Layers of the Protocol Suite

CompE 560
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What is a Network ?

- A **network** is a combination of hardware and software that sends data from one location to another.

- The hardware consists of the physical equipment that carries signals from one point in the network to another.

- The software consists of instructions that make the services that we expect from a network possible.

Network criteria

A network must be able to meet a number of criteria. The most important of these are performance, reliability, and security.

Performance can be measured in many ways, including transit time and response time.

Reliability is measured by the frequency of failure, the time it takes to recover from a failure, and the network's robustness in a catastrophe.

Network security issues include protecting data from unauthorized access, damage and change, and implementing policies and procedures for recovery from breaches and data losses.

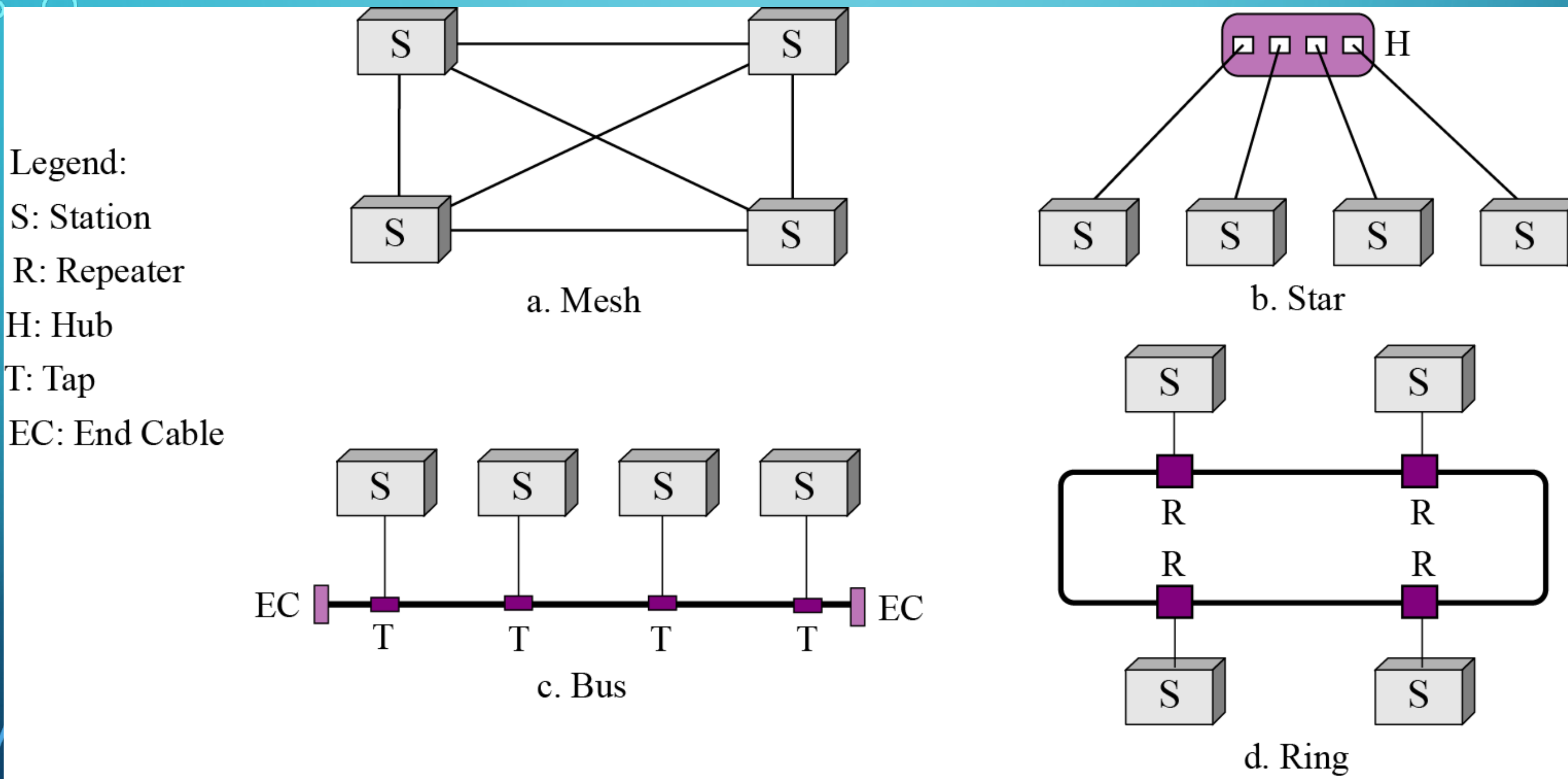
Physical structures

Before discussing networks, we need to define some network attributes.

Types of Connection: A network consists of two or more devices connected through **links**. A link is a communications pathway that transfers data from one device to another. There are two possible types of connections: **point-to-point** and **multipoint**.

Types of connections: point-to-point and multipoint

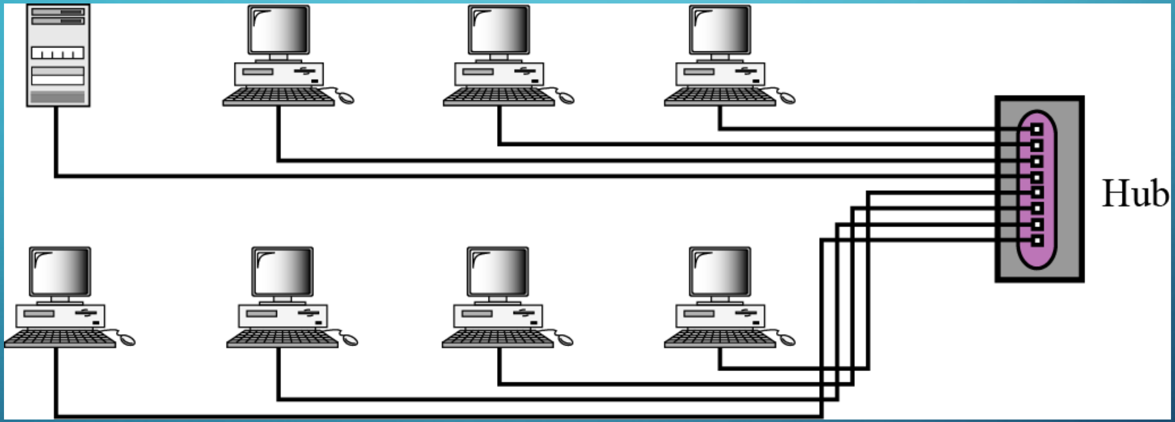
The term **physical topology** refers to the way in which a network is laid out physically. There are four basic topologies possible: mesh, star, bus and ring.



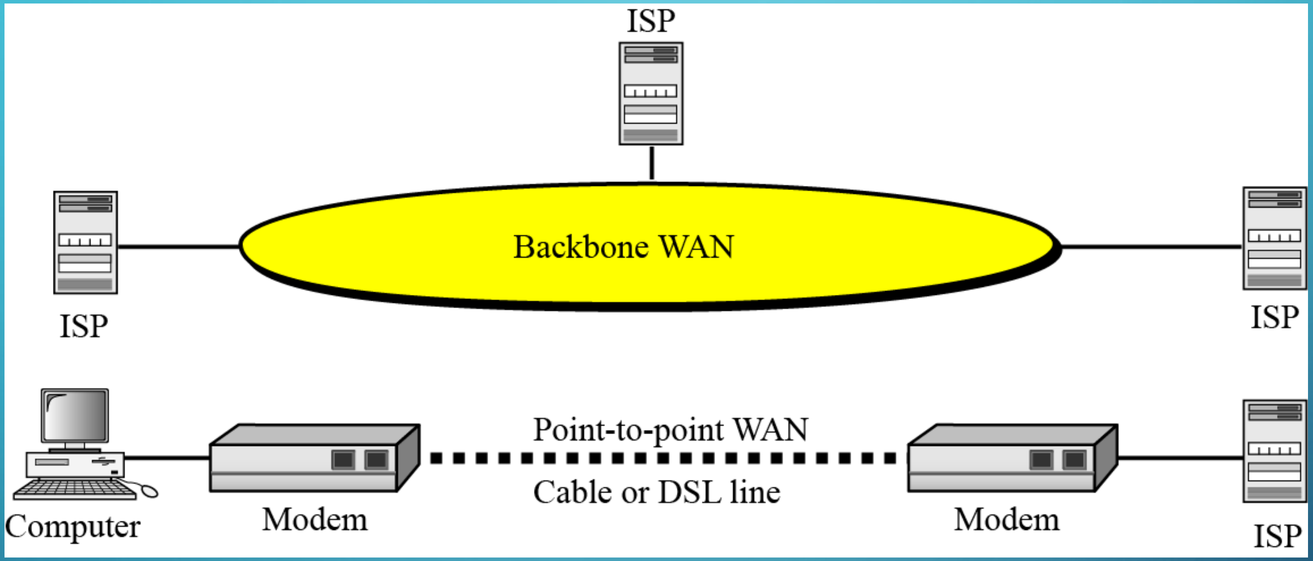
Four physical topologies

Categories of networks

Today networks can be divided into three broad categories: **local-area networks (LANs)**, **wide-area networks (WANs)** and **metropolitan area networks (MANs)**.



