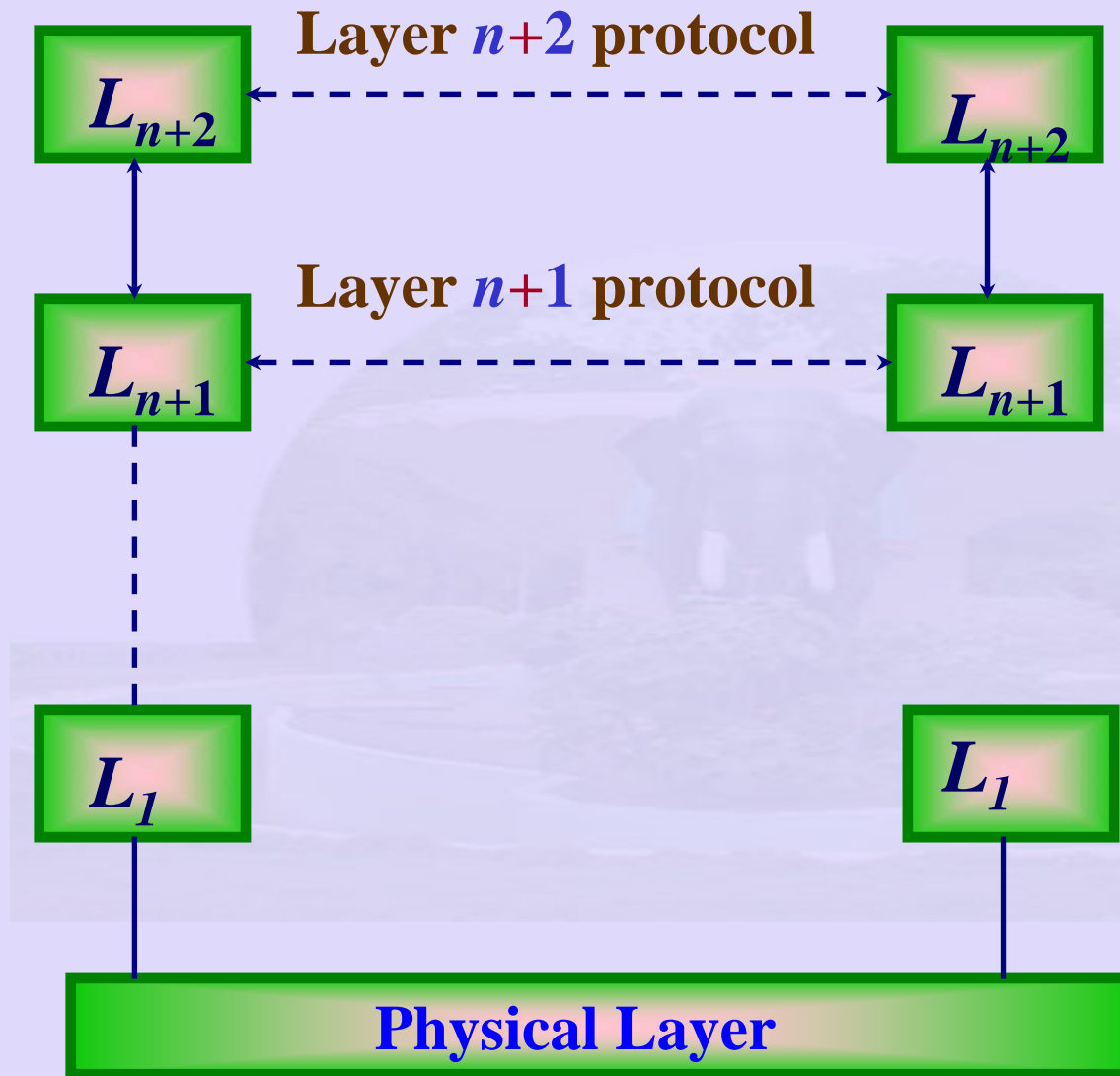


A Layered Approach to Computer Networks

- Physical Layer
 - Data Link Layer
 - Network Layer
 - Transport Layer
 - Session Layer
 - Presentation Layer
 - Application Layer
- **Different layer of abstraction**
 - **Different error control mechanisms at different layers**

