Eighth Semester B.E Degree Examination, June/July 2018
Wireless Communication – 10EC81- Solution

		Marks	OBE CO	OBE RBT
1.(a)	Describe the characteristics of 2G and 3G cellular systems.	[10]	CO1	L4

Soln:

1G CELLULAR SYSTEM

Features/ characteristics of 1G or AMPS System

- 1G (or 1-G) refers to the first-generation.
- It is a analog based voice oriented telecommunications standards
- AMPS (Advanced Mobile Phone system) were the popular 1G cellular system.
- Used analog frequency modulation FM).
- FDD used to achieve Duplexing.
- Type of multiple access is FDMA
- Channel B.W is 30Khz
- Frequency band is 824-894 MHz.
- Forward link and Reverse link separated by 45 MHz.
- ID numbers were assigned to the cellular system (SID) and mobile handset (MIN, SIM).
- The system standard also defines physical layer technical parameters such as max. Permissible power level, Maximum out of band radiation level.
- The standard also prescribes the required protocol for system operations.

Other IG systems: Other first generation cellular other than AMPS are as follows

1. TACS (Total Access Communication System) cellular system)

2. NMT (Nordic Mobile Telephone) cellular system)

3. NTT (Nippon Telegraph and telephone) Cellular system

2G Cellular Systems

Features/ characteristics of 2G

- 2G is digital cellular system
- It uses digital modulation techniques.
- Introduce two major multiplexing schemes called TDMA and CDMA.
- Use digital modulation techniques to send digital control messages rather than SAT tones.

- Use Digital encryption used for security and privacy for the mobile network subscriber.
- Use of digital encoding and decoding schemes.
- Use of error detection and correction codes for reliability.
- Two major 2G technologies and standards are GSM and CDMA.

<u>How do 2G cellular systems support more than one user per channel:</u>

GSM(Global System for Mobile communication)

- It is a 2G digital cellular system
- Began operation in late 1992.
- Approximately 72% of the world's cellular customers subscribing this service.
- GSM technology uses TDMA to allow up to eight users per channel.
- Channels are spaced 200 kHz apart.
- Different Operating frequency bands.
- The basic system uses frequencies in the 900-MHz band (GSM 900),
- An up banded version was added at 1800 MHz (GSM 1800)
- 1900-MHz band was added in the United States for PCS service (GSM 1900).
- GSM service supported circuit-switched data rates of up to 9.6 kbps

CDMA(Code Division Multiple Access)

- It is totally new digital technology known developed by Qualcomm Corporation introduce in 1990s
- CDMA cellular systems use a digital modulation technique known as spread spectrum.
- It is also called for the next generation of wireless service
- CDMA air interface is IS-95.
- The first CDMA commercial network began operation in Hong Kong in 1995.
- CDMA systems have been used in both the cellular and PCS bands extensively in the United States and throughout the rest of the world.

- TDMA or CDMA cellular systems, both control information and traffic share the same radio channel.

- For CDMA systems, control information is carried by dedicated channel elements and traffic is placed on any available traffic channel element.

- Channel elements (CEs) are individual transmitters that are all transmitting on the same frequency simultaneously.

1.(b) Explain with neat flow diagram AMPS mobile originated call. [10] CO1 L4

Soln:

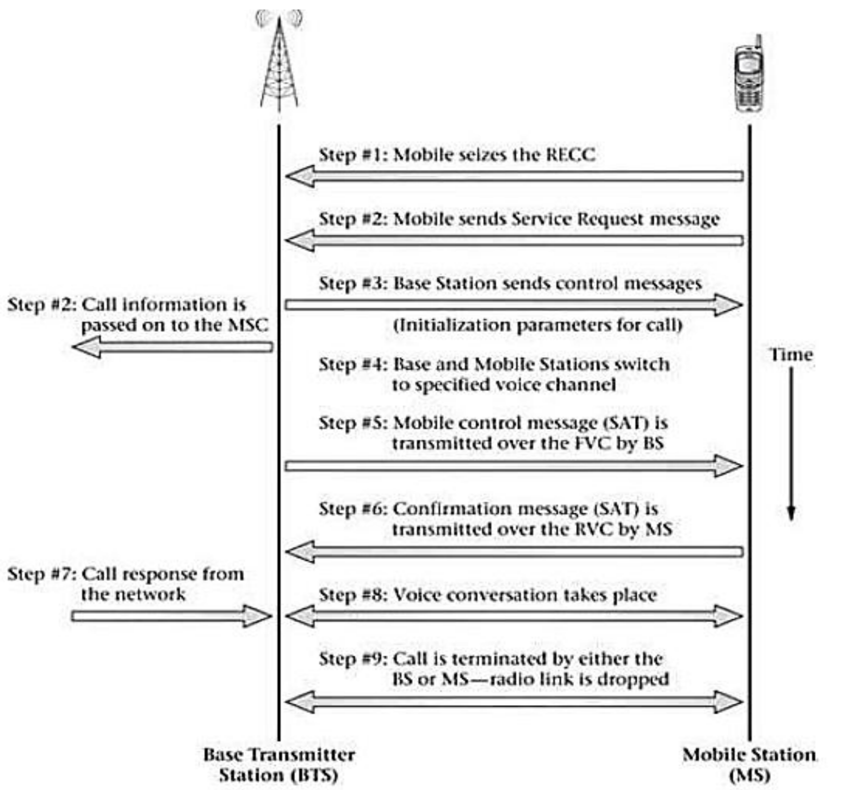


Figure 1.12: AMPS Mobile originated call

2. (a) With a neat block diagram, explain the functions performed by various blocks of subscriber device. [10] CO1 L4

Soln: The man-machine interface:

It can be :

- Standard telephone keypad
- Alphanumeric text display
- Microphone/speaker combination.
- It may be more sophisticated with soft-key keypad functions with multimedia capability and a high-resolution color display
- Video camera or cameras for the transmission and display of video messages.
- Service port or a data port for connection to a PC.

The RF transceiver section:

- It Provides the proper digital modulation and demodulation of the air interface RF signals and the ability to transmit and receive these RF signals.

