Basic Networking Concepts

1. Introduction
2. Protocols
3. Protocol Layers
4. Network Interconnection/Internet

1. Introduction

-A network can be defined as a group of computers and other devices connected in some ways so as to be able to exchange data.

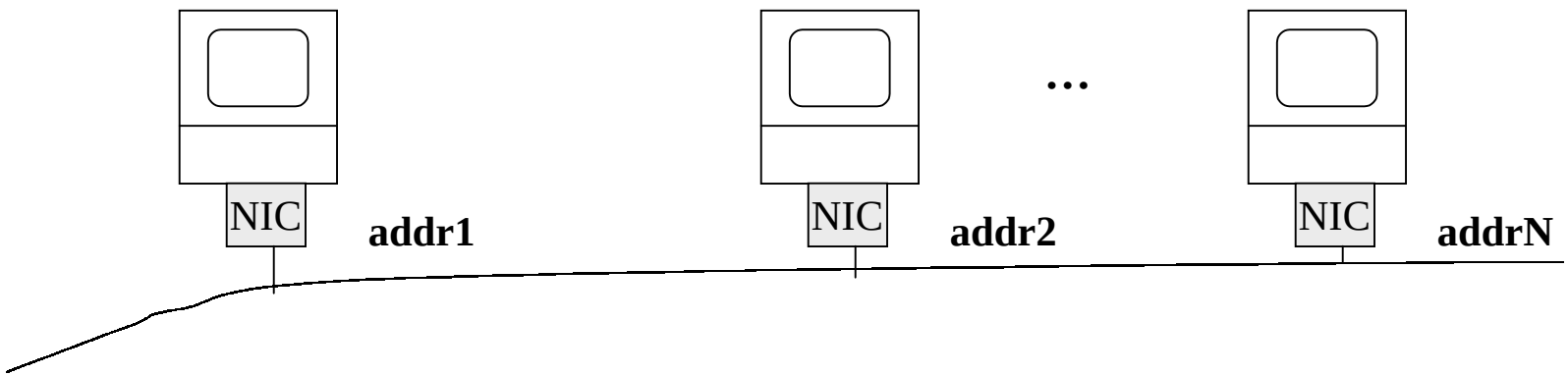
-Each of the devices on the network can be thought of as a node; each node has a unique address.

-Addresses are numeric quantities that are easy for computers to work with, but not for humans to remember.

Example: 204.160.241.98

-Some networks also provide names that humans can more easily remember than numbers.

Example: www.javasoft.com, corresponding to the above numeric address.



Addressing

Internet address

Consists of 4 bytes separated by periods

Example: 136.102.233.49

-The R first bytes (R= 1,2,3) correspond to the network address;

-The remaining H bytes (H = 3,2,1) are used for the host machine.

-**InterNIC Register**: organization in charge of the allocation of the address ranges corresponding to networks.

-Criteria considered:

→ Geographical area (country)

→ Organization, enterprise

→ Department

→ Host

Domain Name System (DNS)

-Mnemonic textual addresses are provided to facilitate the manipulation of internet addresses.

-DNS servers are responsible for translating mnemonic textual Internet addresses into hard numeric Internet addresses.

Ports

-An IP address identifies a host machine on the Internet.

-An IP port will identify a specific application running on an Internet host machine.

-A port is identified by a number, the *port number*.

-The number of ports is not functionally limited, in contrast to serial communications where only 4 ports are allowed.

-There are some port numbers which are dedicated for specific applications.

Applications	**Port numbers**
HTTP	80
FTP	20 and 21
Gopher	70
SMTP (e-mail)	25
POP3 (e-mail)	110
Telnet	23
Finger	79

Data Transmission

-In modern networks, data are transferred using *packet switching*.

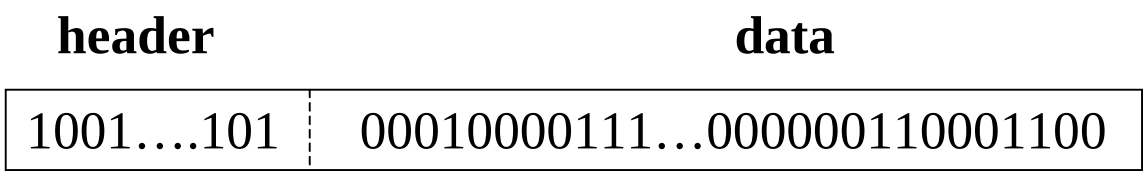
-Messages are broken into units called *packets*, and sent from one computer to the other.

-At the destination, data are extracted from one or more packets and used to reconstruct the original message.

-Each packet has a maximum size, and consists of a header and a data area.

-The header contains the addresses of the source and destination computers and sequencing information necessary to reassemble the message at the destination.

packet



Types of Networks

There are two principle kinds of networks: Wide Area Networks (WANs) and Local Area Networks (LANs).

WANs

-Cover cities, countries, and continents.

-Based on *packet switching* technology

-Examples of WAN technology: Asynchronous Transfer Mode (ATM), Integrated Services Digital Network (ISDN)

LANs

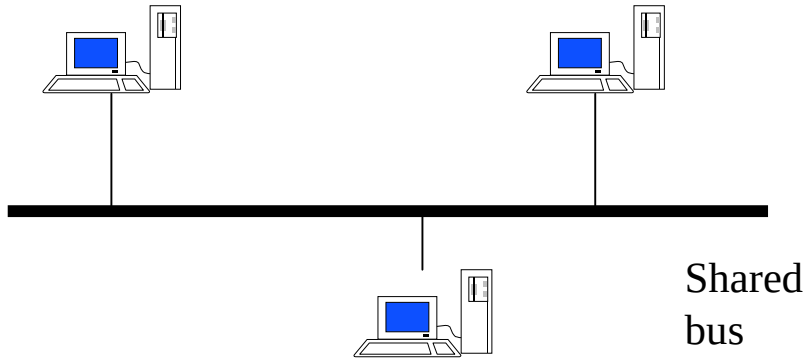
-Cover buildings or a set of closely related buildings.

-Examples of LAN technology: Ethernet, Token Ring, and Fibber Distributed Data Interconnect (FDDI).