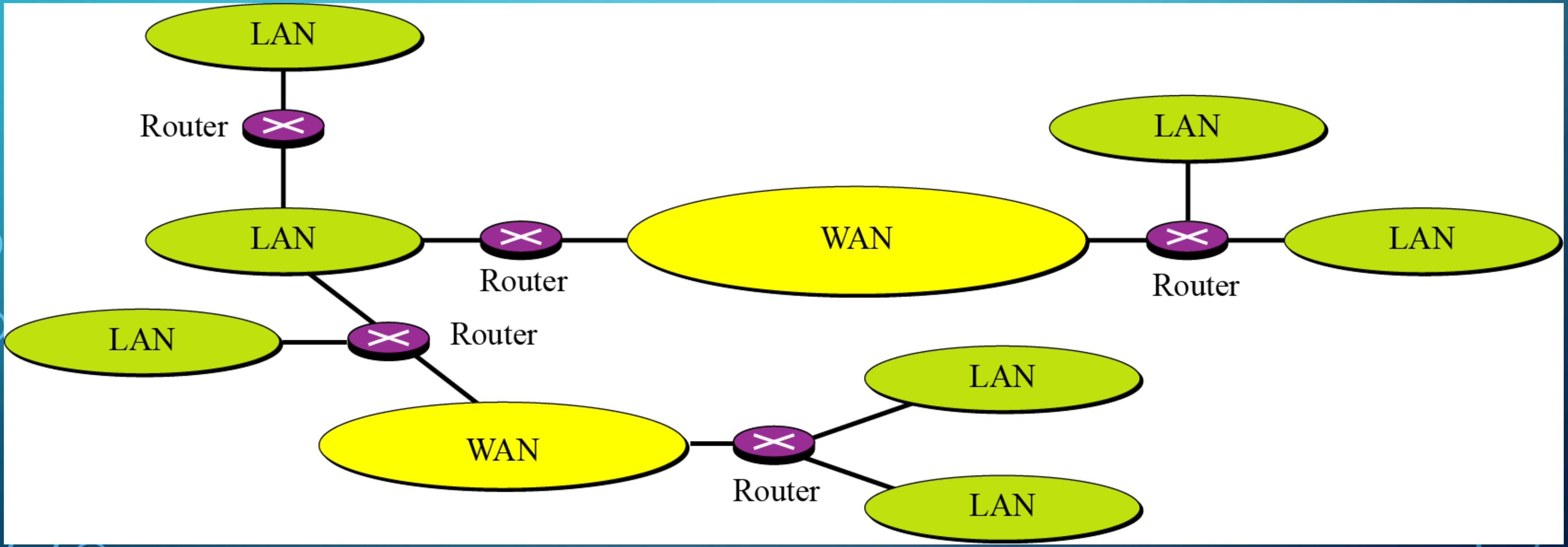
An isolated LAN connecting eight computers to a hub



A point-to-point WAN and a backbone WAN

An internet

Today, it is very rare to see a network in isolation: networks are connected to one another. When two or more networks are connected, they become an **internetwork**, or an **internet** (lowercase "i").

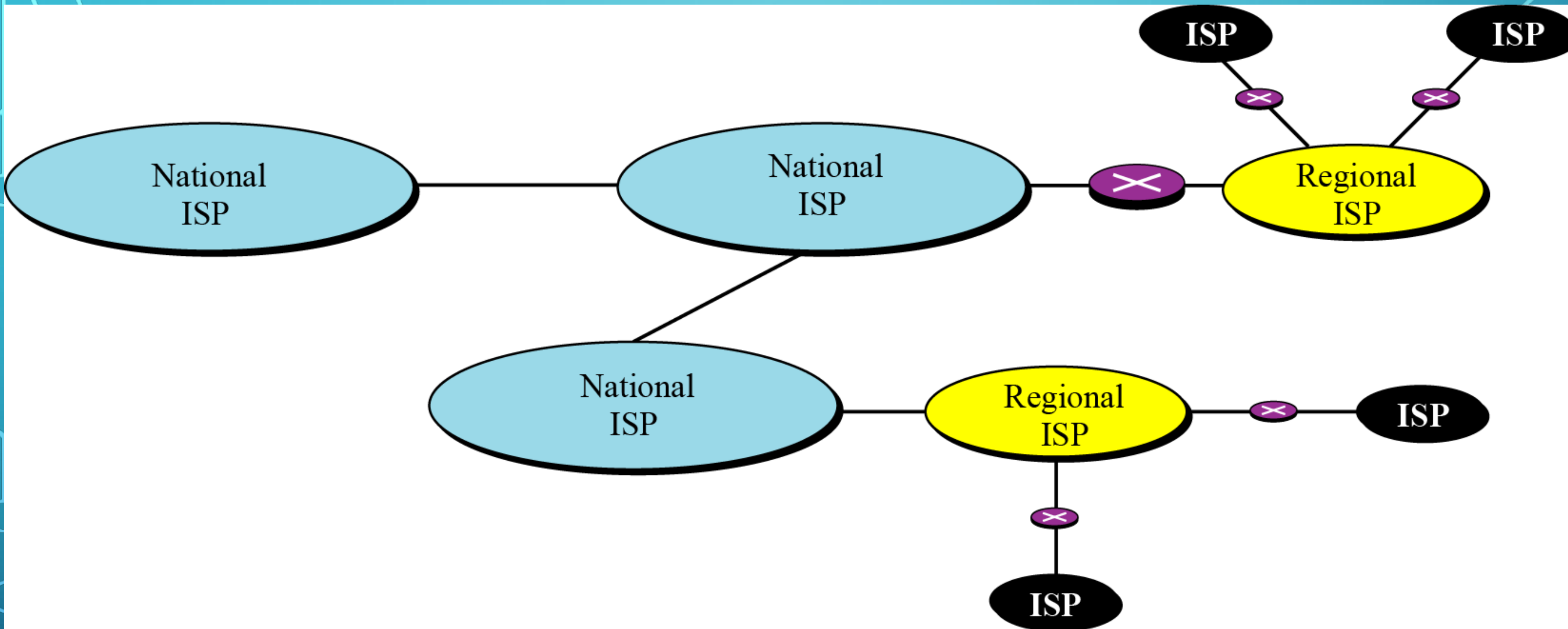


An internet made of WANs, LANs, and routers

The Internet

The most notable internet is the **Internet** (uppercase "I"), a collaboration of hundreds of thousands of interconnected networks. Private individuals, as well as various organizations such as government agencies, schools, research facilities, corporations and libraries in more than 100 countries use the Internet. Millions of people are users.

It is difficult to give an accurate representation of the Internet, because it is continually changing. Today, most end users who want an Internet connection use the services of **Internet service providers (ISPs)**.

