LESSON 2

NETWORK ARCHITECTURE

INTRODUCTION

- Computer networks are designed in a highly structured way to reduce their design complexity. Most networks are organised as a series of *layers* or levels.
- Each layer clearly defines various data communication functions and logical operations. Each level is functionally independent of the others but builds on its predecessor.
- In order to function, higher levels depend on correct operation of the lower levels.

INTRODUCTION CONT...

- The set of rules and conventions that encompasses electrical, mechanical and functional characteristics of a data link, as well as the control procedures for such communication is called the *layer n protocol*.
- The communication between two layers at the same level of two different computers is called *virtual communication*.
- Here, each layer passes data and control information to the layer immediately below it, until the lowest layer (layer 1).

INTRODUCTION CONT...

- At layer 1, information from one computer is physically transferred to layer 1 of the other *(physical communication)*.
- The *interface* between each pair of adjacent layers defines which operations and services the lower layer offers to the upper one.
- The *network architecture* thus can be defined as the set of layers and protocols.

OSI MODEL

Open System Interconnection,

- An ISO standard for worldwide communications that defines a networking framework for implementing protocols in seven layers.
- Open Systems Interconnection (OSI) model is developed by ISO (International organization for standardization) in 1984.

OSI MODEL

Open System Interconnection

- OSI reference model is a logical framework for standards for the network communication.
- OSI reference model is now considered as a primary standard for internetworking and inter computing.
- Today many network communication protocols are based on the standards of OSI model.
- In the OSI model the network/data communication is defined into seven layers.

OSI MODEL/OSI STACK

The OSI model is comprised of seven layers:

