1. **What is internet**.

Internet is a computer network that interconnects hundreds of millions of computing devices throughout the world.

2. **Name Components of Internet and define the role played by them**.

network edge

i. millions of connected **hosts** (or **end systems**) running network apps eg . laptop, desktop, smartphone etc

ii. communication links - eg. twisted copper, fiber,radio, satellite etc

network core :
iii. roiuters or switches : finds/ searches addresses and forward packets (chunks of data/ small parts of files)

protocols eg. HTTP, TCP/IP SMTP etc.

3. **what constitutes edge of internet give an example**

Millions of connected **hosts** (or **end systems**) running network apps eg . laptop, desktop, smartphone etc destop could be client or sser

4. **what is end system or a host give some examples name one unconnventional end system**

the computers and other devices connected to the Internet are often referred to as end systems

(computing devices were primarily traditional desktop PCs, Linux workstations, and so-called servers that store and transmit information such as Web pages and e-mail messages etc now in modern days more movable or mobile devices such as laptops, smartphones, tablets,TVs, gaming consoles, Web cams, automobiles (like your car and scooter or trackable train , bus, aeroplane etc), environmental sensing devices, railway monitors etc, picture frames, and home electrical and security systems are being connected to the Internet)

5. **how are hosts connected to each other name two types of connections give examples**

using communication links - eg. twisted copper, fiber,radio, satellite etc and . roiuters or switches

6. **what is delay throughput and transmission rate**

Delay is the time lag in information exchange or data transfer eg . email does not get delivered instantaneously but takes time like half a day, or youtube video does not start instaneously, there is a gap of 5min between 1st scene and 2nd scene

throughput is slowness or fastness of your network

transmission rate : the no of bits per sec your link can transfer

eg : copper wire offers only few kbps where as fibers MBPS or even GBPS

7**. Name different types of applications offered by internet**

web pages, voice over ip, email , gaming, youtube or video streaming, internet tv (like live news) etc

8. **what is a packet**

When one end system has data to send to another end system, the sending end system segments the data and adds header bytes to each segment. The resulting packages of information, is known as packet

9**. what are the two types of services offered by internet explain with post office example**

reliable and best effort eg. in post office we have speed post, registered post, ordinary post etc

10 **why layered approach is used in internet**

for division of work

11 **what is voip**

placing audio or video calls using internet(eg. whatsapp)

12 what is video streaming how is it different from downloading

Streaming involves downloading a little part of video every minute and discarding it later. downloading involves downloading entire video and storing in your system (downloading a book)

13. **what is route or path in world of internet who finds routes in internet for information exchange how does it do so**

. The sequence of communication links traversed by a packet from the sending end system to the receiving end system is known as a route or path. Router or switch finds route

14. **what is an isp and how does he provide internet connections to many people**

End systems or hosts access the Internet through Internet Service Providers (ISPs) eg . airtel, BSNL, VI, JIO etc.

15 what is information exchange why is it needed

information exchange is transfer of data from one end system to another eg. email, web pages, videos, files etc

What is network edge and core in the world of internet

In the context of the internet, the network can be divided into two main parts: the network edge and the network core.

1. **Network Edge:**
   - The network edge refers to the outermost part of the network where end-users or end-devices connect. This includes devices like smartphones, laptops, desktop computers, servers, and any other devices that access the internet.
   - At the network edge, data is typically processed, generated, and consumed by end-users. This is where content is created, accessed, and interacted with.
2. **Network Core:**
   - The network core, on the other hand, refers to the inner part of the network that connects different parts of the edge network together. It consists of high-capacity routers, switches, and other networking equipment that form the backbone of the internet.
   - In the network core, data is typically transmitted between different parts of the network, often across long distances and through various interconnected networks owned by different Internet Service Providers (ISPs) and telecommunications companies.
   - The network core is responsible for routing data packets efficiently and quickly from the source to the destination, ensuring reliable and timely communication across the internet.

What is a protocol give examples

A protocol is a set of rules and conventions that govern how data is transmitted and communicated over a network. It defines the format, timing, sequencing, and error handling of data exchange between devices. Protocols ensure that devices from different manufacturers and running different software can communicate effectively with each other. Here are some examples of protocols used in computer networking:

1. **Transmission Control Protocol (TCP):**
   - TCP is a connection-oriented protocol that provides reliable, ordered, and error-checked delivery of data packets over a network. It establishes a connection between sender and receiver before transmitting data and ensures that data arrives intact and in the correct order.
2. **Internet Protocol (IP)**:
   - IP is the principal communications protocol in the Internet protocol suite for relaying data across network boundaries. It provides the routing functionality to deliver packets from the source to the destination device.
3. **Hypertext Transfer Protocol (HTTP):**
   - HTTP is an application layer protocol used for transferring hypertext documents, such as HTML files, over the World Wide Web. It defines how web browsers and web servers communicate with each other.
4. **File Transfer Protocol (FTP)**:
   - FTP is a standard network protocol used to transfer files between a client and a server on a computer network. It provides functionalities for uploading, downloading, and managing files on a remote server.
5. **Simple Mail Transfer Protocol (SMTP):**
   - SMTP is an Internet standard protocol for email transmission. It is used to send mail from one server to another and between servers until it reaches its destination.
6. **Domain Name System (DNS)**:
   - DNS is a hierarchical and decentralized naming system for computers, services, or other resources connected to the Internet or a private network. It translates domain names (e.g., www.example.com) to IP addresses and vice versa.
7. **Dynamic Host Configuration Protocol (DHCP):**
   - DHCP is a network management protocol used to automatically assign IP addresses and other network configuration parameters to devices on a network.

What is transmission rate Name some communication links

Transmission rate, also known as data transfer rate or data transmission speed, refers to the speed at which data is transmitted over a communication link. It is typically measured in bits per second (bps), kilobits per second (kbps), megabits per second (Mbps), or gigabits per second (Gbps), depending on the speed of the link.