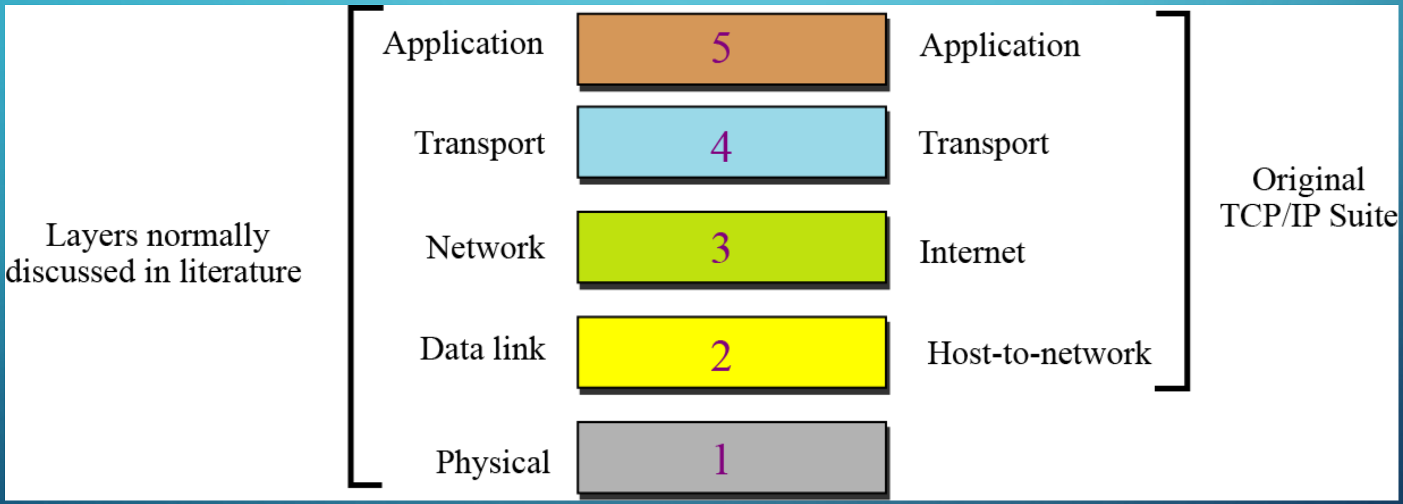


Hierarchical organization of the Internet

TCP/IP PROTOCOL SUITE

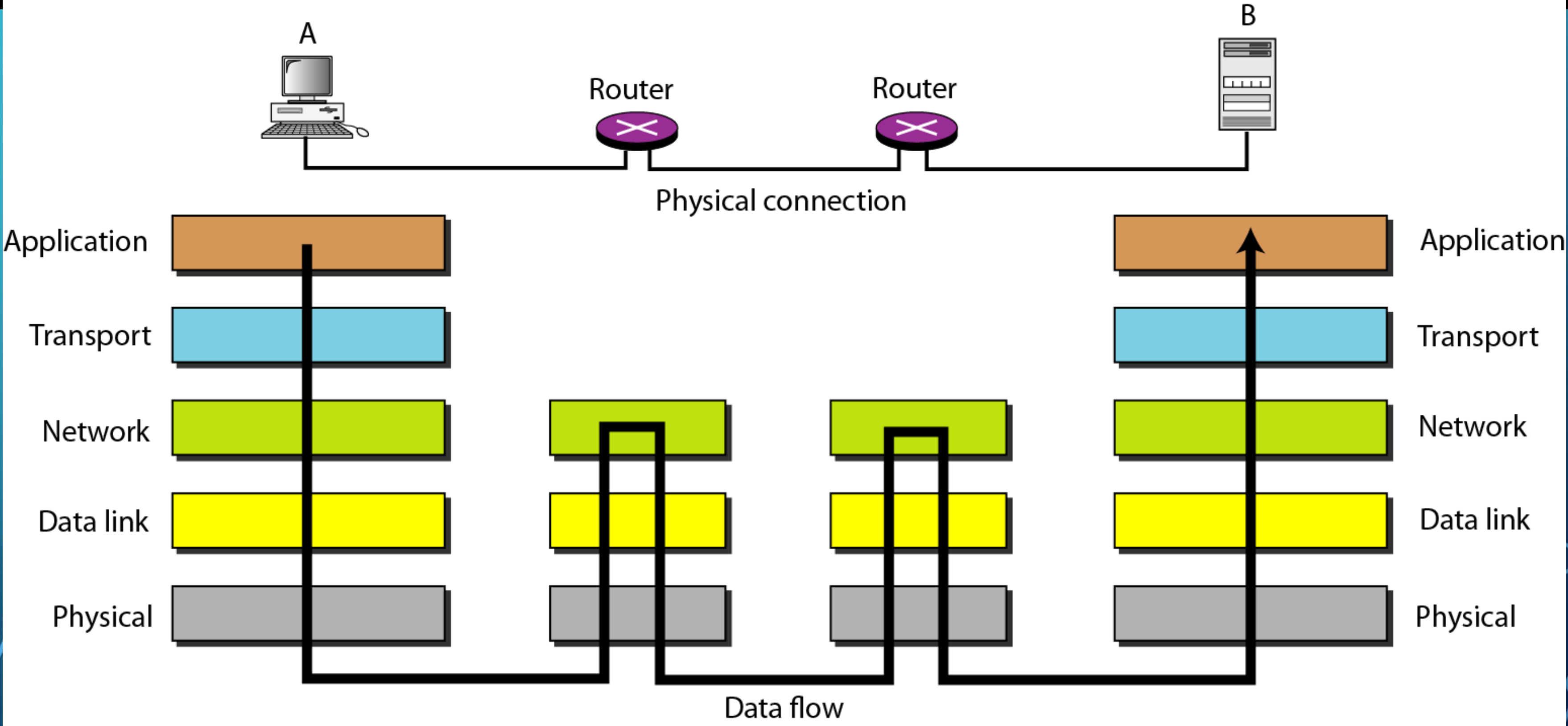
To divide the services required to perform a task, the Internet has created a set of rules called protocols. These allow different local and wide area networks, using different technologies, to be connected together and carry a message from one point to another. The set, or suite, of protocols that controls the Internet today is referred to as the **TCP/IP protocol suite**. The abbreviations (TCP and IP) will become clear as we explain different protocols.

The original TCP/IP protocol suite was defined as having four layers: host-to-network (or link), internet (network), transport and application. However, the TCP/IP protocol suite today is normally considered as a five-layer model, as shown in Figure below.



The TCP/IP protocol suite

Figure below shows the layers involved when a message is sent from device A to device B. As the message travels from A to B, it may pass through many routers. Routers use only the first three layers.



The interaction between layers in the TCP/IP protocol suite

LAYERS

This section briefly describes the function of each **layer** in the TCP/IP protocol suite. We show how a message travels through the different layers until it reaches the physical layer and is sent by the transmission media.

Application layer

The application layer enables a user, whether human or software, to access the network. It provides support for services such as electronic mail, remote file access and transfer, browsing the World Wide Web, and so on.