Layer 7

Layer 6

Layer 5

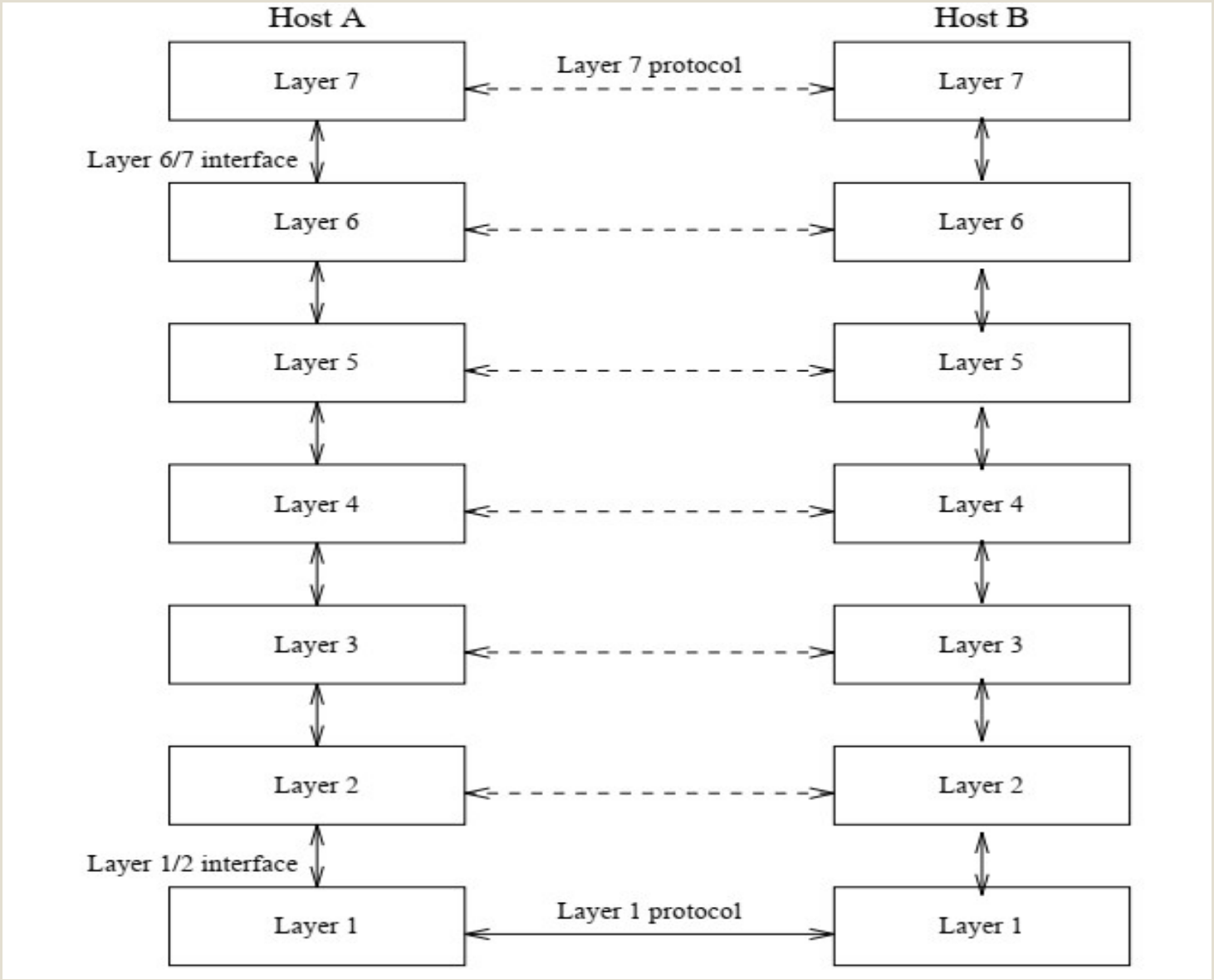
Layer 4

Layer 3

Layer 2

Layer 1

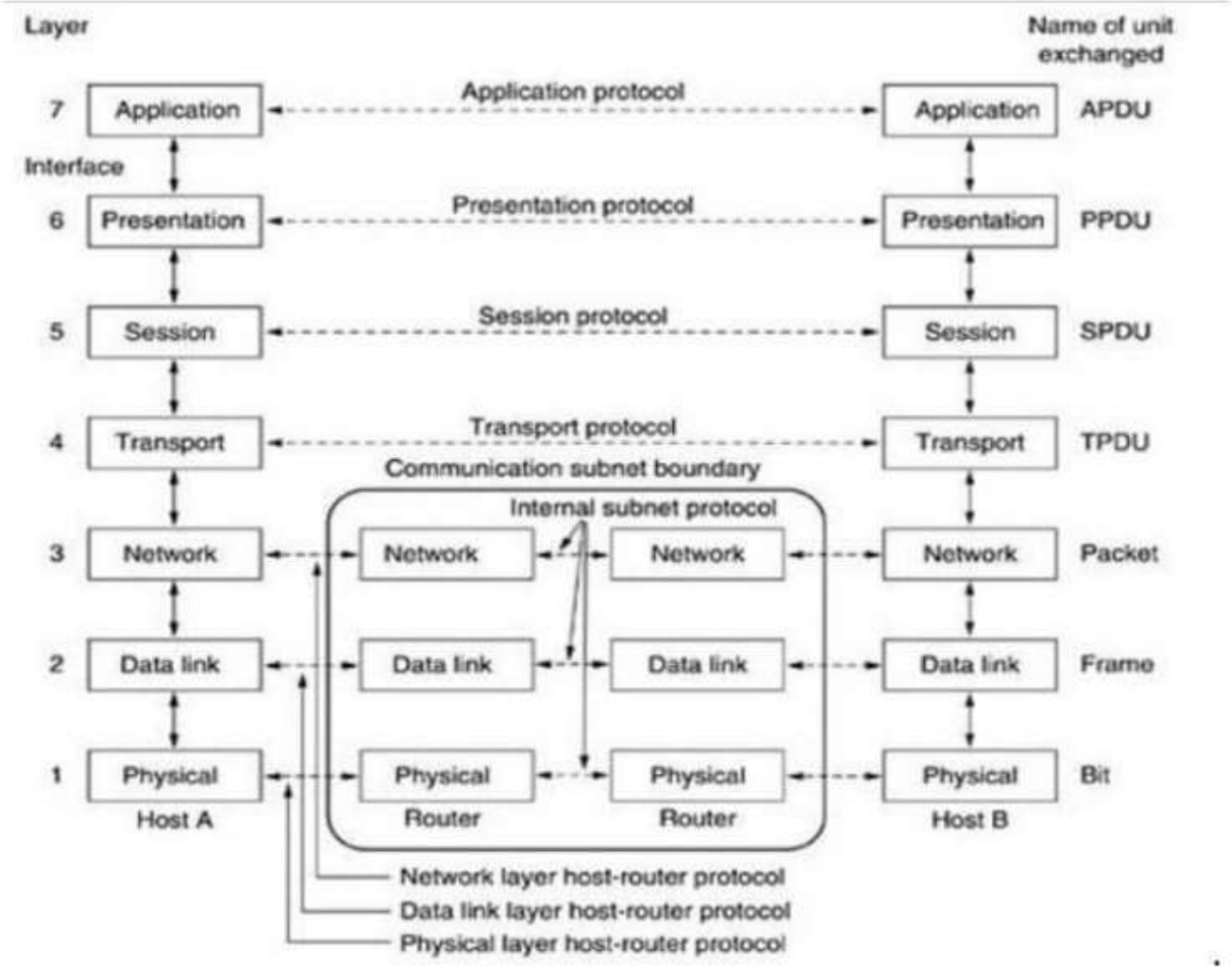
LAYERS, PROTOCOLS AND INTERFACES



LAYERS, PROTOCOLS AND INTERFACES CONT…

- At the physical layer, data is represented in binary expressions (that is, a series of 1s and 0s).
- A binary expression is made up of bits, where a bit is a single 1 or a single 0.
- At upper layers, however, bits are grouped together, into what is known as a *protocol data unit (PDU) or a data service unit* .
- The term *packet is used fairly generically to refer to these PDUs. However, PDUs* might have an additional name, depending on their OSI layer.
- Figure below illustrates these **PDU** names.

LAYERS, PROTOCOLS AND INTERFACES CONT…



LAYER 1: THE PHYSICAL LAYER

The physical layer, is concerned with the transmission of data on the network.

