput and efficiency.

Answer:
ALOHA
This is a single hop system with infinite users. Each user generates packets of data according to a Poisson process with arrival rate λ (packets/sec) and all packets have the same fixed length T. In this scheme, when the MS has a packet to transmit, it transmits the packet right away. The sender side also waits to see whether transmission is acknowledged by the receiver; no response within a specified period of time indicates a collision with another transmission. If the presence of a collision is determined by the

sender, it retransmits after some random wait time, as shown in fig.1 where the arrows indicate the arrival times.



Each packet is generated by different users. In this method, it is assumed that the packets and users are identical. Thus the time point at which the packet transmission attempts are made is only considered. Considering the channel over time, the scheduling time includes both the generation times of new packets and the retransmission times of previously collided packets. Let the rate of scheduling be g (packets/sec). The parameter g is referred to as the offered load to the channel. Since some packets have to be transmitted more than once for successful transmission, $g>\lambda$. It is assumed that this scheduling process is a Poisson process with arrival time g. Consider a new or retransmitted packet scheduled for transmission at some instant t. This packet can be successfully transmitted if there are no other packets scheduled for transmission between the instants t-T and t+ T , where the period 2T is called the vulnerable period. Therefore, the probability, Ps of successful transmission is the probability that no packet is scheduled in an interval of length 2T. Since the distribution of the scheduling time is assumed to be Poisson process, Ps =P (no collision) = P (no transmission in two packets time)= e^{-2gT} (1)

Since packets are scheduled at a rate of g packets per second with only a fraction of Ps successful, the rate of successful transmission is g Ps. Defining throughput as the fraction of time during which the useful information is carried on the channel, it can be written as

$$S_{th}= gTe^{-2gT} =Ge^{-2G}$$

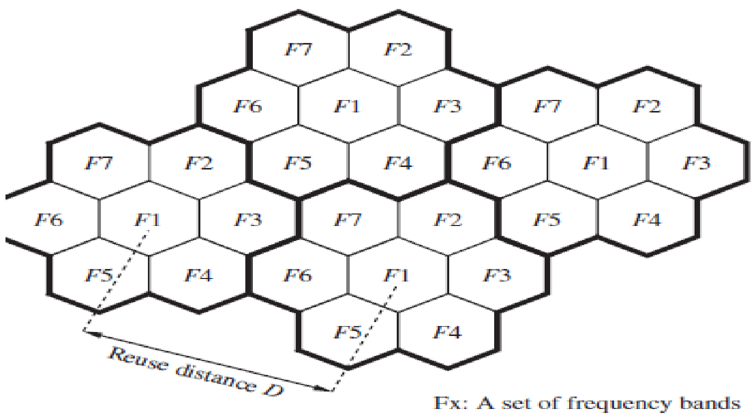
Where G=gT is the normalized offered load to the channel.

b. Describe the concept of frequency reuse and explain why the cells having hexagonal pattern.

Answer:

Frequency reuse

Cellular systems seeks to make an efficient use of available channels by employing low-power transmitters to allow frequency reuse at much smaller distances Maximizing the number of times each channel may be reused in a given geographic area is the key to an efficient cellular system design. Cellular systems are designed to operate with groups of low-power radios spread out over the geographical service area. Each group of radios serve mobile stations located near them. The area served by each group of radios is called a *cell*. Each cell has an appropriate number of low-power radios to communicate within the cell itself. The power transmitted by the cell is chosen to be large enough to communicate with mobile stations located near the edge of the cell.



Hexagonal Cell Geometry:

As the traffic grows, new cells and channels are added to the system. If an irregular cell pattern is selected, it would lead to an inefficient use of the spectrum due to its inability to reuse frequencies because of cochannel interference. In addition, it would also result in an uneconomical deployment of equipment, requiring relocation from one cell site to another. Therefore, a great deal of engineering effort would be required to readjust the transmission, switching, and control resources every time the system goes through its development phase. The use of a regular cell pattern in a cellular system design eliminates all these difficulties. In reality, cell coverage is an irregularly shaped circle. The exact coverage of the cell depends on the terrain and many other factors. For design purposes and as a first-order approximation, we assume that the coverage areas are regular polygons. For example, for omnidirectional antennas with constant signal power, each cell site coverage area would be circular. To achieve full coverage without dead spots, a series of regular polygons are required for cell sites. Any regular polygon such as an equilateral triangle, a square, or a hexagon can be used for cell design. The hexagon is used for two reasons: a hexagonal layout requires fewer cells and, therefore, fewer transmitter sites, and a hexagonal cell layout is less expensive compared to square and triangular cells. In practice, after the polygons are drawn on a map of the coverage area, radial lines are drawn and the signal-to-noise ratio (SNR) calculated for various directions using the propagation.

