Department of Electrical Engineering
Assignment
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Course Details

Course Title: Mobile and broadband network **Module:** 3rd
Instructor: Sir Pir Mehr Ali Shah **Total Marks:** 30

Student Details

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Q1.	(a)	In how many types , an optical access network can be classified explain each of them.	Marks 6
	(b)	What are the advantages of satellite communication over terrestrial communication?	Marks 4
Q2.	(a)	What are the types of wifi technologies, discuss each type .	Marks 4
	(b)	Explain in details about wireless body area network along with its types .	Marks 6
Q3.	(a)	Write a comparative detail about the evolution of mobile technology from 1^{st} generation to 5^{th} generation.	Marks 6
	(b)	What is DSL? Explain its architecture along with its types.	Marks 4

Q1. (a) In how many types, an optical access network can be classified, explain each of them.

ANS: Optical access network, also known as “fiber subscriber loop.” It refers to a set of access connections that use optical transmission or partially share the same network side interface between the service node or the remote module and the user equipment.

Fiber optics uses light signals to transmit data. As this data moves across a fiber, there needs to be a way to separate it so that it gets to the proper destination.

There are two important types of systems that make fiber-to-the-home broadband connections possible. These are **active optical networks** and **passive optical networks.** Each offers ways to separate data and route it to the proper place, and each has advantages and disadvantages as compared to the other.

An active optical system uses electrically powered switching equipment, such as a router or a switch aggregator, to manage signal distribution and direct signals to specific customers. This switch opens and closes in various ways to direct the incoming and outgoing signals to the proper place. In such a system, a customer may have a dedicated fiber running to his or her house.

A passive optical network, on the other hand, does not include electrically powered switching equipment and instead uses optical splitters to separate and collect optical signals as they move through the network. A passive optical network shares fiber optic strands for portions of the network. Powered equipment is required only at the source and receiving ends of the signal.

In some cases, FTTH systems may combine elements of both passive and active architectures to form a hybrid system.

Passive optical networks, or PONs, have some distinct advantages. They're efficient, in that each fiber optic strand can serve up to 32 users. PONs have a low building cost relative to active optical networks along with lower maintenance costs. Because there are few moving or electrical parts, there's simply less that can go wrong in a PON.

Passive optical networks also have some disadvantages. They have less range than an active optical network, meaning subscribers must be geographically closer to the central source of the data. PONs also makes it difficult to isolate a failure when they occur. Also, because the bandwidth in a PON is not dedicated to individual subscribers, data transmission speed may slow down during peak usage times in an effect known as latency. Latency quickly degrades services such as audio and video, which need a smooth rate to maintain quality.

Active optical networks offer certain advantages, as well. Their reliance on Ethernet technology makes interoperability among vendors easy. Subscribers can select hardware that delivers an appropriate data transmission rate and scale up as their needs increase without having to restructure the network.

Active optical networks, however, also have their weaknesses. They require at least one switch aggregator for every 48 subscribers. Because it requires power, an active optical network inherently is less reliable than a passive optical network

The main features of the optical access network

1. The network coverage radius is generally small, and no repeater can be needed. However, due to the sharing of optical power or wavelength distribution caused by many users sharing optical fibers, it may be necessary to use a fiber amplifier for power compensation;

2. It is required to meet the transmission of various broadband services, and the transmission quality is good and the reliability is high;

3. The application range of the fiber access network is broad;

4. The investment cost is large, the network management is complicated, and the remote power supply is difficult.

(b) What are the advantages of Satellite Communication over terrestrial Communication?

ANS: The advantages of satellite communication over terrestrial communication are as follows:

Satellites are mainly wide area broadcast media. The transmitter antenna on a SATCOM may be designed to provide signals to service areas as small as a city or as large as a country. The maximum area that can be covered by a GEO stationary satellite is approximately one third of the earth's surface.

Terrestrial relays are point to point.

The satellite circuits can be installed relatively rapidly. Once the satellite is in position, the earth stations can be installed and communication can be established in days or even hours. Thousands station may be removed relatively quickly from one location and reinstalled elsewhere.

The terrestrial circuits of any kind would require time consuming installation.

Mobile communication can easily be achieved by satellite communication as it has a great degree of flexibility in convincing mobile vehicles. Terrestrial systems have greater limitations.

Satellites have low average operating costs. Manufacturing a satellite is expensive. But a typical satellite will operate continuous for at least one year and typically for at least a few years.

The extended operating time makes SATCOM system competitive with terrestrial microwave systems.

The satellite costs are independent of distance.

The terrestrial network costs are proportional to distance.

The satellite itself is only a single repeater. For terrestrial links, antennas are located on high ground to avoid obstacles such as large buildings or hills and repeaters are used for every 40 to 50 km to compensate for path losses.