The physical layer defines:

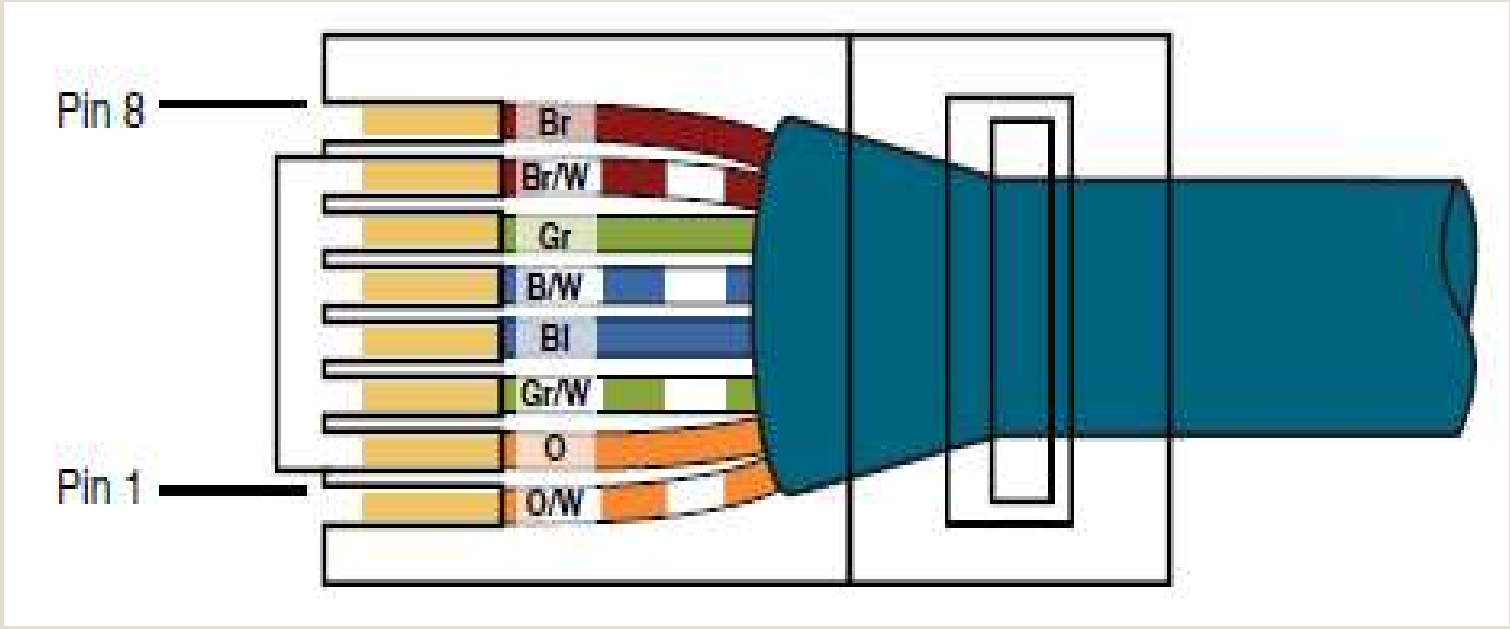
a)How bits are represented on the medium:

Data on a computer network is represented as a binary expression. E.g The presence or the absence of voltage on a wire can represent a binary 1 or a binary 0. The physical layer defines the type of encoding such as Manchester encoding and Non-Return to Zero(NRZ)

THE PHYSICAL LAYER CONT…

b)Wiring standards for connectors and jacks:

- As an example, the TIA/EIA-568-B standard describes how an RJ-45 connector should be wired for use on a 100BASE-TX Ethernet network, as shown in Figure below .



THE PHYSICAL LAYER CONT...

c) Physical topology: Layer 1 devices view a network as a physical topology (as opposed to a logical topology). Examples of a physical topology include bus,ring, and star topologies e.t.c

d)Synchronizing bits: For two networked devices to successfully communicate at the physical layer, they must agree on when one bit stops and another bit starts. Specifically, what is needed is a method to synchronize the bits.

Two basic approaches to bit synchronization include *asynchronous and synchronous(The approaches are differentiated in terms of cost, time interval and existence of gaps between data)*

THE PHYSICAL LAYER CONT…

e) Bandwidth usage: The two fundamental approaches to bandwidth usage on a network are *broadband and baseband.*

- **Broadband**: Broadband technologies divide the bandwidth available on a medium (for example, copper or fiber-optic cabling) into different channels.
- **Baseband:** Baseband technologies, in contrast, use all the available frequencies on a medium to transmit data. Ethernet is an example of a networking technology that uses baseband.

THE PHYSICAL LAYER CONT...

f) **Multiplexing strategy:** Multiplexing allows multiple communications sessions to share the same physical medium. Cable TV, allows you to receive multiple channels over a single physical medium (for example, a coaxial cable plugged into the back of your television).

g) **Transmission mode:** The physical layer also defines the direction of transmission between two devices: simplex, half-duplex, or full-duplex.

LAYER 2: THE DATA LINK LAYER

- The data link layer transforms the physical layer to a reliable link. It makes the physical layer appear error-free to the upper layer (network layer).

- The data link layer, is concerned with packaging data into frames and transmitting those frames on the network, performing error detection/ correction, uniquely identifying network devices with an address, and handling flow control.
- These processes are collectively referred to as *data link control (DLC)*. It has two sublayers MAC and LLC.

LAYER 2: THE DATA LINK LAYER CONT...

- **Characteristics of the Media Access Control (MAC) sublayer include the following:**
  - **Physical addressing:** A common example of a Layer 2 address is a MAC address, which is a 48-bit address assigned to a device's network interface card (NIC). The address is commonly written in hexadecimal notation (for example, 58:55:ca:eb:27:83).
  - The first 24 bits of the 48-bit address are collectively referred to as the *vendor code* . *E*ach vendor is responsible for using unique values in the last 24 bits of a MAC address.

