MOBILE COMPUTING

NOTE:

WBUT course structure and syllabus of 7th Semester has been changed from 2013. **MOBILE COMPUTING** has been introduced as a new optional paper in present curriculum. The syllabus of this subject is almost same as **MOBILE COMPUTING [CS 802A].** Taking special care of this matter we are providing chapterwise model questions and answers from **MOBILE COMPUTING [CS 802A]** along with the complete solutions of new university papers, so that students can get an idea about university questions patterns.

INTRODUCTION TO PERSONAL COMMUNICATIONS SERVICES

Multiple Choice Type Questions

1. GSM uses ..... for multiplexing. [WBUT 2013]
   a) CDMA b) TDMA c) FDMA d) both (b) and (c)
Answer: (d)

2. A single frame in GSM comprises ..... time slots. [WBUT 2013]
   a) 10 b) 7 c) 8 d) 4
Answer: (c)

3. ..... Is a computerized centre responsible for connecting & recording call information and billing. [WBUT 2013]
   a) base station b) cell c) MSC d) mobile station
Answer: (c)

4. Frequency reuse can help which of the following systems? [WBUT 2013]
   a) cellular system b) conventional mobile telephony
   c) paging system d) cordless telephony
Answer: (a)

5. If N is the number of cells per cluster then frequency reuse factor of the cellular system is [WBUT 2013, 2014]
   a) N b) $1/N$ c) N^2 d) none of these
Answer: (b)

6. GSM operates at [WBUT 2014]
   a) 860-960 MHz b) less than 500 MHz
   c) Greater than 500 MHz d) none
Answer: (a)

7. Network signalling in GSM is [WBUT 2014]
   a) SS7 b) SS5 c) cipher d) none
Answer: (a)

8. Which of the following is mobile/wireless simulator? [WBUT 2014]
   a) NS2 b) NS3 c) Qualnet d) all of these
Answer: (d)

9. The coverage and capacity of CDMA system is more than that of GSM system. [WBUT 2015]
a) True b) False c) Equal d) None of these
Answer: (a)

10. The core concept used in cellular technology is [WBUT 2015]
a) TDM b) Frequency reuse
c) Code reuse d) None of these
Answer: (b)

11. The terminal is under observation from the network for the possible problems. Under which list will this belong in EIR? [WBUT 2015]
a) White list b) Grey list
c) Black list d) None of these
Answer: (b)

12. Which of these cells are used for densely populated areas? [WBUT 2015]
a) Macro cells b) Micro cells
c) Selective cells d) Umbrella cells
Answer: (b)

13. Cell A uses the same frequency as cell B. The Cell A is a _____ of Cell B.
a) Adjacent cell b) Co channel cell [WBUT 2015]
c) Macro cell d) Selective cell
Answer: (b)

14. GSM uses two lands of 25 MHz in width for [MODEL QUESTION]
a) Half duplex communication b) Simplex communication
c) Full duplex communication d) None of these
Answer: (c)

15. GPS (Global positioning System) is the example of [MODEL QUESTION]
a) MEO b) LEO c) GEO d) None of these
Answer: (a)

16. GSM system has [MODEL QUESTION]
a) 120 pair of channels b) 128 pair of channels
c) 124 pair of channels d) 100 pair of channels
Answer: (c)

17. GSM mobile stations and transceivers transmit and receive. [MODEL QUESTION]
a) Full – duplex or half – duplex synchronous, asynchronous or synchronous packet data by circuit switching
b) full-duplex or half –duplex synchronous or asynchronous circuit–switched data

c) full-duplex synchronous, asynchronous or synchronous circuit-switched data
d) Full or half-duplex synchronous voice-data and synchronous packet SMS data

Answer: (d)

18. A GSM service visiting location registers information of the currency associated mobile stations. [MODEL QUESTION]
a) The information is about their TMSI, IMSI and MSISDN
b) The information is about their HLR and IMSI
c) The information is about their HLR, IMSI, &MSISDN
d) The information is about their HLR & TNSI

Answer: (b)

19. CDMA systems exhibit soft handover due to [MODEL QUESTION]
a) Autocorrelation codes used in each cell transceiver
b) Each cell using same spread frequency spectrum
c) Negligible narrow band interference and co-channel interference of the signal
d) Each cell having a distinct pseudo-noise code offset, so that the handover to the adjacent cell is simply by adding the offset to the mobile terminal pseudo-noise code

Answer: (d)

20. Mobile computing differs from other of distributed computing by limitations. [MODEL QUESTION]
a) battery, memory resources, long distance bandwidth constrains and network and interoperability issues
b) Use of radio-frequency cellular communication
c) Use of radio frequency in 100-2000 of MHz
d) Inaccessibility of web pages

Answer: (b)

21. Modulation of a modulating signal with a very large carrier frequency in wireless transmission is necessary due to [MODEL QUESTION]
a) antenna requirements, signal propagating medium properties and need to multiplex the multiple channel and users at the transmitter
b) Smaller antenna size at high frequency
c) Little bending of the beams at high frequencies
d) Mobility requirements

Answer: (a)

22. A Cell has [MODEL QUESTION]
a) One base station which interconnects to mobile devices
b) One base station which interconnects to mobile devices and performs handover to the neighboring base station and uses a frequency band which is distinct from the neighboring cell

c) One base station and one access point which connects to mobile devices
d) One base station which interconnects to mobile devices and performs handover to the neighboring base station and uses a frequency band which is same as the neighboring cell to ensure mobility of the device in another cell

Answer: (b)

23. Window CE [MODEL QUESTION]
a) Applications are developed by coding for the interrupt service threads
b) Supports 32 priority level assignments to the threads
c) Provides protection from priority inversion as it provides for priority inheritance mechanism
d) Assumes event handlers as fundamental units of execution and providing access of CPU

Answer: (b)

24. A mobile device can at best find 6 mobile devices reaching its vicinity. Let there be FDMA mode of access by a node. Assuming that f_{bw0} is the bandwidth requirement between two neighbors, what bandwidth will be needed when all next hop neighbors communicate in full duplex mode and in same time slots? [MODEL QUESTION]

a) f_{bw0} b) $2 \infty f_{bw0}$ c) $6 \infty f_{bw0}$ d) $2 \infty 6 \infty f_{bw0}$

Answer: (b)

25. VLR maintains record for [MODEL QUESTION]
a) IMSI b) TMSI c) SIM d) none of these

Answer: (b)

Short Answer Type Questions

1. Define the following terms and state their usage: [WBUT 2013]
i) RVC
ii) TMSI

Answer:

i) **The Reverse Voice Channel (RVC)** is the voice channel that is used in the mobile station to base station direction, also known as the voice channel uplink.

ii) **The Temporary Mobile Subscriber Identity (TMSI)** is the identity that is most commonly sent between the mobile and the network. TMSI is randomly assigned by the VLR to every mobile in the area, the moment it is switched on. The number is local to a location area, and so it has to be updated each time the mobile moves to a new geographical area.

The network can also change the TMSI of the mobile at any time. And it normally does so, in order to avoid the subscriber from being identified, and tracked by eavesdroppers on the radio interface. This makes it difficult to trace which mobile is which, except

briefly, when the mobile is just switched on, or when the data in the mobile becomes invalid for one reason or another. At that point, the global "international mobile subscriber identity" (IMSI) must be sent to the network. The IMSI is sent as rarely as possible, to avoid it being identified and tracked.

A key use of the TMSI is in paging a mobile. "Paging" is the one-to-one communication between the mobile and the base station. The most important use of broadcast information is to set up channels for "paging". Every cellular system has a broadcast mechanism to distribute such information to a plurality of mobiles.

Size of TMSI is 4 octet with full hex digits and can't be all 1 because the SIM uses 4 octets with all bits equal to 1 to indicate that no valid TMSI is available.

2. What is hand-off? What are the different hand-off strategies? Discuss the merits and demerits of each such strategy. **[WBUT 2013]**

OR,

What is Handoff? Differentiate between hard and soft handoffs. **[WBUT 2014]**

OR,

What do you mean by hand-off? Discuss how hard hand-off is different from soft hand-off. **[WBUT 2015]**

Answer:

One of the major tasks in mobile communication system is to maintain continuity of call when a mobile user migrates from one cell to another. This is done by changing the controlling base station and the process is called call handoff or handover. The MSC automatically transfers the call to a new channel belonging to the new base station. This involves identification of a new base station and allocation of voice and control signals to the associated channels of the new base station.

Handover procedure involves measurement, decision and execution. Handover may be based on measurement such as – signal strength, bit error rate, traffic load or carrier to interference ratio etc.

Handoffs may be classified into two types:

- **Hard Handoff**: Characterized by an actual break in the connection while switching from one cell or base station to another. The switch takes place so quickly that it can hardly be noticed by the user. Because only one channel is needed to serve a system designed for hard handoffs, it is the more affordable option. It is also sufficient for services that can allow slight delays, such as mobile broadband Internet.
- **Soft Handoff**: Entails two connections to the cell phone from two different base stations. This ensures that no break ensues during the handoff. Naturally, it is more costly than a hard handoff.

3. What do you mean by Mobile Communication? What are the advantages of Mobile Communication over PSTN? What is the difference between network protocol and network architecture? **[WBUT 2014]**

Answer:

1st Part:

The wireless communication has developed worldwide from the year 1897 by means of radio and the development of the technology is due to revolution in the fields like

i) RF circuit fabrication
ii) Large scale circuit integration
iii) Digital circuit design
iv) Miniaturization technologies

The impact of development of mobile communication is personal communication services. The cellular concepts emerged appreciably and slowly developed by Bell Laboratories in the period between 1960 and 1970.

The mobile communication establishes call, maintains it, and terminates as the call is over. It enables communication even though the distance between them is large.

2nd Part:

In fixed telephone network like PSTN, transfer of information place over landline trunked lines which includes optical fibres, co-axial cables or microwave links. Also network configurations are static in nature.

On the other hand wireless networks are highly dynamic and network configuration being rearranged every time, subscriber moves into coverage area of new base station.

Fixed Networks are difficult to change, while wireless network must reconfigure themselves for users within small interval of time.

3rd Part:

Network architecture refers to the layout of the network, consisting of the hardware, software, connectivity, communication protocols and mode of transmission, such as wired or wireless.

But a network protocol defines rules and conventions for communication between network devices. Protocols for computer networking all generally use packet switching techniques to send and receive messages in the form of packets.

4. Why is the cell structure supposed to be a Hexagon in a mobile network?

[WBUT 2014]

Answer:

To utilize the available bandwidth efficiently and to increase the number of users, frequency reuse is employed. In this technique the same carrier frequencies are used for the radio channels, which serve the areas, which are physically separate from each other. Since the areas are physically separate, the same carrier frequencies on the different channels cannot interfere with each other. Thus frequency reuses has advantage that the entire area need not be covered with the same high power transmitter. Multiple low power transmitters can be employed for small areas with frequency reuses. Fig. shows this concept hexagonal cellular structure. As shown in the Fig., the cells are clustered in a group of seven. Such clusters are marked with dark outlines.

The seven cells in the same cluster used seven different carrier frequencies. For example consider the cell number 1 in the two adjacent clusters. Those cells are shown shaded in the figure. These cells are physically separate by a distance 'D'. The carrier frequencies of these cells can be same. The same method can be applied to cells in all the clusters. Thus to cover the complete area only seven carrier frequencies will be required. This is an advantage of frequency reuse.

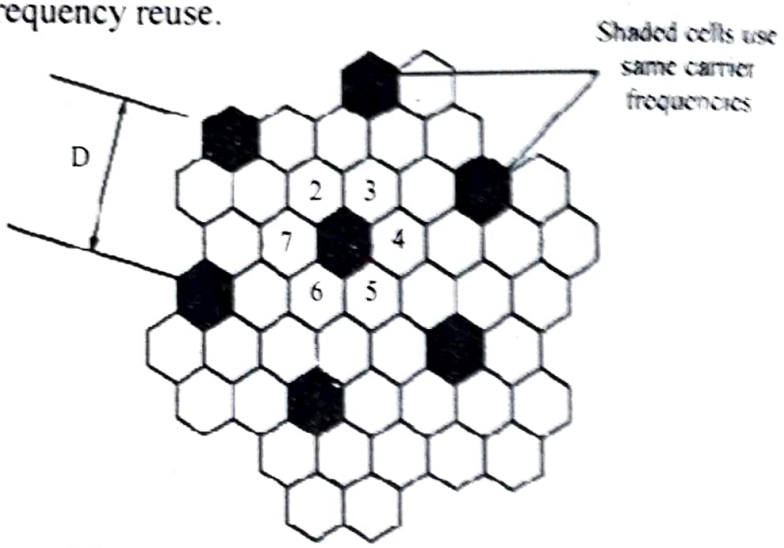


Fig: Frequency reuse using hexagonal cell structure

5. Explain management of mobility in GSM network. **[MODEL QUESTION]**

Answer:

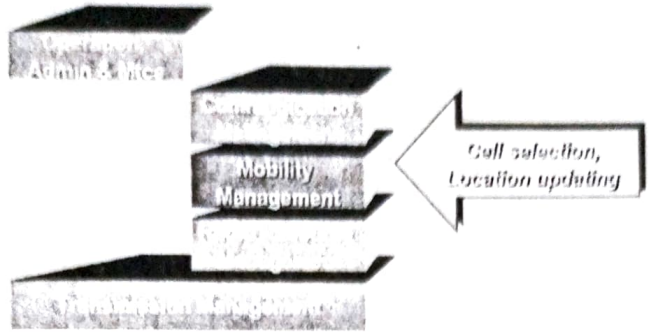
Mobility management is one of the major functions of a GSM network that allows mobile phones to work. The aim of mobility management is to track where the subscribers are, allowing calls, SMS and other mobile phone services to be delivered to them.

A GSM network, like all cellular networks, is a radio network of individual cells, known as base stations. Each base station covers a small geographical area which is part of a uniquely identified location area. By integrating the coverage of each of these base stations, a cellular network provides a radio coverage over a much wider area. A group of base stations is named a location area, or a routing area.

The location update procedure allows a mobile device to inform the cellular network whenever it moves from one location area to the next. Mobiles are responsible for detecting location area codes. When a mobile finds that the location area code is different from its last update, it performs another update by sending to the network, a location update request, together with its previous location, and its Temporary Mobile Subscriber Identity (TMSI).

This can be done by using a communication terminal or else just by using the subscriber identity in the visited network. Roaming is technically supported by mobility management, authentication, authorization and billing procedures.

GSM Mobility Management



6. a) What is Mobile Station Roaming Number? **[MODEL QUESTION]**
b) Differentiate between Soft hand-off and Hard hand-off.
c) What is HLR? What data are stored in it?

Answer:

a) A **Mobile Station Roaming Number** (MSRN) is an E.214 defined telephone number used to route telephone calls in a mobile network from a GMSC (Gateway Mobile Switching Centre) to the target MSC. It can also be defined as a directory number temporarily assigned to a mobile for a mobile terminated call. A MSRN is assigned for every mobile terminated call, not only the calls where the terminating MS lives on a different MSC than the originating MS.

b) An **advantage** of the hard handoff is that at any moment in time one call uses only one channel. The hard handoff event is indeed very short and usually is not perceptible by the user. In the old analog systems it could be heard as a click or a very short beep, in digital systems it is unnoticeable. Another advantage of the hard handoff is that the phone's hardware does not need to be capable of receiving two or more channels in parallel, which makes it cheaper and simpler. A disadvantage is that if a handoff fails the call may be temporarily disrupted or even terminated abnormally. Technologies, which utilise hard handoffs, usually have procedures which can re-establish the connection to the source cell if the connection to the target cell cannot be made. However re-establishing this connection may not always be possible (in which case the call will be terminated) and even when possible the procedure may cause a temporary interruption to the call.
One advantage of the soft handoffs is that the connection to the source cell is broken only when a reliable connection to the target cell has been established and therefore the chances that the call will be terminated abnormally due to a failed handoff are lower. However, by far a bigger advantage comes from the mere fact that simultaneously channels in multiple cells are maintained and the call could only fail if all of the channels are interfered or fade at the same time. Fading and interference in different channels are unrelated and therefore the probability of them taking place at one the same moment in all channels is very low. Thus the reliability of the connection becomes higher when the call is in a soft handoff.

c) Home location register (HLR):
The HLR is a database used for storage and management of subscriptions. The HLR is considered the most important database, as it stores permanent data about subscribers, including a subscriber's service profile, location information, and activity status. When an individual buys a subscription from one of the PCS operators, he or she is registered in the HLR of that operator.

7. What are the main reasons for using cellular system? Describe the dynamic channel allocation in cellular system. [MODEL QUESTION]

Answer:
The cellular concept was a major breakthrough in solving the problem of spectral congestion and user capacity. In this case, a large area is usually divided into many smaller areas, called cells, and each cell has a low power transmitter/receiver (base station) at its centre. Each base station is allocated a portion of the total number of channels available to the entire system and nearly base stations are assigned different group of channels. Neighboring base stations are assigned different group of channels so that the interference between base stations is minimized. The available channels may be systematically distributed throughout the geographic region and may be reused many times. Thus the system capacity (number of users that can be supported) increases since the spectrum was utilized efficiently. Moreover, in this system when a mobile user moves from one cell to another, the call gets automatically transferred. Thus, all the limitations of early days mobile systems were overcome in cellular telephony.
In this case, voice channels are not allocated permanently to the cells. Each time a call request is made, the serving BS requests a channel from the MSC. MSC then allocates a channel to the requested cell in fashion which accounts the chance of future blocking within the cell, the frequency of use of the candidate channel, reuse distance of the channel and other cost functions. Therefore, the MSC only allocates a given frequency if the frequency is not presently in use in the cell or any other cell which falls within the minimum restricted distance of frequency reuse to avoid co-channel interference. Dynamic channel allocation reduces the probability of blocking. It is required by the MSC to collect real time data on channel occupancy, traffic distribution and radio signal strength on a continuous basis. This increases the storage and computational load on the system.

8. In a TDMA cellular system, the one way bandwidth is 12.5 MHz. The channel bandwidth is 30 kHz and there are 395 voice channels in the system. The frame duration is 40ms. With 6 time slots per frame. The system has an individual user data rate of 16.2 kbps in which the speech with error protection has a rate of 13 kbps. Calculate the efficiency of the TDM frame. [MODEL QUESTION]

Answer:

The time slot duration $\tau = \left(\frac{13}{16.2}\right)\left(\frac{40}{6}\right) = 5.35ms$

$T_f = 40ms$, $M_t = 6$

$N_u = 395$, $B_c = 30kHz$ and $B_u = 12.5MHz$

$$\eta_u = \frac{5.35 \times 6}{40} \times \frac{30 \times 395}{12500} = 0.76$$

The overhead portion of the frame = 1.0 – 0.76 = 24%

9. What do you mean by hand off? Discuss how hard hand off is different from soft hand off. **[MODEL QUESTION]**

Answer:

One of the major tasks in mobile communication system is to maintain continuity of call when a mobile user migrates from one cell to another. This is done by changing the controlling base station and the process is called call handoff or handover. The MSC automatically transfers the call to a new channel belonging to the new base station. This involves identification of a new base station and allocation of voice and control signals to the associated channels of the new base station.

Handover procedure involves measurement, decision and execution. Handover may be based on measurement such as – signal strength, bit error rate, traffic load or carrier to interference ratio etc.

Hard handoff is break before make system whereas soft handoff is a make before break system.

10. Write down the limitations of accessing the mobile internet. **[MODEL QUESTION]**

Answer:

Limitations of accessing the mobile internet:

- **Small screen size** – This makes it difficult or impossible to see text and graphics dependent on the standard size of a desktop computer screen.
- **Lack of windows** – On a desktop computer, the ability to open more than one window at a time allows for multi-tasking and for easy revert to a previous page. Historically on mobile web, only one page can be displayed at a time, and pages can only be viewed in the sequence they were originally accessed. However, there are apps for the iPhone (e.g. Oceanus), as well as browsers such as Opera Mini for Java ME, allowing multiple windows, but sometimes a limited number, and not multiple windows in the same screen.
- **Navigation** – Most mobile devices do not use a mouse like pointer, but rather simply an up and down function for scrolling, thereby limiting the flexibility in navigation.
- **Lack of JavaScript and cookies** – Most devices do not support client-side scripting and storage of cookies (Smartphone excluded), which are now widely used in most Web sites for enhancing user experience, facilitating the validation of data entered by the page visitor, etc. This also results in web analytics tools not being suitable for uniquely identifying visitors using mobile devices.
- **Types of pages accessible** – Many sites that can be accessed on a desktop cannot on a mobile device. Many devices cannot access pages with a secured connection, Flash

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or other similar software, PDFs, or video sites, although recently this has been changing.

- **Speed** – On most mobile devices, the speed of service is very slow, often slower than dial-up Internet access.
- **Broken pages** – On many devices, a single page as viewed on a desktop is broken into segments, which are each treated as a separate page. Paired with the slow speed, navigation between these pages is slow.
- **Compressed pages** – Many pages, in their conversion to mobile format, are squeezed into an order different from how they would customarily be viewed on a desktop computer.
- **Size of messages** – Many devices have limits on the number of characters that can be sent in an email message.
- **Cost** – the access and bandwidth charges levied by cell phone networks can be high if there is no flat fee per month.
- **Location of mobile user:**
  - if advertisements reach phone users in private locations, users find them more distressful if the user is abroad the flat fee per month usually does not apply
- **Situation in which ad reaches user** – When advertisements reach users in work-related situations, they may be considered more intrusive than in leisure situations.

Long Answer Type Questions

1. What is multiple access technique? Do a comparative study among FDMA, TDMA and CDMA. **[WBUT 2013]**

Answer:

1st Part:

Multiple access techniques are used to allow a large number of mobile users to share the allocated spectrum in the most efficient manner. As the spectrum is limited, so the sharing is required to increase the capacity of cell or over a geographical area by allowing the available bandwidth to be used at the same time by different users. And this must be done in a way such that the quality of service doesn't degrade within the existing users. Cellular systems divide a geographic region into cells where a mobile unit in each cell communicates with a base station. The goal in the design of cellular systems is to be able to handle as many calls as possible (this is called capacity in cellular terminology) in a given bandwidth with some reliability. There are several different ways to allow access to the channel. These include the following.

- frequency division multiple-access (FDMA)
- time division multiple-access (TDMA)
- time/frequency multiple-access
- random access
- code division multiple-access (CDMA)
  - frequency-hop CDMA
  - direct-sequence CDMA
  - multi-carrier CDMA (FH or DS)

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

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2nd Part:

Time Division Multiple Access (TDMA)

TDMA is a channel access method when multiple users share a single channel. In TDMA system, the entire radio spectrum is divided into time slots and each slot is available to only one user. The users transmit in turns, one after the other, each using its own time slot. Transmission process is not continuous since data are transmitted in bursts. The transmission from many users is interlaced into a repeating structure called frame and this frame is composed of many time slots. A frame is made up of preamble, an information message and tail bits as shown in figure below:

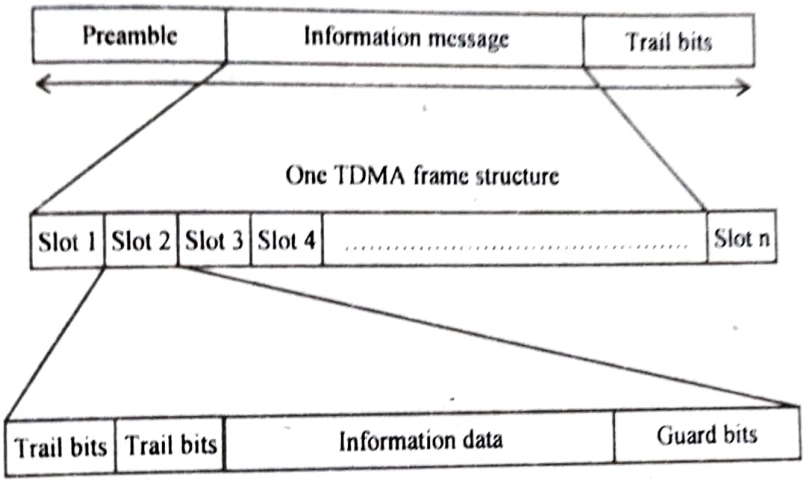
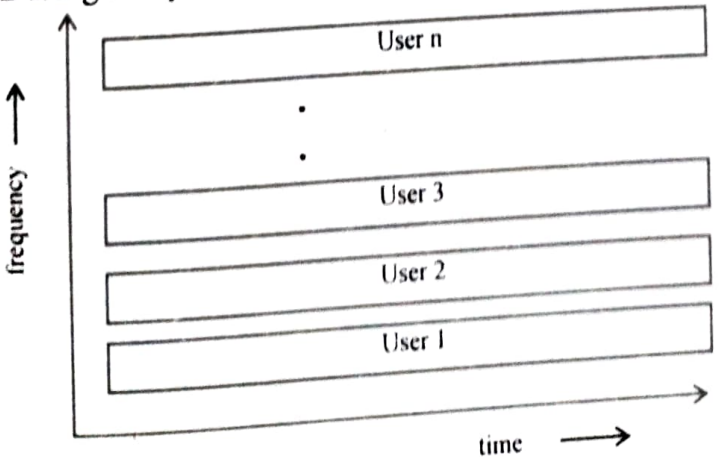


Fig: TDMA frame structure

Frequency Division Multiple Access (FDMA)

FDMA is a multiple access method in which the total amount of radio spectrum is divided into a number of channels and then each channel is permanently assigned to a user. For two way communication, two channels are required. Hence frequency division duplexing (FDD) is used. FDD provides two channels – one from BS to MS and other from MS to BS, separated by sufficient frequency value. This separation is required to avoid interference.

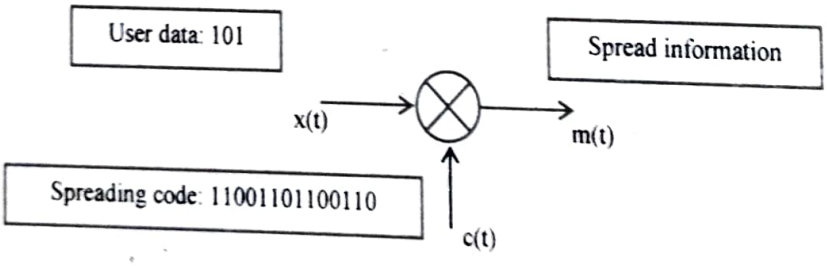
FDMA is a continuous transmission system. However, FDMA leads to wastage of bandwidth as each user is permanently assigned a communication channel which sits idle when not in use. During this period, no other user can access the channel.



Code Division Multiple Access (CDMA):
CDMA is a multiple access method in which several transmitters can send information simultaneously over a single communication channel. CDMA uses a technique known as spread spectrum to make this possible.

Spread Spectrum Technique:
The narrowband message signal is multiplied by a very large bandwidth signal called the spreading signal. The spreading signal is a pseudo-noise code sequence having a very high chip rate. It spreads the message signal in such a way that only it itself can recover it at the receiver end. This spreading signal is unique in nature i.e., it is different for different users and is also orthogonal to other such signals. As a result, the receiver is able to perform a time correlation operation to detect only the desired message despite using the same frequency appear. This entire process is known as spread spectrum technique in CDMA.

Direct Sequence CDMA:
A CDMA in which the spread signal is obtained by direct multiplication of the message signal and the high rate spreading signal, is known as direct sequence CDMA. IN DS – CDMA all users transmit simultaneously at the same frequency. Each message signal is modulated by a unique code word and then their modulated signals are combined together and sent over a channel.
At the receiver end, the receiver multiplies the composite signal by his own code word to receive the message intended for him.
Signal separation at the receiver end is possible only if the codes are orthogonal to each other. For perfect orthogonality between two codes, the cross correlation factor must be zero for a time separation $\tau = 0$.