Q.5 a. Give the comparison between fixed channel allocation and dynamic channel allocation.

Answer:

Fixed Channel Allocation (FCA) systems allocate specific channels to specific cells. This allocation is static and can not be changed. For efficient operation, FCA systems typically allocate channels in a manner that maximizes frequency reuse. Thus, in a FCA system, the distance between cells using the same channel is the minimum reuse distance for that system. The problem with FCA systems is quite simple and occurs whenever the offered traffic to a network of base stations is not uniform. Consider a case in which two adjacent cells are allocated N channels each. There clearly can be situations in which one cell has a need for $N+k$ channels while the adjacent cell only requires N-m channels (for positive integers k and m). In such a case, k users in the first cell would be blocked from making calls while m channels in the second cell would go unused. Clearly in this situation of non-uniform spatial offered traffic, the available channels are not being used efficiently. FCA has been implemented on a widespread level to date.

Dynamic Channel Allocation

Dynamic Channel Allocation (DCA) attempts to alleviate the problem mentioned for FCA systems when offered traffic is non-uniform. In DCA systems, no set relationship exists between channels and cells. Instead, channels are part of a pool of resources. Whenever a channel is needed by a cell, the channel is allocated under the constraint that frequency reuse requirements cannot be violated. There are two problems that typically occur with DCA based systems.

- First, DCA methods typically have a degree of randomness associated with them and this leads to the fact that frequency reuse is often not maximized unlike the case for FCA systems in which cells using the same channel are separated by the minimum reuse distance.

- Secondly, DCA methods often involve complex algorithms for deciding which available channel is most efficient. These algorithms can be very computationally intensive and may require large computing resources in order to be real-time.

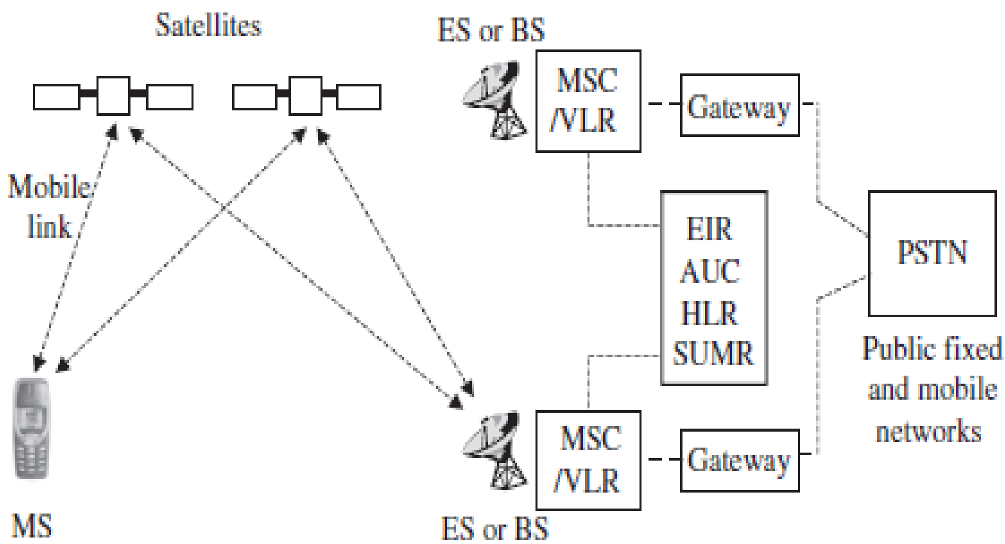
b. Compare FDMA, TDMA, CDMA and SDMA.

Answer:

Technique	FDMA	TDMA	CDMA	SDMA
Concept	Divide the frequency band into disjoint subbands	Divide the time into non-overlapping time slots	Spread the signal with orthogonal codes	Divide the space into sectors
Active terminals	All terminals active on their specified frequencies	Terminals are active in their specified slot on same frequency	All terminals active on same frequency	Number of terminals per beam depends on FDMA/TDMA/ CDMA
Signal separation	Filtering in frequency	Synchronization in time	Code separation	Spatial separation using smart antennas
Handoff	Hard handoff	Hard handoff	Soft handoff	Hard and soft handoffs
Advantages	Simple and robust	Flexible	Flexible	Very simple, increases system capacity
Disadvantages	Inflexible, available frequencies are fixed, requires guard bands	Requires guard space, synchronization problem	Complex receivers, requires power control to avoid near-far problem	Inflexible, requires network monitoring to avoid intracell handoffs
Current applications	Radio, TV, and analog cellular	GSM and PDC	2.5G and 3G	Satellite systems, others being explored

Q.6 a. Draw the satellite system architecture and explain the process of call setup.