LAYER 2: THE DATA LINK LAYER CONT…

Characteristics of the MAC cont…

- **Logical topology**: Layer 2 devices view a network as a logical topology.
- **Method of transmitting on the media:** With several devices connected to a network, there needs to be some strategy for determining when a device is allowed to transmit on the media.

LAYER 2: THE DATA LINK LAYER CONT...

Characteristics of the Logical Link Control (LLC) sublayer:

- **Connection services**: When a device on a network receives a message from another device on the network, that recipient device can provide feedback to the sender in the form of an acknowledgment message.

  Functions provided by these acknowledgment messages:

  - Flow control which limits the amount of data a sender can send at one time; this prevents the receiver from being overwhelmed with too much information.
  - Error control which allows the recipient of data to let the sender know if the expected data frame was not received or if it was received, but is corrupted.

Characteristics of the Logical Link Control (LLC) sublayer Cont…

- **Synchronizing transmissions:** Senders and receivers of data frames need to coordinate when a data frame is being transmitted and should be received.

  Three methods of performing this synchronization are listed as:

  - **Asynchronous-**sends one character at a time with stop, start and optional parity bit.
  - **Synchronous-**sends multiple characters at one time with beginning and ending flags, control, address info, and cyclic checksum.
  - **Isochronous-**sends a steady-rate stream, often in real-time.

LAYER 3: THE NETWORK LAYER

The network layer is primarily concerned with forwarding data/ packets based on logical addresses.

Network layer tasks:

- **Logical addressing:** Although the data link layer uses physical addresses to make forwarding decisions, the network layer uses logical addressing to make forwarding decisions. A variety of routed protocols (for example, AppleTalk and IPX(for Novell networks) have their own logical addressing schemes, but by far, the most widely deployed routed protocol is Internet Protocol (IP).

THE NETWORK LAYER CONT…

- **Switching:** The term switching is often associated with Layer 2 technologies; however, the concept of switching also exists at Layer 3. Switching, at its essence, is making decisions about how data should be forwarded.e.g packet switching,circuit switching and message switching.
- **Route discovery and selection-** When independent networks or links are connected to create intemetworks (network of networks) or a large network, the connecting devices (called routers or switches) route or switch the packets to their final destination.

THE NETWORK LAYER CONT…

- **Connection services:** Just as the data link layer provided connection services for flow control and error control, connection services also exist at the network layer.

LAYER 4: THE TRANSPORT LAYER

- Whereas the network layer oversees source to-destination delivery of individual packets, it does not recognize any relationship between those packets.
- It treats each one independently, as though each piece belonged to a separate message, whether or not it does.
- The transport layer, on the other hand, ensures that the whole message arrives intact and in order, overseeing both error control and flow control at the source to-destination level.

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THE TRANSPORT LAYER CONT…

- Two common transport layer protocols include *Transmission Control Protocol (TCP)* and *User Datagram Protocol (UDP)*.
- A less popular Layer 4 protocol is Novell's *Sequenced Packet Exchange (SPX)*.
- *Similar* to the TCP/IP stack of protocols, Novell's solution (much more popular in the mid 1990s) was the IPX/SPX stack of protocols. However, most modern Novell networks rely on TCP/IP rather than IPX/SPX.

THE TRANSPORT LAYER CONT…

Tasks by Transport layer:

Service-point addressing. Computers often run several programs at the same time.

- For this reason, source-to-destination delivery means delivery not only from one computer to the next but also from a specific process (running program) on one computer to a specific process (running program) on the other.
- The transport layer header must therefore include a type of address called a service-point address (or port address). e.g 20-FTP, 80- HTTP, 161-SNMP

THE TRANSPORT LAYER CONT…

Tasks by Transport layer Cont…:

Segmentation and reassembly. A message is divided into transmittable segments, with each segment containing a sequence number.

- These numbers enable the transport layer to reassemble the message correctly upon arriving at the destination and to identify and replace packets that were lost in transmission.

THE TRANSPORT LAYER CONT...

Tasks by Transport layer Cont...:

Connection control. The transport layer can be either connectionless or connection oriented.

- A connectionless transport layer treats each segment as an independent packet and delivers it to the transport layer at the destination machine.
- A connection oriented transport layer makes a connection with the transport layer at the destination machine first before delivering the packets. After all the data are transferred, the connection is terminated

THE TRANSPORT LAYER CONT…

Tasks by Transport layer Cont…:

Flow control services- Two common flow control approaches at Layer 4 are as follows:

- **Windowing:** TCP communication uses windowing, in that one or more segments are sent at one time, and a receiver can acknowledge the receipt of all the segments in a window with a single acknowledgment.
- **Buffering:** : With buffering, a device (for example, a router) allocates a chunk of memory (sometimes called a buffer or a queue) to store segments if bandwidth is not currently available to transmit those segments. A queue has a finite capacity, however, and can overflow (that is, drop segments) in the event of sustained network congestion.

THE TRANSPORT LAYER CONT...

Tasks by Transport layer Cont...:

Error control. Like the data link layer, the transport layer is responsible for error control.

- However, error control at this layer is performed process-to-process rather than across a single link.
- The sending transport layer makes sure that the entire message arrives at the receiving transport layer without error (damage, loss, or duplication).
- Error correction is usually achieved through retransmission.

LAYER 5: THE SESSION LAYER

The session layer, is responsible for setting up, maintaining, and tearing down sessions.

