Name: Waseem Khan

ID: 12984

Department: BS (CS)

Semester: 8th

Course: Wireless network

Question no 1

Part A) List five ways of increasing the capacity of a cellular system?

A. Cell splitting:

Cell splitting is the process of sub dividing a congested cell into smaller cells, each with its own base station and corresponding reduction in antenna height and transmitted power. Cell splitting increases capacity of a cellular system since it increases number of times that channels are reused. By defining new cells which have a smaller radius than the original cells and by installing these smaller cells between existing cells, capacity increases due to additional number of channels per unit cell area In this D/R ratio is kept constant and entire system is rescaled.

B. Cell sectoring:

In cell sectoring a single omnidirectional antenna at base station is replaced by several directional antennas, each radiating within a specified sector. By using directional antennas power is transmitted in single desired direction decreasing number of interfering co-channel cells and co-channel interference. The technique for decreasing co-channel interference and thus increasing system performance by using directional antennas is called sectoring. The factor by which the co-channel interference is reduced depends on the amount of sectoring used. A cell is normally partitioned into three sectors. When sectoring is employed, the channels used in a particular cell are broken down into sectored groups and are used only within a particular sector.

C. Microcell zone concept:

The increased number of hand off, increase load on the switching and control link because of sectoring. A solution to this problem is given by microcell zone concept Large control base station is replaced by several lower power transmitters on the age of cell .The mobile retains the same channel and the base station simply switches the channel to a different zone site and the mobile moves from zone to zone. Since a given channel is active only in a particular zone in which mobile is travelling, base station radiation is localized and interference is reduced. The advantage of zone cell technique is that while the cell maintains a particular coverage radius, co-channel interference in the cellular system is reduced. As the large central base station is replaced by several lower power transmitters on ages of cell. Decreased co-channel interference improves signal quality leads to increase in capacity without degradation in trucking efficiency caused by sectoring.

D. Frequency borrowing

In the simplest care, frequencies are taken and from adjacent cells by congested cells. The frequencies can also be assigned to cells dynamically.

E. Adding new channels
typically, when a system is set up in a region, not all of the channels are used growth and expansion can be managed in an orderly fashion by adding new channels.

PART B)

3G - Third Generation

This generation set the standards for most of the wireless technology we have come to know and love. Web browsing, email, video downloading, picture sharing and other **Smartphone** technology were introduced in the third generation. Introduced commercially in 2001, the goals set out for third generation mobile communication were to facilitate greater voice and data capacity, support a wider range of applications, and increase data transmission at a **lower cost** .

The 3G standard utilizes a new technology called **UMTS** as its core network architecture - Universal Mobile Telecommunications System. This network combines aspects of the 2G network with some new technology and protocols to deliver a significantly faster data rate. Based on a set of standards used for mobile devices and mobile telecommunications use services and networks that comply with the International Mobile Telecommunications-2000 (**IMT-2000**) specifications by the International Telecommunication Union. One of requirements set by IMT-2000 was that speed should be at least 200Kbps to call it as 3G service.

3G has Multimedia services support along with **streaming** are more popular. In 3G, Universal access and portability across different device types are made possible (Telephones, PDA's, etc.). 3G increased the efficiency of frequency spectrum by improving how audio is **compressed** during a call, so more simultaneous calls can happen in the same frequency range. The UN's International Telecommunications Union **IMT-2000** standard requires stationary speeds of 2Mbps and mobile speeds of 384kbps for a "true" 3G. The theoretical max speed for **HSPA+** is 21.6 Mbps.

Like 2G, 3G evolved into 3.5G and 3.75G as more features were introduced in order to bring about 4G. A 3G phone cannot communicate through a **4G network** , but newer generations of phones are practically always designed to be backward compatible, so a 4G phone can communicate through a 3G or even **2G network** .

4G - Fourth Generation

4G is a very different technology as compared to **3G** and was made possible practically only because of the advancements in the technology in the last 10 years. Its purpose is to provide **high speed** , high quality and high capacity to users while improving security and lower the cost of voice and data services, multimedia and internet over IP. Potential and current applications include amended mobile web access, **IP telephony** , gaming services, high-definition mobile TV, video conferencing, 3D television, and cloud computing.