As compared to optical fiber cable, the COMSAT has the advantage that the quality of transmitted signal and the locations of stations sending and receiving information are independent of distance. So long as the two stations fall within the geographic coverage of the satellite antenna pattern those two stations maintain the same quality of information transfer whether they are near or far apart.

Satellite systems can provide coverage to remote places where terrestrial system fails. For communication between remote areas (Hilly terrains, islands etc.) and the main land satellite communications is the only cost effective option.

Mobile communication is easy to achieve using satellite communication because of its broader coverage area and its flexibility in connecting mobile vehicles.

As compared to optical fiber cable where the signal quality changes with the distance travelled by signal through the cable, satellite communication has an advantage that signal quality is independent of distance as long as the two stations fall within the same geographic coverage areas.

Wide area of application such as whether forecasting, search, navigation, military.

Q2. (a)Write are the types of WiFi Technologies, Discuss each type

ANS: Types of WI-FI Technologies:

Currently they are four major types of WIFI technologies.

Wi-Fi-802.11a

Wi-Fi-802.11b

Wi-Fi-802.11g

Wi-Fi-802.11n

IEEE 802.11

The original! Created in 1997, this now-defunct standard supported a blazing fast maximum connection speed of megabits per second (Mbps). Devices using this haven't been made for over a decade and won't work with today's equipment.

IEEE 802.11a

Created in 1999, this version of Wi-Fi works on the 5GHz band. This was done with the hope of encountering less interference since many devices (like most wireless phones) also use the 2.4GHz band. 802.11a is fairly quick too, with maximum data rates topping out at 54Mbps. However, the 5GHz frequency has more difficulty with objects that are in the signal's path, so the range is often poor.

IEEE 802.11b

Also created in 1999, this standard uses the more typical 2.4GHz band and can achieve a maximum speed of 11Mbps. 802.11b was the standard that kick-started Wi-Fi's popularity.

IEEE 802.11g

Designed in 2003, the 802.11g standard upped the maximum data rate to 54Mbps while retaining usage of the reliable 2.4GHz band. This resulted in widespread adoption of the standard.

IEEE 802.11n

Introduced in 2009, this version had slow initial adoption. 802.11n operates on both 2.4GHz and 5GHz, as well as supporting multi-channel usage. Each channel offers a maximum data rate of 150Mbps, which means the maximum data rate of the standard is 600Mbps.

IEEE 802.11ac

The ac standard is what you will find most wireless devices using at the time of writing. Initially released in 2014, ac drastically increases the data throughput for Wi-Fi devices up to a maximum of 1,300 megabits per second. Furthermore, ac adds MU-MIMO support, additional Wi-Fi broadcast channels for the 5GHz band, and support for more antenna on a single router.

IEEE 802.11ax

Next up for your router and your wireless devices is the ax standard. When ax completes its rollout, you will have access to theoretical network throughput of 10Gbps—around a 30-40 percent improvement over the ac standard. Furthermore, wireless ax will increase network capacity by adding broadcast sub channels, upgrading MU-MIMO, and allowing more simultaneous data streams.

IEEE 802.11ax also known as Wi-Fi 6 is a new standard in the IEEE 802.11 series. It has been designed to provide some significant improvements over 802.11ac, especially in terms of deployment in dense areas, spectral efficiency and user access.

In view of this, IEEE 802.11ax will improve the use is seen as the successor to 802.11ac. The new 802.11ax is still in its early stages of development, but it is anticipated that it will provide up to four times the speed of 11ac.

Another of the key issues that 802.11ax aims to resolve is that of mutual interference between different access points. In some densely covered areas this is significantly slowing down the networks. Solving this issue rather than just providing bearers for faster data rates will have a greater effect on real throughput.

Applications:

Mobile applications

Business applications

Home applications

Computerized application

Automotive segment

Browsing internet

Video conference

Advantages:

Wireless laptop can be moved from one place to another place

Wi-Fi network communication devices without wire can reduce the cost of wires.

Wi-Fi setup and configuration is easy than cabling process

It is completely safe and it will not interfere with any network

We can also connect internet via hot spots

We can connect internet wirelessly.

(b) Explain in detail about Wireless Body Area Network along with its type.

ANS: Wireless communication has a major application in sharing of information anywhere and at anytime. We can use wireless networks in the form of WLAN or Wi-Fi in various fields such as education, healthcare and industrial sector. As the technology is growing, the demands of users as well as the demand of ubiquitous networking are increasing. WBAN (Wireless Body Area Network) allows the user to move another without having the restriction of a cable for sharing information.

