

# Introduction

- Each century is dominated by a particular Technology.
- Key Technology of 20<sup>th</sup> Century- Information Gathering, Processing and Distribution.

Key Developments: Large Telephone Networks, Invention of Radio and Television, Birth of Computers, Communication Satellites, etc.

# Introduction cont..

- What is a computer network?  
Interconnected collection of Autonomous computers.
- Distinction between Computer Networks (CN) and Distributed Systems (DS):  
In DS existence of multiple autonomous computers is transparent to the user.  
Notion-Virtual Uniprocessor.  
In CN the user:
  - ✓ Explicitly logs onto one machine
  - ✓ Explicitly submits jobs remotely
  - ✓ Explicitly moves files around and generally handles the N/W Management personally.

# Why Computer Networks?

- Resource sharing
- High reliability
- Economical
- Good scalability
- Communication medium

# Classification of Networks

- Two parameters:

Transmission technology and Scale

- Two transmission technologies:

Broadcast n/W's and point to point n/W's

Broadcast n/W's:

- ✓ Single communication channel is shared by all machines.
- ✓ Unit of information transfer (packets) contains address of sender and receiver.
- ✓ Complete broadcasting or multicasting is possible.

# Classification cont...

- Point to Point N/W's:
  - ✓ Consists of many connections between individual pairs of machines.
  - ✓ To go from source to destination packet may be required to visit one or more intermediate machine. Multiple routes of different lengths are possible.
  - ✓ Routing is an important issue.

## General Rule :

Smaller, Geographically localized networks use Broadcasting, whereas large networks usually are Point to Point.

# Classification cont...

- Classification based on scale:

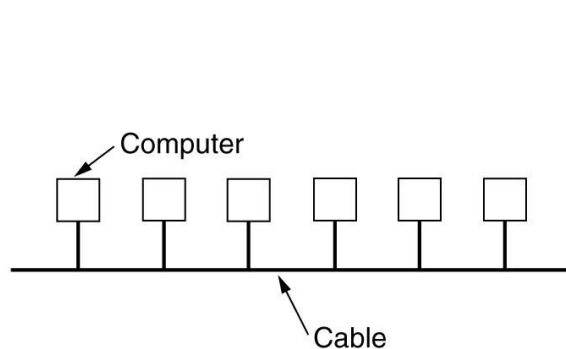
<b>Interprocessor Distance</b>	<b>Processors located in same</b>	<b>Example</b>
0.1 m	Circuit Board	Data flow Machine
1 m	System	Multicomputer
10 m	Room	Local Area Network
100 m	Building	
1 Km	Campus	
10 Km	City	Metropolitan Area Network
100 Km	Country	Wide Area Network
1000 Km	Continent	
10,000 Km	Planet	The Internet

# Local Area Network

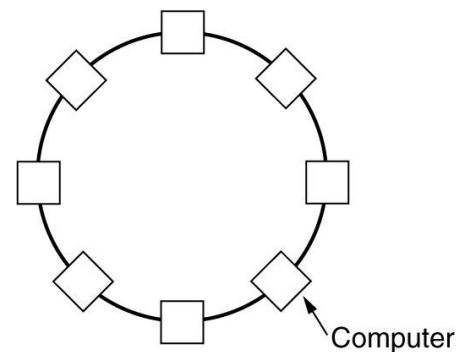
- Privately owned network, within a campus or building, of few Km size.
- Primary purpose: Resource sharing and information exchange
- Due to size restriction, worst case transmission time is bounded and known in advance. It provides flexibility and simplifies N/W management.
- Distinguished from other networks by 3 things: Size, transmission technology and topology.

# LAN cont...

- Features:
  - ✓ Transmission technology consists of a single cable to which all machines are connected.
  - ✓ Speeds: 10-100 Mbps (more is possible)  
(A Mega bit is 1,000,000 bits)
  - ✓ Low delay
  - ✓ Various topologies are possible:



(a)



(b)



# LAN cont...

- Only one machine can be a master and allowed to transmit at any given point of time.
- Arbitration scheme needed to resolve the conflict. Arbitration may be centralized or distributed.
- IEEE 802.3 (Ethernet) is an example of bus based broadcast network with decentralized control, operating at 10-100Mbps.

