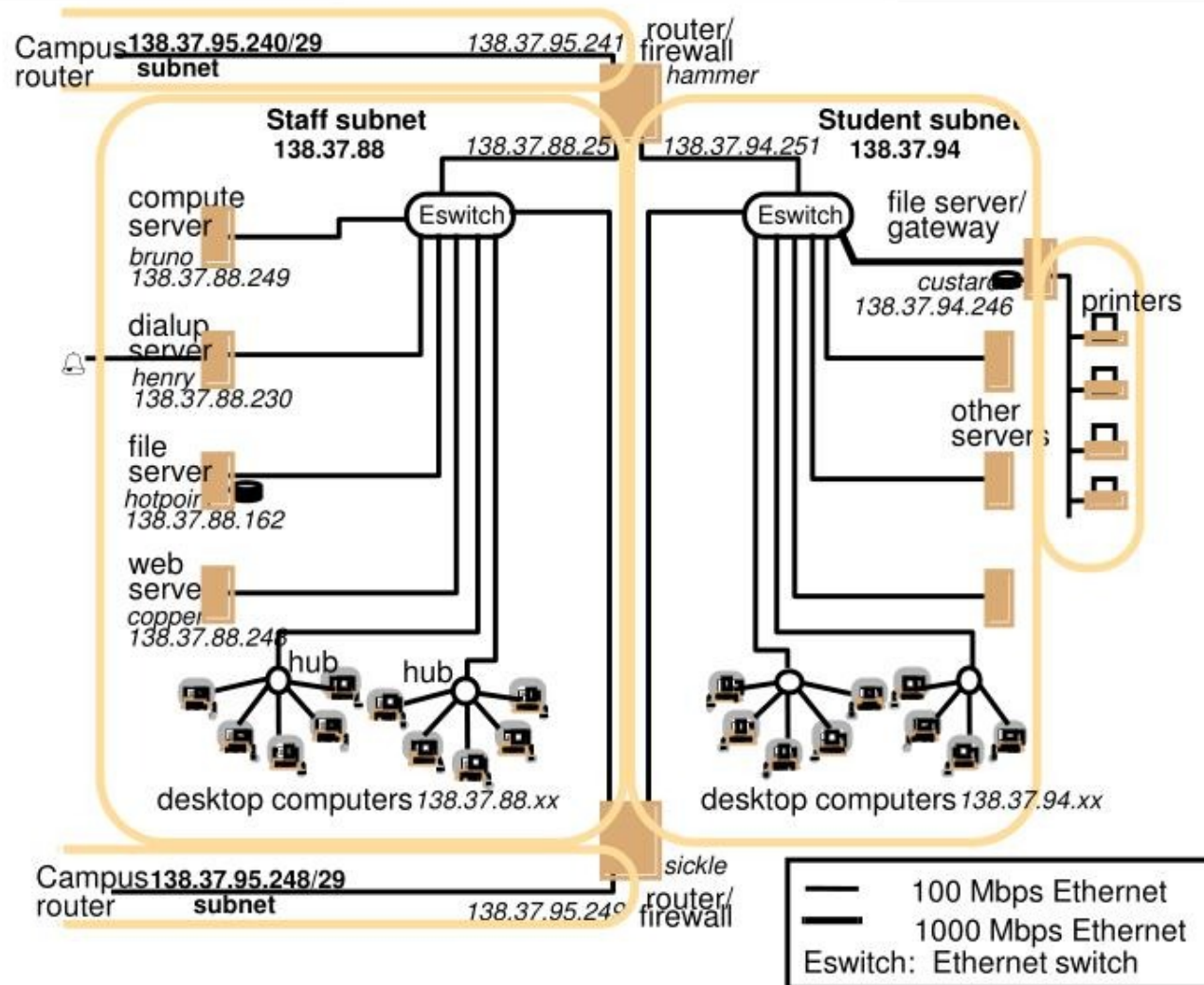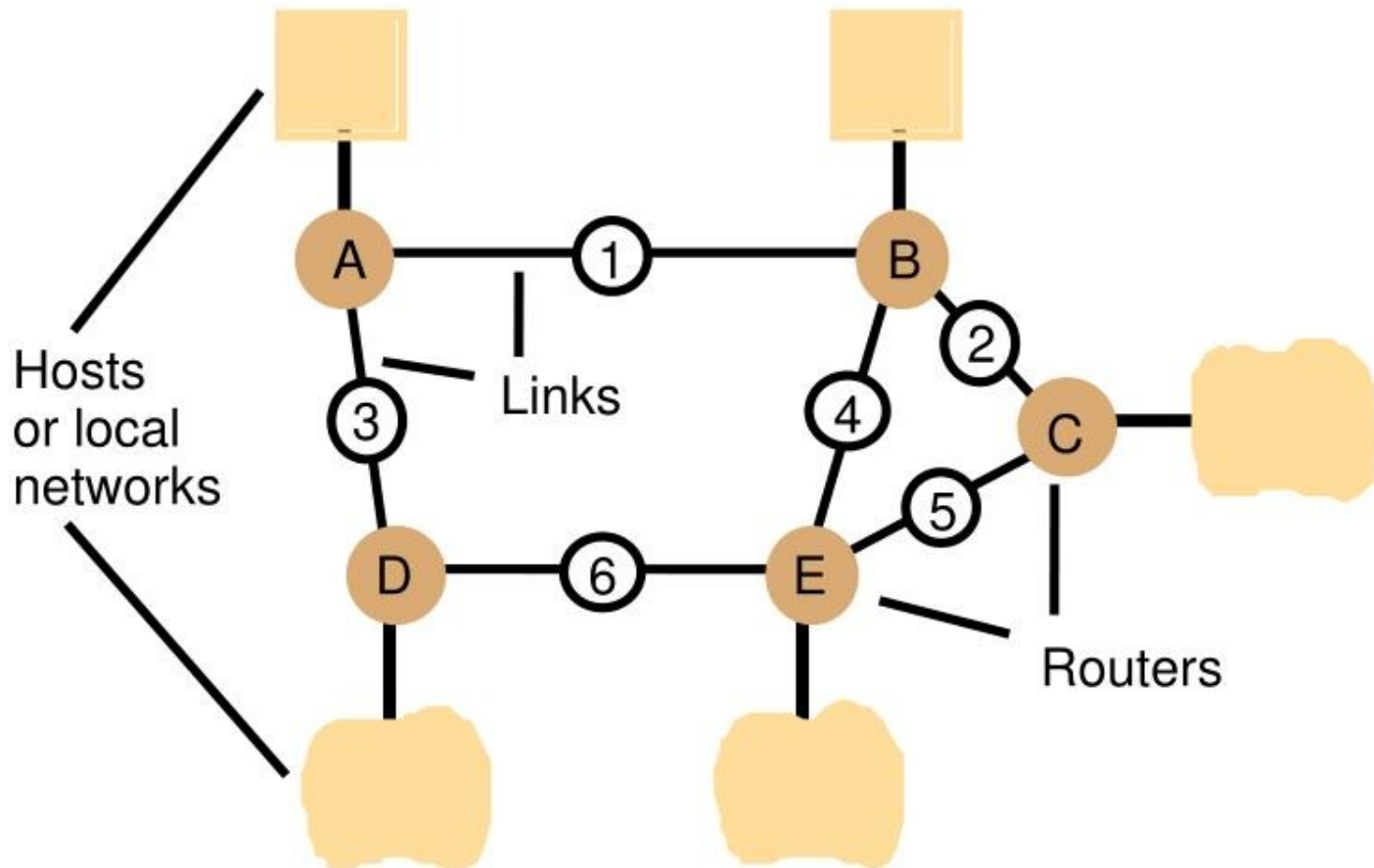# Simplified View of the QMW Computer