Layering in Computer Network

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- Decomposing the problem in more manageable component(Layers)

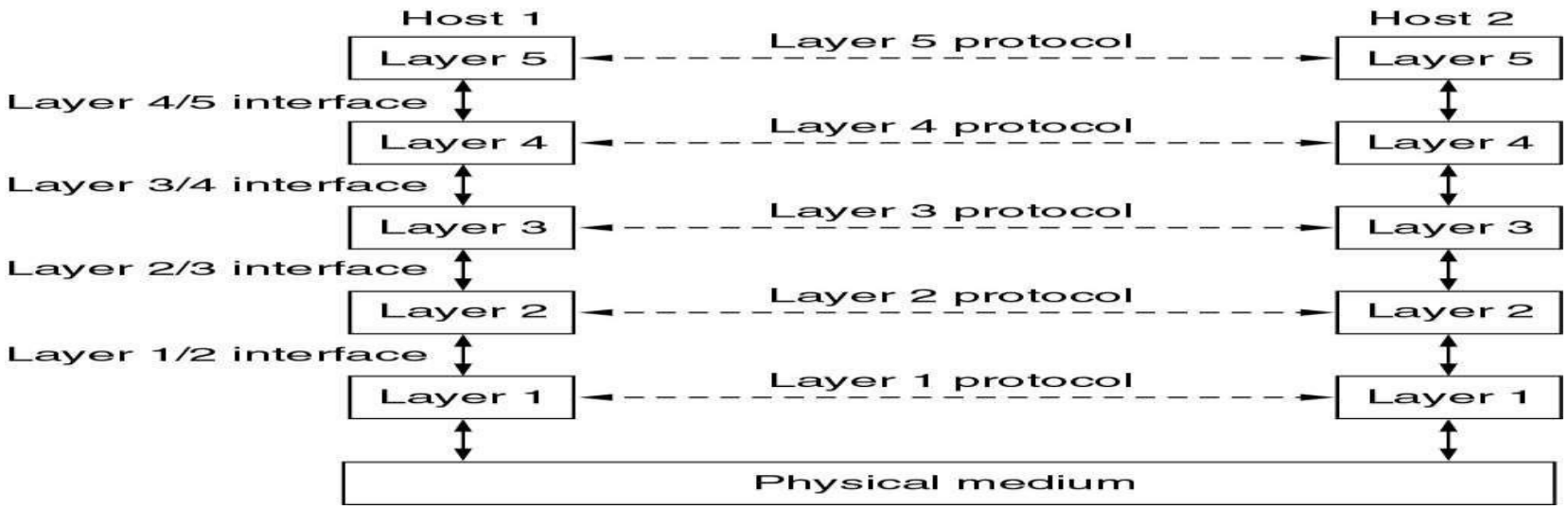
- **Advantages:** 1.It provides more modular design
  2.Easy to troubleshoot

- **Role of Protocols in Layering:**
  - ✓ **Protocols=Rule**
  - ✓ It is a set of rules that governs the data communication
  - ✓ The protocols in each layer governs the activities of the data communications

Protocol Hierarchies

- To reduce the **design complexity**, most networks are organized as a series of layers or levels.
- The number of layers, name of each layer, contents of each layer and the function of each layer differ from network to network.
- The rules and conventions used in this conversation are collectively known as the **Layer Protocol**.

Protocol Hierarchies



- Between each pair of adjacent layers there is an **interface.**
- A set of layers and protocols is called **a network architecture**.
- A list of protocols used by a certain system , one protocol per layer, is called **a protocol stack**.

Design Issues for the Layers

- **Addressing** – each layer needs a mechanism for identifying senders and receivers.
- **The rules of data transfer** – simplex, half-duplex, full- duplex
- **Error Control** – error-correction and error-detection
- **Flow Control** - The communication channels must preserve the order of messages sent on them – disassembling, transmitting, and then reassembling.
- **Multiplexin**g – inconvenient or expensive to set up a connection for each pair of communication process.
- **Routing** – multiple paths between source and destination, a route must be chosen

Connection-Oriented and Connectionless Services

- Connection-oriented is modeled after the **telephone system.**
- To talk to someone, you pick up the phone, dial the number, talk, and then hang up.
- To use a connection-oriented network service, the service user first **establish a connection**, **uses the connection**, and then **releases the connection**.
- Connectionless service is modeled after **postal system**.
- Each message carries the **full destination address**, and each one routed through the system **independent of all the routers**.
- When two messages sent to the same destination, the first one sent will be first one to arrive. If first one is delayed the second one arrives first with connection-oriented service this is not possible.

Service Primitives

Five service primitives for implementing a simple connection-oriented service.

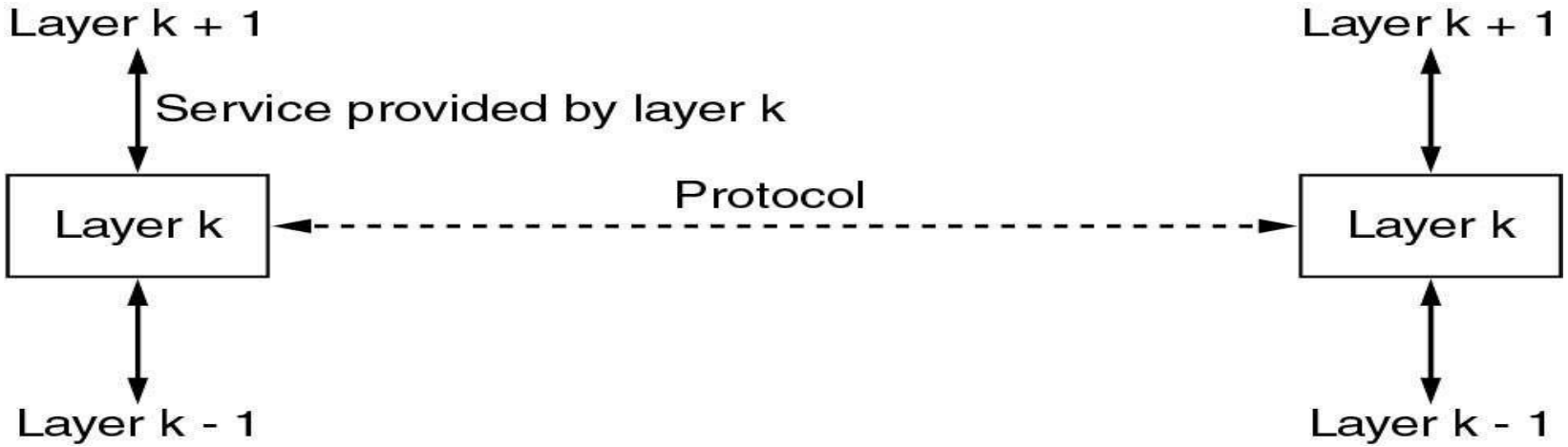
Primitive	Meaning
LISTEN	Block waiting for an incoming connection
CONNECT	Establish a connection with a waiting peer
RECEIVE	Block waiting for an incoming message
SEND	Send a message to the peer
DISCONNECT	Terminate a connection

Service Primitives

Listen	When server is ready to accept request of incoming connection, it simply put this primitive into action. **Listen primitive simply waiting for incoming connection request.**
Connect	This primitive is used to connect the server simply by creating or establishing connection with waiting peer.
Accept	This primitive simply accepts incoming connection form peer.
Receive	These primitive afterwards block the server. Receive primitive simply waits for incoming message.
Send	This primitive is put into action by the client to transmit its request that is followed by putting receive primitive into action to get the reply. Send primitive simply sends or transfer the message to the peer.
Disconnect	This primitive is simply used to terminate or end the connection after which no one will be able to send any of the message.

