Why make a network?

- Because of networks we can …
  - Share resources (Peripherals, files, internet connection etc.)
  - Communicate and collaborate
  - Save data

Network Criteria

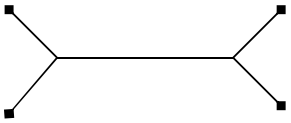
A network must be able to meet a certain number of criteria e.g. …

- Performance
  - often evaluated by throughput, delay etc.
- Reliability
  - measured by the frequency of failure, the time it takes to recover from a failure etc.
- Security

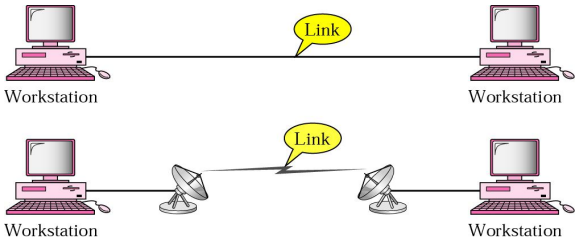
Types of Connection

- A *link* is a communications pathway that transfers data from one device to another
- Point-to-point

- Multipoint

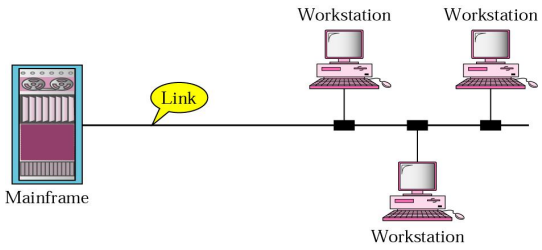


Point-to-point connection



- Provides a dedicated link between devices.
- Entire capacity of the link is reserved for the two devices.

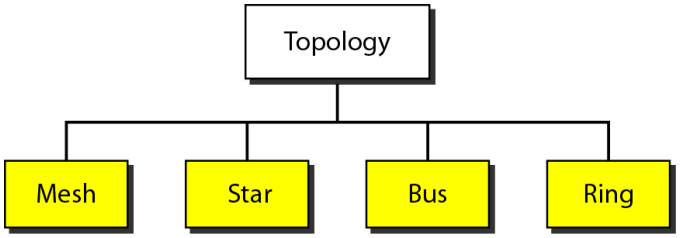
Multipoint connection



- More than two specific devices share a single link.
- The capacity of the channel is shared.

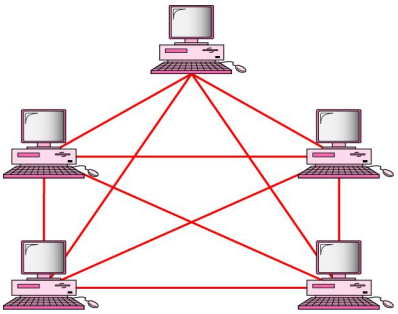
Network Topology

- It refers to the way in which a network is laid out physically.
- It is a geometric representation of the relationship of all the links and linking devices to one another.



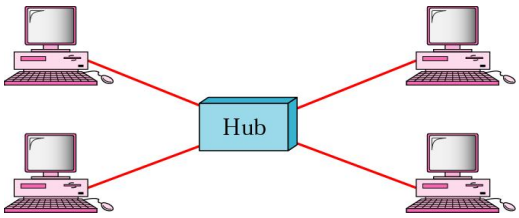
Mesh topology

- Every device has a dedicated point-to-point link to every other device.
- A fully connected mesh network has *n(n-1)/2* physical channels to connect *n* devices with each device having *n-1* I/O ports.



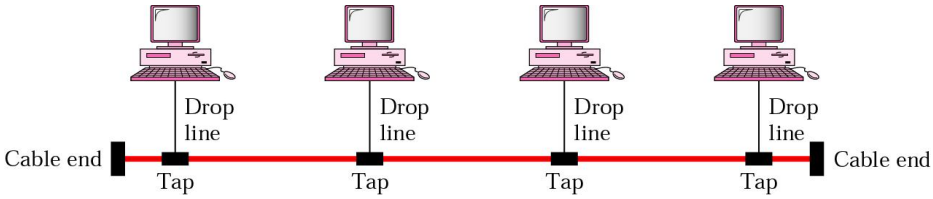
Star topology

- Each device has a dedicated point-to-point link to a central controller (usually a hub).
- Less expensive than mesh.



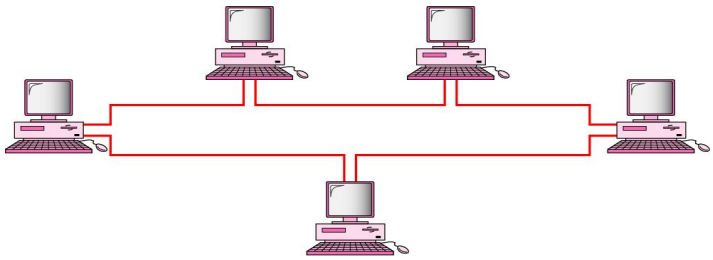
Bus topology

- One long cable acts as a backbone to link all devices.
- Multipoint connection (shared link)



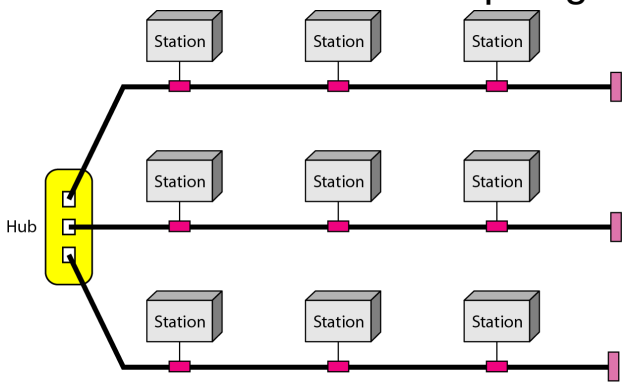
Ring topology

- Each device has a dedicated point-to-point connection only with two other devices.
- A signal is passed along the ring in one direction.