Here are some common communication links along with their typical transmission rates:

1. **Ethernet**:
   - Ethernet is a widely used wired networking technology that operates over twisted pair or fiber optic cables.
   - Common transmission rates for Ethernet include:
     - 10 Mbps (Ethernet)
     - 100 Mbps (Fast Ethernet)
     - 1 Gbps (Gigabit Ethernet)
     - 10 Gbps (10 Gigabit Ethernet)
     - 100 Gbps (100 Gigabit Ethernet)
2. **Wi-Fi (Wireless Fidelity)**:
   - Wi-Fi is a wireless networking technology that allows devices to connect to a local area network (LAN) wirelessly.
   - Common Wi-Fi standards and their transmission rates include:
     - 802.11b: Up to 11 Mbps
     - 802.11g: Up to 54 Mbps
     - 802.11n: Up to 300 Mbps
     - 802.11ac: Up to several Gbps (depending on the specific implementation)
     - 802.11ax (Wi-Fi 6): Up to several Gbps (depending on the specific implementation)
3. **Bluetooth**:
   - Bluetooth is a wireless technology used for short-range communication between devices.
   - Common Bluetooth versions and their data rates include:
     - Bluetooth 1.x: Up to 1 Mbps
     - Bluetooth 2.x: Up to 3 Mbps
     - Bluetooth 3.x: Up to 24 Mbps
     - Bluetooth 4.x: Up to 25 Mbps
     - Bluetooth 5.x: Up to 50 Mbps
4. **Fiber Optic Links**:
   - Fiber optic cables use light to transmit data and offer high-speed communication over long distances.
   - Transmission rates for fiber optic links can range from several Mbps to multiple Gbps or even terabits per second (Tbps), depending on the specific technology and infrastructure.
5. **DSL (Digital Subscriber Line)**:
   - DSL is a technology that uses existing telephone lines to provide high-speed internet access.
   - Common DSL transmission rates include:
     - ADSL (Asymmetric DSL): Up to several Mbps downstream and typically lower upstream rates.
     - VDSL (Very-high-bit-rate DSL): Up to several tens of Mbps downstream and upstream.
6. **Satellite Links**:
   - Satellite communication links provide connectivity over long distances and are often used in remote areas or for global coverage.
   - Transmission rates for satellite links can vary widely depending on factors such as satellite technology, frequency bands used, and available bandwidth, ranging from several Mbps to multiple Gbps.

What is Communication Infrastructure ? Presently in India what kind of Infrastructure is internet dependent upon

Communication infrastructure refers to the physical and virtual components that enable the transmission and exchange of information between individuals, organizations, and devices. It encompasses various technologies, networks, and systems that support communication, including wired and wireless networks, data centers, servers, routers, switches, and telecommunications equipment.

In India, like in many other countries, the internet infrastructure relies on a combination of technologies to provide connectivity to users. Some key components of the internet infrastructure in India include:

1. **Fiber Optic Networks**:
   - Fiber optic cables form the backbone of high-speed internet connectivity in India. These cables transmit data using light signals and offer high bandwidth and reliability.
   - The Government of India has been actively investing in the expansion of fiber optic networks through initiatives like BharatNet, which aims to provide broadband connectivity to rural areas.
2. **Mobile Networks**:
   - Mobile networks, including 4G and increasingly 5G technologies, play a crucial role in providing internet access to a large segment of the Indian population.
   - Mobile operators such as Reliance Jio, Bharti Airtel, and Vodafone Idea provide mobile broadband services across the country.
3. **Satellite Communication**:
   - Satellite communication is used to provide internet connectivity in remote and rural areas where terrestrial infrastructure is limited.
   - Government initiatives like the Indian National Satellite System (INSAT) and the GSAT series of satellites contribute to satellite-based internet connectivity.
4. **Internet Exchange Points (IXPs)**:
   - Internet Exchange Points are physical locations where internet service providers (ISPs) and network operators connect their networks to exchange internet traffic.
   - In India, major IXPs include the National Internet Exchange of India (NIXI) and private IXPs operated by ISPs and data center providers.
5. **Data Centers**:
   - Data centers house servers, storage systems, and networking equipment that host internet services and applications.
   - Major cities in India, including Mumbai, Chennai, Bengaluru, and Delhi, host numerous data centers operated by both domestic and international companies.
6. **International Submarine Cables**:
   - India is connected to the global internet through submarine fiber optic cables that link the country to major internet hubs worldwide.
   - These submarine cables enable high-speed international connectivity for internet traffic to and from India.
7. **Internet Service Providers (ISPs)**:
   - ISPs are responsible for providing internet connectivity to end-users, businesses, and institutions.
   - In India, ISPs such as BSNL, Airtel, Jio, ACT Fibernet, and others offer a range of internet services including broadband, mobile internet, and enterprise connectivity.

What do you mean by network of networks explain ?

The concept of a "network of networks" refers to the interconnectedness of multiple individual networks to form a larger, unified network structure. In essence, it is a hierarchical arrangement where smaller, independent networks are linked together to enable communication and data exchange on a broader scale. This interconnected structure allows devices, systems, and users connected to different networks to communicate with each other seamlessly, regardless of their physical location or organizational boundaries.

Here's an explanation of the key aspects of a network of networks:

1. **Hierarchical Structure**:
   - A network of networks typically follows a hierarchical structure, with smaller networks (such as local area networks or LANs) forming the basic building blocks.
   - These smaller networks are then interconnected through higher-level networks, such as wide area networks (WANs) or the Internet, which serve to link multiple smaller networks together.
2. **Interconnection**:
   - The interconnected nature of a network of networks allows for data to flow between different networks, enabling communication and collaboration across diverse systems and geographical locations.
   - This interconnection is facilitated by various networking technologies, such as routers, switches, gateways, and protocols, which enable data packets to be routed between different networks.
3. **Scalability**:
   - A network of networks can scale to accommodate a wide range of devices, users, and applications, from small-scale local networks to global-scale internet infrastructure.
   - New networks can be added to the existing infrastructure, and existing networks can be expanded or upgraded to support increasing demands for connectivity and bandwidth.
4. **Redundancy and Resilience**:
   - The redundancy built into a network of networks helps ensure reliability and resilience against network failures or disruptions.
   - Multiple paths exist for data to travel between different networks, allowing traffic to be rerouted in case of link failures or congestion, thus minimizing downtime and ensuring continuous connectivity.
5. **Diversity**:
   - A network of networks can encompass a diverse range of network types, technologies, and protocols, reflecting the varying needs and requirements of different organizations, industries, and regions.
   - This diversity enables interoperability and flexibility, allowing for the integration of legacy systems, emerging technologies, and specialized networks into the broader network infrastructure.
6. **Global Reach**:
   - Networks of networks, such as the Internet, have a global reach, connecting millions of devices and users worldwide.
   - This global connectivity enables communication, commerce, and collaboration on a global scale, transcending geographical, cultural, and political boundaries.

1. What is Packet Switching

In a network application, end systems exchange messages with each other. Mes_sages can contain anything the application designer wants. Messages may perform a control function. or can contain data, such as an email message, a JPEG image, or an MP3

audio file. To send a message from a source end system to a destination end system,

the source breaks long messages into smaller chunks of data known as **packets. Such a process of sending packets from one host to another is called packet switching and such a network is called packet switched network.**

2. **What is Packet**

Small chunks of data or small piece of message (the standard size of packet varies with the transmission medium we use......)