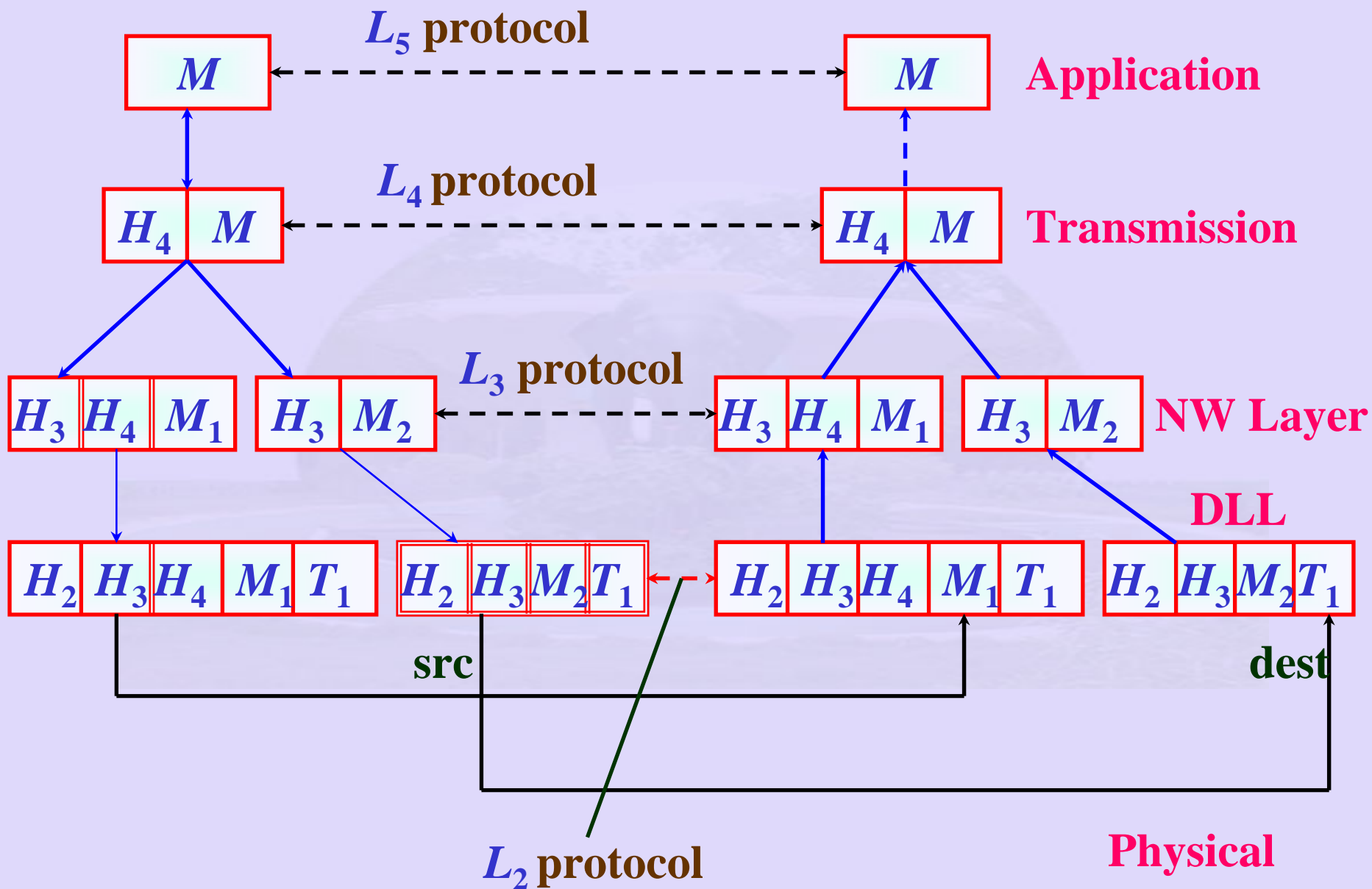


Layer to Layer Communication

- Layer n on 'A' talks to Layer n on 'B'.
 - No data transferred directly between layers at the same level.
 - Data and control flow from one layer to the layer below it until it reaches Physical Layer.
 - All transmission only at the Physical Layer.