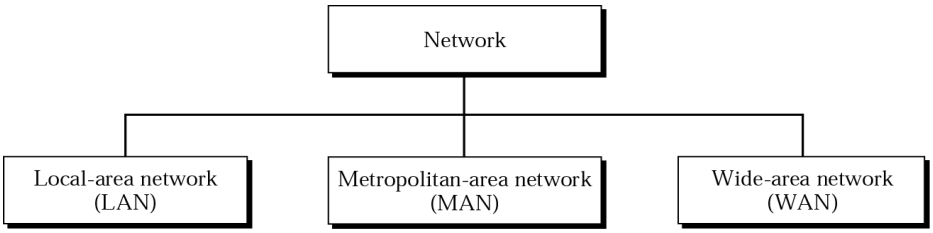
Hybrid topology

- A network can have hybrid or a combination of different topologies e.g.



Categories of networks

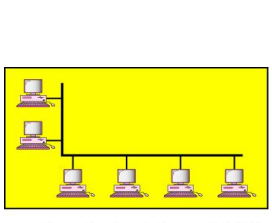
- A Network is categorized with respect to its size, its ownership, the distance it covers and its physical architecture.



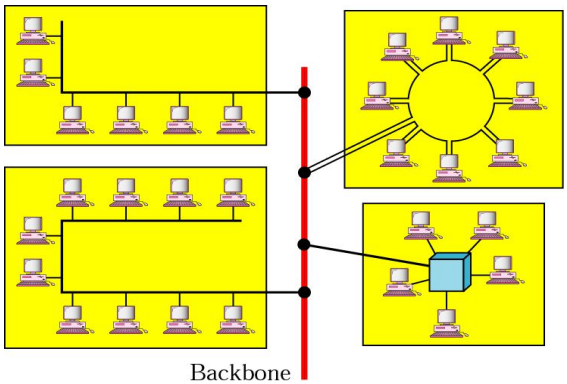
Local Area Network (LAN)

- Smaller scope
  - Building or small campus
- Usually owned by same organization as attached devices
- Data rates much higher
- Usually broadcast systems

LAN



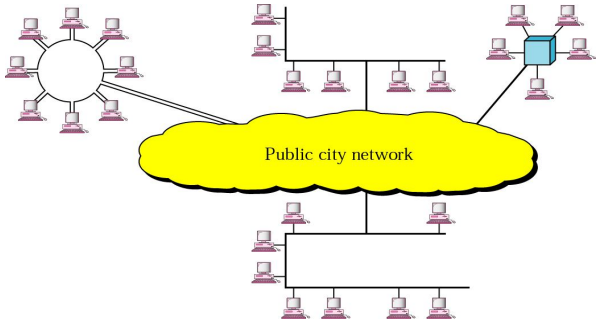
a. Single-building LAN



b. Multiple-building LAN

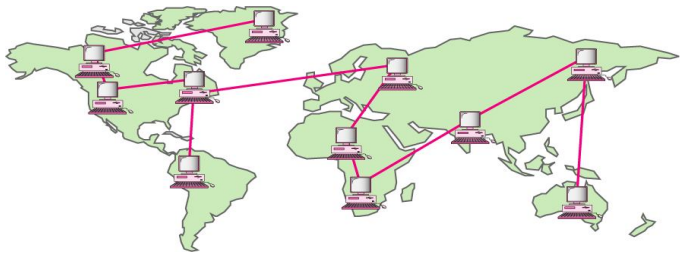
Metropolitan Area Network (MAN)

- Middle ground between LAN and WAN
- May be owned by Private company or a service provided by a public company
- Large area

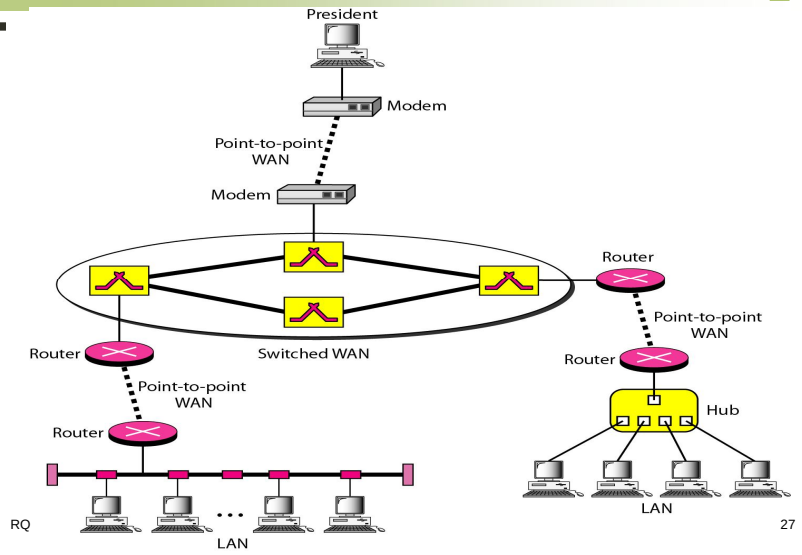


Wide Area Network (WAN)

- Large geographical area
- Crossing public rights of way
- Rely in part on common carrier circuits



Interconnection of Networks: Internetwork



The Internet

- The Internet is a global system of interconnected computer networks.
- It is a *network of networks* that consists of millions networks, linked by a broad array of electronic, wireless, and optical networking technologies.