The key technologies that have made this possible are **MIMO** (Multiple Input Multiple Output) and **OFDM** (Orthogonal Frequency Division Multiplexing). The two important 4G standards are WiMAX (has now fizzled out) and **LTE** (has seen widespread deployment). LTE (Long Term Evolution) is a series of upgrades to existing UMTS technology and will be rolled out on Telstra's existing 1800MHz frequency band. The max speed of a 4G network when the device is moving is 100 Mbps or **1 Gbps** for low mobility communication like when stationary or walking, latency reduced from around 300ms to less than 100ms, and significantly lower congestion. When 4G first became available, it was simply a little faster than 3G. 4G is not the same as **4G LTE** which is very close to meeting the criteria of the standards. To download a new game or stream a TV show in HD, you can do it **without buffering** .

Newer generations of phones are usually designed to be **backward-compatible** , so a 4G phone can communicate through a 3G or even 2G network. All carriers seem to agree that **OFDM** is one of the chief indicators that a service can be legitimately marketed as being 4G. OFDM is a type of digital modulation in which a signal is split into several narrowband channels at different frequencies. There are a significant amount of infrastructure changes needed to be implemented by service providers in order to supply because voice calls in **GSM** , **UMTS** and **CDMA2000** are circuit switched, so with the adoption of LTE, carriers will have to re-engineer their voice call network. And again, we have the fractional parts: **4.5G** and **4.9G** marking the transition of LTE (in the stage called LTE-Advanced Pro) getting us more MIMO, more D2D on the way to IMT-2020 and the requirements of **5G** .

5G - Fifth Generation

5G is a generation currently **under development** , that's intended to improve on 4G. **5G** promises significantly faster data rates, higher connection density, much lower latency, among other improvements. Some of the plans for 5G include **device-to-device** communication, better battery consumption, and improved overall wireless coverage. The max speed of 5G is aimed at being as fast as **35.46 Gbps** , which is over 35 times faster than 4G.

Key technologies to look out for: **Massive MIMO** , Millimeter Wave Mobile Communications etc. Massive MIMO, milimetre wave, small cells, **Li-Fi** all the new technologies from the previous decade could be used to give 10Gb/s to a user, with an unseen low latency, and allow connections for at least **100 billion devices** . Different estimations have been made for the date of commercial introduction of 5G networks. Next Generation Mobile Networks Alliance feel that 5G should be rolled out by **2020** to meet business and consumer demands.

Features	1G	2G	3G	4G	5G
Start/Devlopment	1970/1984	1980/1999	1990/2002	2000/2010	2010/2015
Technology	AMPS, NMT, TACS	GSM	WCDMA	LTE, WiMax	MIMO, mm Waves
Frequency	30 KHz	1.8 Ghz	1.6 - 2 GHz	2 - 8 GHz	3 - 30 Ghz
Bandwidth	2 kbps	14.4 - 64 kbps	2 Mbps	2000 Mbps to 1 Gbps	1 Gbps and higher
AccessSystem	FDMA	TDMA/CDMA	CDMA	CDMA	OFDM/BDMA
Core Network	PSTN	PSTN	Packet Network	Internet	Internet

PART C) Briefly explain Overall GSM Architecture with the help of diagram?

The GSM architecture consists of three major interconnected subsystems that interact with themselves and with users through certain network interface. The subsystems are Base Station Subsystem (BSS), Network Switching Subsystem (NSS) and Operational Support Subsystem (OSS). Mobile Station (MS) is also a subsystem but it is considered as a part of BSS.

1. Mobile Station (MS): Mobile Station is made up of two entities.

A. Mobile equipment (ME):

- It is a portable, vehicle mounted, hand held device.
- It is uniquely identified by an IMEI number.
- It is used for voice and data transmission. It also monitors power and signal quality of surrounding cells foe optimum handover. 160 characters long SMS can also be sent using Mobile Equipment.

B. Subscriber Identity module (SIM):

- It is a smart card that contains the International Mobile Subscriber Identity (IMSI) number.
- It allows users to send and receive calls and receive other subscriber services. - It is protected by password or PIN.
- It contains encoded network identification details. it has key information to activate the phone.
- It can be moved from one mobile to another.

2. Base Station Subsystem (BSS): It is also known as radio subsystem, provides and manages radio transmission paths between the mobile station and the Mobile Switching Centre (MSC). BSS also manages interface between the mobile station and all other subsystems of GSM. It consists of two parts.