Answer:



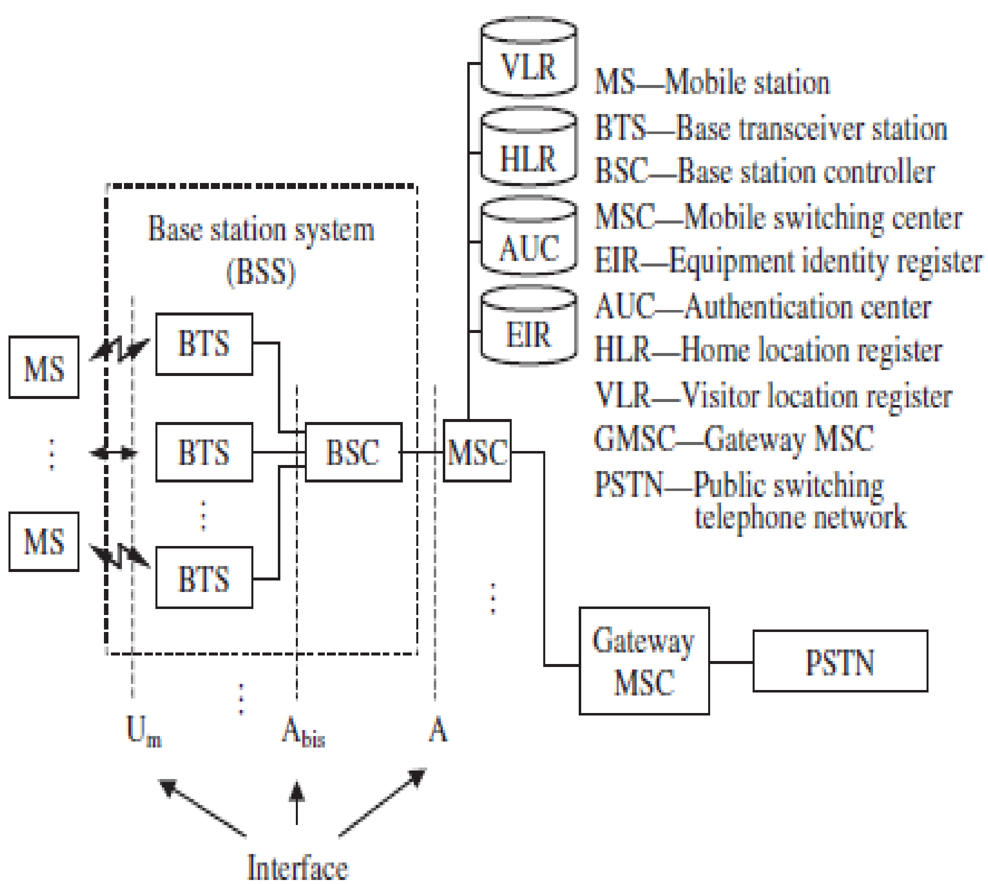
Generic satellite system architecture is shown in Figure, with the ES (BS) constituting the heart of the overall system control. The ES performs functions similar to the BSS of a cellular wireless system. The ES keeps track of all MSs located in the area and controls the allocation and deallocation of radio resources. This includes the use of frequency band or channel in FDMA, time slot for TDMA, and code assignment for CDMA. Both MSC and VLR are important parts of the BS and provide functions similar to those for the cellular network. The databases EIR, AUC, and HLR also perform the same operations as in conventional wireless systems and are an integral part of the overall satellite system. The HLR–VLR pair supports the basic process of mobility management. A satellite user mapping register (SUMR) is also maintained at the BS to note the locations of all satellites and to indicate the satellite assigned to each MS. All these systems are associated with the BS to minimize the weight of satellites. In fact, satellites can be considered to function as relay stations with a worldwide coverage, given that most of the intelligence and decision-making process is performed by the BS. These BSs are also connected to the PSTN and ATM backbone through the appropriate gateway so that calls to regular household phones as well as to cellular devices can be routed and established. For an incoming call from the PSTN, the gateway helps to reach the closest BS, which, in turn, using the HLR–VLR pair, indicates the satellite serving the most recently known location of the MS. The satellite employs a paging channel to inform the MS about an incoming call and the radio resource to be used for the uplink channel. For a call originating from a MS, it accesses the shared control channel of an overhead satellite and the satellite, in turn, informs the BS for authentication of the user/MS. The BS then allocates a traffic channel to the MS via the satellite and informs the gateway about additional control information, if it is necessary to route the call through the backbone. Thus, there may be an exchange of control signalling between the MS, the satellite beam, the ES, and the PSTN gateway. Call setup may involve satellite communication before the actual traffic can be exchanged and can vary in the range of a few hundred nanoseconds (~ 300 ns).

b. Explain multicasting in mobile communication systems.