Science Network (2000)
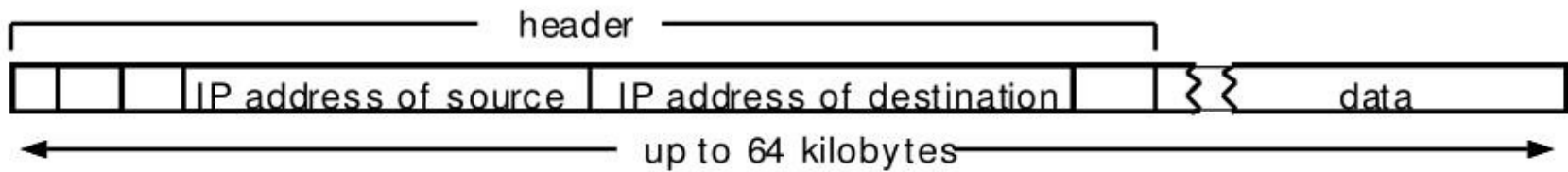
Routing
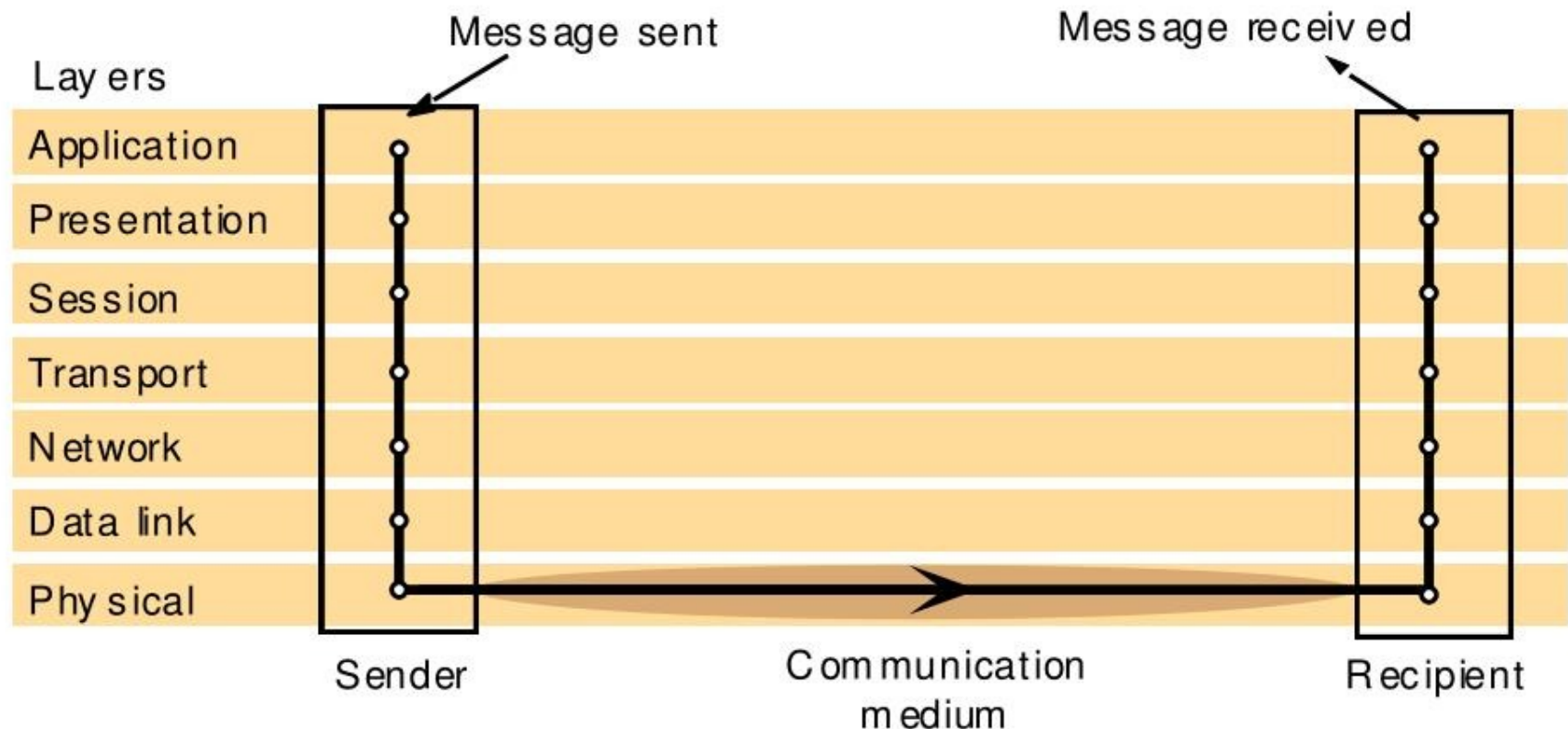
Topics