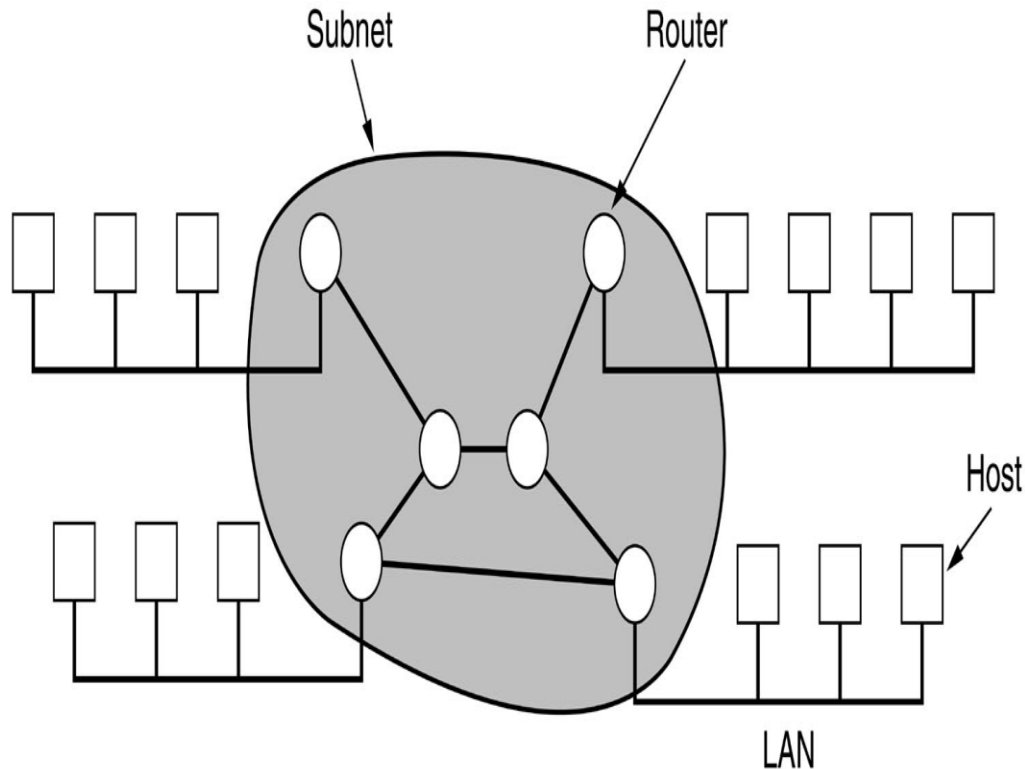
# MAN

- Similar to LAN's, cover larger areas and can be public or private.
- Can support both data and voice.
- Consists of one or two cables without any switching elements. It simplifies the design.
- Standard used-IEEE 802.6(DQDB)
- DQDB uses two unidirectional buses to which all computers are attached. Each bus has a head point that initiates transmission activity.

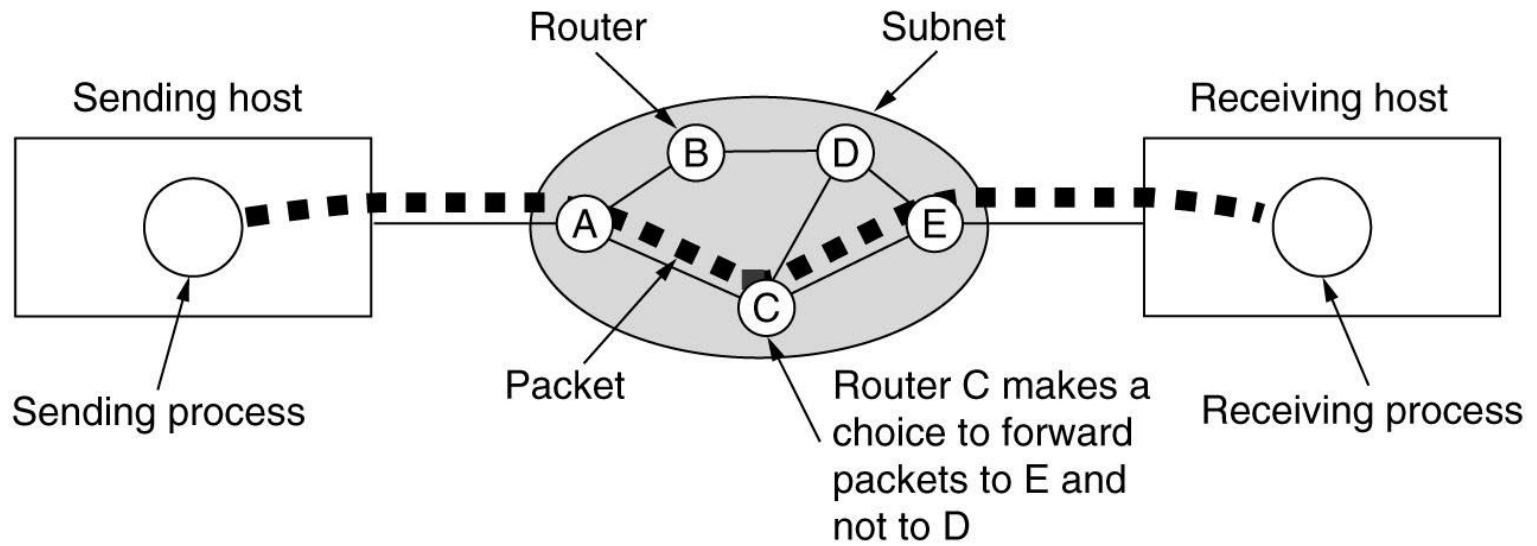
# WAN

- Spans a large geographical area.
- It consists of collection of machines intended for running user (application) programs. (Hosts or End Systems)
- Hosts are connected by a communication subnet or subnet. Subnet carries messages from host to host.
- Subnets consists of Two elements:  
Transmission lines(circuits,channels or trunks) and  
Switching elements (Packet switching nodes,  
Intermediate systems or Routers)

# WAN cont...

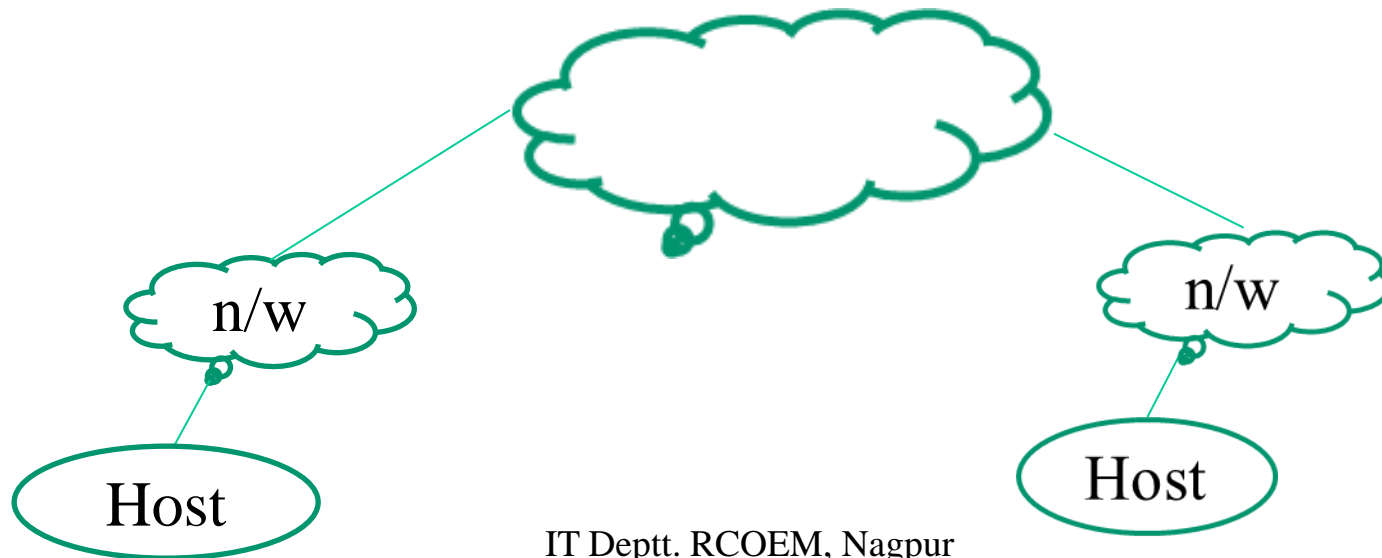


- Two routers need not have a cable between them, they can communicate via other routers.
- At a router, packet is received in its entirety, stored till the output line is free and then forwarded. Thus the subnet is called point to point, store and forward or packet switched subnet.



