LAYERING ARCHITECTURE OF NETWORKS

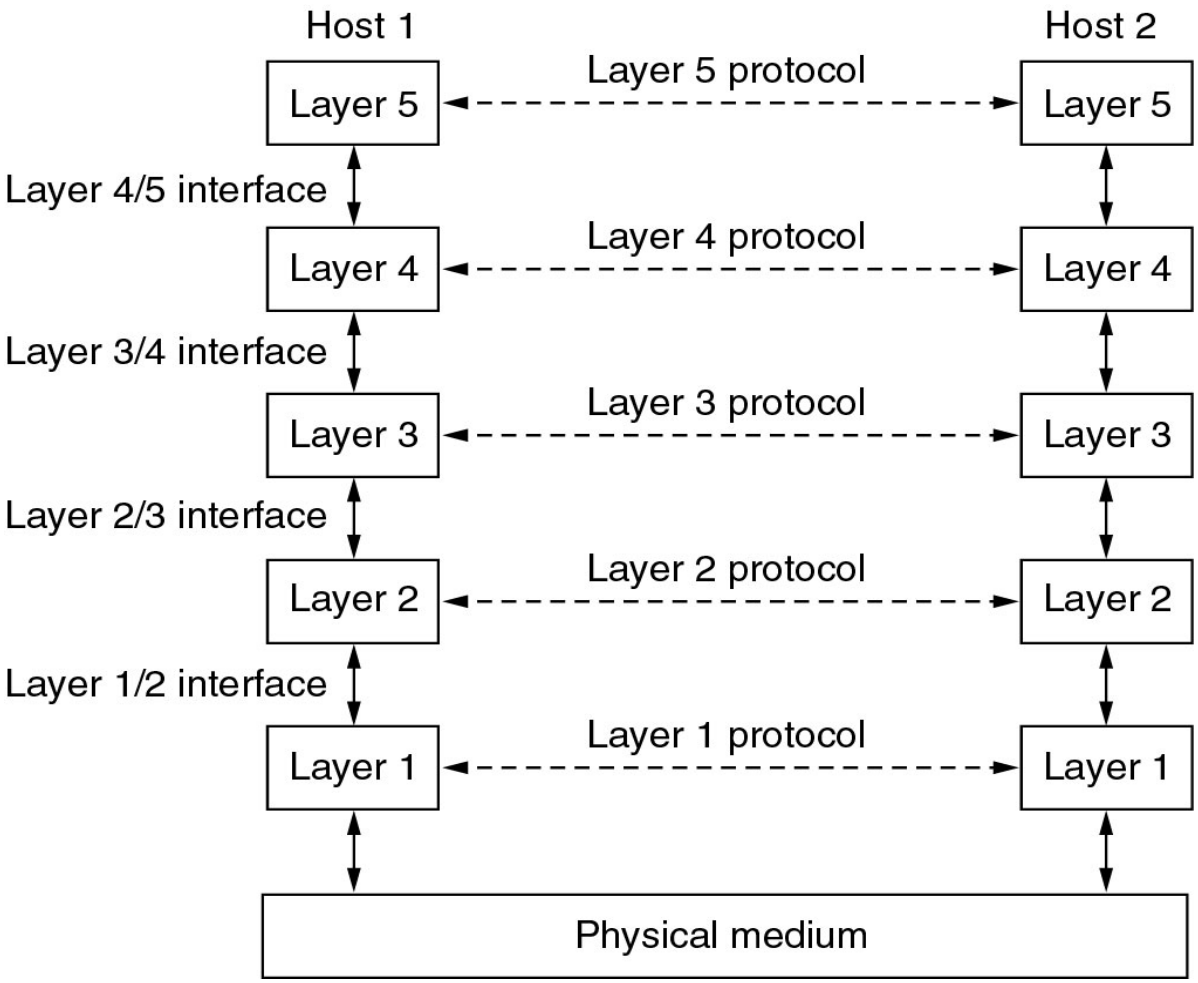
Network Software

- Protocol Hierarchies
- Design Issues for the Layers
- Connection-Oriented and Connectionless Services
- Service Primitives
- The Relationship of Services to Protocols

Protocol Hierarchies

- In order to *reduce the design complexities* most *networks are organized* as a stack of ***layers*** **or levels**
- The number of layers, the name of each layer, the contents of each layer, and the function of *each layer differ* from network to network.
- The purpose of each layer is to offer certain services to the higher layers hiding the details how the offered services are actually implemented.
- In a sense, each layer is a kind of virtual machine, offering certain services to the layer above it.

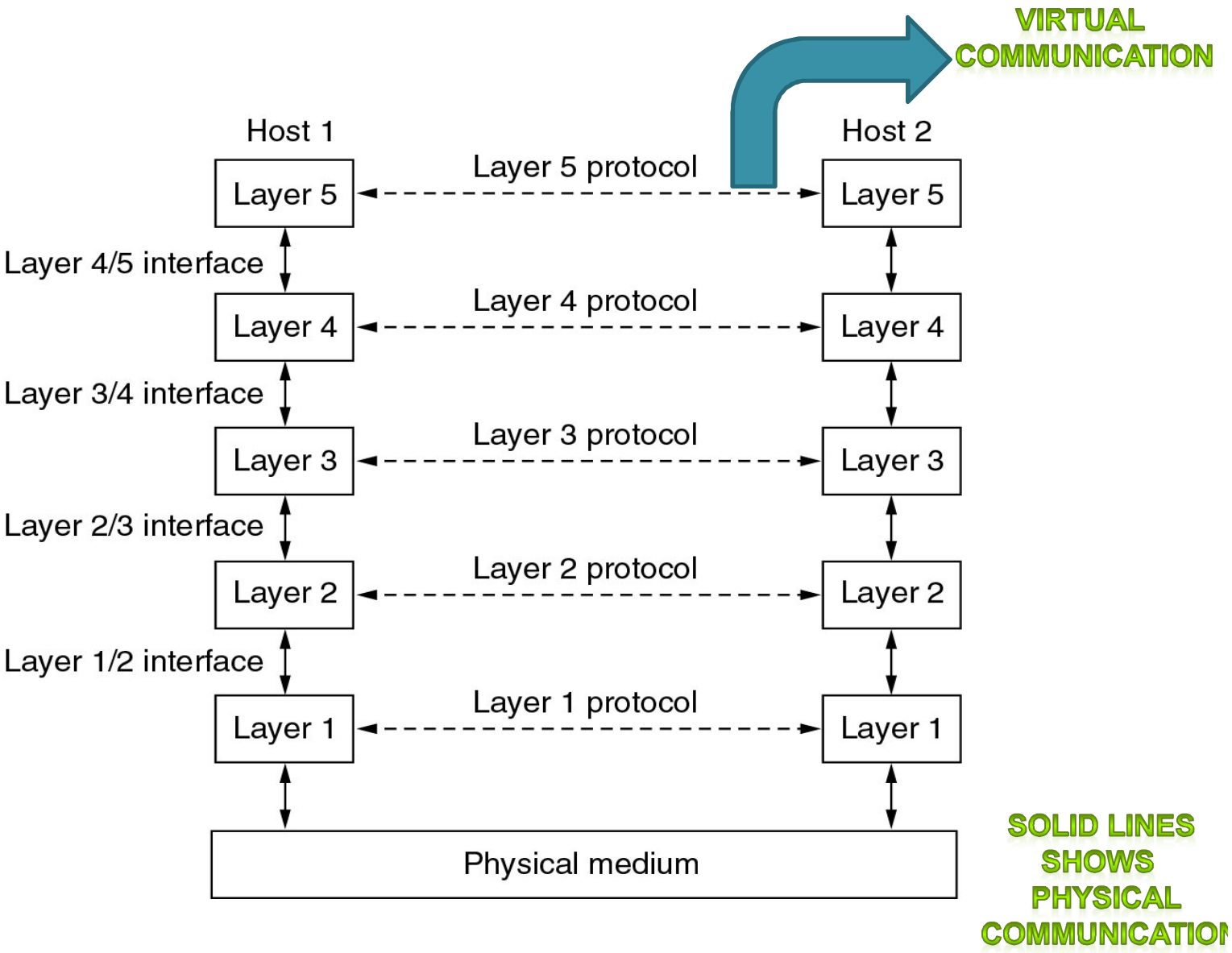
- Layer n on one machine carries a conversation with layer n on another machine
- Rules and conventions used during this conversation are known as Layer n protocol
- Protocol is an agreement between the communicating parties on how communication is to be proceed



Layers, protocols, and interfaces.