- # Networking Issues for Distributed Systems

- # Basics of Networking

- # Internet Protocols

IP Packet Layout

header

IP address of source | IP address of destination | data

up to 64 kilobytes

Protocol Layers in OSI Protocol Model

Protocol layers

- Network software is arranged in a hierarchy of layers

- Data is sent to sender through different layers

- Each layer of network software communicates with the layers above and below it. See the next slide

- The protocol types of the above layers are included in the packets sent by the sender to enable the protocol stack at the receiver for selecting the correct software component to unpack the packets. See encapsulation slide

8

Internet Address Structure
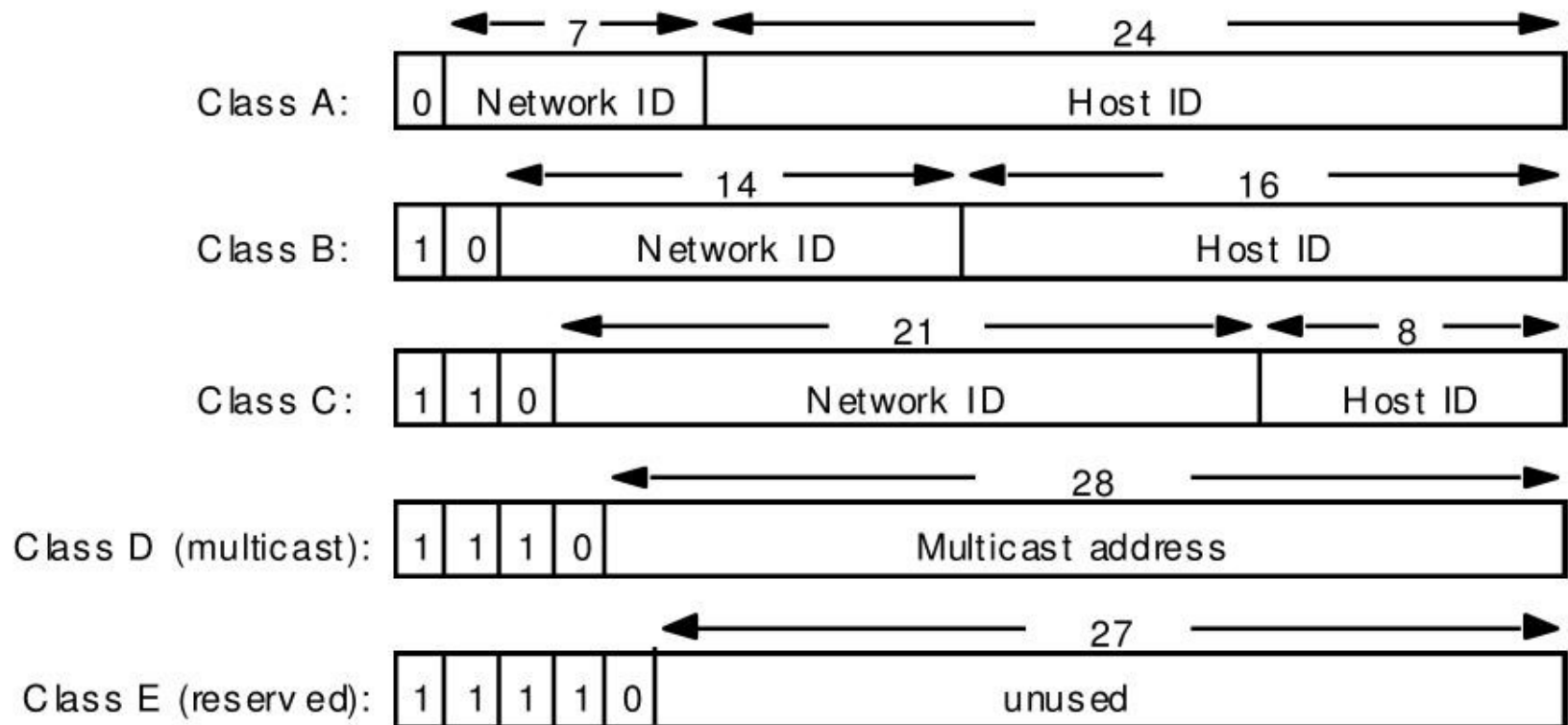
Routing

- Routing is a function that is required in all networks excepts that LANs such as Ethernet that provide the direct connection between all pairs of attached hosts.

- In the large networks *adaptive routing* which is the best route for communication between two points and this route is identifies by periodically re-evaluation, is employed.

- Assume a packet switching network shown in the next slide, the routers located at connection points are responsible for delivery of packets.