Setting up a session: Examples of the procedures involved in setting up a session include:

- Checking user credentials (for example, username and password)
- Assigning numbers to a session's communications flows to uniquely identify each flow
- Negotiating services required during the session
- Negotiating which device begins sending data

THE SESSION LAYER CONT…

Maintaining a session: Examples of the procedures involved in maintaining a session include:

- Transferring data
- Reestablishing a disconnected session
- Acknowledging receipt of data

Tearing down a session: A session can be disconnected based on mutual agreement of the devices in the session.

- Alternately, a session might be torn down because one party disconnects (either intentionally or because of an error condition).

LAYER 6: THE PRESENTATION LAYER

The presentation layer is concerned with the syntax and semantics of the information exchanged between two systems

The presentation layer is responsible for the formatting of data being exchanged and securing that data with encryption.

THE PRESENTATION LAYER CONT…

- **Data formatting:** As an example of how the presentation layer handles data formatting, consider how text is formatted.
- Some applications might format text using American Standard Code for Information Interchange (ASCII), while other applications might format text using Extended Binary Coded Decimal Interchange Code (EBCDIC).

THE PRESENTATION LAYER CONT…

- **Encryption**: Imagine that you are sending sensitive information over a network (for example, your credit-card number or bank password). If a malicious user were to intercept your transmission, he might be able to obtain this sensitive information. To add a layer of security for such transmissions, encryption can be used to scramble up (encrypt) the data in such a way that if the data were intercepted, a third party would not be able to unscramble it (decrypt).
- **Compression**. Data compression reduces the number of bits contained in the information. Data compression becomes particularly important in the transmission of multimedia such as text, audio, and video.

LAYER 7: THE APPLICATION LAYER

The application layer supports services used by end-user applications.

The application layer enables the user, whether human or software, to access the network.

It provides user interfaces and support for services such as electronic mail, remote file access and transfer, shared database management, and other types of distributed information services.

THE APPLICATION LAYER CONT…

Functions of the application layer

- **Application services:** Examples of the application services residing at the application layer include file sharing and e-mail.
- **Service advertisement:** Some applications' services (for example, some networked printers) periodically send out advertisements, making the availability of their service known to other devices on the network.

THE TCP/IP STACK OR DOD MODEL

The TCP/IP protocol suite was developed prior to the OSI model. Therefore, the layers in the TCP/IP protocol suite do not exactly match those in the OSI model.

The ISO developed the OSI reference model to be generic, in terms of what protocols and technologies could be categorized by the model.

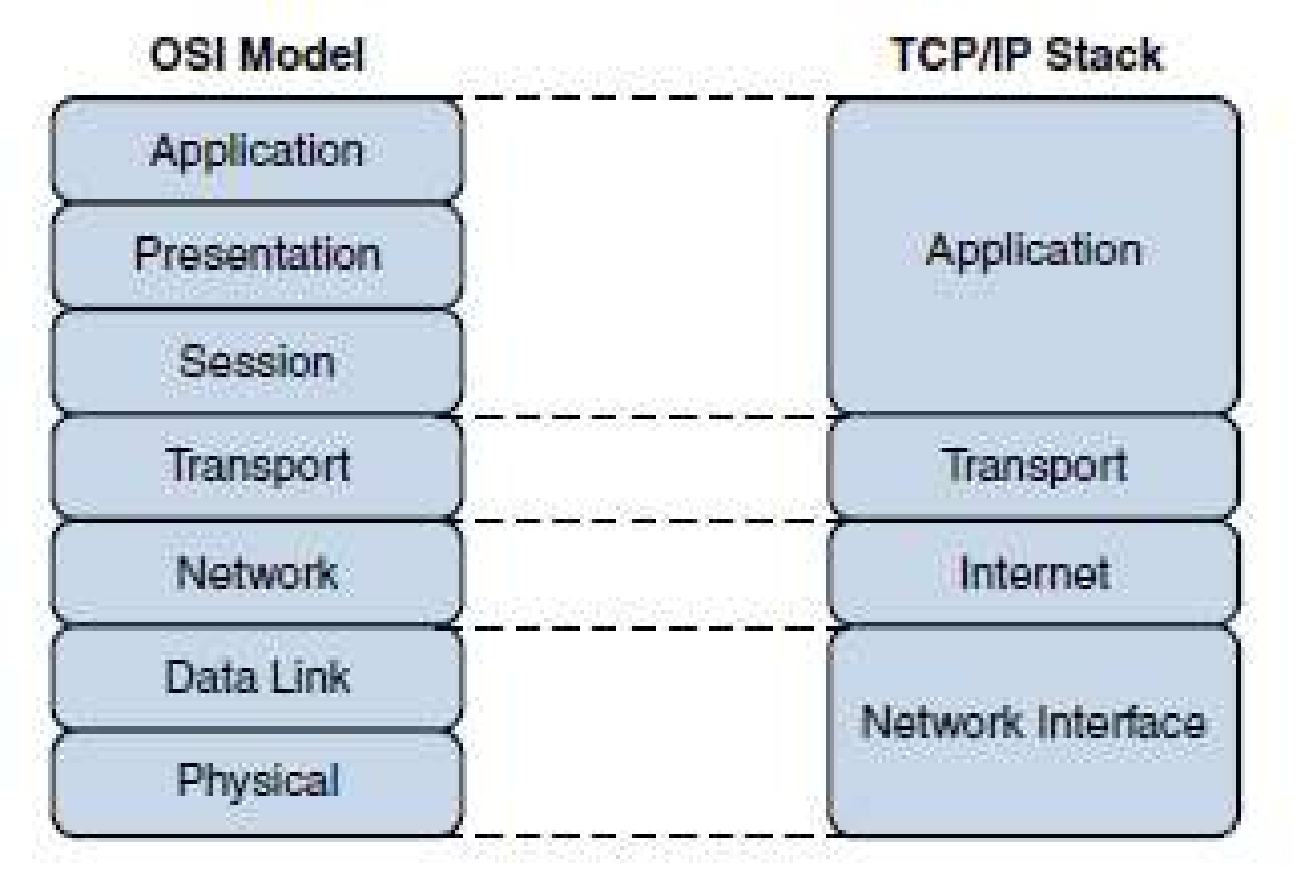
However, the vast majority of traffic on the Internet (and traffic on corporate networks) is based on the TCP/IP protocol suite.