# Internetworks

- Different types of networks exists with differences in hardware and software.
- Important Issue: What happens if a person sitting on one network wants to communicate with another person or resource located at a radically different network?



- Hardware and software approaches are used to resolve the differences and give notion of single uniform network.
- A collection of interconnected networks is called internetwork or internet.

# Network Software

- Network is composed of hardware as well as software.
- To reduce the complexity of networking software, networks are organized as a series of layers. The number of layers, name of each layer, contents and function of each layer differ from network to network.
- Purpose of each layer is to offer certain set of services to the layers above it, shielding the implementation of these services.

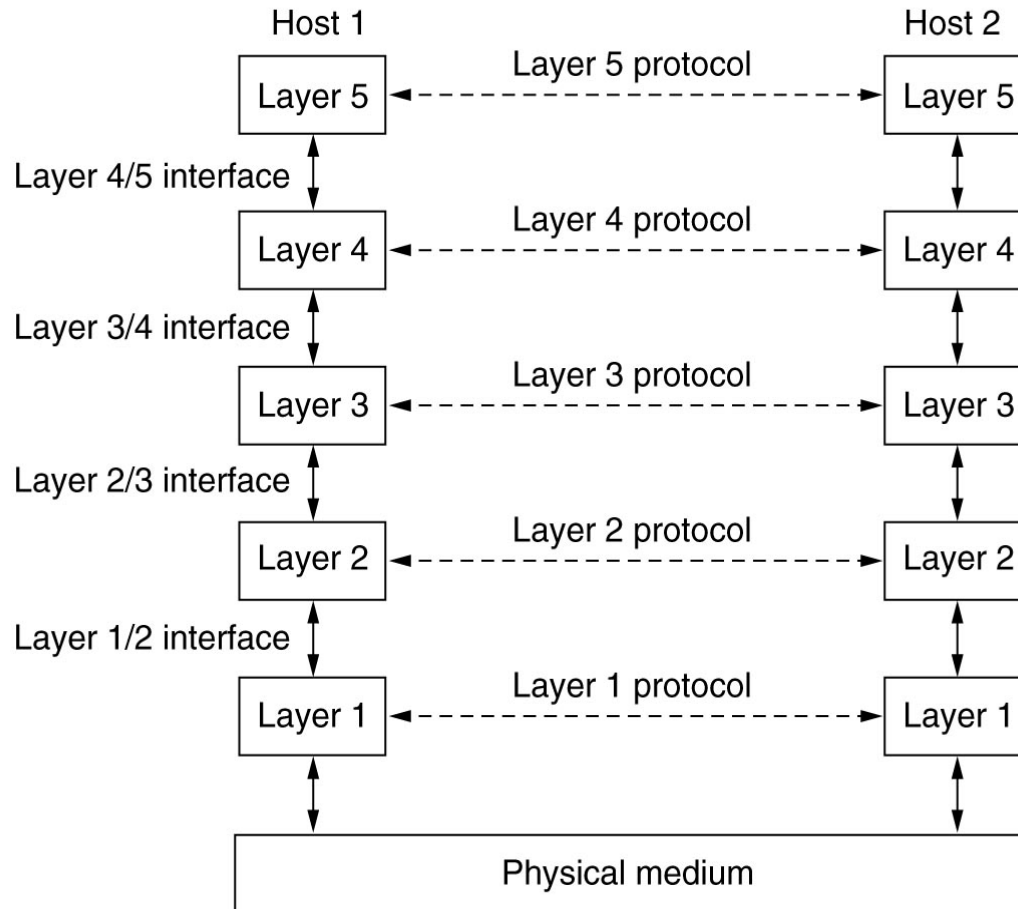


# Network Software cont...

- Layer n on one machine carries on conversation with layer n on another machine. The rules and conventions used in this conversation is called as the layer n protocol.
- The entities comprising the corresponding layers on different machines are called peers.
- It is peers that communicate using the protocol.

# Network Software cont...

- Ex-A five layer network:



# Network Software cont...

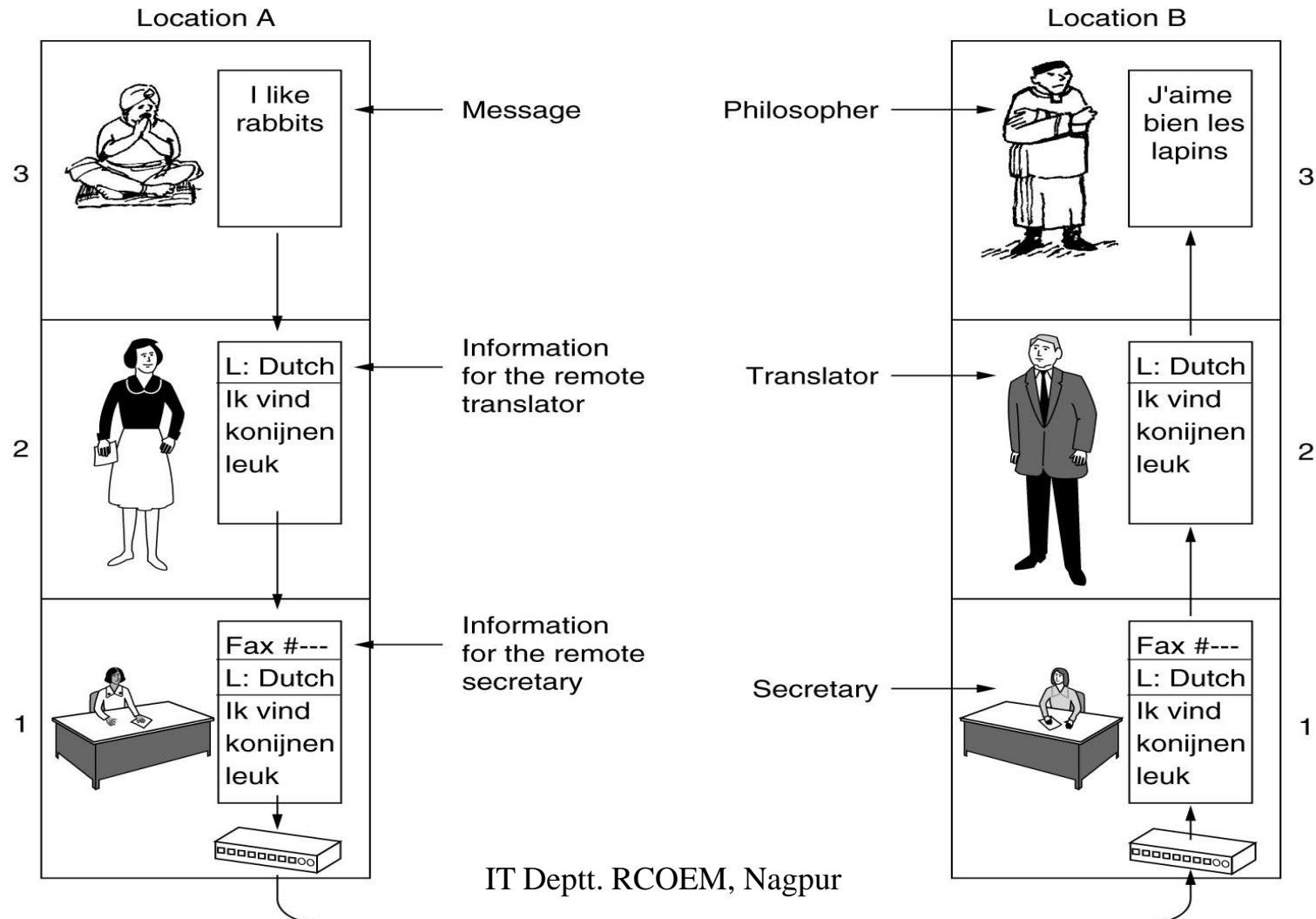
- There is no direct transfer of data from layer n on one machine to layer n on another.
- Each layer passes data and control information to the layer below it.
- Between each pair of adjacent layer there is an interface. It defines the primitive operations and services lower layer offers to layer above it.

Important consideration: clean interfaces.

- Set of layers and protocols is called Network Architecture.
- List of protocols, one per layer, is called protocol stack.

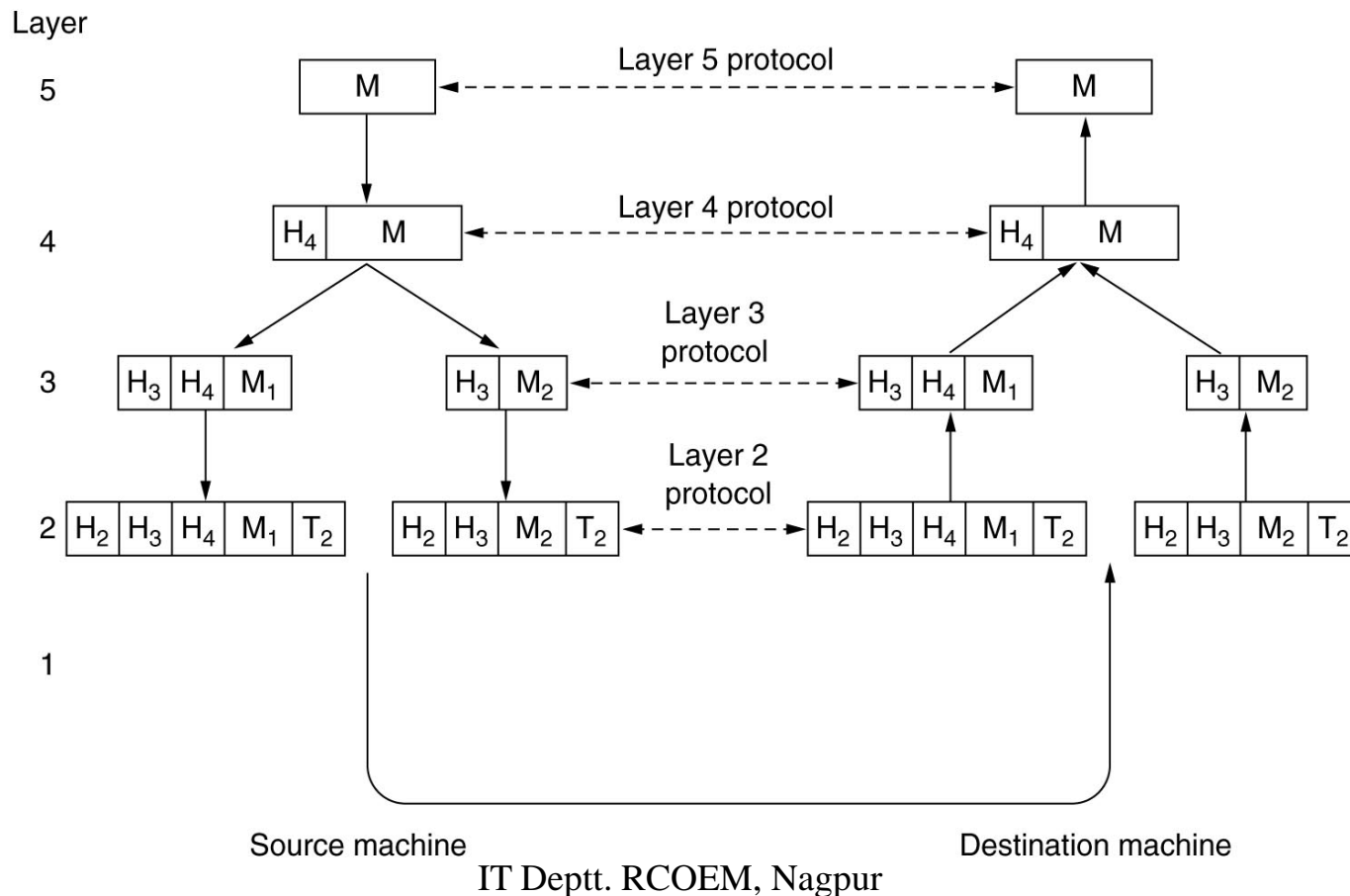
# Practical Example

- Philosopher-translator-secretary architecture



# A technical example

- How to provide communication to the top layer of the five layer network?