In reality

- No data is directly transferred from layer *n on one machine to* layer *n on another machine.*
- Each layer passes data and control information to the layer immediately below it, until the lowest layer is reached.
- Below --- layer 1 is the **physical medium through which actual communication occurs**

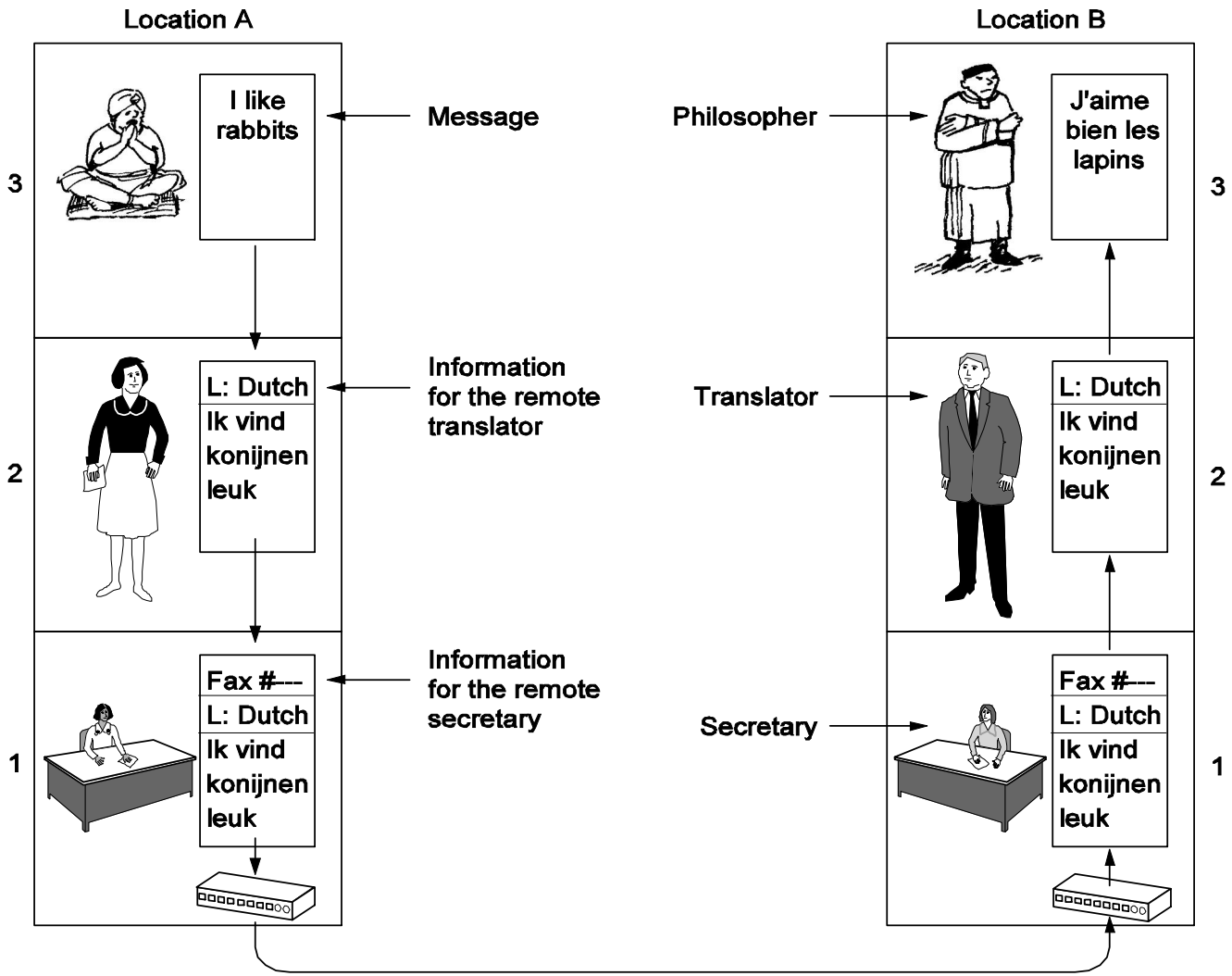


Layers, protocols, and interfaces.