This section must also permit both variable power output and frequency agility under system software control

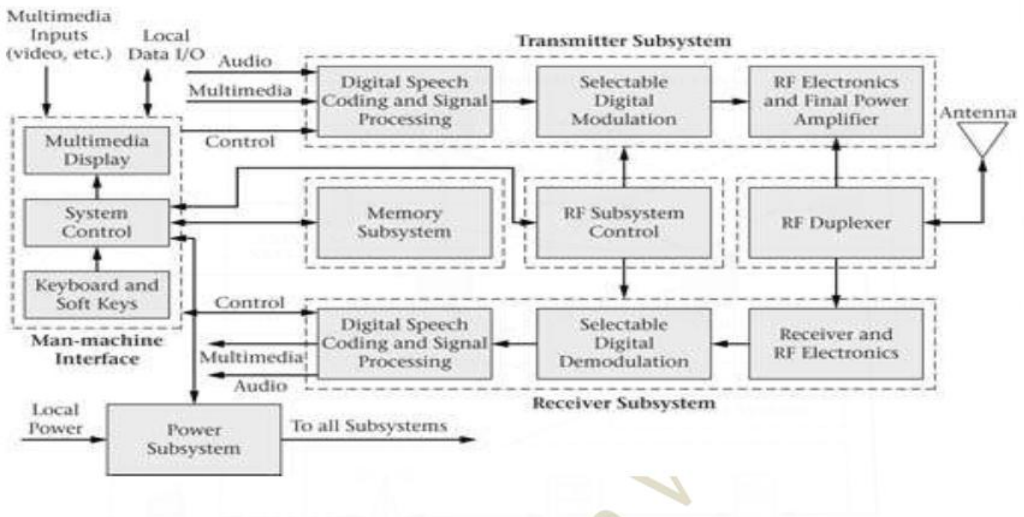


Figure 2.2: Typical subscriber device block diagram

The signal processing section:

- Some of the functions performed by this section are speech sampling and coding, channel coding, and audio and video processing.

The system control processor:

- It provides overall subscriber device management.
- It implements the required interface with the other wireless network elements to provide radio resource, connection management, and mobility management functions through software control of the various functions and operations.
- It must perform to set up and maintain the air interface radio link.

Power supply/ management:

- It provides the power to energize the entire system.
- SD is battery operated with sophisticated algorithms built in to the system to save and minimize power usage as much as possible in an effort to extend the battery life.

2.(b) Define explain the generation of IMSI, IMEI and CGI. **[10]** **CO1** L1

International Mobile Subscriber Identity (IMSI)

- It is assigned to each subscriber of international public land mobile networks.
- It is also used for acquiring other details of the mobile in HLR or in VLR
- IMSI number consists of the following:

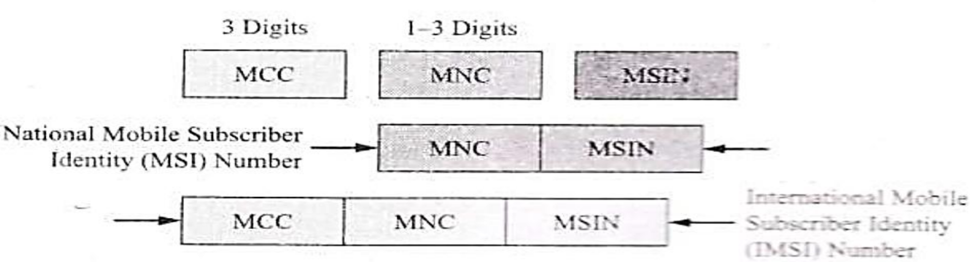
IMSI = MCC + MNC + MSIN

Where, MCC = Mobile Country Code

MNC = Mobile Network Code, and

MSIN = Mobile Subscriber Identification Number

- Figure below indicates how the IMSI is formed.

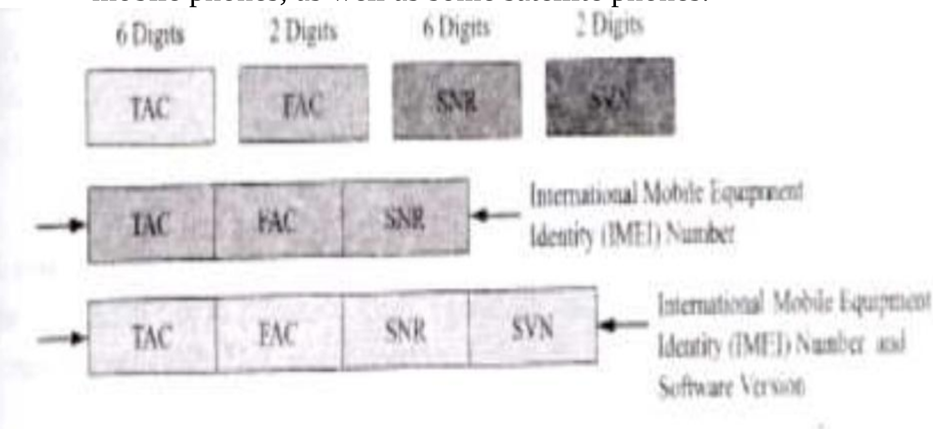


- For a GSM network the IMSI number is stored in the SIM.

- There is also a Temporary Mobile Subscriber Identity (TMSI) number that may be used instead of IMSI. This TMSI number is used to provide security over the air interface and therefore only has local significance within an MSC/VLR area.

International Mobile Equipment Identity(IMEI):

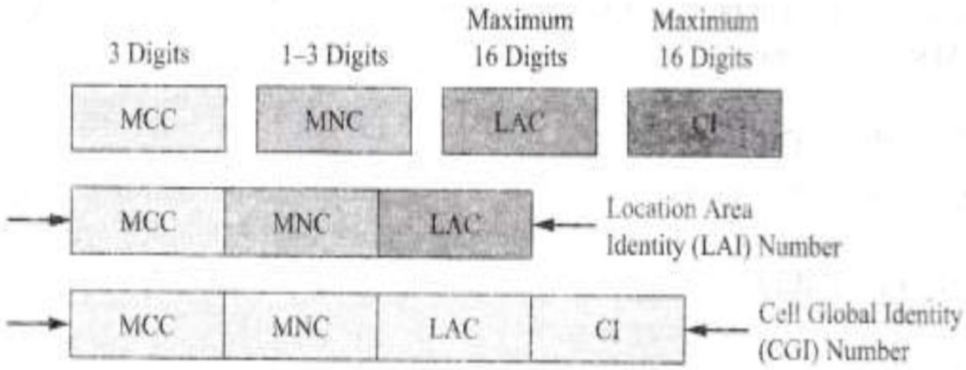
- It is required for international mobile networks.
- It is used to uniquely identify a MS as a piece of equipment to be used within the network.
- IMEI is a number, usually unique, to identify GSM, WCDMA, and iDEN mobile phones, as well as some satellite phones.



- It is usually found printed inside the battery compartment of the phone.
- It can also be displayed on the screen of the phone by entering ***#06#** into the keypad on most phones.
- The IMEI can be modified to include information about the software version of the subscriber device operating system or application software within the identity number.

Cell Global Identity (CGI)

- It is used for the unique identification of a cell within a location area.
- It is formed by adding 16 bits to the end of a LAI.
- This also allows for the possibility of 65,536 cell sites within a location area.
- The code is assigned by the mobile operator.