Encapsulation in a Message Transmitted via TCP over an Ethernet

Application message

TCP header   port

IP header   TCP

Ethernet header   IP

Ethernet frame
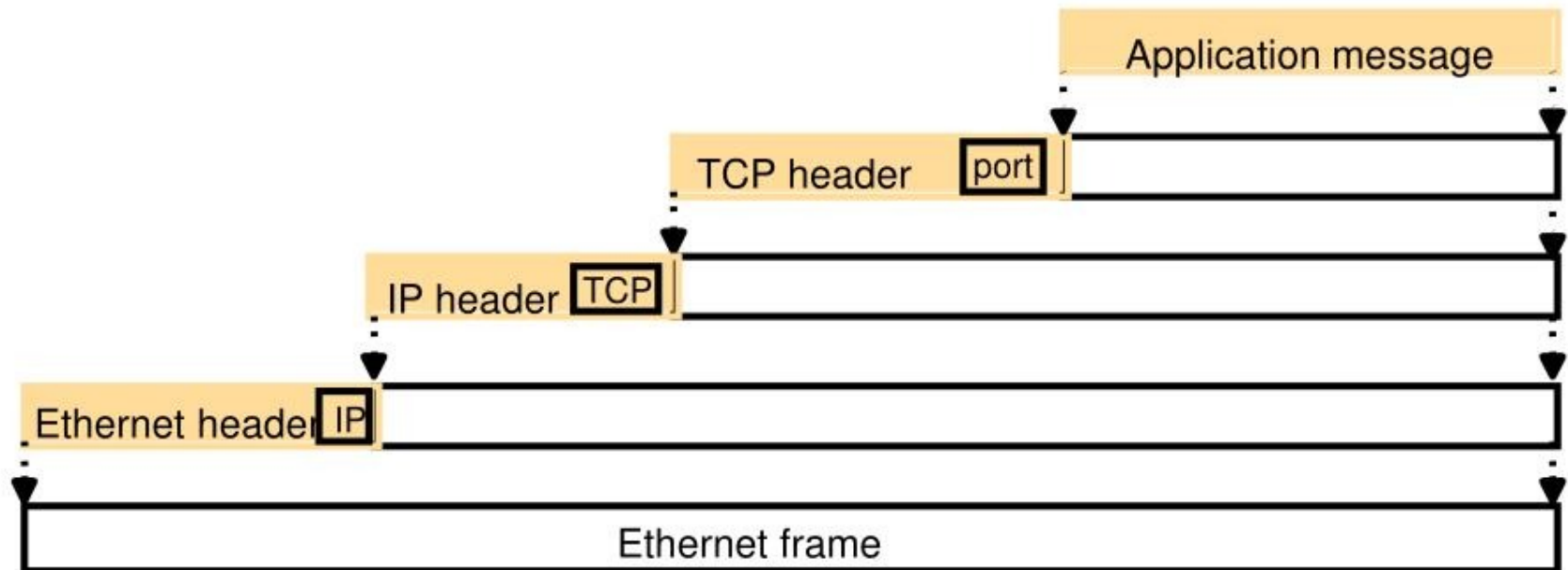
Routing

Routings from A

To	Link	Cost
A	local	0
B	1	1
C	1	2
D	3	1
E	1	2

Routings from B

To	Link	Cost
A	1	1
B	local	0
C	2	1
D	1	2
E	4	1

Routings from C

To	Link	Cost
A	2	2
B	2	1
C	local	0
D	5	2
E	5	1

Routings from D

To	Link	Cost
A	3	1
B	3	2
C	6	2
D	local	0
E	6	1

Routings from E

To	Link	Cost
A	4	2
B	4	1
C	5	1
D	6	1
E	local	0

17

Conceptual Layering of Protocol Software
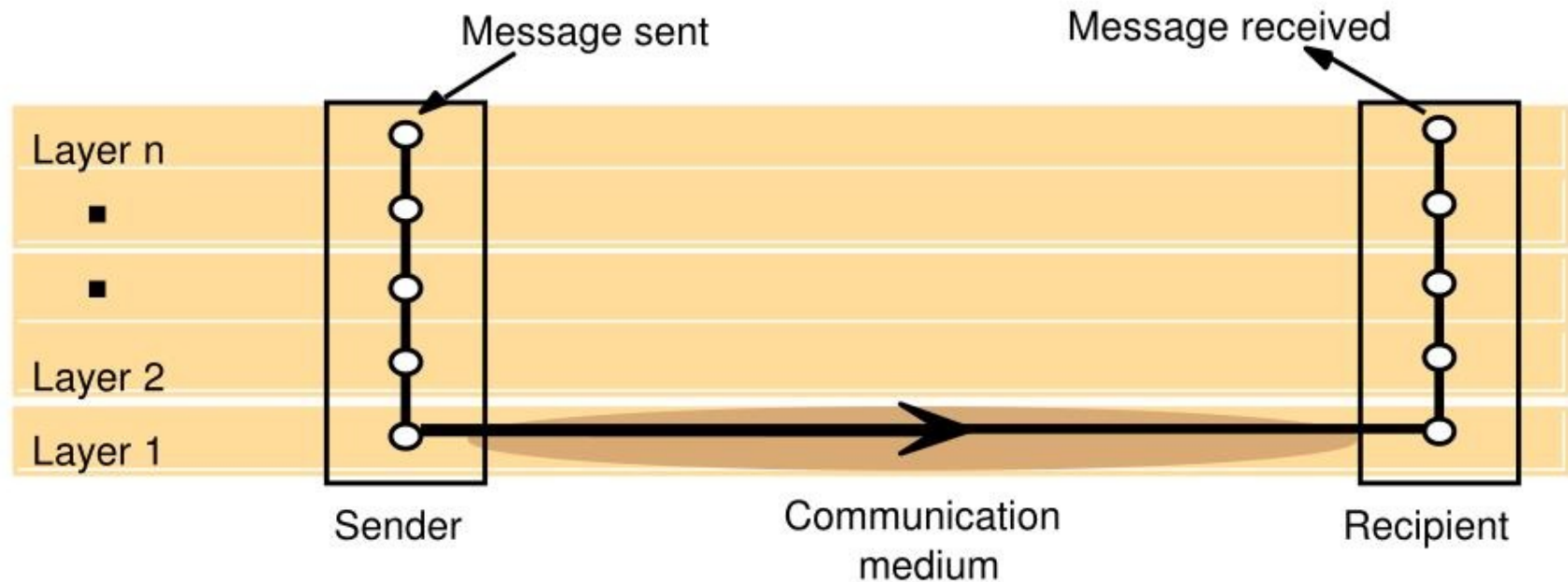
IP Routing

- RIP-1 which is based on distance vector algorithm initially was used in Internet. After that RIP-2 and open shortest path first (OSPF) were also used for IP routing.

- The problem of current Internet is the large number of destinations that makes IP routing very difficult because keeping a routing table to each destination is infeasible.