EACH LAYER
PERFORMS
A SPECIFIC FUNCTION
AND
THERE IS A CLEAN
INTERFACE BETWEEN
THE
LAYERS

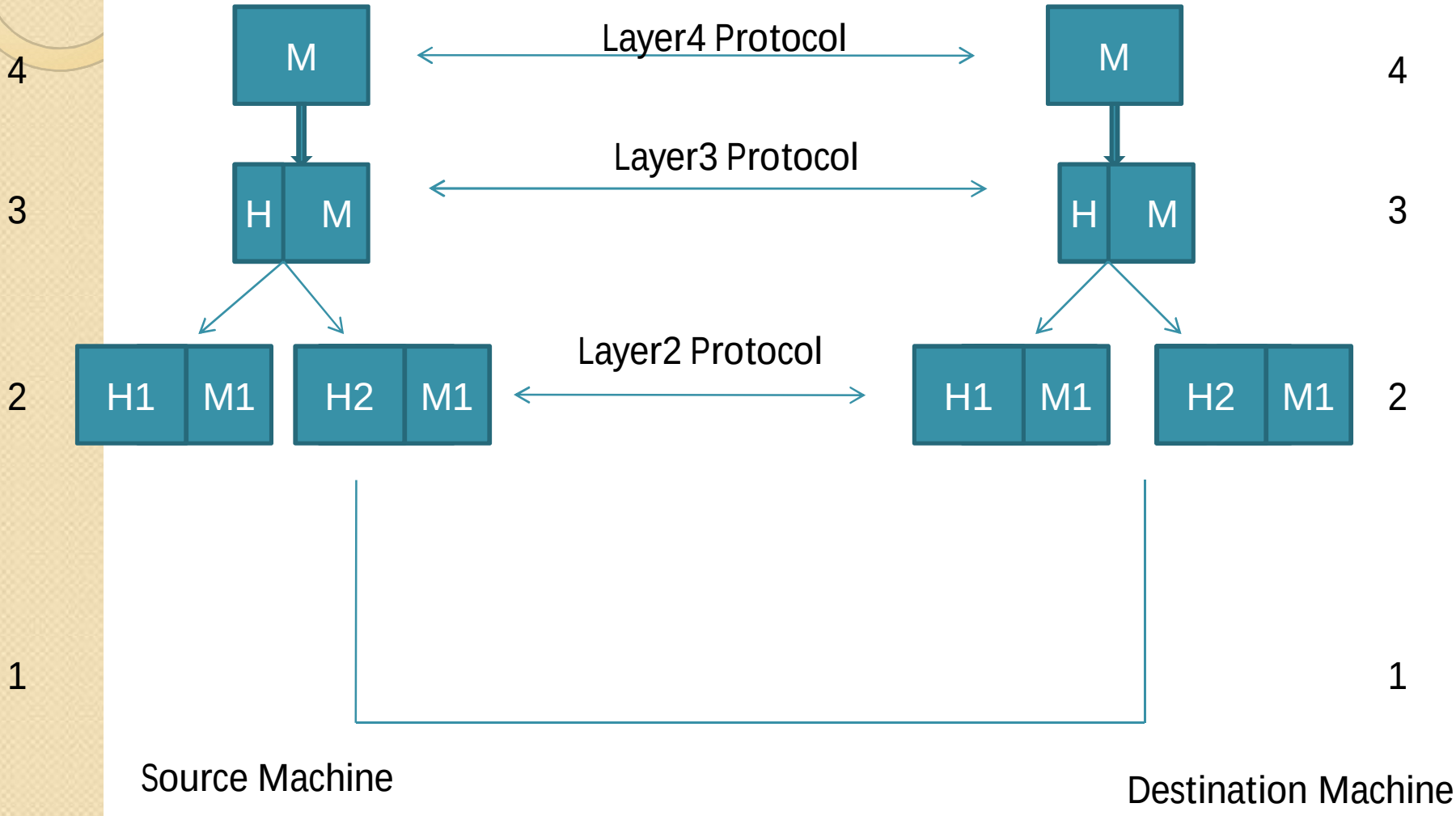
EXAMPLE

- Two philosophers (layer 3), one of whom speaks Urdu and English and one of whom speaks Chinese and French.
- Since they have no common language, they each engage a translator (layer 2)
- Translators in turn contacts a secretary (layer 1).
- Philosopher 1 passes a message (in English) **across the 2/3 interface** to his translator, saying "Ilike rabbits,"
- The translators **have agreed on a neutral language** known to both of them, Dutch, so the message is converted to "Ik vind konijnen leuk." **The choice of language is the layer 2 protocol and is up to the layer 2 peer processes.**
- The translator then gives the message to a secretary for transmission, by, for example**, fax (the layer 1 protocol).**
- When the message arrives, it is translated into French and passed across the 2/3 interface to philosopher 2.
- **Each protocol is completely independent of the other ones**
- The translators can switch from Dutch to say, HINDI, provided that they both agree, and neither changes his interface with either layer 1 or layer 3.
- Similarly, the secretaries can switch from fax to e-mail or telephone without disturbing (or even informing) the other layers.



The philosopher-translator-secretary architecture.

EXAMPLE


4
3
2
1
M
Layer4 Protocol
M
4
H
M
Layer3 Protocol
H
M
3
H1
M1
H2
M1
Layer2 Protocol
H1
M1
H2
M1
2
1
Source Machine
Destination Machine

Design Issues for the Layers

- Addressing
- Error Control
- Flow Control
- Multiplexing
- Routing

Addressing

- A Network has many computers
- Some means is needed to specify with whom sender wants to talk.
- Since multiple destinations are there, -----some form of **addressing** is needed in order to specify a specific destination.

- **Rules for data transfer**
  - In some systems, data only travel in one direction; in others, data can go both ways
  - The protocol must also determine how many channels the connection corresponds to and what their priorities are.
  - Many networks provide at least two channels per connection, one for normal data and one for urgent data.

Error Control

- **Error control is an important issue because physical communication circuits** are not perfect.
- Many error-correcting codes are known, but both ends of the connection must agree on which one is being used.
- Also the receiver must have some way of telling the sender which messages have been correctly received and which have not.

Issues like----

- Not all communication channels preserve the order of messages sent on them.
- To deal with a possible loss of sequencing, the protocol must make explicit **provision for the receiver to allow the pieces to be reassembled properly**.
- An obvious solution is to number the pieces

Another issue is…..

- Fast Sender and Slow receiver

- Solns like acknowledgement
- Other solutions -------
  - limit the sender to an agreed-on transmission rate. This subject is called **flow control.**

- Inability to accept long messages.
- This property leads to mechanisms for disassembling, transmitting, and then reassembling messages

Multiplexing

- To set up a separate connection for each pair of communicating processes is inconvenient or expensive
- the underlying layer may use the same connection for multiple, unrelated conversations
- Multiplexing is needed in the physical layer

Routing

- When there are multiple paths between Source & Destination– A Route must be chosen.
- Sometimes this decision must split over two or more Layers.
- High Level Decision Vs. Low Level Decision based on current traffic load, Known as Routing..

Connection-Oriented and Connectionless Services

- Layers can offer two types of service to the layers above them

Connection oriented service

- Modeled after Telephone System
- You pick up phone---dial num---talk—n hang up
- Similarly connection oriented service first establish the connection---uses the connection and then releases it
- In most cases bits arrive in the same order as released.
- In some cases sender and receiver negotiate about parameters like maximum message size, quality of service etc

Connectionless Service

- Modeled after a postal service
- Each message carries full destination address
- Each one is routed through the system independent of all the others
- Order may not be necessarily followed