Services to Protocols Relationship

- A service is a set of primitives(operations)that a layer provides to the layer above it
- A protocol is a set of rules governing the format and meaning of the frames, packets, or messages that are exchanged by the peer entities within the layer

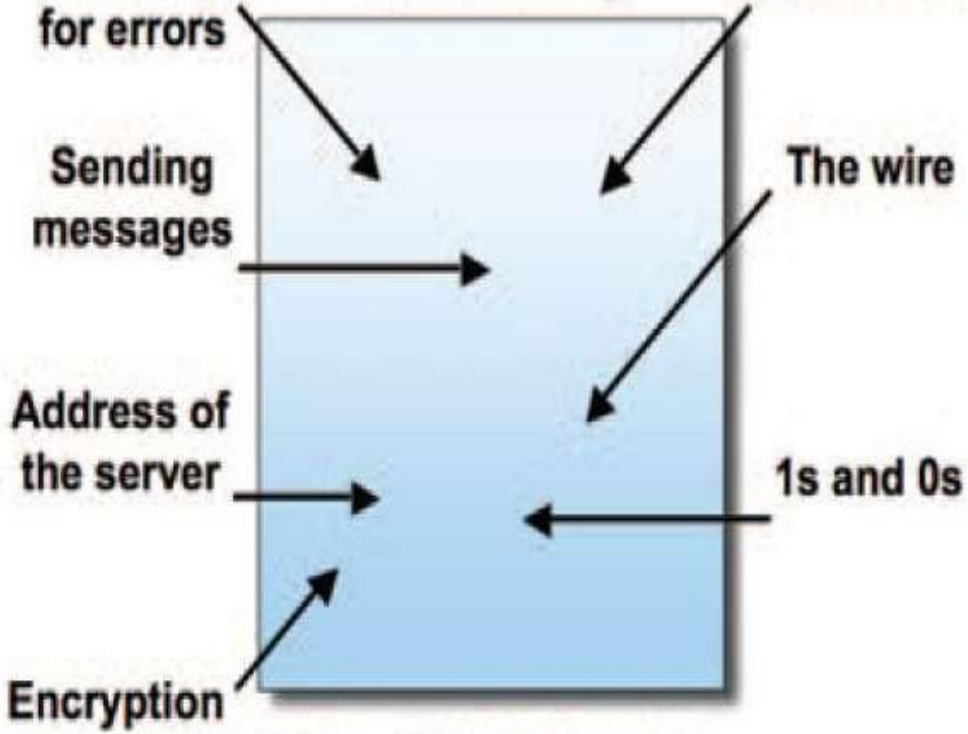


- Available Layer Architectures:
    1. ISO-OSI Reference Model
    2. TCP/IP Model

The OSI Reference Model

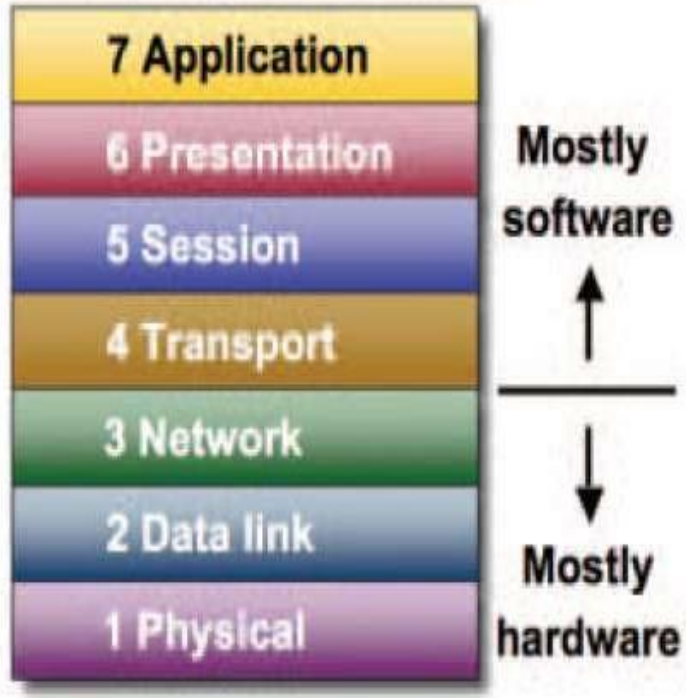
- In 1947, the international standards organization(ISO) is a multinational body dedicated to worldwide agreement on international standards.
- An ISO standard that covers all aspects of network communications is the open systems interconnection model.
- In late 1970s an open system is a set of protocols that allow any two different systems to communicate
- It divides the communications processes into seven layers.

Chaos networking



Without the OSI model, networks would be very difficult to understand and implement.