(a)

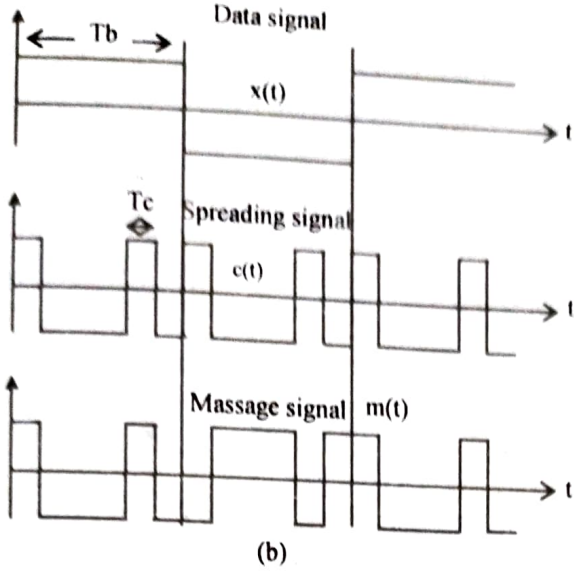


Fig: (a) Basic CDMA technique (b) Spreading of signal

2. Draw the system architecture of GSM and explain the functionality of HLR and VLR. **[WBUT 2013, 2014]**

Answer:

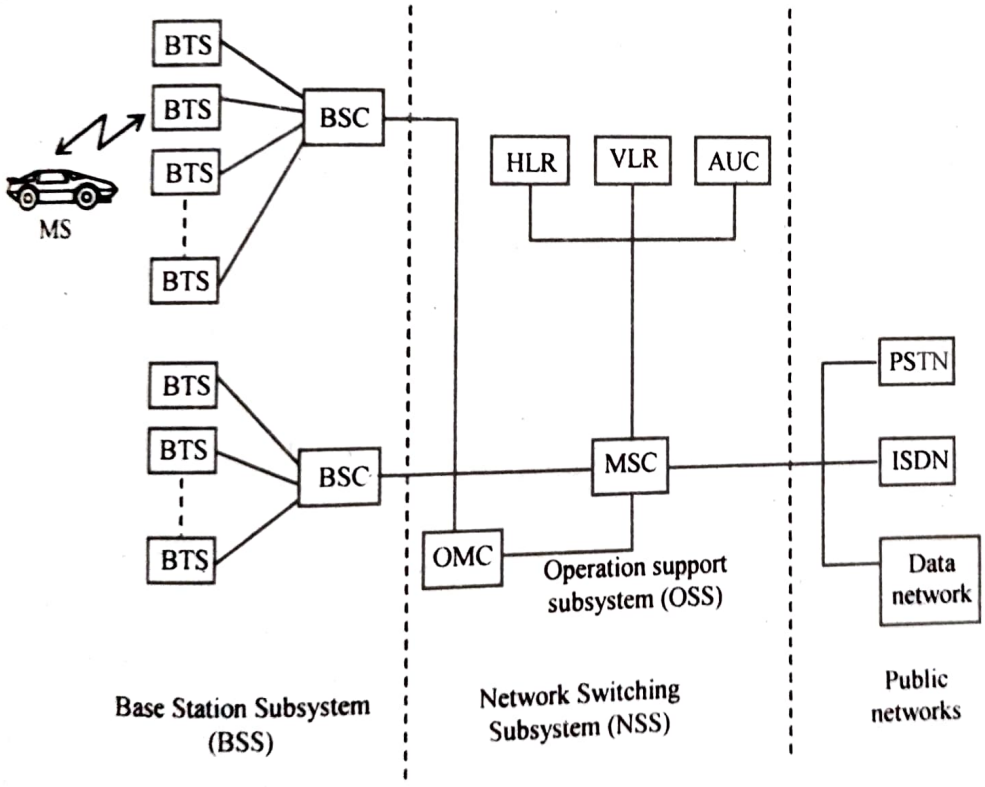


Fig: GSM system architecture

Home Location Register (HLR): This database contains all the administrative information about each subscriber along with their last known location. In this way, the GSM network is able to route calls to the relevant base station for the MS. When a user switches on their phone, the phone registers with the network and from this it is possible to determine which BTS it communicates with so that incoming calls can be routed

appropriately. Even when the phone is not active (but switched on) it re-registers periodically to ensure that the network (HLR) is aware of its latest position. There is one HLR per network, although it may be distributed across various sub-centres to for operational reasons.

Visitor Location Register (VLR): This contains selected information from the HLR that enables the selected services for the individual subscriber to be provided. The VLR can be implemented as a separate entity, but it is commonly realised as an integral part of the MSC, rather than a separate entity. In this way access is made faster and more convenient.

3. a) Discuss the three different mechanisms to improve the cell capacity and coverage area in cellular systems.
b) What is MANET?
c) What is Micro-cell zone concept?
d) Briefly differentiate between GSM and CDMA technologies. **[WBUT 2014]**

Answer:

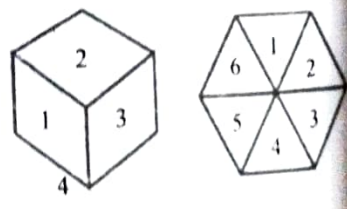
a) In some cases, it may be difficult to predict the need for network expansion or even when network expansion is predictable, the time for network expansion arrives. There are several techniques to expand an already existing network or to add more capacity to a network being built. In the following we discuss three techniques.
Which are i) Cell Splitting ii) Cell sectorization and iii) Use of repeaters respectively.

Call splitting

Every cell has some fixed number of channels. When the service demand in a particular cell exceeds the number of channels allocated to that cell, new subcells are created in that cell. This is called cell splitting. There is also restriction on the area of the cell also. Because the transmitter of the cell can cover the large area, but the cellular (mobile) phase has to communicate back to the base station of the cell. That is cellular phone has very small power. Therefore it cannot cover large distance. Hence the area of the cell should be such that all subscribers in a particular cell should be able to communicate with the base station of that cell. For this reason also cell splitting is required. In the cell splitting, new cells of smaller size are created within the boundaries of old cells. Since the area of these new cells is small, the transmitter power and the antenna height of the new base station in the cells is reduced. Frequency reuse can be employed in those new cells.

Cell sectorization

Capacity of the cell can be further increased by cell sectorization. Each cell is divided into sectors. Those sectors have equal size. But for all the sectors of one cell there is single base station. For each sector, separate antenna can be used. Those antennas are directional and cover particular sector. For example if the cell is sectorized into three sectors as shown in fig.



(a) Three sectors (b) Six sectors

Fig: Cell sectorization

Use of repeaters

Due to the limitations of the radio wave propagation, there are possibilities of having zones in the mobile communication system where the direct signal from the base station does not reach the Mobile Station. These zones are conventionally called "dead zones" such as tunnels, shopping malls and other indoor venues. Repeaters are the most effective and an efficient way to provide the mobile service guarantee from both operator and user point of view. Besides that, operators use repeater to extend network coverage, which leads to a capacity cut off due to the repeater noise. We proposed to consider repeater to increase capacity for urban areas where path loss exponent is more than 3.4. In this paper we analyze the system capacity and coverage for both uplink and downlink with the 3GPP recommended repeater.

b) A mobile **ad-hoc** network mobile **ad-hoc** network MANet is a kind of wireless **ad-hoc** network, and is a self-configuring network of mobile routers and associated hosts connected by wireless links the union of which form configuring network of mobile routers and associated hosts connected by wireless links.

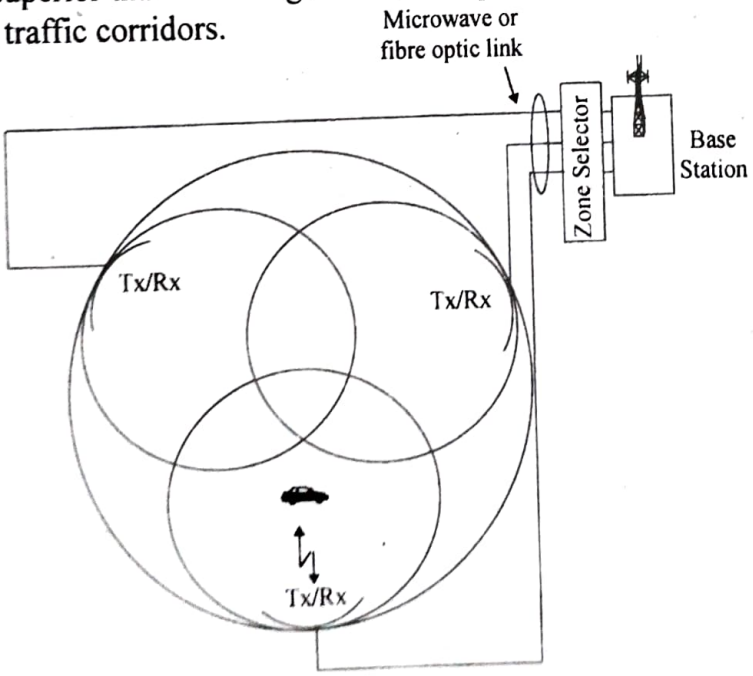
c) **Micro-cell zone Concept**

A cell base station in this system has three or more smaller antennas (Tx/Rx) placed on the edge of the cell rather than single bigger antenna at the center.

All three smaller antenna share same base station, same channel frequencies. Therefore a user roaming in any zone will not notice any difference, no hand-off required, but will experience lower co-channel interference.

The decreased co-channel interference increases SIR, and consequent increase in the cellular capacity of the system.

This scheme is superior than sectoring. This technique is particularly useful on highways and along urban traffic corridors.



d) In the world of wireless technologies today, GSM and CDMA are seriously competing. Some people believe GSM is leading the market with about 84% market share globally and that the remaining 16% market share for CDMA while some believe it is just about 75% market share globally for GSM and 25% market share for CDMA. Some people believe there is no much different or that the CDMA is even better. Take for example in the USA, CDMA is the more dominant standard. Below is the comparison table.

Stands For	Code Division Multiple Access	Global System for Multiple Access
Storage Type	Internal Memory	SIM (Subscriber Identity Module) Card
Global Market Share	25%	75%
Dominance	Dominant Standard in the U.S.	Dominant Standard worldwide except U.S.
Data Transfer	EVDO/3G/4G/LTE	GPRS/E/3G/4G/LTE
Network	There is one physical channel and a special code for every device in the coverage network. Using this code, the signal of the device is multiplexed, and the same physical channel is used to send the signal.	Every cell has a corresponding network tower, which serves the mobile phones in that cellular area.
International Roaming	Less Accessible	Most Accessible
Frequency band	Single (850 MHz)	Multiple(850/900/1800/1900 MHz)
Network service	Handset specific	SIM specific. User has option to select handset of his choice.

4. a) Explain the concept of frequency reuse in cellular systems. [WBUT 2014]
b) What do you mean by co-channel interference and system capacity?
Answer:

a) The cellular concept was a major breakthrough in solving the problem of spectral congestion and user capacity. In this case, a large area is usually divided into many smaller areas, called cells, and each cell has a low power transmitter/receiver (base station) at its centre. Each base station is allocated a portion of the total number of channels available to the entire system and nearly base stations are assigned different group of channels. Neighboring base stations are assigned different group of channels so that the interference between base stations is minimized. The available channels may be systematically distributed throughout the geographic region and may be reused many times. Thus the system capacity (number of users that can be supported) increases since the spectrum was utilized efficiently. Moreover, in this system when a mobile user moves

from one cell to another, the call gets automatically transferred. Thus, all the limitations of early days mobile systems were overcome in cellular telephony.

In GSM cellular system, the allotted band (radio channels) is divided into smaller frequency bands and allocated to different base stations. These groups of base stations are said to form a cluster. These group of cells (cluster) are repeated again and again to cover a large area and also for greater system capacity and improved frequency spectrum utilization. This is known as frequency reuse.

Figure below shows that concept of frequency reuse. Cells labeled with the same letter use the same group of channels. Clusters are shown by thicker line boundaries.

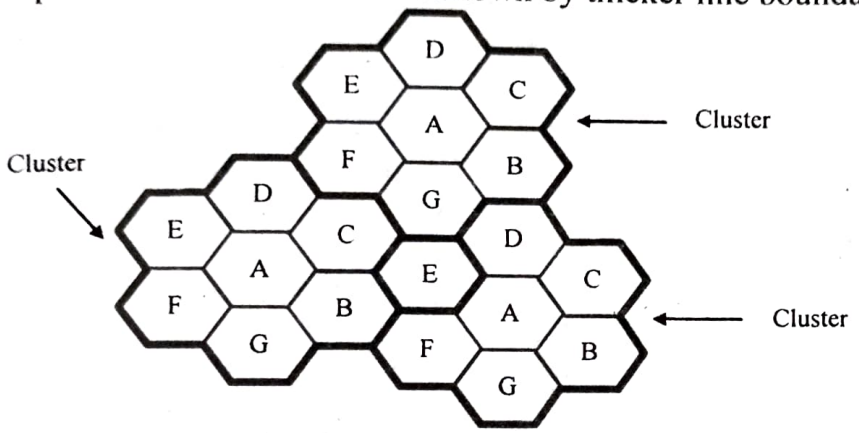


Fig: Frequency reuse

b) Frequency reuse implies that in a given coverage area there are several cells that use the same set of frequencies. These cells are called co-channel cells and the interference between signals from these cells is called co-channel interference. Unlike thermal noise, which can be overcome by increasing the signal-to-noise ratio (SNR), co-channel interference cannot be combated by simply increasing the carrier power of a transmitter. This is because an increase in carrier transmit power increases the interference to neighbouring co-channel cells. To reduce co-channel interference, co-channel cells must be physically separated by a minimum distance to provide sufficient isolation due to propagation.

When the size of each cell is approximately the same and the base stations transmit the same power, the co-channel interference ratio is independent of the transmitted power and becomes a function of the radius of the cell (R) and the distance between centers of the nearest co-channel cells (D). By increasing the ratio of D/R, the spatial separation between co-channel cells relative to the coverage distance of a cell is increased. Thus, interference is reduced from improved isolation of RF energy from the co-channel cell. The parameter Q, called the co-channel reuse ratio, is related to the cluster size. For a hexagonal geometry

$$Q = \frac{D}{R} = \sqrt{3N}$$

A small value of Q provides larger capacity since the cluster sized N is small, whereas a large value of Q improves the transmission quality, due to a smaller level of co-

channel interference. A trade-off must be made between these two objectives in actual cellular design.

5. Explain how Handover takes place in GSM. What are the problems associated with Handover in GSM? **[WBUT 2015]**

Answer:

1st Part:

The typical reason for a handover is a weaker signal from the current base station compared with a neighbouring base station. Another reason could be the current load situation: the network could decide to offload some users from a crowded cell.

Handover in GSM is accomplished using the procedure shown in figure below. In this example, the mobile station is currently communicating through base transceiver station A (BTS_a) and is to be handed over to a new base transceiver station B (BTS_a) that is attached to the same base station controller (BSC). The BSC begins by sending a command to BTS_a to allocate a radio channel to the mobile, which is acknowledged by BTS_a. If the channel allocation was successful, the BSC sends a handover command to the mobile via BTS_A. The mobile acknowledges receipt of this message to BTS_A and then sends a handover access message to BTS_a. On receipt of this message, BTS_a informs the BSC that the handover has been successful, following which the BSC instructs BTS_A to release the radio channel on which the mobile was previously communicating.

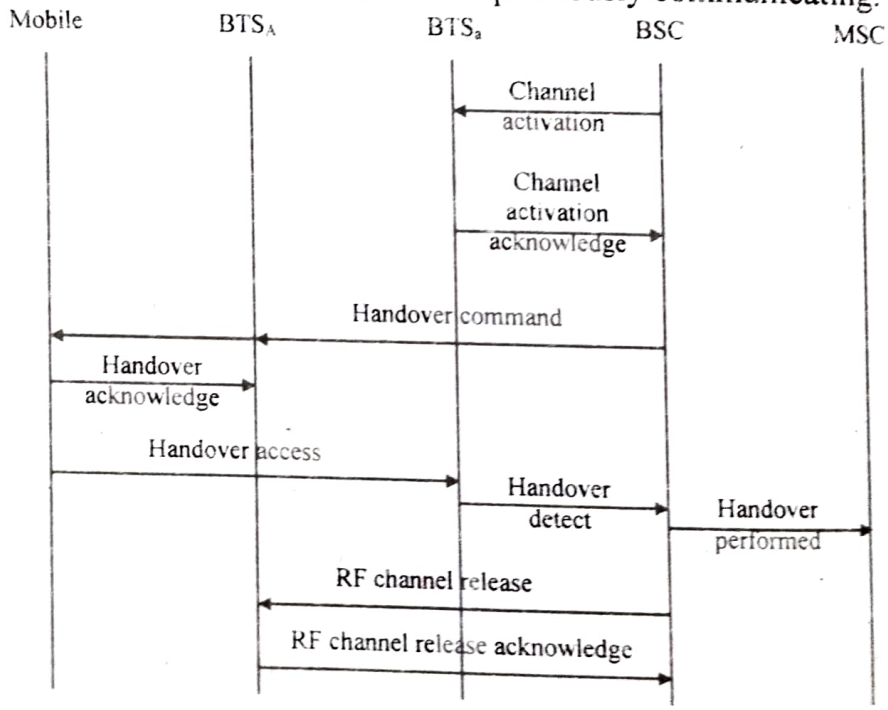


Fig: GSM handover sequence

Within the GSM system there are four types of handover that can be performed for GSM only systems:

- ***Intra-BTS handover:*** This form of GSM handover occurs if it is required to change the frequency or slot being used by a mobile because of interference, or

other reasons. In this form of GSM handover, the mobile remains attached to the same base station transceiver, but changes the channel or slot.

- ***Inter-BTS Intra BSC handover:*** This form of GSM handover or GSM handoff occurs when the mobile moves out of the coverage area of one BTS but into another controlled by the same BSC. In this instance the BSC is able to perform the handover and it assigns a new channel and slot to the mobile, before releasing the old BTS from communicating with the mobile.
- ***Inter-BSC handover:*** When the mobile moves out of the range of cells controlled by one BSC, a more involved form of handover has to be performed, handing over not only from one BTS to another but one BSC to another. For this the handover is controlled by the MSC.
- ***Inter-MSC handover:*** This form of handover occurs when changing between networks. The two MSCs involved negotiate to control the handover.

2nd Part:

The process of handover or handoff within any cellular system is of great importance. It is a critical process and if performed incorrectly handover can result in the loss of the call. Dropped calls are particularly annoying to users and if the number of dropped calls rises, customer dissatisfaction increases and they are likely to change to another network.

6. a) Discuss how digital communication is better than analog communication?
b) What are the main reasons for using cellular system? Describe the dynamic channel allocation in cellular system.
c) What are the limitations of GSM cell in terms of capacity for traditional GSM? How can the capacity be increased? [WBUT 2015]

Answer:

a) There are many advantages of using Digital Communication over Analog Communication. Some of them are listed as below:

1. The digital communication has mostly common structure of encoding a signal so devices used are mostly similar.
2. The Digital Communication's main advantage is that it provides us added security to our information signal.
3. The digital Communication system has more immunity to noise and external interference.
4. Digital information can be saved and retrieved when necessary while it is not possible in analog.
5. Digital Communication is cheaper than Analog Communication.
6. The configuring process of digital communication system is simple as compared to analog communication system. Although, they are complex.
7. In Digital Communication System, the error correction and detection techniques can be implemented easily.

b) 1st Part:
Higher capacity, higher number of the users: cellular systems can reuse spectrum according to certain patterns. Each cell can support a maximum number of users.
Support user localisation and location based services: Less transmission power needed. Smaller cells also allow for less transmission power (thus less radiation). The mobile systems can enjoy longer runtime.

2nd Part:
The problem with Fixed Channel Allocation (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.
Dynamic Channel Allocation (DCA) attempts to alleviate the problem mentioned 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 can not 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.

c) A 3/9 (3-cell/9-sector) reuse pattern is achievable for most GSM systems that use frequency hopping; without frequency hopping, a 4/12 reuse pattern may be possible. A capacity gain is achieved with frequency hopping, since the CCI is averaged over the set of hop frequencies. GSM has 8 logical channels that are time division multiplexed onto a single radio frequency carrier and the carriers are spaced 200kHz apart. Therefore, the bandwidth per channel is roughly 25kHz, which was common in first generation European analog mobile phone systems. The analog AMPS system in North America had 30kHz carrier spacings. In a nominal bandwidth of 1.25MHz (uplink or downlink), there are $1250/25 = 6.25$ carriers spaced 200kHz apart. Hence, there are $6.25/9 \approx 0.694$ carriers per sector or $6.25/3 = 2.083$ carriers/cell. Each carrier commonly carries half-rate traffic, such that there are 16 channels/carrier. Hence, the 3/9 reuse system has a sector capacity of 11.11 channels/sector or a cell capacity of 33.33 channels/cell in 1.25MH.
Cell overlap and balancing scheme is used to increase the GSM cell capacity.

7. Write short notes on the following:
a) Call setup of GSM network for mobile-to-mobile call **[WBUT 2013]**
b) Pervasive computing **[WBUT 2013]**

Answer:

a) Call setup of GSM network for mobile-to-mobile call:

The operation of the GSM system can be understood by studying the sequence of events that takes place when a call is initiated from the Mobile Station.

Call from Mobile Phone to PSTN:

When a mobile subscriber makes a call to a PSTN telephone subscriber, the following sequence of events takes place:

- The MSC/VLR receives the message of a call request.
- The MSC/VLR checks if the mobile station is authorized to access the network. If so, the mobile station is activated. If the mobile station is not authorized, service will be denied.
- MSC/VLR analyzes the number and initiates a call setup with the PSTN.
- MSC/VLR asks the corresponding BSC to allocate a traffic channel (a radio channel and a time slot).
- The BSC allocates the traffic channel and passes the information to the mobile station.
- The called party answers the call and the conversation takes place.
- The mobile station keeps on taking measurements of the radio channels in the present cell and neighboring cells and passes the information to the BSC. The BSC decides if handover is required, if so, a new traffic channel is allocated to the mobile station and the handover is performed. If handover is not required, the mobile station continues to transmit in the same frequency.

Call from PSTN to Mobile Phone:

When a PSTN subscriber calls a mobile station, the sequence of events is as follows:

- The Gateway MSC receives the call and queries the HLR for the information needed to route the call to the serving MSC/VLR.
- The GMSC routes the call to the MSC/VLR.
- The MSC checks the VLR for the location area of the MS.
- The MSC contacts the MS via the BSC through a broadcast message, that is, through a paging request.
- The MS responds to the page request.
- The BSC allocates a traffic channel and sends a message to the MS to tune to the channel. The MS generates a ringing signal and, after the subscriber answers, the speech connection is established.
- Handover, if required, takes place, as discussed in the earlier case.

b) Pervasive computing:

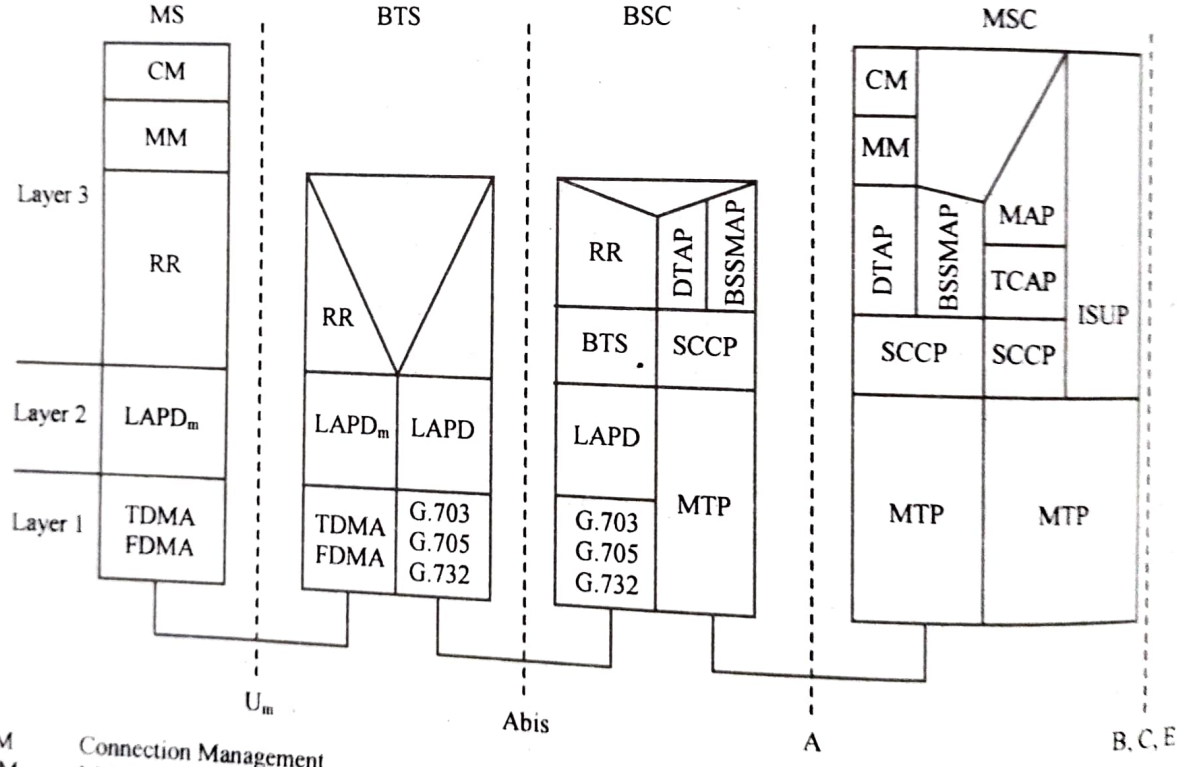
The idea that technology is moving beyond the personal computer to everyday devices with embedded technology and connectivity as computing devices become progressively smaller and more powerful. Also called *ubiquitous computing*, pervasive computing is

the result of computer technology advancing at exponential speeds -- a trend toward all man-made and some natural products having hardware and software. The goal of pervasive computing, which combines current network technologies with wireless computing, voice recognition, Internet capability and artificial intelligence, is to create an environment where the connectivity of devices is embedded in such a way that the connectivity is unobtrusive and always available.

8. Briefly discuss GSM signaling protocol architecture. **[MODEL QUESTION]**

Answer:

GSM communication protocols are structured on the ISO/OSI reference model (ITU-T Recommendations X.200–X.219) with other protocol functions specific to cellular radio networks being developed. The layer 1 to layer 3 GSM signaling protocol architecture and its distribution among the network nodes is shown in figure. Interfaces Um and Abis are GSM specific while interfaces A, B, C and E are based on common channel signaling systems No. 7 (SSN7) reported in ITU-T Series Q.700–795. The Um-interface is defined between an MS and a BTS, whereas the Abis-interface is located between a BTS and a BSC. Signalling exchange between a BSC and an MSC is through the A-interface. Communication between an MSC and the VLR, HLR and other MSCs are via the B-, C- and E-interfaces, respectively.



CM	Connection Management
MM	Mobility Management
RR	Resource Radio Management
$LAPD_m$	Link Access Protocol on D_m Channel
BYSM	Base Transceiving Station Management
MAP	Mobile Application Part

BSSMAP	Base Station System Management Application Part
DTAP	Direct Transfer Application Part
SCCP	Signalling Connection Control Part
TCAP	Transaction Capabilities Application part
MTP	Message Transfer Part
ISUP	ISDN User Part

Fig: GSM signaling protocols and distribution among network elements

In layer 2 of the MS and BTS protocol stacks, a modified link access protocol on the D channel ($LAPD_m$) is used. $LAPD_m$ is a modified version of the ISDN LAPD protocol specifically for use in mobile applications. It protects the data transfer between the MS and BTS over the radio interface.

A mobile application part (MAP) is specifically developed in order to accommodate radio signalling in GSM networks. It is implemented in all the switching centres directly linked to the mobile network. MAP groups a number of protocols which are able to support mobility control functions and is specified in GSM Recommendation 09.08 [ETS-94]. It consists of several application service elements (ASE) necessary for registration transaction and data-base inquiry and for the determination of a mobile station's current location.

Of particular interest to this chapter is the functions defined in the *radio resource* (*RR*) *management*, *mobility management* (*MM*) and the *connection management* (*CM*) layers. These three layers are sub-layers to the network layers or layer 3 of the ISO/OSI reference model.

The RR layer handles the administration of frequencies and channels. It is responsible for the set-up, maintenance and termination of dedicated RR connections, which are used for point-to-point communication between the MS and the network. It also includes cell selection when the mobile station is in idle mode (the term idle mode refers to the state when the mobile is switched-on but is not in the process of a call) and in handover procedures. It also performs monitoring on the broadcast control channel (BCCH) and common control channel (CCCH) on the downlink when there is no active RR connection.

The MM layer is responsible for all functions that support mobility of the mobile terminal. It includes registration, location update, authentication and allocation of new temporary mobile subscriber identity (TMSI).

The CM layer is responsible for the set-up, maintenance and termination of circuit-switched calls. It provides the transport layer with a point-to-point connection between two physical subsystems.