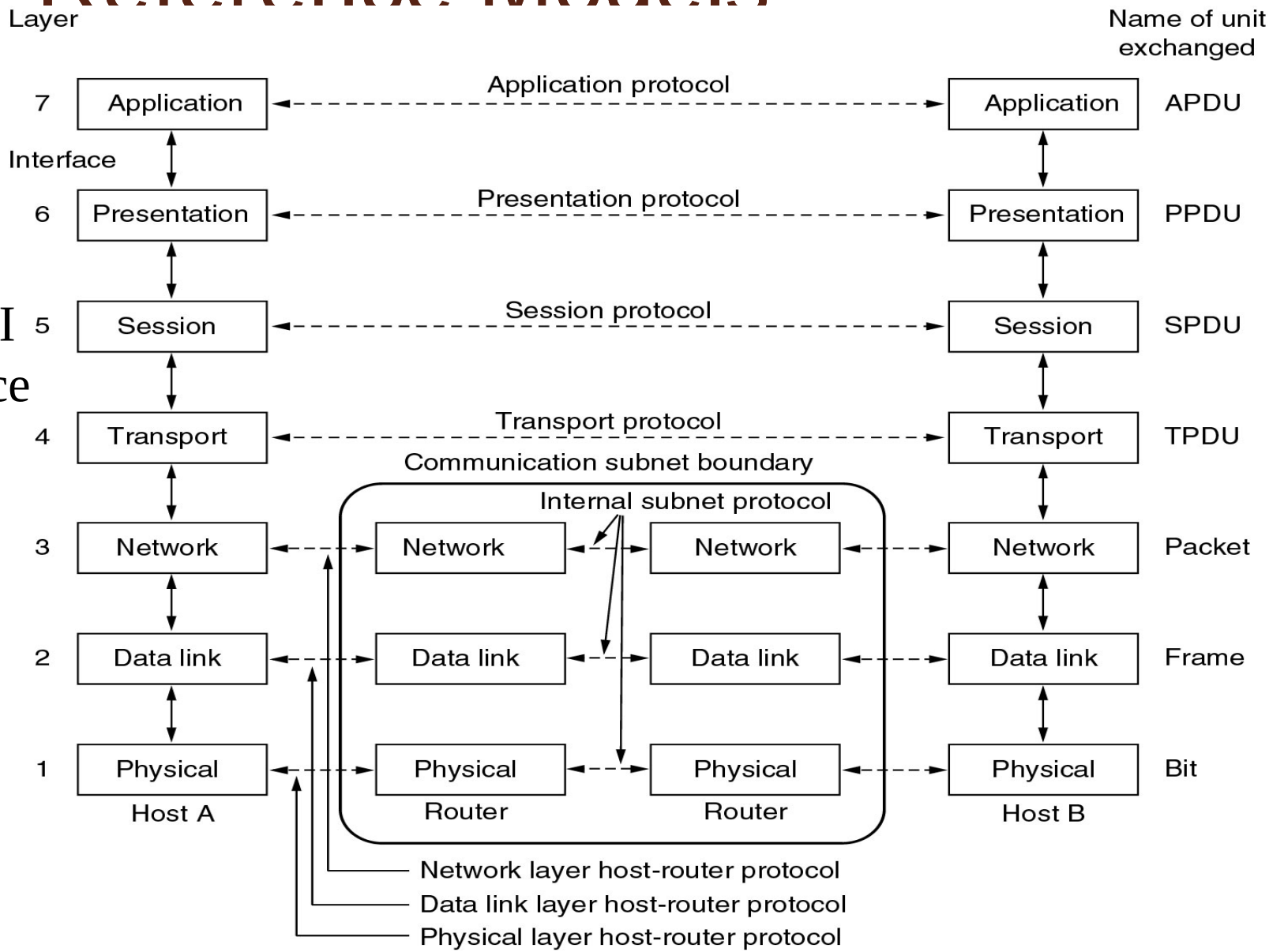
OSI Model

- The model is called the **ISO OSI (Open Systems Interconnection) Reference Model because it deals with connecting open systems—that is, systems** that are open for communication with other systems.

- The OSI model has seven layers.

Reference Models

The OSI reference model.



- Host X wants to send some data to host Y
- This message will be travelled via various intermediate nodes.
- These intermediate nodes as well as X and Y are concerned with the three lowest most OSI layers i.e. physical, dll, n/w
- The other four layers are used by the sender X and recipient Y only. Therefore they are known as **end-to-end layers**

Physical Layer

- 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.

- Source and destination nodes have to agree on a number of factors---
  - What voltage constitutes bit 1
  - What voltage constitutes bit 0

- Whether the communication is only one or both the directions
  - Simplex
  - Half duplex
  - Full duplex
- The design issues here largely deal with mechanical and electrical, specifications of the cables, connectors.

Physical layer takes into account following

- Signal Encoding
  - How are the bits 1 and 0 represented
- Medium
  - What is the medium used and what are its properties
- Bit synchronization
  - is the transmission asynchronous or synchronous
- Transmission type
  - Is the transmission serial or parallel
- Transmission mode
  - Simplex, half-duplex or full-duplex
- Topology
  - Star, bus, ring, mesh
- Interface
  - How closely linked devices are connected
- Bandwidth
- Signal type
  - Analog or digital

Physical Layer (contd…)

- **Protocols used:**
  RS 232C
  X.21

- **Physical Layer Devices:**
  Network Interface Card (NIC)
  Transceivers
  Repeaters
  Hubs

- **Limitation:** doesn’t ensure the reliability of data.

Data Link Layer

Data Link Layer

- Communication Circuits make errors occasionally
- DLL specific functions are:
  - Providing a well defined service interface to the network layer
  - Dealing with transmission errors
  - Regulating the flow of data so that the receivers are not swamped by the fast senders

- To accomplish these goals DLL takes the packets from the network layer and encapsulates them into frames for transmission

- Each frame contains a frame header, a payload for holding the packet and a trailer

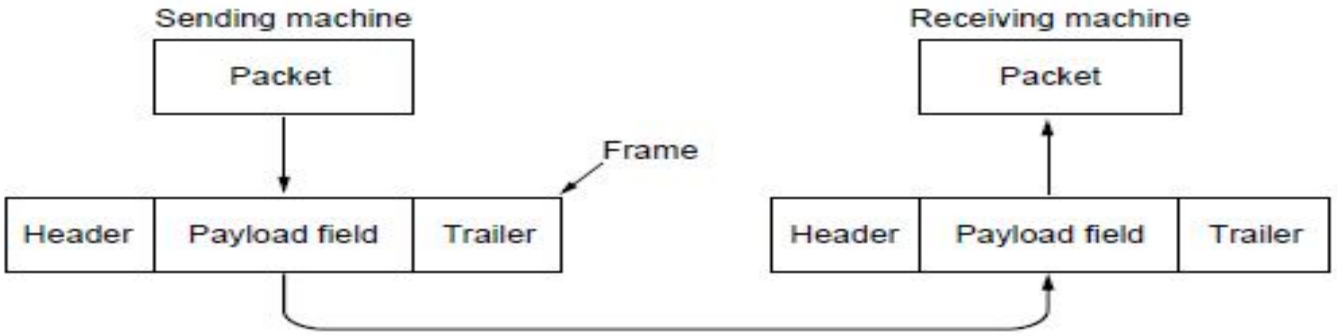


Fig. 3-1. Relationship between packets and frames.

Data Link Layer--contd

- **Protocols used:** HDLC

  DLL is responsible for:
- Logical (MAC) addressing
- Logical link control processing
- Creating logical topologies
- Controlling media access

  DLL Devices:
- Bridges
- Switches

Services provided

1. Unacknowledged Connectionless Service
2. Acknowledged Connectionless Service
3. Acknowledged Connection oriented Service

Unacknowledged Connectionless Service

- Source machine sends independent frames to the destination m/c without having the destination m/c acknowledge them
- No logical connection is estd or released.
- If the frame is lost no attempt is made to detect the loss or recover from it in the DLL

Acknowledged Connectionless Service

- No connection is estd but each frame sent is individually acknowledged.
- In this way sender knows whether a frame has arrived correctly
- If not arrived within a specified time interval it can be sent again.
- Trouble with this strategy is frame have a strict maximum length imposed by the h/w and n/w layer.
- If packets can be broken into say 10 frames and 20% frames are lost ---- 2 frames are lost
- SO it may take a long time for a packet to get through
- BUT for unreliable wireless channels it is well worth the cost

Acknowledged Connection oriented Service

- SRc and Destn establishes the connection before any data is transferred
- Each frame is sent over connection is numbered and DLL guarantees that each frame is received and that too received exactly once and all frames are received in the order

Example

- A Wan subnet consisting of routers connected by point-to-point leased telephone lines.
- When a frame arrives at a router, the h/w checks it for errors then passes the frame to DLL s/w (which might be embedded in a chip on the network interface board)
- The DLL s/w checks to see id this is the frame expected, and if so, gives the packets contained in the payload field to the routing s/w.
- The routing s/w then chooses the appropriate outgoing line and passes the packets down to the DLL s/w which then transmits it

CHECKING THE ERRORS

- FRAMING IS DONE TO BREAK THE BIT STREAM UP INTO DISCRETE FRAMES AND COMPUTE THE CHECKSUM FOR EACH FRAME.
- WHEN FRAME ARRIVES AT THE DESTINATION THE CHECKSUM IS RECOMPUTED.
- IF THE CHECKSUM IS DIFFERENT THAT MEANS AN ERROR HAS OCCURRED AND TAKE STEPS TO DEAL WITH IT

FLOW CONTROL

- FEEDBACK BASED FLOW CONTROL
  - Receiver sends back the information to the sender giving it permission to send more data
- RATE BASED FLOW CONTROL
  - The protocol has built in mechanism that limits the rate at which sender may transmits data without using feedback from the receiver

Physical Addressing

- DLL layer adds header to the frame to define the sender and receiver of the frame.