THE TCP/IP STACK CONT…

- Therefore, a more relevant model for many network designers and administrators to reference is a model developed by the United States Department of Defense (DoD).

THE TCP/IP STACK CONT…

- It has only four defined layers, as opposed to the seven layers of the OSI model.



THE TCP/IP STACK CONT…

- **Network interface:** The TCP/IP stack's network interface layer encompasses the technologies addressed by Layers 1 and 2 (physical and data link layers) of the OSI model.
- **Internet:** The Internet layer of the TCP/IP stack maps to Layer 3 (the network layer) of the OSI model. The Internet layer of the TCP/IP stack focuses on IP as the protocol to be routed through a network.
- **Transport:** The transport layer of the TCP/IP stack maps to Layer 4 (the transport layer) of the OSI model. The two primary protocols found at the TCP/IP stack's transport layer are TCP and UDP.

THE TCP/IP STACK CONT…

- **Application:** The biggest difference between the TCP/IP stack and the OSI model is found at the TCP/IP stack's application layer. This layer addresses concepts described by Layers 5, 6, and 7 (the session, presentation, and application layers) of the OSI model.
- Application layer protocols in the TCP/IP stack are identifiable by unique *port numbers* .e.g Hypertext Transfer Protocol (HTTP), which is the protocol commonly used by web servers, uses a TCP port of 80.
- NB/ Ports numbered 1023 and below are called *well-known ports, while ports* numbered above 1023 are called *ephemeral ports* .*The maximum value of a port is* 65,535.

COMPARISON OF THE OSI AND TCP/IP REFERENCE MODELS:

- Both are based on the concept of a stack of independent protocols.
- In both models the layers up through and including the transport layer are there to provide an end-to-end, network-independent transport service to processes wishing to communicate.
- In both models, the layers above transport are application-oriented users of the transport service.
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COMPARISON OF THE OSI AND TCP/IP CONT…

- The TCP/IP model did not originally clearly distinguish between service, interface, and protocol, although people have tried to retrofit it after the fact to make it more OSI-like. For example, the only real services offered by the internet layer are SEND IP PACKET and RECEIVE IP PACKET.
- As a consequence, the protocols in the OSI model are better hidden than in the TCP/IP model and can be replaced relatively easily as the technology changes.

COMPARISON OF THE OSI AND TCP/IP CONT…

- The OSI model supports both connectionless and connection-oriented communication in the network layer, but only connection-oriented communication in the transport layer
- The TCP/IP model has only one mode in the network layer (connectionless) but supports both modes in the transport layer

IBM'S SYSTEM NETWORK ARCHITECTURE(SNA)

- IBM's System network architecture is a method for unifying network operations.
- Its a data communication **architecture** established by IBM to specify common conventions for communication among the wide array of IBM hardware and software data communication products and other platforms.
- It was created in 1974

IBM'S SYSTEM NETWORK ARCHITECTURE(SNA) CONT…

- SNA describes the division of network functions into discrete layers and defines protocols and formats for communication between equivalent layers.
- SNA describes a network in terms of a **physical network** and a **logical network**.
- The physical network consists of a collection of nodes: host node, front end communication node, concentration node and terminal node.
-

SNA CONT…

- The host node is the central processor;
- The front end communication node is concerned with data transmission functions;
- The concentration node supervises the behaviour of terminals and other peripherals;
- The terminal node is concerned with the input and output of information through terminal devices.

SNA CONT...

- The SNA logical network consists of three layers:

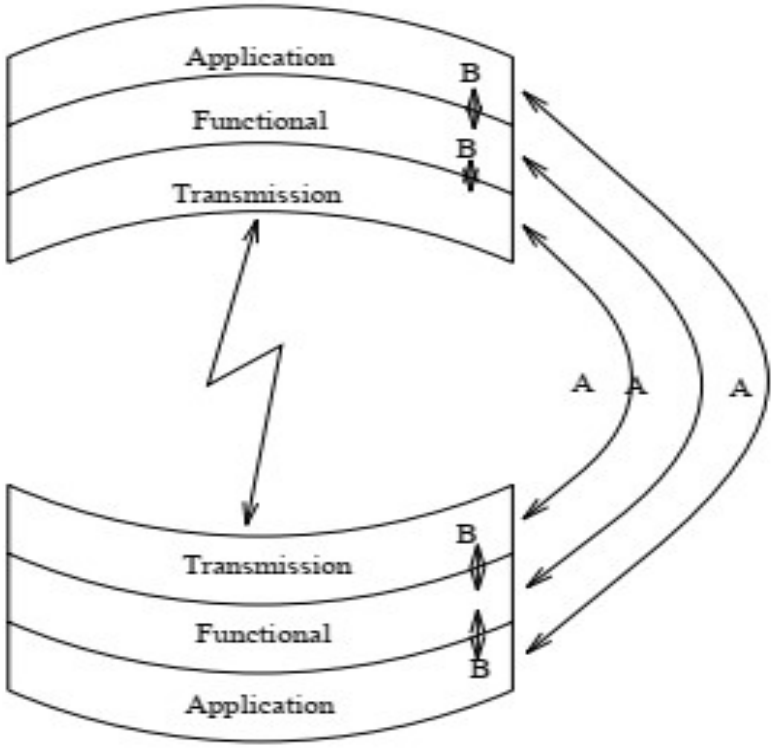
-Transmission management;
-Function management; and
-Application.