3.(a) Explain capacity expansion techniques: **[10]** CO2 L4

i) Cell Splitting
ii) Cell Sectoring
iii) Overlaid cells

i) Cell Splitting

m

The process of subdividing a congested cell into smaller cells. (each with its own base station and a corresponding reduction in antenna height and transmitter power). Cell splitting preserves the geometry of the architecture and therefore simply scales the geometry of the architecture

The increased number of cells would increase the number of clusters which in turn would increase the number of channels reused and capacity.

Assume that Cell A has become saturated and is unable to support its traffic load. Using cell splitting, six new smaller cells with approximately one-quarter the area of the larger cells are inserted into the system around A in such a way as to be halfway between two co channel cells.

These smaller cells will use the same channels as the corresponding pair of larger co-channel cells. In order that the overall system frequency reuse plan be preserved, the transmit power of these cells must be reduced by a factor of approximately 16 or 12dB

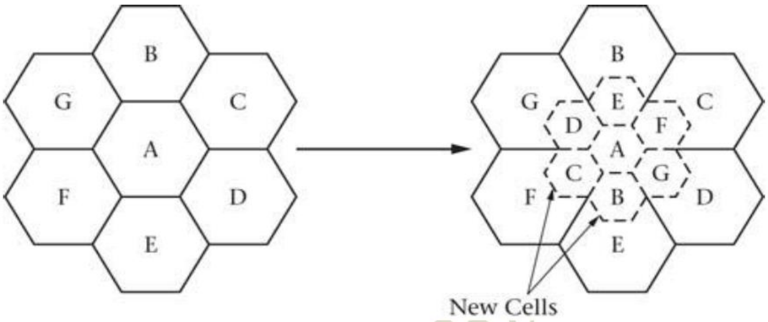


Fig: 3.4 Increase capacities by cell splitting

Cell splitting effectively increases system capacity by reducing the cell size and therefore reducing the frequency reuse distance thus permitting the use of more channels.

ii) Cell Sectoring

Another technique to increase cellular system capacity

Uses directional antennas to effectively split a cell into 3 or sometimes 6 new cells. It seek methods to decrease the D /R ratio.

Reuse Factor/ frequency reuse ratio :

$$Q = D/R = (3N)^{1/2}$$

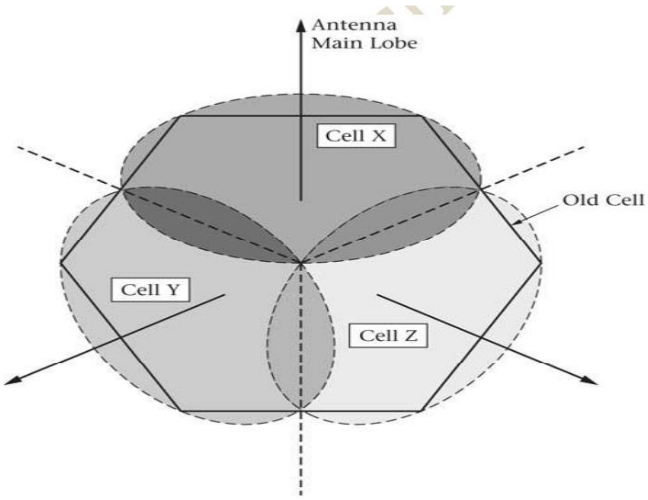


Figure 3.5: Increasing capacity by cell sectoring

Fig: Three directional antennas with 120^o beamwidths to illuminate the entire area previously services by omnidirectional antenna

It provides interference reduction, hence S/I ratio increases.

To address co-channel interference. It does not require new cell sites and additional antennas and triangular mounting only.

Demerits: Increased network system architecture complexity

Sectoring of a cell results in a reduction in the amount of interference that the sector experiences from its co channel neighbors in adjacent

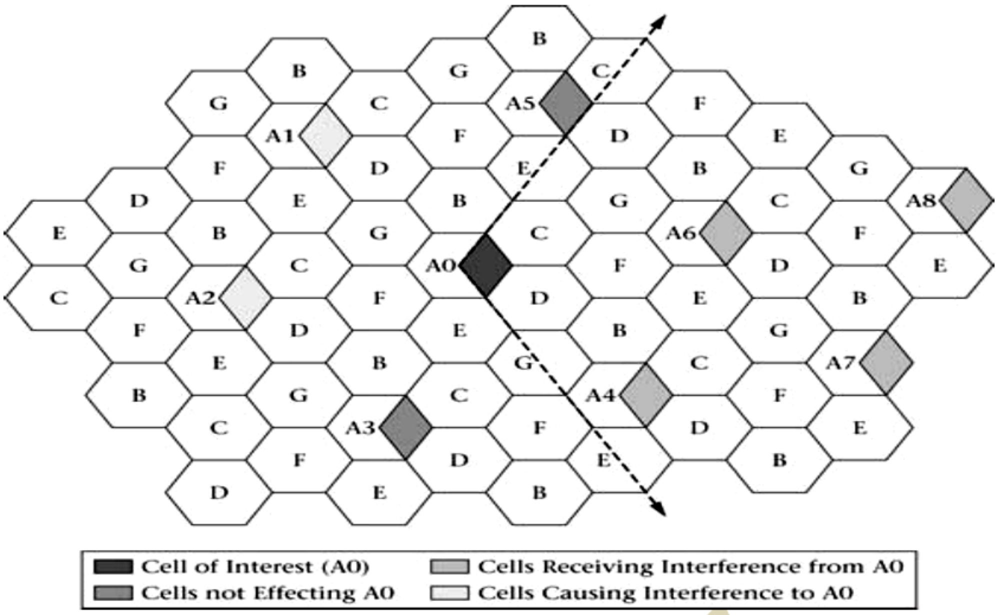


Fig 3.6: Interference reduction due to cell sectoring

iii) Overlaid cells

This method can be used to expand the capacity of cellular systems in two ways.

- Split-band analog systems.
- Reduced cluster size systems

Overlaid cells in a split-band system:

An operational wideband analog system could be upgraded to increase its capacity by overlaying another analog system with narrower bandwidth requirements over it. In such a split-band overlay system, channels are divided between a larger macrocell (using AMPS or TACS) and the overlaid microcell (using NAMPS or NTACS) that is contained in its entirety within the macrocell. Channels are divided among a larger macrocell that coexists with a smaller microcell contained entirely within the macrocell „

BS serves both macro- and microcells „

R1, D1: macrocell; R2, D2: microcell.