- ****
- If the frame is intended for a system outside the sender's network, the receiver address is the address of the device that connects the network to the next one

Physical Address	Logical address
• It is the address of the node as defined by its LAN or WAN • Size and format of these address depends on the network • Generally it the address imprinted on the network interface card (NIC)	• It is the address for universal communication that are independent of the underlying physical networks • Physical n/ws are not adequate for internetworks • Universal addressing system is needed in which each host is identified uniquely, regardless of the underlying physical network • Logical address of the internet is 32 bit IP address

NETWORK LAYER

- This layer is responsible for the src to destination delivery of packets across the networks

Responsibilities included by the n/w layer

- Logical Addressing:
  - Physical addressing is implemented by the DLL handles the addressing problem locally.
  - If the packet passes boundary we needed logical addressing to distinguish the src and destination
  - The network layer adds header to the packets received from upper layer which defines the logical address of the sender and receiver

Ex:

- A wants to send some data to D
- Path to be followed is A-F-G-D
- Logical address will remain the same while moving from A-f-G-D
- PHYSICAL ADDRESS WILL CHANGE
  - A-F
  - F-G
  - G-D

Routing

- The **network layer controls the operation of the subnet**
- A key design issue is determining how packets are routed from source to destination
- Routes can be dependent upon many things like current network load or on static tables
- The control of congestion also belongs to the network layer.
- It is up to the network layer to allow heterogeneous networks to be interconnected.

Network Layer

Functions

- Routing: means to identify best shortest path b/w source & destination.

  Static routing- path is known in advance.

  Dynamic routing- path is dynamic.
- Congestion control
- Interconnection of heterogeneous n/w

Network Devices:

- Routers
- Brouters
- Layer 3 switches.

TRANSPORT LAYER

- The basic function of the **transport layer is to accept data from above, split it** up into smaller units if need, pass these to the network layer, and ensure that the pieces all arrive correctly at the other end.
- 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..

- Transport layer is responsible for process to process delivery of the entire message
- It treats each packets independently, as though each piece is a separate message.
- Transport layer on the receiving side ensures that whole message arrives intact and in order overseeing error control and flow control at the source to destination level
- Network layer gets each packet to the correct computer
- Transport layer gets the entire message on that computer

- Segmentation
  - Message is divided into transmittable segments, with each segment containing a sequence numbers

Session Layer

- The main functions of the session layer are to establish, maintain and synchronize the interaction between two communicating hosts

- Ex: A wants to send a document of 1000 pages to another user B
  - A session was established
  - After first 105 pages have been sent the connection between two hosts is broken for some reason
  - Question is:-
    - When the connection is restored after some time transmission must start from the first page or 106th page.

    - THESE ISSUES ARE THE CONCERNS OF THE SESSION LAYER

- To avoid these issues
  - Session layer could create sub-sessions
  - After each sub-session is over , a checkpoint can be taken
  - Say after 10 pages
  - So in this retransmission will be from 101st page

- In some cases checkpoint is not reqd where the data is small
- When when the session layer receives the data from presentation layer it adds a header which among other things also contains inforation as to whether there is any checkpoiting and if there is then at what point

- Session layer checks and establishes connection between hosts of two different users.
- Users might need to enter identification information such as LOGIN AND Password

- and finally SESSION CLOSURE
  - That is the session between the hosts is closed gracefully

PRESENTATION LAYER

Translation

- SENDER AND RECEIVER might be using different coding standards and character sets for representing data.

- Sender is using ASCII code
- Receiver is using EBCDIC

- Presentation layer has to take care fo such differences

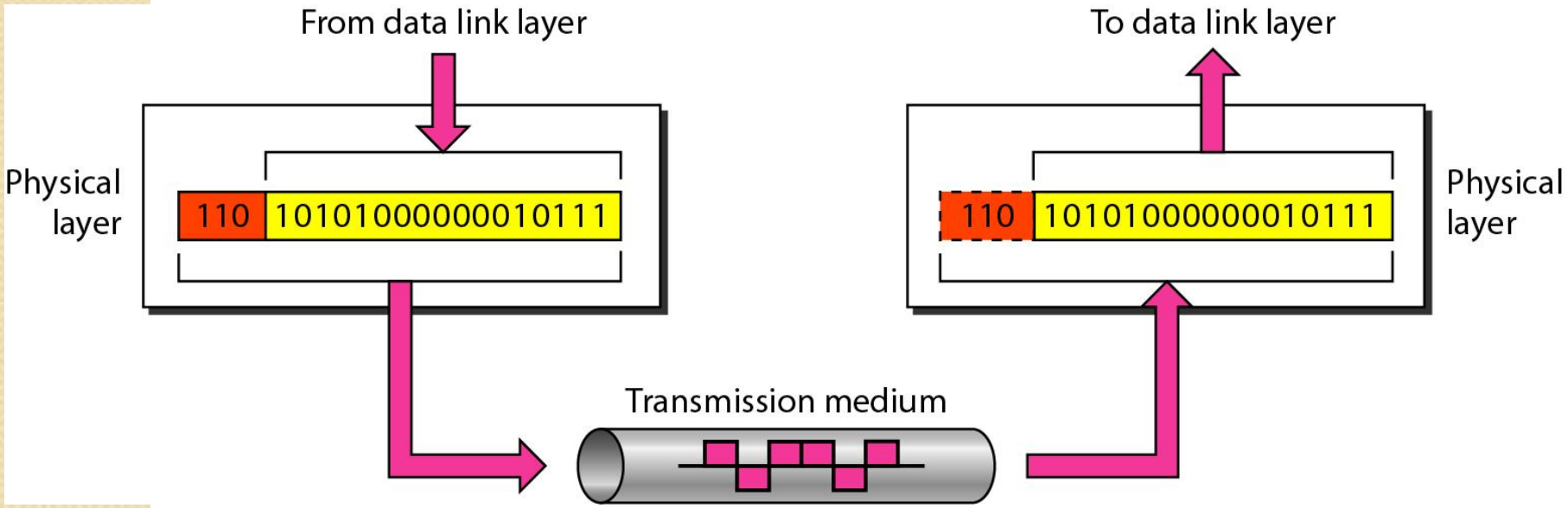
- Then other responsibilities includes:-
  - Encryption and Decryption
  - Compression

Application Layer

- Application layer enables the user to access the network
- Application programs which uses the networks services also reside at this layer
- Like--- telnet----www----ftp etc……