Design of a Network

- Layer to Layer interface must be well understood.
- A set of layers and protocols constitute a **network architecture**.
- A list of protocols used by a system, one per layer is called a **protocol stack**.



Design of a Network

- Addresses for source and destination
 - multiple machines with multiple processes
 - a process on one machine must know the identity of process on the other machine that it wants to talk to
 - Machine Address
 - Process Address

Design of a Network

- Virtual communication between peers except Physical Layer.
- Each layer thinks that there is a horizontal communication.
- At each layer:Procedures:
 - Send To Other Side
 - Get From Other Side
 - each communicates with lower layers.
 - each layer needs a mechanism to identify senders and receivers

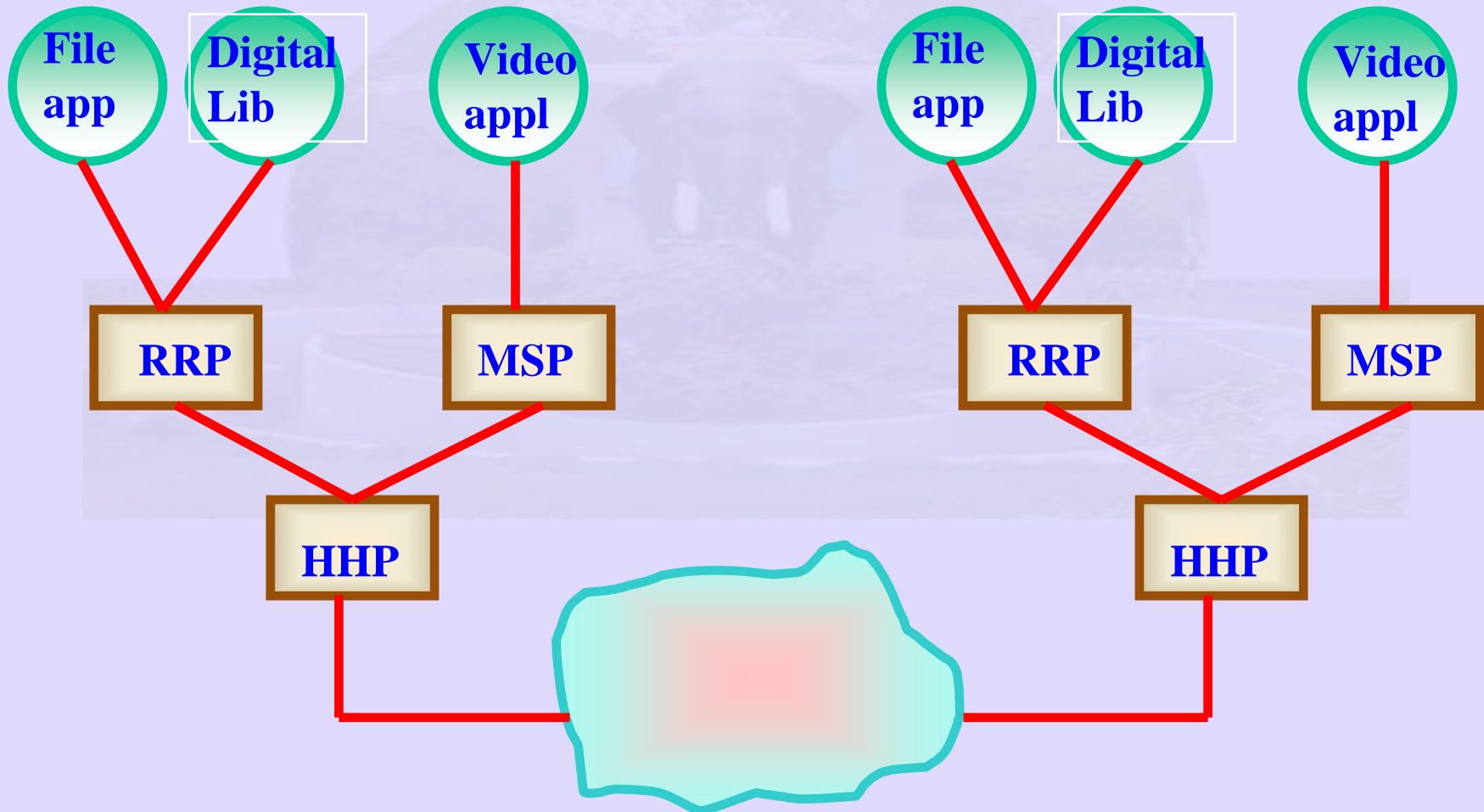
Design of a Network (Continued)