A classification of networks by scale

Interprocessor distance	Processors located in same	Example
1 m	Square meter	Personal area network
10 m	Room	Local area network
100 m	Building	
1 km	Campus	
10 km	City	Metropolitan area network
100 km	Country	Wide area network
1000 km	Continent	
10,000 km	Planet	The Internet

Protocol

- A protocol is a set of rules that govern data communications.
- It defines what is communicated, how it is communicated, and when it is communicated.

1. Syntax: refers to the structure or format of the data, meaning the order in which they are presented.
2. Semantics: refers to the meaning of each section of bits.
3. Timing: refers to two characteristics: when data should be sent and how fast they can be sent.

Standards

- Standards provide guidelines to manufacturers, vendors, government agencies, and other service providers to ensure the kind of interconnectivity necessary in today's marketplace and in international communications.

Standards Organizations

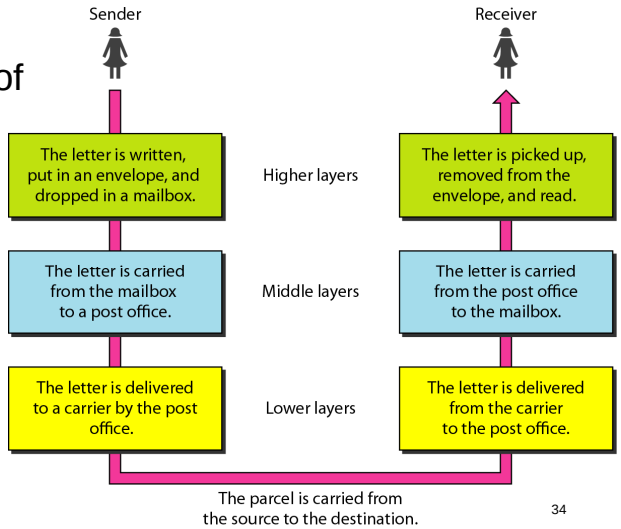
- International Organization for Standardization (ISO)
- International Telecommunication Union-Telecommunication Standards Sector (ITU-T)
- American National Standards Institute (ANSI)
- Institute of Electrical and Electronics Engineers (IEEE)
- Electronic Industries Association (EIA)

Internet Standards

- An *Internet draft* is a working document (a work in progress) with no official status and a 6-month lifetime.
- Upon recommendation from the Internet authorities, a draft may be published as a *Request for Comment* (RFC).
- An *Internet standard* is a thoroughly tested specification that is useful to and adhered to by those who work with the Internet.

Layered Tasks

- The concept of layered tasks is common in our daily life, e.g. postal mail.



Standardized Protocol Architectures

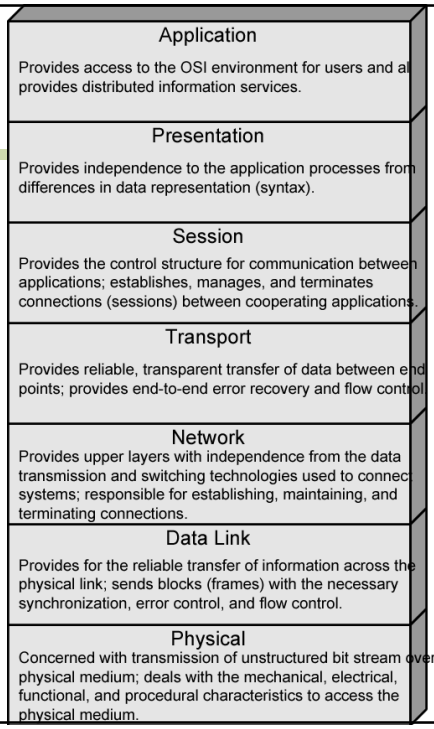
- Required for devices to communicate
- Vendors have more marketable products
- Customers can insist on standards based equipment
- Two standards:
  - OSI Reference model
  - TCP/IP protocol suite
    - Most widely used
- Also: IBM Systems Network Architecture (SNA)

The OSI Model

- International Standards Organization (ISO)
  - An organization dedicated to worldwide agreement on international standards.
- Open Systems Interconnection (OSI)
  - An ISO standard/model that covers all aspects of network communications.
- The OSI model is not a protocol; it is a model for understanding and designing a network architecture.