Summarize OSI Model

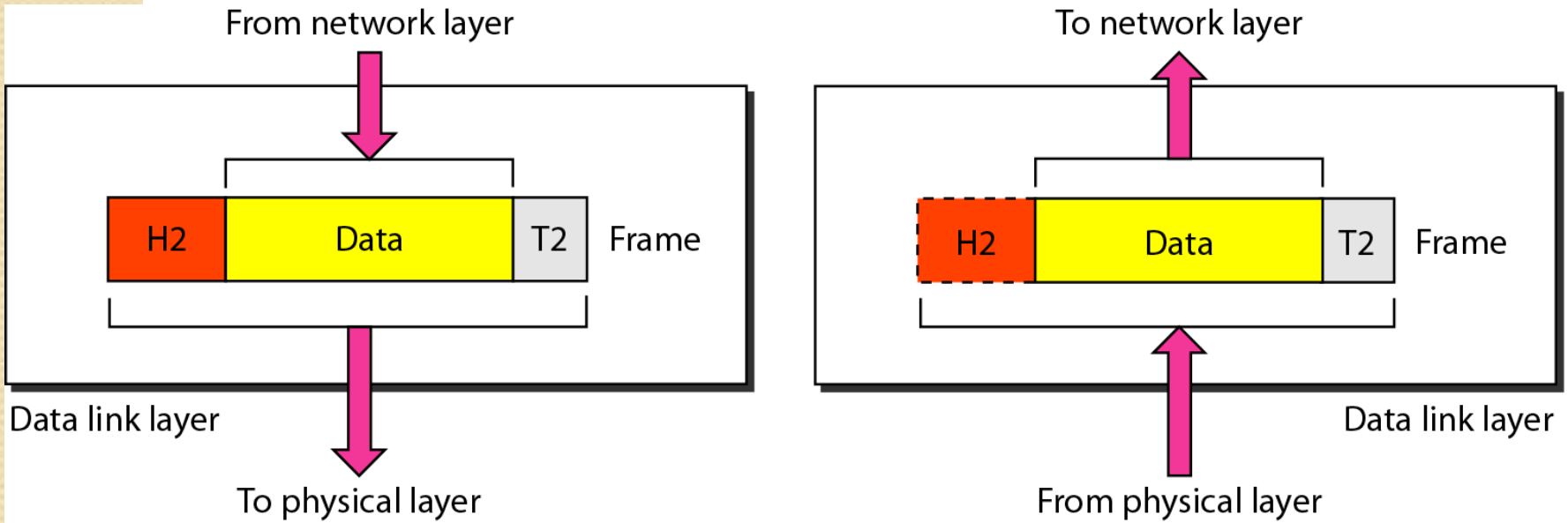
Figure 2.5 *Physical layer*



Note

The physical layer is responsible for movements of individual bits from one hop (node) to the next.

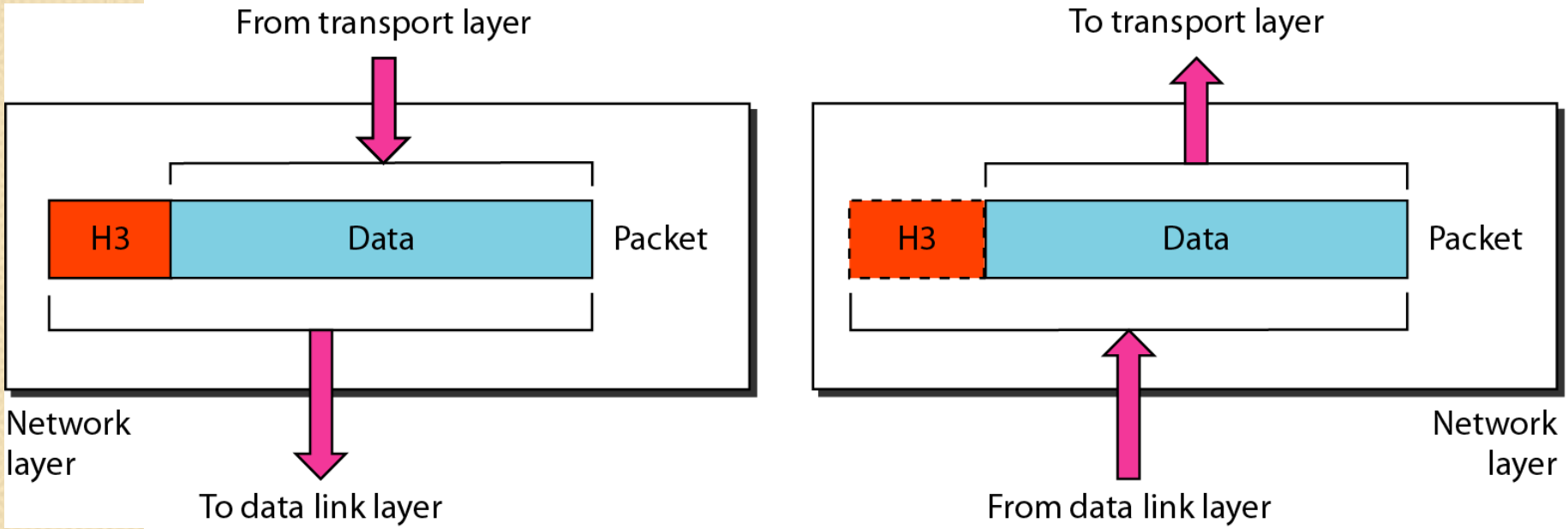
Figure 2.6 *Data link layer*



Note

The data link layer is responsible for moving frames from one hop (node) to the next.