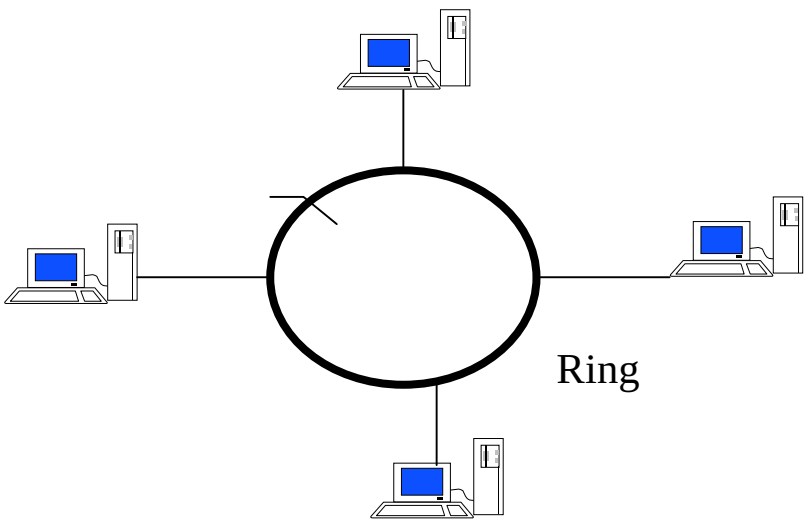
Ethernet LANs: based on a bus topology and broadcast communication

Token ring LANs: based on ring topology

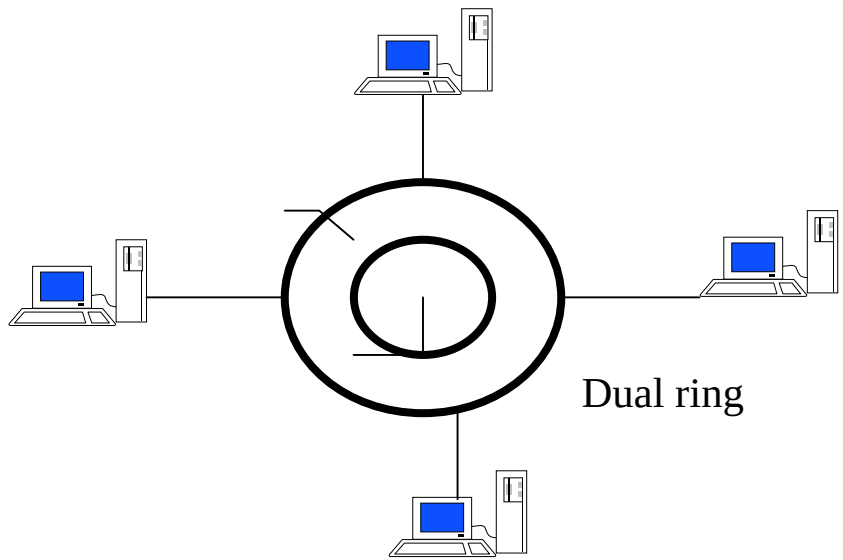
FDDI LANs: use optical fibbers and an improved token ring mechanism based on two rings flowing in opposite directions.



(a) Ethernet LAN



(b) Token Ring LAN



(c) FDDI LAN

Network connectivity type	Speed	Transmission time for 10 Mbytes
(Telephone) dial-up modem	14.4 Kbps	90 min
ISDN modem	56/128 Kbps	45/12min
T1 connection	1.54 Mbps	50s
Ethernet	10 Mbps	9s
Token ring	4/16 Mbps	
Fast Ethernet	100 Mbps	
FDDI	100 Mbps	
Gigabit Ethernet	1 Gbps	
ATM	25Mbps/2.4Gbs	

Interconnection

-Networks of low capacity may be connected together via a *backbone* network which is a network of high capacity such as a FDDI network, a WAN network etc.

-LANs and WANs can be interconnected via T1 or T3 digital leased lines

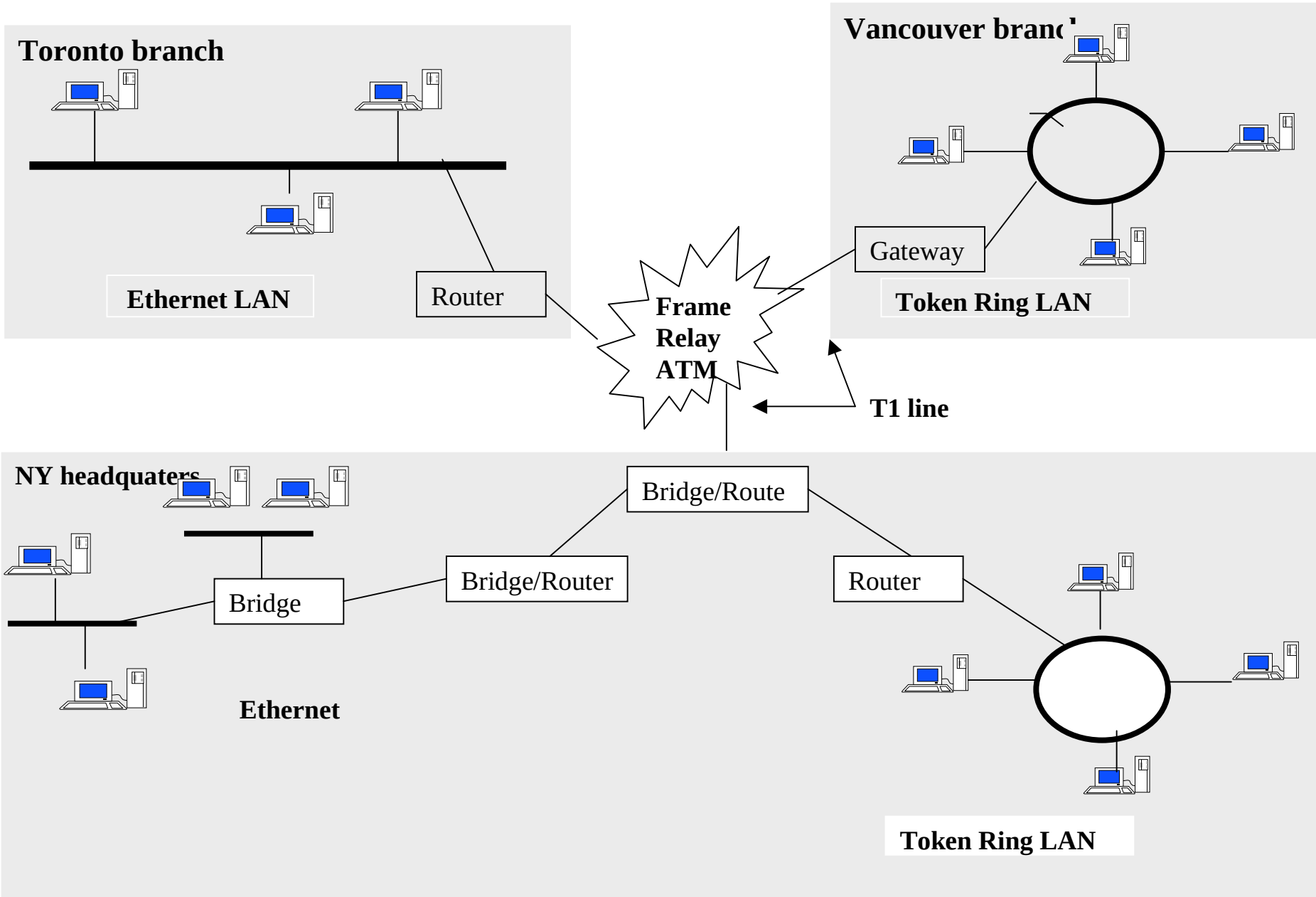
-According to the protocols involved, networks interconnection is achieved using one or several of the following devices:

→*Bridge:* a computer or device that links two similar LANs based on the same protocol.

→ *Router:* a communication computer that connects different types of networks using different protocols.

→ *B-router or Bridge/Router:* a single device that combines both the functions of bridge and router.

→ *Gateway:* a network device that connects two different systems, using direct and systematic translation between protocols.


Toronto branch
Ethernet LAN
Router
Frame
Relay
ATM
T1 line
Gateway
Token Ring LAN
NY headquaters
Bridge
Bridge/Router
Bridge/Route
Router
Ethernet
Token Ring LAN

Network Topology Diagram

The specification of the network topology diagram requires the definition of the characteristics and entities underlying the network:

-Geographical locations of the different components or subnets involved in the network.

-Description of the LAN topology

-Description of the WAN topology

-Description of the network connectors such as routers, bridges, repeaters, and gateways.

2. Protocols

-Define the rules that govern the communications between two computers connected to the network.

-Roles: addressing and routing of messages, error detection and recovery, sequence and flow controls etc.

-A protocol specification consists of the *syntax*, which defines the kinds and formats of the messages exchanged, and the *semantic*, which specifies the action taken by each entity when specific events occur.

Example: HTTP protocol for communication between web browsers and servers.

Request For Comments (RFC): specifications of the protocols involved in Internet Communications.

-Example: sample of RFC 821 describing communications between SMTP server and client.

S: MAIL FROM: Paul@Alpha.ARPA
R: 250 OK

S: RCPT TO: Jack@Beta.ARPA
R: 250 OK

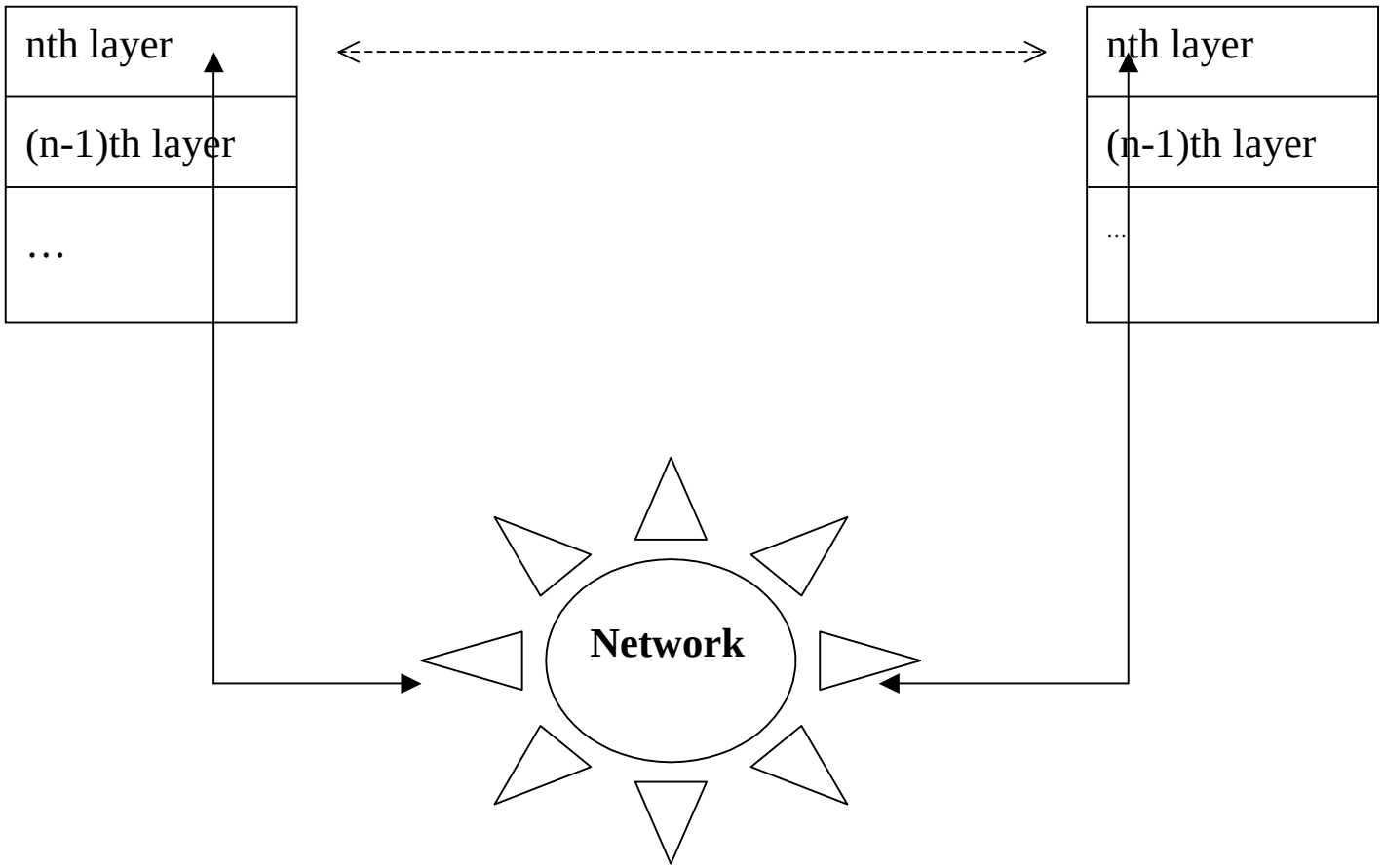
S: DATA
R: 354 Beginning of mail; ending by <*CRLF*>.<*CRLF*>