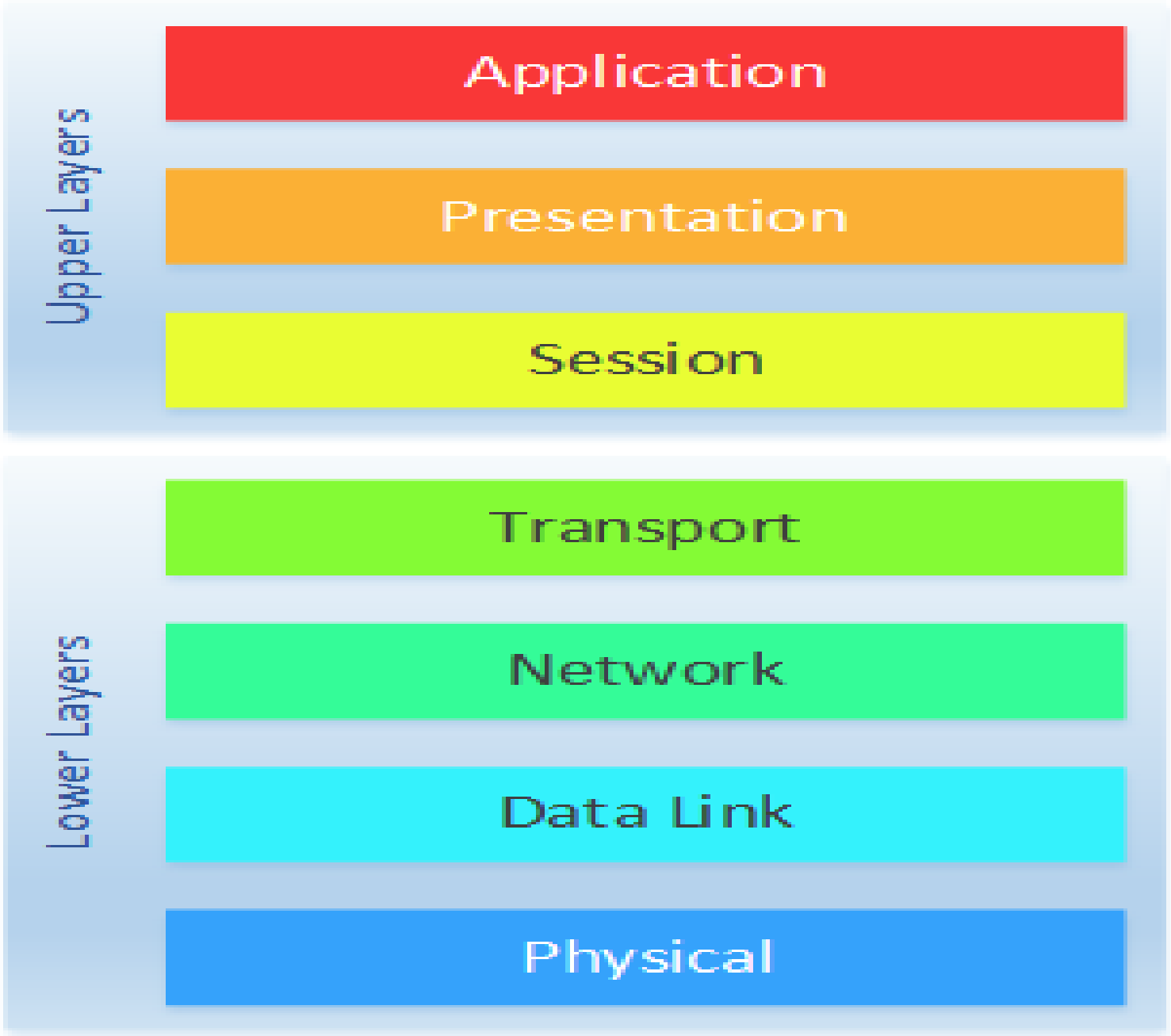
Networking OSI seven-layer model



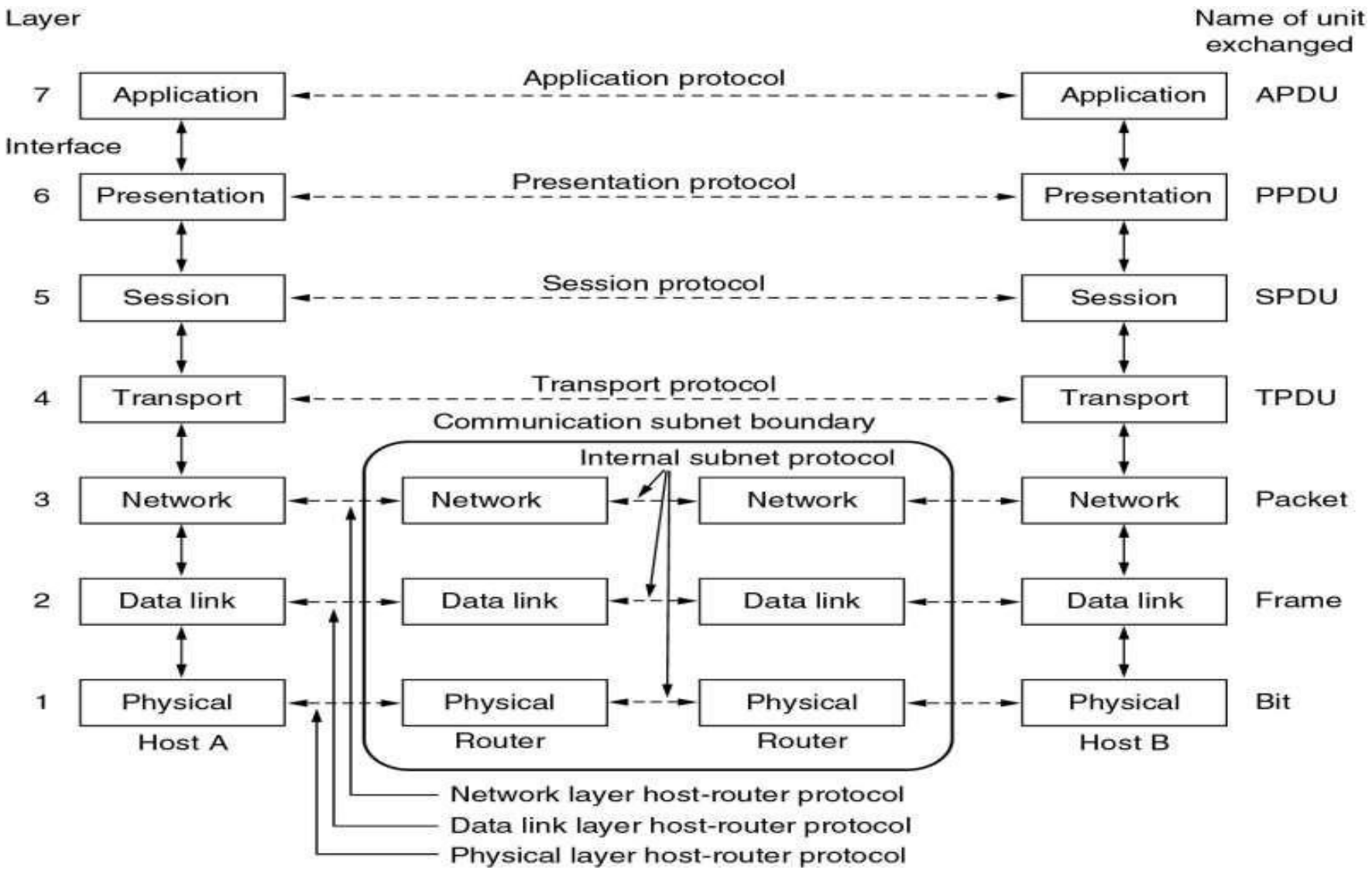
With the OSI model, networks can be broken up into manageable pieces. The OSI model provides a common language to explain components and their functionality.

Layering Principle

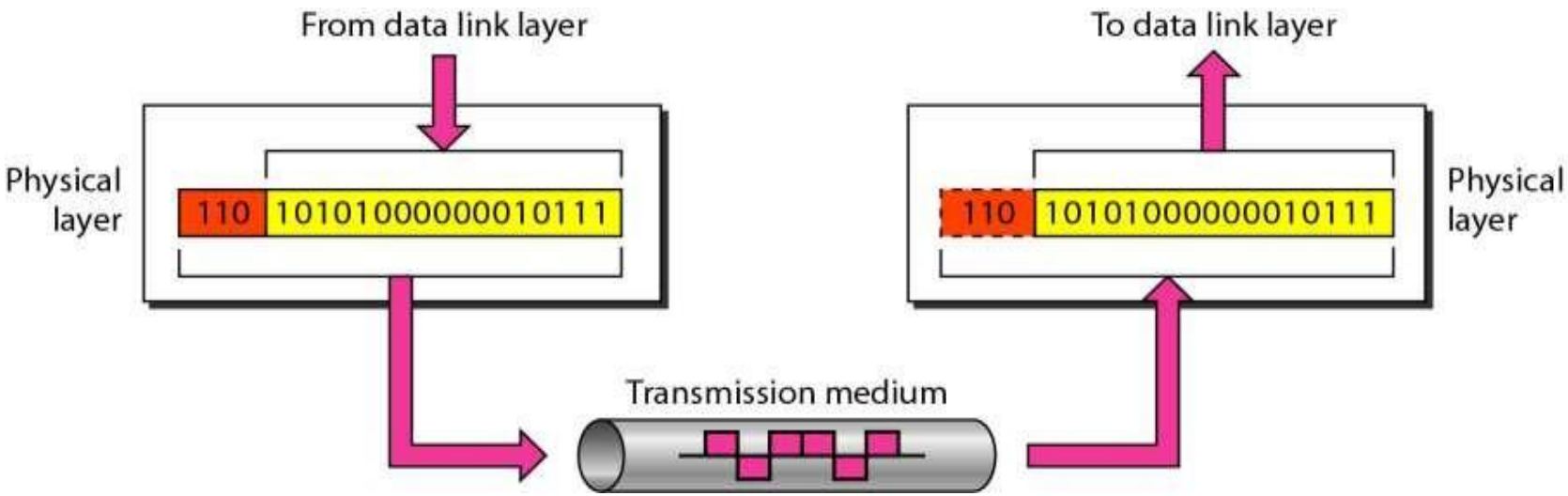
- A layer should be created where a different level of abstraction is needed.
- Each layer should perform a well defined function.
- The function of each layer should be chosen with an eye toward defining internationally standardized protocols.
- The layers boundaries should be chosen to minimize the information flow across the interfaces.
- The number of layers large enough that distinct functions need not be thrown together in the same layer out of necessity, and small enough that the architecture does not become unwieldy