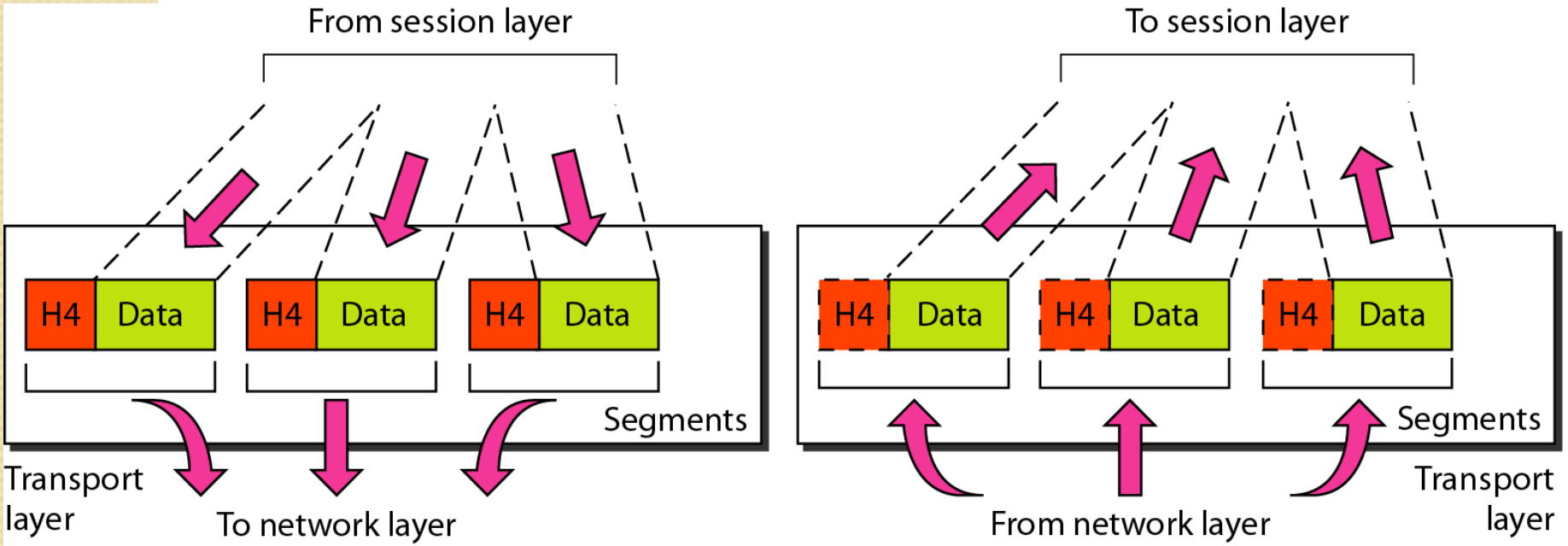
Figure 2.8 *Network layer*



Note

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

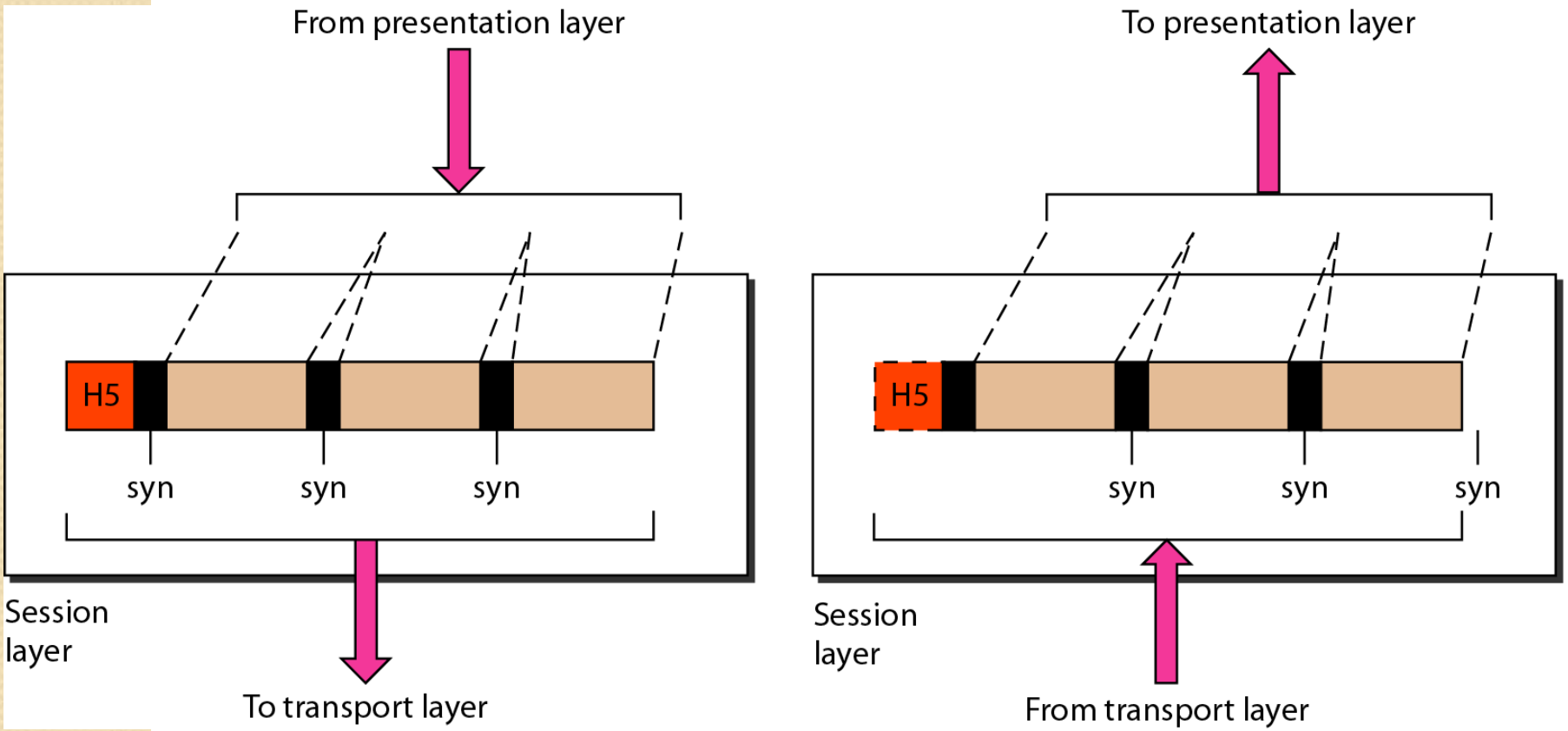
Figure 2.10 *Transport layer*



Note

The transport layer is responsible for the delivery of a message from one process to another.

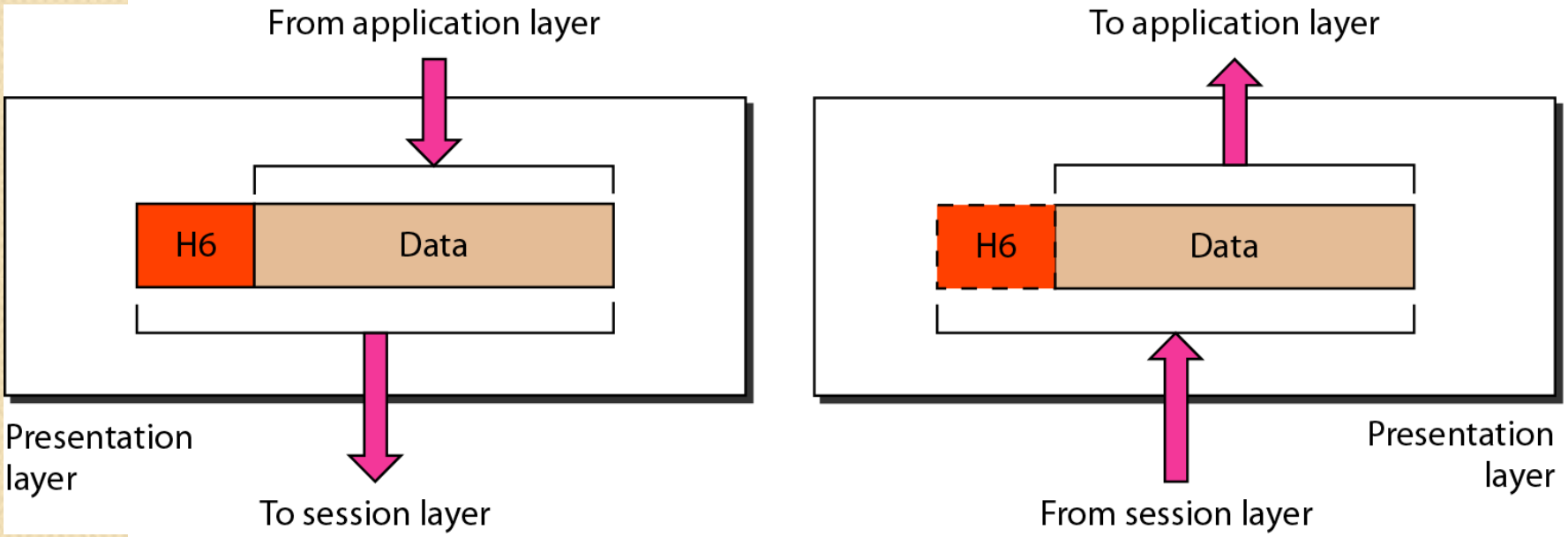
Figure 2.12 *Session layer*



Note

The session layer is responsible for dialog control and synchronization.