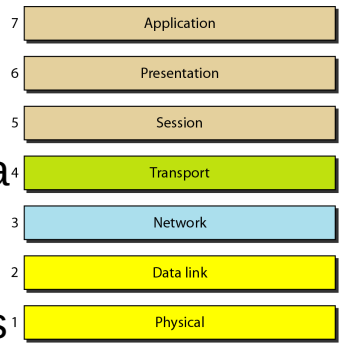
OSI Model

- All
- People
- Seems
- To
- Need
- Data
- Processing

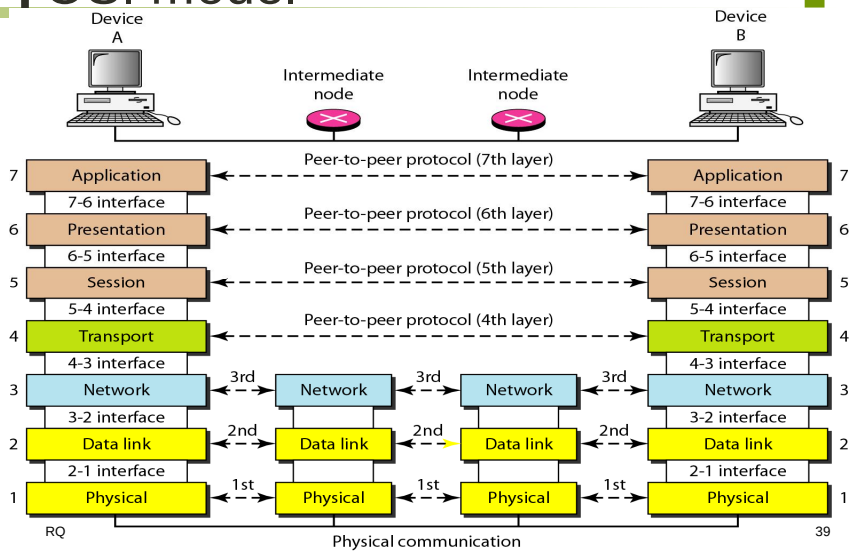


Organization of the Layers

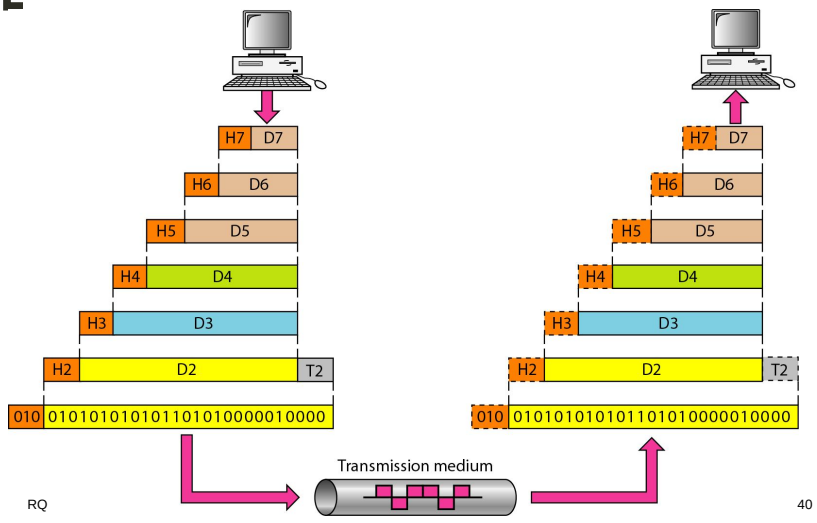
- The upper OSI layers are almost always implemented in software
- The lower OSI layers are a combination of hardware and software, except for the physical layer, which is mostly hardware



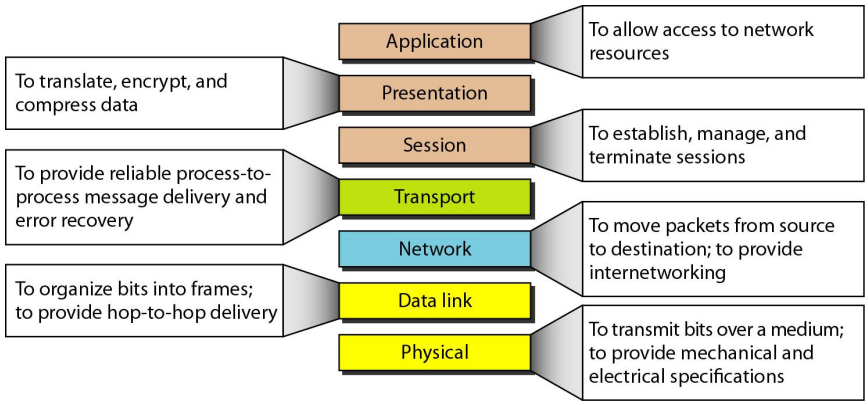
Interaction between layers in OSI model



Encapsulation and Decapsulation in OSI model



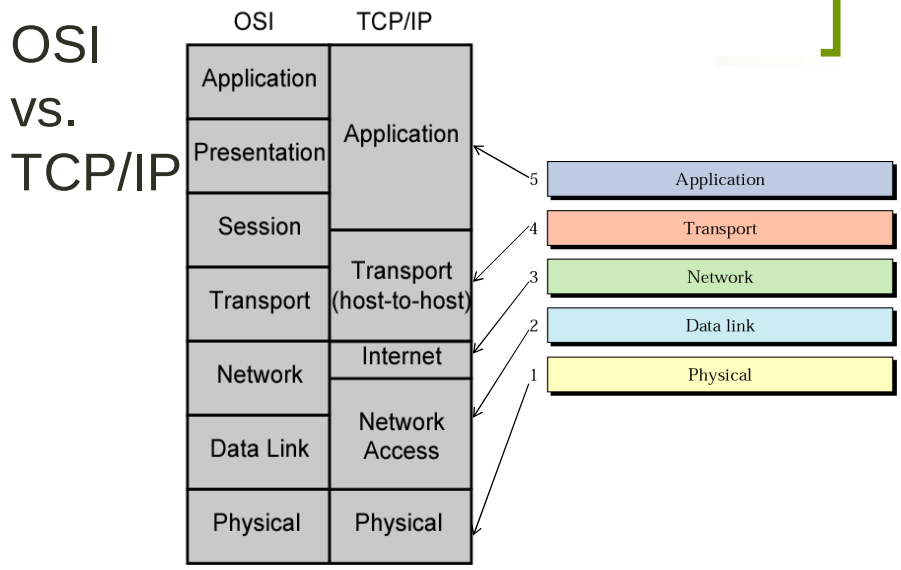
OSI Layers



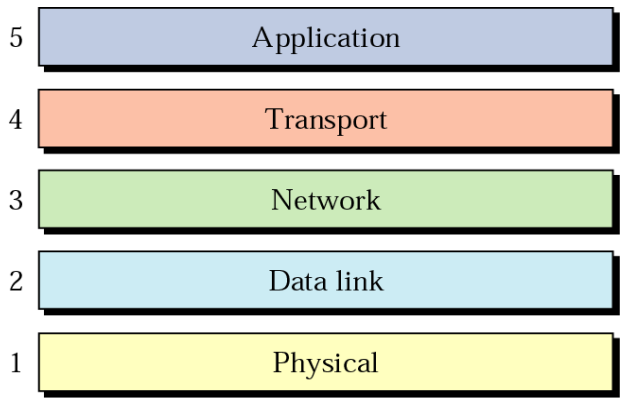
TCP/IP Protocol Suite

- The layers in the TCP/IP protocol suite do not exactly match those in the OSI model.
- The original TCP/IP protocol suite was defined as having four layers: host-to-network, internet, transport, and application.
- However, when TCP/IP is compared to OSI, we can say that the TCP/IP protocol suite is made of five layers: physical, data link, network, transport, and application.