3.**What is a packet switch**

Packet switch is a device that switches packets from one communication link to the other . Packet switches are two predominant types, routers and link_layer switches. Most packet switches use store-and-forward transmission at the inputs to the links. A router takes a packet arriving on one of its attached communication links and forwards that packet onto another one of its attached communication links.

When a packet arrives at a router in the network, the router examines a portion of the packet's destination address and for_wards the packet to an adjacent router. More specifically, each router has a forwarding table that maps destination addresses (or portions of the destination addresses) to that router's outbound links.

4**. What is store-and-forward transmission**

Most packet switches use store-and-forward transmission at the inputs to the links. Store-and-forward transmission means that the packet switch must receive the entire packet before it can begin to transmit the first bit of the packet onto the outbound link.

Consider a **simple network consisting of two end systems** connected by a single router, as shown in Figure below . The source has three packets, each consisting of L bits, to send to the destination. At the snapshot of time the source has transmitted some of packet 1, and the front of packet 1. Because the router employs **store-and-forwarding**, at this instant of time, the router cannot transmit the bits it has received; instead **it must first buffer (i.e., "store") the packet's bits**. Only after the router has received all of the packet's bits can it begin to transmit (i.e., "forward") the packet onto the outbound link.

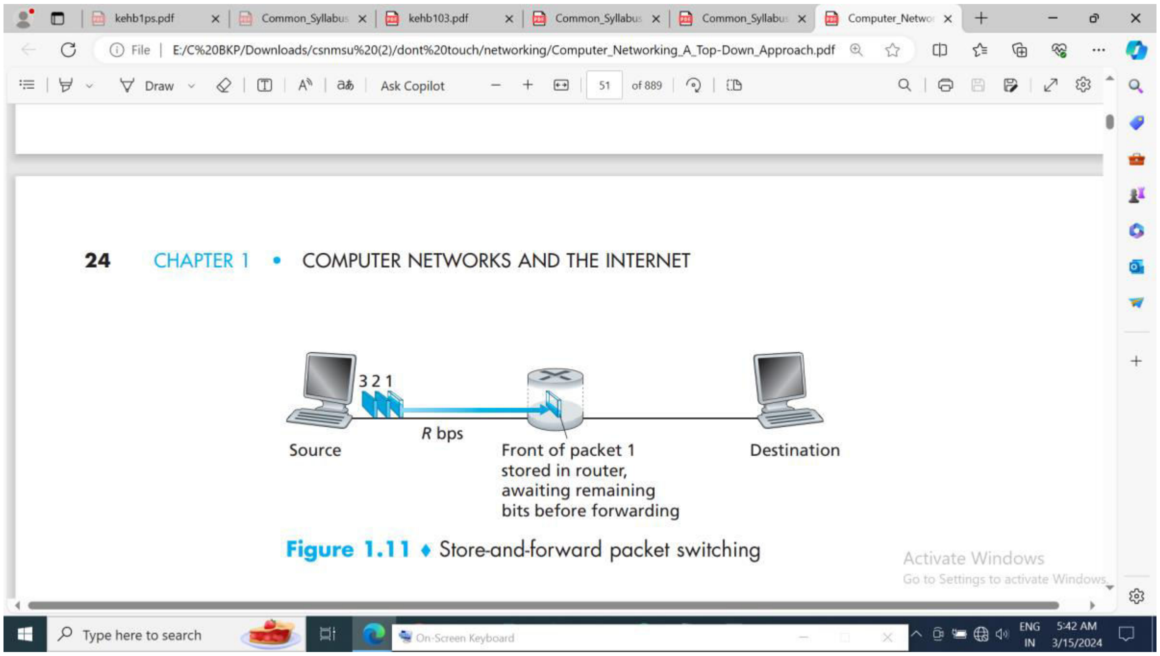
Figure 1.11 ♦ Store-and-forward packet switching

To gain some insight into store-and-forward transmission, let's now calculate the amount of time that elapses from when the source begins to send the packet until the destination has received the entire packet. The source begins to transmit at time 0; at time L/R seconds, the source has transmitted the entire packet, and the entire packet has been received and stored at the router**. At time L/R econds,the router has just receives entire packet** and can begin to transmit the packet onto the outbound link towards the destination; **at time 2L/R, the router has transmitted the entire packet**, and the entire packet has been received by the destination. **Thus, the total delay is 2L/R** has already arrived at the router. **If the switch instead forwarded bits as soon as they arrive** (without first receiving the entire packet), then **the total delay would be L/R** since bits are not held up at the router.

5. **If a source end system or a packet switch is sending a packet of L bits over a link with transmission rate R bits/sec. How much time does the packet take to reach to destination**

If a source end system or a packet switch is sending a packet of L bits over a link with transmission rate R bits/sec, then the **time to transmit the packet is L/R seconds.**

6. Consider a simple network consisting of two end systems connected by a single router, as shown in Figure below.Suppose the source has transmitted some of packet1 and transmit 3 packets to destination how long will it take.



- Because the router employs **store-and-forwarding**, at this instant of time, the router cannot transmit the bits it has received; instead **it must first buffer (i.e., "store") the packet's bits.**
- Only **after the router has received all of the packet's bits** can **it begin to transmit** (i.e., "forward") the packet onto the outbound link.
- The source **begins to transmit at time 0; at time L/R seconds, the source has transmitted the entire packe**t, and the entire packet has been received and stored at the router.
- **At time L/R seconds, since the router has just received the entire packet, it can begin to transmit the packet onto the outbound link** towards the destination;
- **At time 2L/R, the router has transmitted the entire packet**, and the entire packet has been received **by the destination**.
- Thus, **the total delay is 2L/R.**
- If the switch instead forwarded bits as soon as they arrive (without first receiving the entire packet), then the total delay would be L/R since bits are not held up at the router. .

For three packets this is the scenario

At time 0 ...... source **begins to transmit at time 0**

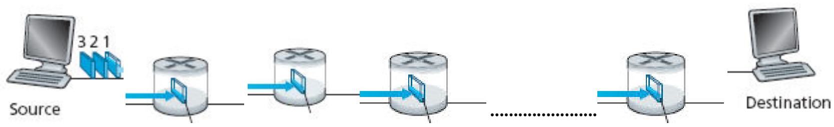
at time L/R seconds ...... the source has transmitted the entire packet , the router has recieved the entire first packet and hence the router begins to forward the first packet. But also **at time L/R** the source will begin to send the second packet

at **2L/R ....the destination has received the first packet and the router has received the second packet,** the source will begin to send the **third packet**

at 3L/R, the destination has received the first two packets and the router has received the third packet. Since the source has nothing to send it will not send any

at time 4L/R ....the destination has received all three packets

7. Consider the general case of sending one packet from source to destination over a path consisting of N links each of rate R (thus, there are N-1 routersbetween source and destination). How long will it take.