S: Blah blah blah
S: …etc.
S: <CRLF>.<CRLF>
R: 250 OK

-Protocols are designed based on a layered architecture such as the OSI reference model.

-Each entity at a layer *n* communicates only with entities at layer *n-1*.

-The data exchanged, known as Protocol Data Unit (PDU), goes back and forth through the layers, each layer adds or removes its own header and vice-versa. Therefore a layer *n* PDU may become a layer *n-1* data.



3. Protocol Layers

The OSI (Open Systems Interconnection) Data Model

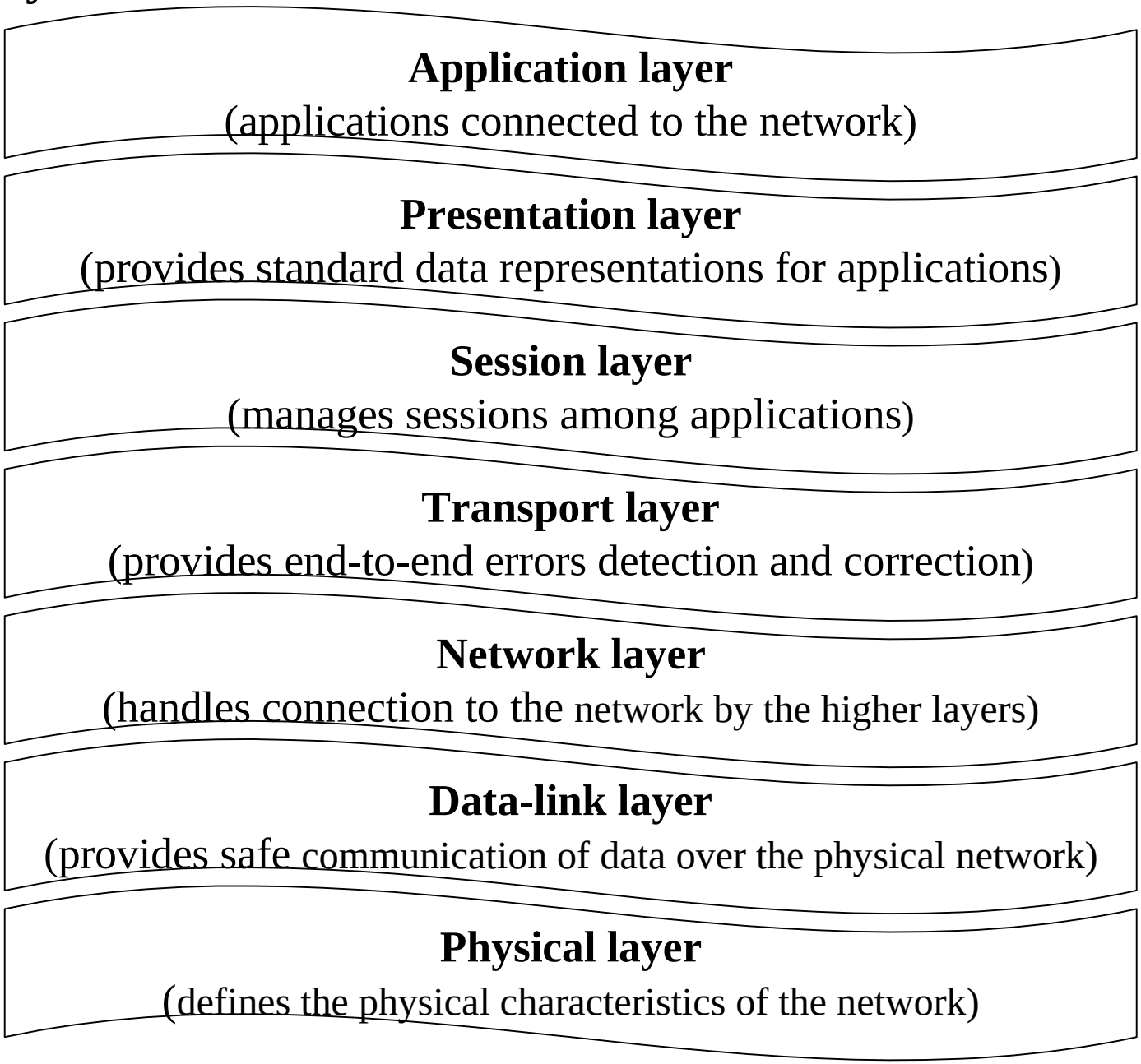
-ISO standard for computer networks design and functioning.

-Involves at least 7 layers, each playing a specific role when applications are communicating over the net.

-During the sending process, each layer (from top to down) will add a specific header to the raw data.

-At the reception, headers are eliminated conversely until the data arrived to the receiving application.

OSI Layers


Application layer
(applications connected to the network)
Presentation layer
(provides standard data representations for applications)
Session layer
(manages sessions among applications)
Transport layer
(provides end-to-end errors detection and correction)
Network layer
(handles connection to the network by the higher layers)
Data-link layer
(provides safe communication of data over the physical network)
Physical layer
(defines the physical characteristics of the network)

Physical layer: ensures a safe and efficient travel of data; consists of electronic circuits for data transmission etc.

Data link layer: in charge of data encapsulation under the form of packets and their interpretation at the physical layer.