A. Base Transceiver Station (BTS):

- It encodes, encrypts, multiplexes, modulates and feeds the RF signal to the antenna.
- It consists of transceiver units.
- It communicates with mobile stations via radio air interface and also communicates with BSC via Abis interface.

B. Base Station Controller (BSC):

- It manages radio resources for BTS. It assigns frequency and time slots for all mobile stations in its area.
- It handles call set up, transcoding and adaptation functionality handover for each MS radio power control.
- It communicates with MSC via A interface and also with BTS.

3. Network Switching Subsystem (NSS): it manages the switching functions of the system and allows MSCs to communicate with other networks such as PSTN and ISDN. It consist of

A. Mobile switching Centre:

- It is a heart of the network. It manages communication between GSM and other networks.
- It manages call set up function, routing and basic switching.

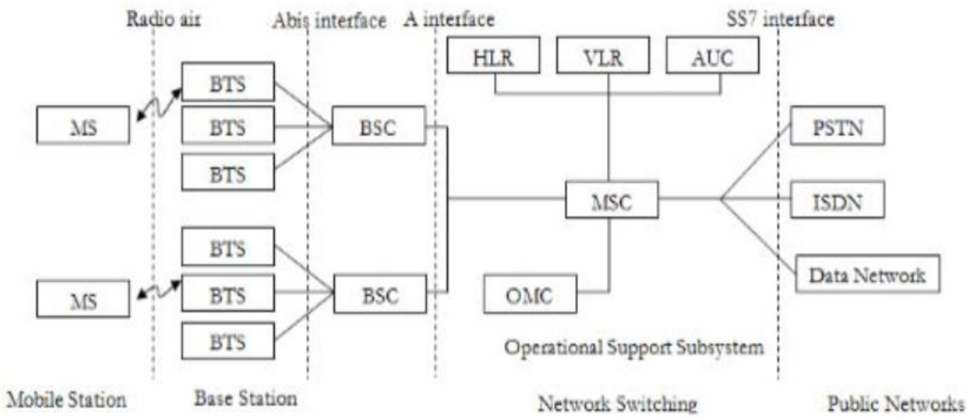


Fig: GSM Architecture

- It performs mobility management including registration, location updating and inter BSS and inter MSC call handoff.
- It provides billing information.
- MSC does gateway function while its customers roam to other network by using HLR/VLR.

B. Home Location Registers (HLR): - It is a permanent database about mobile subscriber in a large service area. **-** Its database contains IMSI, IMSISDN, prepaid/post-paid, roaming restrictions, supplementary services.

C. Visitor Location Registers (VLR): - It is a temporary database which updates whenever new MS enters its area by HLR database. **-** It controls mobiles roaming in its area. It reduces number of queries to HLR. **-** Its database contains IMSI, TMSI, IMSISDN, MSRN, location, area authentication key.

D. Authentication Centre: - It provides protection against intruders in air interface. - It maintains authentication keys and algorithms and provides security triplets (RAND, SRES, Ki).

E. Equipment Identity Registry (EIR):

- It is a database that is used to track handset using the IMEI number.
- It is made up of three sub classes- the white list, the black list and the gray list.

4. Operational Support Subsystem (OSS): It supports the operation and maintenance of GSM and allows system engineers to monitor, diagnose and troubleshoot all aspects of GSM system. It supports one or more Operation Maintenance Centres (OMC) which are used to monitor the performance of each MS, Bs, BSC and MSC within a GSM system. It has three main functions:

- To maintain all telecommunication hardware and network operations with a particular market.
- To manage all charging and billing procedures
- To manage all mobile equipment in the system.
- **Interfaces used for GSM network : (ref fig 2)**
  1)UM Interface –Used to communicate between BTS with MS
  2)Abis Interface— Used to communicate BSC TO BTS
  3)A Interface-- Used to communicate BSC and MSC
  4) Singling protocol (SS 7)- Used to communicate MSC with other network.

PART D) A telephony connection has duration of 35 minutes. This is the only connection made by this caller during the course of an hour. How much is the amount of traffic, in Erlangs, of this connection?