Upper Layers
Application
Presentation
Session
Lower Layers
Transport
Network
Data Link
Physical

OSI reference model



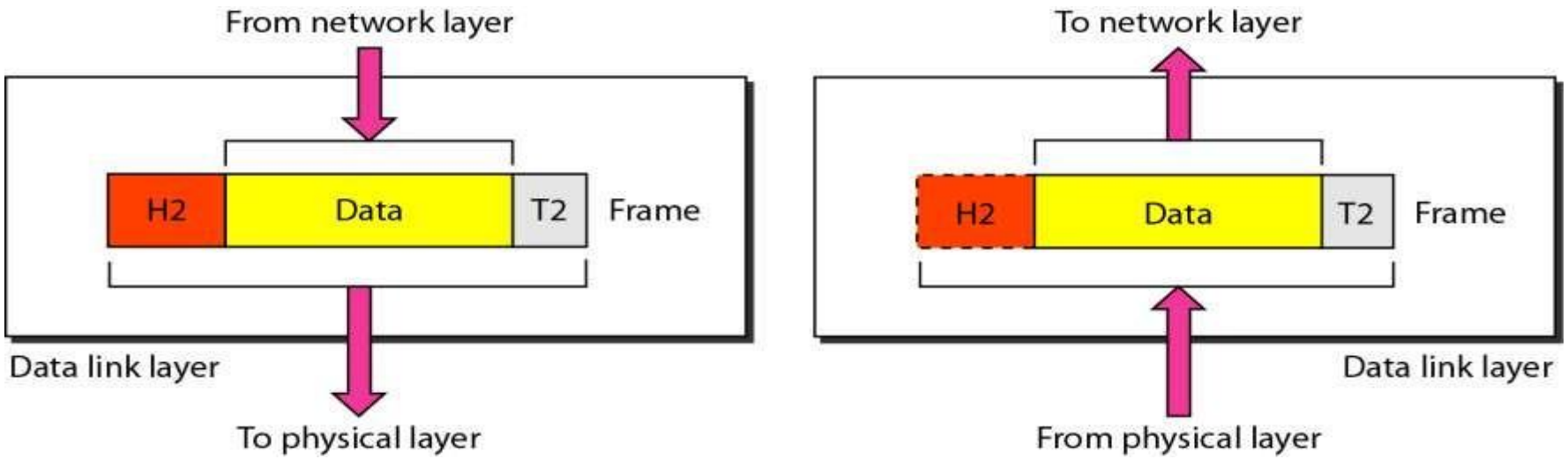
Physical layer



Physical layer

- Converts bits into electronic signals for outgoing messages
- Converts electronic signals into bits for incoming messages
- The physical layer is concerned with transmitting raw bits over a communication channel. The design issues have to do with making sure that when one side sends a 1 bit, it is received by the other side as a 1 bit, not as a 0 bit.
- **The design issues are**
  - ✓ Transmission medium
  - ✓ Synchronization of bits
  - ✓ Physical topology
  - ✓ Transmission mode

Data link layer

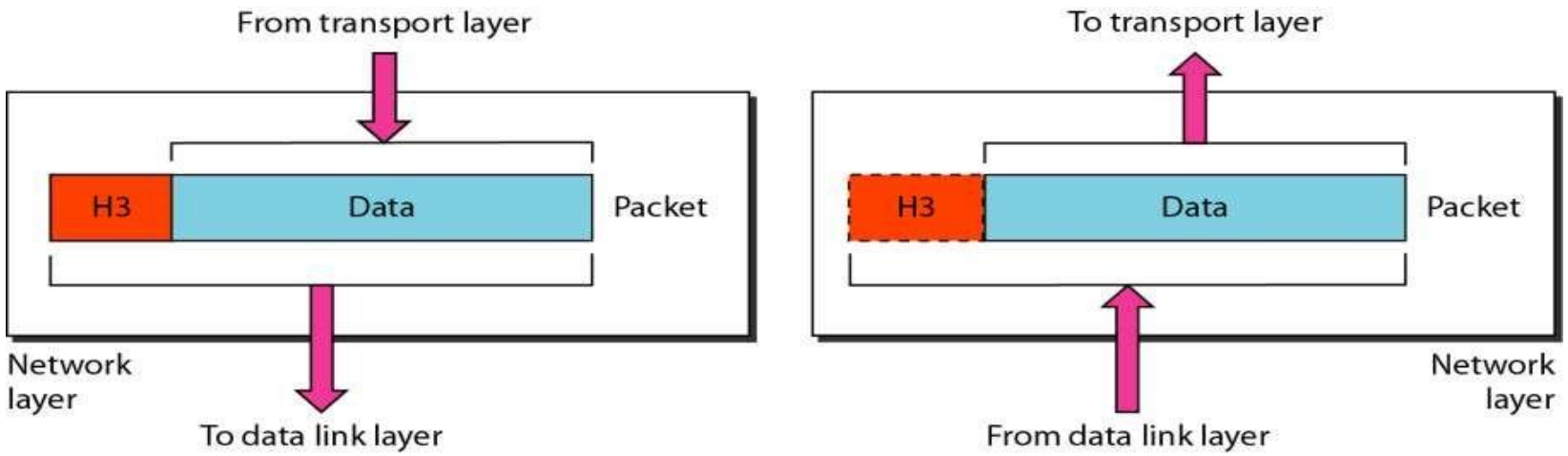


- The main task of the data link layer is to detected transmission errors
- It accomplishes this task by having the sender break up the input data into data frames and transmits the frames sequentially.

Data Link Layer

- At the receiving end, this layer packages raw data from the physical layer into data frames for delivery to the Network layer
- At the sending end this layer handles conversion of data into raw formats that can be handled by the Physical Layer
- If the service is reliable, the receiver confirms correct receipt of each frame by sending back an **acknowledgement frame**
- The physical layer accepts and transmits stream of bits, the data link layer should create and recognize frame boundaries. This can be accomplished by attaching special bit patterns to the beginning and ending of frame.
- A duplicate frame could be sent if the acknowledgement frame from receiver back to the sender were lost.