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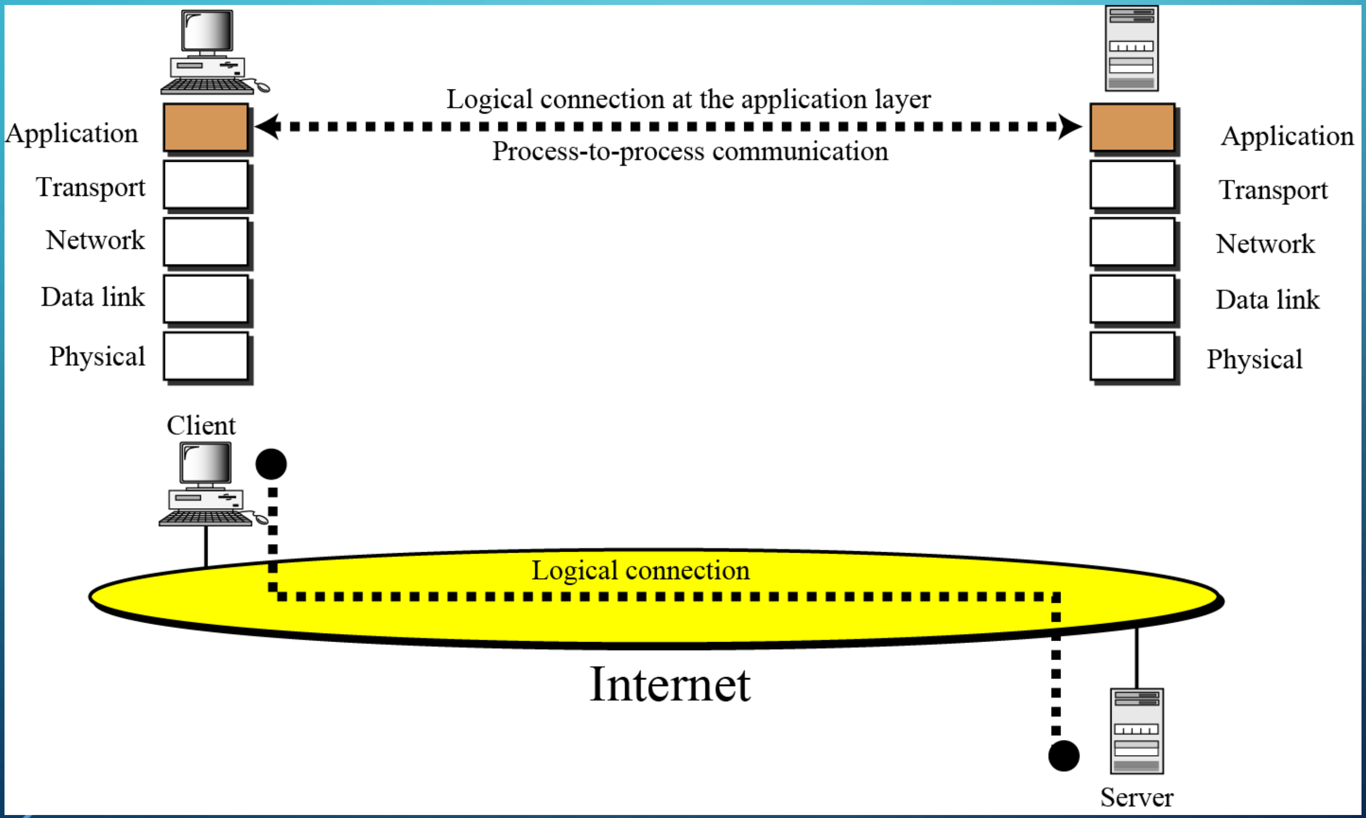
The application layer is responsible for providing services to the user.

Client-server architecture

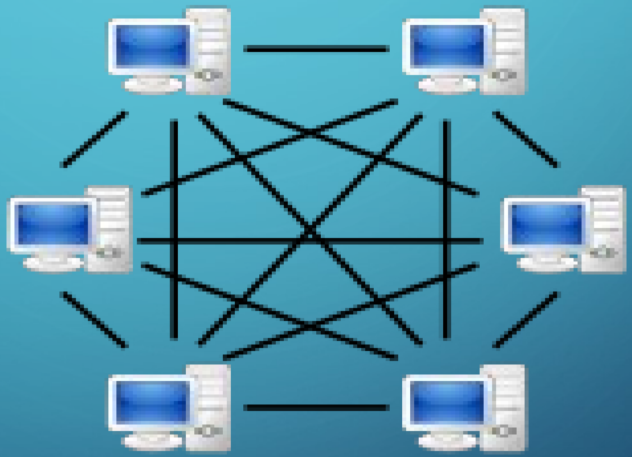
Although there are two architectures (designs) that allow two application programs, running on two remote computers, to communicate with each other, **client-server architecture** is more common.



Communication at the application layer

Peer-to-Peer architecture

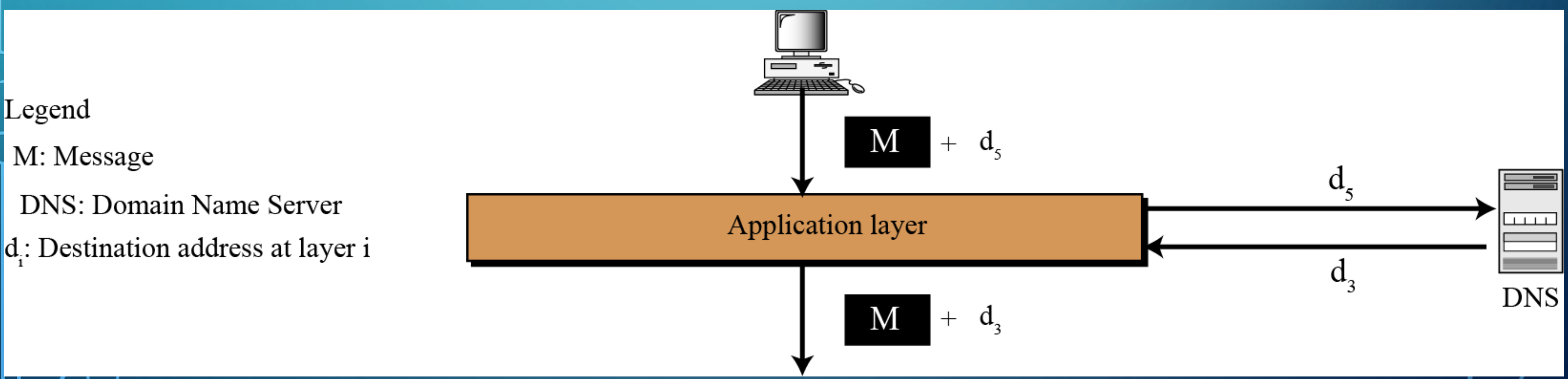
A peer-to-peer (or P2P) computer network uses diverse connectivity between participants in a network and the cumulative bandwidth of network participants rather than conventional centralized resources where a relatively low number of servers provide the core value to a service or application. P2P networks are typically used for connecting nodes via largely *ad hoc* connections. Such networks are useful for many purposes. Sharing content files (see file sharing) containing audio, video, data or anything in digital format is very common, and real time data, such as telephony traffic, is also passed using P2P technology..



Communication at the application layer

Application-layer address

When a client needs to send a request to a server, it needs the server application-layer address. For example, to identify one particular site, the client uses a Uniform Resource Locator (URL). As we will see later, the server application-layer address is not used for delivery of messages, it only helps the client to find the actual address of the server computer.



Addresses at the Application layer

Transport layer

The transport layer is responsible for process-to-process delivery of the entire message: logical communication is created between the transport layer of the client and the server computer. In other words, although physical communication is between two physical layers (through many possible links and routers), the two application layers consider the transport layer as the agent that takes responsibility for delivering the messages.