# Design Issues for the layers

- Each layer needs mechanism to identify senders and receivers.
- Rules for data transfer  
simplex, half duplex or full duplex.
- Enforcing error control.
- Ordering of messages.
- Handling fast sender slow receiver.
- Handling inability of processes to handle arbitrarily long messages.
- Handling connections.
- Handling multiple paths from source to destination.

# Interfaces and Services

- Each layer provides services to the layer above it. Thus service provided by layer  $n$  is used by layer  $n+1$ .

Layer  $n$  – Service provider

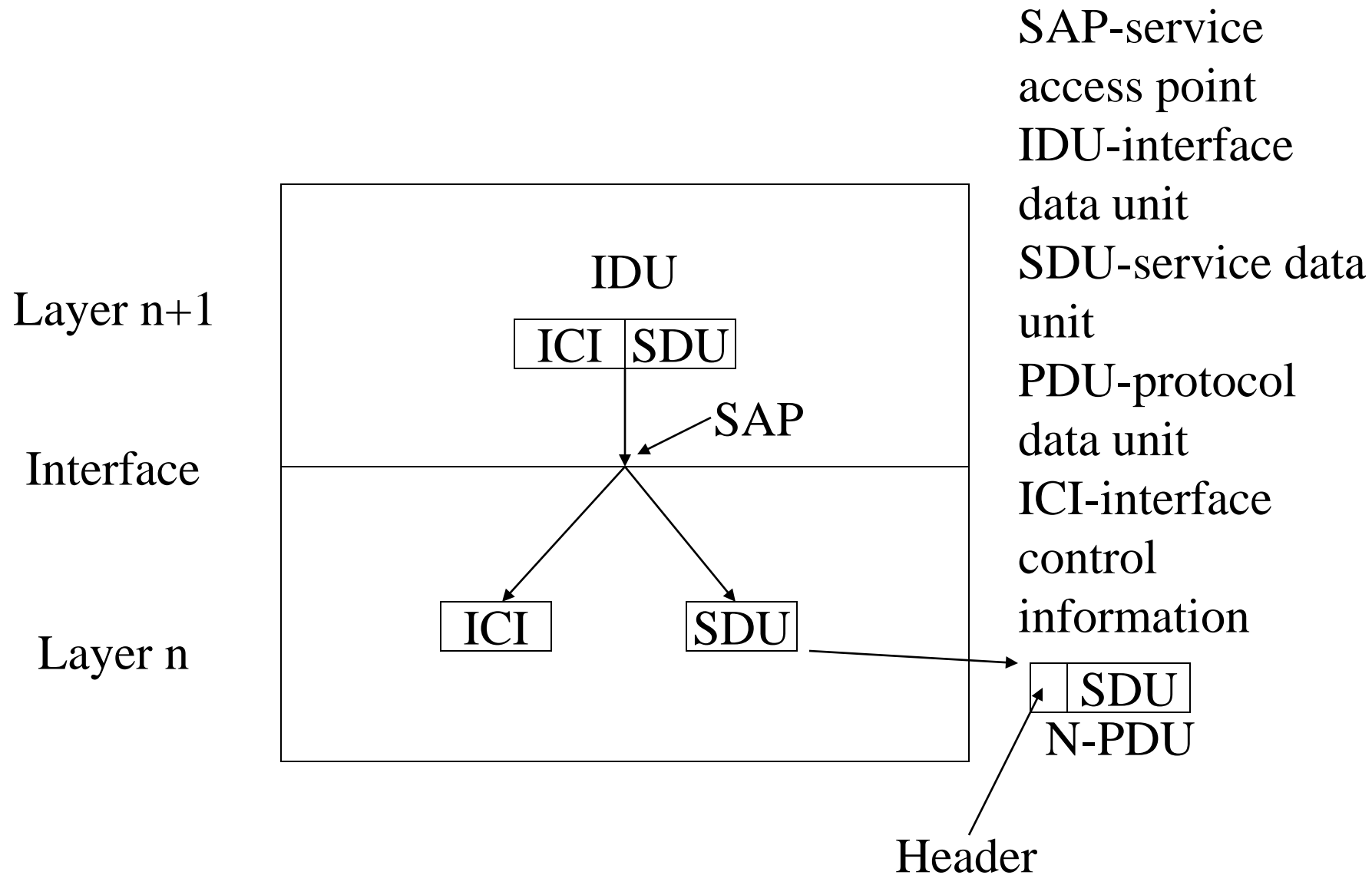
Layer  $n+1$  - Service user

- Services are available at SAP's (Service Access Points). Each SAP has an address that uniquely identifies it.

(Analogy Telephone or Postal system)

- For exchanging information across the interface, agreed upon rules are used.

# Interfaces and Services cont...





# Services

- Layers can offer two types of services to the layer above them:  
Connection oriented service and  
Connectionless service.
- Each service is characterized by Quality of Service (QoS). Quality implies reliability. Thus the two services can be reliable or unreliable. Nature of application dictates which service is desired!!!.
- Reliability is usually achieved through acknowledgements.