9. What is handoff? How is handoff different from roaming? [MODEL QUESTION]

Answer:

Handoff:

In cellular telecommunications, the term **handoff** refers to the process of transferring an ongoing call or data session from one channel connected to the core network to another. In satellite communications it is the process of transferring satellite control responsibility from one earth station to another without loss or interruption of service. The British English term for transferring a cellular call is **handoff**, which is the terminology standardised by 3GPP within such European originated technologies as GSM and UMTS.

Purpose

In telecommunications there may be different reasons why a handoff (handoff) might be conducted:

- when the phone is moving away from the area covered by one cell and entering the area covered by another cell the call is transferred to the second cell in order to avoid call termination when the phone gets outside the range of the first cell;
- when the capacity for connecting new calls of a given cell is used up and an existing or new call from a phone, which is located in an area overlapped by another cell, is transferred to that cell in order to free-up some capacity in the first cell for other users, who can only be connected to that cell; etc.

Types of Handoff

In addition to the above classification of *inter-cell* and *intra-cell* classification of handoffs, they also can be divided into *hard* and *soft* handoffs.

Roaming:

In wireless telecommunications, roaming is a general term that refers to the extending of connectivity service in a location that is different from the home location where the service was registered. Roaming ensures that the wireless device keeps connected to the network, without losing the connection. The term "roaming" originates from the GSM (Global System for Mobile Communications) sphere; the term "roaming" can also be applied to the CDMA technology.

Traditional GSM Roaming is defined (cf. GSM Association Permanent Reference Document AA.39) as the ability for a cellular customer to automatically make and receive voice calls, send and receive data, or access other services, including home data services, when travelling outside the geographical coverage area of the home network, by means of using a visited network.

10. a) Write the main differences between Adhoc networks and other networks.
b) What advantages do Adhoc network offer? Explain in detail by giving suitable example.
c) What are the main problems in signal propagation? Why is reflection both useful and harmful?

Answer: **[MODEL QUESTION]**

a) With nodes sending data at a constant rate. **Different** protocols are then evaluated based on the packet drop rate, the overhead introduced by the routing protocol, and other measures. A mobile **ad-hoc** network mobile **ad-hoc** network MANet is a kind of wireless **ad-hoc** network, and is a self-configuring network of mobile routers and associated hosts connected by wireless links the union of which form configuring network of mobile routers and associated hosts connected by wireless links.

b) Advantages of Ad Hoc Networks

The principal advantages of an ad hoc network include the following:

- Independence from central network administration
- Self-configuring, nodes are also routers

- Self-healing through continuous re-configuration
- Scalable—accommodates the addition of more nodes
- Flexible—similar to being able to access the Internet from many different locations:

The term **ad-hoc** networks is certainly not new to most of the readers of Eurescom However, there are probably many **different** associations that people have when thinking of **ad-hoc** networks. Since the inception of wireless networking there have been two types of wireless networks: the infrastructure network, including some local area networks (LANs), and the ad hoc network. *Ad hoc* is Latin meaning "for this purpose." Ad hoc networks therefore refer to networks created for a particular purpose. They are often created on-the-fly and for one-time or temporary use. Often, ad hoc networks are comprised of a group of workstations or other wireless devices which communicate directly with each other to exchange information. Think of these connections as spontaneous networks, available to whomever is in a given area.

An ad hoc network is one where there are no access points passing information between participants. Infrastructure networks pass information through a central information hub which can be a hardware device or software on a computer. Office networks, for example, generally use a server to which company workstations connect to receive their information. Ad hoc networks, on the other hand, do not go through a central information hub.

c) 1st Part:

Common amateur activity falls into three major bands: **HF**, **VHF**, and **UHF** bands. HF includes frequencies from 160 meters all the way up to 10 meters. These bands will give you world wide communications. In the Novice and Technician Plus classes, most of this activity is restricted to data transmissions, but you can make voice transmissions on the 10 meter band.. The lower band waves are able to travel far into the atmosphere (almost into space) and then bounce off one of a few layers of ionized gases in the **ionosphere**. This property is what allows energy waves to travel so far across the earth - the energy is radiated, bounces off of a layer, then is reflected back to another point on the earth. Bouncing waves off of the ionosphere is called **sky-wave propagation**. Theoretically speaking, if you pretend that the earth is perfectly round, that there is no loss in radio wave energy during transmission / reflection, and that you could reflect a wave from an infinite distance away from the earth and then back to the earth, then one could reach any point on the globe. But, there are much interference during transmission and the physical characteristics of the earth deviate, so this will hardly be possible most of the time. But you can probably envision this: the farther away that energy is reflected away from the earth, then the greater physical distance on the earth that can be covered with that energy.

2nd Part:

Because lower Frequencies are for long range whereas higher frequencies such as microwave go much shorter distances such as line of sight but can carry more information due to the complexity of the waveform. Do a search for spectrum management and I'm sure you can find what you are looking for. I just think of a radio

wave as the least complex because it is a low frequency and has lots of power behind it to broadcast to a big audience by blanketing a large surface whereas a satellite is a small complex antenna that discharges a high frequency burst from point to point but can carry a lot more information.

11. Write short note on the following:
a) Voice across the Internet **[MODEL QUESTION]**
b) GSM Network **[MODEL QUESTION]**
Answer:

a) Voice across the Internet:

Voice across the Internet or VoIP services convert your voice into a digital signal that travels over the Internet. If you are calling a regular phone number, the signal is converted to a regular telephone signal before it reaches the destination. VoIP can allow you to make a call directly from a computer, a special VoIP phone, or a traditional phone connected to a special adapter. In addition, wireless "hot spots" in locations such as airports, parks, and cafes allow you to connect to the Internet and may enable you to use VoIP service wirelessly required. This can be through a cable modem, or high speed services such as DSL or a local area network. A computer, adaptor, or specialized phone is required. Some VoIP services only work over your computer or a special VoIP phone, while other services allow you to use a traditional phone connected to a VoIP adapter. If you use your computer, you will need some software and an inexpensive microphone. Special VoIP phones plug directly into your broadband connection and operate largely like a traditional telephone. If you use a telephone with a VoIP adapter, you'll be able to dial just as you always have, and the service provider may also provide a dial tone.

b) GSM Network:

GSM originally used two 25 MHz bands for all member countries but now it is used globally in many bands. The base station to subscriber transmission uses 935 – 960 MHz band, called forward link and the subscriber to base station link called reverse link uses 890 – 915 MHz.

GSM uses frequency division duplex (FDD) i.e. two separate channels on a single radio channel for communication to and from the user. GSM also uses a combination of TDMA and FDMA schemes to provide multiple accesses to mobile users. The combination is referred as FDMA/TDMA/FDD. The available frequency bands are divided into 200 KHz wide channels called Absolute Radio Frequency Channel Number (ARFCN). The ARFCN denotes forward and reverse channel pair which is separated in frequency by 45 MHz and each channel is time shared by as many as eight subscribers using TDMA.

All the eight subscribers sharing the same channel uses the same ARFCN and occupies a unique timeslot per frame. Radio transmissions are made on specific time slot or frame may be dedicated to either handling traffic data, signaling data or control channel data. Table summarizes the GSM air interface specifications.

Parameter	Specification
Reverse Channel Frequency	890 – 915 MHz
Forward Channel Frequency	935 – 960 MHz
ARFCN Number	0 to 124 and 975 to 1023
TX RX Frequency spacing	45 MHz
TX RX Time slot spacing	3 time slots
Modulation data rate	270.833 Kbps
Frame period	4.615 ms
users per frame	8
Time slot period	576.9 μs
Bit period	3.692 μs
Modulation	0.3 GMSK
ARFCN channel spacing	200 KHz
Max. delay	40 ms.
Voice Coder Bit Rate	13.14 Kbps

Table: GSM Air Interface Specifications

GENERAL PACKET RADIO SERVICES

Multiple Choice Type Questions

1. Full form of HSCSD is [WBUT 2013]
   a) High Spectrum Circuit Switched Data
   b) High Speed Channel Switched Data
   c) High Speed Circuit Switched Data
   d) High Speed Circuit Switched Devices

Answer: (c)

2. GPRS is [WBUT 2014]
   a) general packet radio service
   b) global packet radio service
   c) general police radio service
   d) none

Answer: (a)

Short Answer Type Questions

1. Define packet switching and circuit switching. [WBUT 2013]

Answer:

Packet-switched networks move data in separate, small blocks -- packets -- based on the destination address in each packet. When received, packets are reassembled in the proper sequence to make up the message. Circuit-switched networks require dedicated point-to-point connections during calls.

Circuit-switched networks and packet-switched networks have traditionally occupied different spaces within corporations. Circuit-switched networks were used for phone calls and packet-switched networks handled data. But because of the reach of phone lines and the efficiency and low cost of data networks, the two technologies have shared chores for years.

In modern circuit-switched networks, electronic signals pass through several switches before a connection is established. And during a call, no other network traffic can use those switches.

In packet-based networks, however, the message gets broken into small data packets that seek out the most efficient route as circuits become available.

2. What does GPRS stand for? [WBUT 2014]

Answer:

General Packet Radio Service (GPRS) is a packet oriented Mobile Data Service available to users of Global System for Mobile Communications (GSM) and IS-136 mobile phones. It provides data rates from 56 up to 114 kbps.

3. Describe the protocols of a GPRS system. [MODEL QUESTION]

Answer:

The block diagram below shows the GPRS transmission plane protocol reference model.

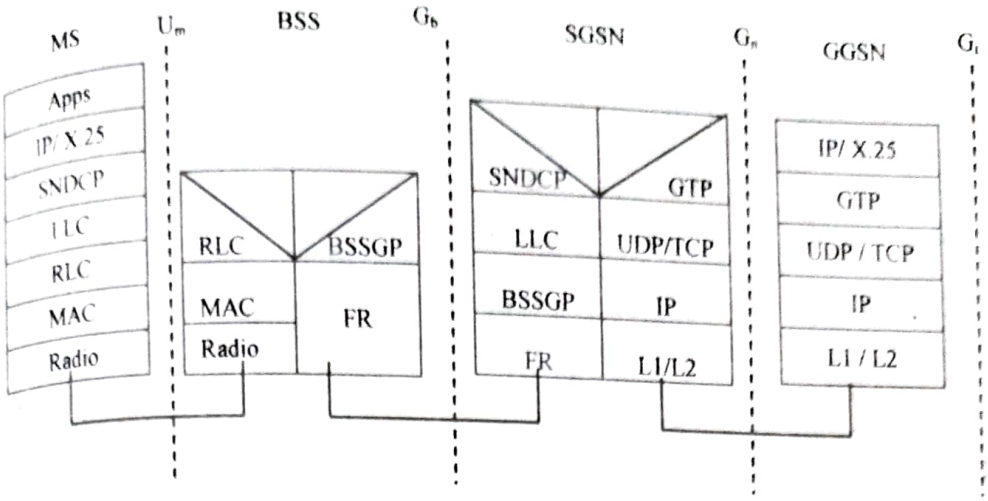


Fig: GPRS Transport Plane

All data within the GPRS backbone i.e. between the GGSN and SGSN, is transferred using the GPRS tunneling protocol (GTP). GTP can use two different transport protocols:
(i) the reliable TCP protocol or
(ii) non-reliable UDP protocol. TCP protocol is needed for reliable transfer of X.25 packets whereas UDP protocol is used for IP packets. The network protocol for the GPRS backbone is IP. To adapt to the different characteristics for the underlying networks, the sub-network dependent convergence protocol (SNDCP) is used between an SGCN and the MS. On top of SNDCP and GTP, user packet data are tunneled from the MS to the GGCN and vice versa. To achieve high reliability of packet transfer between SGSN and MS, a special LLC is used, which comprises ARQ and FEC mechanisms for PTP and (PTM) devices.
A base station subsystem GPRS protocol (BSSGP) is used to convey routing and QoS – related information between the BSS and SGSN. BSSGP does not perform error correction and works on top of a frame relay (FR) network. The radio link protocol (RLC) provides a reliable link while the MAC controls access with signaling procedures for the radio channel and the mapping of LLC frames onto the GSM physical channels. The radio interface at U_m needed for GPRS does not require fundamental changes compared to standard GSM. However, several new logical channels and their mapping onto physical resources have been defined. For example, one MS can allocate up to eight packet data traffic channels (PDTCHS). Capacity can be allocated on demand and shared between circuit- switched channels and GPRS. This allocation can be done dynamically with load supervision or alternatively, capacity can be pre-allocated.

4. How mobile station is attached and detached with the SGSN of the GPRS network? Explain the PDP context activation in GPRS network.

[MODEL QUESTION]

Answer:

Procedure of MS attached and detached with the SGSN of the GPRS network

Before MS can use the GPRS service, first the MS must register with SGSN of the GPRS network and become known to the PDN. The network checks for authorization of the

user, copies the user profile from HLR data base to the SGSN and assign the packet temporary mobile subscriber identity (P-TMSI) to the user. This procedure is called GPRS attach. The disconnection from the GPRS network is called GPRS detach.

PDP context activation in GPRS network

After a successful GPRS attach process, data packets still cannot be routed in GPRS because no address is assigned to the MS. The address is called PDP address (Packet Data Protocol Address). For example, this is IP address in case the PDN is an IP network. For each session, a so-called PDP context is created which contains PDP type, PDP address assigned to the mobile station, the requested QoS and the address of GGSN that serves as the access point to the PDN. This context is distributed and stored in MS, SGSN and GGSN. In the other way, the PDP context deactivation procedure is called to deactivate an existing PDP context between the MS and the network. After deactivation, no data transfer is any more possible.

The procedure to create PDP context is shown below:

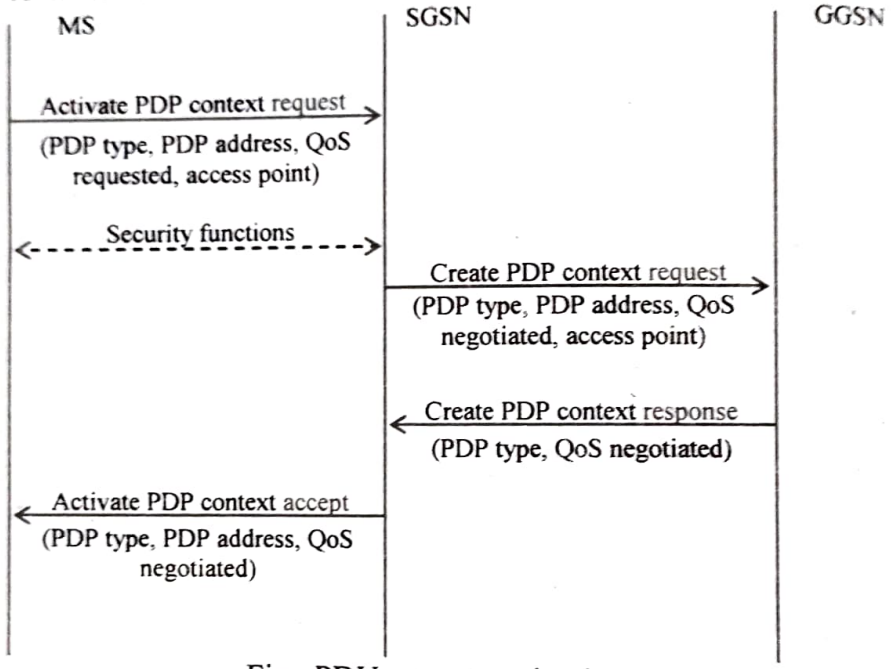


Fig: PDU context activation

Long Answer Type Questions

1. Write a short note on GPRS. **[WBUT 2013, 2015]**

Answer:

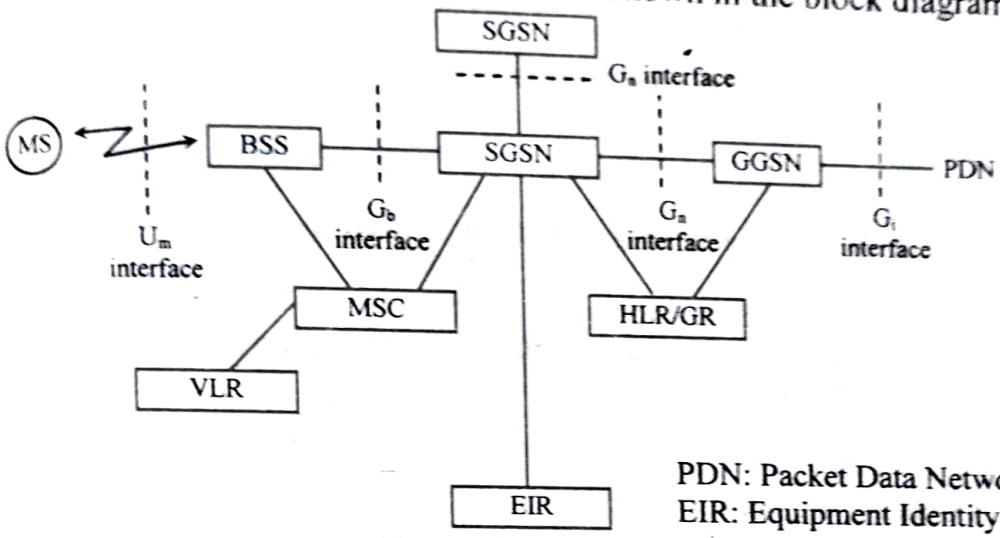
General Packet Radio Service (GPRS) is a packet oriented Mobile Data Service available to users of Global System for Mobile Communications (GSM) and IS-136 mobile phones. It provides data rates from 56 up to 114 kbps.

GPRS architecture introduces two new network elements called GPRS support nodes (GSN). These nodes are in fact routers. The first node, known as the gateway GPRS support node (GGSN) is the unit between the GPRS network and the external packet data networks (PDN). This node contains routing information for GPRS users, performs

address conversion and tunnels data to a user via encapsulation. GGSN is connected to external networks (e.g. IP or X.25) via the Gi interface. It transfers packets to the SGSN via an IP-based GPRS backbone network called Gn interface.

The other new element is the serving GPRS support node (SGSN). It supports the MS via the Gp interface. The SGSN requests user addresses from the GPRS register (GR). It keeps tracks of the individual MS's location and is responsible for collecting billing information. It also performs several security functions such as access control. The SGSN is connected to a BSC via frame relay. It is basically of the same hierarchy level as an MSC. The GR is typically a part of the HLR and stores all GPRS- relevant data.

A typical GPRS architecture reference model is shown in the block diagram below.



PDN: Packet Data Network
EIR: Equipment Identity Register

GPRS Architecture

Packet data is transmitted from a PDN via the GGSN and SGSN directly to the BSS and finally to the MS. The MSC is only used for signaling in the GPRS scheme. In the traditional circuit-switched GSM, the MSC is responsible for data transport.

SGSN: SGSN can be viewed as a 'packet-switched MSC'. It delivers packets to mobile stations (MSs) within its service area. SGSN sends queries to home location registers (HLR) to obtain profile data of GPRS subscribers. SGSNs detect new GPRS MSs in a given service area, process registration of new mobile subscribers and keep record of their location inside a given area. Therefore, SGSN performs mobility management functions such as mobile subscriber attach/detach and location management. The SGSN is connected to the base station subsystem (BSS) via a frame relay connection to the BSC.

GGSN: It is used as interfaces to external IP networks such as public internet, other mobile service providers' GPRS services or enterprise intranets. GGSNs maintain routing information that is necessary to tunnel the protocol data units (PDUs) to the SGSNs that service particular MSs. Other functions include network and subscribes screening and address mapping. One (or more) GGSNs may be provided to support multiple SGSNs.

DATA COMMUNICATION

Multiple Choice Type Questions

1. IEEE 802.11b has data transfer rate of [WBUT 2013]
   a) 11 mbps b) 13 mbps c) 10 mbps d) none of these

Answer: (a)

2. WLAN is [WBUT 2013]
   a) infrastructure network
   b) ad hoc network
   c) may be either infrastructure or ad hoc network
   d) none of these

Answer: (c)

3. Which of the following is the problem in IPV4 addressing for physical mobility? [WBUT 2014]
   a) it has 32-bit address
   b) it does not provide QoS support
   c) its routing and forwarding require a fixed IP determined by a network
   d) it has security issues

Answer: (c)

4. Which one is used in WLAN? [WBUT 2014]
   a) access point b) router
   c) both (a) and (b) d) none of these

Answer: (c)

5. Which multiple access technique is used by IEEE 802.11 standard for wireless LAN? [WBUT 2015]
   a) CDMA b) CSMA/CA c) ALOHA d) None of these

Answer: (b)

6. What is the access point (AP) in wireless LAN? [WBUT 2015]
   a) Device that allows wireless devices to connect to a wired network
   b) Wireless devices itself that allows wireless devices to connect to a wired network
   c) Both (a) and (b)
   d) None of these

Answer: (a)

7. The registration process of Mobile IP uses.....as transport protocol. [MODEL QUESTION]
   a) UDP b) TCP c) IP d) none of these

Answer: (b)

8. IEEE 802.11 supports [MODEL QUESTION]
   a) Infrared
   b) Frequency Hopping spread spectrum
   c) Direct sequenced spread spectrum
   d) All of these

Answer: (c)

9. WLANS are [MODEL QUESTION]
   a) Infrastructured b) Adhoc
   c) May be both Infrastructured and Adhoc d) None of these

Answer: (c)

10. A Wireless LAN using FHSS hops 10 times per cycle. If the bandwidth of the original is 10MHz, and 2GHz is the lowest frequency, the highest frequency (GHz) of the spectrum is [MODEL QUESTION]
   a) 2.2 b) 2 c) 2.1 d) 3

Answer: (b)

11. What is the basic access method for WLANs as defined by IEEE 802.11? [MODEL QUESTION]
   a) LLC b) PCF c) DCF d) BFD

Answer: (b)

12. WLAN service uses [MODEL QUESTION]
   a) 802.11 protocol and long distance communication at high data rates
   b) 802.16 protocol and long distance communication at small data rates
   c) 802.16 protocol and short distance communication at high data rates
   d) 802.11 protocol and short distance communication at high data rates

Answer: (a)

Short Answer Type Questions

1. Define the following terms and state the usage of Near-far effect. [WBUT 2013]

Answer:

All users use the same bandwidth at the same time and therefore users interfere with one another. Due to the propagation path loss, the signal received by the base station from a UE close to the base station will be stronger than the Signal received from another terminal located at the boundary. Hence, the distant user will be dominated by the close user. This is called the near-far effect. To achieve a considerable capacity, all signals, irrespective of distance, should arrive at the base station with the same mean power. A solution to this problem is power control, which attempts to achieve the same mean received power for each user.

2. What are tunneling and encapsulation in the context of mobile IP? [WBUT 2013]

Answer:

Encapsulation is required because each datagram we intercept and forward needs to be resent over the network to the device's care-of address. In theory, the designers might conceivably have done this by just having the home agent change the destination address and stick it back out on the network, but there are various complications that make this unwise. It makes more sense to take the entire datagram and wrap it in a new set of headers before retransmitting.

The encapsulation process creates a logical construct called a tunnel between the device that encapsulates and the one that decapsulates. This is the same idea of a tunnel used in discussions of virtual private networks (VPNs), IPSec tunnel mode, or the various other tunneling protocols used for security. The tunnel represents a conduit over which datagrams are forwarded across an arbitrary internetwork, with the details of the encapsulated datagram (meaning the original IP headers) temporarily hidden.

3. What is spread spectrum technique? Name two standard spread spectrum techniques and state the main difference in their principles of operation.

[WBUT 2013]

Answer:

Refer to Question No. 5 of Short Answer Type Questions.

4. What are hidden station problem and exposed station problem in WLAN? How are the problems solved? [WBUT 2013]

Answer:

1st Part:

***Hidden terminal problem* and *exposed terminal problem* in Wireless LAN.**

In a wired LAN, if there is no activity or a collision of messages, every station connected to the LAN will be able to sense the collection almost instantly.

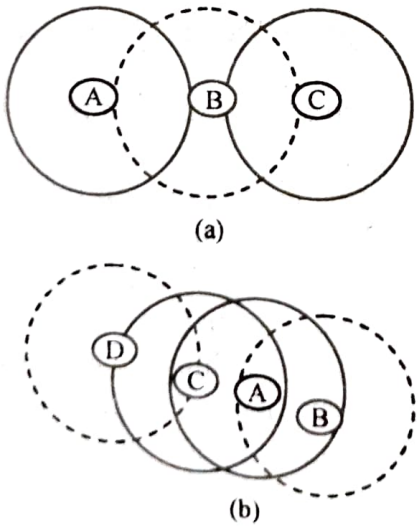


Fig: (a) Hidden terminal; (b) Exposed terminal

This is not true in the case of wireless media. In the case of wireless LANs, a Carrier Sense Multiple Access/Collision Avoidance (CSMA/CA) protocol is used, as it is not possible to detect a collision of data packets in mid air.

Consider the scenario with three mobile nodes as shown in Figure (a). The transmission of A reaches B, but not C. The transmission of C reaches B, but not A. However, the radio signal of B reaches both A and C making A and C both in the range of B. The net effect is A cannot detect C and vice versa.

A starts sending to B, C does not receive this transmission. C also wants to send to B and senses the medium. To C the medium appears to be free. Thus C starts sending causing collision at B. But now A cannot detect the collision and continues with its transmission. A is 'hidden' for C and vice versa.

Consider another case as shown in Figure (b). The radio transmission signal of A reaches C and B. The radio signal of C reaches both A and D. A wants to communicate to B, A starts sending signal to B. C wants to communicate to D, C senses the carrier and finds that A is talking to B. C has to wait till the time A finishes with B. However, D is outside the range of A, therefore waiting is not necessary. In fact A, B and C, D can communicate to each other in parallel without any collision, but according to the protocol that is not possible. A and C are 'exposed' terminals.

2nd Part:

To overcome these problems a directional antennas have been extensively used in designing MAC protocols for wireless sensor networks. Directional antennas provide many advantages over the classical antennas. These advantages include spatial reuse channel and increases in coverage range distance. One of the main considerations in designing MAC protocols for static wireless sensor networks is to reduce power consumption at the sensor nodes. This is usually done by imposing transmission and receiving schedules on the sensor nodes from only one side at same time. Since it is desirable for a sensor network to be self managed, these schedules need to be worked out by individual nodes in a distributed fashion.

5. What are the difficulties in using CSMA/CD in wireless LANs? What alternative methods can be used? **[WBUT 2014]**

Answer:

1st Part:

Wireless LAN cannot implement CSMA/CD for three reasons:

1. Station must be able to send and receive data at the same time.
2. Collision may not be detected because of the hidden terminal problem.
3. Distance between stations in wireless LANs can be great. Signal fading could prevent a station at one end from hearing a collision at other end.

2nd Part:

There are three main ways by which WLANs transmit information: microwave, spread spectrum and infrared.

Microwave Transmission

Motorola's WLAN product (ALTAIR) transmits data by using low powered microwave radio signals. It operates at the 18GHz frequency band.

Spread Spectrum Transmission

With this transmission technology, there are two methods used by wireless LAN products: frequency hopping and direct sequence modulation.

- **Frequency Hopping**

The signal jumps from one frequency to another within a given frequency range. The transmitter device "listens" to a channel, if it detects an idle time (i.e. no signal is transmitted), it transmits the data using the full channel bandwidth. If the channel is full, it "hops" to another channel and repeats the process. The transmitter and the receiver "jump" in the same manner.

- **Direct Sequence Modulation**

This method uses a wide frequency band together with Code Division Multiple Access (CDMA). Signals from different units are transmitted at a given frequency range. The power levels of these signals are very low (just above background noise). A code is transmitted with each signal so that the receiver can identify the appropriate signal transmitted by the sender unit. The frequency at which such signals are transmitted is called the ISM (industrial, scientific and medical) band. This frequency band is reserved for ISM devices. The ISM band has three frequency ranges : 902-928, 2400-2483.5 and 5725-5850 MHz. An exception to this is Motorola's ALTAIR which operates at 18GHz. Spread spectrum transmission technology is used by many wireless LAN manufacturers such as NCR for waveLAN product and SpectraLink for the 2000 PCS.

Infrared Transmission

This method uses infrared light to carry information. There are three types of infrared transmission: diffused, directed and directed point-to-point.

- **Diffused**

The infrared light transmitted by the sender unit fills the area (e.g. office). Therefore the receiver unit located anywhere in that area can receive the signal.