Network Layer

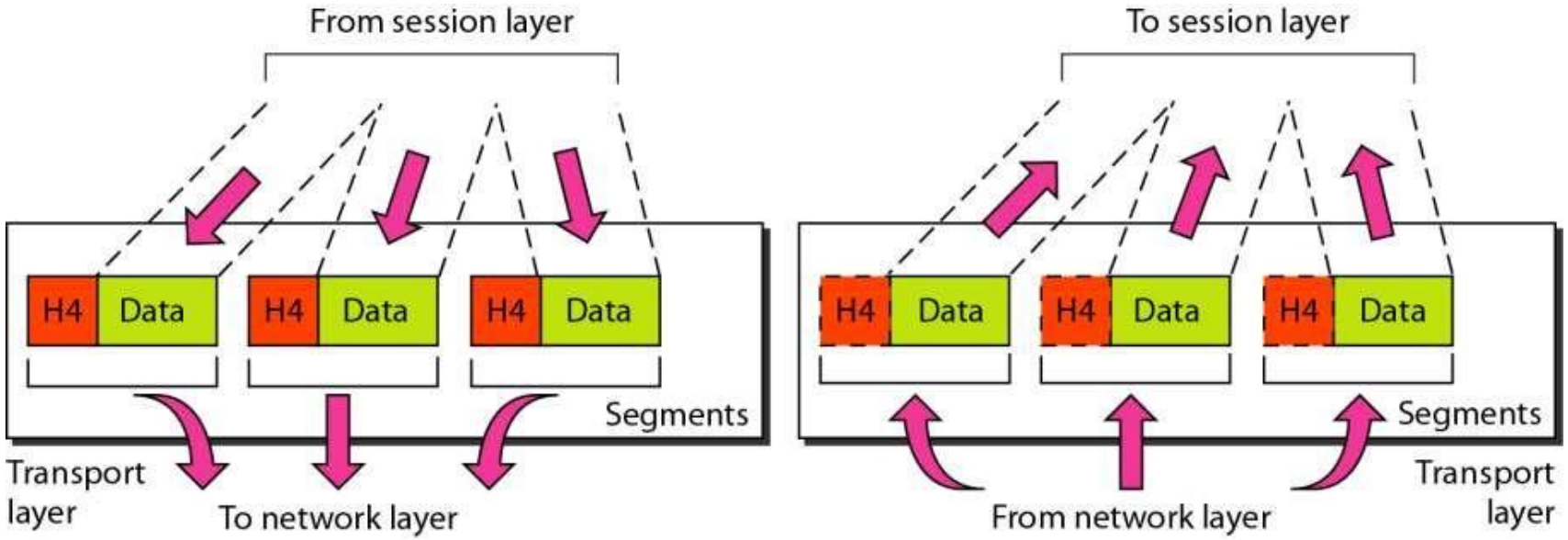


- The network layer controls the operation of the subnet.
- The network layer is responsible for the delivery of individual packets from the source host to the destination host. A key design issue is determining how packets are routed from source to destination.

Network Layer

- Routes can be based on **static tables .**They can also be determined at the **start of each conversation.**
- If too many packets are present in the subnet at the same time, they will get in one another's way, forming bottlenecks leads to **congestion . Hence Congestion Control** also belongs to the network layer.
- When a packet has to travel from one network to another to get to its destination, many problems can arise. The **addressing** used by the second network **may be different** from the first one. The second one may not accept the packet at all because it is **too large**. The **protocols may differ**, and so on. It is up to the network layer to overcome all these problems

Transport Layer



- **Manages the data transmission** across a network
- Manages the flow of data between parties by segmenting long data streams into smaller data chunks (based on allowed "packet" size for a given transmission medium)
- Provides **acknowledgements of successful transmissions** and requests **resends for packets** which arrive with **errors**

Transport Layer

- The basic function of the transport layer is to accept data from above, split it up into smaller units , pass these to the network layer, and ensure that the pieces all arrive correctly at the other end.
- The transport layer is responsible for the delivery of a message from one process to another.
- **If** transport connection requires a high throughput, the transport layer might create multiple network connections.
- The transport layer also determines what type of service to provide to the session layer, and, ultimately, to the users of the network. The most popular type of transport connection is an **error-free point-to-point channel** that delivers messages or bytes in the order in which they were sent. The type of service is determined when the **connection is established**.

Transport Layer

- The transport layer is a **true end-to-end layer**, all the way from the source to the destination.

- The difference between layer 1 through 3 , which are chained, and layer 4 through 7, which are end-to-end

Session Layer

- The session layer allows users on different machines to establish sessions between them.

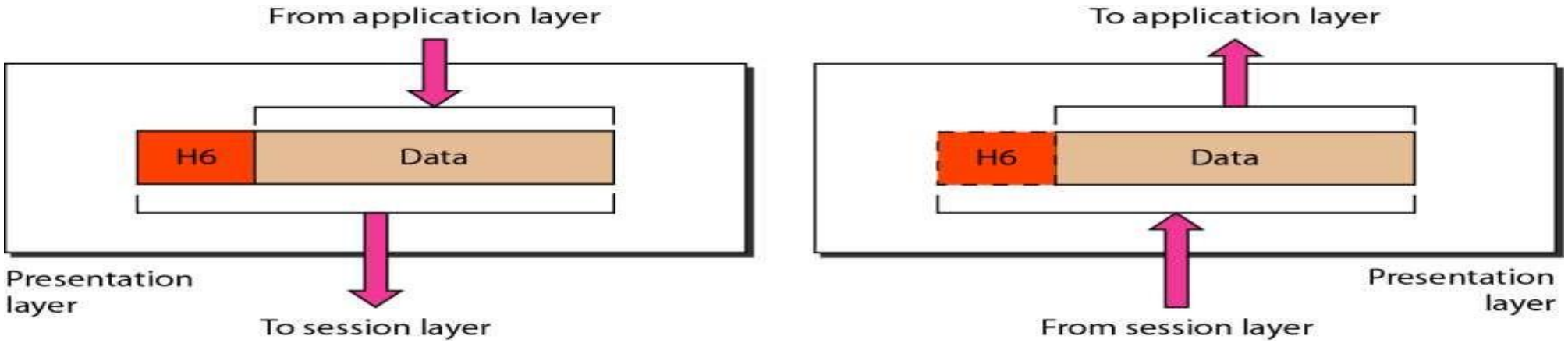
- Various services offer by Session layer are:

  dialog control (keeping track of whose turn it is to transmit),

  token management (preventing two parties from attempting the same operation at the same time),