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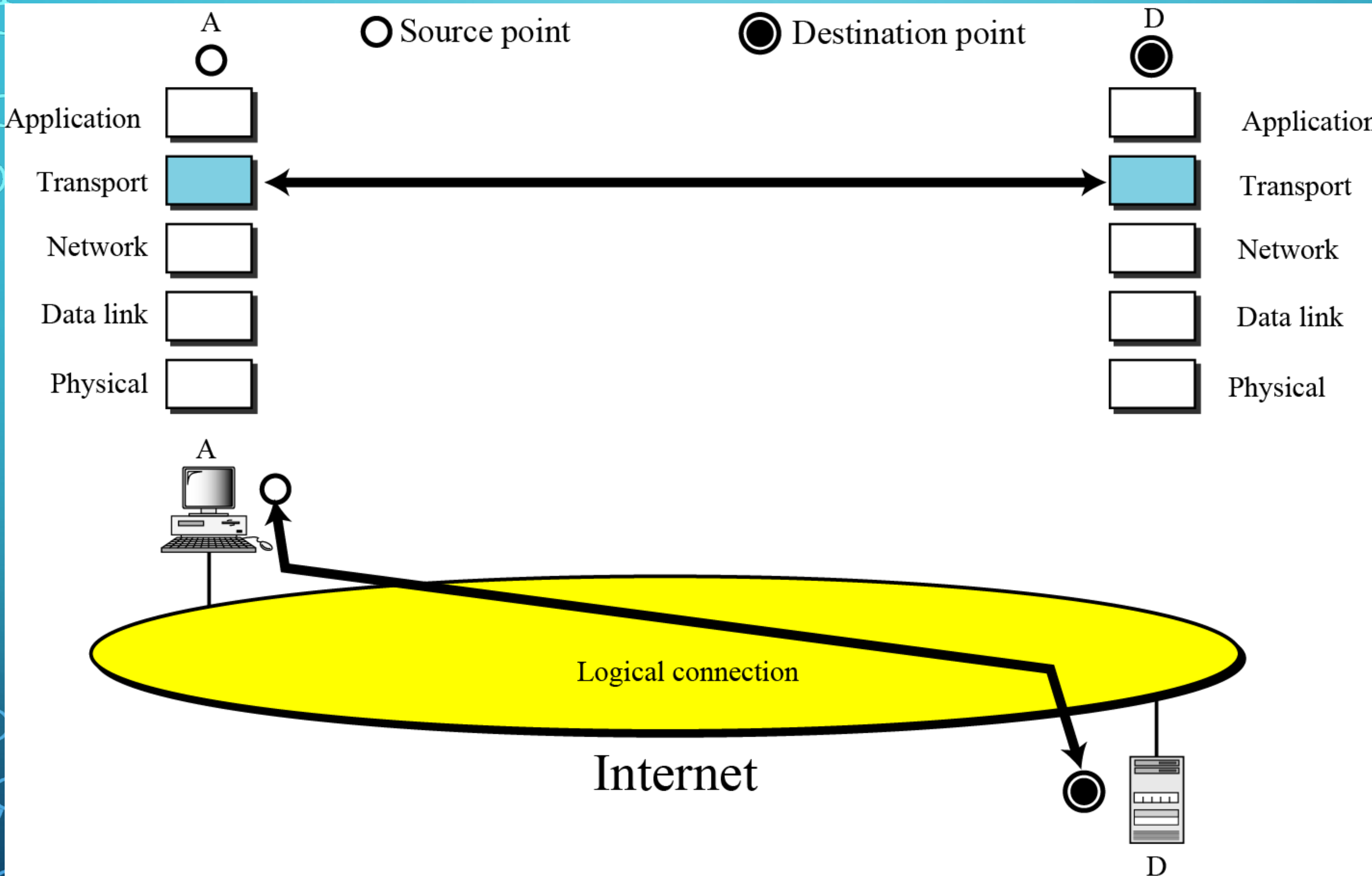
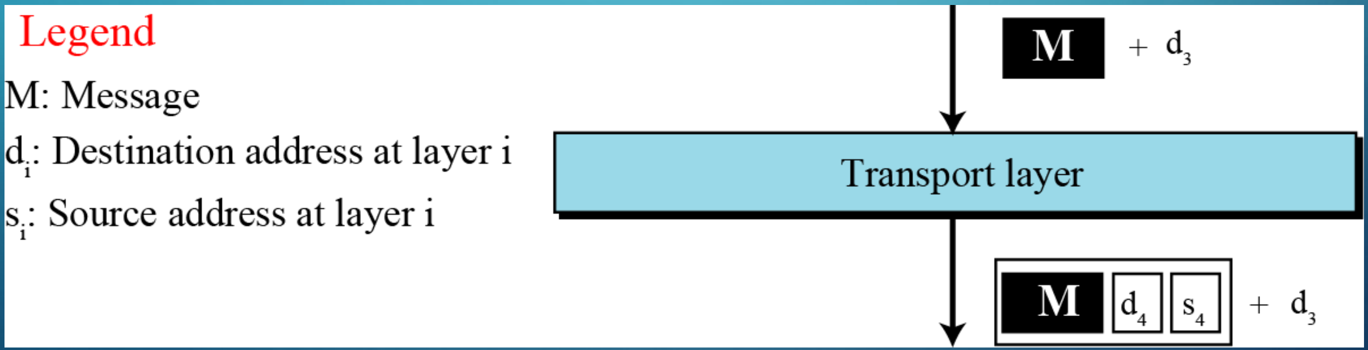
The transport layer is responsible for the logical delivery of a message between client and server processes.



Communication at the Transport layer

Transport-layer addresses (port numbers)

The server computer may be running several processes at the same time, for example an FTP server process and an HTTP server process. When the message arrives at the server, it must be directed to the correct process. We need another address for server process identification, called a port number.



Addresses at the Transport layer

Transport-layer protocols

During the life of the TCP/IP protocol suite three transport layer protocols have been designed: **UDP**, **TCP** and **SCTP**.

The **User Datagram Protocol (UDP)** is the simplest of all three protocols. UDP does multiplexing and de-multiplexing It also does a type of error control by adding a checksum to the packet.

Transmission Control Protocol (TCP) is a protocol that supports all the duties of a transport layer. However, it is not as fast as UDP. TCP uses sequence numbers, acknowledgment numbers and checksums. It also uses buffers at the sender's site. This combination of provisions provides multiplexing, de-multiplexing, flow control, congestion control and error control.

The Network layer

The Network layer is responsible for the source-to-destination (computer-to-computer or host-to-host) delivery of a packet, possibly across multiple networks (links). The network layer ensures that each packet gets from its point of origin to its final destination.

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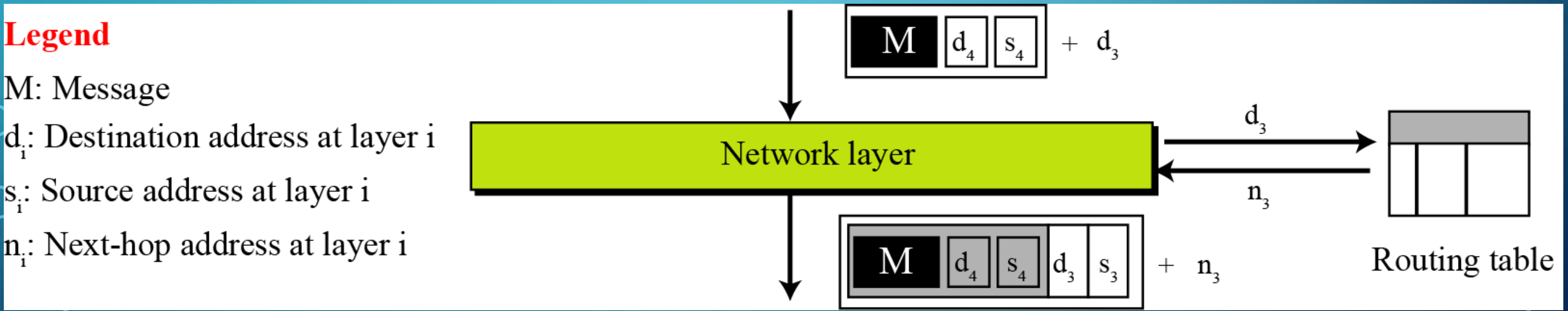
The network layer is responsible for the delivery of individual packets from the source host to the destination host.