The term 'Wireless Body Area Network' was coined in 2001 by Van Dam. It basically is a network containing sensor nodes which are attached to the human body, used to measure the bio signals(heart rate, blood pressure, brain signals etc.) of humans. It has majority of applications in medical sector.

The communication in body sensor networks is of 2 types:

- **In-body communication**
- **On-body communication**

In-body communication is the communication between sensor nodes which are implanted inside human body. The **MICS** (*Medical Implant Communication System*) communication can be used only for in-body communication. On-body communication occurs between wearable devices which consist of sensor nodes. The **ISM** (*Industrial Scientific and Medical*) band and **UWB** (*Ultra-wide band*) communication can be used only for on-body communication.

WBAN requirements:

- Low power consumption
- Interoperability
- Self-healing
- Security
- Low latency

WBAN architecture:
The network architecture is divided into 4 sections-

1. **WBAN Part –**
   It contains several number of cheap and low-power sensor nodes, which can be used for continuous monitoring of heart rate, ECG, blood pressure etc. of a person. Being wireless in nature, this does not restrict the mobility of the person for continuous evaluation. Hence, WBAN is used in healthcare systems for patients monitoring.
2. **CCU (Central Control Unit) –**
   All sensor nodes provide their outputs to a central coordination node present in the CCU. CCU receives the signals from nodes and transmits it to the next section for monitoring the human body.
3. **WBAN communication –**
   Receives information from CCU and acts as gateway to transfer information to the destination. For ex. mobile node is a gateway to remote station to send message to cellular network using GSM/3G/4G.
4. **Control center –**
   It is responsible for storing the information of user which can be used in the future or for monitoring purpose. It consists of end node devices like mobile phones(for messaging), computer systems (for monitoring) and server(for storing information in database).

WBAN applications:
These are various application:

1. Medical Applications:

- **Remote healthcare monitoring –** Sensors are put on patient's body to monitor heart rate, blood pressure and ECG.
- **Telemedicine –** Provides healthcare services over a long distance with the help of IT and communication.

2. Non-medical Applications:

- **Sports –** Sensors can be used to measure navigation, timer, distance, pulse rate and body temperature.
- **Military –** Can be used for communication between soldiers and sending information about attacking, retreating or running to their base commander.

- **Lifestyle and entertainment –** Wireless music player and making video calls.

WBAN is legal, affordable and user friendly. It is an emerging technology and is expected to have a big impact on the society.

Q3. (a) Write a comparative detail about the evolution of mobile technology from 1st Generation to 5th Generation.

ANS: **1G - First Generation**

This was the first generation of cell phone technology. The very first generation of commercial cellular network was introduced in the late 70's with fully implemented standards being established throughout the 80's. It was introduced in 1987 by Telecom (known today as Telstra), Australia received its first cellular mobile phone network utilizing a 1G analog system. 1G is an analog technology and the phones generally had poor battery life and voice quality was large without much security, and would sometimes experience dropped calls. These are the analog telecommunications standards that were introduced in the 1980s and continued until being replaced by 2G digital telecommunications. The maximum speed of 1G is 2.4 Kbps.

2G - Second Generation

Cell phones received their first major upgrade when they went from 1G to 2G. The main difference between the two mobile telephone systems (1G and 2G), is that the radio signals used by 1G network are analog, while 2G networks are digital . Main motive of this generation was to provide secure and reliable communication channel. It implemented the concept of CDMA and GSM. Provided small data service like sms and mms. Second generation 2G cellular telecom networks were commercially launched on the GSM standard in Finland by Radiolinja (now part of Elisa Oyj) in 1991. 2G capabilities are achieved by allowing multiple users on a single channel via multiplexing. During 2G Cellular phones are used for data also along with voice. The advance in technology from 1G to 2G introduced many of the fundamental services that we still use today, such as SMS, internal roaming, conference calls, call hold and billing based on services e.g. charges based on long distance calls and real time billing. The max speed of 2G with General Packet Radio Service (GPRS) is 50 Kbps or 1 Mbps with Enhanced Data Rates for GSM Evolution (EDGE). Before making the major leap from 2G to 3G wireless networks, the lesser-known 2.5G and 2.75G was an interim standard that bridged the gap.

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, millimeter 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 feels 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

(b) What is DSL? Explain its architecture along with its types.

ANS: Stands for "Digital Subscriber Line." DSL is a communications medium used to transfer digital signals over standard telephone lines. Along with cable Internet, DSL is one of the most popular ways ISPs provide broadband Internet access.

When you make a telephone call using a landline, the voice signal is transmitted using low frequencies from 0 Hz to 4 kHz. This range, called the "voiceband," only uses a small part of the frequency range supported by copper phone lines. Therefore, DSL makes use of the higher frequencies to transmit digital signals, in the range of 25 kHz to 1.5 MHz while these frequencies are higher than the highest audible frequency (20 kHz), then can still cause interference during phone conversations. Therefore, DSL filters or splitters are used to make sure the high frequencies do not interfere with phone calls.