This is the only connection made by this caller during the course of an hour"
Therefore it stated that only 1 call takes place.
So number of calls=1
Minutes of traffic in the hour=number of calls x duration
Minutes of traffic in the hour=1 x 35
Minutes of traffic in the hour=35
Hours of traffic in the hour=35 / 60
Hours of traffic in the hour=0.5833
Amount of Traffic =0.5833 Erlangs

PART E) What are the current and future cellular network issues and challenges?

Most networks today are under stress due to growing broadband traffic. The networks that are easily the most stressed are cellular networks and I think that there can be lessons learned in looking how mobile providers are struggling to keep up with demand. Consider the following current issues faced by cellular network owners:

Traffic Volume Growth. Around the world cellular networks are seeing between 60% to 120% annual growth in data volumes. The problem with that kind of growth is that as soon as any upgrade is made to a part of the network it is consumed by the growth. This kind of growth means constant choke points in the network and problems encountered by customers.
The large cellular companies like Verizon and AT&T are handling this with big annual capital budgets for network improvements. But they will be the first to tell you that even with those expenditures they are only putting band-aids on the problem and are not able to get ahead of the demand curve.

Network Problems Can be Extremely Local. The vagaries of wireless delivery mean that there can be network congestion at a location but no network issues as close as 50 yards away. This makes it very hard to diagnose and fix network issues. Problems can pop up and disappear quickly. A few more large data users than normal can temporarily cripple a given cell site.

Networks are Operating too Many Technologies. It's not unusual to find a given cell site operating several versions of 3G and 4G and sometimes still even 2G. The average cell site carries 2.2 different technologies, provided by 1.3 different vendors.

Still Too Many Failures. There are still a lot of dropped voice calls, and 80% of them are caused by mobility failures, meaning a failure of the network to handle a customer on the move. 50% of dropped data sessions are due to capacity issues.
Cellular providers are looking for the capacity to more dynamically assign radio resources on the fly at different times of the day. It's been shown that there are software techniques that can optimize the local network and can reduce failures by as much as 25%.

CHALLENGES TO FUTURE MOBILE NETWORKS The main objective of future mobile networks is to integrate all mobile networks by providing the roaming and seamless handover facility between different cellular networks and public private unlicensed networks, hence raising different challenges. We can divide the challenges of future mobile networks into following categories:

- Efficient utilization of network resources in CHN environment.
- Technological independent network access, end to end connection and seamless handover.
- Maintaining the certain level of QoS (Quality of Service) for user applications.
- Cooperative network management.
- An intelligent billing policy.

Networks, different types of wireless

networks are interconnected to support handoff from one technology to another. These wireless systems were
designed independently and targeting different service types, data rates, and users, and thus require an intelligent
interworking approach. Effective, secure and efficient operations and management are the major challenge for
the development of 4G. In such environment, both the mobile user and the interconnected wireless networks
together play an important role in determining how service continuity and service quality can be served in a handover
and helps in providing best service to the user [2]. There are number of research challenges which need to be solved
in order to achieve 4G network goals. These challenges
are listed below.

A. Network Discovery:

4G – Network devices will be multi-mode, multi-access and reconfigurable. Which
means each terminal can be using more than one type of network and possibly can access multiple networks

simultaneously for different applications. In such an environment, a terminal must be able to discover what networks are available for use. As a solution to this issue currently a technique namely Software defined radio is proposed. In this technique components that have been implemented in hardware are instead implemented using software on a personal computer or other embedded computing devices.

B. Access technologies:

4G- network is a heterogeneous wireless environment consist of number of radio technologies and may have overlapped radio coverage. A mobile user needs to switch between access networks to maintain service continuity and optimize service quality. Dealing with heterogeneous access technologies is a challenge to the design of 4G – Network. More over selecting the network that will satisfy the Qu's

QUESTION NO 2

PART A)

List and briefly define the capabilities provided by Mobile IP?

1. Discovery: In order to identify prospective home agents and foreign agents, a mobile node uses agent discovery
2. Registration: an authenticated registration procedure is used to inform its home agent of its care-of address.
3. Tunneling: IP datagrams are forwarded from a home address to a care-of address.

PART B)

What are the two different types of destination addresses that can be assigned to a mobile node while it is attached to a foreign network?

There are two different types of destination addresses that can allocated to a mobile node while it is attached to a foreign network.