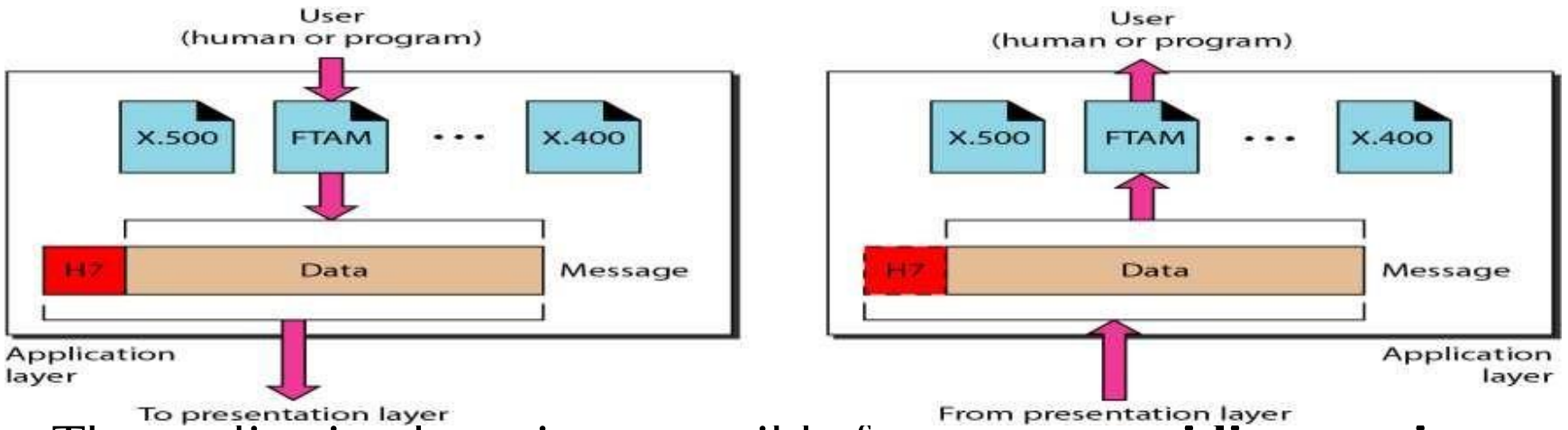
  synchronization (check pointing to continue from where they were after a crash).

Presentation Layer



- The presentation layer is concerned with the **syntax** and **semantics** of the information transmitted.
- In order to make it possible for computers with different data representations to communicate, the data structures to be exchanged can be defined in an abstract way, along with a standard encoding to be used "on the wire." The presentation layer manages these abstract data structures and allows higher-level data structures (e.g., banking records), to be defined and exchanged

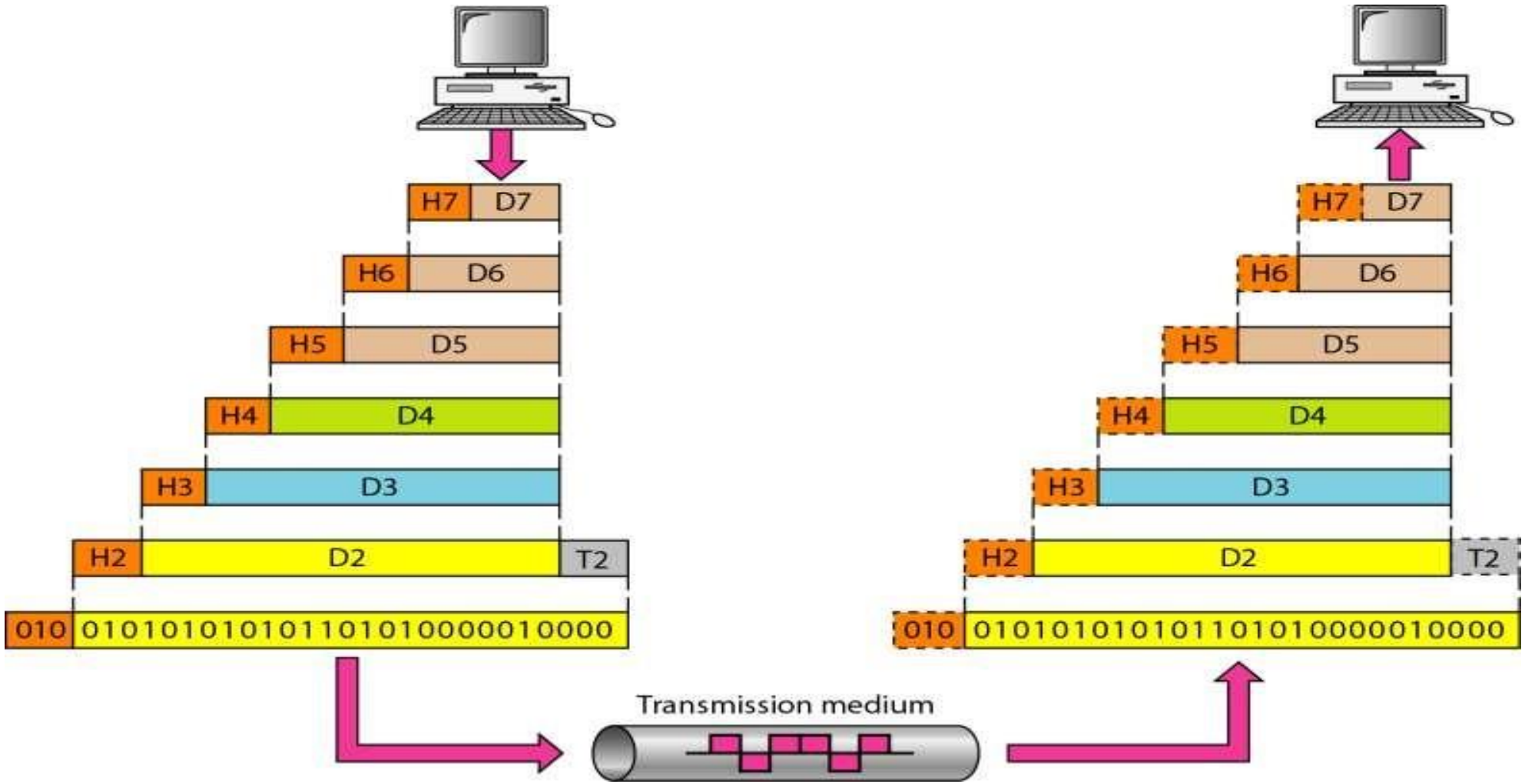
Application layer



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

•The application layer contains a variety of protocols that are commonly needed by users. One widely-used application protocol is HTTP (Hypertext Transfer Protocol), which is the basis for the World Wide Web. When a browser wants a Web page, it sends the name of the page it wants to the server using HTTP. The server then sends the page back. Other application protocols are used for file transfer, electronic mail, and network news.