(Source) Router R1 R2 R3............................RN-1 (Destination)

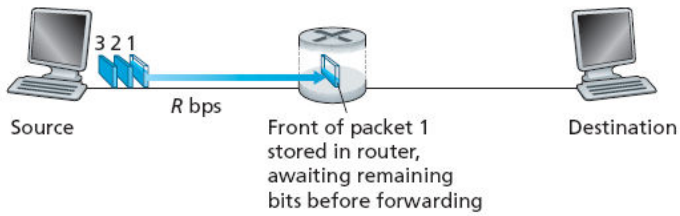
First Packet : at 0 it it is at Source . at L/R at R1, at 2L/R at R2 at 3L/R at R3 at N-1L/R at (N-1)L/R at NL/R it recived by Destination

Thus 1 packet takes NL/R seconds to reach to destination over N links

8. **What is end to end delay or rather store and forward delay**

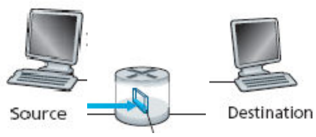
Store-and-forward transmission means that the packet switch must receive the entire packet before it can begin to transmit the first bit of the packet onto the outbound link consider a simple network consisting of two end systems connected by a single router, as shown in Figure below. A router will typically have many incident links, since its job
is to switch an incoming packet onto an outgoing link; in this simple example, the router has the rather simple task of transferring a packet from one (input) link to the only other attached link.At the snapshot of time shown in Figure, the source has transmitted some of packet 1, and the front of packet (of size Lbits) has already arrived at the router. Because the router employs store-and-forwarding, at this instant of time, the router cannot transmit the bits it has received; instead it must first buffer (i.e., "store") the packet's bits. Only after the router has received *all* of the packet's bits can it begin to transmit (i.e., "forward") the packet onto the outbound link. Thus store-and-forward transmission is all about the amount of time that elapses from when the source begins to send the packet until the destination has received the entire packet. Here we will ignore propagation delay—the time it takes for the bits to travel across the wire at near the speed of light, processing delay analg to digital or segmenting the bit stream to packets etc nor queuing delay because we have only one packet.). So end to end delay is just store and forward delay. if transmission rate is R then it is L/R sec before the packet reaches router.

The source begins to transmit at time 0; at time L/R seconds, the source has transmitted the entire packet, and the entire packet has been received and stored at the router (since there is no propagation delay). At time L/R seconds, since the router has just received the entire packet, it can begin to transmit the packet onto the outbound link towards the destination; at time $2L/R$, the router has transmitted the entire packet, and the entire
packet has been received by the destination

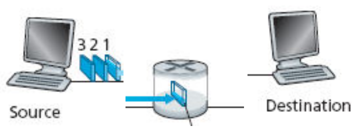


9 Determine what the delay would be for P packets sent over a series of N links

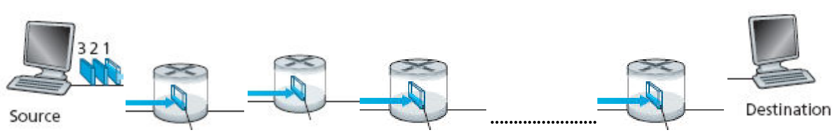
FOR ONE PACKET TO TRANSFER TO A DESTINATION VIA ONE ROUTER IS 2L/R



FOR 3 **PACKET TO TRANSFER TO A DESTINATION VIA ONE ROUTER IS 4L/R**



FOR ONE PACKET TO TRANSFER TO A DESTINATION VIA N-1 ROUTERS IS NL/R

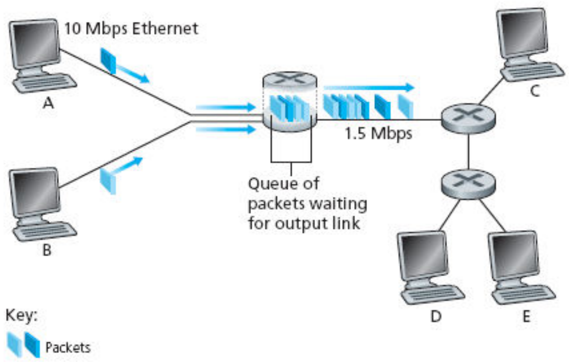


FOR P **PACKETS TO TRANSFER TO A DESTINATION VIA N LINKS OR N-1 ROUTERS IS (P+1)NL/R**

9. **What is queuing delay and what is packet loss. How much buffer space does routers have is it limited or unlimited**

Each packet switch has multiple links attached to it. For each attached link, the packet switch has an output buffer (also called an output queue), which stores packets that the router is about to send into that link. If an arriving packet needs to be transmitted onto a link but finds the link busy with the transmission of another packet, the arriving packet must wait in the output buffer. Thus, in addition to the store-and-forward delays, packets suffer output buffer queuing delays These delays are variable and depend on the level of congestion in the network. Since the amount of buffer space is finite, an arriving packet may find that the buffer is completely full with other packets wait_ing for transmission. In this case, packet loss will occur—either the arriving packet or one of the already-queued packets will be dropped.