- **Directed**

The infrared light is focused before transmitting the signal. This method increases the transmission speed.

- **Directed point-to-point**

Directed point-to-point infrared transmission provides the highest transmission speed. Here the receiver is aligned with the sender unit. The infrared light is then transmitted directly to the receiver.

The light source used in infrared transmission depends on the environment. Light emitting diode (LED) is used in indoor areas, while lasers are used in outdoor areas.

Infrared radiation (IR) has major biological effects. It greatly affects the eyes and skin. Microwave signals are also dangerous to health. But with proper design of systems, these effects are reduced considerably.

6. What do you mean by tunnelling and encapsulation in the contest of Mobile IP? [WBUT 2014]

Answer:

Once a mobile node on a foreign network has completed a successful registration with its home agent, the Mobile IP datagram forwarding process described in the general operation topic will be fully "activated". The home agent will intercept datagrams intended for the mobile node as they are routed to its home network, and forward them to the mobile node. This is done by encapsulating the datagrams and then sending them to the node's care-of address.

Mobile IP Data Encapsulation Techniques

Encapsulation is required because each datagram we intercept and forward needs to be resent over the network to the device's care-of address. In theory, the designers might conceivably have done this by just having the home agent change the destination address and stick it back out on the network, but there are various complications that make this unwise. It makes more sense to take the entire datagram and wrap it in a new set of headers before retransmitting. In our mail analogy, this is comparable to taking a letter received for our traveling consultant and putting it into a fresh envelope for forwarding, as opposed to just crossing off the original address and putting a new one on.

The default encapsulation process used in Mobile IP is called IP Encapsulation Within IP, defined in RFC 2003 and commonly abbreviated IP-in-IP. It is a relatively simple method that describes how to take an IP datagram and make it the payload of another IP datagram. In Mobile IP, the new headers specify how to send the encapsulated datagram to the mobile node's care-of address.

In addition to IP-in-IP, two other encapsulation methods may be optionally used: Minimal Encapsulation Within IP, defined in RFC 2004, and Generic Routing Encapsulation (GRE), defined in RFC 1701. To use either of these, the mobile node must request the appropriate method in its Registration Request and the home agent must agree to use it. If foreign agent care-of addressing is used, the foreign agent also must support the method desired.

The Mobile IP Data Delivery Tunnel

The encapsulation process creates a logical construct called a tunnel between the device that encapsulates and the one that decapsulates. This is the same idea of a tunnel used in discussions of virtual private networks (VPNs), IPSec tunnel mode, or the various other tunneling protocols used for security. The tunnel represents a conduit over which datagrams are forwarded across an arbitrary internetwork, with the details of the encapsulated datagram (meaning the original IP headers) temporarily hidden.

In Mobile IP, the start of the tunnel is the home agent, which does the encapsulation. The end of the tunnel depends on what sort of care-of address is being used:

- **Foreign Agent Care-Of Address:** The foreign agent is the end of the tunnel. It receives encapsulated messages from the home agent, strips off the outer IP header and then delivers the datagram to the mobile node. This is generally done using layer two, because the mobile node and foreign agent are on the same local network, and of

course, the mobile node does not have its own IP address on that network (it is using that of the foreign agent.)

- **Co-Located Care-Of Address:** The mobile node itself is the end of the tunnel and strips off the outer header.

7. Define WLAN. **[WBUT 2014]**

Answer:

A wireless local area network (WLAN) is a wireless distribution method for two or more devices that use high-frequency radio waves and often include an access point to the Internet. A WLAN allows users to move around the coverage area, often a home or small office, while maintaining a network connection.

8. Discuss briefly the relative advantages and disadvantages of WLAN network. **[MODEL QUESTION]**

Answer:

The advantages of wireless LAN are given below:

(i) ***Mobility:*** WLAN can provide mobility to the users. There are two different types of mobility – full mobility and weak mobility. Full mobility is the ability to send and receive information while moving inside the area covered by the WLAN. Weak mobility is the capacity of having a connection to the network by placing a fixed terminal in the network.

(ii) ***Installation speed and simplicity:*** WLAN can be easily installed because of the absence of physical wire.

(iii) ***Installation flexibility:*** WLAN can be installed in a place where it is impossible to install a wired LAN.

(iv) ***Reduced cost of ownership:*** Equipment for WLAN is more expensive but the cabling cost is not there. Moreover, WLAN has an almost zero reconfiguration cost.

(v) *Scalability:* WLAN systems can be configured in a variety of topologies to meet the needs of specific applications and installations.

The disadvantages of wireless LAN are given below:

1. It's a bit more difficult to setup WLAN properly
2. There is a Risk of accessing 'outsiders' to the WLAN network unless robust security protocols are enabled (e.g. WPA, WPA2)
3. Significantly slower than a wired network
4. The network can be less stable.

9. Describe steps involved in Data transfer from mobile node to a fixed node and vice versa with respect to respect to mobile IP? **[MODEL QUESTION]**

Answer:

Steps involved in data transfer from mobile node to fixed node and vice versa:

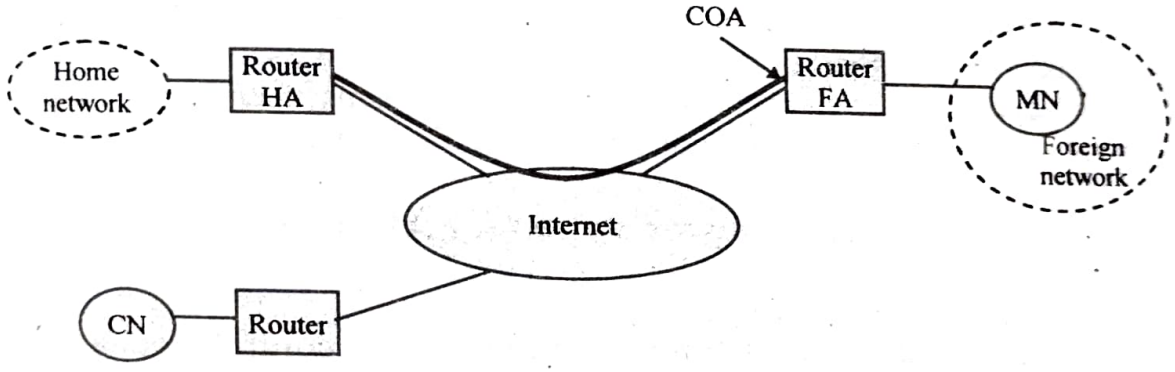
In case fixed and mobile node both is in home network

- CN (it is a fixed node) message transmits for connection establishment or a packet using the IP protocol.

- HA (the home agent for MN (mobile node)) receives the message or packet and, using the information that the destined MN is at the home network itself, it delivers the message or packet to MN.
- Receives the response message or packet from MN.
- Delivers it to the CN using the IP protocol.

In case fixed and mobile node is in foreign network

- CN transmits a message for connection establishment or a packet using the IP protocol.
- HA receives the packets and uses the information that the destined mobile node MN is not at the home network and is presently visiting a foreign network and is reachable via a foreign agent FA.
- HA encapsulates the received IP packet using a new header.
- Care-of address (COA) at the new header over the IP packet sent by HA.
- Handover— Packet encapsulated with the new header with COA transmits to FA by tunneling.
- The FA reads the COA and decapsulates the IP packet.
- Reads the destination IP address and transfers the packet to MN.
- Receives the response message or packet from MN.
- Delivers it to the CN using the IP protocol.



10. Explain steps of communication using mobile IP. **[MODEL QUESTION]**

Answer:

A corresponding node CN wants to send an IP packet to the MN. One of the requirements of mobile IP was to support hiding the mobility of the MN. CN does not need to know anything about the MN's current location and sends the packet as usual to the IP address of MN (step 1). This means that CN sends an IP packet with MN as a destination address and CN as a source address. The internet, not having information on the current location of MN, routes the packet to the router responsible for the home network of MN. This is done using the standard routing mechanisms of the internet.

The HA now intercepts the packet, knowing that MN is currently not in its home network. The packet is not forwarded into the subnet as usual, but encapsulated and tunneled to the COA. A new header is put in front of the old IP header showing the COA as new destination and HA as source of the encapsulated packet (step 2).

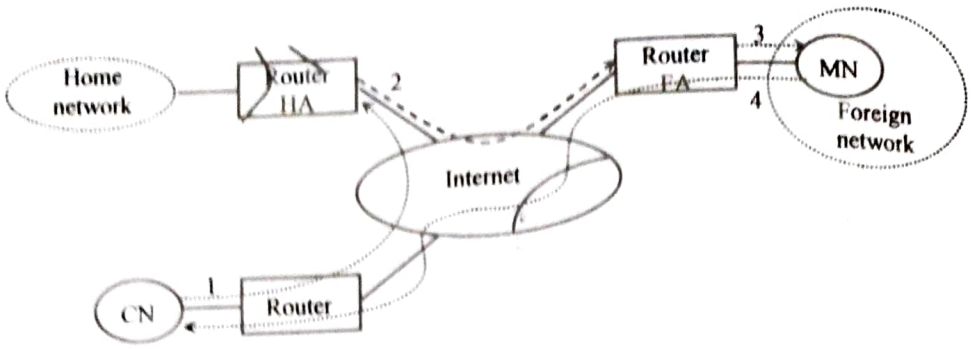


Fig: Packet delivery to and from the mobile node

The foreign agent now decapsulates the packet i.e., removes the additional header, and forwards the original packet with CN as source and MN as destination to the MN (step 3). Again, for the MN mobility is not visible. It receives the packet with the same sender and receiver address as it would have done in the home network.

At first glance, sending packets from the MN to the CN is much simpler. The MN sends the packet as usual with its own fixed IP address as source and CN's address as destination (step 4). The router with the FA acts as default router and forwards the packet in the same way as it would do for any other node in the foreign network. As long as CN is a fixed node the reminder is in the fixed internet as usual. If CN were also a mobile node residing in a foreign network, the same mechanisms as described in steps 1 through 3 would apply now in the other direction.

The following sections present some additional mechanisms needed for mobile IP to work, some enhancements to the protocol, and some efficiency and security problems.

Long Answer Type Questions

1. a) What is meant by access control?
b) What are contention-based and contention-free access control mechanisms?
c) Why does CSMA/CD not work for medium access control of WLAN?
d) What is the alternative mechanism of CSMA/CD? Write steps of operation to implement such an alternative mechanism. **[WBUT 2013]**

Answer:

a) Access control is a way of limiting access to a system or to physical or virtual resources. In computing, access control is a process by which users are granted access and certain privileges to systems, resources or information.

In access control systems, users must present credentials before they can be granted access.

b) A contention-based protocol (CBP) is a communications protocol for operating wireless telecommunication equipment that allows many users to use the same radio channel without pre-coordination. The "listen before talk" operating procedure in IEEE 802.11 is the most well known contention-based protocol.

A MAC protocol specifies how nodes in a sensor network access a shared communication channel. Desired properties of such MAC protocol are: it should

be distributed and contention-free (avoid collisions); it should self-stabilize to changes in the network (such as arrival of new nodes), and these changes should be *contained*, i.e., affect only the nodes in the vicinity of the change; it should not assume that nodes have a global time reference, i.e., nodes may not be time-synchronized. We give the first MAC protocols that satisfy all of these requirements, i.e., we give distributed, contention-free, self-stabilizing MAC protocols which do not assume a global time reference.

c) & d) ***Refer to Question No. 5 of Short Answer Type Questions.***

2. a) What are the functions of Home agent and Foreign agent in Mobile IP?
b) How does I-TCP differ from traditional TCP? Describe with suitable diagram.
c) Briefly describe the congestion control, slow start and fast retransmit mechanism.
[WBUT 2014]

Answer:

a) In Mobile Internet Protocol (Mobile IP), a home agent is a router on a mobile node's home network that maintains information about the device's current location, as identified in its care-of address. The home agent uses tunneling mechanisms to forward Internet traffic so that the device's IP address doesn't have to be changed each time it connects from a different location. A home agent may work in conjunction with a foreign agent, which is a router on the visited network. The foreign agent and the home agent are two types of mobility agents, defined in the Internet Engineering Task Force (IETF) RFC 2002 specification called IP Mobility Support.

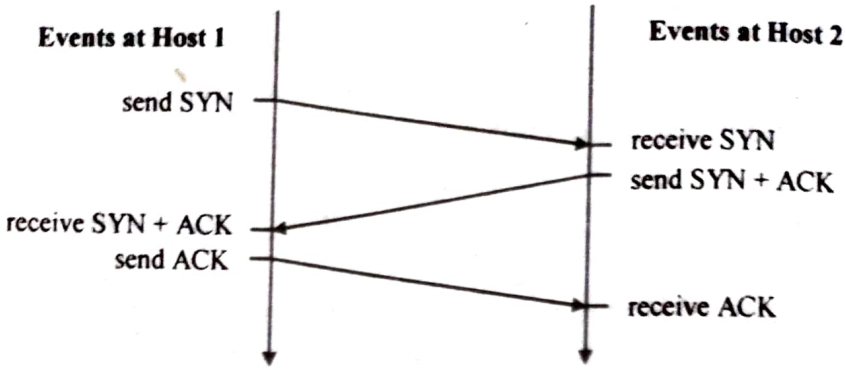
b) The Transmission Control Protocol (TCP) is one of the core protocols of the internet protocol suite, often simply referred to as TCP/IP. TCP is reliable, guarantees in-order delivery of data and incorporates congestion control and flow control mechanisms.

To establish a connection, TCP uses a three-way handshake. Before a client attempts to connect with a server, the server must first bind to and listen at a port to open it up for connections: this is called a passive open. Once the passive open is established, a client may initiate an active open. To establish a connection, the three-way (or 3-step) handshake occurs:

1. **SYN**: The active open is performed by the client sending a SYN to the server. The client sets the segment's sequence number to a random value A.
2. **SYN-ACK**: In response, the server replies with a SYN-ACK. The acknowledgment number is set to one more than the received sequence number i.e. A+1, and the sequence number that the server chooses for the packet is another random number, B.
3. **ACK**: Finally, the client sends an ACK back to the server. The sequence number is set to the received acknowledgement value i.e. A+1, and the acknowledgement number is set to one more than the received sequence number i.e. B+1.

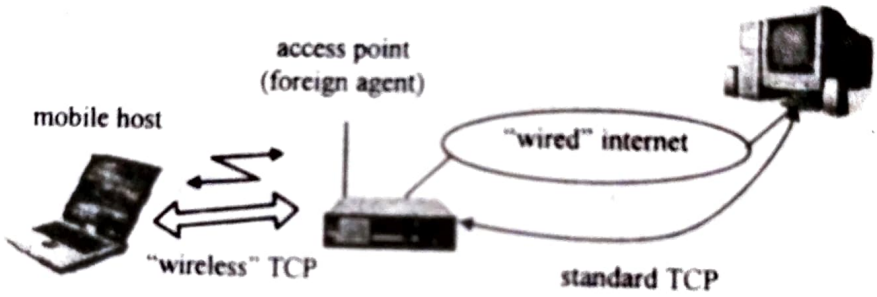
At this point, both the client and server have received an acknowledgment of the connection. The steps 1, 2 establish the connection parameter (sequence number) for one direction and it is acknowledged. The steps 2, 3 establish the connection parameter (sequence number) for the other direction and it is acknowledged. With these, a full-

duplex communication is established. The connection establishment in standard TCP is shown below:



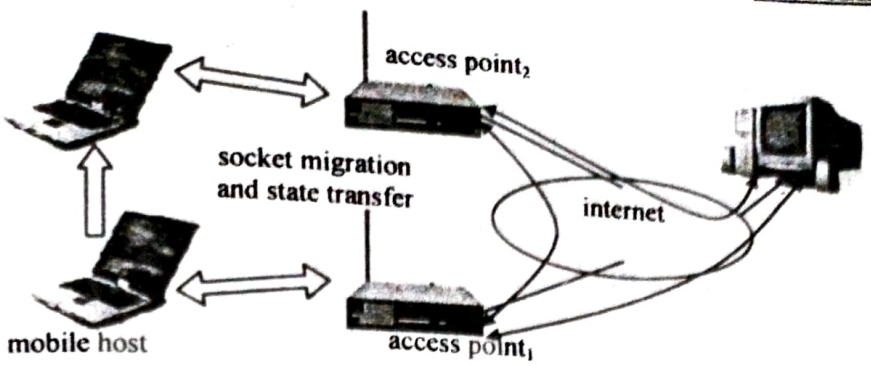
Indirect TCP (I-TCP):

Indirect TCP segments a TCP connection into a fixed part and a wireless part. The following figure shows an example with a mobile host connected via a wireless link and an access point to the 'wired' internet where the correspondent host resides.



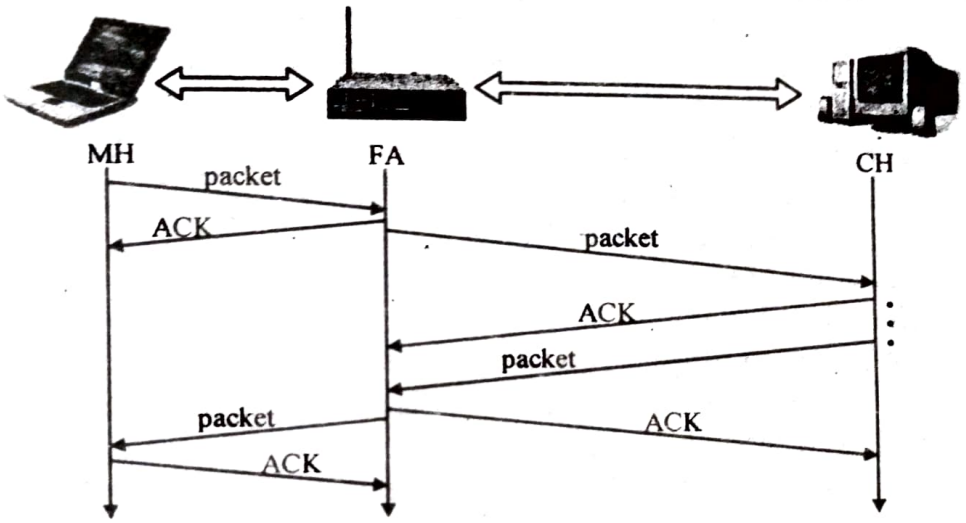
Standard TCP is used between the fixed computer and the access point. No computer in the internet recognizes any changes to TCP, instead of the mobile host, the access point now terminates the standard TCP connection, acting as a proxy. This means that the access point is now seen as the mobile host for the fixed host and as the fixed host for the mobile host. Between the access point and the mobile host, a special TCP, adapted to wireless links, is used. However, changing TCP for the wireless link is not a requirement. A suitable place for segmenting the connection is at the foreign agent as it not only controls the mobility of the mobile host anyway and can also handover the connection to the next foreign agent when the mobile host moves on.

The foreign agent acts as a proxy and relays all data in both directions. If CH (correspondent host) sends a packet to the MH, the FA acknowledges it and forwards it to the MH. MH acknowledges on successful reception, but this is only used by the FA. If a packet is lost on the wireless link, CH doesn't observe it and FA tries to retransmit it locally to maintain reliable data transport. If the MH sends a packet, the FA acknowledges it and forwards it to CH. If the packet is lost on the wireless link, the mobile hosts notice this much faster due to the lower round trip time and can directly retransmit the packet. Packet loss in the wired network is now handled by the foreign agent.



Socket and state migration after handover of a mobile host

During handover, the buffered packets, as well as the system state (packet sequence number, acknowledgements, ports, etc.), must migrate to the new agent. No new connection may be established for the mobile host and the correspondent host must not see any changes in connection state. Packet delivery in I-TCP is shown below.



c) **Congestion control** can be used to calculate the amount of data the sender can send to the destination on the network. Determining the amount of data is not easy, as the bandwidth changes from time to time, the connections get connected and disconnected. Based on these factors the sender should be able to adjust the traffic. TCP congestion control algorithms are used to detect and control congestion. The following are the congestion algorithms we will be discussing.

TCP slow start is an algorithm which balances the speed of a network connection. Slow start gradually increases the amount of data transmitted until it finds the network's maximum carrying capacity.

Slow start prevents a network from becoming congested by regulating the amount of data that's sent over it. It negotiates the connection between a sender and receiver by defining the amount of data that can be transmitted with each packet, and slowly increases the amount of data until the network's capacity is reached. This ensures that as much data is transmitted as possible without clogging the network.

Fast Retransmit is an enhancement to TCP which reduces the time a sender waits before retransmitting a lost segment.

A TCP sender uses a timer to recognize lost segments. If an acknowledgement is not received for a particular segment within a specified time (a function of the estimated Round-trip delay time), the sender will assume the segment was lost in the network, and will retransmit the segment.
Duplicate acknowledgement is the basis for the fast retransmit mechanism which works as follows: after receiving a packet (e.g. with sequence number 1), the receiver sends an acknowledgement by adding 1 to the sequence number (i.e., acknowledgement number 2) which means that the receiver receives the packet number 1 and it expects packet number 2 from the sender.

3. a) What is direct sequence spread spectrum technology? **[WBUT 2015]**
b) Distinguish between collisions of PHY and MAC layer.

Answer:

a) ***Direct-sequence spread spectrum (DSSS)*** is a spread spectrum technology used with wireless LANs and defined by the original IEEE 802.11 standard. Like FHSS, DSSS supports data rates of 1 and 2 Mbps and is considered slow by today's computer networking requirements.
DSSS uses special techniques to transmit digital data across the air using radio frequency. This is accomplished by modulating or modifying the radio frequency characteristics such as phase, amplitude and frequency.
In addition to modulation, DSSS uses technology known as a *spreading code* to provide redundancy of the digital data as it traverses through the air. The spreading code transmits information on multiple subcarriers and the redundancy helps the receiver detect transmission errors due to interference. This spreading of information across the 22 MHz-wide channel is what helps makes DSSS resilient to interference. The spreading code technology allows the receiver to determine if a bit of digital data received is a binary 0 or binary 1.
Depending on the data rate, the transmitter and receiver understand the spreading code in use and therefore are able to communicate.
An example of a coding technique is Barker code. Barker code is used as the spreading code for DSSS at the data rates of 1 and 2 Mbps.
DSSS operates within a range of RF frequency also known as a *channel*. Unlike narrow-band communication, which operates on a single frequency, a DSSS channel is 22 MHz wide and is one of 14 channels in the 2.4 GHz to 2.5GHz ISM band. The country and location of the device will determine which of the 14 channels are available for use.

b) During polling, there are no collisions on the MAC layers of HiperLAN2 and Bluetooth as the access point/master controls the medium. However, in order to access the access point, nodes may transmit during a random access phase in HiperLAN2 (random channel with feedback from the access point). At this point collisions may occur on the MAC layer. For 802.11 collisions on the MAC layer are nothing unusual. The MAC algorithm with back-off solves this problem. Collisions on the PHY layer may occur in Bluetooth only if another piconet randomly jumps to the same frequency at the same time.

4. a) Compare radio waves, microwaves and infrared waves, with respect to their data rates, transmission distance, interference and cost.
b) Explain clearly why cellular IP cannot be used in place of mobile IP.

[WBUT 2015]

Answer:

a) Radio waves:

Radio waves are present at the lower end of the spectrum and are widely used for both indoor and outdoor communication. They have the advantage that they are omnidirectional and are able to travel long distances, penetrating easily through buildings. Their disadvantages are that they suffer from interference between users and from electrical equipment. They also exhibit frequency-dependent properties; that is, at low frequencies, they pass through objects, but attenuation in power occurs as distance from the source increases. On the other hand, high-frequency radio waves travel in straight lines and cannot penetrate through obstacles. Furthermore, rain and sleet absorb such waves.

Microwaves:

Frequencies above 100 MHz are called microwaves. These have the advantage that they can be narrowly focused because they travel in straight lines. Thus by properly aligning the sending and receiving antennae, they are able to give much higher signal-to-noise ratio. For the same reason, they are affected by the curvature of the earth if long-distance communication is to be used, making it necessary to build repeater towers for the transmitting antennae. Microwaves are less expensive to use than optical fibres and are therefore popular in mountainous and urban areas.

Microwaves have the disadvantage that they suffer from **multipath fading**. This is because they do not pass easily through buildings and obstacles and are refracted by the atmosphere layer; some waves therefore arrive out-of-phase with the direct ones, resulting in cancellation of the signal. The effect of this type of fading changes with weather and frequency.

Infrared waves:

Unguided infrared and millimeter waves offer an alternative to the standard radio frequency communication for short ranges. However, they are subject to the following restrictions:

- Transmission distance of less than 2 miles
- Line-of-sight limitations
- Restricted to 16 Mbps throughput
- Presence of environmental disturbances, such as fog, dust and heavy rain

However, the advantages of this technology are as follows:

- Reasonable high bandwidth
- No government license required for operation
- Cost-effective
- Capable of traversing multiple paths without interferences

- More secure than radio
- Immune to radio frequency interference and electromagnetic interference

Infrared communication has very little use on the desktop. For example, it can be used for connecting notebook computers and printers, but is not used in computer-to-computer communication. The infrared Data Association (IrDA) has defined a number of standards governing infrared wireless communication. These include the IrDA-data and IrDA-control standards.

b) *Mobile IP* not appropriate for cell-granularity, but can provide global mobility support. *Cellular IP* is defined as an extension to Mobile IP. It works locally in a cellular access network. Cellular IP can work with Mobile IP to support wide-area mobility. Cellular IP optimizes the cellular network for fast handovers. It also provides integrated mobility control and location management functions at the wireless access points. As Mobile IP manages macro mobility, Cellular IP manages micro mobility.

Cellular IP networks are connected to the Internet via gateway routers. Mobile terminals are identified to the network by using the IP address of the BS (access router) as a COA. Because Cellular IP assumes that Mobile IP manages macro mobility, the HA tunnels the IP packets to the gateway router of the Cellular IP network. Within the network, packets are routed upon the home address of the mobile terminal. In the reverse direction, packets from mobile terminal are routed to the gateway hop-by-hop. After reaching the gateway router, packets are routed through Mobile IP.

5. a) What do you mean by "Call Admission Control" in mobile communication? Discuss any two of the CAC schemes for mobile communication.
b) What is congestion problem? Briefly point out some features of TCP congestion control and congestion in mobile ad-hoc network. [WBUT 2015]

Answer:

a) 1st Part:

Call admission control (CAC) is the practice or process of regulating traffic volume in voice communications, particularly in wireless mobile networks and in VoIP (voice over Internet Protocol, also known as Internet telephony). Call admission control can also be used to ensure, or maintain, a certain level of audio quality in voice communications networks, or a certain level of performance in Internet nodes and servers where VoIP traffic exists.