- One of the solution to this problem is using Unregistered Address by using Network Adrress Translator (NAT) enabled router for compute attached to local networks (See next Slide)

Networking Issues for Distributed Systems

- Following the subsequent development of distributed applications that access the share resources a higher standard of performance is required for networks underlying distributed applications

- Also with the growth of Internet and its commercialization more stringent requirements for reliability, scalability, mobility, security and quality of service have emerged. Here we define performance in more details:

3

Encapsulation in layered protocols

Application-layer message

Presentation header

Session header

Transport header

Network header
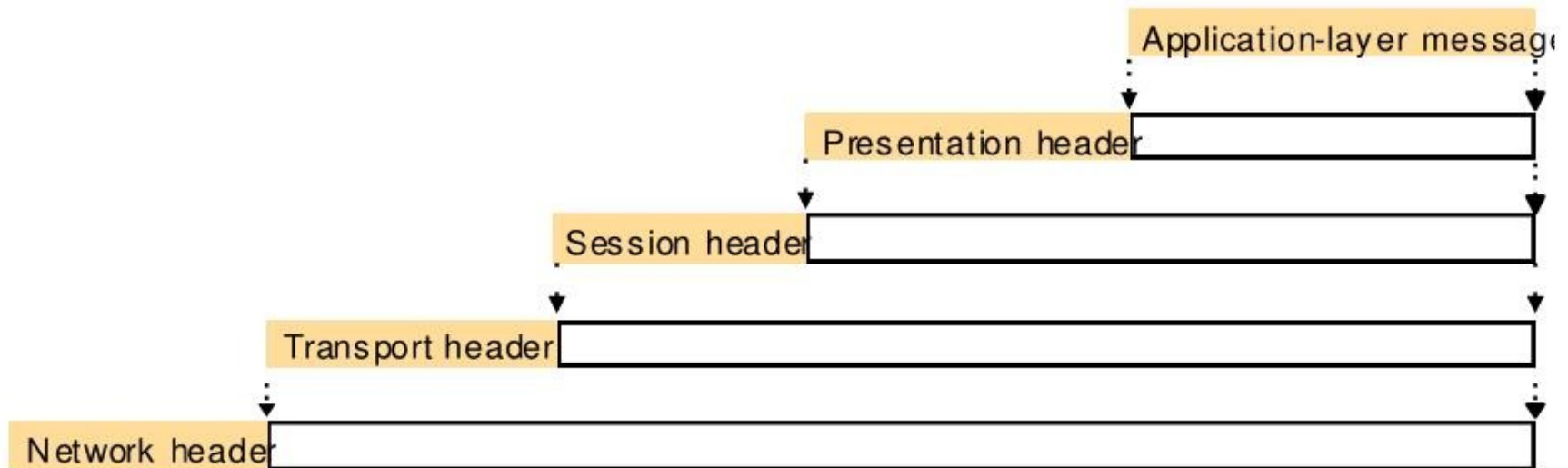
RIP Routing Algorithm

- Each router exchanges and modifies information of its routing table by using router information protocol (RIP) routing algorithm, which does the following high level actions :