Network-layer addresses

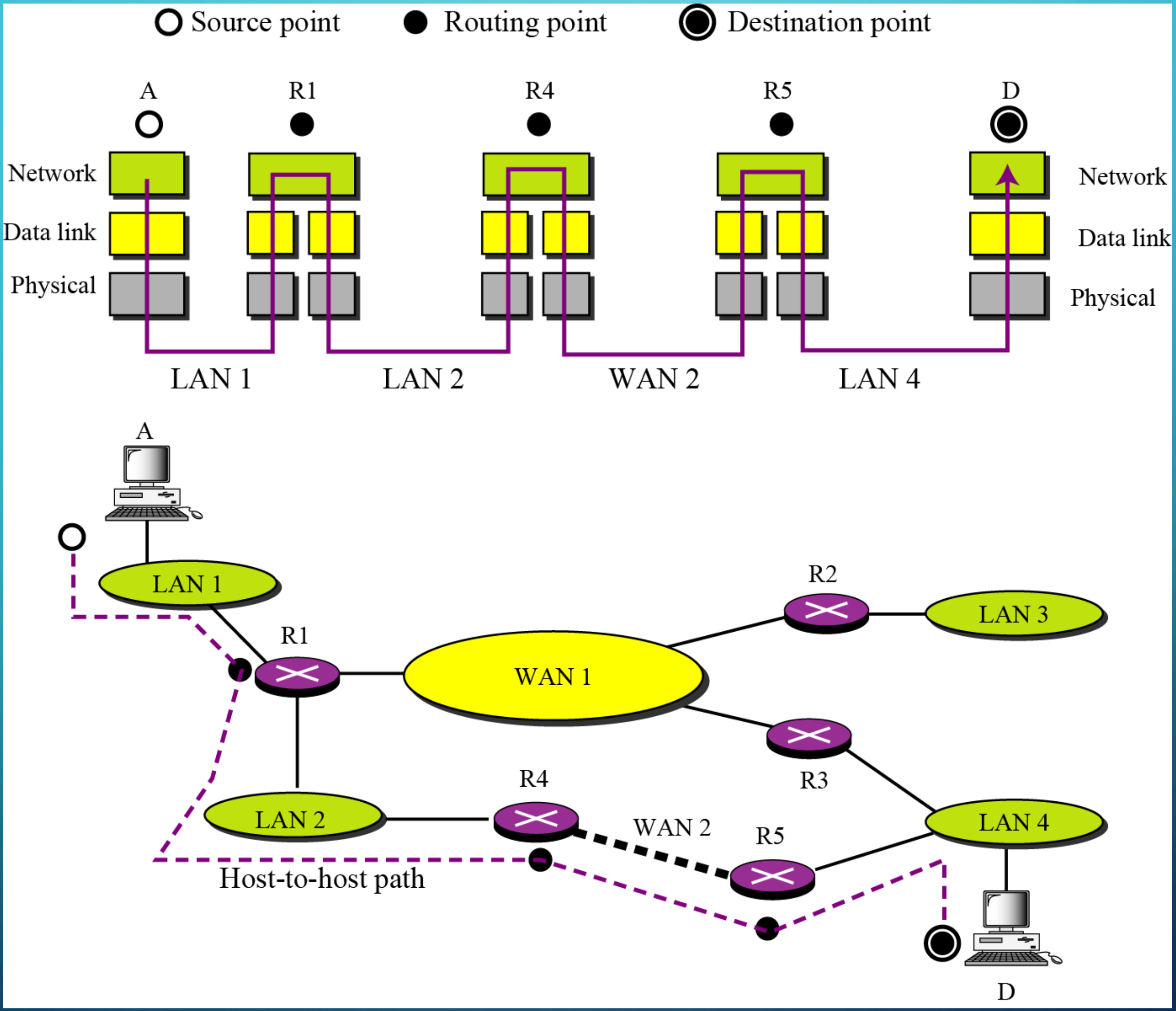
The packet traveling from the client to the server and the packet returning from the server need a network-layer address. The server address is provided by the server, as discussed above, while the client address is known by the client computer.



Addresses at the Network layer

Routing

The network layer has a specific duty: routing. Routing means determination of the partial or total path of a packet. As the Internet is a collection of networks (LANs, WANs, and MANs), the delivery of a packet from its source to its destination may be a combination of several deliveries: a source-to-router delivery, several router-to-router delivery, and finally a router-to-destination delivery.



Routing at the Network layer

Network-layer protocols

The TCP/IP protocol suite supports one main protocol (IP) and several auxiliary protocols to help IP to perform its duties.

In the TCP/IP protocol suite, the main protocol at the network layer is **Internet Protocol (IP)**. The current version is IPv4 (version 4) although IPv6 (version 6) is also in use, although not ubiquitously. IPv4 is responsible for the delivery of a packet from the source computer to the destination computer. For this purpose, every computer and router in the world is identified by a 32-bit IP address, which is presented in dotted decimal notation.

The notation divides the 32-bit address into four 8-bit sections and writes each section as a decimal number between 0 and 255 with three dots separating the sections. For example, an IPv4 address

00001010 00011001 10101100 00001111

is written as

10.25.172.15

Dotted-Decimal Notation

Data link layer

As we saw in the previous section, the network layer packet may pass through several routers in its journey from its source to its destination. Carrying the packet from one node to another (where a node can be a computer or a router) is the responsibility of the data link layer.

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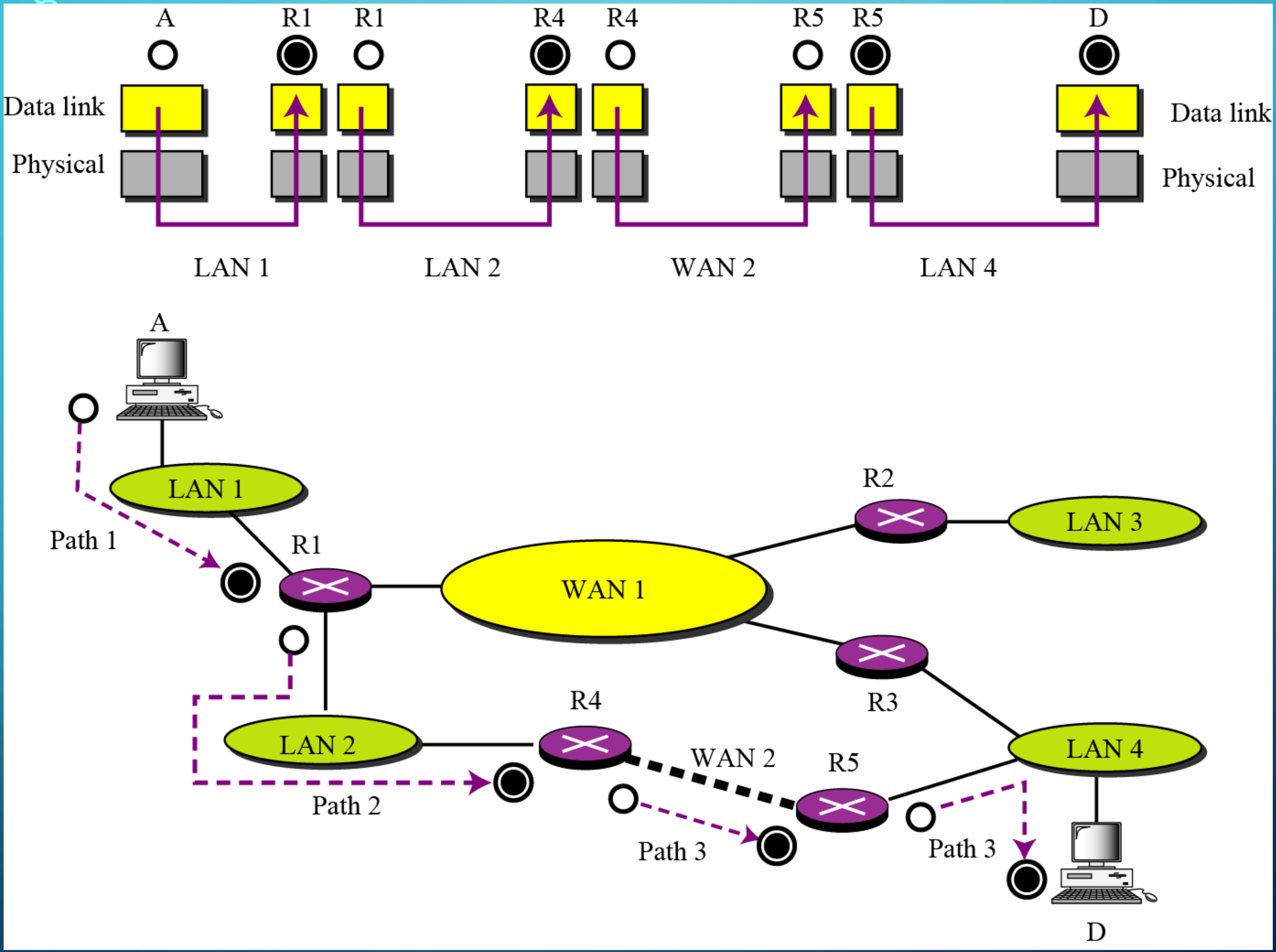
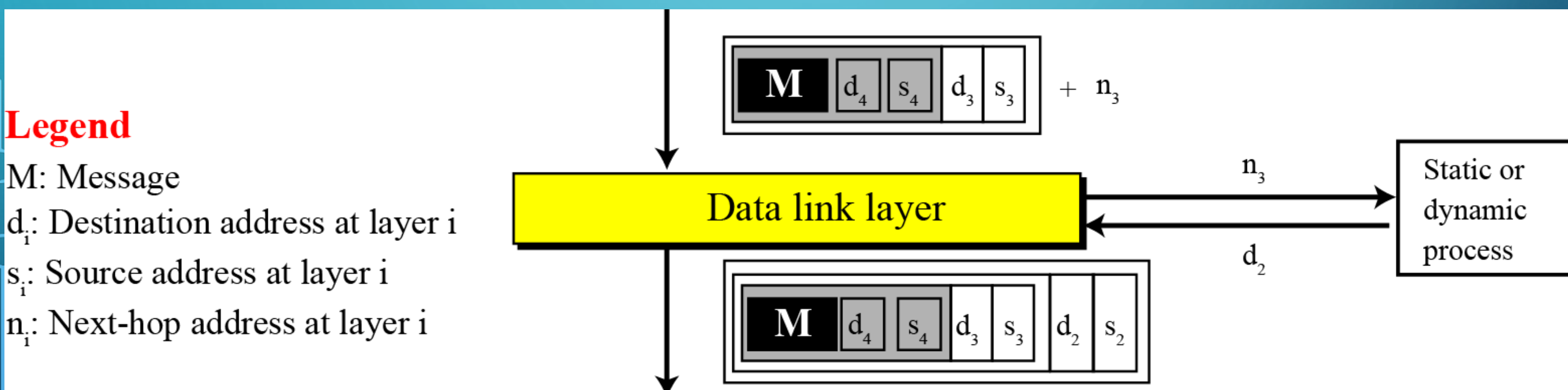
The data link layer is responsible for node-to-node delivery of frames.