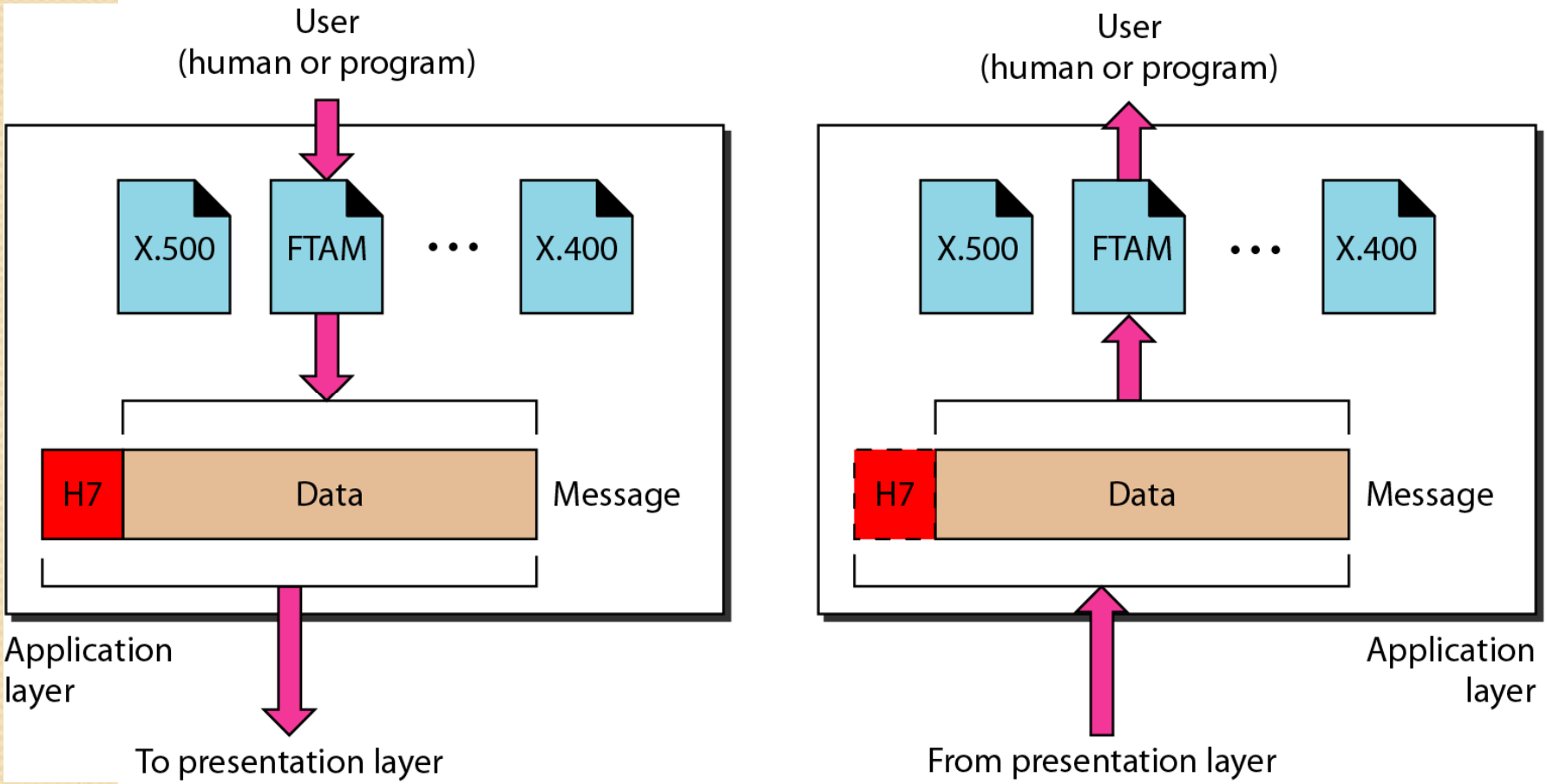
Figure 2.13 *Presentation layer*



Note

The presentation layer is responsible for translation, compression, and encryption.

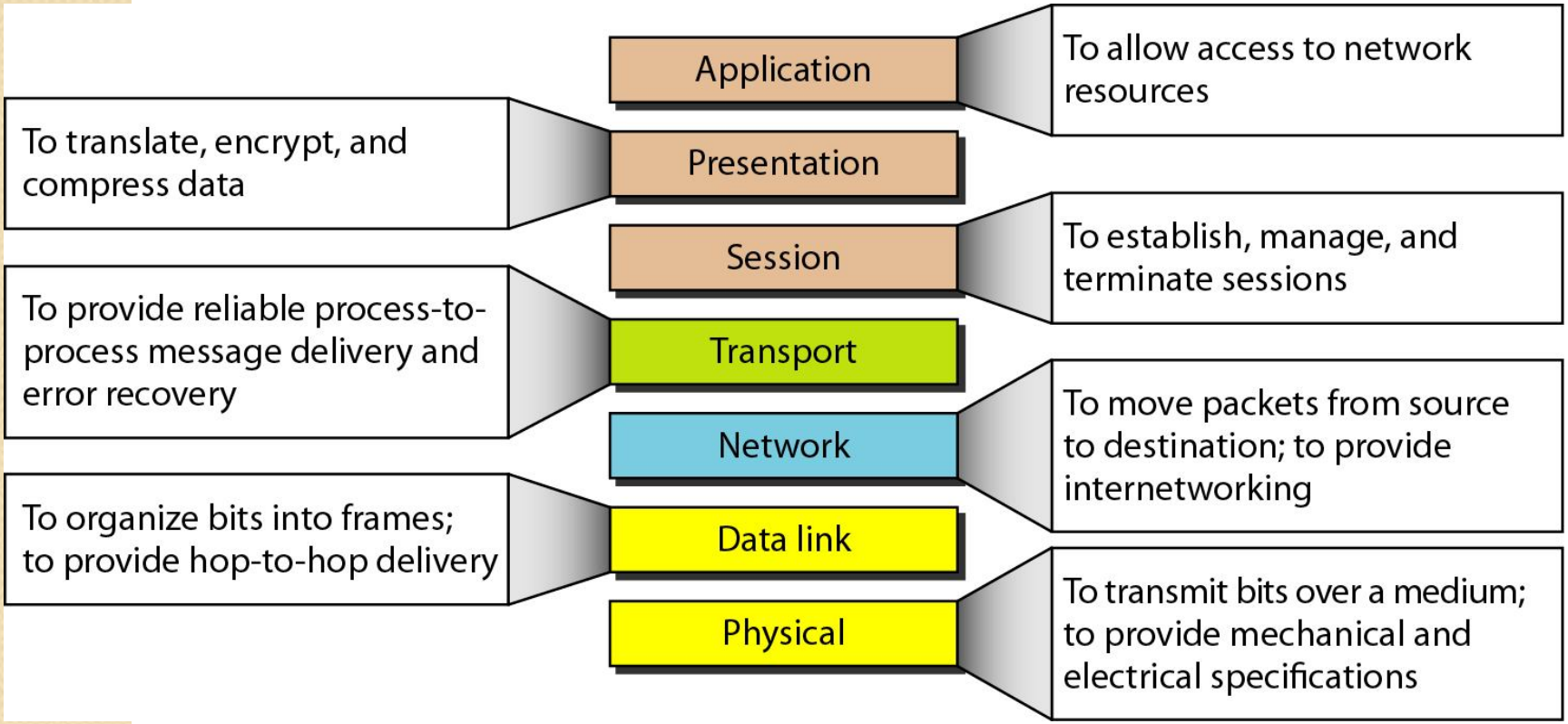
Figure 2.14 *Application layer*



Note

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

Figure 2.15 *Summary of layers*



Application

- ISO-OSI Network model is a standard given by ISO but is never implemented in practice till date. It is only helpful to understand the whole data communication process layer wise.
- Network model which is practically implemented is TCP/IP model.

Scope of Research

- Cross layer architecture
- Security in network model

Assignment

- At which layer of OSI model process to process communication is carried out?

- Discuss limitations of OSI Model