These are following

1. Home address
An IP address that is assigned for an extended period of time to a mobile node. It remains unchanged regardless of where the node is attached to the internet

2. Care Address
The termination point of a tunnel toward a mobile node, for datagrams forwarded to the mobile node while it is away from home.

PART C) what is tunneling?

Tunneling is a protocol that allows for the secure movement of data from one network to another. Tunneling involves allowing private network communications to be sent across a public network, such as the Internet, through a process called encapsulation. The encapsulation process allows for data packets to appear as though they are of a public nature to a public network when they are actually private data packets, allowing them to pass through unnoticed.

There are various protocols that allow tunneling to occur, including:

- Point-to-Point Tunneling Protocol (PPTP): PPTP keeps proprietary data secure even when it is being communicated over public networks. Authorized users can access a private network called a virtual private network, which is provided by an Internet service provider. This is a private network in the "virtual" sense because it is actually being created in a tunneled environment.
- Layer Two Tunneling Protocol (L2TP): This type of tunneling protocol involves a combination of using PPTP and Layer 2 Forwarding.

Tunneling is a way for communication to be conducted over a private network but tunneled through a public network. This is particularly useful in a corporate setting and also offers security features such as encryption options.

PART D)

Briefly explain WAE, WSP, WTP, WTLS, WDP & WCMP Protocols in WAP Protocol Stack?

The WAP stack consists of the following layers:

WAE – WIRELESS APPLICATION ENVIRONMENT

The Wireless Application Environment (WAE) defines the following functions:

Wireless Markup Language (WML).

WML is an XML-based markup language for the visual display of WAP-based contents. Once HTML and WML will converge into XML, many compatibility problems, during conversion from HTML to WML, will cease to exist.

WML Script.

A script language, very similar to JavaScript.

Wireless Telephony Application (WTA, WTAI).

Telephony services and Programming interfaces.

Content formats.

These are specifications for data formats, including images, telephone directories, calendar information, and so on.

The WAE corresponds to the application layer in the OSI model.

WSP – WIRELESS SESSION PROTOCOL

The Wireless Session Protocol (WSP) implements an interface for connection-oriented and connectionless session services. The connection-oriented session service operates using the protocol of the transaction layer. However, the connectionless session service uses a secure or non-secure datagram service.

WSP offers the following basic functions:

- Functions and semantics of HTTP/1.1, using a compact coding scheme
- Pausing and resuming sessions
- A general facility for reliable and unreliable data push
- Negotiation of protocol functions

WTP – WIRELESS TRANSACTION PROTOCOL

The Wireless Transaction Protocol (WTP) is a transaction-oriented protocol, executed using a datagram service. WTP offers the following functions:

Three classes of transaction services

(a) Unreliable one-way requests

(b) Reliable one-way requests

(c) Reliable two-way request/response transactions

Optional user-to-user reliability feature.

The WTP user triggers confirmation for each received message.

Optional out-of-band data for confirmations.

Protocol Data Unit (PDU) chaining and delayed confirmation.

In order to reduce the number of sent messages

Asynchronous transactions

WTLS – WIRELESS TRANSACTION LAYER SECURITY

The WTLS layer implements a security protocol based on the TLS (Transport Layer Security) industry standard. WTLS is intended for use with the WAP transport protocols and has the following features:

Data integrity – WTLS ensures that the data sent between the terminal and an application server is in no way altered or damaged.

Confidentiality – WTLS ensures that the data sent between the terminal and an application server remains confidential and cannot be understood by any other participant who may have intercepted the data stream.

Authentication – WTLS ensures the authenticity of the terminal and of the application server.

Denial-of-service protection – Wireless Transaction Layer Security (WTLS) contains features that will recognize and reject data that has been repeated or not verified successfully. WTLS hinders many typical denial-of-service attacks and protects the upper protocol layers. Though, this is not a perfect solution.

WDP – WIRELESS DATAGRAM PROTOCOL

The WDP layer operates on various bearers that depend on the used network type. WDP offers a consistent interface for the upper layers, so that communications occurs transparently using one of the available bearer services. Therefore, the transport layer is adapted to the specific functions of the underlying bearer.