OSI vs. TCP/IP

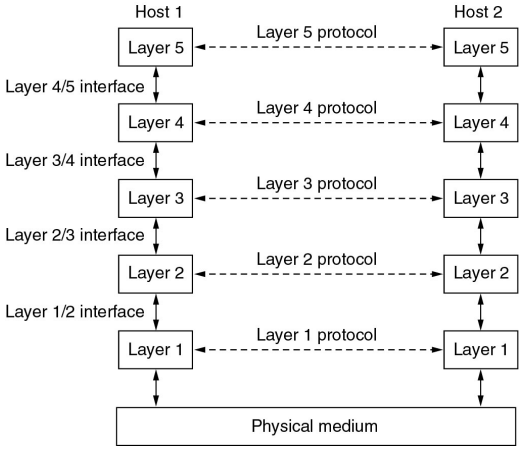


Internet (TCP/IP) Model

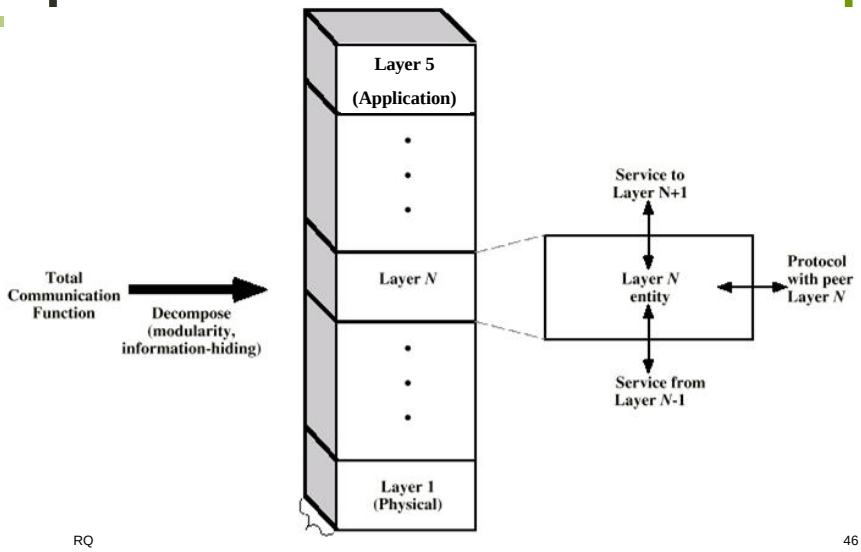


Protocol Hierarchies

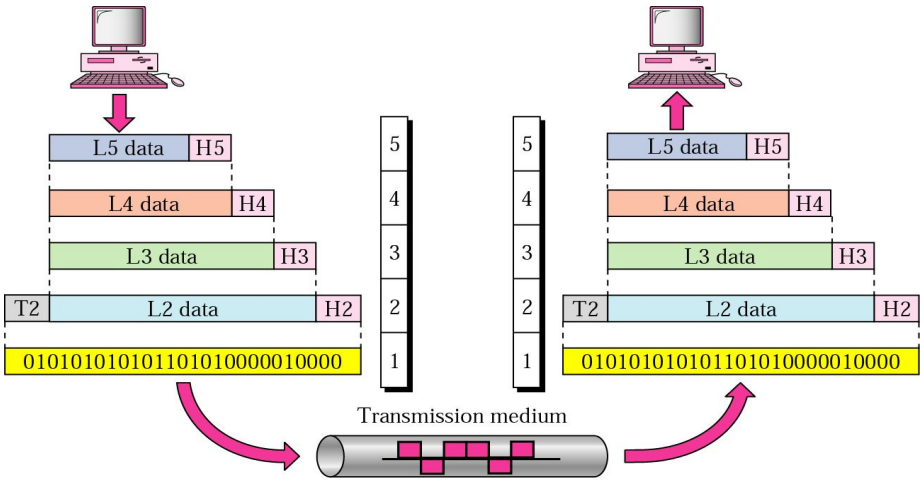
- The entities comprising the corresponding layers on different machines are called peers.