    1. Periodically and when the local routing changes each router sends the table to all accessible neighbors. The summary of table is sent in a RIP packet.

    2. When a table is received from a neighboring router if received table shows a rout to a new destination or lower cost rout to an existing destination then it updates the local table with the new rout.

Network Performance

	Example	*Range*	*Bandwidth (Mbps)*	*Latency (ms)*
Wired:				
LAN	Ethernet	1-2 kms	10-1000	1-10
WAN	IP routing	worldwide	0.010-600	100-500
MAN	ATM	250 kms	1-150	10
Internetwork	Internet	worldwide	0.5-600	100-500
Wireless:				
WPAN	Bluetooth (802.15.1)	10 - 30m	0.5-2	5-20
WLAN	WiFi (IEEE 802.11)	0.15-1.5 km	2-54	5-20
WMAN	WiMAX (802.16)	550 km	1.5-20	5-20
WWAN	GSM, 3G phone nets	worldwide	0.01-02	100-500

TCP/IP Layers
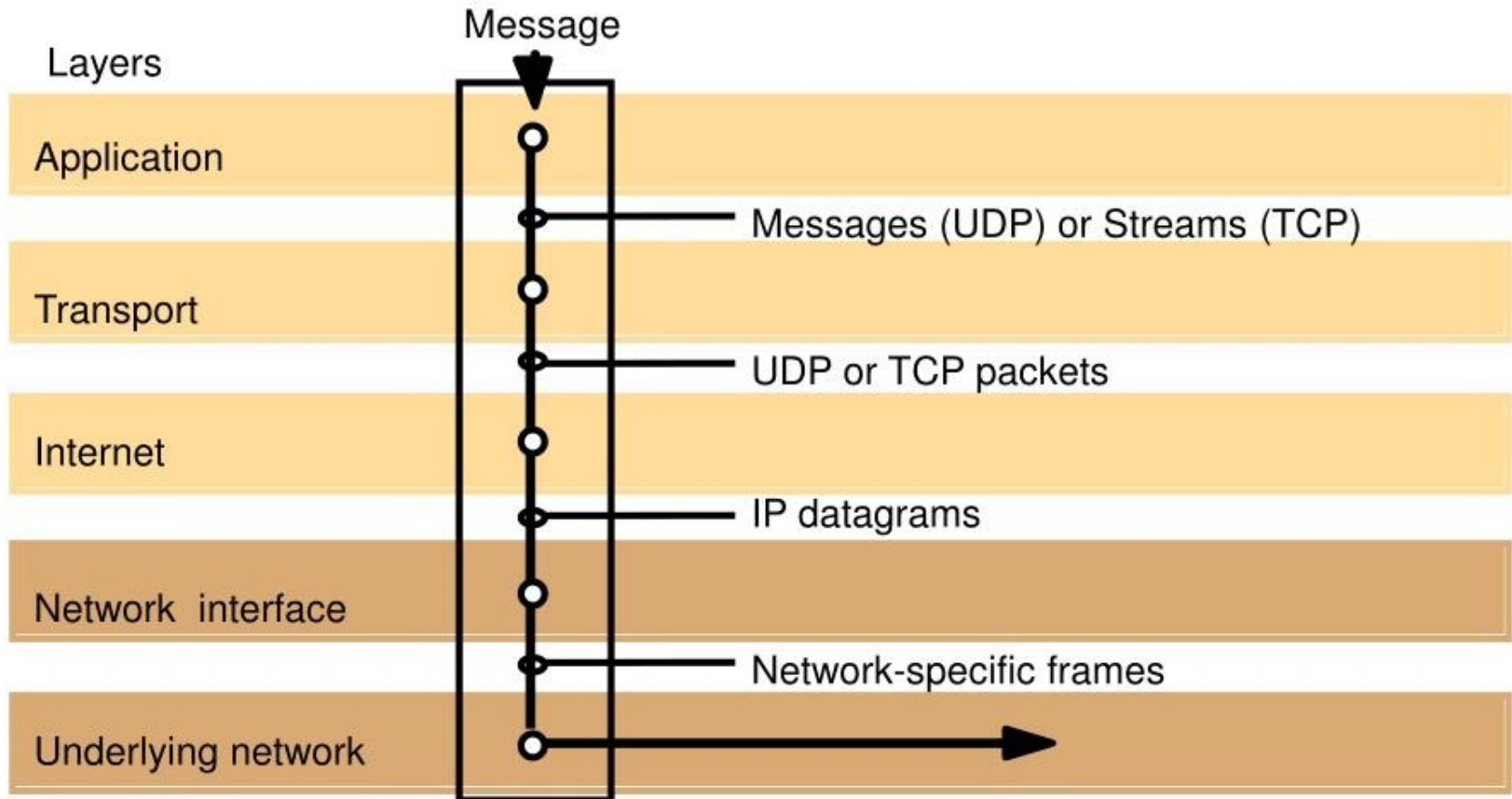
NETWORKING AND

INTERNETWORKING