# Services cont...

Connection-oriented	Service	Example
	Reliable message stream	Sequence of pages
	Reliable byte stream	Remote login
Connection-less	Unreliable connection	Digitized voice
	Unreliable datagram	Electronic junk mail
	Acknowledged datagram	Registered mail
	Request-reply	Database query

# Service primitives

- A service is specified by a set of primitives.
- These primitives tell the service to perform some action or report on the action taken by a peer entity. Service primitives can be divided into four classes:

Primitives	Meaning
Request	An entity wants the service to to do some work
Indication	An entity is to be informed about an event
Response	An entity wants to respond to an event
Confirm	The response to an earlier request has come back

# Service primitives cont...

- Primitives can have parameters. For example CONNECT.request might specify machine to connect to, type of service and max. message size to be used on connection.
- Services can be confirmed (all primitives are used) or unconfirmed (only request and an indication is used).
- CONNECT is a confirmed service whereas DISCONNECT is not.

# A simple connection oriented service

- CONNECT.request
- CONNECT.indication
- CONNECT.response
- CONNECT.confirm
- DATA.request
- DATA.indication
- DISCONNECT.request
- DISCONNECT.indication

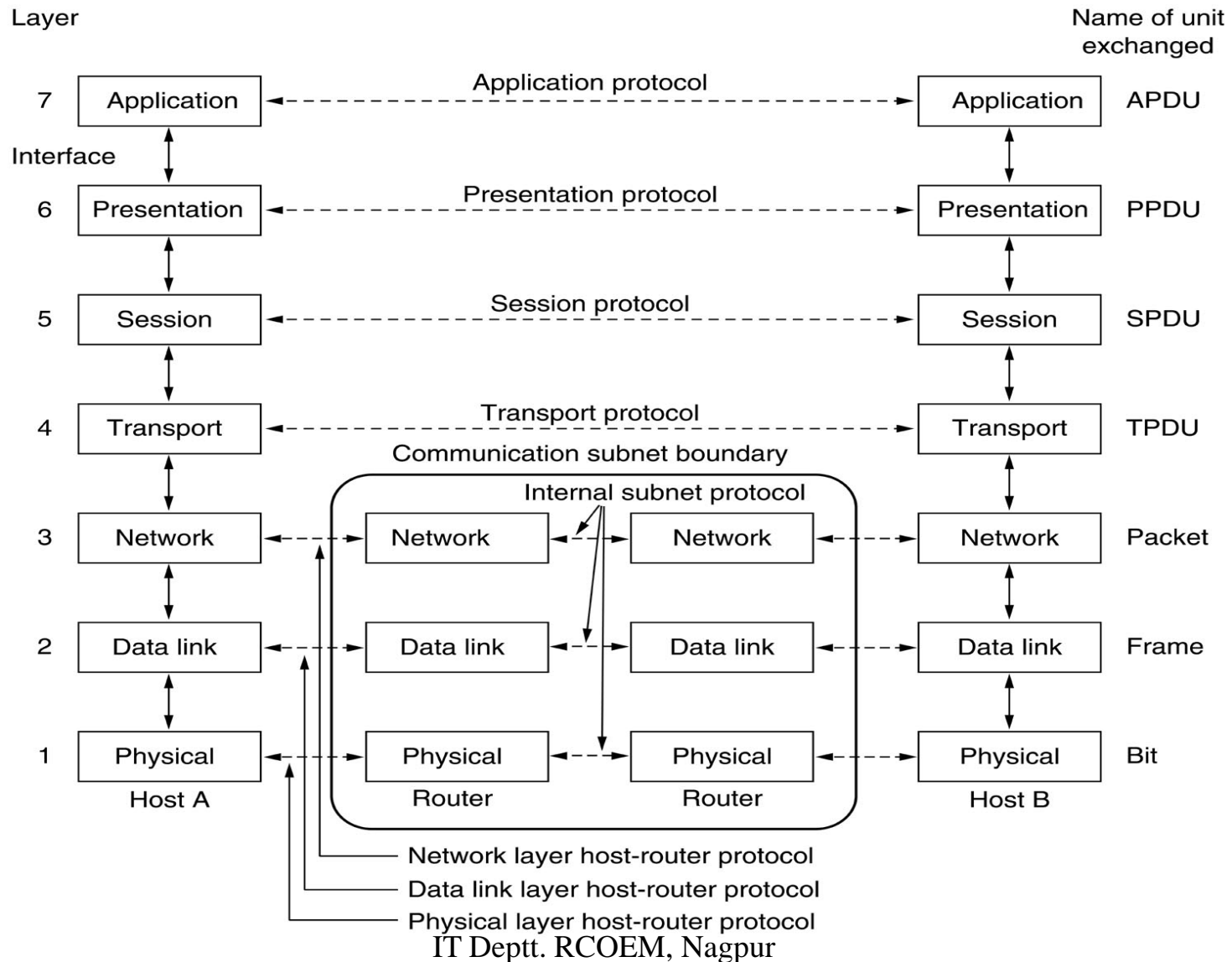
# Services and Protocols

- Service- a set of primitives that a layer provides to the layer above it. It defines what operations the layer is prepared to perform on behalf of its users, but nothing it says about how these operations are implemented. A service relates to an interface between two layers.
- Protocol- Set of rules governing the format and meaning of the frames, packets or messages exchanged by the peers within a layer. Entities use protocols to implement their service definitions.

# The ISO OSI Reference model

- OSI model itself is not a network architecture. It does not specify the exact services and protocols to be used in each layer. It just tells what each layer does.
- ISO has produced standards for all layers.
- It essentially a 7 layer model with each layer performing a well defined function.

# The OSI reference model





# Functions of each layer

- Physical layer
  - ✓ Concerned with transmission of raw data over communication channel.
  - ✓ Design issues largely deal with the electrical, mechanical and physical transmission medium.
- Data link layer
  - ✓ Create and recognize frame boundaries
  - ✓ Remove transmission errors
  - ✓ Process acknowledgements and solve the problems caused by the damaged, lost and duplication of frames.
  - ✓ Enforce flow control
  - ✓ Use MAC to control access to shared channel.