WCMP – WIRELESS CONTROL MESSAGE PROTOCOL

The Wireless Control Message Protocol defines the error reporting mechanism for WDP datagrams as well as the protocol elements that can be used for diagnosis and informational purposes (for example, WCMP echo request and response). WCMP is determined depending on the bearer used. In IP-based networks, WCMP functions are implemented using the Internet Control Message Protocol (ICMP).

QUESTION NO 3

PART A) List and briefly define the IEEE 802 protocol layers?

Protocol Architecture Protocols defined specifically for LAN and MAN (metropolitan area network) transmission address issues relating to the transmission of blocks of data over the network. In OSI terms, higher-layer protocols (layer 3 or 4 and above) are independent of network architecture and are applicable to LANs, MANs, and WANs. Thus, a discussion of LAN protocols is concerned principally with lower layers of the OSI model. Figure 14.1 relates the LAN protocols to the OSI architecture (Figure 4.3). This architecture was developed by the IEEE 802 committee and has been adopted by all organizations working on the specification of LAN standards. It is generally referred to as the IEEE 802 reference model.1 Working from the bottom up, the lowest layer of the IEEE 802 reference model corresponds to the physical layer of the OSI model and includes such functions as

• Encoding/decoding of signals

• Preamble generation/removal (for synchronization)

• Bit transmission/reception

In addition, the physical layer of the 802 model includes a specification of the transmission medium and the topology. Generally, this is considered “below” the lowest layer of the OSI model. However, the choice of transmission medium and topology is critical in LAN design, and so a specification of the medium is included. Above the physical layer are the functions associated with providing service to LAN users. These include the following:

• On transmission, assemble data into a frame with address and error detection fields.

• On reception, disassemble frame, and perform address recognition and error detection.

• Govern access to the LAN transmission medium.

• Provide an interface to higher layers and perform flow and error control.

flow and error control. These are functions typically associated with OSI layer 2. The set of functions in the last bullet item are grouped into a logical link control (LLC) layer. The functions in the first three bullet items are treated as a separate layer, called medium access control (MAC). The separation is done for the following reasons: • The logic required to manage access to a shared-access medium is not found in traditional layer 2 data link control. • For the same LLC, several MAC options may be provided. Figure 14.2, which reproduces Figure 11.16, illustrates the relationship between the levels of the architecture. Higher-level data are passed down to LLC, which appends control information as a header, creating an LLC protocol data unit (PDU). This control information is used in the operation of the LLC protocol. The entire LLC PDU is then passed down to the MAC layer, which appends control information at the front and back of the packet, forming a MAC frame. Again, the control information in the frame is needed for the operation of the MAC protocol. For context, the figure also shows the use of TCP/IP and an application layer above the LAN protocols.

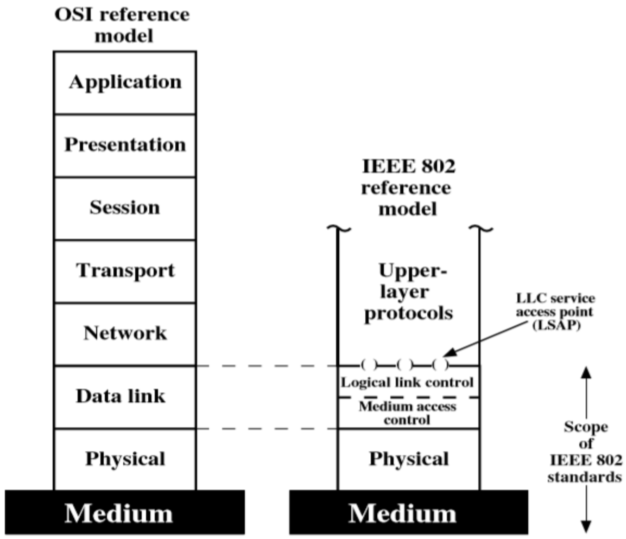


Figure 14.1 IEEE 802 Protocol Layers Compared to OSI Model

PART B)

Briefly differentiate between IEEE 802.11 n, o, p, r, s, t, u, v standards and their services?

802.11n — 802.11n builds upon previous 802.11 standards by adding ***m**ultiple-**i**nput **m**ultiple-**o**utput* (MIMO). The additional transmitter and receiver antennas allow for increased data throughput through spatial multiplexing and increased range by exploiting the spatial diversity through coding schemes like Alamouti coding. The real speed would be 100 Mbit/s (even 250 Mbit/s in PHY level), and so up to 4-5 times faster than 802.11g.