**From Chapter 3 of Distributed Systems
Concepts and Design,4th Edition,**

By G. Coulouris, J. Dollimore and T. Kindberg

**Published by Addison Wesley/Pearson
Education June 2005**

A Typical NAT-Based Home Network

DSL or Cable
connection to ISP
83.215.152.95
192.168.1.x subnet
Modem / firewall / router (NAT enabled)
192.168.1.1

Ethernet switch

WiFi base station/
access point
192.168.1.2

printer
192.168.1.10

PC 1
192.168.1.5

Laptop
192.168.1.104

PC 2
192.168.1.101

Bluetooth
adapter

Game box
192.168.1.105

TV monitor

Bluetooth
printer

Media hub
192.168.1.106

Camera
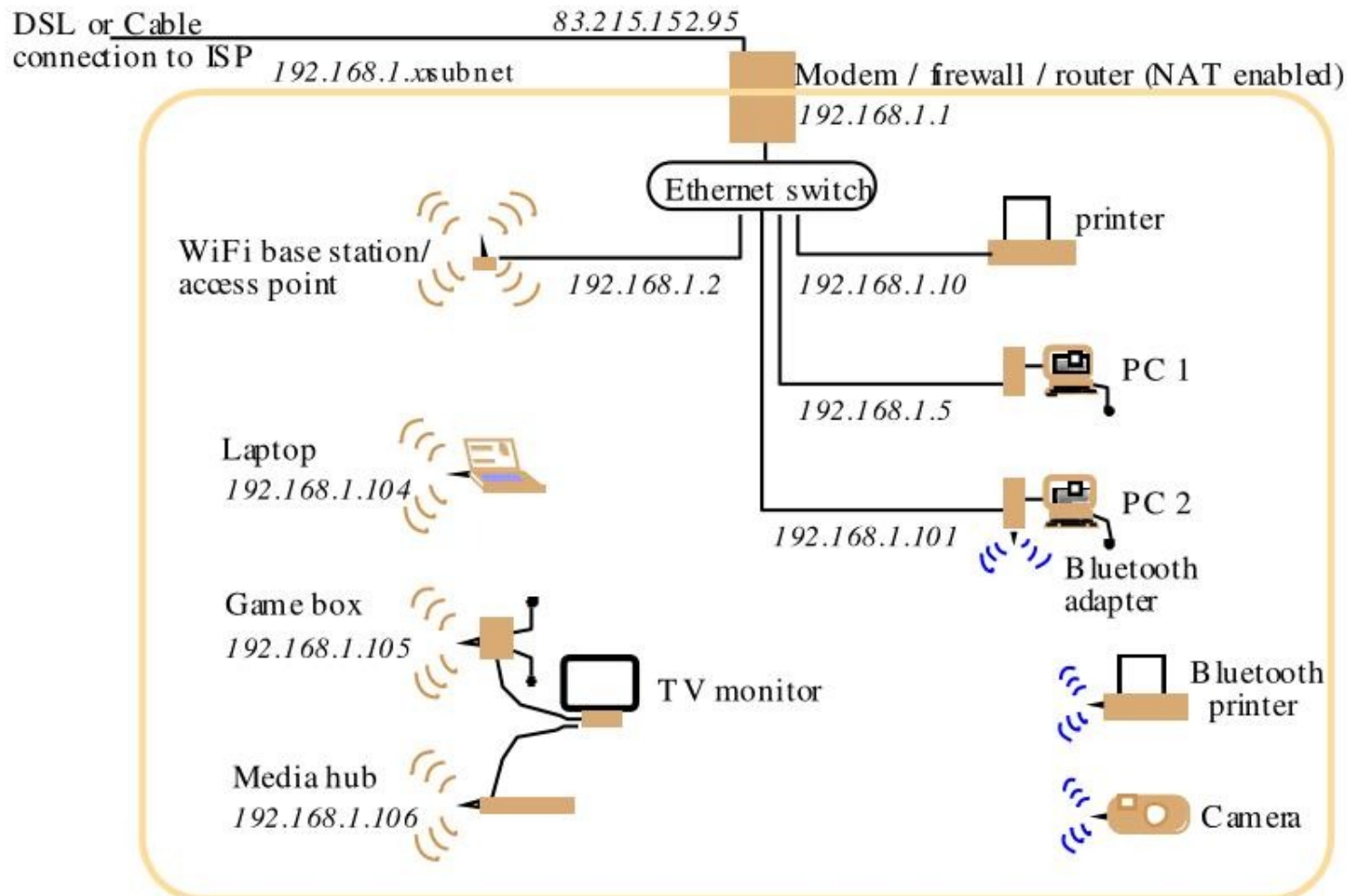
Performance

- Performance: the performance parameters are those affecting the speed of message transfer. They are as the followings:

  - Latency: Delay that occurs after a send operation is executed before the data start to arrive at the destination computer.