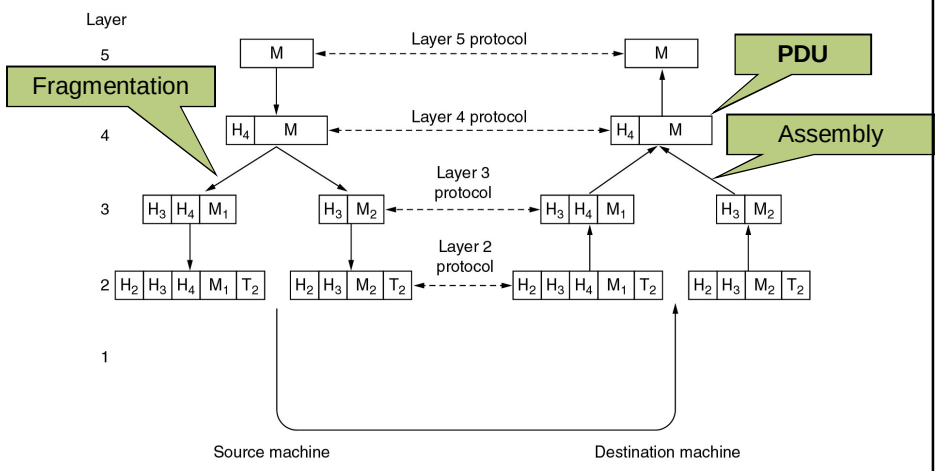
Protocol Hierarchies



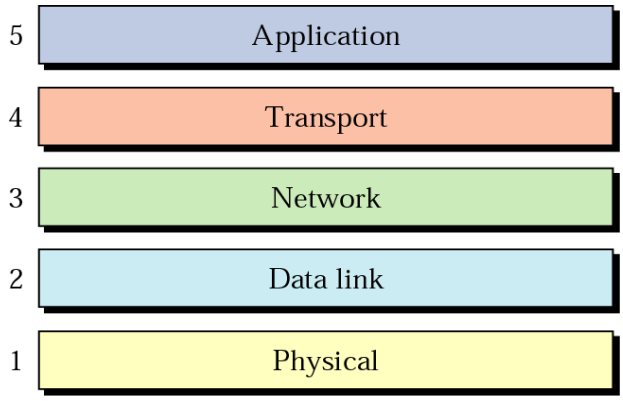
Protocol Hierarchies



Protocol Hierarchies

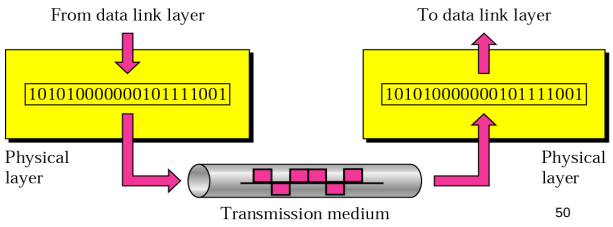


Internet Layers



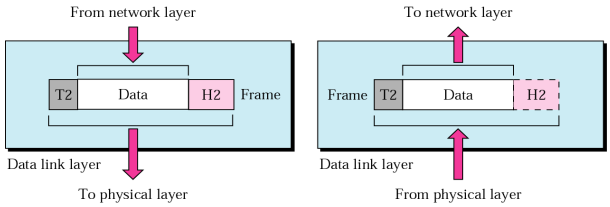
Physical Layer

- It is responsible for transmitting individual bits from one node to the next.
- It is mainly concerned with …
  - Characteristics of transmission medium
  - Signal levels
  - Data rates



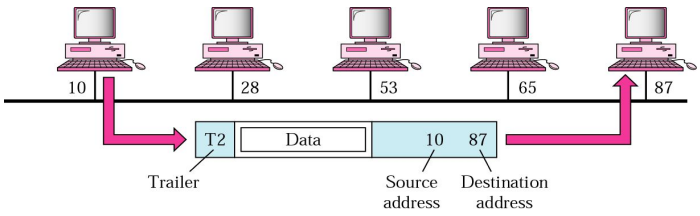
Data Link Layer

- It is responsible for transmitting frames from one node to the next.
- Its major duties are …
  - Framing
  - Physical Addressing
  - Flow Control
  - Error Control
  - Access Control

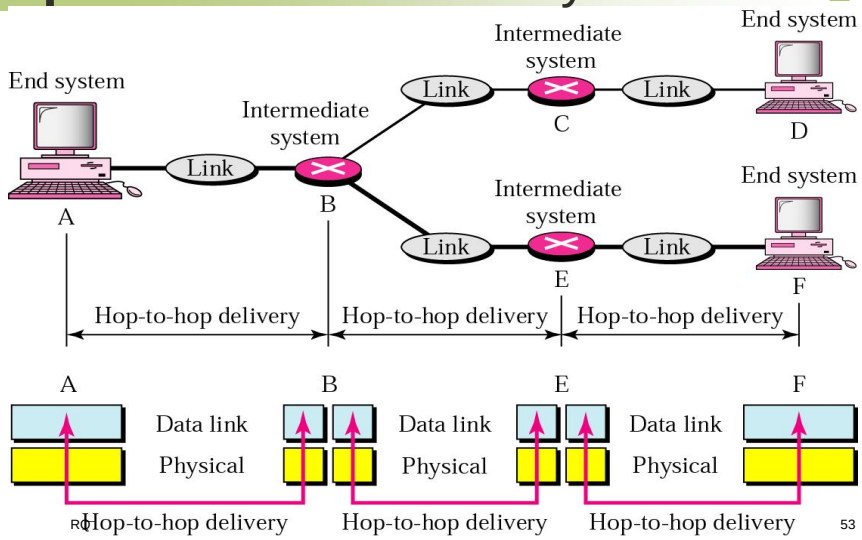


Node to node delivery

- A node with physical address 10 sends a frame to a node with physical address 87. The two nodes are connected by a link.
- At the data link level this frame contains physical addresses in the header. These are the only addresses needed.
- The rest of the header contains other information needed at this level.
- The trailer usually contains extra bits needed for error detection