2nd Part:

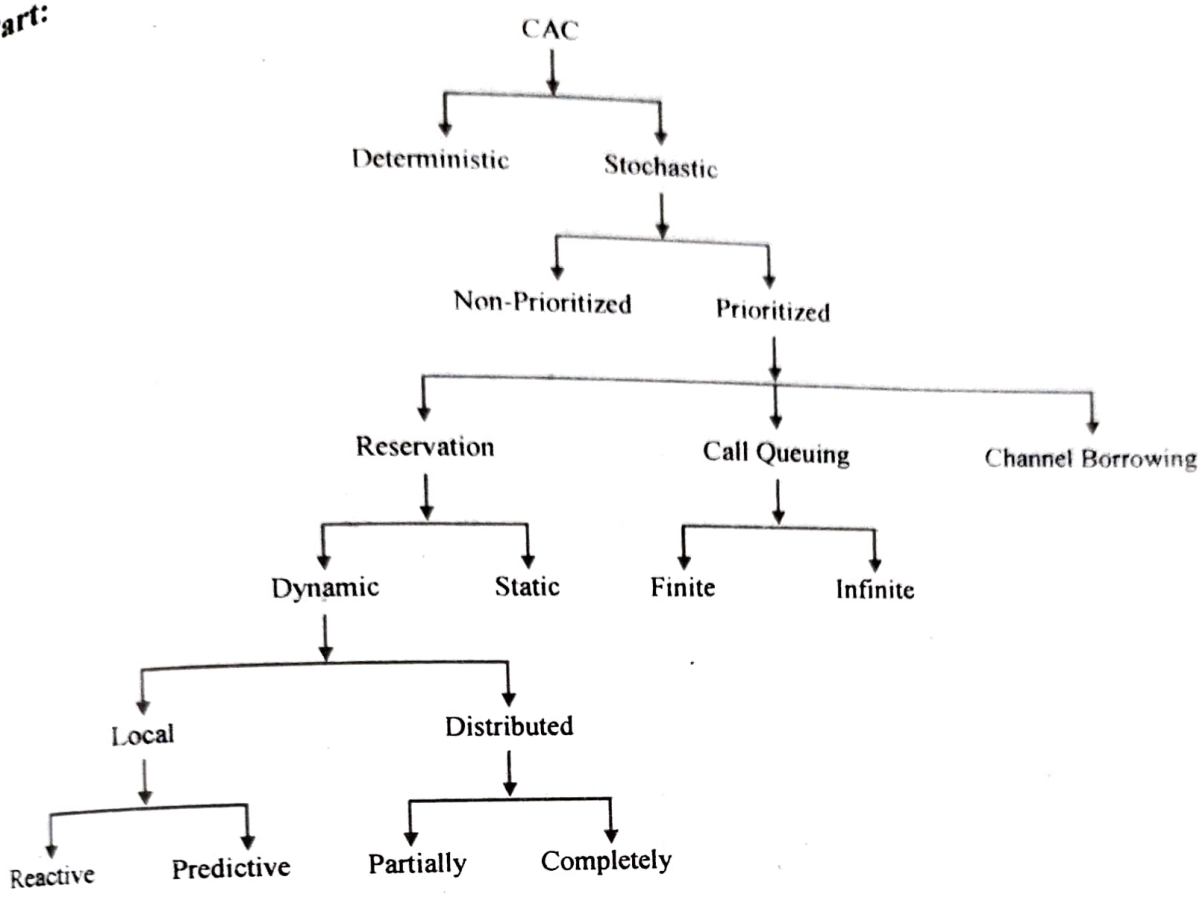


Fig: Different types of CAC protocols

In general, CAC schemes are mainly of two categories (a) Deterministic CAC, and (b) Stochastic CAC. In deterministic schemes, QoS parameters are guranteed with 100% confidence, which require knowledge of user mobility, which is not practical. In stochastic schemes, QoS parameters are guranteed with some probabilistic confidence. This stochastic scheme achieves higher resource utilization than deterministic schemes. Stochastic schemes are of two types: (i) Non-Prioritized and (ii) Prioritized. The prioritized scheme is further divided into three types: (a) Channel borrowing scheme (b) Call queuing scheme, and (c) Reservation scheme. Channels are made available at each cell by channel assignment schemes: (i) Fixed Channel Assignment (FCA), (ii) Dynamic Channel Assignment (DCA), and (iii) Hybrid Channel Assignment (HCA) schemes.

In FCA scheme, a set of nominal channels is permanently assigned to each BS. A new call can only be accepted if there is a free channel available in the cell. Several variations are there in FCA, one approach is called the **channel borrowing strategy**. In a channel borrowing scheme, a cell that has used all its assigned channels, can borrow free channels that does not interfere with existing calls. A cell is allowed to borrow channel from a neighbouring cell, if all of its own channels are already occupied. In DCA, all channels are kept in a central pool to be shared by all calls in every cell. DCA is flexible but it is less efficient in heavy traffic. HCA, combination of FCA and DCA schemes, overcome these drawbacks.

In call queuing scheme, queuing of hand-off requests, when there is no channel available can reduce the dropping probability at the expense of higher new call blocking probability (CBP). The queue can be of finite length which is more realistic than infinite length queue concept. In finite queue scheme, hand-off calls waiting in the queue have priority over new calls waiting in the queue to gain access to available channels.
Reservation schemes are of two types: (i) Static Reservation and (ii) Dynamic Reservation.

b) 1st Part:
The congestion occurs when the traffic generated by the network users exceeds the available bandwidth in the communication system. In such circumstances, not all the packets sent by the sources can be immediately relayed on the route towards their destination. Instead, they accumulate in the buffers at the intermediate modes and wait for the bandwidth increase. If the incoming rate is not reduced (or stopped) before the queue of awaiting packets reaches its limit, typically defined by the amount of the reserved memory at the node, the new data pieces must be discarded. The lost fragments are retransmitted, which further deepens the congestion at the bottleneck point. At certain stage, the network becomes clogged with retransmissions and stops providing its services – this state is referred to as a deadlock or congestion collapse.

2nd Part:
TCP Congestion Control
TCP uses a round-trip delay estimate for its adaptive windowing scheme to transmit data reliably over an unreliable network with time varying bandwidth. An estimate of the round trip time is maintained as a smoothed moving average using the relation –

$$srtt = \alpha \times srtt + (1 - \alpha) \times rtt$$

Similarly a smoothed variance (estimated as mean difference to avoid square root calculations in the kernel) is also maintained. A initial retransmission timeout is then set as - timeout = $srtt + 2 \times$ variance
If an acknowledgement for a segment is not received within the timeout, it is re-transmitted.
TCP uses a congestion window in the sender side to do congestion avoidance. The congestion window indicates the maximum amount of data that can be sent out on a connection without being acknowledged. TCP detects congestion when it fails to receive an acknowledgement for a packet within the estimated timeout. In such a situation, it decreases the congestion window to one maximum segment size (MSS), and under other cases it increases the congestion window by one MSS. There also exists a congestion window threshold, which is set to half the congestion window size at the time when a re-transmit was required.
The inherent assumption in this mechanism is that lack of an acknowledgement is due to network congestion. If a packet, however, is lost by the network for reasons other than network congestion, then waiting for the timer to run out is wasteful. This is a situation that may happen quite frequently in wireless networks, and so to improve TCP

performance, it is needed to pre-empt re-transmissions before waiting for the timer to run out.

To guard against this scenario, Reno TCP uses Fast Re-transmit and Fast Recovery algorithms. Both these algorithms depend on counting duplicate acknowledgements sent by the data receiver in response to each additional segment received following some missing data. Fast Re-transmit detects loss of a segment when three duplicate acknowledgements are received, and re-transmits it. Fast Recovery algorithm attempts to estimate how much data is outstanding in the network by counting duplicate acknowledgements.

Congestion in MANET:

Congestion takes place in MANETs with limited resources. In these networks, shared wireless channel and dynamic topology leads to interference and fading during packet transmission. Packet losses and bandwidth degradation are caused due to congestion, and thus, time and energy is wasted during its recovery. Congestion can be prevented using congestion-aware protocol through bypassing the affected links. Severe throughput degradation and massive fairness problems are some of the identified congestion related problems. These problems are incurred from MAC, routing and transport layers.

Congestion control is the major problem in mobile ad hoc networks. Congestion control is related to controlling traffic entering into a telecommunication network. To avoid congestive collapse or link capabilities of the intermediate nodes and networks and to reduce the rate of sending packets congestion control is used extensively. Congestion control and reliability mechanisms are combined by TCP to perform the congestion control without explicit feedback about the congestion state and without the intermediate nodes being directly interrupted. Their principles include packet conservation, additive increase/multiplicative decrease in sending rate, stable network. End system flow control, network congestion control, network based congestion avoidance and resource allocation includes the basic techniques for congestion control.

6. Write short note on WLAN. **[WBUT 2015]**

Answer:

A wireless local area network (WLAN) is a wireless distribution method for two or more devices that use high-frequency radio waves and often include an access point to the Internet. A WLAN allows users to move around the coverage area, often a home or small office, while maintaining a network connection.

And, ***Refer to Question No. 8 of Short Answer Type Questions.***

7. Define the following terms with respect to mobile IP. **[MODEL QUESTION]**

(i) Agent Solicitation
(ii) Registration
(iii) Discovery
(iv) Co-located Address

Answer:

(i) ***Agent solicitation:*** If no agent advertisements are present or the inter-arrival time is too high, and an MN has not received a COA by other means, e.g., DHCP, the mobile node must send agent solicitations. Care must be taken to ensure that these solicitation messages do not flood the network, but basically an MN can search for an FA endlessly sending out solicitation messages. Typically, a mobile node can send out three solicitations, one per second, as soon as it enters a new network. It should be noted that in highly dynamic wireless networks with moving MNs and probably with applications requiring continuous packet streams even one second intervals between solicitation messages might be too long. Before an MN even gets a new address many packets will be lost without additional mechanisms.

If a node does not receive an answer to its solicitations it must decrease the rate of solicitations exponentially to avoid flooding the network until it reaches a maximum interval between solicitations which is typically one minute. Discovering a new agent can be done anytime, not just if the MN is not connected to one. Consider the case that an MN is looking for a better connection while still sending via the old path. This is the case while moving through several cells of different wireless networks.

(ii) ***Registration:*** Registration consists of the following steps:

1. If a mobile node discovers that it is on the home network, it operates without any mobility services.
2. If the mobile node is on a new network, it registers with the foreign agent by sending a Registration Request message which includes the permanent IP address of the mobile host and the IP address of its home agent.
3. The foreign agent in turn performs the registration process on behalf of the mobile host by sending a Registration Request containing the permanent IP address of the mobile node and the IP address of the foreign agent to the home agent.
4. When the home agent receives the Registration Request, it updates the mobility binding by associating the care-of address of the mobile node with its home address.
5. The home agent then sends an acknowledgement to the foreign agent.
6. The foreign agent in turn updates its visitor list by inserting the entry for the mobile node and relays the reply to the mobile node.

(iii) Agent discovery related to IPV4:

Agent Discovery consists of the following steps:

1. Mobility agents advertise their presence by periodically broadcasting Agent Advertisement messages. An Agent Advertisement message lists one or more care-of addresses and a flag indicating whether it is a home agent or a foreign agent.
2. The mobile node receiving the Agent Advertisement message observes whether the message is from its own home agent and determines whether it is on the home network or a foreign network.

If a mobile node does not wish to wait for the periodic advertisement, it can send out Agent Solicitation messages that will be responded by a mobility agent.

(iv) ***Co-located COA:*** The COA is co-located if the MN temporarily acquired an additional IP address which acts as COA. This address is now topologically correct, and the tunnel endpoint is at the MN. Co-located address can be acquired using services such as DHCP. One problem associated with this approach is the need for additional address if MNs request a COA. This is not always a good idea considering the scarcity of IPv4 addresses.

8. Describe the medium access procedure using basic DCF (CSMA/CA) in WLANs along with required improvisations to improve the system. [MODEL QUESTION]

Answer:

While Collision Detection mechanisms are a good idea on a wired LAN, they cannot be used on a Wireless LAN environment for two main reasons:

- Implementing a Collision Detection Mechanism requires the implementation of a Full Duplex radio capable of transmitting and receiving at the same time. This increases the cost significantly.
- In a Wireless environment we cannot assume that all stations will be able to receive radio signal from each other (which is the basic assumption of the Collision Detection scheme). The fact that a station wants to transmit and senses the medium as free (not able to sense signal from another station) does not necessarily mean that the medium is free (like the case of the hidden terminal) around the receiver area.

CSMA/CA is used and the mechanism is as follows:

- When a wireless station (a wireless LAN device) wants to communicate, it first listens to its media (radio spectrum) to check if it can senses radio wave from any other wireless station.
- If the medium is free for a specified time then the station is allowed to transmit. This time interval is called Distributed Inter Frame Space (DIFS).
- If the current device senses carrier signal of another wireless device on the same frequency, as it wants transmit on, it backs off (does not transmit) and initiates a random timeout.
- After the timeout has expired, the wireless station again listens to the radio spectrum and if it still senses another wireless station transmitting, continues to initiate random timeouts until it does not detect or senses another wireless station transmitting on the same frequency.
- When it does not sense another wireless station transmitting, the current wireless station starts transmitting its own carrier signal to communicate with the other wireless station, and once synchronized. transmits the data.
- The receiving station checks the CRC of the received packet and sends an acknowledgement packet (ACK). Receipt of the acknowledgement indicates to

the transmitter that no collision occurred. If the sender does not receive the acknowledgement then it retransmits the fragment until it receives acknowledgement or is abandoned after a given number of retransmissions.

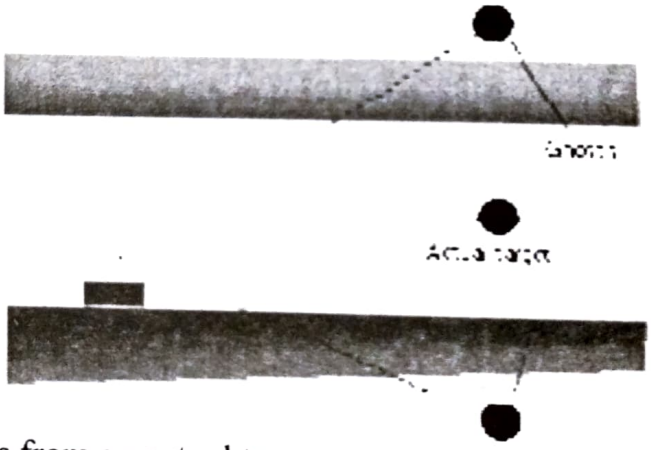
9. a) Discuss the effect of multi-path propagation in wireless communication.
b) Define hopping sequence and dwell time.
c) Mention the features of infrared and radio transmission in WLAN and also state their advantages and disadvantages. **[MODEL QUESTION]**

Answer:

a) The effects of multipath include constructive and destructive interference, and phase shifting of the signal. This causes Rayleigh fading. The standard statistical model of this gives a distribution known as the Rayleigh distribution.

Rayleigh fading with a strong line of sight content is said to have a Rician distribution, or to be Rician fading.

In facsimile and television transmission, multipath causes jitter and ghosting, seen as a faded duplicate image to the right of the main image. Ghosts occur when transmissions bounce off a mountain or other large object, while also arriving at the antenna by a shorter, direct route, with the receiver picking up two signals separated by a delay.



Radar multipath echoes from an actual target cause ghosts to appear.

In radar processing, multipath causes ghost targets to appear, deceiving the radar receive. These ghosts are particularly bothersome since they move and behave like the normal targets (which they echo), and so the receiver has difficulty in isolating the correct target echo. These problems can be overcome by incorporating a ground map of the radar's surroundings and eliminating all echoes which appear to originate below ground or above a certain height.

In digital radio communications (such as GSM) multipath can cause errors and affect the quality of communications. The errors are due to intersymbol interference (ISI). Equalisers are often used to correct the ISI. Alternatively, techniques such as orthogonal frequency division modulation and rake receivers may be used.

In a Global Positioning System receiver, Multipath Effect can cause a stationary receiver's output to indicate as if it were randomly jumping about or creeping. When the unit is moving the jumping or creeping is hidden, but it still degrades the displayed accuracy.

b) Hopping Sequence

Transmitter and receiver stay on one of the channels like and TDM. The pattern of channel usage is called the hopping sequence,

Dwell Time

The time spend on a channel with a certain frequency is called the dwell time. Features of infrared transmission:

- Simple
- Extremely cheap
- Licenses are not needed
- Electrical devices do not interfere

c) Features of radio transmission:

- Cover large areas

There are several methods of establishing wireless links between two points, only two are capable of supporting the high-speed data transmission necessary" for WLANs. These two methods are called radio frequency transmission and infrared transmission. (Within the radio frequency or RF method is included the microwave frequency.) Radio frequency and infrared refer to energy wave lengths within the electromagnetic spectrum. The electromagnetic spectrum is the known range of wavelengths emitted by matter.

Advantages:

The advantages infrared transmissions are:

- its portability,
- ease of installation,
- And practicality.
- The most appealing aspect of WLAN is its convenience, allowing flexibility and roaming.

A user is not tied down to a LAN and can move around with relative ease while staying connected. WLAN are also easy to install, an entire network can be put together in a matter of hours rather than days. Finally, WLAN may be installed where rewiring is impractical. Wireless systems can be installed in different environments and users can communicate with the existing wired network through access points or wireless adapters.

The main advantages of infrared transmission

- Infrared: based on transmission of infrared light
- Infrared uses diffuse light reflected at walls or directed light if a line-of-sight (LOF) exists between sender and receiver

The main disadvantages of infrared:

- Low bandwidth compared with other LAN technologies
- Limited transfer rate
- Infrared transmission can not penetrate walls or other obstacles
- For good transmission LOS is needed

The main advantages of radio transmission:

- Long-term experience for wide area networks and mobile cellular phones
- Can cover larger area and can penetrate walls, furniture..
- Does not need LOS
- Current radio-based products offer higher
- transmission rates (10 Mbit/s)

The main disadvantages of radio transmission:

- Shielding is not simple(this is also the main advantage),
- radio transmission can interfere with other senders or electrical devices can destroy data transmitted
- It is only permitted in certain frequency bands
- Very limited ranges of license-free bands are available but they are not the same in all countries

10. a) Briefly discuss the hand off management in WLAN. **[MODEL QUESTION]**
b) Explain the operation of MIPv6
c) Write down the advantages of MIPv6 compared with MIPv4.

Answer:

a) ***Proposed Handoff Mechanism***

The subscription and service profile of GMS are maintained by GPRS network at two entities. Its GPRS profile is stored at home location register (HLR) and its WLAN profiles are stored at HA. The subscription and service profile of WH are maintained by its HA in Internet. In our proposed WLAN/GPRS interworking architecture, two types handoff procedures are performed.

Handoff from GPRS to WLAN

We take the scenario that a GMS is initially in GPRS network and she maintains a session with correspondent node (CN) N1 in the Internet through GPRS network (Fig.1). The terminal's GPRS system is active and WLAN radio system is in passive scan mode. When the GMS moves to WLAN hotspot, her WLAN card is activated on receipt of beacon signal from WLAN access point (AP). The GPRS system is triggered off and terminal performs association with AP. subsequently she performs MIP based registration with HA at GGSN. After MIP based handoff completion, she can send packets to CN through

WLAN wit much higher speed and packets are directly routed in the Internet. Thus GGSN acts as an anchor point of GMS while she is in a WLAN hotspot. The incoming packets from the Internet are routed to GGSN. If destination WMS is in a WLAN hotspot, GGSN forwards the packets to responsible FA using MIP tunneling.

Handoff from WLAN to GPRS

The AAA (authentication, authorization and accounting) profiles of a WH are maintained at HA in Internet. A WH has the capability to access GPRS network. GPRS entertains IP

connection for a WH because the GPRS operator has an agreement with the Internet. The GPRS network maintains the profiles for service and Quos that a WH can avail through GPRS network. A WH may have subscriptions to access GPRS network from selected cells or routine area also. When WH comes out of a WLAN hotspot, she will in cellular coverage. Therefore, her IP based ongoing sessions can continue through GPRS network. She will perform MIP based signaling for mobility and handoff management through GPRS network GPRS network provides the bearer service for IP Packets in conjunction with PDP context maintained at SGSN and GGSN. The MIP registration request is a IP packet which needs PDP context for transportation through GPRS network.

b) Defined by

- RFC3775: Mobility Support i n IPv6 (June 2004)
- RFC3776: Using IPSec to Protect Mobile IPv6 Signaling between
- Mobile Nodes and Home Agents

Goals of IPv6 mobility

- Always o n I P connectivity
- Roaming between different L2 technologies
- WLAN, WiMAX, UMTS, fixed
- Roaming between different (sub)network ks
- Huge WLAN deployments mostly use different L3 subnets
- Application continuity (Session persistence)
- Static IP Addresses for mobile nodes
- Mobile devices may act as servers

c) The benefits of Mobile IPv6 over Mobile IPv4 are as follows:

MOBILE IPv6	MOBILE IPv4
Mobile IPv6 has a built-in feature of route optimization.	Mobile IPv4 has built-in feature of route optimization available via an optional set of extensions, which was not supported by all nodes.
In Mobile IPv6, there is no need of the foreign agents. Neighbor discovery and address auto-configuration features enable mobile nodes to function in any location without the services of any special router in that location.	There is a requirement of foreign agent in Mobile IPv4.
Mobile IPv6 does not have the ingress filtering problem. The correspondent node puts the care-of address as the source address, and have a home address destination option, which allows the use of the care-of address to be transparent over the IP layer.	In Mobile IPv4, the ingress filtering problem exists because the correspondent node puts its home address as the source address of the packet.

11. Briefly discuss on Physical layer description in WLAN. [MODEL QUESTION]

Answer:

The architecture of the Physical layer comprises of the two sublayers for each station:

- ***PLCP (Physical Layer convergence Procedure):*** PLCP sublayer is responsible for the Carrier Sense (CS) part of the carrier Sense Multiple Access/Collision Avoidance (CSMA/CA) protocol. PLCP layer prepares the MAC Protocol Data Unit (MPDU) for transmission. The PLCP also delivers the incoming frames from the wireless medium to the MAC layer. LPCP appends fields to the MPDU that contains information needed by the physical layer transmitter and receiver. This frame is called PLCP Protocol Data Unit (PPDU). The structure of PLCP provides for asynchronous transfer of MPDU between stations. The PLCP header contains logical information that allows the receiving stations physical layer to synchronize with each individual incoming packet.
- ***PMD (Physical Medium Dependent):*** The PMD provides the actual transmission and reception of physical layer entities between stations through the wireless media. This sublayer provides the modulation/demodulation of the transmission.

FHSS (Frequency Hopping Spread Spectrum) Physical Layer

In FHSS mode, this layer carries the clocking information to synchronize the receiver clock with the clock of the transmitted packet. Figure depicts the FHSS PPDU packet. The fields in the FHSS PLCP are as follows:

1. ***SYNC:*** This field is made up of alternate zeroes and ones. This bit pattern is to synchronize the clock of the receiver.
2. ***Start Frame Delimiter:*** This field indicates the beginning of the frame and the content of this field is fixed and always is 0000110010111101.
3. ***PSDU Length Word (PLW):*** This field specifies the length of the PSDU in octets.

80 Bits	16 Bits	12 Bits	4 Bits	16Bits	Variable PLCP Service Data Unit
SYNC	Start Frame Delimiter	PLW	PSF	Header Error Check	Payload

Fig: Frequency Hopping Spread Spectrum PLCP

4. ***PLCP signaling (PSF):*** This field contains information about the data rate of the fields from whitened PSDU. The PLCP preamble is always transmitted at 1Mbps irrespective of the data rate of the wireless LAN. This field contains information about the speed of the link. For example 0000 means 1Mbps and 0111 signifies 4.5 Mbps bandwidth.
5. ***Header Error Check:*** This field contains the CRC (Cyclic Redundancy Check).

Direct Sequence Spread Spectrum (DSSS) Physical Layer

DSSS PLCP is responsible for synchronizing the receiving the data bits correctly. Figure below depicts the DSSS PPDU packet.

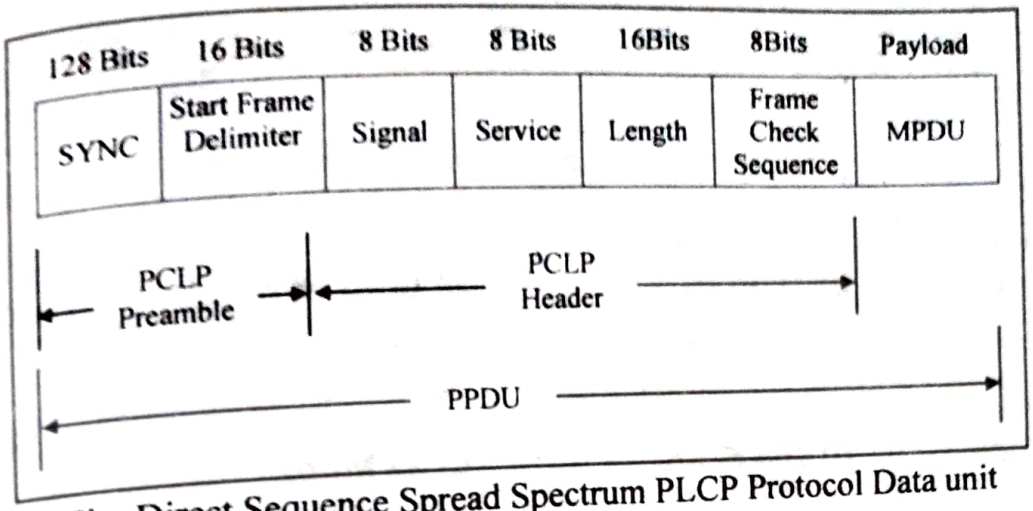


Fig: Direct Sequence Spread Spectrum PLCP Protocol Data unit

The fields in the DSSS PLCP are as following:

1. ***SYNC:*** This field is made up of alternate zeroes and ones. This bit pattern is to synchronize the clock of the receiver with the received frame.
2. ***Start Frame Delimiter:*** This field indicates the beginning of the frame and the content of this field is fixed and is always 1111001110100000.
3. ***Signal:*** This field defines the type of modulation the receiver must use to demodulate the signal. When the value of this field is multiplied by 100 Kbps we get the bandwidth of the transmission. For 11 Mbps bandwidth this field will have a value of 01101110 (decimal 110). The PLCP preamble and the header are always transmitted at 1 Mbps. The bandwidth defined by this field applies to MPDU field.
4. ***Service:*** This field is not used and is usually 0.
5. ***Length:*** This field contains an unsigned 16-bit integer indicating the length of the frame. However, unlike the FHSS, this is not in octets. It is rather in microseconds. The receiver will use this to synchronize with the clock to determine the end of frame.

Frame Check Sequence: This is a 16-bit checksum based on CCITT CRC-16 algorithm.

WIRELESS APPLICATION PROTOCOL

Multiple Choice Type Questions

1. WAP protocol stack has similarity to [WBUT 2013]
a) OS model b) TCP/IP c) both of these d) none of these
Answer: (c)

2. WAP 2.0 runs at [WBUT 2014]
a) 384 Kbps b) 364 Kbps c) 54 Mbps d) 11 Mbps
Answer: (a)

3. The class O transaction service with no WTP is [MODEL QUESTION]
a) Reliable invoke message with no result message
b) Unreliable invoke message with no result message
c) Unreliable invoke message with one reliable result message
d) None of these
Answer: (b)

4. Wireless Transport Layer security (WTLS) of WAP is used between [MODEL QUESTION]
a) The client and the server b) The gateway and the target server
c) The client and the gateway d) None of these
Answer: (c)

5. The security layer of WAP consists of [MODEL QUESTION]
a) WTLS b) WSP c) WCMP d) WAE
Answer: (a)

Short Answer Type Questions

1. What is WAP? Why is it used? [WBUT 2013]
Answer:
Wireless Application Protocol (commonly referred to as **WAP**) is an open international standard for application-layer network communications in a wireless-communication environment. Most use of WAP involves accessing the mobile web from a mobile phone or from a PDA.
Before the introduction of WAP, the subscribers could only get voice and SMS-based services from the cellular networks (cellular data networks were not deployed yet). There was a growing demand for connecting to Internet through cellular networks and access the information. However, most of the technology developed for the Internet access was designed for desktop and similar computers having medium-to-high-bandwidth connections over reliable wire-line data networks. Since the mobile devices and cellular networks had certain limitations, as shown below, the existing Internet access mechanism

(HTTP over TCP/IP) was found to be inefficient for mobile devices to access Internet. Some of the important limitations of mobile devices and cellular networks that prevented subscribers from using existing Internet access mechanisms are mentioned below:

- Mobile devices have limited computing power and hence could not implement all the existing protocols and technologies needed to connect to Internet.
- Like processing power, the mobile handsets also had limited working memory (RAM) compared to personal computers.
- Mobile devices have smaller displays compared to personal computers. This made the current form of Web navigation very difficult in mobile handsets.
- The cellular networks offered less bandwidth to the mobile devices compared to the bandwidth possible in wire-line network technologies such as ADSL and Ethernet.
- The cellular network environment was also characterised by a wide range of network latency, ranging from sub-second round-trip communication time up to many tens of seconds. This results in lot of packet re-transmissions and hence slower response to the mobile devices from the Web servers using the existing communication protocols.

2. Describe the system architecture and protocol architecture of IEEE 802.11 with suitable diagram. **[WBUT 2014, 2015]**

Answer:

The IEEE 802.11 is a standard constituted by a PHY layer and a MAC layer. Over this layer, the standard foresees interfacing with the standard data LLC layer IEEE 802.2. The protocol architecture is depicted in figure (i) where the PHY is chosen among three possibilities:

- Frequency hopping (FH) spread spectrum
- Direct sequence (DS) spread spectrum
- Infrared (IR)

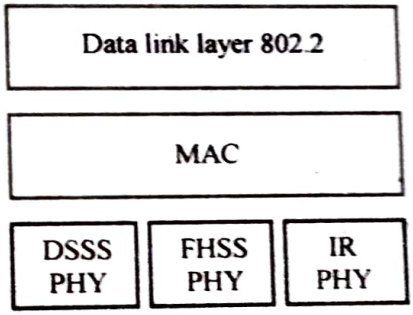


Fig: (i) Protocol Stack

The system is constituted by the following entities:

- **Station (STA):** The object of the communication, in general a mobile station;
- **Access point (AP):** A special central traffic relay station that normally operates on a fixed channel and is stationary – can be partially seen as the coordinator within a group of STAs;
- **Portal (PO):** A particular access point that interconnects IEEE 802.11 WLANs and wired 802.x LANs. Thus, it provides the logical integration between both types of architectures.