D2/R2>D1/R1 „

SIR for microcells substantially greater than that for macrocells -- and this situation may be exploited to increase network capacity by using split-band analog system, or reuse partitioning

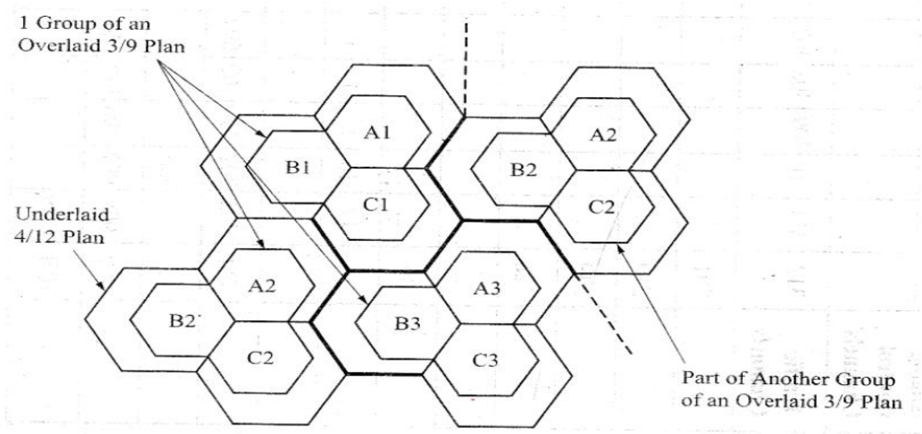


Figure 3.8 Overlaid cells in a reduced cluster size system

3.(b) Explain the concept of frequency reuse for cellular system. For a mobile system of a cluster size of 7, determine the frequency reuse distance if the cell radius is 5km. Repeat the calculation for a cluster size of 4. [10] CO2 L3

Frequency Reuse:

- A cell is assigned one of these bands.
- This means all communications (transmissions to and from users) in this cell occur over these frequencies only.
- Neighboring cells are assigned a different frequency band.
- This ensures that nearby transmissions do not interfere with each other.
- The same frequency band is reused in another cell that is far away.
- This large distance limits the interference caused by this co-frequency cell.

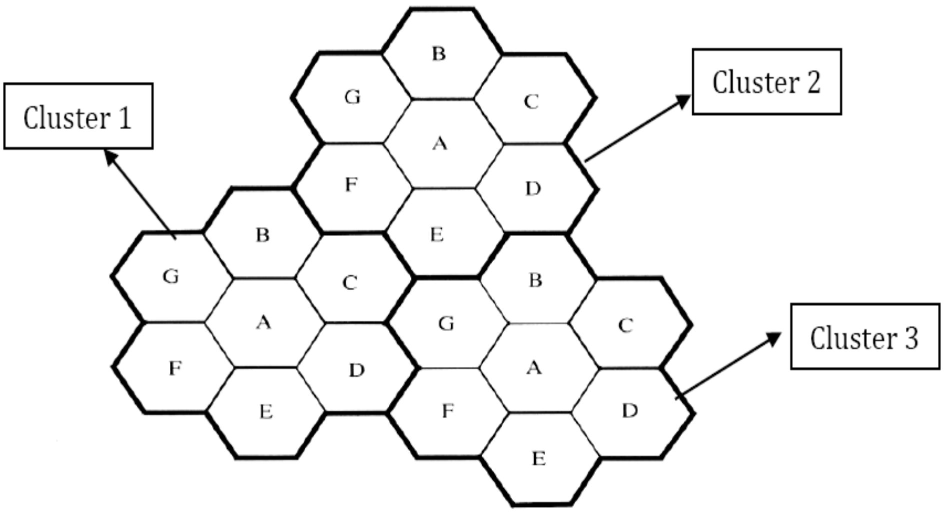


Figure 3.1 Illustration of the cellular frequency reuse concept. Cells with the same letter use the same set of frequencies. A cell cluster is outlined in bold and replicated over the coverage area. In this example, the cluster size, *N*, is equal to seven, and the frequency reuse factor is 1/7 since each cell contains one-seventh of the total number of available channels.

Cluster :

- It is a group of cell that makes use of all the available radio spectrum.
- Cluster has N cells with unique and disjoint channel.
- Since adjacent cell cannot use the same frequency channels, the total frequency allocation is divided up over the cluster and then repeated for other clusters in the system.
- The number of cells in a cluster is known as the cluster size or the frequency reuse factor (1/N)

Given N=7,
We know that

(i) $D = R(3N)^{½}$

$=5(3*7)^{1/2}$

$= 5(21)^{1/2} = 5(4.5823) = 22.913$km

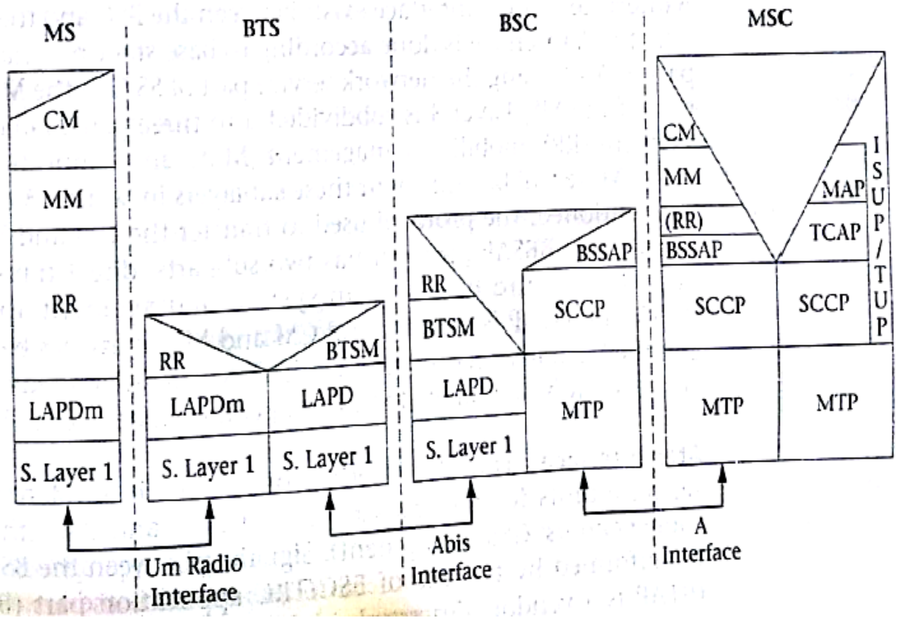
(ii) $D = R(3N)^{½}$

$=5(3*4)^{1/2}$

$= 5(12)^{1/2} = 5(3.4641) = 17.32$km

4.(a) With a neat sketch explain GSM signaling model. [10] CO3 L4

FIGURE 5–6
GSM
signaling
model.