Each node in the SNA physical network may contain any or all of these three layers.

SNA CONT…

- The transmission management layer controls movement of user data through the network. It involves routing, scheduling and transmission functions. (Exists in every intermediate node through which the data units flow)
- The functional management layers controls the presentation format of information sent from and received by the application layer, i.e. it converts the data into a form convenient to the user.
- The application layer consists of the user's application programs and is concerned only with the processing of information

SNA CONT...



A: Peer layer communication

B: Adjacent layer communication

SNA CONT...

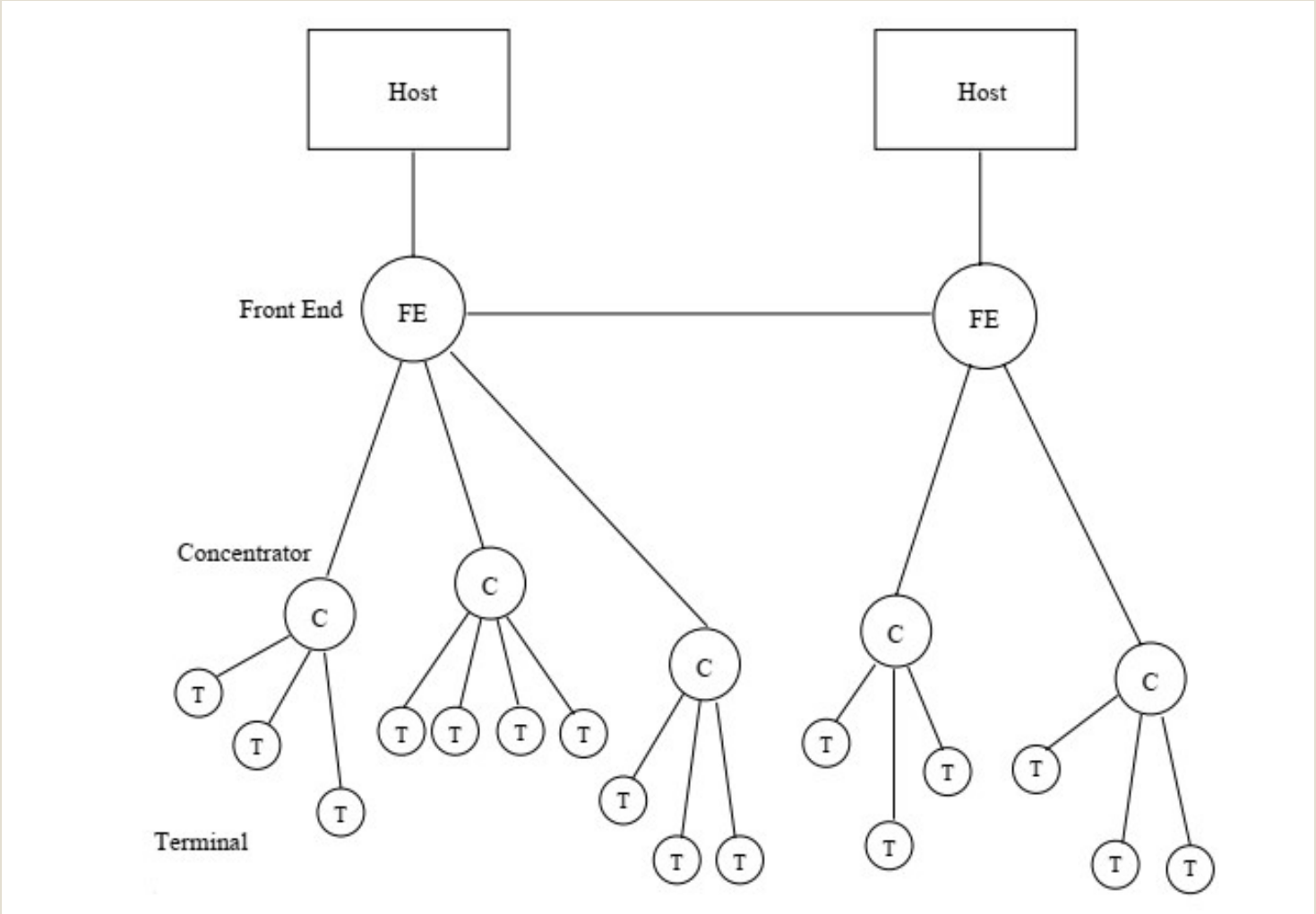
- Each node contains one or more Network Addressable Units (NAU).

There are three types of NAU.