•Network virtual terminal


H7
D7
H6
D6
H5
D5
H4
D4
H3
D3
H2
D2
T2
010
0101010101011010100000010000
Transmission medium
H7
D7
H6
D6
H5
D5
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T2
010
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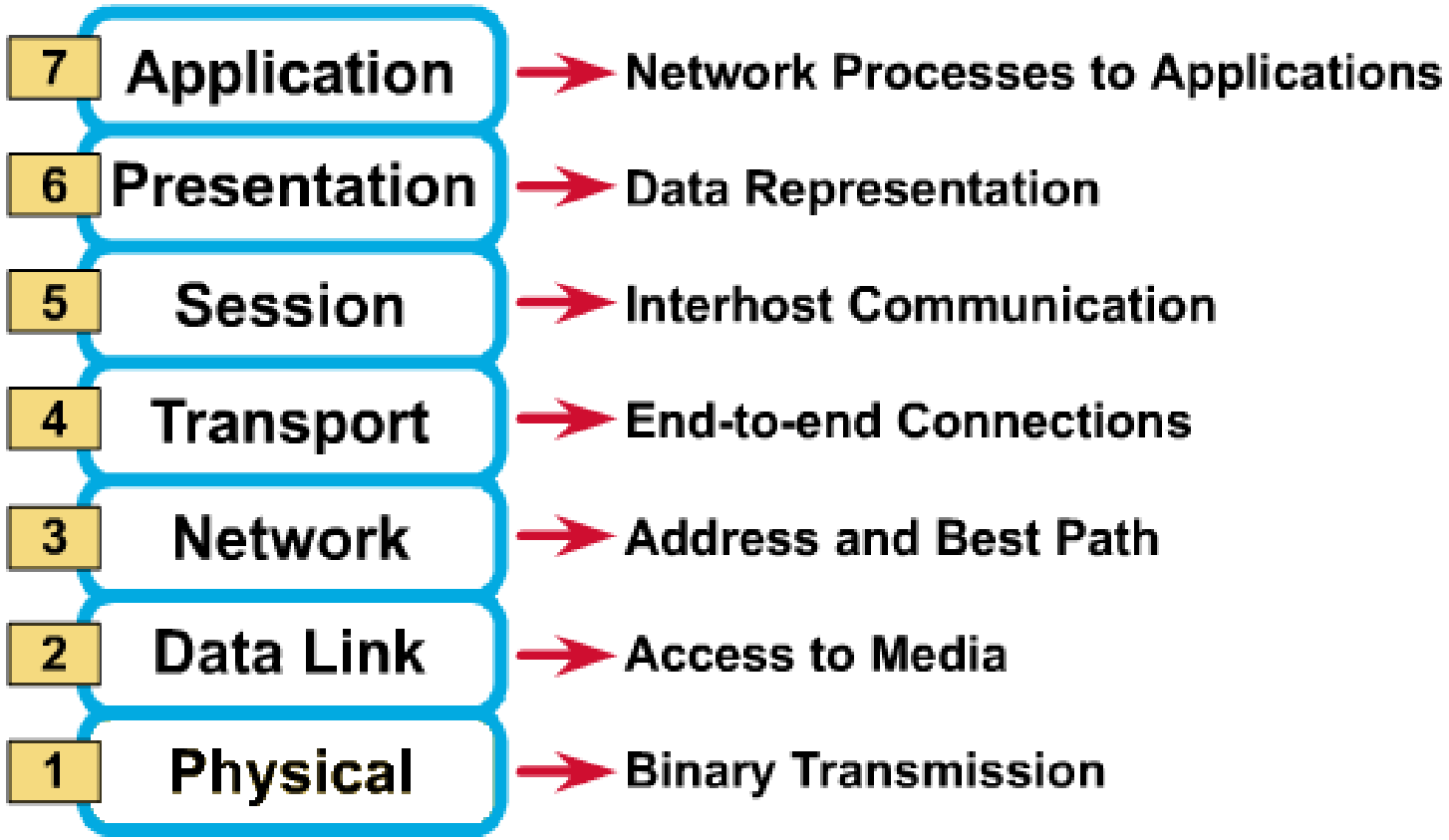
THE SEVEN OSI REFERENCE MODEL LAYERS



The TCP/IP reference model

The TCP/IP reference model was developed prior to OSI model. The major design goals of this model were,

1.To connect multiple networks together so that they appear as a single network.

2.To survive after partial subnet hardware failures.

3.To provide a flexible architecture.