Network layer: in charge of packets transmission from a source A to a destination B.

Transport layer: in charge of the delivery of packets from a source A to a destination B

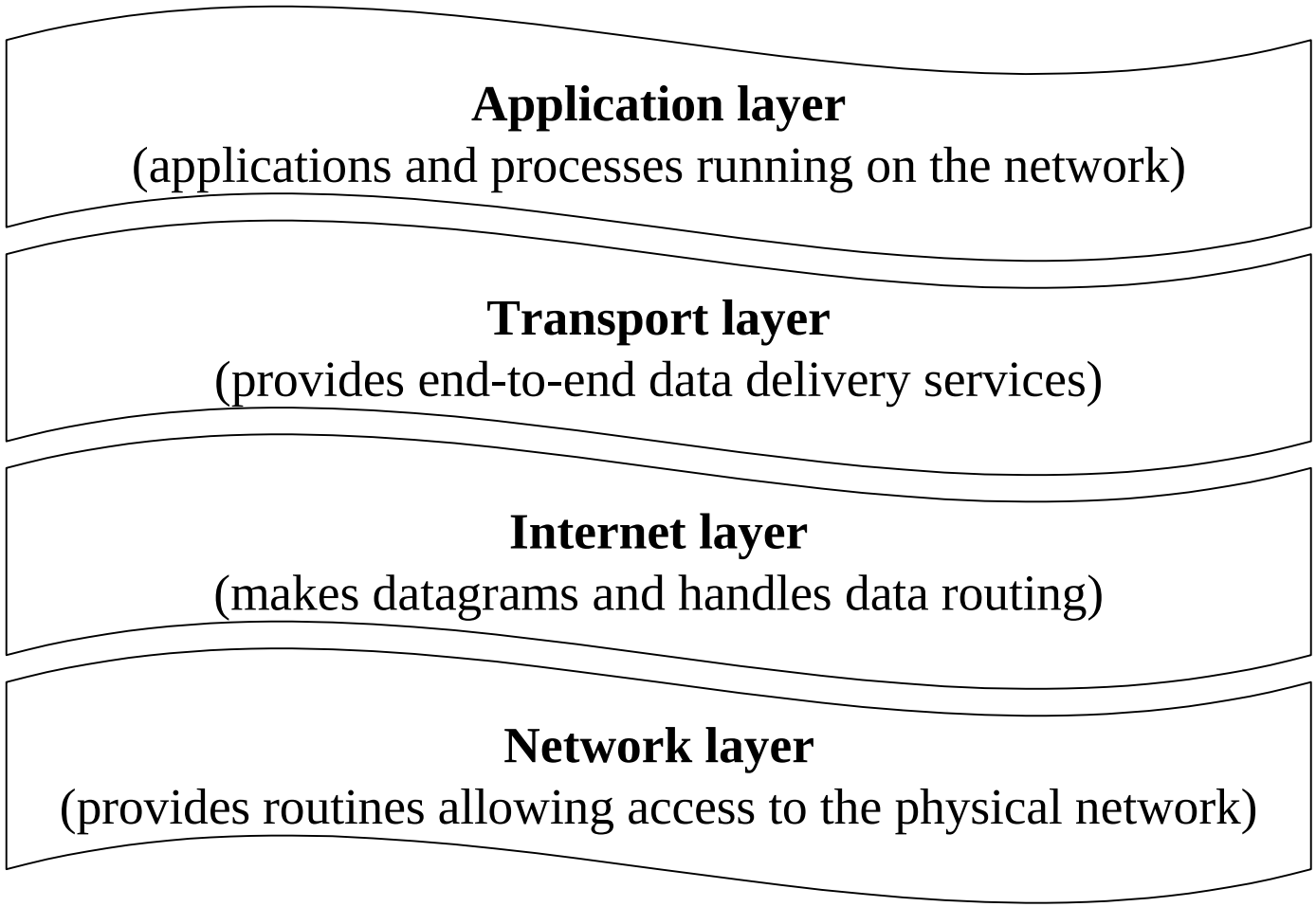
Session layer: in charge of the management of network access.
Presentation layer: determines the format of the data transmitted to applications, data compressing/decompressing, encrypting etc.

Application layer: contains the applications which are used by the end-user, such as Java, Word etc.

The TCP/IP Model

-Consists of only 4 layers: application, transport, internet and network.

Layers



Network layer

-Provides the same functionality as the physical, the data link and network layers in the OSI model.

-Mapping between IP addresses and network physical addresses.

-Encapsulation of IP datagrams, e.g packets, in format understandable by the network.

Internet layer

-Lies at the heart of TCP/IP.

-Based on the Internet Protocol (IP), which provides the frame for transmitting data from place *A* to place *B*.

Transport layer

-Based on two main protocols: TCP (Transmission Control Protocol) and UDP (User Datagram protocol)

Application layer

-Combines the functions of the OSI application, presentation, and session layers.

-Protocols involved in this layer: HTTP, FTP, SMTP etc.