Answer: Page no 204 of Text Book

Q7 a. Explain GSM architecture in detail.

Answer:
A block diagram representation of the GSM architecture is given in Figure, The radio link interface through the air is between the MS and the base transceiver station (BTS). A MS interfaces only with the BTS. Many BTSs are controlled by a BS controller (BSC), which in turn has an interface to a MSC. Specific functions of different constituents are as follows:



Base station controller (BSC): The main function of the BSC is to look over a certain number of BTSs to ensure proper operation. It takes care of handoff from one BTS to the other, maintains appropriate power levels of the signal, and administers frequency among BTSs.

Mobile switching center (MSC): The MSC basically performs the switching functions of the system by controlling calls to and from other telephone and data systems. It also does functions such as network interfacing and common channel signaling. If the MSC has an interface to the PSTN, then it is called a gateway MSC. GSM uses two important databases called HLR and VLR, to keep track of the current location of a MS.

Authentication center (AUC): AUC unit provides authentication and encryption parameters that verify the user's identity and ensure the confidentiality of each call. The AUC protects network operators from different types of frauds and spoofing found in today's cellular world.

Equipment identity register (EIR): EIR is a database that contains information about the identity of mobile equipment that prevents calls from being stolen and prevents unauthorized or defective MSs. Both AUC and EIR can be implemented as individual stand-alone nodes or as a combined AUC/EIR node.

b. Explain the Power Control mechanism in IS-95.

Answer: Page no 247 of Text Book

Q8. a. Enlist the characteristics and application of mobile Ad hoc networks (MANET).

Answer:

Salient characteristics:

1. Dynamic topologies: Nodes are free to move arbitrarily; thus, the network topology may change randomly and unpredictably and primarily consists of bidirectional links. In some cases, where the transmission power of two nodes is different, a unidirectional link may exist.
2. Bandwidth-constrained and variable capacity links: Wireless links continue to have significantly lower capacity than infrastructured networks. In addition, the realized throughput of wireless communications—after accounting for the effects of multiple access, fading, noise, interference conditions, and so on— is often much less than a radio's maximum transmission rate. One effect of relatively low to moderate link capacities is that congestion is typically the norm rather than the exception (i.e., aggregate application demand could likely approach or exceed network capacity frequently). As a MANET is often simply an extension of the fixed network infrastructure, mobile ad hoc users would demand similar services.
3. Energy-constrained operation: Some or all of the MSs in a MANET may rely on batteries or other exhaustible means for their energy. For these nodes, the most important system design optimization criteria may be energy conservation.

4. Limited physical security: MANETs are generally more prone to physical security threats than wireline networks. The increased possibility of eavesdropping, spoofing, and denial of service (DoS) attacks should be carefully considered.

Applications:

1. Defense applications: Many defense applications require on-the-fly communications set up, and ad hoc/sensor networks are excellent candidates for use in battlefield management. MANETs can be formed among soldiers on the ground or fighter planes in the air, while sensors can be deployed to monitor activities in the area of interest.
2. Crisis-management applications: These arise, for example, as a result of natural disasters in which the entire communication infrastructure is in disarray. Restoring communications quickly is essential. With wideband wireless mobile communications, limited and even total communication capability, including Internet and video services, could be set up in hours instead of days or even weeks required for restoration of wireline communications.
3. Telemedicine: The paramedic assisting the victim of a traffic accident in a remote location must access medical records (e.g., X-rays) and may need video conference assistance from a surgeon for an emergency intervention. In fact, the paramedic may need to instantaneously relay back to the hospital the victim's X-rays and other diagnostic tests from the site of the accident.
4. Tele-geoprocessing applications: The combination of geographical information systems (GIS), GPS, and high-capacity wireless mobile systems enables a new type of application referred to as tele-geoprocessing.

b. Explain wireless sensor networks and enlist the advantages of wireless sensor network over wired ones.

Answer:

A wireless sensor network is a collection of tiny disposable and low-power devices. A sensor node is a device that converts a physical attribute (e.g., temperature, vibrations) into a form understandable by users. Any of such devices may include a sensing module, a communication module (display or a medium to transmit data to the user), memory (to hold data until it can be used), and typically an exhaustible source of power like a small battery.