Communication at the data-link layer

Data-link layer addresses

Two questions that come to mind are how computer A knows the data-link layer address of router R_1, or router R_1 knows the data-link layer address of router R_4. A device can find the data-link address of another device either **statically** or **dynamically**.



Addresses at the data link layer

Unlike IP addresses, addresses at the data-link layer cannot be universal. Each data link protocol may have a different address format and size. The Ethernet protocol, the most prevalent local area network in use today, uses a 48-bit address, which is normally written in hexadecimal format (grouped in six sections, each with two hexadecimal digits) as shown below:

07:01:02:11:2C:5B

Physical layer

The physical layer coordinates the functions required to carry a bit stream over a physical medium. Although the data link layer is responsible for moving a **frame** from one node to another, the physical layer is responsible for moving the **individual bits** that make up the frame to the next node. In other words, the unit of transfer in the data link layer is a frame, while the unit of transfer in the physical layer is a bit.

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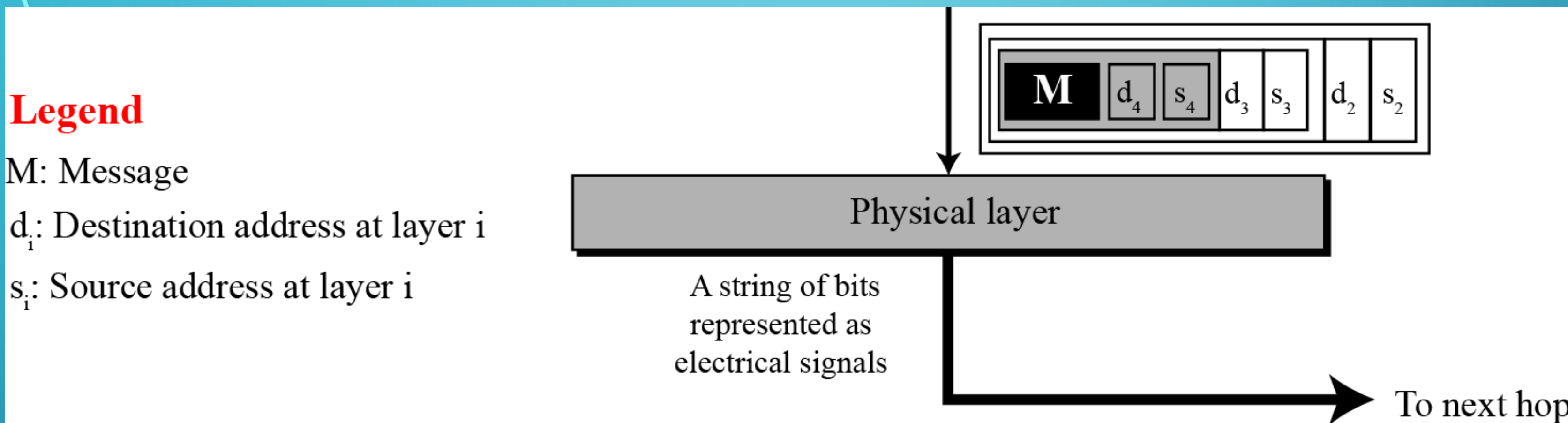
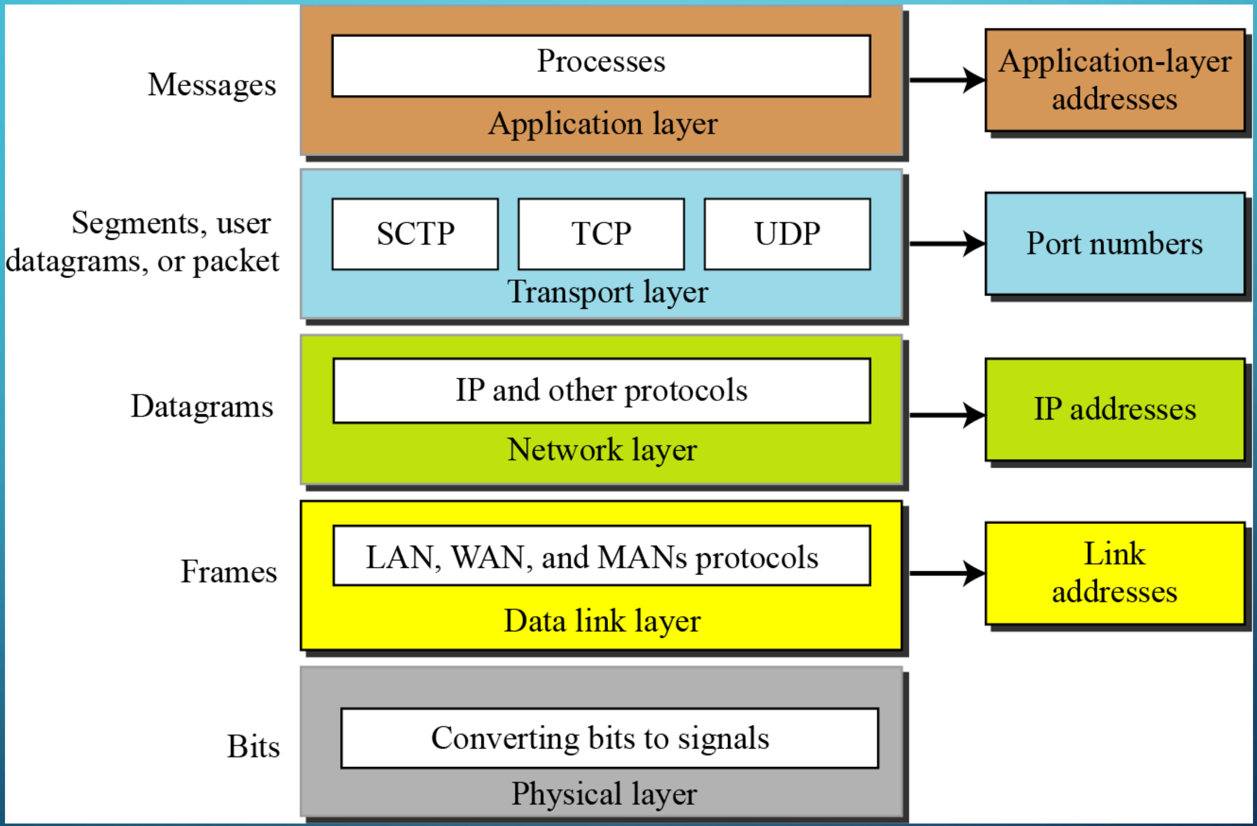
The physical layer is responsible for node-to-node delivery of bits