4. Networks Interconnection/Internet

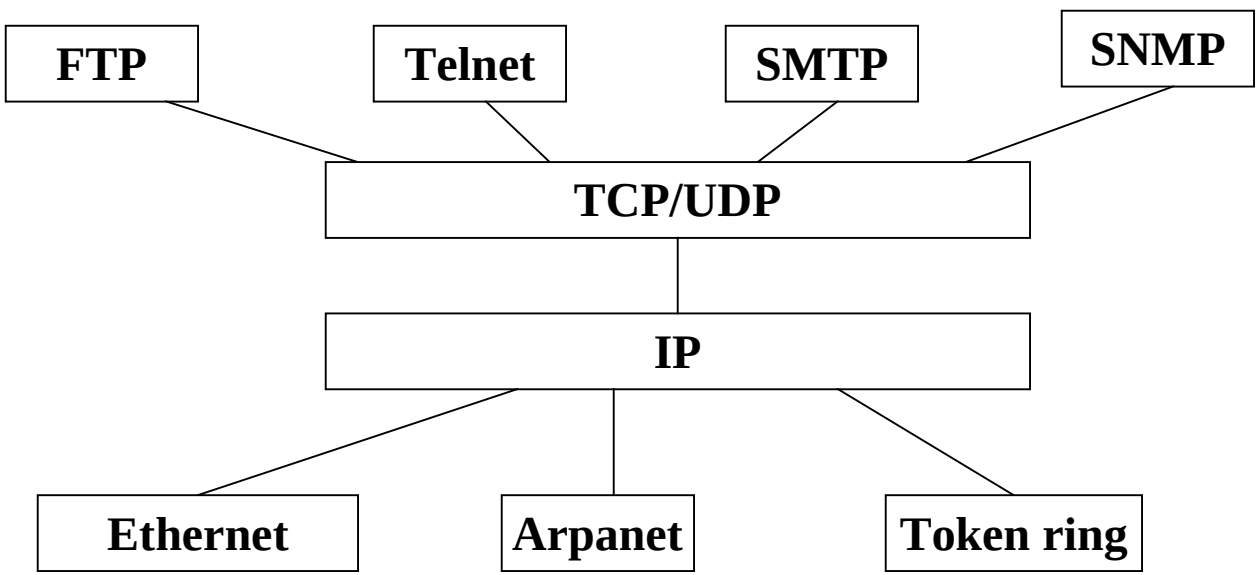
Concept of Network Interconnection

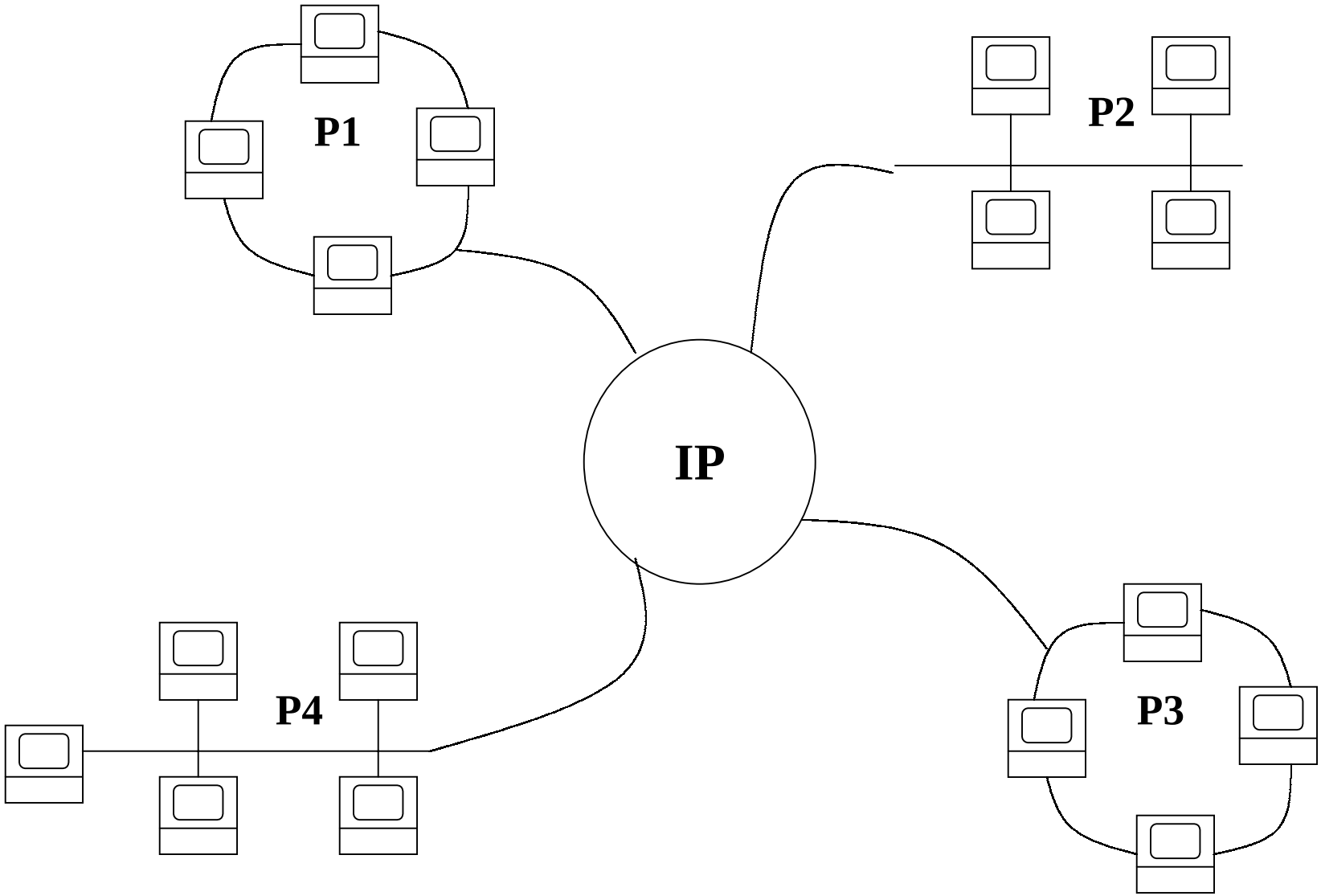
-First implemented in the Defense Advanced Research Project Agency Network (Arpanet), in 1966 in USA.

-Consists of connecting several computer networks based on different protocols

-Requires the definition of a common interconnection protocol on top the local protocols.

-The *Internet Protocol (IP)* plays this role, by defining unique addresses for a network and a host machine.




P1
P2
IP
P4
P3

Internet Protocol (IP)

Overview

-The IP protocol provides two main functionality:

→Decomposition of the initial information flow into packets of standardized size, and reassembling at the destination.

→Routing of a packet through successive networks, from the source machine to the destination identified by its IP address.

-Transmitted packets are not guaranteed to be delivered (*datagram protocol).*

-The IP protocol does not request for connection (*connectionless*) before sending data and does not make any error detection.