Advantages:

1. Ease of deployment: These wireless sensors can be deployed (dropped from a plane or placed in a factory) at the site of interest without any preorganization, thus reducing the installation cost and increasing the flexibility of arrangement.

2. Extended range: One single huge wired sensor (macrosensor) can be replaced by many smaller wireless sensors for the same cost. One macrosensor can sense only a limited region, whereas a network of smaller sensors can be distributed over a wider region.

3. Fault tolerance: Since sensor networks are mostly unattended, they should be fault-tolerant with macrosensors, the failure of one node makes that area completely unmonitored until it is replaced. In wireless sensors, failure of one node may not affect the network operation, as there are other nodes collecting similar data. At most, the accuracy of data collected may be reduced, but typically the entire area of interest is still covered.

4. Mobility: Since these wireless sensors are equipped with a battery, they can be mobile. Thus, if a region becomes unmonitored, we can have the nodes rearrange themselves to distribute evenly (i.e., these nodes can be made to move toward an area of interest). It should be noted that these nodes have limited mobility as compared to ad hoc networks.

Q9 a. Write short note on the Ultrawideband technology.

Answer:

UWB differs substantially from conventional narrowband radio frequency (RF) and spread spectrum technologies (SS), such as Bluetooth Technology and 802.11a/g. UWB uses an extremely wide band of RF spectrum to transmit data. In so doing, UWB is able to transmit more data in a given period of time than the more traditional technologies.

The potential data rate over a given RF link is proportional to the bandwidth of the channel and the logarithm of the signal-to-noise ratio (Shannon's Law). RF design engineers typically have little control over the bandwidth parameter, because this is dictated by FCC regulations that stipulate the allowable bandwidth of the signal for a given radio type and application. Bluetooth Technology, 802.11a/g Wi-Fi, cordless phones, and numerous other devices are relegated to the unlicensed frequency bands that are provided at 900 MHz, 2.4 GHz, and 5.1 GHz. Each radio channel is constrained to occupy only a narrow band of frequencies, relative to what is allowed for UWB.

UWB is a unique and new usage of a recently legalized frequency spectrum. UWB radios can use frequencies from 3.1 GHz to 10.6 GHz—a band more than 7 GHz wide. Each radio channel can have a bandwidth of more than 500 MHz, depending on its center frequency. To allow for such a large signal bandwidth, the FCC put in place severe broadcast power restrictions. By doing so, UWB devices can make use of an extremely wide frequency band while not emitting enough energy to be noticed by narrower band devices nearby, such as 802.11a/g radios. This sharing of spectrum allows devices to obtain very high data throughput, but they must be within close proximity.

Strict power limits mean the radios themselves must be lowpower consumers. Because of the low power requirements, it is feasible to develop cost-effective CMOS implementations of UWB radios. With the characteristics of low power, low cost, and very high data rates at limited range, UWB is positioned to address the market for a high-speed WPAN.

b. Compare Wireless LAN and Wired LAN in detail.

Answer:

Although WLANs and LANs both provide connectivity between the end users, they have some key differences that include both physical and logical differences between the topologies. In WLANs, radio frequencies are used as the physical layer of the network. Differences also exist in the way the frame is formatted and in the transmission methods, detailed as follows:

WLANs use carrier sense multiple access with collision avoidance (CSMA/CA) instead of carrier sense multiple access collision detect (CSMA/CD), which is used by Ethernet LANs. Collision detection is not possible in WLANs, because a sending station cannot receive at the same time that it transmits and, therefore, cannot detect a collision. Instead, WLANs use the Ready To Send (RTS) and Clear To Send (CTS) protocols to avoid collisions.

WLANs use a different frame format than wired Ethernet LANs use. WLANs require additional information in the Layer 2 header of the frame.

Radio waves cause problems not found in LANs, such as the following:

Connectivity issues occur because of coverage problems, RF transmission, multipath distortion, and interference from other wireless services or other WLANs.

Privacy issues occur because radio frequencies can reach outside the facility.

In WLANs, mobile clients connect to the network through an access point, which is the equivalent of a wired Ethernet hub. These connections are characterized as follows:

- There is no physical connection to the network.
- The mobile devices are often battery-powered, as opposed to plugged-in LAN devices.WLANs must meet country-specific RF regulations. The aim of standardization is to make WLANs available worldwide. Because WLANs use radio frequencies, they must follow country-specific regulations of RF power and frequencies. This requirement does not apply to wired LANs.

<u>Text Book</u>

Introduction to Wireless & Mobile Systems, II Edition(2007), Dharma Prakash Agarwal & Qing-an Zeng, Thomson India Edition