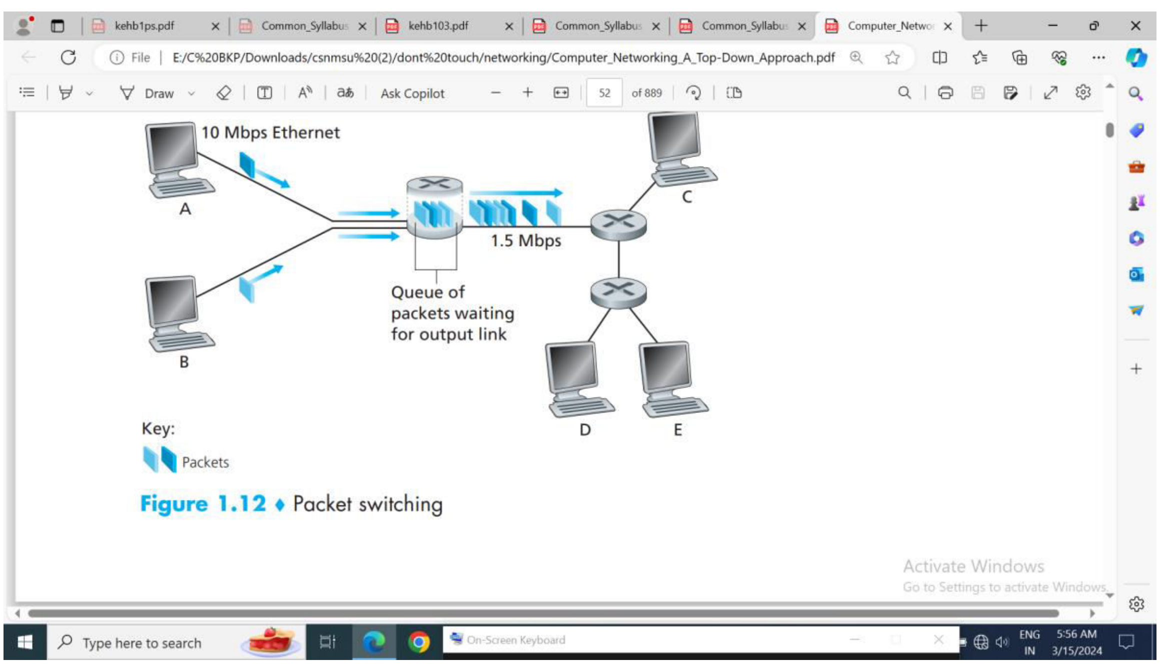
Suppose Hosts A and B are sending packets to Host E. Hosts A and B first send their packets along 10 Mbps Ethernet links to the first router. The router then directs these packets to the 1.5 Mbps link as shown in fig below.



If, during a short interval of time, the arrival rate of packets to the router (when converted to bits per second) exceeds 1.5 Mbps, congestion will occur at the router as packets queue in the link's output buffer before being transmitted onto the link. For example, if Host A and B each send a burst of five packets back-to-back at the same time, then most of these packets will spend some time waiting in the queue

If **La/R > 1,** **(traffic intensity**) then the average rate at which bits arrive at the queue exceeds the rate at which the bits can be transmitted from the queue. In this unfortunate situation, the queue will tend to increase without bound and the queuing delay will approach infinity!

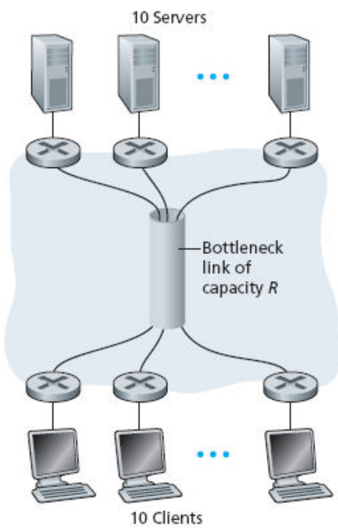
10.



Explain what will happen to packets in the above diagram . Where will they spend most of their time. What do you mean by a bottle neck in network.

If, during a short interval of time, the arrival rate of packets to the router (when converted to bits per second) exceeds 1.5 Mbps, congestion will occur at the router as packets queue in the link's output buffer before being transmitted onto the link. For example, if Host A and B each send a burst of five packets back-to-back at the same time, then most of these **packets will spend some time waiting in the queue.**

A bottleneck node is one whose arrival link or incoming link offers greater rate than transmission or outgoing link capacity . In the above diagram the arrival rate at router is (10+10) 20Mbps if the sources ae continuosly transmitting and the transmission rate via outbound link is 1.5Mbps. (its like recieving water from big pipe and tranfering via very small diameter pipe



10. **What is forwarding table. How different is it from routing table. By the way how are packets forwarded to destination address by the router**

A router takes a packet arriving on one of its attached communication links and forwards that packet onto another one of its attached communication links. Packet forwarding is actually done in different ways in different types of computer networks

In the Internet, every end system **has an address called an IP address**. When a source end system wants to send a packet to a destination end system, **the source includes the destination's IP address** in the packet's header. As with postal addresses, this address has a hierarchical structure. When a packet arrives at a router in the network, the router examines a portion of the packet's destination address and for_wards the packet to an adjacent router. More specifically, each router has a **forwarding table that maps destination addresses** (**or portions of the destination addresses**) to that router's outbound links. When a packet arrives at a router, the **router examines the address and searches its forwarding table,** using this destination address, to find the appropriate outbound link. The router then directs the packet to this outbound link.

Fig below shows typical routing table.

Destination Address Range	Link Interface
11100000 00000000 00000000 00000000 through 11100000 00111111 11111111 11111111	0
11100000 01000000 00000000 00000000 through 11100000 01000000 11111111 11111111	1
11100000 01000001 00000000 00000000 through 11100001 01111111 11111111 11111111	2
otherwise	3

11. **What is queuing delay how different is it from store and forward delay**

Store-and-forward transmission means that the packet switch must receive the entire packet before it can begin to transmit the first bit of the packet onto the outbound link.
So, if a source end system or a packet switch is sending a packet of *L* bits over a link with transmission rate *R* bits/sec, then the time to transmit the packet is *L/R* seconds. Thus the router recieves entire packet only after L/*R* seconds Because the router employs store-and-forwarding, the router cannot transmit the bits it has received; instead it must first buffer (i.e., "store") the packet's bits. Only after the router has received *all* of the packet's bits can it begin to transmit (i.e., "forward") the packet onto the outbound link i.e at L/R sec it stats transmitting thus destination recieves the entire packet at 2L/R seconds **the time elapsed in this storing and forwarding is called store and forward delay**

Each packet switch has multiple links attached to it. For each attached link, the packet switch has an **output buffer** (also called an **output queue**), which stores packets that the router is about to send into that link. The output buffers play a key role in packet switching. If an arriving packet needs to be transmitted onto a link but finds the link busy with the transmission of another packet, the arriving packet must wait in the output buffer**. thie time elapsed by the packet in wating in the output buffer before it is transmitted on to an outbound link is called queuing delay**

Suppose Hosts A and B are sending packets to Host E. Hosts A and B first send their packets along 10 Mbps Ethernet links to the first router. The router then directs these packets to the 1.5 Mbps link. If, during a short interval of time, **the arrival rate of packets to the router exceeds 1.5 Mbps(transmission rate), congestion will occur at the router as packets queue in the link's output buffer before being transmitted onto the link**

12. **How are these routing tables filled.**

The Internet has a number of special **routing protocols** that are used to automatically set the forwarding tables. A routing protocol may, for example, determine the shortest path from each router to each destination and use the shortest path results to configure the forwarding tables in the routers.