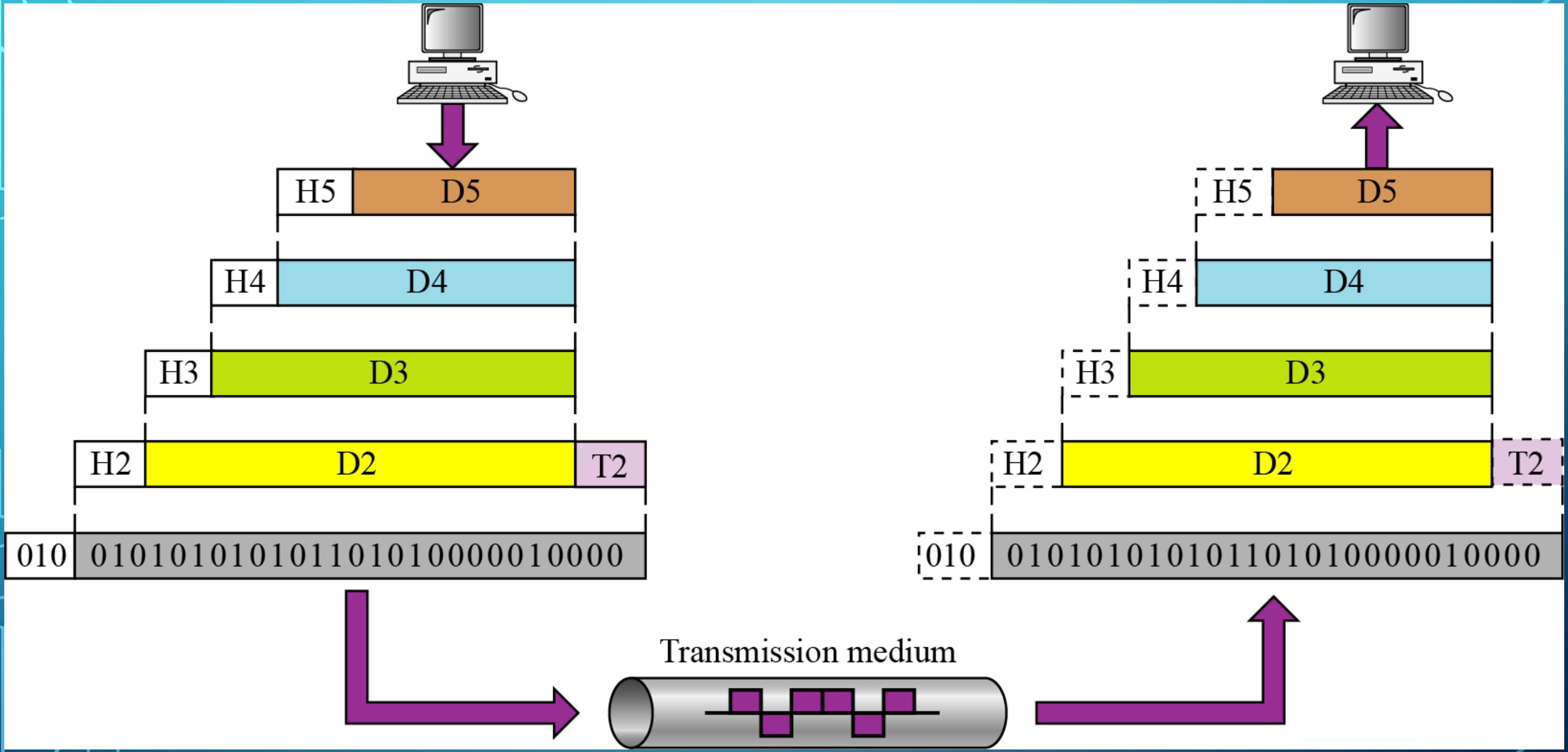
Duty of the physical layer

Summary of layers

Figure below summarizes the duties of each layer in the TCP/IP protocol and the addresses involved in each layer.



Four levels of addressing in the Internet



An exchange using the TCP/IP model

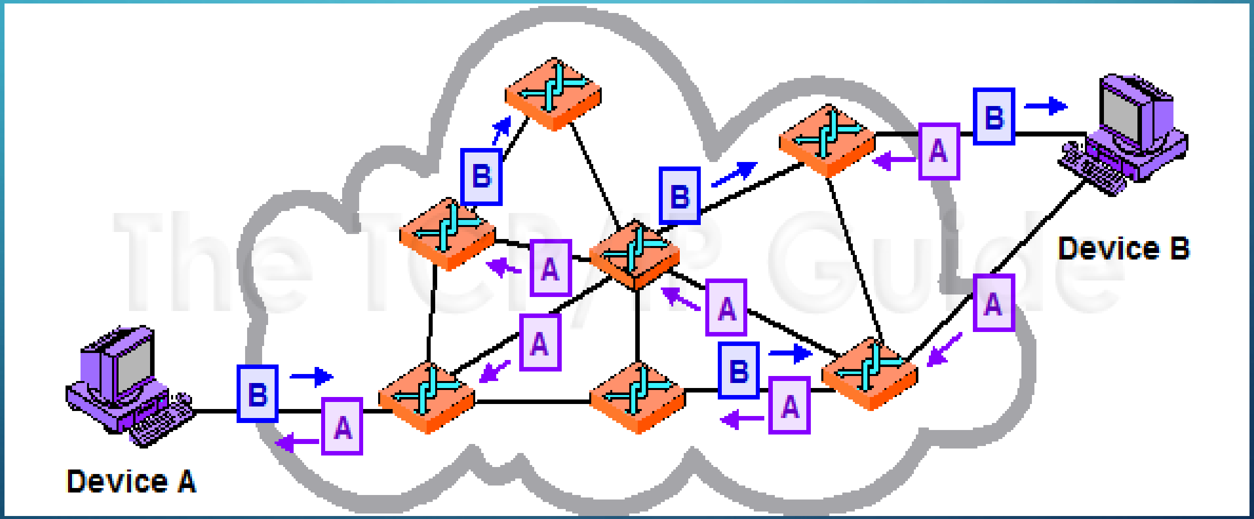
CONNECTION-ORIENTED AND CONNECTIONLESS SERVICES

- CO: like telephone system – establish a connection, use it, release it
- CL: like postal system – route each message independent of other –

	Service	Example
Connection-oriented	Reliable message stream	Sequence of pages
	Reliable byte stream	Remote login
	Unreliable connection	Digitized voice
Connection-less	Unreliable datagram	Electronic junk mail
	Acknowledged datagram	Registered mail
	Request-reply	Database query

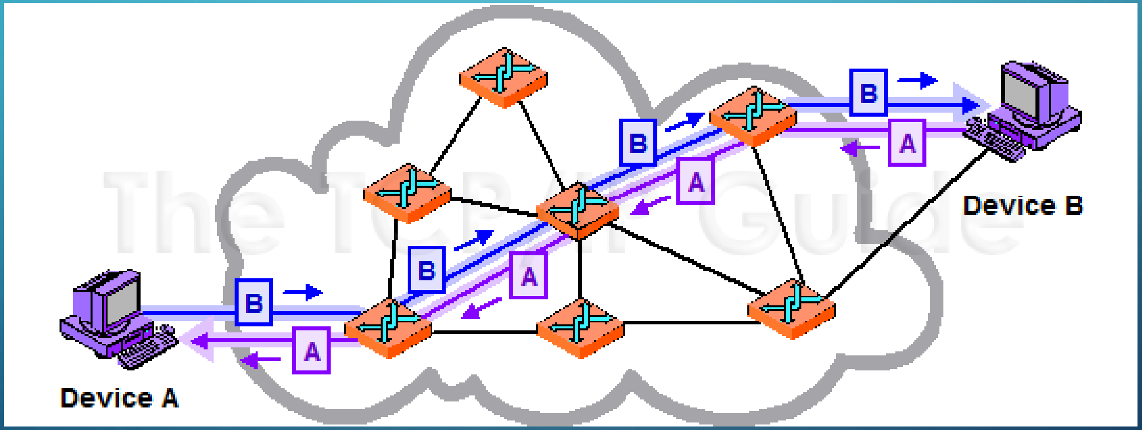
PACKET SWITCHING VS CIRCUIT SWITCHING

- Packet Switching: message broken into packets each of which may take a separate path from sender to receiver.



PACKET SWITCHING VS CIRCUIT SWITCHING

- Circuit Switching: a dedicated connection called a circuit is set up between two devices which is used for the entire communication.



HIGHLIGHTS FROM CHAPTER 1

- Client-Server Model vs P-2-P network
- Applications of a computer network, usage of Internet
- PAN vs LAN vs WAN vs MAN
- Store-n-forward/Packet Switch vs Circuit Switch
- Connection oriented vs Connectionless
- Layers – functionalities of each layer
- Service vs Interface vs Protocols
- Interesting Topics : ARPANET, Internet Architecture, Ethernet, P-2-P Networks