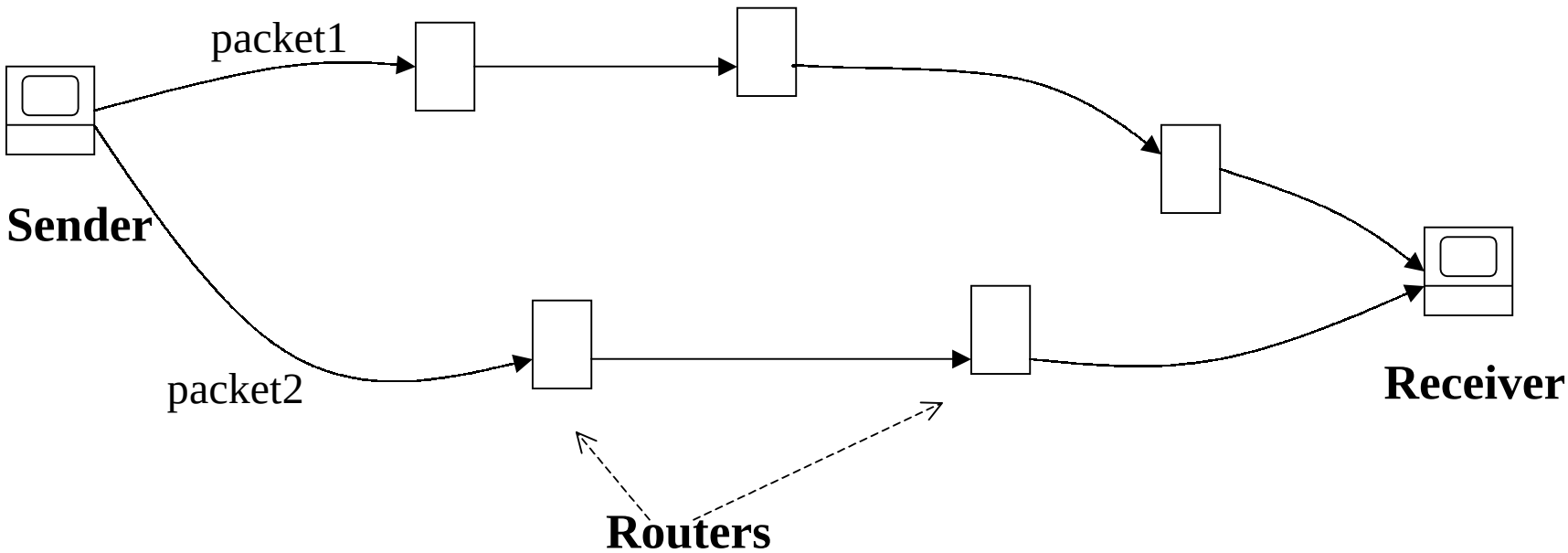
Functions

-Decompose the initial data (to be sent) into datagrams.

-Each datagram will have a header including, the IP address and the port number of the destination.

-Datagrams are then sent to selected gateways, e.g IP routers, connected at the same time to the local network and to an IP service provider network.

-Datagrams are transferred from gateways to gateways until they arrived at their final destination.



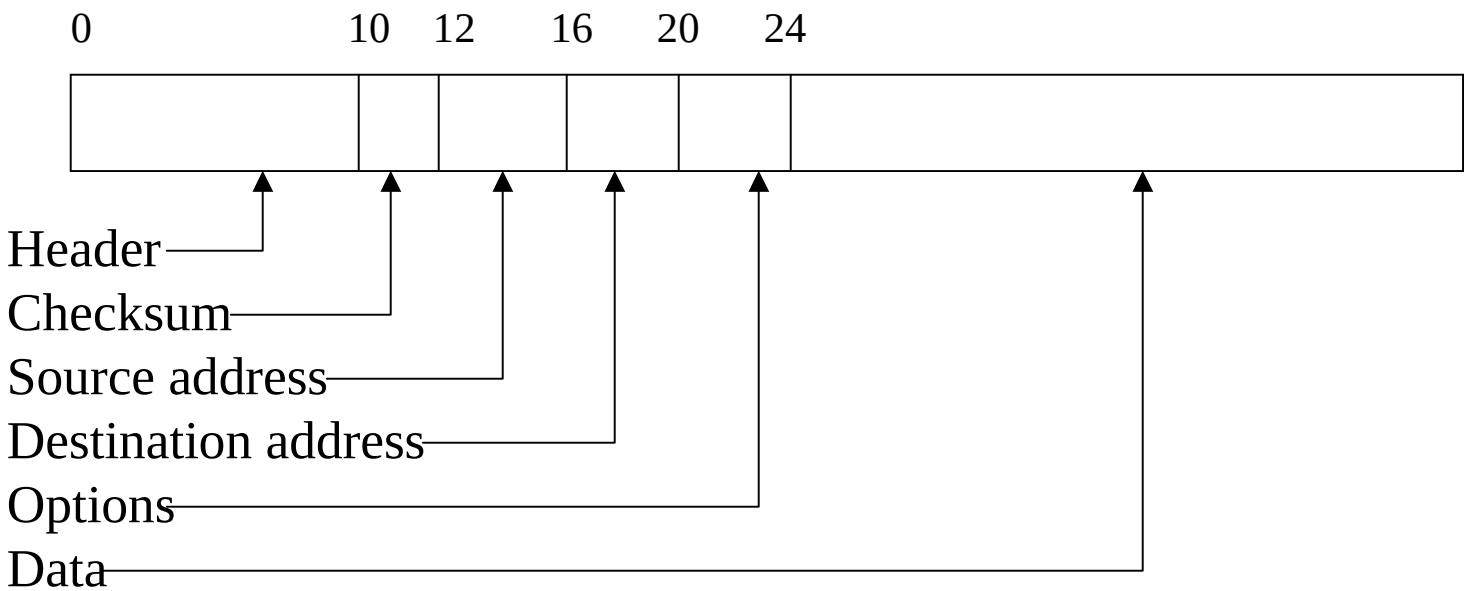
Structure of an IP packet

-The fields at the beginning of the packet, called the frame header, define the IP protocol's functionality and limitations.

-32 bits are allocated for encoding source and destination addresses (32 bits for each of these address fields).

-The remainder of the header (16 bits) encodes various information such as the total packet length in bytes.

-Hence an IP packet can be a maximum of 64Kb long.