Types of DSL –

Symmetric DSL

Asymmetric DSL

Symmetric DSL – SDSL splits the upstream and downstream frequencies evenly, providing equal speeds to both uploading and downloading data transfer. This connection may provide 2 Mbps upstream and downstream. It is mostly preferred by small organizations.

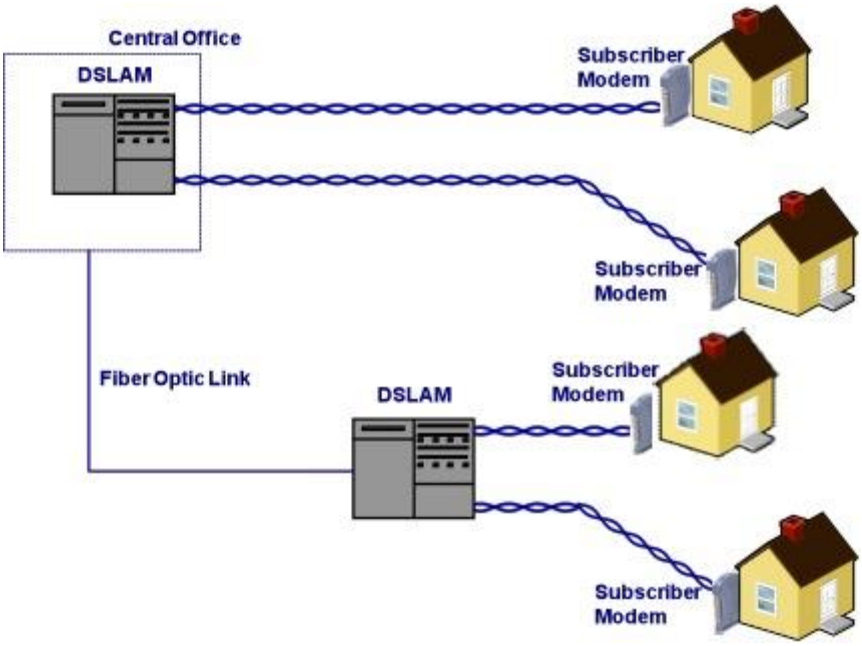
Asymmetric DSL – ADSL provides a wider frequency range for downstream transfers, which offers several times faster downstream speeds. An ADSL connection may offer 20 Mbps downstream and 1.5 Mbps upstream, it is because most users download more data than they upload.

Symmetric DSL (SDSL) splits the upstream and downstream frequencies evenly, providing equal speeds for both sending and receiving data. However, since most users download more data than they upload, ISPs typically offer asymmetric DSL (ADSL) service. ADSL provides a wider frequency range for downstream transfers, which offers several times faster downstream speeds. For example, an SDSL connection may provide 2 Mbps upstream and downstream, while an ASDL connection may offer 20 Mbps downstream and 1.5 Mbps upstream.

DSL copper wiring runs from a telephone company's Central Office (CO), the location where voice switching and other traditional telephony functions are performed, to a subscriber's home or business.

Increasingly, DSL is delivered from a device situated closer to the subscriber's home or business that is connected to a CO via an optical fiber link, and then to the subscriber's premises via copper wires. In all cases, however, DSL delivers broadband over the copper connections that exist already in almost every residence and business in the developing and developed worlds.

This architecture is depicted in the figure below. At the CO, or at a remote location typically connected to the CO via fiber optics, there is a DSL Access Multiplexer (DSLAM) that sends and receives broadband data to many subscribers via DSL technology. At each subscriber's location, there is a modem (modulator-demodulator) that communicates with the DSLAM to send and receive that subscriber's broadband data to and from the Internet and other networks. A DSLAM communicates with many individual subscriber modems. Each subscriber's modem is dedicated to that subscriber's broadband connection.



Voice services utilize only a small fraction of the total information carrying capacity of copper connections. In an analogous manner to Ethernet technology, which can transmit a Gigabit (more than one billion bits) per second of data over copper connections or the equivalent of tens of thousands of simultaneous phone conversations, DSL exploits the information carrying capacity of copper lines to deliver broadband services over long distances.

In order to access the Internet using DSL, you must connect to a DSL Internet service provider (ISP). The ISP will provide you with a DSL modem, which you can connect to either a router or a computer. Some DSL modems now have a built-in wireless router, which allows you to connect to your DSL modem via Wi-Fi. A DSL kit may also include a splitter and filters that you can connect to landline phones.