(Simply visit the site www.traceroute.org, choose a source in a particular country, and trace the route from that source to your computer you will understand how routes

are traced over internet.)

13. **What is circuit switching and what is packet switching. What kind of resources are needed for a source to send a message to destination.**

There are two fundamental approaches to moving data through a network of links and switches: **circuit switching and packet switching**

Packet Switching

In a network application, **end systems exchange messages with each other**. **Messages (control, data) can contain anything the application designer wants**. To send a message from a source end system to a destination end system, **the source breaks long messages into smaller chunks of data known as packets**. Between source and destination, each packet travels through communication links and **packet switches** (**for which there are two predominant types, routers and link_layer switches**). Packets Packets are transmitted over each communication link at a rate equal to the **full transmission rate of the link**. A network that switches packets from a source to destination randomly without reserving any resources (guarenteed transmission rate, place in output buffer) is called packet switching.

Circuit Switching

In **circuit-switched networks**, the **resources needed along a path**

- **buffers,**
- **link transmission rate**

to provide for communication between the end systems are ***reserved*** for the duration of the communication session between the end systems.

In **packet-switched networks**, these **resources are not reserved**; a session's messages **use the resources on demand**, and as a consequence, may have to **wait** (**that is,queue**) for **access to a communication link.**

Eg. a simple analogy, consider two restaurants, a doctors appointment

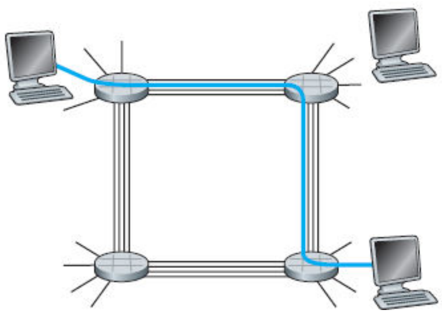
Case1 **:** One that requires reservations .... For this restaurant we go through the hassle of calling before we leave home......... When we arrive at the restaurant we, immediately be seated and order our meal (table is booked)

Case 2 : Here reservations are accepted..... here don't need to bother to reserve a table. But when we arrive at the restaurant, we may have to wait for a table before we can be seated

Eg Traditional telephone networks are circuit-switched networks ....

if one person wants to send information (voice or facsimile) to another over **telephone network.** Before the sender can send the information, the network must **establish a connection between** the sender and the **receiver.**

This is a **bonafide** connection for which the switches on the path between the sender and receiver maintain connection **state for that connection**. **In the jargon of telephony, this connection is called a circuit.** When the network establishes the circuit, it also reserves a constant transmission rate in the network's links (representing a fraction of each link's transmission capacity) for the duration of the connection. Since a given transmission rate has been **reserved for this sender-to-receiver connection**, the sender can transfer the data to the receiver at the **guaranteed constant rate.**



In the above figure When two hosts want to communicate**, the network establishes a dedicated end-to-end connection between the two hosts.** Thus, **in order for Host A to communicate with Host B, the network must first reserve one circuit on each of two links** A circuit in a link is implemented with either **frequency-division multiplexing (FDM)** or **time-division multiplexing (TDM)**.

14. **What is a circuit**

if one person wants to send information (voice or facsimile) to another over **telephone network.** Before the sender can send the information, the network must **establish a connection between** the sender and the **receiver so that it reserves needed resources (frequenc or bandwidth or time etc) to send message**

This is a **bonafide** connection for which the switches on the path between the sender and receiver maintain connection **state for that connection**. **In the jargon of telephony, this connection is called a circuit.** When the network establishes the circuit, it also reserves a constant transmission rate in the network's links (representing a fraction of each link's transmission capacity) for the duration of the connection. Since a given transmission rate has been **reserved for this sender-to-receiver connection**, the sender can transfer the data to the receiver at the **guaranteed constant rate.**

15. What is trace route utility in internet. Explain its uses with the help of online libraries.

Traceroute is a simple program that can run in any Internet host. When the user specifies **a destination hostname**, **the program in the source host sends multiple, special packets toward that destination.** As these packets work their way toward the destination, they pass through a series of routers. When a router receives one of these special packets, it sends back to the source a short message that contains the name and address of the router

The source records the time that elapses between when it sends a packet and when it receives the corresponding return message; it also records the name and address of the router (or the destination host) that returns the message. In this manner, **the source can reconstruct the route** taken by packets flowing from source to destination, and the source can determine the **round-trip delays(The famous network parameter RTT ..The Round Trip Time)** intervening routers.Usually Trace_route actually repeats the experiment just described three times sending 3N packets

16**. A packet switch receives a packet and determines the outbound link to which the packet should be forwarded. When the packet arrives, one other packet is halfway done being transmitted on this outbound link and four other packets are waiting to be transmitted. Packets are transmitted in order of arrival. Suppose all packets are 1,500 bytes and the link rate is 2 Mbps. What is the queuing delay for the packet? More generally, what is the queuing delay when all packets have length L, the transmission rate is R, x bits of the currently-being-transmitted packet have been transmitted, and n packets are already in the queue?**

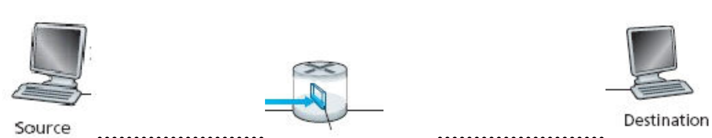
L = 1,500 bytes R = 2Mbps

17. **What is packet sniffing**

Many users today access the Internet via wireless devices, such as WiFi-connected laptops or handheld devices with cellular Internet connections. While ubiquitous Internet access is extremely convenient and enables marvelous new applications for mobile users, it also creates a major security vulnerability—by placing a passive receiver in the vicinity of the wireless transmitter, that receiver can obtain a copy of every packet that is transmitted! These packets can contain all kinds of sensitive information, including passwords, social security numbers, trade secrets, and private personal messages. A passive receiver that records a copy of every packet that flies by is called a **packet sniffer. The process of obtaining copies of packets being trnsmitted over the network is called packet sniffing.**
Sniffers can be deployed in wired environments as well. In wired broadcast environments,
as in many Ethernet LANs, a packet sniffer can obtain copies of broadcast packets sent over the LAN. As described in Section 1.2, cable access technologiesalso broadcast packets and are thus vulnerable to sniffing. Furthermore, a bad guy who gains access to an institution's access rou ter or access link to the Internet may

18. Suppose there is exactly one packet switch between a sending host and a receiving host. The transmission rates between the sending host and the switch and between the switch and the receiving host are R1 and R2, respectively. Assuming that the switch uses store-and-forward packet switching,what is the total end-to-end delay to send a packet Sof length L?