The TCP/IP reference model

Transmission control protocol/ information protocol

Unlike OSI reference model, TCP/IP reference model has only 4 layers. They are,

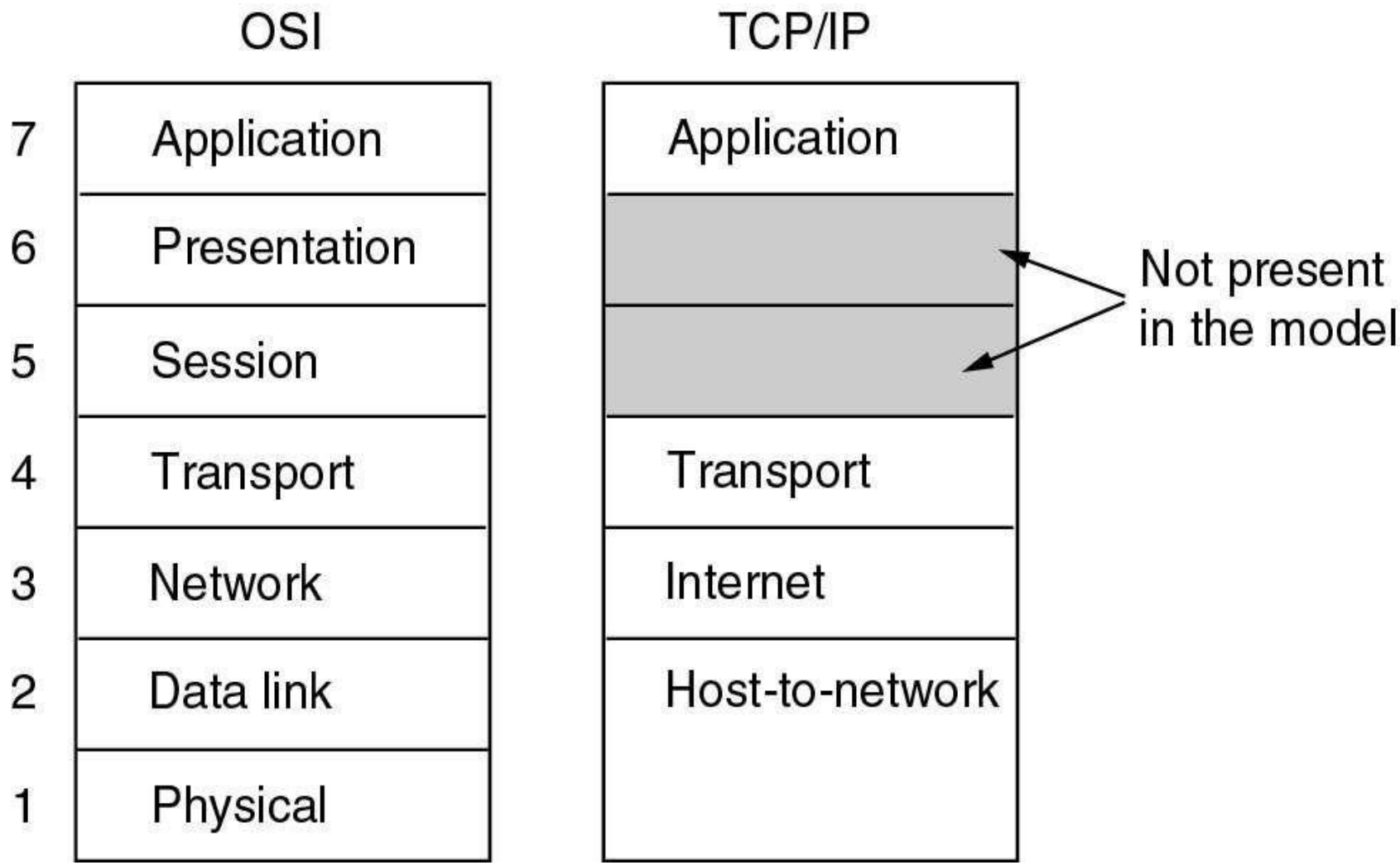
1.Host-to-Network Layer

2.Internet Layer

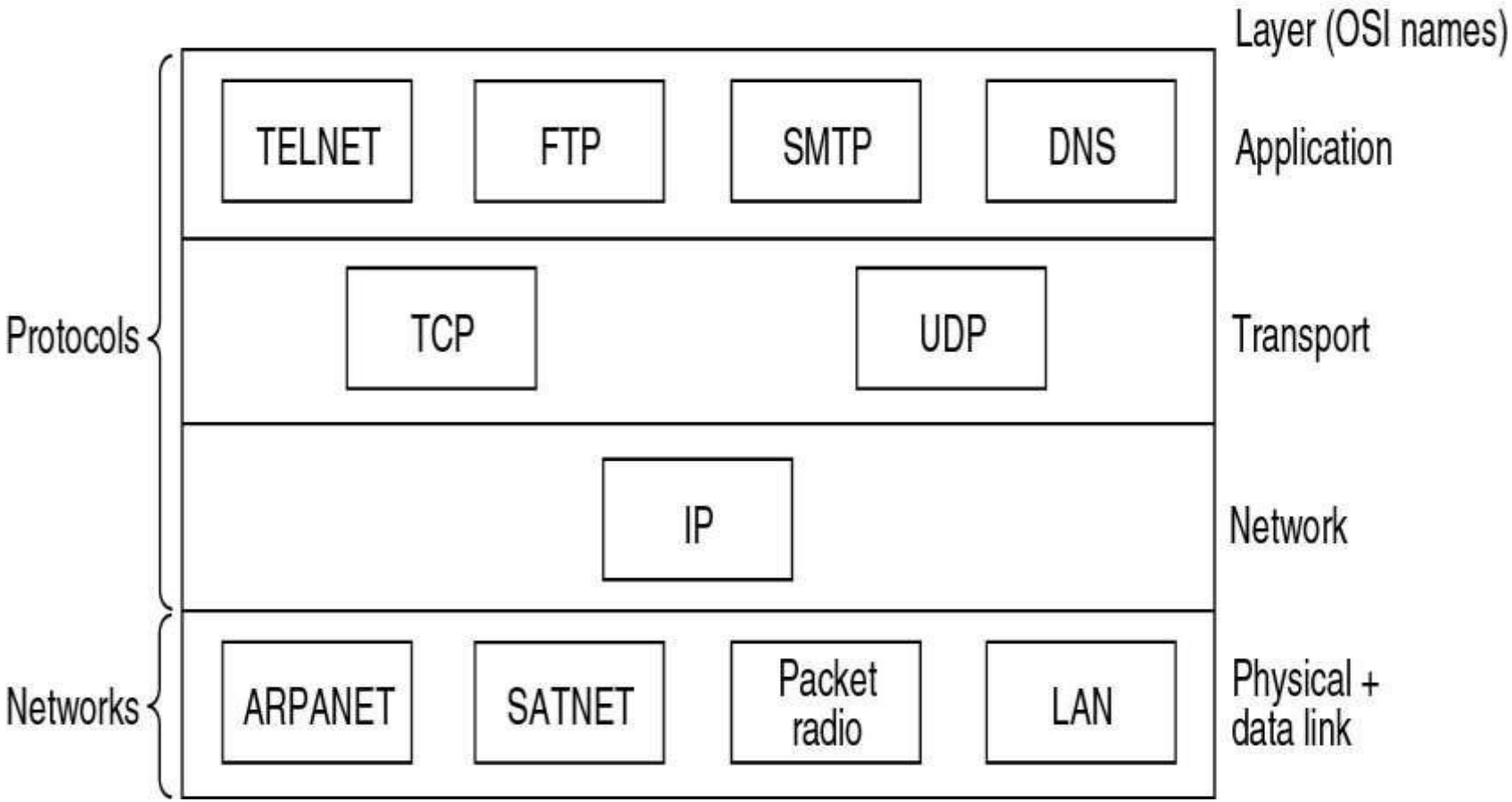
3.Transport Layer

4.Application Layer

The TCP/IP reference model.



Protocols and networks in the TCP/IP model initially.



Internet layer

- It injects packets into any network and they travel independently to the destination
- They may even arrive in a different order than they were sent, in which case it is the job of higher layers to rearrange them, if in-order delivery is desired.
- The internet layer defines an official packet format and protocol called **IP (Internet Protocol).**
- The job of the internet layer is to deliver IP packets where they are supposed to go.
- **Packet routing** is clearly the major issue here, as is avoiding **congestion**.

Transmission Control Protocol

Two end-to-end transport protocols have been defined here.

- **TCP** (Transmission Control Protocol), is a **reliable connection-oriented protocol** that allows a byte stream originating on one machine to be delivered without error on any other machine in the internet.
  - TCP also handles ***flow control***
- **UDP** (User Datagram Protocol), is an **unreliable, connectionless protocol** for applications that do not want TCP's sequencing or flow control and wish to provide their own.

  –It is also widely used for one-shot, client-server-type request-reply queries and applications in which prompt delivery is more important than accurate delivery(transmitting speech or video.)

Application layer

- On top of the transport layer is the application layer. It contains all the higher-level protocols.
- Protocols included are (TELNET), file transfer (FTP), and electronic mail (SMTP).
- The virtual terminal protocol allows a user on one machine to log onto a distant machine and work there.
- The file transfer protocol provides a way to move data efficiently from one machine to another.
- Electronic mail was originally just a kind of file transfer, but later a specialized protocol (SMTP) was developed for it. Many other protocols have been added to these over the years: the Domain Name System (DNS) for mapping host names onto their network addresses, and HTTP, the protocol for fetching pages on the World Wide Web, and many others.

ARPANET

- The **Advanced Research Projects Agency Network** (**ARPANET**) was one of the world's first operational packet switching networks, the first network to implement TCP/IP, and was the main progenitor of what was to become the global Internet.
- The network was initially funded by the Advanced Research Projects Agency (ARPA, later DARPA) within the U.S. Department of Defense for use by its projects at universities and research laboratories in the US.
- The packet switching of the ARPANET, together with TCP/IP, would form the backbone of how the Internet works.

SATNet

- SATNet - Satellites Network
- The SATNet network is providing the first network for sharing ground stations in between the members of the community of CubeSat developers

Packet radio

- **Packet radio** is a form of packet switching technology used to transmit digital data via radio or wireless communications link
- A **datagram** is a basic transfer unit associated with a packet-switched network. The delivery, arrival time, and order of arrival need not be guaranteed by the network.

Comparing OSI and TCP/IP Models

Concepts central to the OSI model

- ✓ Services
- ✓ Interfaces
- ✓ Protocols

A Critique of the OSI Model and Protocols

- Bad timing
- Bad technology
- Bad implementations
- Bad politics

A Critique of the TCP/IP Reference Model

- Service, interface, and protocol not distinguished
- Not a general model
- Host-to-network “layer” not really a layer
- No mention of physical and data link layers
- Minor protocols deeply entrenched, hard to replace