- Modes of data transfer
 - Simplex, duplex, half-duplex
- Number of logical channels
 - Minimum two
 - One for data, one for control

Design of a Network (Continued)

- Layers of abstraction
- Packet format at each layer
- Mechanisms for error control at each layer
- Sequencing of packets at each layer
- Support multiple protocols at each layer

Example of Multiple protocols at the same layer



Different requirements for different Applications

- protocol stack for:
 - file application:
 - RRP / HHP
 - Digital Library
 - RRP / HHP
 - Video Application:
 - MSP / HHP - enable QoS, jitter, delay
video on demand / video conferencing
- Must ensure reliable transmission

Layering in a Network

- Abstracting details away from physical layer:
 - keeps switches in the middle of the Network as simple as possible
 - Compare with telephone network: put intelligence in switch
 - telephone handsets as simple as possible
 - A single physical connection to multiplex different conversations

Layering in a Network

- flow and control:
 - prevented sender from swamping receiver.
- message formats:
 - different sizes at different levels
 - assemble / disassemble messages

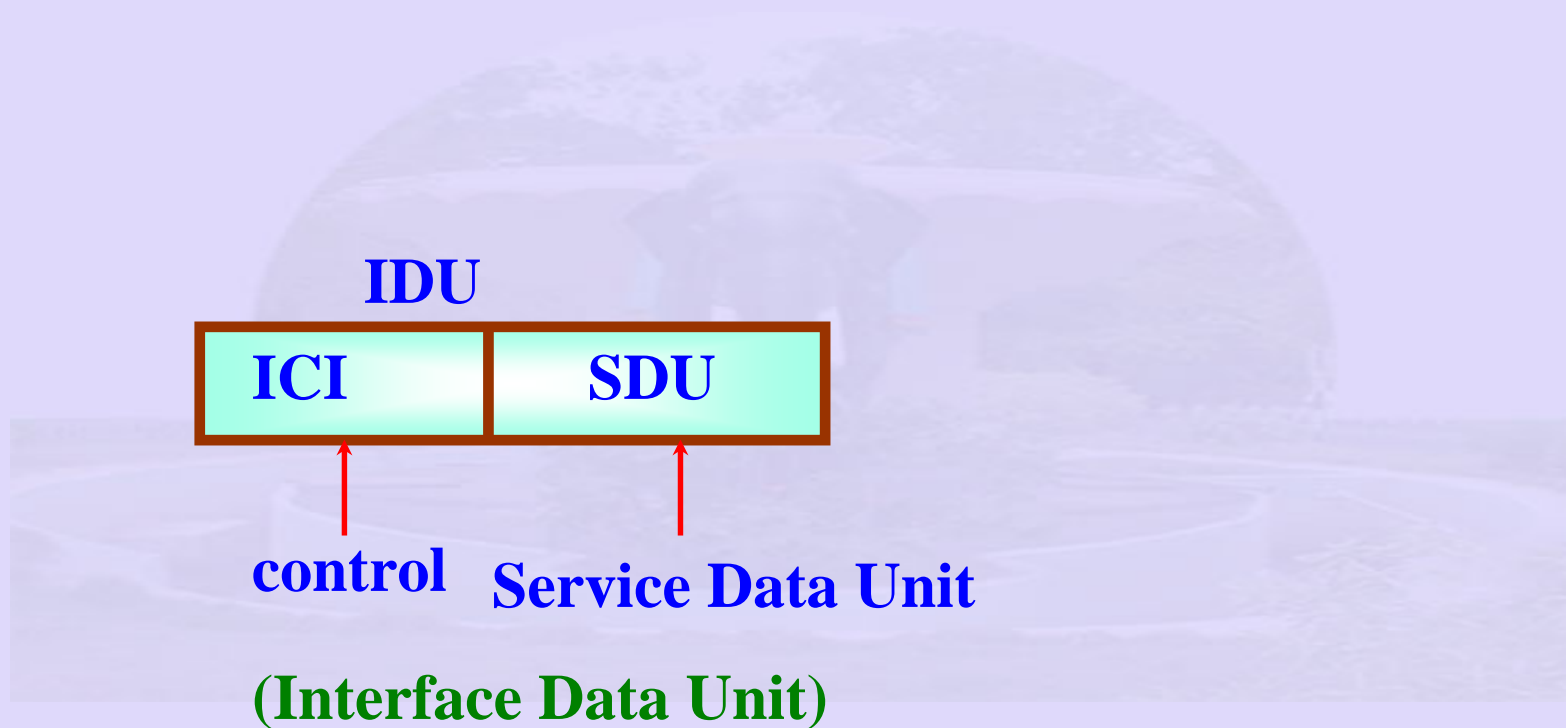
Layer to Layer Communication

- Each layer provides service to the layer above it
 - Layer **n** provides services for Layer **n+1**
 - Layer **n** service provider
 - Layer **n+1** service user

Interfaces between Layers

- Service access point (SAP)
 - place where Layer $n+1$ accesses Layer n services
- unique address
 - SAP in telephone NW
 - telephone jack or socket