- A Logical Unit (LU) is a NAU which users use to address their process.
- A Physical Unit (PU) is a NAU which the network uses to address a physical device, without reference to which processes are using it.
- System Services Control Point (SSCP) which has control over all front ends, remote concentrators and terminals attached to the host.

The three types of NAU communicate with each other by invoking the services of the transmission management layer

SNA CONT…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SNA PROTOCOLS

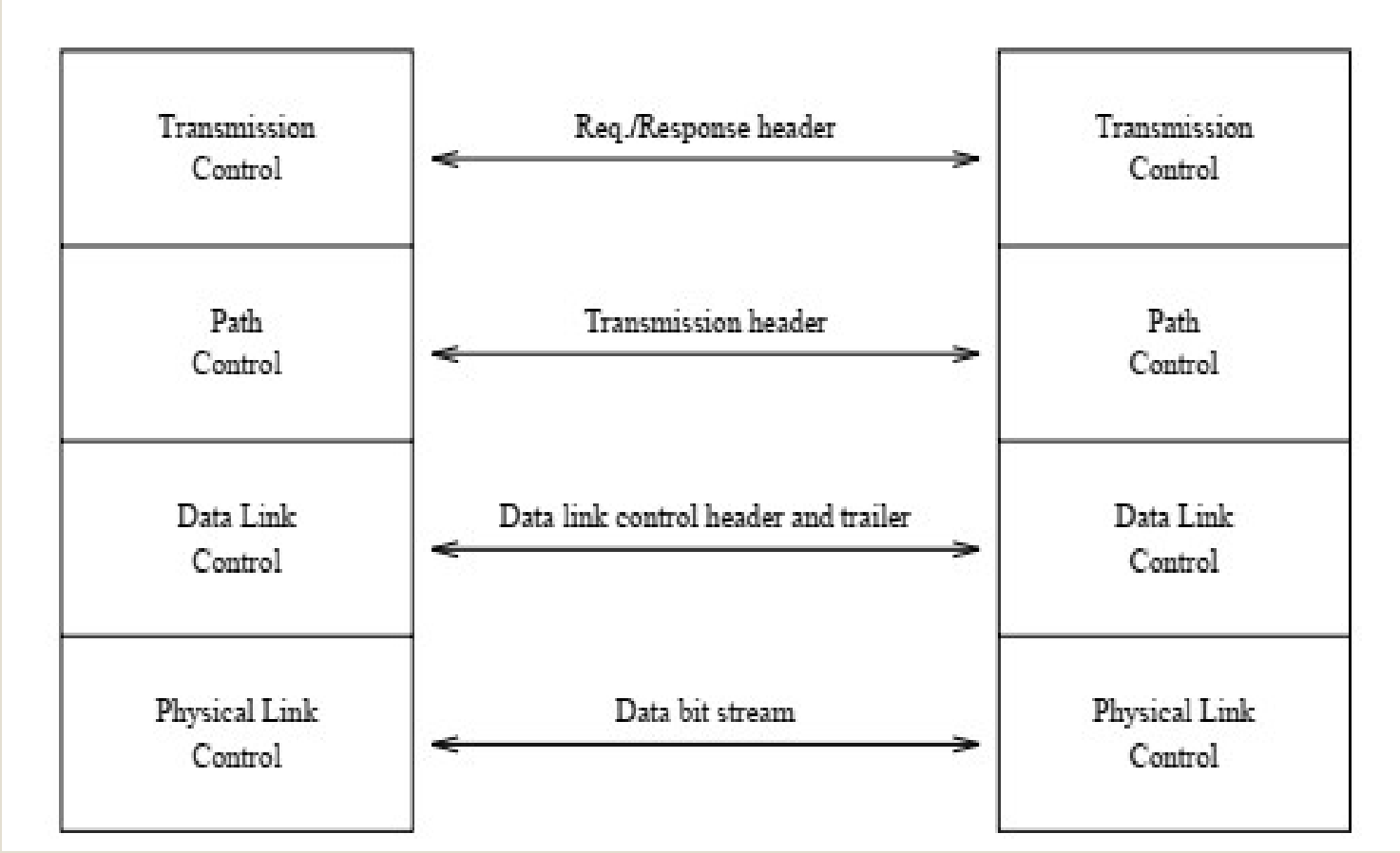
The physical link control protocol takes care of electrical transmission of data bits from one node to another.

The data link control protocol constructs frames from the data stream, detecting and recovering from transmission errors. This level 2 protocol is called SDLC (Synchronous Data Link Control).

The path control protocol performs the path-selection and congestion control functions within the subnet.

The transmission control protocol initiates, recovers and terminates transport connections (called sessions) in SNA. It also controls the flow of data to and from other NAUs.

SNA PROTOCOLS



DECNET'S DNA (DIGITAL NETWORK ARCHITECTURE)

- A DECNET is just a collection of computers (nodes) whose functions include running user programs, performing packet switching or both.
- The architecture of DECNET is called digital network architecture (DNA).
- DNA has five layers. The physical layer, data link control layer, transport layer and network services layer and and its application layer

COMPARISON OF ARCHITECTURE CONTROL LEVELS

Layer	OSI	TCP/IP	SNA	DECNET
7	Application	Application	End User	Application
6	Presentation		NAU Services	
5	Session		Data Flow Control	None
4	Transport	Transport	Transmission Control	Network Service
3	Network	Internet	Path Control	Transport
2	Data Link	Network Interface	Data Link	Data Link
1	Physical		Physical	Physical

Q & A

END