Since there is just one packet of length L to send between a sending host and a recieving host



(Source) R1 Switch R2 (Destination)

At time 0 source starts tansmitting bits to switch. Time taken to transmit all the bits of packet from Source to Switch is L/R1 . Since the switch employs stoe and forward mechanism it waits until all the bits are collected before it starts transferring bits onto outbound link.At L/R1 all bits completely arrive at Switch. At time L/R1 the Switch starts transmitting bits onto outbound link of capacity R2. The time taken by the switch to transmit all bits to destination host is L/R2 . Total end to end delay from Switch to Destination is

L/R1 + L/R2

19. **Suppose end system A wants to send a large file to end system B. At a very high level, describe how end system A creates packets from the file. When one of these packets arrives to a packet switch, what information in the packet does the switch use to determine the link onto which the packet is forwarded? Why is packet switching in the Internet analogous to driving from one city to another and asking directions along the way?**

End system A breaks the large file into chunks called packet size depends on the nature of the link. It adds header to each chunk, thereby generating multiple packets from the file. The header in each packet includes the IP address of both source and destination (end system B). The ip address consists of the heirarchical structure (eg. 128.34.108.63) The packet switch uses full destination IP address or part of it in the header of packet to determine the outgoing link by matching it t its routing table. Asking traffic police or people surrounding while travelling from one city to other , which road to take is analogous to a packet asking which outgoing link it should be forwarded on, given the packet's destination address. Thus **is packet switching in the Internet analogous to driving from one city to another and asking directions along the way.**

20 **Visit the Queuing and Loss applet at the companion Web site {http://www.pearsonhighered.com/kurose-ross}. What is the maximum emission rate and the minimum transmission rate? With those rates, what is the traffic intensity? Run the applet with these rates and determine how long it takes for packet loss to occur. Then repeat the experiment a second time and determine again how long it takes for packet loss to occur. Are the values different? Why or why not?**

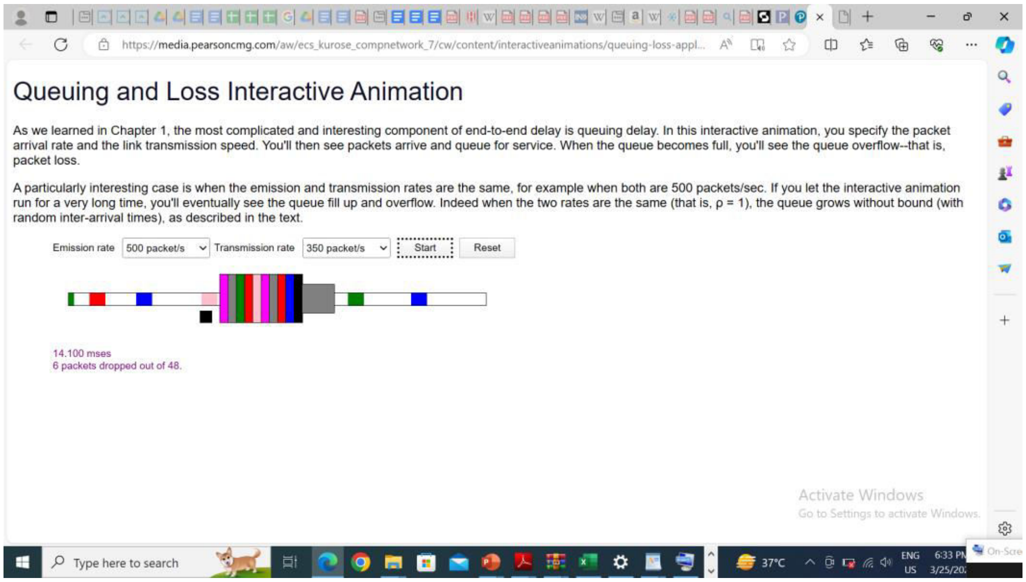
There are three cases in the applet

Case 1 Arrival rate is 500 pkts/s and transmission rate is 1000 pkts/s . In this case the traffic intensity is 500/1000 = 0.5<1 thus no packet loss occurs

Case 2 Arrival rate is 500 pkts/s and transmission rate is 500 pkts/s . In this case the traffic intensity is 500/500 = 1 thus no or rare packet loss occurs .

Case 3 Arrival rate is 500 pkts/s and transmission rate is 350 pkts/s. In this case the traffic intensity is 500/350 = 1.43 > 1thus no packet loss occurs. Loss will eventually occur for each experiment; but the time when loss first occurs will be different from one experiment to the next due to the randomness in the emission process.

The screen shot of applet is given below and the address where u can see the applet is https://media.pearsoncmg.com/aw/ecs_kurose_compnetwork_7/cw/content/interactiveanimations/queuing-loss-applet/index.html



21. **Suppose Host A wants to send a large file to Host B. The path from Host A to Host B has three links, of rates R1 = 500 kbps, R2 = 2 Mbps, and R3 = 1 Mbps. a. Assuming no other traffic in the network, what is the throughput for the file transfer? b. Suppose the file is 4 million bytes. Dividing the file size by the throughput, roughly how long will it take to transfer the file to Host B? c. Repeat (a) and (b), but now with R2 reduced to 100 kbps.**

(Source) R1 (500kbps) Switch R2(2 Mbps) R31 Mbps) Destination

(a) Throughput in the above scenario is min(R1,R2,R3)

Throughput = min(R1,R2,R3) = min(500kbps, 2Mbps, 1Mbps)

= 500kbps

(*At the end of the day effective flowrate through 3 pipes will be min of the 3 pipes flow rate***)**

(b) Size of the file 4 million bytes Throughput is 500kbps the time taken by 4 million bytes ($4x8x10^6$) file to be transmitted through a series of links with throughput 500 kbps = 4 x 10^6x8/500 x 10^3 = (4x8)/5 x 10 = 320/5 = 64sec

(c) Repeat (a) and (b), but now with R2 reduced to 100 kbps.