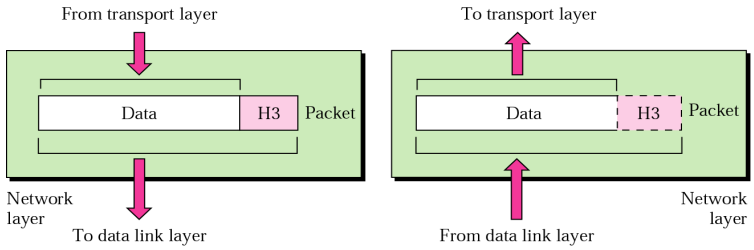


Node to node delivery

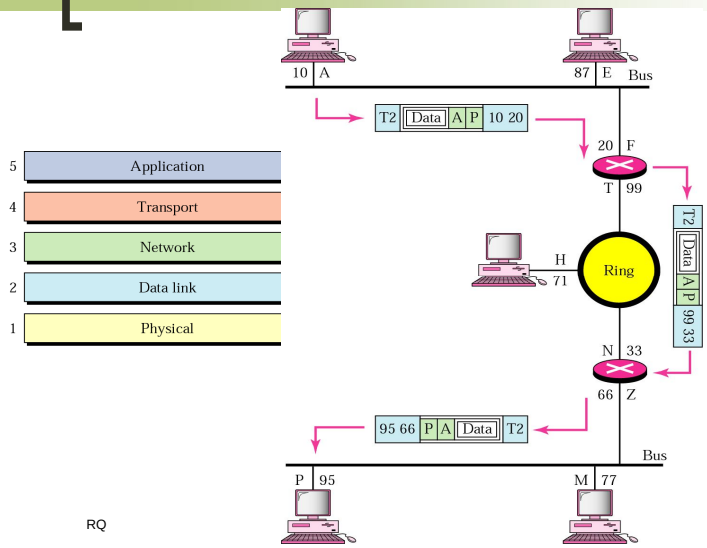


Network Layer

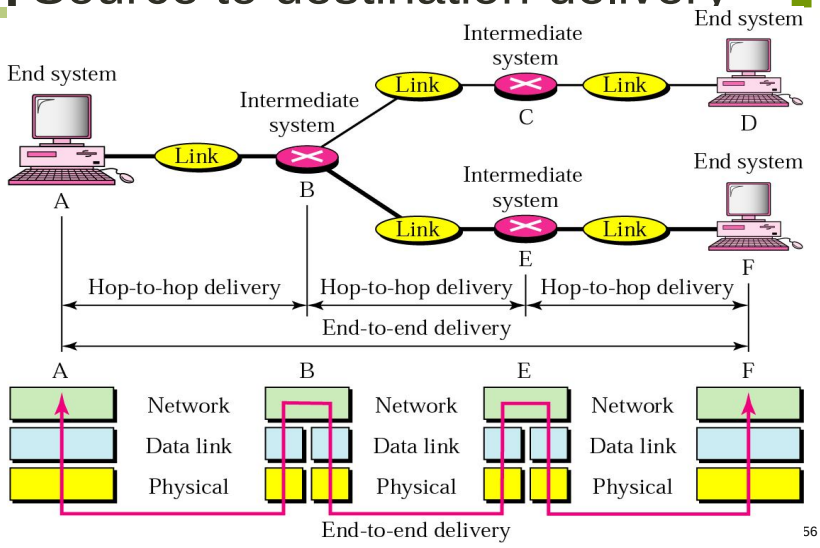
- Responsible for the delivery of packets from the original source to the final destination.
- Performs routing functions across multiple networks
- Implemented in end systems and routers



Source to destination delivery

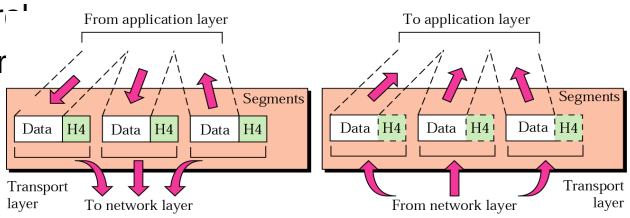


Source to destination delivery

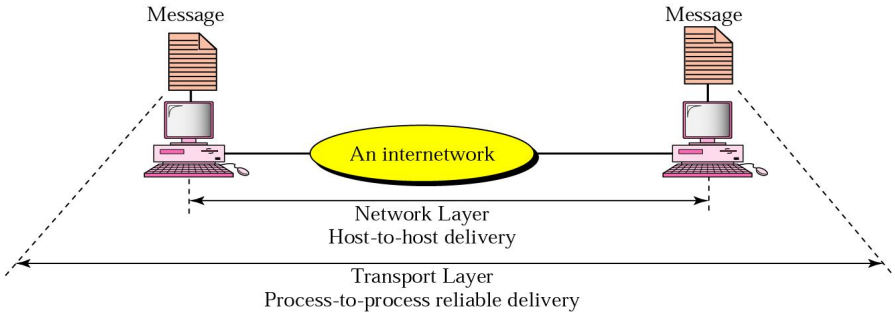


Transport Layer

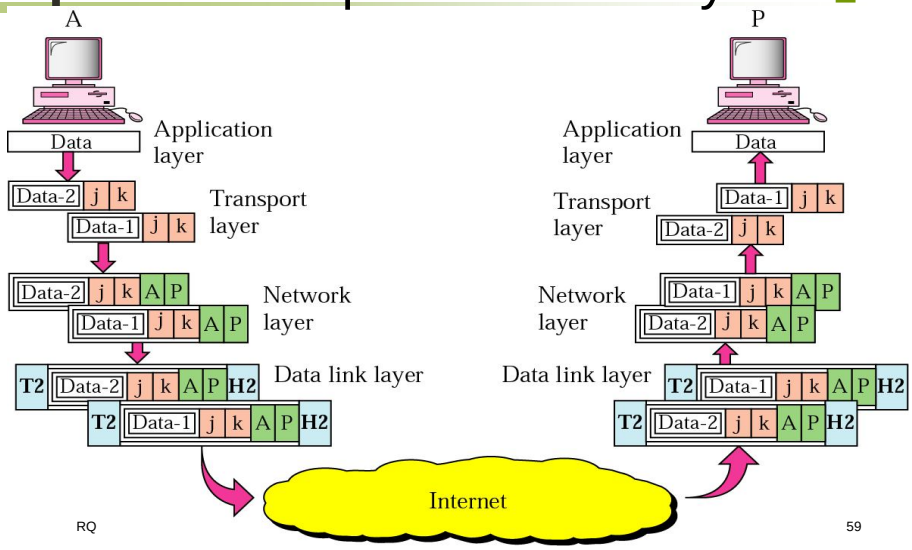
- It is responsible for delivery of a message from one process to another.
- Its major functions are …
  - Port Addressing
  - Connection Control
  - Flow Contr
  - Error Contr