Each of these entities implements the protocol structure of fig. (i) but employs different functions.

System Architecture

A set of STA and eventually an AP, constitutes a *Basic Service Set* (BSS), which is the basic block of the IEEE 802.11 WLAN.

The simplest BSS is constituted by two STAs that can communicate directly. This mode of operation is often referred to as an ad hoc network because this type of IEEE 802.11 WLAN is typically created and maintained as needed without prior administrative arrangement for specific purposes (such as transferring a file from one personal computer to another). This basic type of IEEE 802.11 WLAN is called *Independent BSS* (IBSS).

The second type of BSS is an infrastructure BSS. Within an infrastructure BSS, an AP (which is a particular STA) acts as the coordinator of the BSS.

Instead of existing independently, two or more BSS can be connected together through some kind of backbone network that is called the *Distribution System* (DS). The whole interconnected WLAN (some BSSs and a DS) is identified by the IEEE 802.11, as a single wireless network called *Extended Service Set* (ESS). The whole scenario is shown in fig. (ii).

The association between an STA and a particular BSS is dynamic; as a consequence, the set up of the system is automatic.

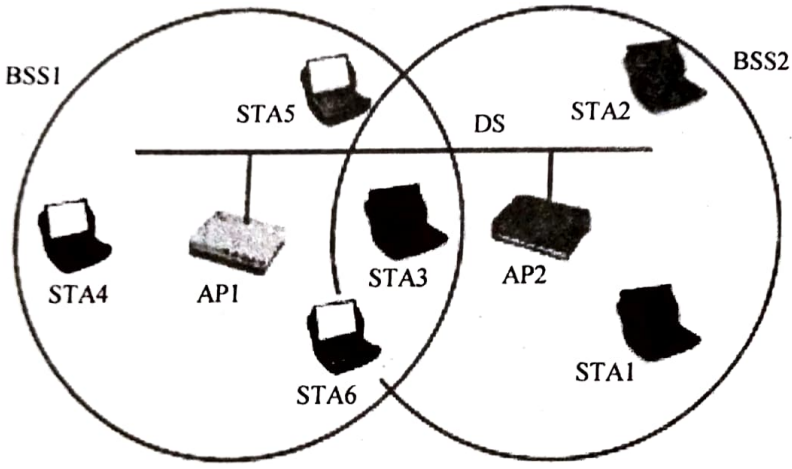


Fig: An ESS

3. Explain the system architecture of infrastructure-based wireless networks with diagrams. **[WBUT 2015]**

Answer:

A single access point can support to a small number of wireless network users and can perform within a range up to a few hundreds of feet. The access point (or the antenna attached to the access point) is usually mounted on roofs or walls but may be mounted any where that it is practical as long as the desired radio coverage is obtained. End users access the wireless LAN through wireless-LAN adapters, which are integrated within handheld computers. Wireless LAN adapters provide an interface between the client's network operating system and the airwaves via an antenna.

One of the main concerns of the users of wireless LANs has been the apparent reduction in privacy and security. To address this issues, WLANs use multiple levels of security to prevent unauthorized access to network resources. Figure shows the architecture of an infrastructure based IEEE 802.11 network.

In figure, observe that the access points are connected among themselves and with the switch through a distribution system which is usually a fiber optic cable. As shown, mobile nodes are connected to access points. The 802.11 standard notes that the distribution system may operate using any technology, such as Ethernet, token ring, etc. The majority of actual installations, however, utilize Ethernet (802.3). An 802.3-based distribution system (also referred to as the 'wired backbone') consists of switches or hubs that tie together users (PCs and access points) equipped with 802.3 network interface cards (NICs). The switch or hub is somewhat analogues to an 802.11 access point. The main difference is that a hub or switch provides connection over a physical medium and an access point provides wireless connectivity. In the example of fig., two 802.11 LANs are connected via a distribution system. A distribution system can also be used to increase network coverage through roaming between cells. The distribution system also provides connectivity to the Internet through a switch.

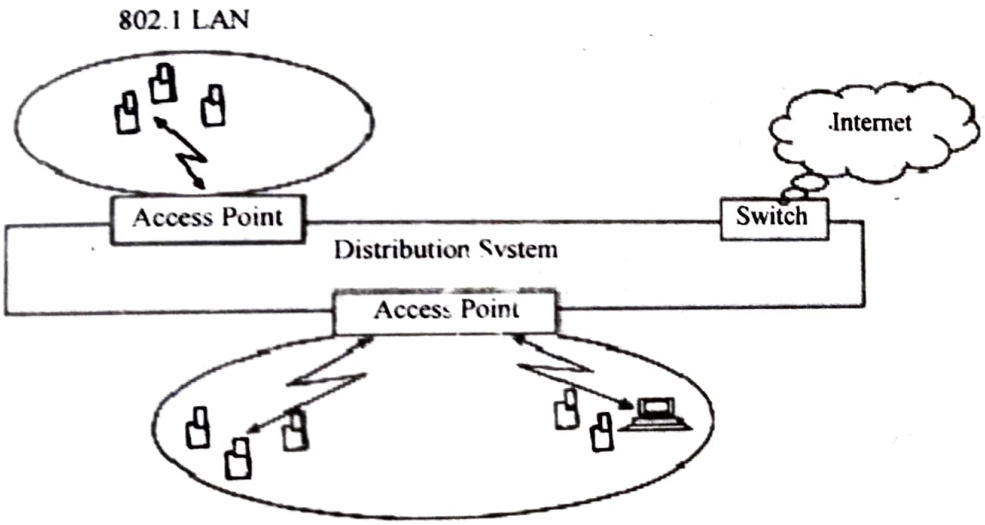


Fig: Architecture of an infrastructure-based IEEE 802.11 network

4. What are the features of WML? **[MODEL QUESTION]**

Answer:

Wireless Markup Language (WML): a lightweight markup language, similar to HTML, but optimized for use in wireless devices.

Features of WML:

- WML has support of Variables.
- Text formatting can be implemented in WML.
- Support for images.
- Support for soft-buttons
- Navigation control
- Control of browser history

- Support for event handling (for e.g. telephony services)
- Different types of user interactions, e.g. selection lists and input fields

Long Answer Type Questions

1. What is WSP? What are the services provided by WSP? Explain WSP session suspend and session resume services. **[MODEL QUESTION]**

Answer:

Abbreviation for Wireless Session Protocol. The Session layer protocol family in the WAP architecture is called the Wireless Session Protocol, WSP. WSP provides the upper-level application layer of WAP with a consistent interface for two session services. The first is a connection-mode service that operates above a transaction layer protocol WTP, and the second is a connectionless service that operates above a secure or non-secure datagram transport service.

A protocol in the Wireless Application Protocol (WAP) suite, provides the Wireless Application Environment a consistent interface with two services: connection-oriented service to operate above the Transaction Layer Protocol (WTP) and a connectionless service that operates above either secure or non-secure datagram service (WDP). Currently the protocols of the WSP family provide HTTP/1.1 functionality and semantics in a compact encoding, long lived session state with session suspend and resume capabilities, a common facility for reliable and unreliable data push as well as a protocol feature negotiation. These protocols are optimised to be used in low-bandwidth bearer networks with relative long latency in order to connect a WAP client to a HTTP server.

2. a) How can we reach the security in WAP applications? **[MODEL QUESTION]**
b) Explain the WML documents modes with examples.

Answer:

a) WAP Security

Applications on the Web typically require a secure connection between the client and the application server. The WAP specification ensures that a secure protocol is available for these transactions on a wireless handset. The wireless Transport Layer Security (WTLS) protocol is based on the industry-standard Transport Layer Security (TLS) protocol, more popularly known as Secure Sockets Layer (SSL). WTLS is intended for use with the WAP transport protocols and has been optimized for use over narrow-band communication channels.

WTLS ensures data integrity, privacy, authentication and denial-of-service protection. WTLS does not support non-repudiation. The WTLS specification is designed to work even if packets are dropped or delivered out of sequence – a more common phenomenon in some wireless networks. Another issue is that some WTLS messages can be sent without authentication of origin.

Many initial implementations of WAP will have a client – proxy – server model architecture where the proxy can be used to present a simplified view of familiar websites. An important security function performed by a proxy is that it unwraps the WAP WTLS secure data from the client and then re-wraps it into SSL/TLS before

passing it to a Web server. For Web applications that employ standard Internet security techniques with TLS, the WAP Gateway automatically and transparently manages wireless security with minimal overhead.

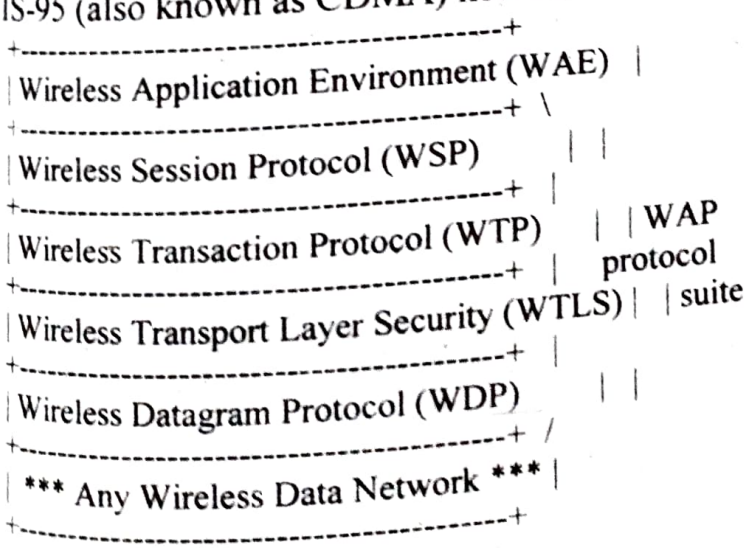
b) WML documents are XML documents that validate against the WML DTD (Document Type Definition). The W3C Markup Validation service can be used to validate WML documents (they are validated against their declared document type).
A WML document is known as a "deck". Data in the deck is structured into one or more "cards" (pages) – each of which represents a single interaction with the user. The introduction of the terms "deck" and "card" into the internet and mobile phone communities was a result of the user interface software and its interaction with wireless communications services having to comply with the requirements of the laws of two or more nations
WML decks are stored on an ordinary web server configured to serve the text/vnd.wap.wml MIME type in addition to plain HTML and variants. The WML cards when requested by a device are accessed by a bridge WAP gateway, which sits between mobile devices and the World Wide Web, passing pages from one to the other much like a proxy. The gateways send the WML pages on in a form suitable for mobile device reception (WAP Binary XML). This process is hidden from the phone, so it may access the page in the same way as a browser accesses HTML, using a URL. (Provided the mobile phone operator has not specifically locked the phone to prevent access of user-specified URLs.)

3. What is WAP gateway? Write down it's functionalities. Discuss different WAP protocols. **[MODEL QUESTION]**

Answer:

'WAP Gateway':

- The WAP standard describes a protocol suite that allows the interoperability of WAP equipment and software with many different network technologies, thus allowing the building of a single platform for competing network technologies such as GSM and IS-95 (also known as CDMA) networks.



- The bottom-most protocol in the suite, the WAP Datagram Protocol (WDP), functions as an adaptation layer that makes every data network look a bit like UDP to the upper layers by providing unreliable transport of data with two 16-bit port numbers (origin and destination). All the upper layers view WDP as one and the same protocol, which has several "technical realizations" on top of other "data bearers" such as SMS, USSD, etc. On native IP bearers such as GPRS, UMTS packet-radio service, or PPP on top of a circuit-switched data connection, WDP is in fact exactly UDP.
- WTLS, an optional layer, provides a public-key cryptography-based security mechanism similar to TLS.
- WTP provides transaction support (reliable request/response) adapted to the wireless world. WTP supports more effectively than TCP the problem of packet loss, which occurs commonly in 2G wireless technologies in most radio conditions, but is misinterpreted by TCP as network congestion.
- Finally, one can think of WSP initially as a compressed version of HTTP.

This protocol suite allows a terminal to transmit requests that have an HTTP or HTTPS equivalent to a WAP gateway; the gateway translates requests into plain HTTP.
The WAP Forum dates from 1997. It aimed primarily to bring together the various wireless technologies in a standardised protocol.
In 2002 the WAP Forum was consolidated (along with many other forums of the industry) into OMA (Open Mobile Alliance), which covers virtually everything in future development of wireless data services.

4. What are the WAP components used in mobile devices? With a neat diagram explain the WAP architecture. **[MODEL QUESTION]**

Answer:

WAP components used in mobile devices:

A WAP browser provides all of the basic services of a computer-based web browser but simplified to operate within the restrictions of a mobile phone, such as its smaller view screen. Users can connect to **WAP sites**: websites written in, or dynamically converted to, WML (Wireless Markup Language) and accessed via the WAP browser.
Before the introduction of WAP, service providers had extremely limited opportunities to offer interactive data services, but needed interactivity to support now-commonplace activities such as:

- Email by mobile phone
- Tracking of stock-market prices
- Sports results
- News headlines
- Music downloads

WAP architecture:

The WAP Protocol Stack

Like the International Organization for Standardization (ISO) reference model of the Internet protocol (IP) stack, the WAP is based on a layered architecture that provides Internet-like scalability and extensibility for mobile application development. Figure shows all of the protocol layers that make up the WAP. Each layer in this protocol stack can be accessed by the layer above; other services and applications can be accessed by means of well-defined interfaces. This structure makes it possible for external applications to interface directly with any one of the application, session, transaction, security, or transport layers in the WAP protocol stack. To better understand the impact this design makes, each of these protocols layers should be looked at in a little more detail.

The Wireless Application Environment (WAE)

The Wireless Application Environment (WAE) defines the specifications for the development of mobile device-side environment to host WAP applications. It provides the wireless application developers an environment, very similar to an Internet browser like Netscape Navigator or Internet Explorer, which is independent of any specific device type or network operator. This design ensures that WAP applications written once can be run on several different platforms without the need for code changes. The following elements make up the WAE:

- **Wireless Markup Language (WML)** is an XML-based markup language very similar to HTML, but much more

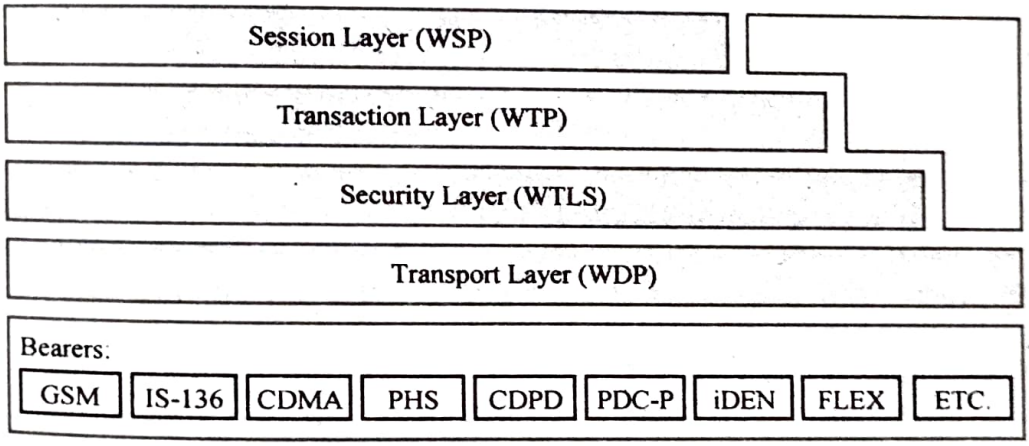


Fig: The WAP protocol stack

- **Denial-of-service protection** ensures that the upper layers of the WAP protocol stack are protected against denial of service (DoS) attacks by properly identifying and rejecting repeated or unverified messages.

Given the close compatibility of WAP with the Internet, it shouldn't be a surprise that any end-to-end security solution in a WAP architecture will use both WTLS (for security between the mobile device and the gateway) and TLS or SSL (for securing the gateway to application/content server communication).

Wireless Datagram Protocol (WDP)

The Wireless Datagram Protocol (WDP) is what gives WAP all its flexibility and the power to adapt to the data transport layers of any network. WDP encapsulates all the network and bearer-specific transport features and provides a consistent interface to all the upper layers of the WAP protocol stack.

Bearers

Each wireless network provides data transport functionality through the use of data bearers that have their own specific ways of transmitting and receiving wireless data. Some of the common bearers are SMS, CSD, USSD, all discussed here.

Short Message Service (SMS) is one of the slowest bearers used by the WAP protocol. Each SMS message has to be broken down into a short message of no more than 160 characters. That process essentially translates to multiple message creations and delivery for even the simplest WAP transactions. SMS is inherently a stateless bearer that operates in a store-and-forward manner for message transmission.

Circuit Switched Data (CSD) uses circuit switching to establish a connection to the WAP gateway at the start of a session. The bearer uses that connection for the transmission of data at typical speeds of around 9600 bits per second (bps). Aside from the initial connection set-up time, which could take up to half a minute, the transmission rate is much faster than the SMS bearer.

Unstructured Supplementary Services Data (USSD) is another common bearer used for wireless message transmission in GSM networks.

It is very similar to the SMS bearer in that it uses small minute, the transmission rate is much faster than the SMS bearer.

Unstructured Supplementary Services Data (USSD) is another common bearer used for wireless message transmission in GSM networks. It is very similar to the SMS bearer in that it uses small messages of up to 182 characters, but unlike SMS, USSD is a session-based bearer and hence somewhat similar to CSD in that respect. Because of its session-based nature, USSD is much faster than SMS.

One of the fastest bearers that continues to be developed is General Packet Radio Service (GPRS), which uses packet-based data transmission and provides speeds of up to 171.2 kilobits per second (kbps). GPRS is also connection-based, but unlike CSD the connection is established at the time the GPRS-enabled phone is turned on and stays established as long as the phone is on. This way the subscriber does not have to wait for any amount of time before assessing WAP applications.

WIRELESS LOCAL LOOP

Multiple Choice Type Questions

1. Ad hoc networks are examples of which type of networks? [WBUT 2013]
   a) fixed and wired
   b) mobile and wired
   c) fixed and wireless
   d) mobile and wireless

Answer: (d)

2. WLL uses [WBUT 2014]
   a) specified bound
   b) unspecified bound
   c) low pass filter
   d) none

Answer: (d)

3. The process of channel coding, encryption, multiplexing and modulation for Transmission and reception are to be carried out by [WBUT 2015]
   a) BTS
   b) BSC
   c) MSC
   d) MS

Answer: (a)

Short Answer Type Questions

1. a) What are the key advantages of WLL over a wired subscriber loop?
   b) What is Ad-hoc wireless network? [MODEL QUESTION]

Answer:

a) The biggest advantage is that there are no airtime charges. All incoming calls are free of cost. Outgoing calls are charged at Rs. 1.2 per three minutes, which is the same as a landline call. So, WLL mobile provides the facility of cellular phones at the same cost as a landline connection. The flip side is that the matter is currently under litigation and in the extreme case the telecom tribunal which is required to look at several legal aspects in the case, the service could fail in its present form.

Cost – Wireless systems are less expensive due to cost of cable installation that's avoided.

Installation time – WLL systems can be installed in a small fraction of time required for a new wired system.

Selective installation – radio units installed for subscribers who want service at a given time.

With a wired system, cable is laid out in anticipation of serving every subscriber in a given area.

b) A **wireless ad-hoc network** is a decentralized type of wireless network. The network is ad hoc because it does not rely on a preexisting infrastructure, such as routers in wired networks or access points in managed (infrastructure) wireless networks. Instead, each node participates in routing by forwarding data for other nodes, and so the determination

of which nodes forward data is made dynamically based on the network connectivity. In addition to the classic routing, ad hoc networks can use flooding for forwarding the data.

Long Answer Type Questions

1. Write short notes on the following:
a) Wireless local loop **[WBUT 2013]**
b) WAP Protocol Stack **[WBUT 2015]**

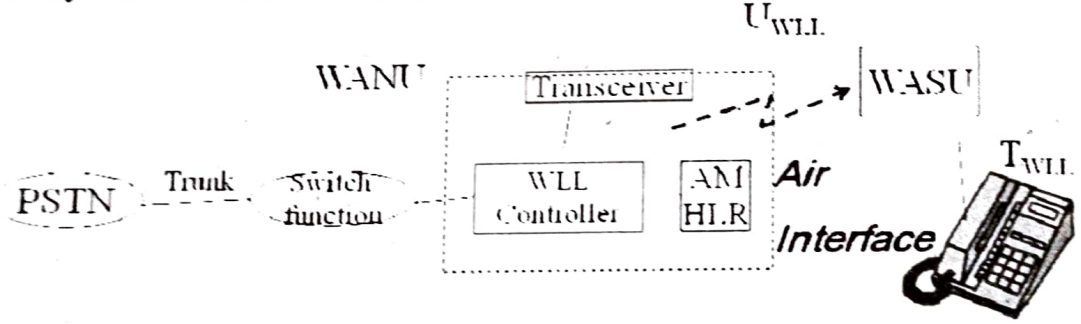
Answer:

a) Wireless local loop:

WLL (Wireless in Local Loop) is an emerging access network technology based on CDMA (Code Division Multiple Access) principle. This technology is useful for providing cost effective mobile services and wireless telephone connection in areas where provision of landline telephone connection is not feasible or where demand for mobile phones is very high.

At present, there are two types of services offered: WLL with limited mobility and WLL with fixed line (FWT service).

WLL is a system that connects subscribers to the local telephone station wirelessly.

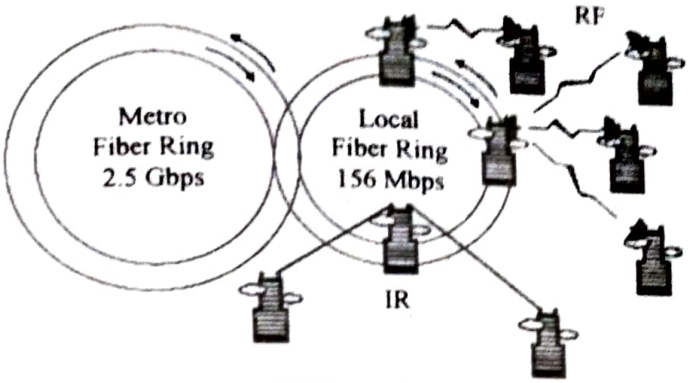


Wireless Access Network Unit (WANU)

- Interface between underlying telephone network and wireless link
- consists of
  - Base Station Transceivers (BTS)
  - Radio Controller(RPCU)
  - Access Manager(AM)
  - Home Location Register(HLR)

Wireless Access Subscriber Unit (WASU)

- located at the subscriber
- translates wireless link into a traditional telephone connection



WLL configuration

RF-based WLL configurations includes centralized antennas, or base station that either located at the edge of the carrier network or are corrected at the network edge via optical fiber, DSL facilities, or perhaps microwave. Base station connects to the marching antennas at the customer premises.

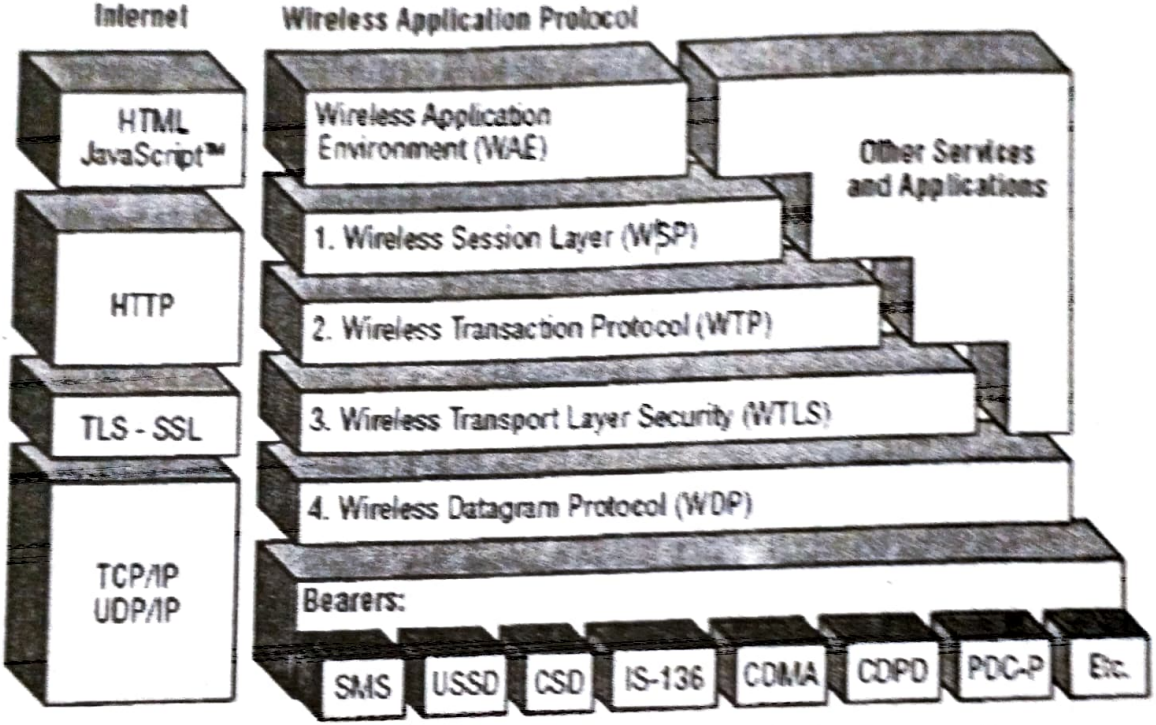
b) WAP Protocol Stack:

WAP is designed in a layered fashion, so that it can be extensible, flexible, and scalable. As a result, the WAP protocol stack is divided into five layers:

- **Application Layer**
  Wireless Application Environment (WAE). This layer is of most interest to content developers because it contains among other things, device specifications, and the content development programming languages, WML, and WMLScript.
- **Session Layer**
  Wireless Session Protocol (WSP). Unlike HTTP, WSP has been designed by the WAP Forum to provide fast connection suspension and reconnection.
- **Transaction Layer**
  Wireless Transaction Protocol (WTP). The WTP runs on top of a datagram service, such as User Datagram Protocol (UDP) and is part of the standard suite of TCP/IP protocols used to provide a simplified protocol suitable for low bandwidth wireless stations.
- **Security Layer**
  Wireless Transport Layer Security (WTLS). WTLS incorporates security features that are based upon the established Transport Layer Security (TLS) protocol standard. It includes data integrity checks, privacy, service denial, and authentication services.
- **Transport Layer**
  Wireless Datagram Protocol (WDP). The WDP allows WAP to be bearer-independent by adapting the transport layer of the underlying bearer. The WDP presents a consistent data format to the higher layers of the WAP protocol stack, thereby offering the advantage of bearer independence to application developers.

Each of these layers provides a well-defined interface to the layer above it. This means that the internal workings of any layer are transparent or invisible to the layers above it. The layered architecture allows other applications and services to utilise the features

provided by the WAP-stack as well. This makes it possible to use the WAP-stack for services and applications that currently are not specified by WAP.
The WAP protocol architecture is shown below alongside a typical Internet Protocol stack.



Note that the mobile network bearers in the lower part of the figure above are not part of the WAP protocol stack.

3G MOBILE SERVICES

Multiple Choice Type Questions

1. 4th generation communication network has [MODEL QUESTION]
a) mobile nodes b) fixed nodes
c) combination of (a) and (b) d) not specific
Answer: (c)

2. Which mobile generation technology is EDGE? [MODEL QUESTION]
a) 2G b) 3G c) 2.5G d) 1G
Answer: (c)

Short Answer Type Questions

1. Define the following term and state their usage: [WBUT 2013]
Orthogonal code and its usage in mobile communication
Answer:
Each user in synchronous CDMA uses a code orthogonal to the others' codes to modulate their signal. There is no effect of interference between the two sets of signals on the received output. Orthogonal codes have a cross-correlation equal to zero; in other words, they do not interfere with each other. In the case of IS-95 64 bit Walsh codes are used to encode the signal to separate different users. Since each of the 64 Walsh codes are orthogonal to one another, the signals are channelized into 64 orthogonal signals.