Physical layer

- Layer 1, which is a radio interface, provides the functionality required to transfer the bit streams over the physical channels on the radio medium.
- The physical channels are defined here by a TDMA scheme.
- The services provided by this layer to those above include:
  - **Channel mapping (logical to physical)**
  - **Channel coding and ciphering**
  - **Digital modulation**
  - **Frequency hopping**
  - **Timing advance and power control**

Data link layer

- Signaling Layer 2 is based on the LAPDm protocol, which is a variation of the ISDN LAP-D protocol.
  - In Integrated Services Digital Network (ISDN) telecommunications, **Link Access Procedures, D channel** is part

of the network's communications protocol which ensures that messages are error free and executed in the right sequence.

  - D channel (delta channel) is a telecommunications term which refers to the ISDN channel in which the control and signaling information is carried.

The bit rate of the D channel of a basic rate interface is 16 kbit/s, whereas it amounts to 64 kbit/s on a primary rate interface

- LAPDm forms Layer 2 of the Um interface between the Base Transceiver Station and Mobile station, which is to say that it is used in the radio link between the cellular network and the subscriber handset.

- Layer 2 is the data link layer, which does following three main functions.

  - Establish, maintain and tear down the link
  - Flow control
  - Error detection
  - Work on the Layer-3 frames

- LAPD at BTS converts potentially unreliable physical link of MS into reliable link.
- This connects with BSC's MTP part.
- This is done with the use of CRC and ARQ techniques.
- ARQ stands for Automatic Repeat Request.
- ARQ works on the principle of re-transmission of packet when the erroneous packet is received at the receiver.

Network layer.

- Signaling Layer 3 takes care of signaling procedures between an MS and the network.

- At layer-3 there are many protocols involved as mentioned below with their respective functions:

- **RRM**- Stands for Radio Resource Management, takes care of radio channel and handover functionalities. Assign, maintain and release radio frequency carriers/channels.

- **MM**- Stands for Mobility management, takes care of location update, registration, security and authentication functionalities of mobile station with the GSM network.

- **CM**- Stands for Connection Management, takes care of call setup, call maintenance and call termination funtions of end devices.

- **BTSM**- stands for BTS Management, takes care of BTS admin and management functions under BSC control.

- **MAP**(Mobile Application Part): takes care of signaling between various network entities.

4. (b) Explain various logical channels used in GSM. [10] CO3 L4

Logical Channels

1. **Broadcast channels** – Provides information to the MS about various system parameters and also information about the location area identity (LAI). Three types of broadcast channels
   - **Broadcast control channel (BCCH)** – Contains information that is needed by the MS concerning the cell that is attached to in order for the MS to be able to start making or receiving call or to start roaming.
   - Type of information includes: LAI, o/p power allowed in cell, BCCH carrier frequencies for neighboring cells. Only txted on downlink from BTS to MS.
   - **Frequency correction channel (FCCH)**- Transmits bursts of zeros to the MS. Broadcast only on downlink.
   - **Synchronization channel (SCH)**– It is used to transmit the required information for the MS to synchronize itself with the timing within a particular cell
2. **Common control channels (CCCHs) -** Provides paging messages to the MS and a means by which the mobile can request a signaling channel that it can use to contact a network
   - **Paging channel (PCH)** – It is used by the system to send paging messages to the mobiles attached to the cell
   - **Random access channel (RACH)**– Used by the mobile to respond to a paging message
   - **Access grant channel (AGCH)** – Used by the network to assign a signaling channel to the MS
3. **Dedicated control channels (DCCHs) –** Used for specific call setup, handover, short message delivery functions.

- **Stand-alone dedicated control channel (SDCCH**) – Both MS and BTS switch over n/w assigned SDCCH.
- **Slow associated control channel (SACCH**) – Used to transmit information about measurements made by the MS
- **Fast associated control channel (FACCH**) – Used to facilitate the handover operation in a GSM system
- **Cell broadcast channel (CBCH**) – Used to deliver short message service

5.(a) Explain GSM inter-BSC handover operation with a neat block diagram. [10] CO3 L4

In this case BSC1, (old BSC) does not control the letter cell which is the target for the handover. This means that the MSC (Figure 3.3) will be part of the link procedure between BSC1 and BSC2 (new BSC).
BSC1 will use the MSC to send a handover request to BSC2. The MSC will know which BSC controls that cell

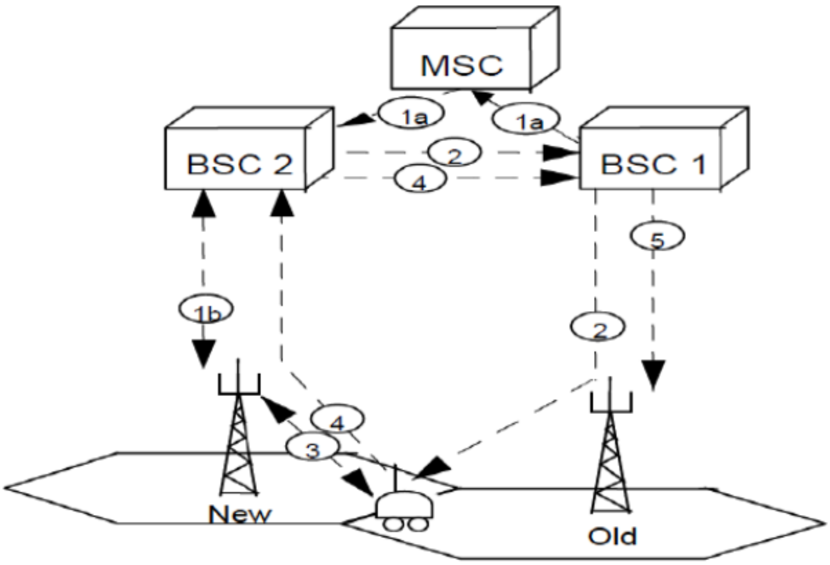
Activation of New Channel
BSC2 will allocate a TCH in the target cell and then order the BTS to activate it. The chosen HO will be part of the activation message. The BTS will acknowledge that the activation has been made

Handover Command
After the activation the new BSC commands the MS to change to the new channel. The message is sent on FACCH via the old channel and will contain a full description of the new channel and the HO