Transmission Control Protocol (TCP)

Overview

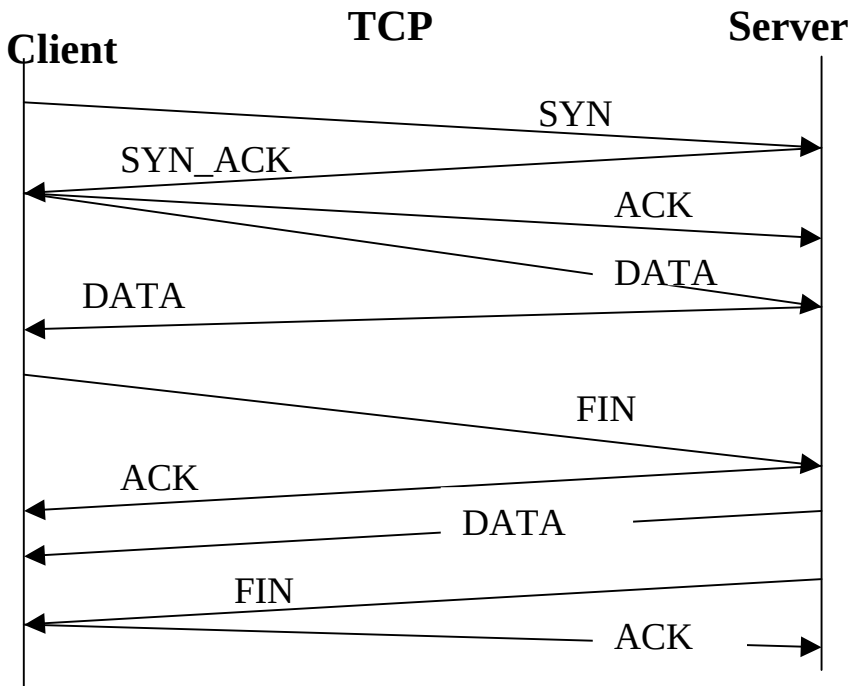
-TCP provides by using IP packets a basic service that does guarantee safe delivery:

→error detection

→safe data transmission

→assurance that data are received in the correct order

-Before sending data, TCP requires that the computers communicating establish a connection (*connection-oriented protocol*).



-TCP provides support for sending and receiving arbitrary amounts of data as one big stream of byte data (IP is limited to 64Kb).

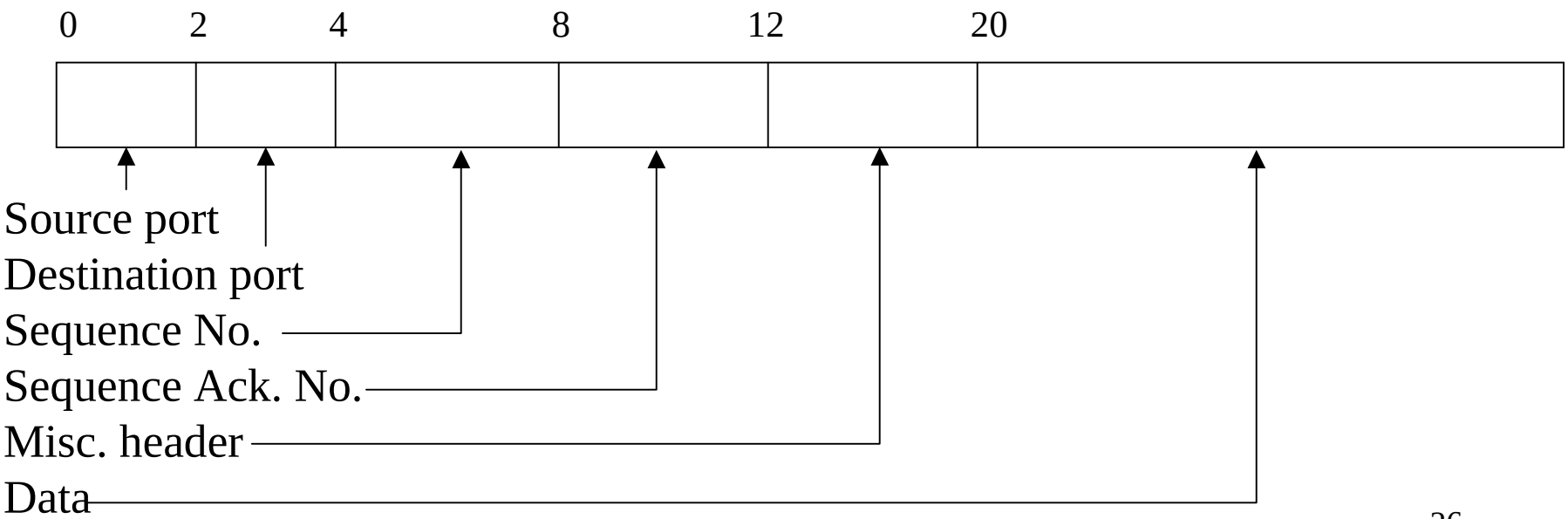
-TCP does so by breaking up the data stream into separate IP packets.

-Packets are numbered, and reassembled on arrival, using sequence and sequence acknowledge numbers.

-TCP also improves the capability of IP by specifying port numbers.

→ There are 65,536 different TCP ports (sockets) through which every TCP/IP machine can talk.

Structure of a TCP packet



User Datagram Protocol (UDP)

Overview

-Datagram protocol also built on top of IP.

-Has the same packet-size limit (64Kb) as IP, but allows for port number specification.

-Provides also 65,536 different ports.

-Hence, every machine has two sets of 65,536 ports: one for TCP and the other for UDP.

-Connectionless protocol, without any error detection facility.

-Provides only support for data transmission from one end to the other, without any further verification.

-The main interest of UDP is that since it does not make further verification, it is very fast.

-Useful for sending small size data in a repetitive way such as time information.

4.5 Internet Application Protocols

On top of TCP/IP, several services have been developed in order to homogenize applications of same nature:

-**FTP** (File Transfer Protocol) allows the transfer of collection of files between two machines connected to the Internet.

-**Telnet** (Terminal Protocol) allows a user to connect to a remote host in terminal mode.

-**NNTP** (Network News Transfer Protocol) allows the constitution of communication groups (newsgroups) organized around specific topics.

-**SMTP** (Simple Mail Transfer Protocol) defines a basic service for electronic mails.

-**SNMP** (Simple Network Management Protocol) allows the management of the network.