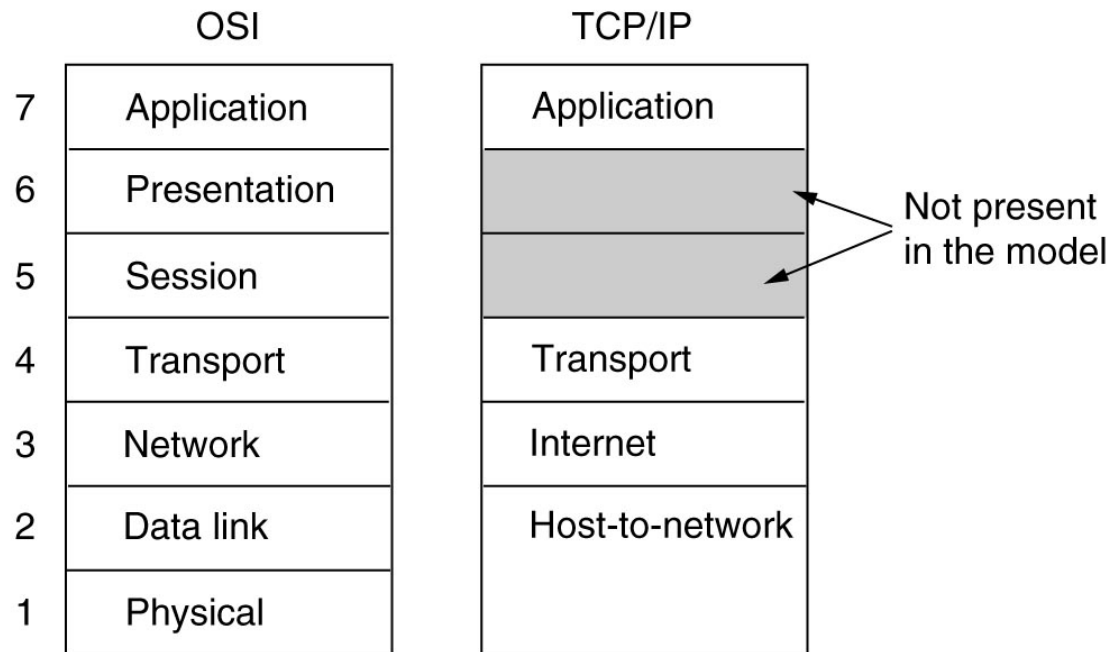
- Network layer:
  - ✓ Concerned with controlling the operation of subnet.
  - ✓ Design issues largely deal with routing of packets from source to destination.
  - ✓ Handles congestion control.
  - ✓ Implements accounting function.
  - ✓ Handles heterogeneity of networks
  - ✓ Note : In broadcast networks, routing problem is simple so this layer is non existent.

- Transport layer:
  - ✓ Creates network connections, one for each transport connection requested by session layer.
  - ✓ Multiple connections may be created to improve the throughput or may multiplex several transport connections to a single network connection to reduce the cost.
  - ✓ Also determines type of service provided. Type of service is determined when the connection is established.
  - ✓ It's a true end to end layer from source to destination.

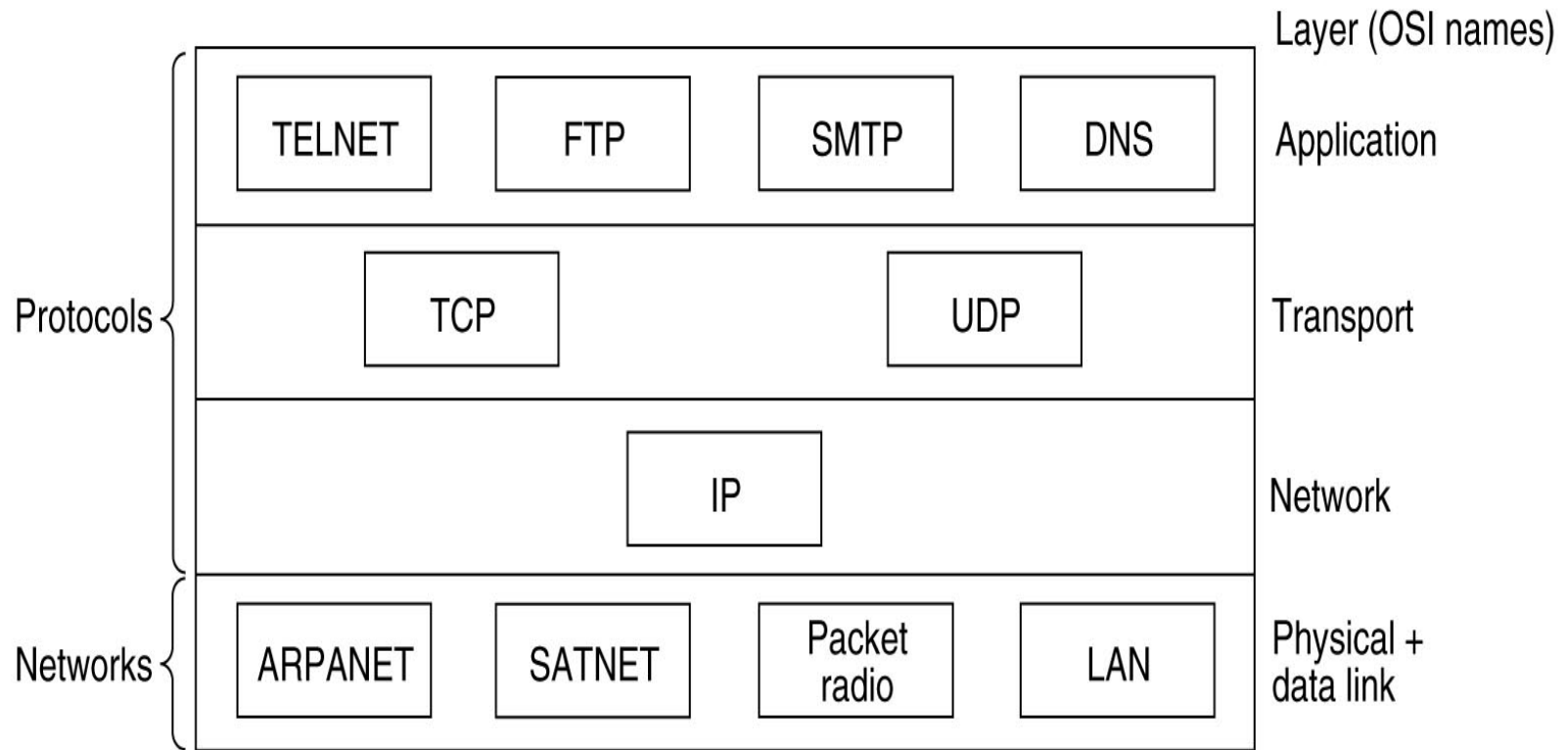
- Session layer:
  - ✓ Allows users on different machines to establish sessions between them.
  - ✓ Apart from data transport, it provides enhanced services useful in some applications. Ex. Logging on to a remote timesharing system.
  - ✓ Manages Dialogue control, Token management and Synchronization.
- Presentation layer:
  - ✓ Concerned with syntax and semantics of the information transmitted.
- Application layer:
  - ✓ It contains many protocols which are commonly needed.
  - ✓ Ex. Network virtual terminal, File transfer, E-mail, Directory look up etc.