2. What are the frequency bands of operation for CDMA? [WBUT 2014]
Answer:
Three sets of frequency bands are recommended - 450 mhz, 800 mhz and 2.1 ghz. For CDMA players like Reliance and Tata Teleservices 1.25 MHz each is offered. CDMA operators are free to bid both in the 2.1 GHz and the 450 MHz bands, but they will be allocated spectrum only in one. The pricing of these two bands is linked to the auction in the 2.1 GHz band.

3. What are the features proposed for 4G systems? Explain. [WBUT 2015]
Answer:
The following are some possible features of the 4G systems :
1. Support interactive multimedia, voice, video, wireless internet and other broadband services.
2. High speed, high capacity and low cost per bit.
3. Global mobility, service portability, scalable mobile networks.
4. Seamless switching, variety of services based on Quality of Service (QoS) requirements.
5. Better scheduling and call admission control techniques.
6. Ad hoc networks and multi-hop networks.

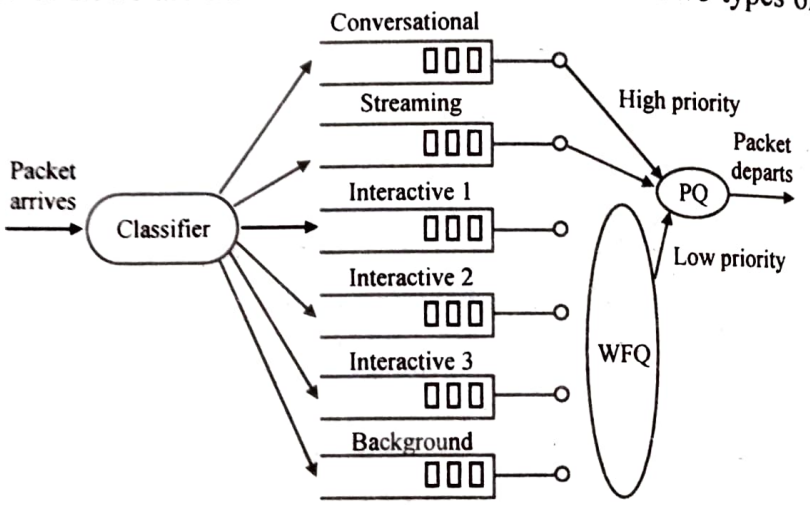
4. What are the main components in RCL architecture? How will you design a UMTS router output port? [MODEL QUESTION]

Answer:

The three key components of RCL are the resource control agent (RCA), the admission control agent (ACA), and the end-user application toolkit (EAT).

- The RCA represents the ultimate principle in an administrative domain concerning the management of network resources
- The ACA mainly performs user authentication and authorization, reservation handling, and admission control. Policing and admission control are made only at the edges of the network;
- Reservation requests are forwarded to the ACAs from the EAT, which mediates between end users or applications and the network. The EAT interacts with the ACA to be aware of the available network services.

In UMTS network a number of flows are transmitted in a bottleneck link. Two types of queue are maintained in designing the UMTS router output port, PQ (Packet Queue) and WFQ (Wait-for Queue). PQ+WFQ is considered a good candidate for the UMTS classes, since both conversational and streaming have strict QoS requirements in terms of delay and packet loss, while the interactive and background classes particularly require throughput guarantees. The WFQ weights are configured based on the sharing of bandwidth between the traffic classes for both networks.



The HLR contains all the administrative information of each subscriber registered in the corresponding GSM network, along with the current location of the mobile.

The Visitor Location Register (VLR) contains selected administrative information from the HLR, necessary for call control and provision of the subscribed services, for each mobile currently located in the geographical area controlled by the VLR.

VLR is a database which temporarily stores IMSI and customer information for each roaming subscriber who is visiting the coverage area of that particular MSC, as a roaming subscriber. The VLR is linked between several MSCs in a region and contains subscription information of every roaming user. Once a roaming mobile is logged in the VLR, the MSC sends the necessary information to the visiting subscriber's HLR so that calls to the roaming mobile unit can be appropriately routed over the PSTN by the roaming user's HLR.

Long Answer Type Questions

1. Describe the architecture of a 3G network. What are the various services associated with a 3G network? **[WBUT 2013]**

Answer:

The 3G system consists of two main parts: the User Equipment (UE) and the UMTS Terrestrial Radio Access Network (UTRAN).

The UE is the mobile phone and the UTRAN is the base station and the network intelligence. Both the UE and the UTRAN are composed of different layers.

The four lowest layers are:

- the physical layer (PHY)
- the Medium Access Layer (MAC)
- the Radio Link Layer (RLC)
- the Radio Resource Layer (RRC).

This text will provide a general description of the UE and the function of the different layers.

The RRC layer is the highest layer in the protocol stack and it handles most of the decisions and supervisory functions. Below follows a sample of the functions:

- Broadcast of information.
- Establishment, maintenance and release of an RRC connection between the UE and UTRAN.
- Establishment, reconfiguration and release of Radio Bearers.
- Assignment, reconfiguration and release of radio resources for the RRC connection.
- RRC connection mobility functions.
- Control of requested Quality of Service.
- UE measurement reporting and control of the reporting.
- Outer loop power control.
- Control of ciphering.
- Paging
- Initial cell selection and cell re-selection.
- RRC message integrity protection.

The RLC layer is the layer below the RRC in the protocol stack and it is focused on the actual data transfers. Below follows a sample of the functions:

- Segmentation and reassembly.
- Padding.
- Error correction.
- In-sequence delivery of upper layer Packet Data Units (PDU:s).
- Duplicate detection.
- Flow control.
- Sequence number check.

- Protocol error detection and recovery.
- Ciphering.

The RLC is responsible for retransmission, segmentation and reassembly.

The MAC layer is responsible for the handling of the logic channels and most of the priority and multiplexing issues. The functions of MAC include:

- Mapping between logical channels and transport channels.
- Selection of appropriate Transport Format for each Transport Channel.
- Priority handling between data flows of one UE.
- Multiplexing/demultiplexing of upper layer PDU:s into/from transport blocks delivered to/from the physical layer on common transport channels.
- Traffic volume measurement.
- Transport Channel type switching.
- Ciphering for transparent mode RLC.

The MAC layer handles the timing of the packet releases and the adding of transport entity addresses on the outgoing traffic.

The physical layer takes care of coding, interleaving and the adding of CRC to the packets.

Some of the features of the physical layers are:

- Error detection on transport channels and indication to higher layers.
- Encoding/decoding of transport channels.
- Modulation and spreading/demodulation and despreading of physical channels.
- Frequency and time (chip, bit, slot, frame) synchronisation.
- Radio characteristics measurements and indication to higher layers.
- Inner - loop power control.
- Radio frequency processing.

The Physical layer administrates all radio communication. It handles power control, modulation and measurements.

2. a) How does CDMA technology improve system performance as compared to FDMA?

b) Discuss the relative merits of W-CDMA and CDMA 2000. [MODEL QUESTION]

Answer:

a) The primary advantage of CDMA is its ability to tolerate a fair amount of interfering signal compared to FDMA and TDMA. As a result of the interference tolerance of CDMA, the problems of frequency band assignment and adjacent cell interference are greatly simplified.

On the other hand, FDMA and TDMA radio systems must be carefully assigned a frequency or time slot to assure that there is no interference with other similar radios. Therefore, sophisticated filtering and guard band protection is needed with FDMA and TDMA technologies. With CDMA, adjacent microcells share the same frequencies unlike FDMA and TDMA.

b) We have already started using 3G systems which promise multi-megabit internet access, communication using Voice over Internet Protocol (VoIP), voice activated calls, unparallel network capacity any many more. The 3G evolution for CDMA systems leads to CDMA 2000. The 3G evolution for GSM, IS-136 and PDC systems lead to Wideband CDMA (W-CDMA), also called Universal Mobile Telecommunications Service (UMTS). CDMA 2000 is based on IS-95 and IS-95B technologies and W-CDMA is based on GSM. International Telecommunications Union (ITU) formulated a plan to implement a global frequency band in 2 GHz range that would support a single, ubiquitous wireless communication standard for all countries, called International Mobile Telephone 2000 (IMT-2000). The ITU IMT-2000 standards organizations are currently separated into two major organizations –

(i) 3GPP (3G Partnership Project) for wideband CDMA standards based on backward compatibility with GSM and IS-136/PDC.

(ii) 3GPP2 for CDMA 2000 standards based on backward compatibility with IS-95.

W-CDMA assures backward compatibility with second generation GSM, IS-136 and PDC TDMA technologies, as well as all 2.5G technologies. The network structure and bit level packaging of GSM data is retained by W-CDMA with additional capacity and bandwidth provided by a new CDMA air interface. Fig. 1.6 shows how the various 2G and 2.5G TDMA technologies will evolve into a common W-CDMA standard. The 3G W-CDMA air interface standard has been designed for "ALWAYS ON' packet based wireless service so that computers, entertainment devices and telephones may all share the same wireless network and may be connected to the internet, anytime, anywhere. W-CDMA supports data rates up to 2.048 Mbps per user, and allows high quality data, multimedia, streaming audio, streaming video and broadcast type services to consumers. Future versions of W-CDMA will support user data rates in excess of 8 Mbps. With W-CDMA the data is carried on a single W-CDMA 5 MHz radio channel and each channel can support 100 to 350 simultaneous voice calls depending on factors such as antenna sectoring, propagation conditions, user velocity etc. The installation of W-CDMA is slow because it requires expensive new base station equipments.

The CDMA 2000 vision provides a seamless and evolutionary high data rate upgrade path for current users of 2G and 2.5G CDMA technology, based on the original 2G CDMA channel bandwidth of 1.25 MHz per radio channel. The first 3G CDMA air in face, CDMA 2000 1×RTT implies that a single 1.25 MHz radio channel is used. 1× implies one time the original cdmaone channel bandwidth. RTT stands for Radio Transmission Technology. CDMA 2000 1× supports an instantaneous data rate of up to 307 Kbps for a user in packet mode and yields typical throughput rates of up to 144 Kbps per user depending on number of users, velocity, propagation condition.

3. Write short note on 3G mobile telecommunication. **[MODEL QUESTION]**

Answer:

3G or 3rd generation mobile telecommunications, is a generation of standards for mobile phones and mobile telecommunications services fulfilling the International Mobile Telecommunications-2000 (IMT – 2000) specifications by the International Telecommunication Union.

The following standards are typically branded 3G:

- the UMTS system, first offered in 2001, standardized by 3GPP, used primarily in Europe, Japan, China (however with a different radio interface) and other regions predominated by GSM 2G system infrastructure. The cell phones are typically UMTS and GSM hybrids. Several radio interfaces are offered, sharing the same infrastructure:
  - The original and most widespread radio interface is called W-CDMA.
  - The TD-SCDMA radio interface was commercialized in 2009 and is only offered in China.
  - The latest UMTS release, HSPA+, can provide peak data rates up to 56 Mbit/s in the downlink in theory (28 Mbit/s in existing services) and 22 Mbit/s in the uplink.
- the CDMA2000 system, first offered in 2002, standardized by 3GPP2, used especially in North America and South Korea, sharing infrastructure with the IS-95 2G standard. The cell phones are typically CDMA2000 and IS-95 hybrids. The latest release EVDO Rev B offers peak rates of 14.7 M bit/s downstream.

GLOBAL MOBILE SATELLITE SYSTEMS

Long Answer Type Questions

1. Write short note on Iridium satellite system. **[WBUT 2013]**

Answer:

Iridium Satellite is the only mobile satellite service (MSS) company offering coverage over the entire globe. The Iridium constellation of low-earth orbiting (LEO), cross-linked satellites provides critical voice and data services for areas not served by terrestrial communication networks.

Iridium has launched a major development program for its next-generation satellite constellation, Iridium NEXT, which will result in continued and new Iridium MSS offerings.

Here at World Communication Center, we are true believers in the total global coverage of the Iridium satellite system. We aim to serve the general public, businesses and governments with Iridium satellite solutions to meet most any application worldwide.

As an official Iridium service provider with a value-added manufacturer and reseller status, WCC not only provides the standard Iridium satellite phones and plans, but a suite of rental and purchase opportunities with the most creative products and services in the industry.

2. a) What is SUMR (Satellite User Mobile Register)? **[MODEL QUESTION]**

b) Define the following terms with respect to satellite system.

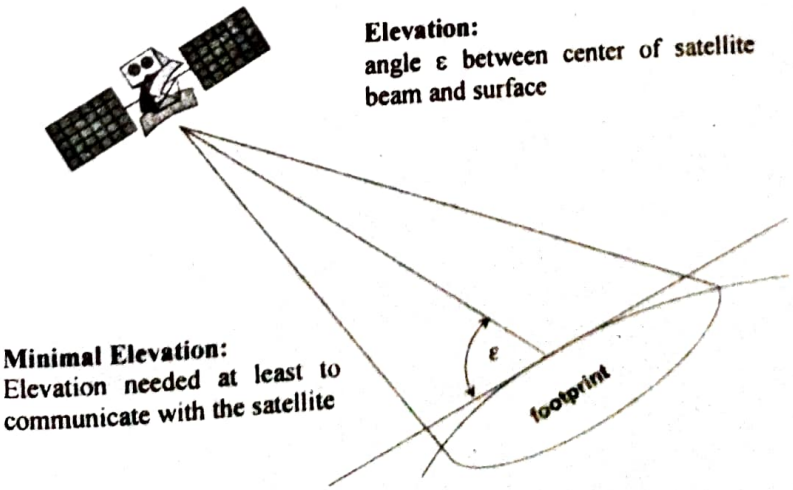
i. **Coverage Angle**
ii. **Elevation Angle**
iii. **Foot Print**

Answer:

a) SUMR (Satellite User Mapping Register):

- satellite assigned to a mobile station
- positions of all satellites

b)



(i) Coverage angle:
A measure of the portion of the earth surface visible to a satellite taking the minimum elevation angle into account.

(ii) Elevation Angle:
Elevation refers to the angle between the dish pointing direction, directly towards the satellite, and the local horizontal plane. It is the up-down angle. The elevation angle of a satellite is the angle measured between the horizon as you see it and a line drawn between you and the satellite. Because the Earth is round, the angles in the UK are typically 20 to 26 degrees. In Europe 26 to 36 degrees and, of course, if you are standing on the Equator in Africa, the satellites are almost directly above you at 90 degrees.
Use an az/el calculator to determine the satellite location relative to your lat/long position.

(iii) Foot print:
The footprint of a communications satellite is the ground area that its transponders offer coverage, and determines the satellite dish diameter required to receive each transponder's signal. There is usually a different map for each transponder (or group of transponders) as each may be aimed to cover different areas of the ground.

3. a) What do you mean by satellite network? **[MODEL QUESTION]**
b) Briefly explain different types of satellites.

Answer:

a) Satellite network is a network in which two stations can use a satellite as a relay station for their communication.

- One Earth Station sends a transmission to the satellite. This is called a Uplink.
- The satellite Transponder converts the signal and sends it down to the second earth station. This is called a Downlink.

b) Types of Satellites:

Pupil Worksheet

Satellites are usually classified according to the type of orbit they are in. There are four types of orbit associated with satellites, and the type of orbit dictates a satellite's use.

Low Earth Orbits

Satellites in low Earth orbits are normally military reconnaissance satellites that can pick out tanks from 160 km above the Earth. They orbit the earth very quickly, one complete orbit normally taking 90 minutes. However, these orbits have very short lifetimes in the order of weeks compared with decades for geostationary satellites. Simple launch vehicles can be used to place these satellites of large masses into orbit.

Sun-Synchronous orbits

Meteorological satellites are often placed in a sun-synchronous or heliosynchronous orbit. These satellites are in polar orbits. The orbits are designed so that the satellite's orientation is fixed relative to the Sun throughout the year, allowing very accurate weather predictions to be made. Most meteorological satellites orbit the Earth 15 to 16 *times per day.*

Geosynchronous satellites

Earth-synchronous or geosynchronous satellites are placed into orbit so that their period of rotation exactly matches the Earth's rotation. They take 24 hours to make one rotation. However, the plane of orbit for these satellites is generally not the equatorial plane. Apart from geostationary satellites (see below), the satellites are used for communications at high latitudes, particularly in Russia and Canada. The orbits are called Molniya orbits. The satellites are placed in highly elliptical orbits which enable them to appear to hover above one point on the Earth for most of the day. In twenty four hours they move over the Earth in a figure of eight pattern centred on a fixed longitude, moving slowly where they can be useful and quickly where they are of little use.

Geostationary satellites

The majority of communications satellites are in fact geostationary satellites. Geostationary satellites like geosynchronous satellites take 24 hours to complete a rotation. However, geostationary satellites are positioned directly over the equator and their path follows the equatorial plane of the Earth. As a result geostationary satellites don't move North or South during the day and are permanently fixed above one point on the equator of the Earth.

Most video or T.V. communications systems use geostationary satellites. Geosynchronous and geostationary satellites are typically orbiting at 35,788 km (22,238 miles) above the surface of the planet (42,000 km from its centre).

Modern satellites have a mass of several thousand kilograms, compared with just 180 kilograms for Sputnik. Modern satellites are placed in space using launch vehicles like the Arianne Rocket or the Space Shuttle. Once in space, most satellites obtain their power from the Sun using solar panels. Satellites travelling deep into space often carry additional nuclear power supplies.

WIRELESS ENTERPRISE NETWORKS

Multiple Choice Type Questions

1. Which of the following is the main standard for Bluetooth? [WBUT 2014]
   a) IEEE802.15 b) IEEE802.3 c) IEEE802.11 d) IEEE802.16

Answer: (a)

2. Bluetooth uses [MODEL QUESTION]
   a) 2.5 GHz ISM band b) 2.4 GHz ISM band
   c) 2.4 MHz ISM band d) None of these

Answer: (b)

3. Link manager protocol of Bluetooth [MODEL QUESTION]
   a) Provides both connection less and connection oriented servers
   b) Responsible for link set-up between Bluetooth devices and ongoing link management
   c) Is a client-server protocol
   d) None of these

Answer: (b)

4. Bluetooth provides [MODEL QUESTION]
   a) connectionless-oriented communication
   b) peer-to-peer slave communication within same Pico net with negligible interference between Pico nets as each uses distinct channel-frequency hoping sequences.
   c) Ad-hoc network peer-to-peer communication when two devices are on two different Pico nets specifying a scatter net
   d) Wireless LAN connectivity

Answer: (c)

5. The authentication and encryption in Bluetooth is provided by [MODEL QUESTION]
   a) LMP b) L2CAP c) SDP d) none of these

Answer: (b)

6. Which one of the following is true statement? [MODEL QUESTION]
   a) MANET is established using service discovery and then services of Jini, TCP/IP, Bluetooth and WiFi are discovered.
   b) MANET discovers services by establishing Bluetooth and WiFi for service discovery.
   c) MANET is established using service location protocol.
   d) MANET is established using ad-hoc service discovery protocol

Answer: (b)

7. Bluetooth base band protocol is a combination of [MODEL QUESTION]
a) circuit & packet switching
b) circuit & message switching
c) both of these
d) none of these

Answer: (a)

8. Ad-hoc networks are examples of which types of networks? [MODEL QUESTION]
a) Fixed and wired
b) Mobile and wired
c) Fixed and wireless
d) Mobile and wireless

Answer: (d)

9. The profile synchronization in Bluetooth is achieved by [MODEL QUESTION]
a) OBEX b) TCS BIN c) AT Commands d) PPP

Answer: (b)

Short Answer Type Questions

1. Define the following term and state their usage: [WBUT 2013]
FCC

Answer:
The Forward Control Channel (FCC) is a downlink analogue AMPS (Advanced Mobile Phone Service) channel. It is used to support paging, broadcast and access messages to the mobile.

2. What are the differences between Destination sequence distance vector and the Standard distance vector routing algorithms? [WBUT 2014]

Answer:
Destination-Sequenced Distance Vector (DSDV) routing protocol is a pro-active, table-driven routing protocol for MANETs. It uses the hop count as metric in route selection. Every node will maintain a table listing all the other nodes it has known either directly or through some neighbors. Every node has a single entry in the routing table. The entry will have information about the node's IP address, last known sequence number and the hop count to reach that node. Along with these details the table also keeps track of the next hop neighbor to reach the destination node, the timestamp of the last update received for that node.

The DSDV update message consists of three fields, Destination Address, Sequence Number and Hop Count.

On the name distance vector is derived from the fact that routes are advertised as vectors of (distance, direction), where distance is defined in terms of a metric and direction is defined in terms of the next-hop router. For example, "Destination A is a distance of 5 hops away, in the direction of next-hop router X." As that statement implies, each router learns routes from its neighboring routers' perspectives and then advertises the routes from its own perspective. Because each router depends on its neighbors for information, which the neighbors in turn may have learned from their neighbors, and so on, distance vector routing is sometimes facetiously referred to as "routing by rumor."

3. What do you mean by ad-hoc piconet? Mention the different criteria of WPAN.
[WBUT 2015]

Answer:

1st Part:

A piconet is an adhoc network which links a wireless user group of devices using Bluetooth technology protocols. A piconet consists of two or more devices occupying the same physical channel (synchronized to a common clock and hopping sequence).

2nd Part:

Wireless Private Area Network (WPAN) has following five criteria:

- **Market potential:** How many applications, devices, vendors, customers are available for a certain technology?
- **Compatibility:** Compatibility with IEEE 802.
- **Distinct Identity:** Originally, the study group did not want to establish a second 802.11 standard. However, topics such as, low cost, low power, or small form factor are not addressed in the 802.11 standard.
- **Technical feasibility:** Prototypes are necessary for further discussion, so the study group would not rely on paper work.
- **Economic feasibility:** Everything developed within this group should be cheaper than other solutions and allow for high-volume production.

4. Discuss the advantages and limitations of Bluetooth as wireless standard.
[WBUT 2015]

Answer:

Advantages:

Bluetooth has a lot to offer with an increasingly difficult market place. Bluetooth helps to bring with it the promise of freedom from the cables and simplicity in networking that has yet to be matched by LAN (Local Area Network). In the key marketplace, of wireless and handheld devices, the closest competitor to Bluetooth is infrared. Infrared holds many key features, although the line of sight it provides doesn't go through walls or through obstacles like that of the Bluetooth technology.

Unlike infrared, Bluetooth isn't a line of sight and it provides ranges of up to 100 meters. Bluetooth is also low power and low processing with an overhead protocol. What this means, is that it's ideal for integration into small battery powered devices. To put it short, the applications with Bluetooth are virtually endless.

Disadvantages:

Bluetooth has several positive features and one would be extremely hard pressed to find downsides when given the current competition. The only real downsides are the data rate and security.

Infrared can have data rates of up to 4 Mbps, which provides very fast rates for data transfer, while Bluetooth only offers 1Mbps. For this very reason, infrared has yet to be dispensed with completely and is considered by many to be the complimentary technology to that of Bluetooth, Infrared has inherent security due to its line of sight. The

greater range and radio frequency (RF) of Bluetooth make it much more open to interception and attack.
For this reason, security is a very key aspect to the Bluetooth specification. Although there are very few disadvantages. Bluetooth still remains the best for short range wireless technology.

5. Distinguish between Bluetooth and Hyper LAN. **[MODEL QUESTION]**

Answer:
Bluetooth was the nickname of a Danish king Harald Blatand, who unified Denmark and Norway in the 10th century. The concept behind Bluetooth wireless technology was unifying the telecom and computing industries. Bluetooth technology allows users to make ad hoc wireless connections between devices like mobile phones, desktop or notebook computers without any cable. Devices carrying Bluetooth-enabled chips can easily transfer data at a speed of about 720 Kbps within 50 meters (150 feet) of range or beyond through walls, clothing and even luggage bags.
Bluetooth offers security infrastructure starting from authentication, key exchange, to encryption. In addition to encryption, a frequency hopping scheme with 1600 hops/sec is employed. All of these make the system difficult to eavesdrop. At the lowest levels of the protocol stack, Bluetooth uses the publicly available cipher algorithm known as SAFER+ to authenticate a device's identity. In addition to these basic security functions, different application verticals use their own security infrastructure at the application layers.

HyperLAN began in Europe as a specification ratified in 1996 by the ETSI Broadband Radio Access Network group.

- ***HIPERLAN1:*** This high-speed WLAN supports mobility at data rates above 20 Mbit/s. Range is 50 m, connections are multi-point-to-multi-point using ad-hoc or infrastructure networks (ETSI, 1998b)
- ***HIPERLAN2:*** This technology can be used for wireless access to ATMN or IP networks and supports usp to 25 Mbit/s user data rate in a point-to-multi-point configuration Transmission range is 50 m with support of slow (< 10 m/s) mobility (ETSI, 1997). This standard has been modified over time and is presented in section 7.4.4 as a high performance WLAN with QoS support.

Features in the mandatory parts of the standard (HiperLAN2, 2002).

- High-throughput transmission
- Connection-oriented
- Quality of service support
- Dynamic Frequency-selection
- Security support
- Mobility support
- Power Save

6. What is the basic unit of networking in Bluetooth? **[MODEL QUESTION]**

Answer:

The basic unit of a Bluetooth network is a centralized master-slave topology, namely a piconet, that can be easily extended into a multi-hop adhoc network called a scatternet.

Long Answer Type Questions

1. Write short notes on the following:

a) Hiper LAN **[WBUT 2015]**

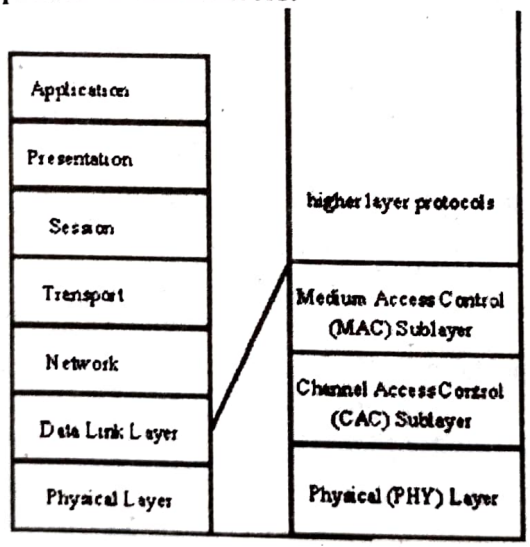
b) MANET **[WBUT 2015]**

Answer:

a) Hiper LAN:

HIPERLAN is a European family of standards on digital high speed wireless communication in the 5.15-5.3 GHz and the 17.1-17.3 GHz spectrum developed by ETSI. The committee responsible for HIPERLAN is RES-10 which has been working on the standard since November 1991.

The standard serves to ensure the possible interoperability of different manufacturers' wireless communications equipment that operate in this spectrum. The HIPERLAN standard only describes a common air interface including the physical layer for wireless communications equipment, while leaving decisions on higher level configurations and functions open to the equipment manufacturers.



The choice of frequencies allocated to HIPERLAN was part of the 5-5.30 GHz band being allocated globally to aviation purposes. The Aviation industry only used the 5-5.15GHz frequency, thus making the 5.15-5.30 frequency band accessible to HIPERLAN standards.

HIPERLAN is designed to work without any infrastructure. Two stations may exchange data directly, without any interaction from a wired (or radio-based) infrastructure. The simplest HIPERLAN thus consists of two stations. Further, if two HIPERLAN stations

are not in radio contact with each other, they may use a third station (i.e. the third station must relay messages between the two communicating stations).
Products compliant to the HIPERLAN 5 GHz standard shall be possible to implement on a PCMCIA Type III card. Thus the standard will enable users to truly take computing power on the road.
The HIPERLAN standard has been developed at the same time as the development of the SUPERnet standard in the United States.

b) MANET:
Mobile Ad Hoc Networks (MANETs) are an emerging type of wireless networking, in which mobile nodes associate on an extemporaneous or ad hoc basis. MANETs are both self-forming and self-healing, enabling peer-level communications between mobile nodes without reliance on centralized resources or fixed infrastructure.
These attributes enable MANETs to deliver significant benefits in virtually any scenario that includes a cadre of highly mobile users or platforms, a strong need to share IP-based information, and an environment in which fixed network infrastructure is impractical, impaired, or impossible. Key applications include disaster recovery, heavy construction, mining, transportation, defense, and special event management.

2. a) Briefly discuss Bluetooth protocol stack. **[MODEL QUESTION]**
b) Give two examples of Bluetooth application.