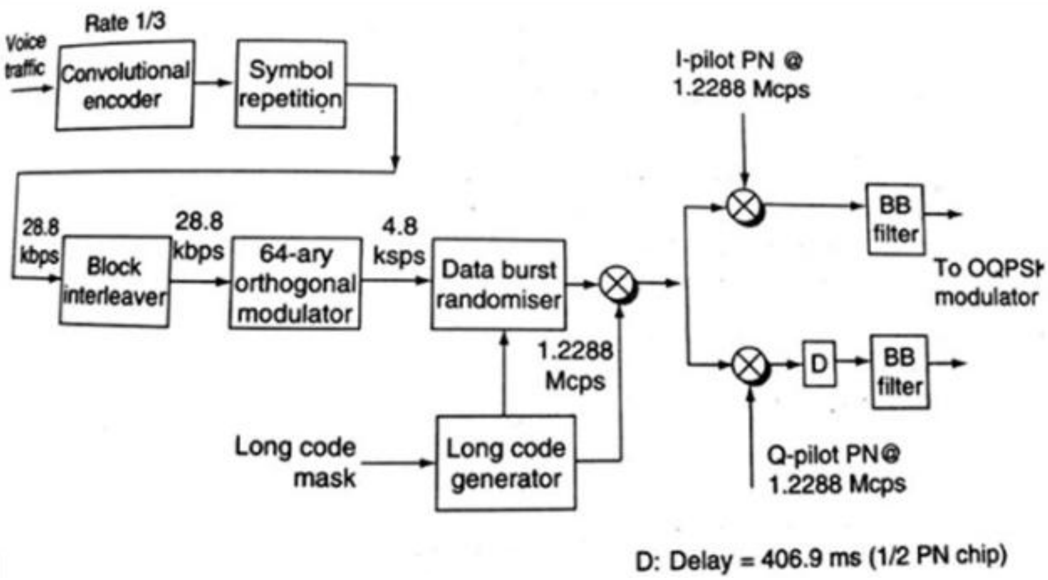
Handover Bursts
When the MS has changed to the new channel, it will send handover bursts on the new channel. The information content is the HO. The bursts are as short as the access bursts. This is because the MS does not know the new Timing Advance (TA) value yet. On the detection of the handover bursts, and check of HO, the new BTS will send the new TA.

Handover Complete
Now the MS is ready to continue the traffic and will send a handover complete message, which will be addressed to the old BSC as a clear command.

Release of Old Channel
When the old BSC receives the clear command from the MSC, the BSC knows that the handover was successful. The BSC orders the BTS to release the TCH and the BTS will acknowledge

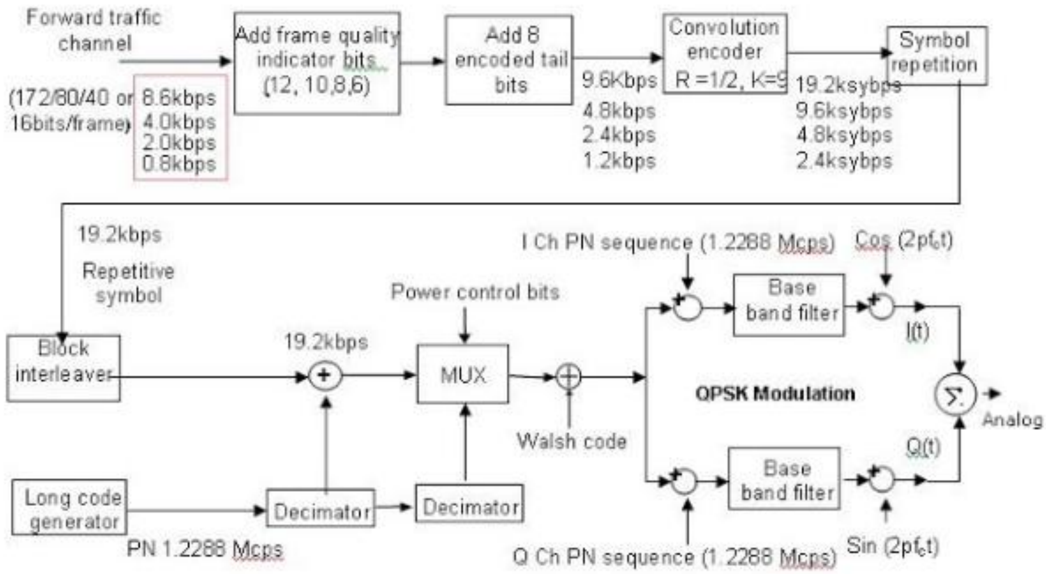


5.(b) With a neat block diagram, explain the generation of CDMA reverse access channel. [10] CO3 L4



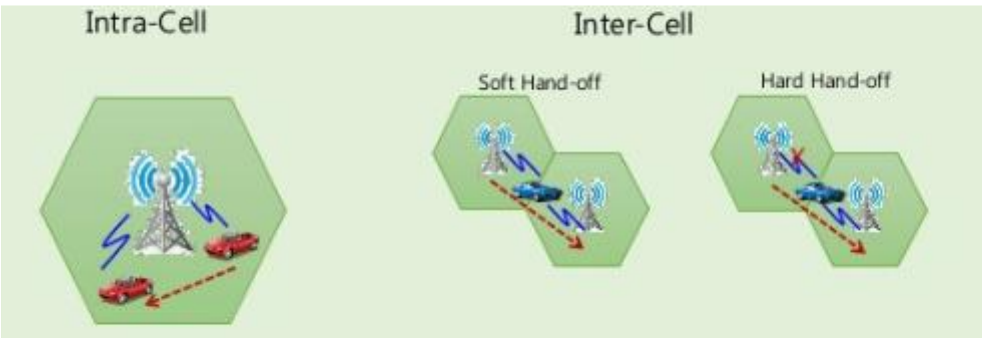
6.(a) Explain with block diagram, the generation of CDMA fwd traffic control with power control for 14.4 kbps traffic. [10] CO3 L4

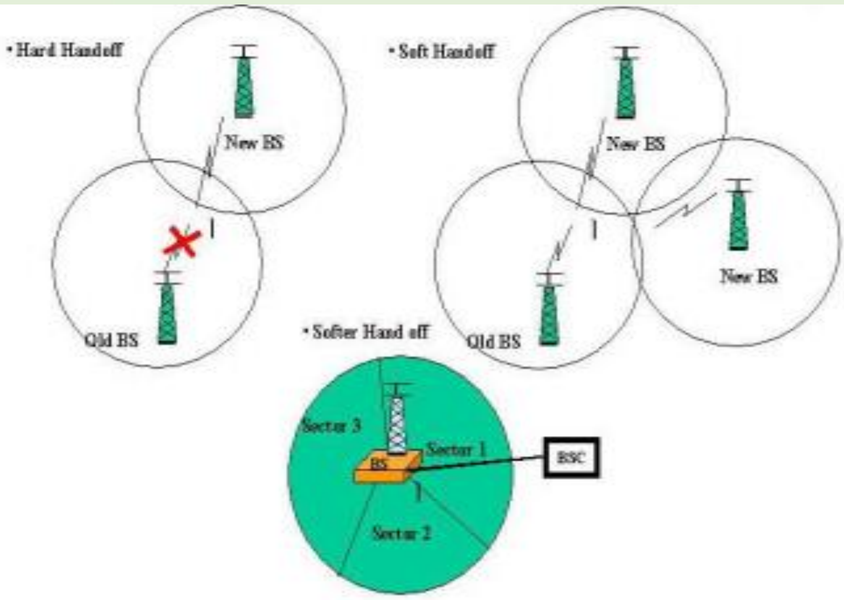
Soln:



6. (b)Describe soft hand off process in CDMA. [10] CO3 L4

Soln:





7.(a) Explain convolutional and Turbo encoders. **[6]** **CO4** L4

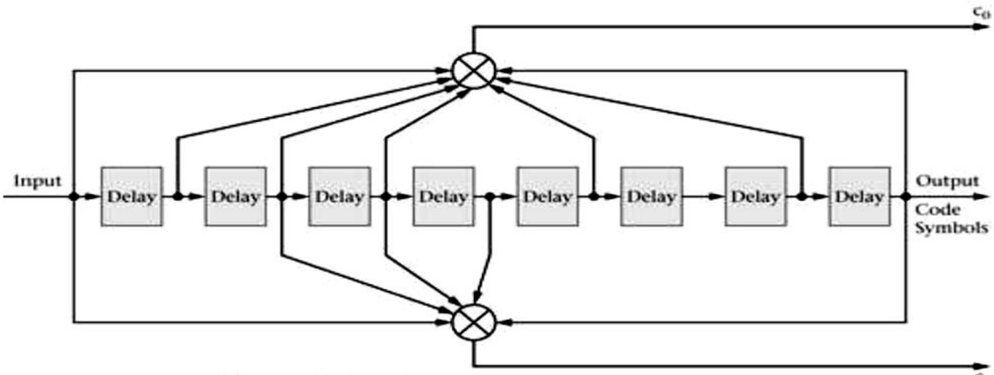
Convolutional codes

- Convolutional codes are applied in applications that require good performance with low implementation complexity.

- They operate on code streams (not in blocks)
- It maps information to code bits sequentially by convolving a sequence of information bits with “generator”.
- k & n are very small (usually k=1-3, n=2-6)

Input depends not only on current set of k input bits, but also on past input

- In cdma2000 system a convolutional encoder with R=1/3 and K=9 is used.
- In practice, the use of convolutional encoders provides better FEC capabilities than available from block codes.
- Figure shows in block diagram form an implementation of a convolutional encoder (with K=9 and R=1/2) specified for use in cdma2000

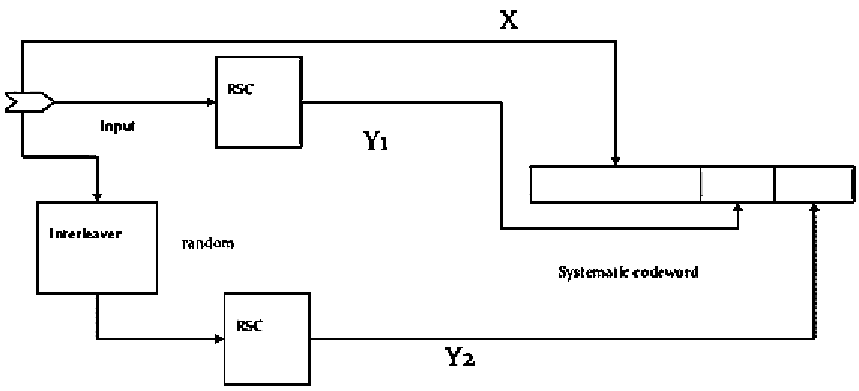


Rate 1/2, $K = 9$ Convolutional Encoder

- Turbo codes are a class of error correcting codes codes introduced in 1993 that come closer to approaching Shannon’s limit than any other class of error correcting codes.

- Turbo codes achieve their remarkable performance with relatively low complexity encoding and decoding algorithms.

- Turbo encoders are a modified form of combined convolutional encoders that can be used to create a new class of enhanced error correction codes.
- It is constructed from two systematic, recursive convolutional encoders connected in parallel with an interleaver preceding the input to the second convolutional encoder.
- The output bit steams of the two convolutional encoders are multiplexed together and repeated to form the final code symbols.
- For cdma2000, Rate 1/2, 1/3, 1/4 and 1/5 turbo encoders are employed instead of convolutional encoders for various higher-bit transfer rates and radio configurations
- The turbo decoder uses soft decision to decode the bits and the decoding is done in an iterative fashion to increase reliability of the decision.
- performance of the turbo code improves by increasing the number of iterations.
- Interleaver is used to scramble bits before being input to the second encoder.
- This makes the output of one encoder different from the other encoder.



- Thus, even if one of the encoders occasionally produces a low-weight, the probability of both the encoders producing a low-weight output is extremely small.

7.(b) Discuss path loss model. **[4]** CO4 L2

Path-loss models are used to predict the average received signal strength at receiver for given transmitted power at a distance d.

- Types of Path loss model
- Free space model
- Two-ray model
- Okumura model
- Okumura-Hata model. Etc

Free space propagation model

- This model is used to predict received signal strength when the transmitter and receiver have a clear line-of-sight path between them.
  Examples :
- Satellite communication
- Microwave line-of-sight radio link
  The received signal power at distance d (Friis free space equation)

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

Where

Pt : transmitted power, d : T-R separation distance (m)
Pr : Received power, Gt: transmitter antenna gain , λ : =c/f
Gr : receiver antenna gain

- Limitation: It does not give accurate result when applied to mobile radio environments.

7.(c) Explain with a neat block diagram RAKE receiver. [10] CO4 L4

- A rake receiver is a radio receiver designed to counter the effects of multipath fading.
- It does this by using several "sub-receivers" called fingers, that is, several correlators each assigned to a different multipath component.
- Each finger independently decodes a single multipath component; at a later stage the contribution of all fingers are **combined** in order to make the most use of the different transmission characteristics of each transmission path.
- This could very well result in higher signal-to-noise ratio (or Eb/N0) in a multipath environment than in a "clean" environment.
- Since each component contains the original information, if the magnitude and time-of-arrival (phase) of each component is computed at the receiver

(through a process called channel estimation), then all the components can be added.

- The outputs of each correlator are weighted to provide better estimate of the transmitted signal than is provided by a single component.
- Demodulation and bit decisions are then based on the weighted outputs of the *M* correlators.

Rake receivers are common in a wide variety of CDMA and W-CDMA radio devices such as mobile phones and wireless LAN equipment.