 - SAP address:
 - telephone number

Exchange of information between two layers. (IDU)



Interfaces and Services

- **SDU** transmitted across Network
- **Control** useful for lower layer to do their job
- e.g. number of bytes
- **Layer n fragments data into PDUs (Protocol Data Unit – packets)**
 - each **PDU** has a header.
- **PDUs** are used by peers to carry out peer control.

Services and Protocols

- **Services:**
 - set of primitives or operations that a layer provides to the layer above it.
- **Protocols:**
 - set of rules governing the format and meaning of frames, packets, messages exchanged between peers.

Types of Services

- connection oriented service
 - Telephone system
- connection less – postal system
 - (second message come before first – no acknowledgement)
 - Two letters posted at the same time to same address
- reply paid telegram
 - Acknowledgement received for message

Layers and their functions

- Physical layer:
 - Transmits bits 0 & 1
 - what voltage to use
 - width of a bit
 - connection establishment
 - tearing down of connection
 - number of pins on Network connector and use of each pin on the connector

Layers and their functions

- Data Link Layer:
 - convert it to a line that appears free of undetected transmission errors to the layer above it.
 - data frames, ack frames
 - handshaking between transmitter, receiver
 - control access to the shared channel

Layers and their functions

- Network Layer:
 - operation of the subnet
 - routing of packets src to destination
 - static / dynamic routing;
 - congestion control