Answer:

a) Bluetooth protocol stack can be thought of combination of multiple application specific stacks as depicted in the figure. Different applications run over one or more vertical slices from this protocol stack. These are RFCOMM (Radio Frequency COMMunication, TCS Binary (Telephony Control Specification) and SDP (Service Discovery Protocol). Each application environments use a common data link and physical layer. RFCOMM and the TCS binary (Telephony Control Specification) protocol are based on the ETSI TS 07.10 and ITU-T Recommendation Q.931 respectively. Some applications have some relationship with other protocols, e.g. L2CAP (Logical Link Control and Adaptation Protocol) or TCS may use LMP (Link Manager protocol) to control the link manager.
Bluetooth protocol stack can be divided into four basic layers according to their functions.

These are:
Bluetooth Core Protocols: This comprises of Baseband, Link Manager Protocol (LMP), Logical Link Control and Adaptation Protocol (L2CAP), and Service Discovery Protocol (SDP).

- ***Base band:*** The Baseband and Link Control layer enables the physical RF link between Bluetooth units forming a piconet. This layer uses inquiry and paging procedures to synchronize the transmission with different Bluetooth devices. Using SCO and ACL link different packets can be provided with different levels of CRC

(Cyclic Redundancy Code) or FEC (Forward Error Correction) for error detection/correction.

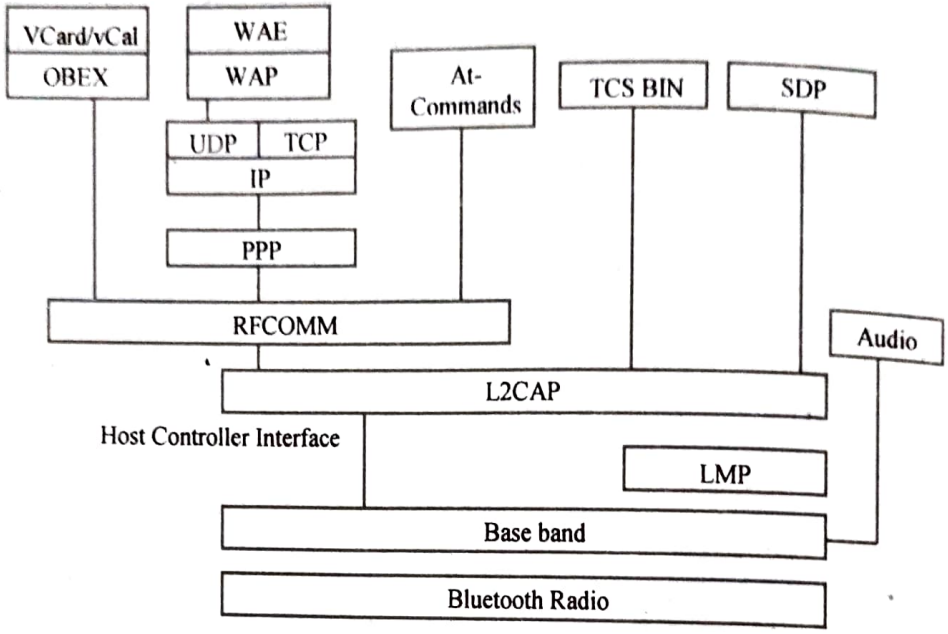


Fig: Bluetooth Protocol stack

- ***Link Manager Protocol (LMP):*** When two Bluetooth devices come within each other's radio range, link managers of either device discover each other LMP then engages itself in peer-to-peer message exchange. These messages perform various security functions starting from authentication to encryption. LMP layer performs generation and exchange of encryption keys as well. This layer performs the link setup and negotiation of baseband packet size. LMP also controls the power modes, connection state, and duty cycles of Bluetooth devices in a piconet.
- ***Logical Link Control and Adaptation Protocol (L2CAP):*** This layer is responsible for segmentation of large packets and the reassembly of fragmented packets. L2CAP is also responsible for multiplexing of Bluetooth packets from different applications.
- ***Service Discovery Protocol (ADP):*** The Service Discovery Protocol SDP enables a Bluetooth device to join a piconet. Using SDP a device inquires what services are available in a piconet and how to access them. SDP uses a client-server model where the server has a list of services defined through service records. One service record in a server describes the characteristics of one service. In a Bluetooth device there can be only one SDP server. If a device provides multiple services, one SDP server acts on behalf of all of them. Similarly multiple applications in a device may use a single SDP client to query servers for service records. A Bluetooth device in an inquiry mode broadcasts ID packets on 32 frequency channels of the Inquiry Hopping Sequence. It sends two ID packets every 625μs and then listens for responses the following 625μs. At this stage the unique identity of the devices called Bluetooth global ID is exchanged. A global Id indicates a device's profile along with capability functions. Upon matching of the device profile a connection is set up and devices exchange data. When a connection is set up, the paging device becomes the

master and the paged device becomes the slave. A Bluetooth device may operate both as a server and as a client at the same time forming a scatternet. They can also switch from master to slave and vice versa. The master slave switch can take between 4.375 and 41.875 ms. In a piconet, a master device can be a laptop or PDA, while slaves devices could be printers, mouse, cellular phones etc.

Cable Replacement Protocol: This protocol stack has only one member viz., Radio Frequency Communication (RFCOMM).

- **RFCOMM** his is a serial line communication protocol and is based on ETSI 07.10 specification. The "cable replacement" protocol emulates RS-232 control and data signals over Bluetooth baseband protocol.

Telephony Control Protocol: This comprises of two protocol stacks viz., Telephony Control Specification Binary (TCS BIN), and the AT-Commands.

- **Telephony Control protocol Binary** TCS Binary or TCS BIN is a bit-oriented protocol. TCS BIN defines the call control signaling protocol for set up of speech and data calls between Bluetooth devices. It also defines mobility management procedures for handing groups of Bluetooth TCS devices. TCS Binary is based on the ITU-T Recommendation Q.931.
- **AT-Commands** this protocol defines a set of AT-commands by which a mobile phone can be used and controlled as a modern for fax and data transfers. AT (short form of attention) commands are used from a computer or DTE (Data Terminal Equipment) to control a modem or DCE (Data Circuit terminating Equipment). AT-commands in Bluetooth are based on ITU-T Recommendation V.250 and GSM 07.07.

Adopted Protocols: This has many protocol stacks like Point-to-Point Protocol (PPP), TCP/IP Protocol, OBEX (Object Exchange Protocol), Wireless Application Protocol (WAP), vCard, vCalendar, Infrared Mobile Communication (IrMC), etc.

- ***PPP*** Bluetooth offers ***PPP*** over ***RFCOMM*** to accomplish point-to-point connections. Point-to-Point Protocol is the means of taking IP packets to/from the PPP layer and placing them onto the LAN.
- ***TCP/IP*** Protocol is used for communication across the Internet. TCP/IP stacks are used in numerous devices including printers, handheld computers, and mobile handsets. Access to these protocols is operating system independent, although traditionally realized using a socket programming interface model. TCP/IP/PPP is used for the all Internet Bridge usage scenarios. UDP/IP/PPP is also available as transport for WAP.
- ***OBEX Protocol OBEX*** is a session protocol developed by the Infrared Data Association (IrDA) to exchange objects. OBEX provides the functionality of HTTP in a much lighter fashion. The OBEX protocol defines a folder listing object, which can be used to browse the contents of folders on remote devices.

- ***Content Formats*** vCard and Calendar specifications define the format of an electronic business card and personal calendar entries developed by the Versit consortium. These are now maintained by the Internet Mail Consortium. Other content formats, supported by OBEX, are vMessage and vNote. These content formats are used to exchange messages and notes. They are defined in the IrMC (IrDA Mobile Communication) specification. IrMC also defines a format for synchronization of data between devices.

b) *Bluetooth applications*

- ***File Transfer:*** The file transfer usage model offers the ability to transfer data objects from one device (e.g., smart-phone, or PDA) to another. Object types include .xls, .ppt, .wav, .jpg, .doc files, folders or directories or streaming media formats. Also, this model offers a possibility to browse the contents of the folders on a remote device.
- ***Headset:*** The headset can be wirelessly connected for the purpose of acting as a remote device's audio input and output interface. This is very convenient for hands free cellular phone usage in automobiles.

3. a) Show master-slave architecture in a piconet of Bluetooth devices.
b) What are the features of palm OS?
c) Explain Symbian OS architecture. **[MODEL QUESTION]**

Answer:

a) Assuming a computer was equipped with all Bluetooth enabled peripherals. How is this configured, as single/multiple piconet(s), and thus who is master and who is slave.

2 (slightly) differing answers given:

i) The BT unit attached to the CPU should become the master and will control all the slaves (which are peripherals). So that the BT at the CPU could contact all the other devices without switching the piconet. If required, the devices may switch roles at any time.

ii) The BT unit who wants to be Master becomes Master of the piconet it formed. It is all up to the unit itself (perhaps controlled by the application running on the unit).

b) The key features of the Palm OS are:

- Simple, single-tasking environment to allow launching of full screen applications with a basic, common GUI set
- Monochrome or color screens with resolutions up to 480x320 pixel
- Handwriting recognition input system called Graffiti 2
- HotSync technology for data synchronization with desktop computers
- Sound playback and record capabilities
- Simple security model: Device can be locked by password, arbitrary application records can be made private
- TCP/IP network access
- Serial port/USB, infrared, Bluetooth and Wi-Fi connections

- Expansion memory card support
- Defined standard data format for personal information management applications
- to store calendar, address, task and note entries, accessible by third-party applications.

c) Symbian OS architecture:

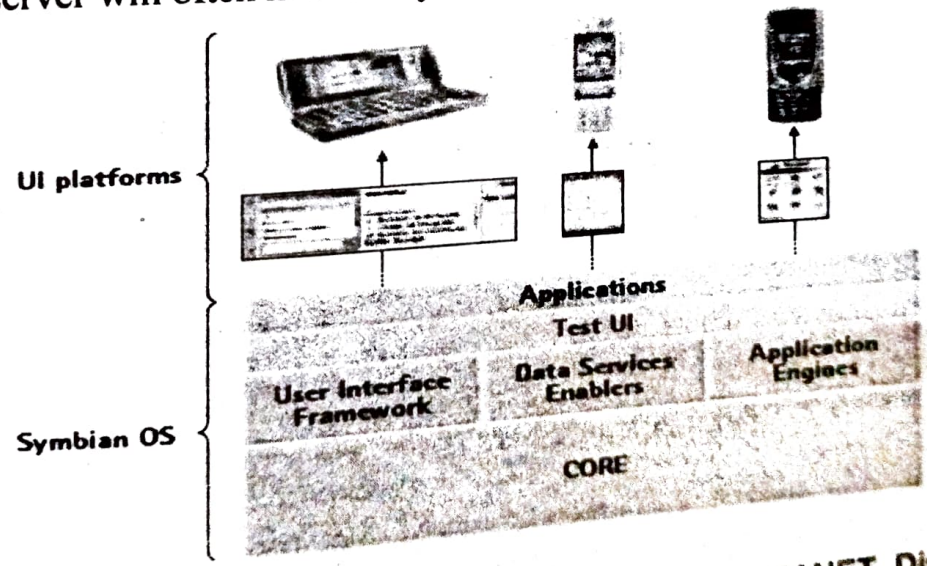
Symbian OS architecture is designed to meet no of requirements. It must be hardware independent so it can be used on verity of phone types. It must be extendable so it can cope with feature development and it must be open to all to develop for.

Architectural Overview:

- Core - symbian devices core is common to all devices i.e. kernel, file server.
- System layer - the system layer provides communications and computing services such as SMS.
- Application engines - above the system layer lies the application engines enabling software developers to create user interfaces to data.
- User interface Software - can be made or licensed by manufacturer.
- Applications – is allotted above the user interface.

Client Server Architecture:

The power of client server framework is widely acknowledged by the software community. In Symbian OS, the client is a programs that have user interfaces, and server are programs that can only be accessed via a well defined interface and other programs. The role of a server is to serve the user while server ensures timely response to all the clients while controlling the access to the resources of the actual system. Additionally, in practice, one server will often have many extra servers relying on the one original server.



4. Explain different proactive & reactive protocols used in MANET. Discuss passive & active attacks to MANET. **[MODEL QUESTION]**

Answer:

Proactive protocols used in MANET:

In proactive routing protocols a table is maintained which contains the shortest route to the destination.

The protocols are,

DSDV: Destination-Sequenced Distance-Vector Routing (DSDV) is a table-driven routing scheme for ad hoc mobile networks based on the Bellman-Ford algorithm.

1. Each mobile node advertise its own route tables to its current neighbors
2. Routing tables update periodically to adapt the dynamic change and maintain table consistency
3. When advertisement, each mobile node contain its new sequence number and the following information for each new route
   - The destination's address
   - The number of costs (hops) required to reach the destination
   - The sequence number of the information received, originally stamped by the destination.

WRP: Wireless Routing Protocol (WRP) is a proactive unicast routing protocol for mobile ad-hoc networks (MANET).

WRP is a table-based protocol with the goal of maintaining routing information among all nodes in the network.

WRP used an enhanced version of the distance-vector routing protocol, which used the Bellman-Ford algorithm to calculate paths.

Reactive protocols used in MANET:

In reactive routing protocols the route is optimized on demand.

The protocols are,

DSR: Dynamic Source Routing (**DSR**) is a reactive routing protocol.

1. Sender floods RREQ through the network
2. Nodes forward RREQs after appending their names
3. Destination node receives RREQ and unicasts a RREP back to sender node

AODV: Ad hoc On-Demand Distance Vector (AODV) Routing is a routing protocol for mobile ad hoc networks (MANETs) and other wireless ad-hoc networks. It is a reactive routing protocol that is the routing table built on demand.

Passive & active attacks to MANET:

Active attacks actively alter the data with the intention to obstruct the operation of the targeted networks.

Examples of active attacks in mobile ad hoc network comprise actions such as message modifications, message replays, message fabrications and the denial of service attacks.

On the other hand, passive attacks do not intend to disrupt the network operations;

Passive attacks are launched to steal valuable information in the targeted networks.

Examples of passive attacks are eavesdropping attacks and traffic analysis attacks.

Detecting this kind of attack is difficult because neither the system resources nor the critical network functions are physically affected to prove the intrusions.

QUESTION 2013

GROUP – A
(Multiple Choice Type Questions)

1. Choose the correct alternatives for the following:

i) GSM uses ..... for multiplexing.

a) CDMA b) TDMA c) FDMA ✓d) both (b) and (c)

ii) ..... Is a computerized centre responsible for connecting & recording call information and billing.

a) base station b) cell ✓c) MSC d) mobile station

iii) A single frame in GSM comprises ..... time slots.

a) 10 b) 7 ✓c) 8 d) 4

iv) IEEE 802.11b has data transfer rate of

✓a) 11 mbps b) 13 mbps c) 10 mbps d) none of these

v) Frequency reuse can help which of the following systems?

✓a) cellular system b) conventional mobile telephony

c) paging system d) cordless telephony

vi) WAP protocol stack has similarity to

a) OS model b) TCP/IP ✓c) both of these d) none of these

vii) WLAN is

a) infrastructure network b) ad hoc network

✓c) may be either infrastructure or ad hoc network d) none of these

viii) Full form of HSCSD is

a) High Spectrum Circuit Switched Data b) High Speed Channel Switched Data

✓c) High Speed Circuit Switched Data d) High Speed Circuit Switched Devices

ix) Ad hoc networks are examples of which type of networks?

a) fixed and wired b) mobile and wired

c) fixed and wireless ✓d) mobile and wireless

x) If N is the number of cells per cluster then frequency reuse factor of the cellular system is

a) N ✓b) $1/N$ c) N^2 d) none of these

GROUP – B

(Short Answer Type Questions)

2. What is hand-off? What are the different hand-off strategies? Discuss the merits and demerits of each such strategy.

See Topic: INTRODUCTION TO PERSONAL COMMUNICATIONS SERVICES, Short Answer Type Questions No. 2.

3. What is WAP? Why is it used?

See Topic: WIRELESS APPLICATION PROTOCOL, Short Answer Type Questions No. 1.

4. What are tunneling and encapsulation in the context of mobile IP?

See Topic: DATA COMMUNICATION, Short Answer Type Questions No. 2.

5. What is spread spectrum technique? Name two standard spread spectrum techniques and state the main difference in their principles of operation.

See Topic: DATA COMMUNICATION, Short Answer Type Questions No. 3.

6. What are hidden station problem and exposed station problem in WLAN? How are the problems solved?

See Topic: DATA COMMUNICATION, Short Answer Type Questions No. 4.

GROUP – C

(Long Answer Type Questions)

7. Define the following terms and state their usage:

a) Near-far effect

b) Orthogonal code and its usage in mobile communication

c) FCC

d) RVC

e) TMSI

a) See Topic: DATA COMMUNICATION, Short Answer Type Questions No. 1.

b) See Topic: 3G MOBILE SERVICES, Short Answer Type Questions No. 1.

c) See Topic: WIRELESS ENTERPRISE NETWORK, Short Answer Type Questions No. 1.

d) See Topic: INTRODUCTION TO PERSONAL COMMUNICATIONS SERVICES, Short Answer Type Questions No. 1(i).

e) See Topic: INTRODUCTION TO PERSONAL COMMUNICATIONS SERVICES, Short Answer Type Questions No. 1(ii).

8. What is multiple access technique? Do a comparative study among FDMA, TDMA and CDMA.

See Topic: INTRODUCTION TO PERSONAL COMMUNICATIONS SERVICES, Long Answer Type Questions No. 1.

9. a) What is meant by access control?
b) What are contention-based and contention-free access control mechanisms?
c) Why does CSMA/CD not work for medium access control of WLAN?
d) What is the alternative mechanism of CSMA/CD? Write steps of operation to implement such an alternative mechanism.

See Topic: DATA COMMUNICATION, Long Answer Type Questions No. 1.

10. a) Draw the system architecture of GSM and explain the functionality of HLR and VLR.
b) Describe the architecture of a 3G network. What are the various services associated with a 3G network?
c) Define packet switching and circuit switching.

a) See Topic: INTRODUCTION TO PERSONAL COMMUNICATIONS SERVICES, Long Answer Type Questions No. 2.
b) See Topic: 3G MOBILE SERVICES, Long Answer Type Questions No. 1.
c) See Topic: GENERAL PACKET RADIO SERVICES, Short Answer Type Questions No. 1.

11. Write short notes on any three of the following:
a) Wireless local loop
b) Call setup of GSM network for mobile-to-mobile call
c) Pervasive computing
d) GPRS
e) Iridium satellite system

a) See Topic: WIRELESS LOCAL LOOP, Long Answer Type Questions No. 1(a).
b) See Topic: INTRODUCTION TO PERSONAL COMMUNICATIONS SERVICES, Long Answer Type Questions No. 7(a)
c) See Topic: INTRODUCTION TO PERSONAL COMMUNICATIONS SERVICES, Long Answer Type Questions No. 7(b).
d) See Topic: GENERAL PACKET RADIO SERVICES, Long Answer Type Questions No. 1.
e) See Topic: GLOBAL MOBILE SATELLITE SYSTEMS, Long Answer Type Questions No. 1.

QUESTION 2014

GROUP – A
(Multiple Choice Type Questions)

1. Choose the correct alternatives for the following:

i) GSM operates at
✓a) 860-960 MHz
b) less than 500 MHz
c) Greater than 500 MHz
d) none

ii) Network signalling in GSM is

✓a) SS7 b) SS5 c) cipher d) none

iii) Which of the following is the main standard for Bluetooth?

✓a) IEEE802.15 b) IEEE802.3 c) IEEE802.11 d) IEEE802.16

iv) GPRS is

✓a) general packet radio service b) global packet radio service

c) general police radio service d) none

v) Which of the following is the problem in IPV4 addressing for physical mobility?

a) it has 32-bit address

b) it does not provide QoS support

✓c) its routing and forwarding require a fixed IP determined by a network

d) it has security issues

vi) WAP 2.0 runs at

✓a) 384 Kbps b) 364 Kbps c) 54 Mbps d) 11 Mbps

vii) Which of the following is mobile/wireless simulator?

a) NS2 b) NS3 c) Qualnet ✓d) all of these

viii) WLL uses

a) specified bound b) unspecified bound

c) low pass filter ✓d) none

ix) If N is the number of cells per cluster, then frequency reuse factor of the cellular system is

a) N ✓b) 1/N c) N2 d) none of these

x) Which one is used in WLAN?

a) access point b) router

✓c) both (a) and (b) d) none of these

GROUP – B

(Short Answer Type Questions)

2. What do you mean by Mobile Communication? What are the advantages of Mobile Communication over PSTN? What is the difference between network protocol and network architecture?

See Topic: INTRODUCTION TO PERSONAL COMMUNICATIONS SERVICES, Short Answer Type Questions No. 3.

3. What is Handoff? Differentiate between hard and soft handoffs. What does GPRS stand for?
1st & 2nd part: See Topic: INTRODUCTION TO PERSONAL COMMUNICATIONS SERVICES, Short Answer Type Questions No. 2.
3rd part: See Topic: GENERAL PACKET RADIO SERVICES, Short Answer Type Questions No. 2.

4. What are the differences between Destination sequence distance vector and the Standard distance vector routing algorithms? What are the frequency bands of operation for CDMA?
1st part: See Topic: WIRELESS ENTERPRISE NETWORKS, Short Answer Type Questions No. 2.
2nd part: See Topic: 3G MOBILE SERVICES, Short Answer Type Questions No. 2.

5. What are the difficulties in using CSMA/CD in wireless LANs? What alternative methods can be used?
See Topic: DATA COMMUNICATION, Short Answer Type Questions No. 5.

6. What do you mean by tunnelling and encapsulation in the contest of Mobile IP?
See Topic: DATA COMMUNICATION, Short Answer Type Questions No. 6.

GROUP – C
(Long Answer Type Questions)

7. a) What are the functions of Home agent and Foreign agent in Mobile IP?
b) How does I-TCP differ from traditional TCP? Describe with suitable diagram.
c) Briefly describe the congestion control, slow start and fast retransmit mechanism.
See Topic: DATA COMMUNICATION, Long Answer Type Questions No. 2.

8. a) Discuss the three different mechanisms to improve the cell capacity and coverage area in cellular systems.
b) What is MANET?
c) What is Micro-cell zone concept?
d) Briefly differentiate between GSM and CDMA technologies.
See Topic: INTRODUCTION TO PERSONAL COMMUNICATIONS SERVICES, Long Answer Type Questions No. 3.

9. a) Draw the system architecture of the GSM network and discuss VLR, HLR on that context.
b) Why is the cell structure supposed to be a Hexagon in a mobile network?
a) See Topic: INTRODUCTION TO PERSONAL COMMUNICATIONS SERVICES, Long Answer Type Questions No. 2.
b) See Topic: INTRODUCTION TO PERSONAL COMMUNICATIONS SERVICES, Short Answer Type Questions No. 4.

10. a) Define WLAN.
b) Illustrate the system architecture of IEE 802.11 WLAN
c) Explain with diagram the protocol architectures and manage of IEEE 802.11.
a) See Topic: DATA COMMUNICATION, Short Answer Type Questions No. 7.
b) & c) See Topic: WIRELESS APPLICATION PROTOCOL, Short Answer Type Questions No. 2.

11. a) Explain the concept of frequency reuse in cellular systems.
b) What do you mean by co-channel interference and system capacity?
c) Discuss three different mechanisms to improve the cell capacity and coverage area in a cellular system.
a) & b) See Topic: INTRODUCTION TO PERSONAL COMMUNICATIONS SERVICES, Long Answer Type Questions No. 4.
c) See Topic: INTRODUCTION TO PERSONAL COMMUNICATIONS SERVICES, Long Answer Type Questions No. 3(a).

QUESTION 2015

GROUP – A
(Multiple Choice Type Questions)

1. Choose the correct alternatives for the following:

i) Which of the following is/are the main part(s) of basic cellular system?
a) A mobile unit
b) A cell site
c) A mobile telephone switching office
✓d) All of these

ii) In _____ frequency spectrum is divided into smaller spectra and is allocated to each user
a) TDMA
b) CDMA
✓c) FDMA
d) OFDMA

iii) Which of these cells are used for densely populated areas?
a) Macro cells
✓b) Micro cells
c) Selective cells
d) Umbrella cells

iv) Cell A uses the same frequency as cell B. The Cell A is a _____ of Cell B.
a) Adjacent cell
✓b) Co channel cell
c) Macro cell
d) Selective cell

v) The process of channel coding, encryption, multiplexing and modulation for Transmission and reception are to be carried out by
✓a) BTS
b) BSC
c) MSC
d) MS

vi) The coverage and capacity of CDMA system is more than that of GSM system.
✓a) True b) False c) Equal d) None of these

vii) The core concept used in cellular technology is
a) TDM ✓b) Frequency reuse c) Code reuse d) None of these

viii) The terminal is under observation from the network for the possible problems. Under which list will this belong in EIR?
a) White list ✓b) Grey list c) Black list d) None of these

ix) Which multiple access technique is used by IEEE 802.11 standard for wireless LAN?
a) CDMA ✓b) CSMA/CA c) ALOHA d) None of these

x) What is the access point (AP) in wireless LAN?
✓a) Device that allows wireless devices to connect to a wired network
b) Wireless devices itself that allows wireless devices to connect to a wired network
c) Both (a) and (b)
d) None of these

GROUP – B
(Short Answer Type Questions)

2. Explain the system architecture of infrastructure-based wireless networks with diagrams.
See Topic: **WIRELESS APPLICATION PROTOCOL, Short Answer Type Questions No. 3.**

3. What do you mean by hand-off? Discuss how hard hand-off is different from soft hand-off.
See Topic: **INTRODUCTION TO PERSONAL COMMUNICATIONS SERVICES, Short Answer Type Questions No. 2.**

4. Describe the system architecture and protocol architecture of IEEE 802.11 with suitable diagram.
See Topic: **WIRELESS APPLICATION PROTOCOL, Short Answer Type Questions No. 2.**

5. What are the features proposed for 4G systems? Explain.
See Topic: **3G MOBILE SERVICES, Short Answer Type Questions No. 3.**

6. What do you mean by ad-hoc piconet? Mention the different criteria of WPAN.
See Topic: **WIRELESS ENTERPRISE NETWORK, Short Answer Type Questions No. 3.**

GROUP – C
(Long Answer Type Questions)

7. a) What is direct sequence spread spectrum technology?
b) Distinguish between collisions of PHY and MAC layer.

c) Explain how Handover takes place in GSM. What are the problems associated with Handover in GSM?

a) & b) See Topic: DATA COMMUNICATION, Long Answer Type Questions No. 3.

c) See Topic: INTRODUCTION TO PERSONAL COMMUNICATIONS SERVICES, Long Answer Type Questions No. 5.

8. a) Discuss how digital communication is better than analog communication?

b) What are the main reasons for using cellular system? Describe the dynamic channel allocation in cellular system.

c) What are the limitations of GSM cell in terms of capacity for traditional GSM? How can the capacity be increased?

See Topic: INTRODUCTION TO PERSONAL COMMUNICATIONS SERVICES, Long Answer Type Questions No. 6.

9. a) Discuss the advantages and limitations of Bluetooth as wireless standard.

b) Compare radio waves, microwaves and infrared waves, with respect to their data rates, transmission distance, interference and cost.

c) Explain clearly why cellular IP cannot be used in place of mobile IP.

a) See Topic: WIRELESS ENTERPRISE NETWORK, Short Answer Type Questions No. 4.

b) & c) See Topic: DATA COMMUNICATION, Long Answer Type Questions No. 4.

10. a) What do you mean by "Call Admission Control" in mobile communication? Discuss any two of the CAC schemes for mobile communication.

b) What is congestion problem? Briefly point out some features of TCP congestion control and congestion in mobile ad-hoc network.

See Topic: DATA COMMUNICATION, Long Answer Type Questions No. 5.

11. Write short notes on any three of the following:

a) WAP Protocol Stack

b) GPRS

c) Hiper LAN

d) WLAN

e) MANET

a) See Topic: WIRELESS LOCAL LOOP, Long Answer Type Questions No. 1(b).

b) See Topic: GENERAL PACKET RADIO SERVICES, Long Answer Type Questions No. 1.

c) See Topic: WIRELESS ENTERPRISE NETWORK, Long Answer Type Questions No. 1(a).

d) See Topic: DATA COMMUNICATION, Long Answer Type Questions No. 6.

e) See Topic: WIRELESS ENTERPRISE NETWORK, Long Answer Type Questions No. 1(b).