- Each correlator detects a time-shifted version of the original CDMA transmission, and each finger of the RAKE correlates to a portion of the signal, which is delayed by at least one chip in time from the other fingers.
- Assume M correlators are used in a CDMA receiver to capture M strongest multipath components.
- A weighting network is used to provide a linear combination of the correlator output for bit decision.
- Correlator 1 is synchronized to the strongest multipath m1.
- Multipath component m2 arrived t1 later than m1 but has low correlation with m1.

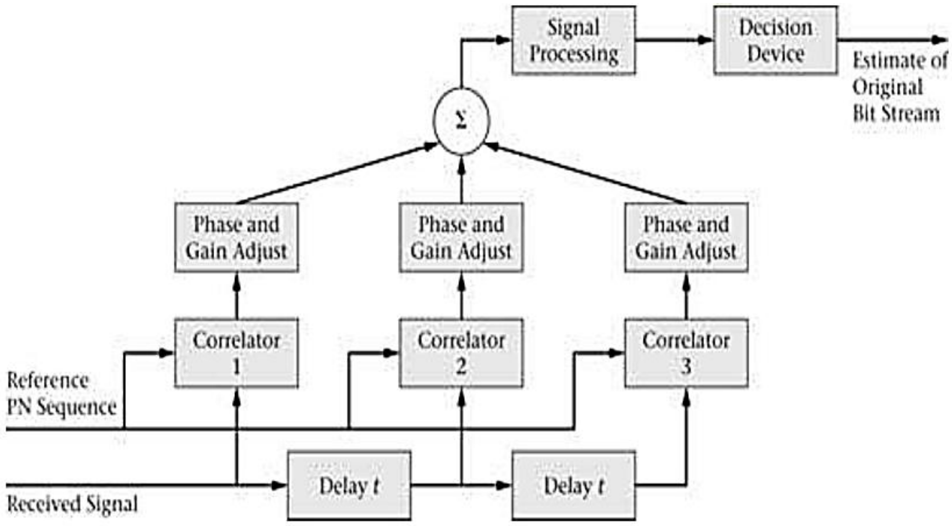


Figure 7.10: RAKE receiver block diagram

8.(a) What are IEEE 802.11 extensions? [6] CO5 L1

The IEEE 802.11a Standard

- – Data rates up to 54 Mbps in the 5-GHz frequency band.
- – It uses an OFDM encoding scheme rather than FHSS or DSSS.

The IEEE 802.1Ib Standard

- – It is also referred to as High Rate or Wi-Fi standard
- – Data rate of 11 Mbps in the 2.4 GHz band.
- – It uses only DSSS.

The IEEE 802.11g Standard

- – It offers wireless transmission over relatively short distances at 20 - 54 Mbps in the 2.4 GHz band.

- – It uses the OFDM encoding scheme.

The IEEE 802.11e Standard
The IEEE 802.11f Standard
The IEEE 802.11h Standard
The IEEE 802.11i Standard
The IEEE 802.11j Standard

The IEEE 802.11k Standard

The IEEE 802.11ma Standard

- – It updates the standard by providing editorial and technical corrections.

The IEEE 802.11n Standard

- – It enhances the WLAN user's experience by providing data throughput rates in excess of 100 mbps.

The IEEE 802.11p Standard

The IEEE 802.11r Standard

The IEEE 802.11s Standard

The IEEE 802.11u Standard

The IEEE 802.11v Standard

8. (b) Describe Bluetooth protocol stack with relevant figures. [8] CO5 L3

- The Bluetooth standard call for a set of communication protocols and a set of interoperable application that are used to support the usages address in the specifications.
- The link manager protocol (LMP) and the Logical Link Control And Adaptation(L2CAP) layer protocol are Bluetooth specific whereas the protocols within the "Other" box are not.
- Some of these other protocols are the point-to-point protocol (PPP) and wireless application protocol (WAP).
- **Physical radio layer:** It is for Tx and Rx data and voice.
- **Baseband layer:** It enables RF link between Bluetooth devices.
- **Link manager**: It is the protocol that handles link establishment b/w Bluetooth devices which include authentication and encryptions.
- **LLC and L2CAP:** It is connection based communication protocol that implements multiplexing. No flow control. But provide reliable base band link.
- **Audio profile:** It responsible for managing connection for Tx /Rx data from audio devices.
- **Control:** For control signal generations for various activities.

Other LLC: Link controller for optional device, fax, headsets like cordless phone etc

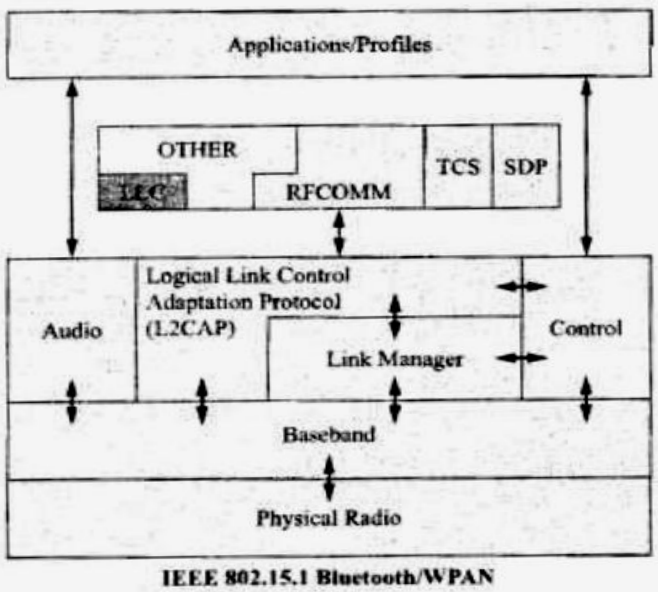


Figure 10–7 The Bluetooth protocol stack (Courtesy of IEEE).

8.(c) Depict the relationship between 802.11 sending and receiving station with a state diagram. [10] CO5 L3

When a station is going to communicate with another station over the WM, the type of messages (MAC frames) that can be sent from the source to the destination depends upon the current state existing between the two stations. Figure 9–7 shows the connection between the allowable architectural services and the current relationship of the sending station and the destination station. As shown by the figure, different levels or states of station authentication and association correspond to different types of transferable frame classes. Class 1 frames are various control (request to send, clear to send, acknowledgement, etc.), management, and restricted data frames; Class 2 frames are only management frames (e.g., association, reassociation, and disassociation); and Class 3 includes all three types of frames including unrestricted data frames. If incorrect or unallowed classes of frames are sent and received, deauthentication or disassociation frames (as appropriate) will be sent back to the sending station.

Each one of the services introduced previously in this section is supported by one or more IEEE 802.11 messages. To give the reader a feel for the general makeup of the message and type of information contained in the messages, several examples of different message types will be given here.