# TCP/IP Reference model

- Successor of ARPNET.
- Aim: Communication between heterogeneous networks.



# Protocols and Networks in TCP/IP model initially



# Comparison of OSI and TCP/IP models

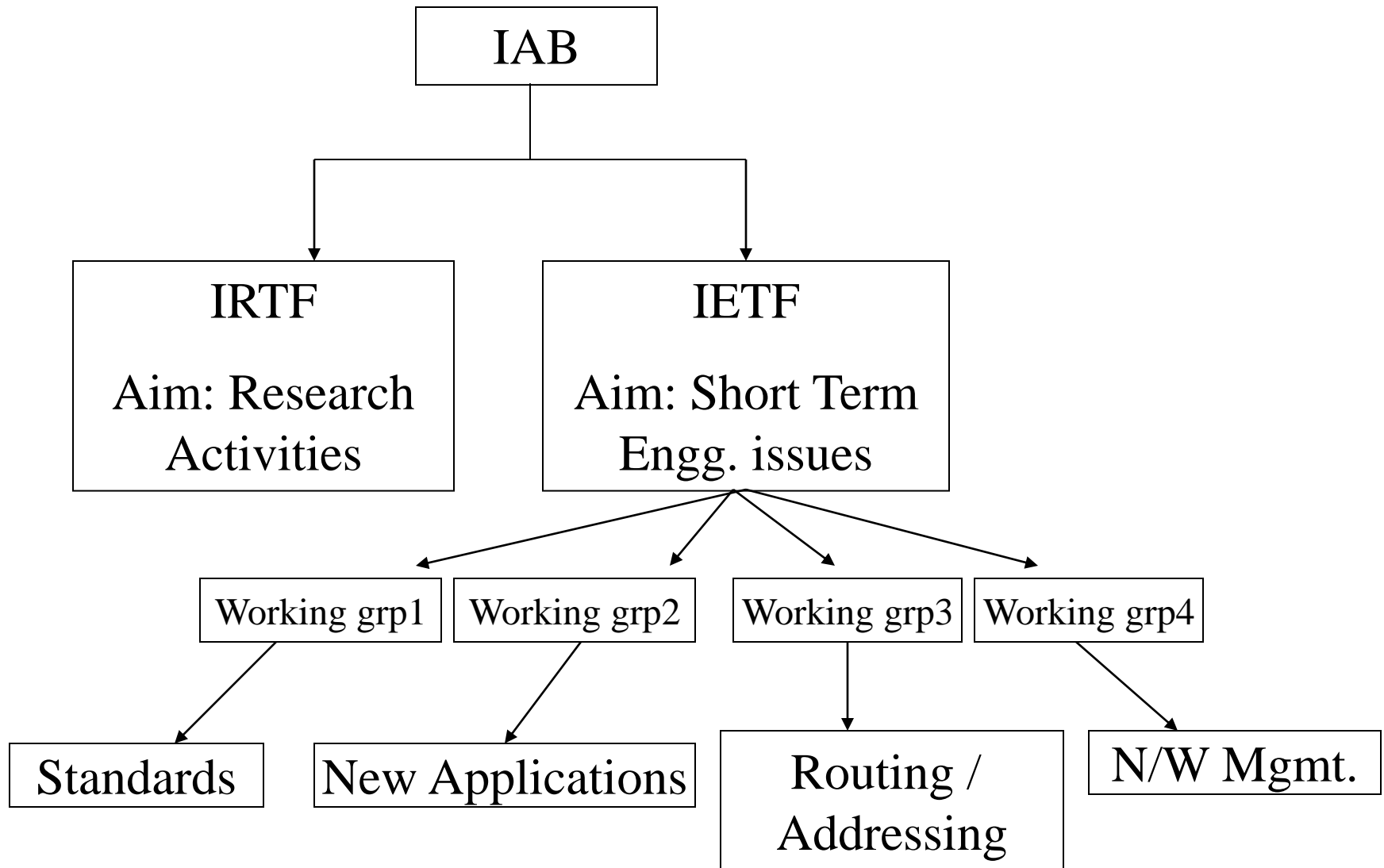
- In OSI model was devised before the protocols. Reverse is true for TCP/IP.
- Number of layers are less in TCP/IP(04).
- OSI model supports connectionless and connection oriented communication in the network layer but only connection oriented communication in transport layer. In case of TCP/IP model the network layer supports only one mode (connectionless) but supports both modes in transport layer.

# Internet Standards World

- Apex body: IAB (Internet Architecture Board)
- Initially called as Internet Activities Board  
(committee to overlook the activities of ARPNET consisting of 10 members and most of the implementations done by students)
- Technical reports on the recommendations are available in the form of RFC's
- In 1989 Internet Activities Board was reorganized



# Internet Architecture Board



- To become a standard an idea needs to go through the following steps:
  - ✓ Must be explained in RFC and have sufficient interest in the community
  - ✓ Working implementation has to be thoroughly tested at two different site for 4 months to become a draft standard
  - ✓ If the IAB is convinced that the idea is sound and the software works, it can declare the RFC to be an Internet standard