  - Data transfer rate: Speed at which the data can be transferred between two computers once transmission has begun.

- Thus the transfer time for a message containing *length* bit is: *latency + length/data transfer rate*

4

Routing

- A simple algorithm for routing discussed here is "distance vector" algorithm which is the basis for link-state algorithm that is used by Internet.

- In this algorithm each router has a table contains a single entry for each possible destination showing the next *hope* (link field in the table) that packet must take toward its destination.

- Cost field in the table is simple calculation of vector distance or number of hopes for a given destination. See the next slide that shows routing tables for the previous network.

Internetworking

- To build an integrated network (an *internetwork*) many subnets of different network technologies are integrated. Internet made this possible by providing the following items:

  1. IP addresses

  2. IP protocol

  3. Intrenet Routers

- Next slide shows part of intranet the comprises several subnets interconnected by routers

Routing

- For a packet addressed to C, when it arrives at the router at A, the algorithm uses routing table in A and choose the row staring with C therefore forwards the packet to link labeled 1.

- When the packet arrives at B same procedure is followed and link 2 will be selected

- When packet arrives at C, routing table entry shows local that means packet should be delivered to a local host

- The routing tables will be built up and maintained whenever faults occur in the network

Protocol Suites

- A complete set of protocols is referred to as *protocol suites* or *protocol stack* , reflecting the layered structure.

- Seven layer reference model for open systems interconnection (OSI) adopted by International Organization for Standardization (ISO) to encourage the development of protocol standards that would meet the requirements for open systems.

- Next slides show OSI model and summary of its protocols

Internetworking

- In the previous slide the routers are in fact the general purpose computers that serves as firewalls. They may be interconnected through the subnets or direct connection (as showed in the routing slide). In any case they are responsible for forwarding the internetwork packets and maintaining routing tables.

- Switches: Performs similar function as routers but for local networks (usually Ethernet) only.

- Hubs: used for connecting hosts and extension

Internet Protocols

- Internet emerged from the development of ARPANET computer network and TCP/IP protocol suites.

- TCP stands for Transmission Control Protocol and IP for Internet Protocol.

- The technologies that are based on TCP/IP with their application layer protocols (shown in parentheses) including the Web(HTTP), email (SMTP),netnews (NNTP), file transfer (FTP) and Telnet (telnet)

- TCP/IP layers are shown in the next slide

Performance

- The equation for message transfer rate is only valid if the length of message does not exceed a maximum that is determined by the underlying network technology. Longer messages have to be segmented and transmission time is sum of the times for segments.

- For example if message transfer is performed between two processes in a distributed system since messages are small, latency has greater significance than transfer rate in that case.

Performance

- The *total system bandwidth* of a network is a measure of throughput

- The *throughput* is the total volume of traffic that can be transferred across the network in a given time.

- In many Local Are Networks (LAN) such as Ethernet system bandwidth is the same as the data transfer rate.

- In most Wide Area Networks (WAN) since messages can be transferred in different channels simultaneously, total system bandwidth is different from transfer rate.

- Next slide shows some networks performance

Internet Protocols

- Note that the Internet Protocol (IP) is underlying layer of Internet virtual network, which means IP datagrams provides the basic transmission mechanism for Internet and other TCP/IP networks.

- Internet protocols (*i.e.,* TCP/IP) are the layers over another network technology such as Ethernet or ATM. Next Slide shows encapsulation of the TCP/IP packets over Ethernet.

- IP packets produced by Internet layer can be transferred over any underlying networks or data links.

OSI Protocol Summary

Layer	Description	Examples
Application	Protocols that are designed to meet the communication requirements of specific applications, often defining the interface to a service.	HTTP, FTP, SMTP, CORBA IIOP
Presentation	Protocols at this level transmit data in a network representation that is independent of the representations used in individual computers, which may differ. Encryption is also performed in this layer, if required.	Secure Sockets (SSL), CORBA Data Rep.
Session	At this level reliability and adaptation are performed, such as detection of failures and automatic recovery.	
Transport	This is the lowest level at which messages (rather than packets) are handled. Messages are addressed to communication ports attached to processes, Protocols in this layer may be connection-oriented or connectionless.	TCP, UDP
Network	Transfers data packets between computers in a specific network. In a WAN or an internetwork this involves the generation of a route passing through routers. In a single LAN no routing is required.	IP, ATM virtual circuits
Data link	Responsible for transmission of packets between nodes that are directly connected by a physical link. In a WAN transmission is between pairs of routers or between routers and hosts. In a LAN it is between any pair of hosts.	Ethernet MAC, ATM cell transfer, PPP
Physical	The circuits and hardware that drive the network. It transmits sequences of binary data by analogue signalling, using amplitude or frequency modulation of electrical signals (on cable circuits), light signals (on fibre optic circuits) or other electromagnetic signals (on radio and microwave circuits).	Ethernet base- band signalling, ISDN

Internet Protocols

- The success of TCP/IP is based on their independence of underlying transmission technology, which enables the internetworking to be built up from many heterogeneous networks and data links.

- IP addressing and IP protocols are two design aspects of Internet protocols.

- The version of IP currently using is IPv4. New version is IPv6 that designed to overcome addressing limitation of IPv4.

- The design of Internet address space and IP packet layout are shown in the next Slides