Process to process delivery

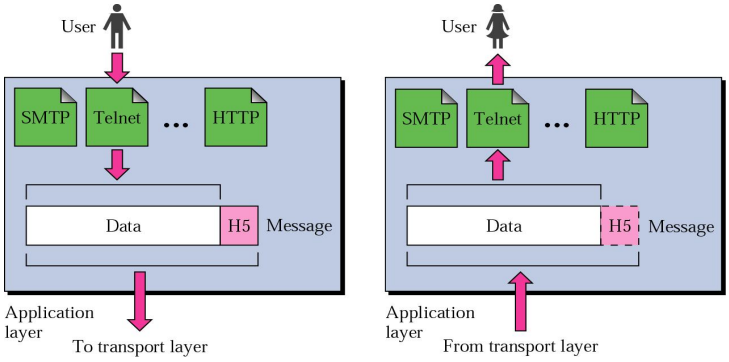


Process to process delivery

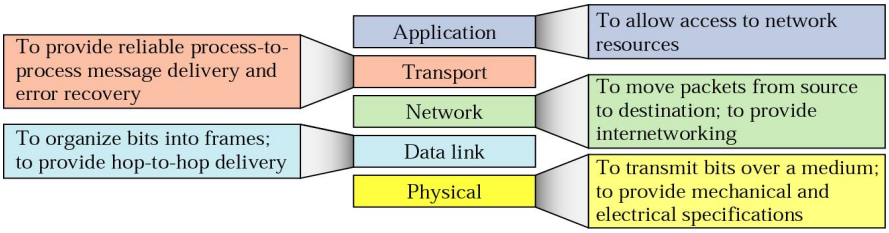


Application Layer

- It is responsible for providing services to the user.

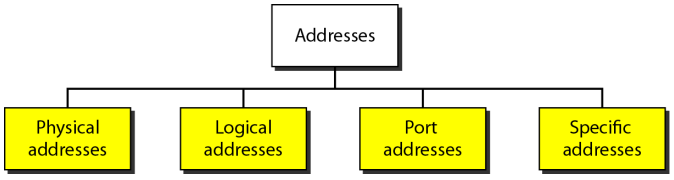


Summary of Layers (TCP/IP)

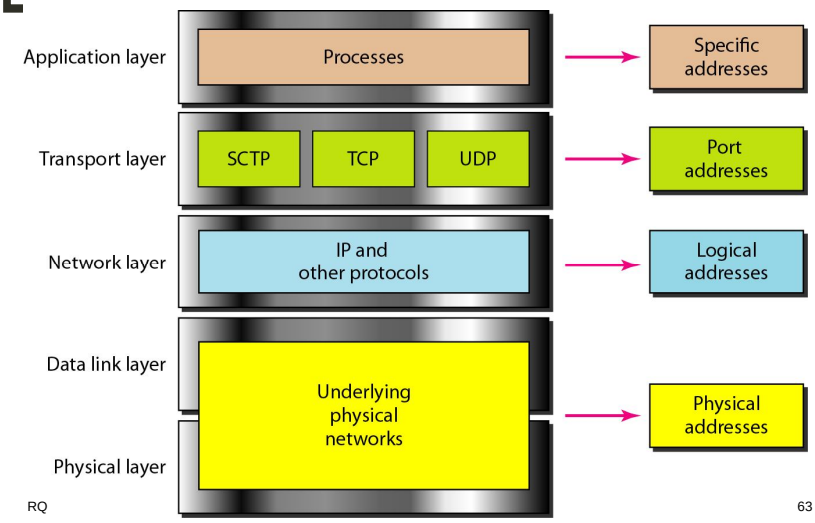


Addresses

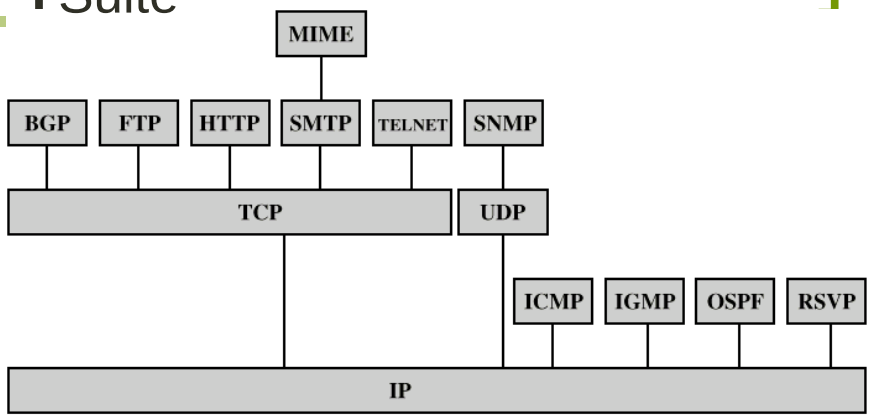
- Four levels of addresses are used in an internet employing the TCP/IP protocols:



Addresses



Some Protocols in TCP/IP Suite



BGP = Border Gateway Protocol
FTP = File Transfer Protocol
HTTP = Hypertext Transfer Protocol
ICMP = Internet Control Message Protocol
IGMP = Internet Group Management Protocol
IP = Internet Protocol
MIME = Multi-Purpose Internet Mail Extension
OSPF = Open Shortest Path First
RSVP = Resource ReSerVation Protocol
SMTP = Simple Mail Transfer Protocol
SNMP = Simple Network Management Protocol
TCP = Transmission Control Protocol
UDP = User Datagram Protocol