802.11r - 802.11r, also called *Fast **B**asic **S**ervice **S**et* (BSS) Transition, supports VoWi-Fi handoff between access points to enable VoIP roaming on a Wi-Fi network with 802.1X authentication.

IEEE 802.11r-2008 or **fast BSS transition** (**FT**), also called **fast roaming**, is an amendment to the IEEE 802.11 standard to permit continuous connectivity aboard wireless devices in motion, with fast and secure handoffs from one base station to another managed in a seamless manner. It was published on July 15, 2008. IEEE 802.11r-2008 was rolled up into 802.11-2012.[1]

802.11o Reserved and will not be used.

802.11p Defines WAVE (Wireless Access for Vehicular Environment) for ambulances and other high-speed vehicles and a roadside infrastructure in the licensed band of 5.9 GHz.

802.11s is a proposed amendment to the 802.11 wireless networking standards that will provide a vendor-neutral way to build wireless mesh networks over a wireless LAN (WLAN). Currently, enterprise mesh solutions rely on proprietary protocols to link access points together in a mesh. 802.11s enables interoperability between client devices of all types and manufacturers, enabling any device to link to a common mesh network.

IEEE 802.11T Task Group to develop a test specification document, "Recommended Practice for the Evaluation of 802.11 Wireless Performance," expected to be completed in January 2008. By forming the task group, the IEEE has acknowledged the need to provide users with an objective means of evaluating functionality and performance of 802.11 products.

IEEE 802.11p is an approved amendment to the IEEE 802.11 standard to add wireless access in vehicular environments (WAVE), a vehicular communication system. It defines enhancements to 802.11 (the basis of products marketed as Wi-Fi) required to support Intelligent Transportation Systems (ITS) applications. This includes data exchange between high-speed vehicles and between the vehicles and the roadside infrastructure, so called V2X communication, in the licensed ITS band of 5.9 GHz (5.85–5.925 GHz). IEEE 1609 is a higher layer standard based on the IEEE 802.11p

IEEE 802.11r-2008 or **fast BSS transition** (**FT**), also called fast roaming, is an amendment to the IEEE 802.11 standard to permit continuous connectivity aboard wireless devices in motion, with fast and secure handoffs from one base station to another managed in a seamless manner. It was published on July 15, 2008. IEEE 802.11r-2008 was rolled up into 802.11-2012

IEEE 802.11:

In July 2004, the IEEE formed the IEEE 802.11T Task Group to develop a test specification document, "Recommended Practice for the Evaluation of 802.11 Wireless Performance," expected to be completed in January 2008. By forming the task group, the IEEE has acknowledged the need to provide users with an objective means of evaluating functionality and performance of 802.11 products.

The 802.11T document defines test metrics in the context of use cases. The three principal-use cases are data, latency sensitive and streaming media.

IEEE 802.11u-2011 is an amendment to the IEEE 802.11-2007 standard to add features that improve interworking with external networks.

802.11 is a family of IEEE technical standards for mobile communication devices such as laptop computers or multi-mode phones to join a wireless local area network (WLAN) widely used in the home, public hotspots and commercial establishments.

The IEEE 802.11u standard was published on February 25, 2011.

802.11v is the Wireless Network Management standard for the IEEE 802.11 family of standards. 802.11v allows client devices to exchange information about the network topology, including information about the RF environment, making each client network aware, facilitating overall improvement of the wireless network.

802.11v describes enhancements to wireless network management, such as:

- Network assisted Power Savings - Helps clients to improve battery life by enabling them to sleep longer. For example, mobile devices use a certain amount of idle period to ensure that they remain connected to access points and therefore consume more power when performing the following tasks in a wireless network.

Network assisted Roaming - Enables the WLAN to send messages to associated clients, for better APs to associate with clients. This is useful for both load balancing and in directing poorly connected clients.

QUESTION NO 4

PART A) Throw some light on Bluetooth Low Energy (BLE) wireless technology

For a novice, it is simple to see BLE as a type of Bluetooth that uses less power, consumption or energy. It is an eco-friendly form of Bluetooth that has been developed specifically to facilitate the "Internet of Things". I guess by now almost every soul on the planet is familiar with what Bluetooth is, right? Anyways, to shed more light; think of using a wireless headset to listen to your favorite song on your smartphone. Yes, that is an application of Bluetooth.