Throughput = min(R1,R2,R3) = min(500kbps, 100kbps, 1Mbps)

= 100kbps

the time taken by 4 million bytes file to be transmitted through a series of links with throughput 100 kbps = $4 \times 10^6 x8/100 \times 10^3$ = 320sec

22. **How long does it take a packet of length 1,000 bytes to propagate over a link of distance 2,500 km, propagation speed 2.5 · 108 m/s, and transmission rate 2 Mbps? More generally, how long does it take a packet of length L to propagate over a link of distance d, propagation speed s, and transmission rate R bps? Does this delay depend on packet length? Does this delay depend on transmission rate?**

Delay = Propagation Delay + transmission delay = speed x distance + L/R

Propagation Delay = distance/speed = 2500×10^3 / $2.5 \cdot 10^8$ m/s = $2.5 \times 10^6 / 2.5 \cdot 10^8$ = 10msec

transmission delay = L/R = $1000 \times 8 / 2 \times 10^6$ = 4msec

Total Delay = 10 + 4 = 14msec

However the time taken by the packet to propagate over the link = 10msec , the other delay is the store and forward delay. Propagation Delays are independent of packet length**.**

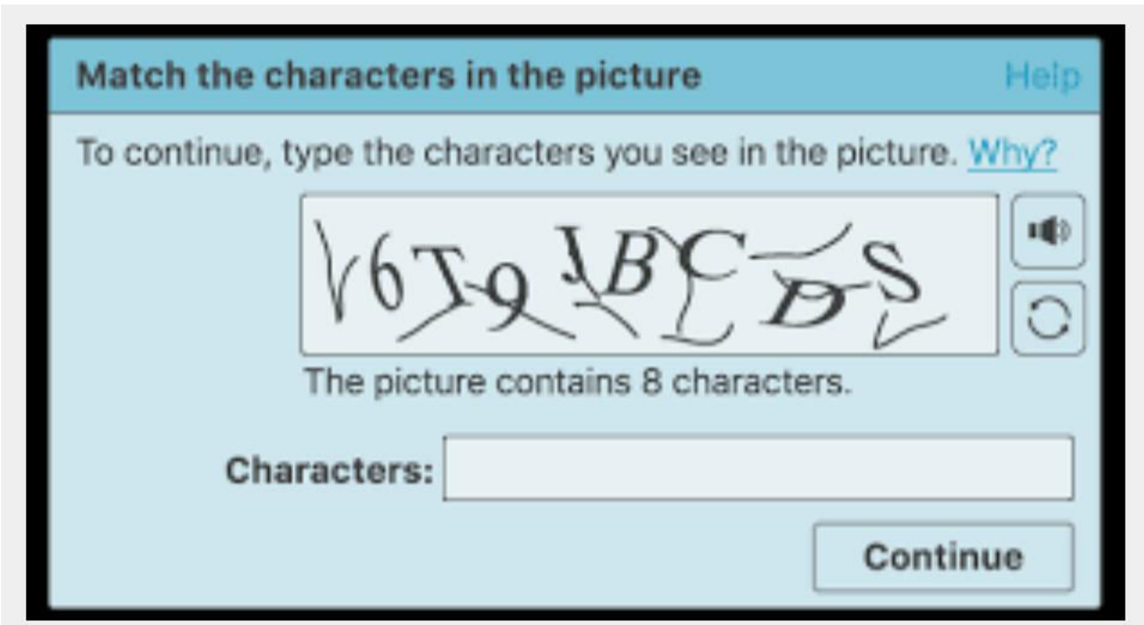
23 **What is a botnet. Why do we see captcha in websites**

We attach devices to the Internet because we want to receive/send data from/to the Internet. This includes all kinds of good stuff, including Web pages, e-mail messages, MP3s, telephone calls, live video, search engine results, and so on.But, unfortunately, along with all that good stuff comes malicious stuff—collectively known as **malware**—that can also enter and infect our devices. Once malware infects our device it can do all kinds of devious things, including deleting our files; installing spyware that collects our private information, such as social security numbers, passwords, and keystrokes, and then sends this (over the Internet, of course!) back to the bad guys. Our compromised host may also be enrolled in a network of thousands of similarly compromised devices, collectively known as a **botnet**, which the bad guys control and leverage for spam email distribution or distributed denial-of-service attacks against targeted hosts.

A distributed denial-of-service attack i.e. DDoS attacks leveraging botnets with thousands of comprised hosts are a common occurrence today

Such a large-scale DDoS attack against DNS root servers actually took place on October 21, 2002. In this attack, the attackers leveraged a botnet to send truck loads of ICMP ping messages to each of the 13 DNS root servers

With cybersecurity threats on the rise, organizations need to protect all areas of their business. This includes defending their websites and web applications from bots, spam, and abuse. In particular, web interactions such as logins, registrations, and online forms are increasingly under attack. Preventing and mitigating botnet attacks can be challenging, due to the complexity and resilience of botnets. However, there are several strategies that can be effective, including maintaining good cybersecurity hygiene, using advanced detection and response tools, and participating in collaborative efforts to dismantle botnets. one of the versatile and most used tecniques include use of a Friendly Captcha which offers a secure and invisible alternative to traditional captchas. It is used successfully by large corporations, governments and startups worldwide.



24. We consider sending real-time voice from Host A to Host B over a packet-switched network (VoIP). Host A converts analog voice to a digital 64 kbps bit stream on the fly. Host A then groups the bits into 56-byte packets. There is one link between Hosts A and B; its transmission rate is 2 Mbps and its propagation delay is 10 msec. As soon as Host A gathers a packet, it sends it to Host B. As soon as Host B receives an entire packet, it converts the packet's bits to an analog signal. How much time elapses from the time a bit is created (from the original analog signal at Host A) until the bit is decoded (as part of the analog signal at Host B)?

The above problem involves three types of delays for creation of bit until it is decoded at the destination

1. processing delay : conversion of voip to analog of 64kbps bit stream and then grouping it to 56byte packets . the time talken for one 56byte packet to be created is

= 56x8/64kbps = 56x8/64x10^3 = 7msec

2. Transmission delay = L/R = 56byte/2Mbps = 56x8/2x10^6 =224usec

3. propagation delay = 10msec

Total Delay = 7msec + 244sec + 10msec = 17.22msec

25. **What is propagation delay define and derive an expression.**

Once a bit is pushed into the link, it needs to propagate to router B. The time required to propagate from the beginning of the link to router B is the **propagation delay**. The bit propagates at the propagation speed of the link. The propagation speed depends on the physical medium of the link (that is, fiber optics, twisted-pair copper wire, and so on) and is in the range of Once a bit is pushed into the link, it needs to propagate to router B. The time required to propagate from the beginning of the link to router B is the **propagation delay**. The bit propagates at the propagation speed of the link. The propagation speed depends on the physical medium of the link (that is, fiber optics, twisted-pair copper wire, and so on) and is in the range of In wide-area networks, propagation delays are on the order of milliseconds.