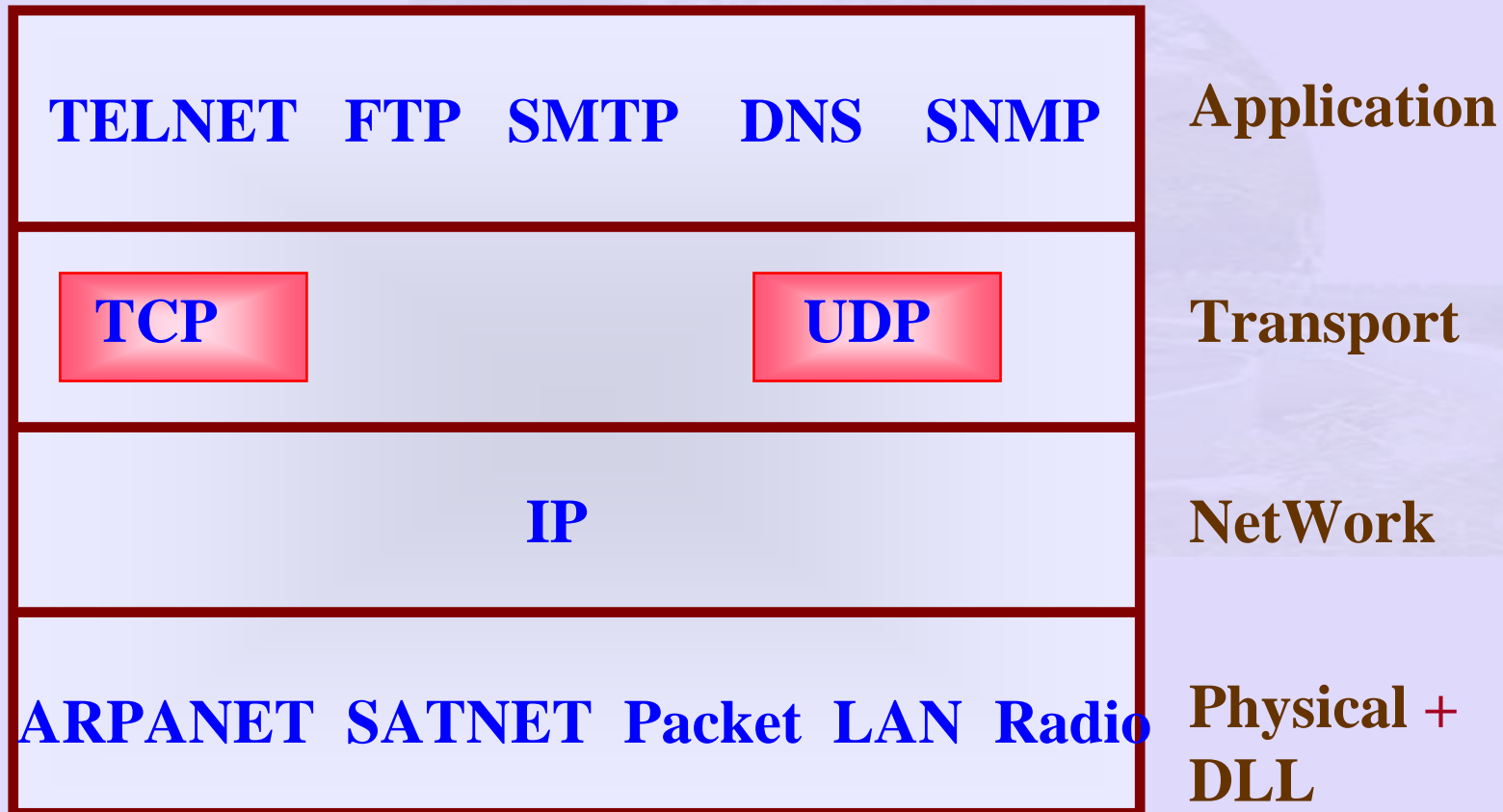
Layers and their functions

- **Transport Layer:**
 - split data from session passes to Network Layer, pieces arrive correctly at the other end.
 - flow control
- **Session Layer (not used):**
 - allows users on different machines to establish a session between them.
 - synchronisation, check parity

Layers and their functions

- Presentation Layer (not used):
 - coding standards machine to Network and back
 - Example: ASCII to Unicode and vice versa
- Application Layer:
 - variety of protocols required
 - File transfer protocol, Simple Mail Transfer Protocol, Directory Server, Simple Network Management Protocol

The TCP/IP Protocol Stack



A Simple Network

- Connecting two machines directly to physical medium
 - Encoding
 - Framing and error detection
 - Link should appear reliable
 - shared link
 - medium access