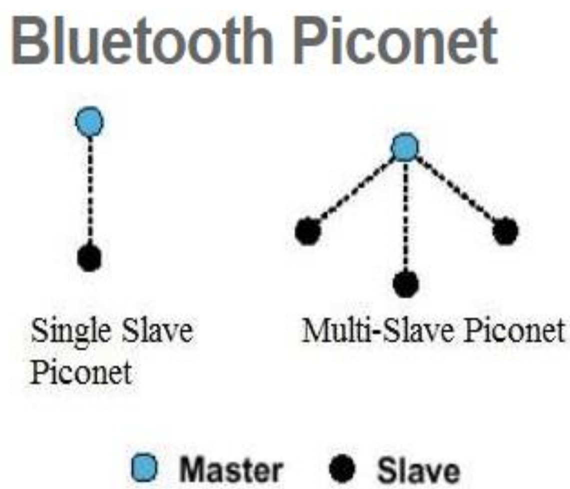
However, a new wave of technological advancement is on the horizon known as the Internet of Things or for short (IoT). This next wave of mainstream tech will enable the connectivity of your everyday household devices (like the washing machine, cooker, toaster, kettles, etc.) to one another and to the internet. These devices will be able to communicate with you directly or be controlled by a smart device such as your smartphone or tablet. Yes, that's right! You won't need to border about turning "on" or "off" the washing machine or heating the kettle manually as these would be possible just by the touch of a button on your smartphone. How cool is that?

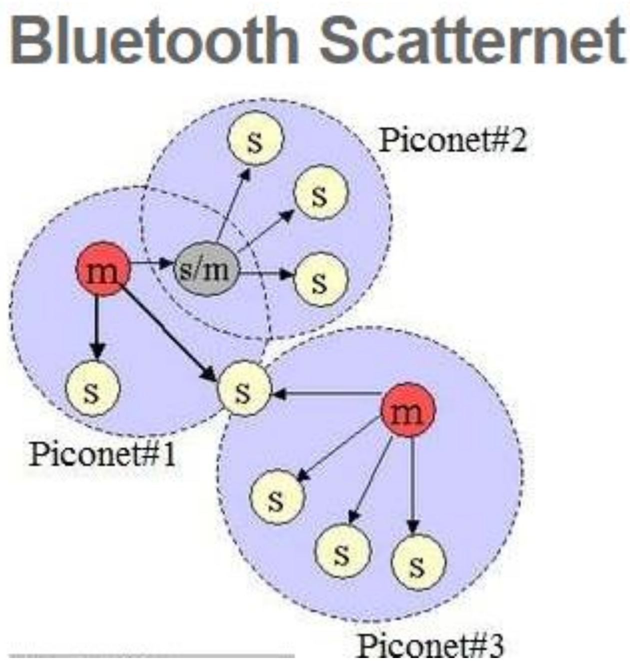
PART B)

Tabular difference between Piconet and Scatternet

Following table mentions difference between Piconet and Scatternet in bluetooth.

Piconet	Scatternet
In this bluetooth network, device can function either as master or slave.	In this bluetooth network, device can function as master or slave or (master+slave)
It serves smaller coverage area.	It serves larger coverage area.
It supports maximum 8 nodes.	It supports more than 8 nodes.
It allows less efficient use of available bluetooth channel bandwidth.	It allows more efficient use of available bluetooth channel bandwidth.





PART C)

Define L2CAP data packet format?

The Logical Link Control and Adaptation Layer Protocol (L2CAP) is layered over the Baseband Protocol and resides in the data link layer. L2CAP provides connection-oriented and connectionless data services to upper layer protocols with protocol multiplexing capability, segmentation and reassembly operation, and group abstractions. L2CAP permits higher level protocols and applications to transmit and receive L2CAP data packets up to 64 kilobytes in length.

Two link types are supported for the Baseband layer : Synchronous Connection-Oriented (SCO) links and Asynchronous Connection-Less (ACL) links. SCO links support real-time voice traffic using reserved bandwidth.

ACL links support best effort traffic. The L2CAP Specification is defined for only ACL links and no support for SCO links is planned.