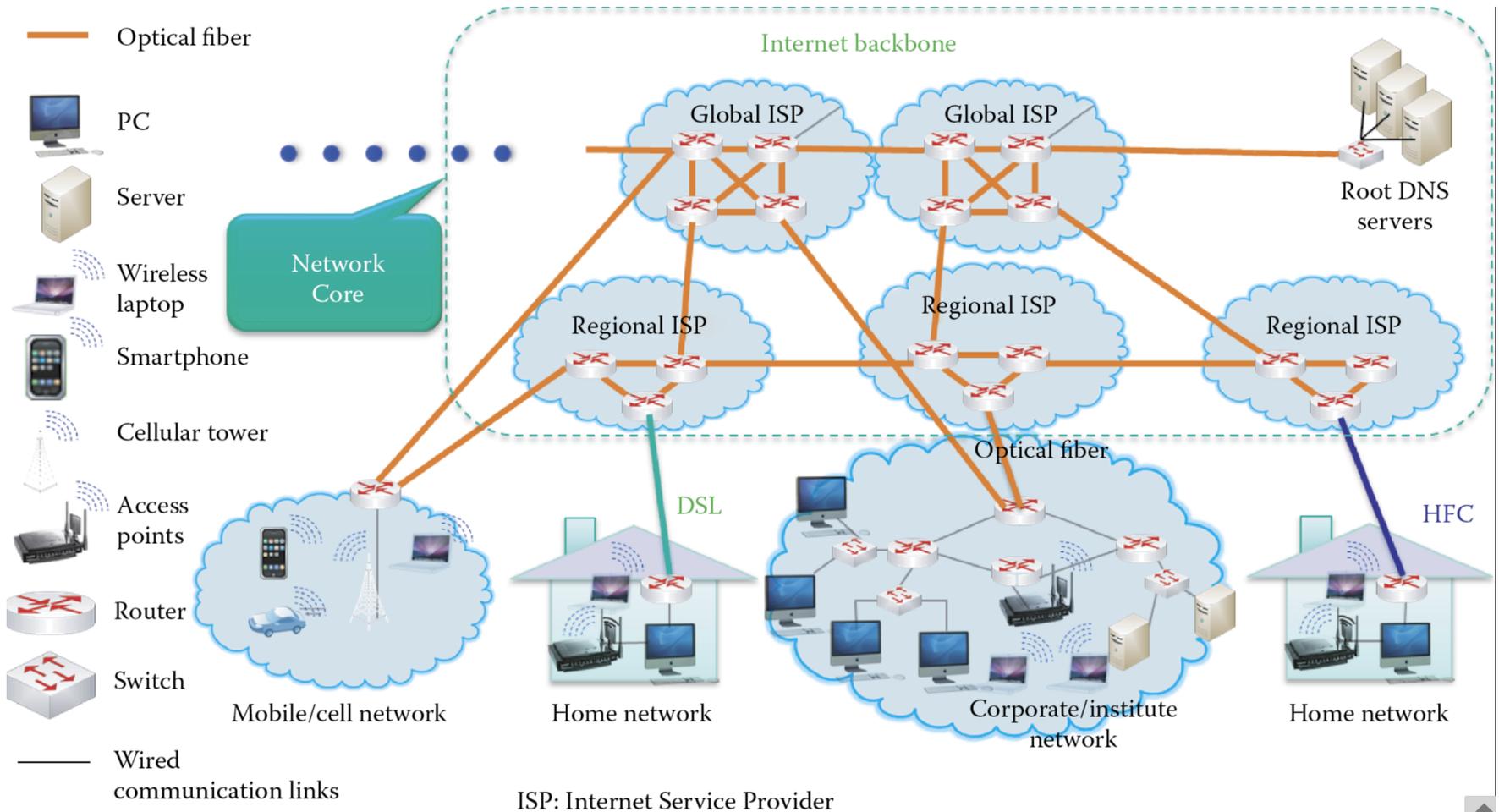# CS322 Introduction
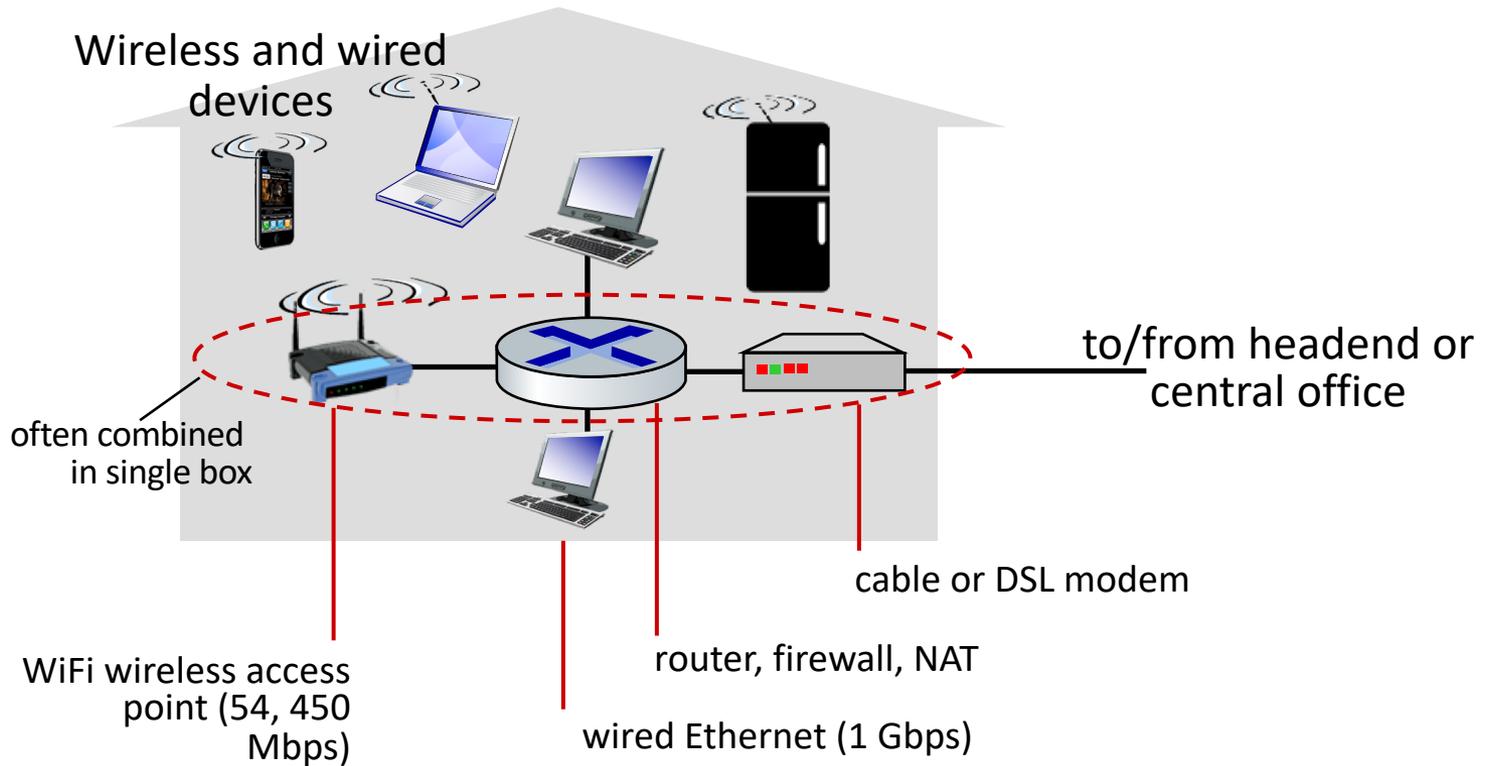
The Network

Access networks: home networks

Wireless and wired devices

often combined in single box

to/from headend or central office

cable or DSL modem

router, firewall, NAT

WiFi wireless access point (54, 450 Mbps)

wired Ethernet (1 Gbps)

Internet Stacks

Internet Stack	Layer
Application	Layer 5
Transport	Layer 4
Network	Layer 3
Data Link	Layer 2
Physical	Layer 1

OSI Stack
Application
Presentation
Session
Transport
Network
Data Link
Physical

OSI

Layered Operation

Messages

Addresses

Application	Layer 5	
Transport	Layer 4	Port Numbers (16 bit)
Network	Layer 3	IP Addresses (32, 128 bits)
Data Link	Layer 2	MAC Addresses (48 bits)
Physical	Layer 1	

Protocols

• Sender

ε
Send("Knock, Knock.")

Rcv(data) &&
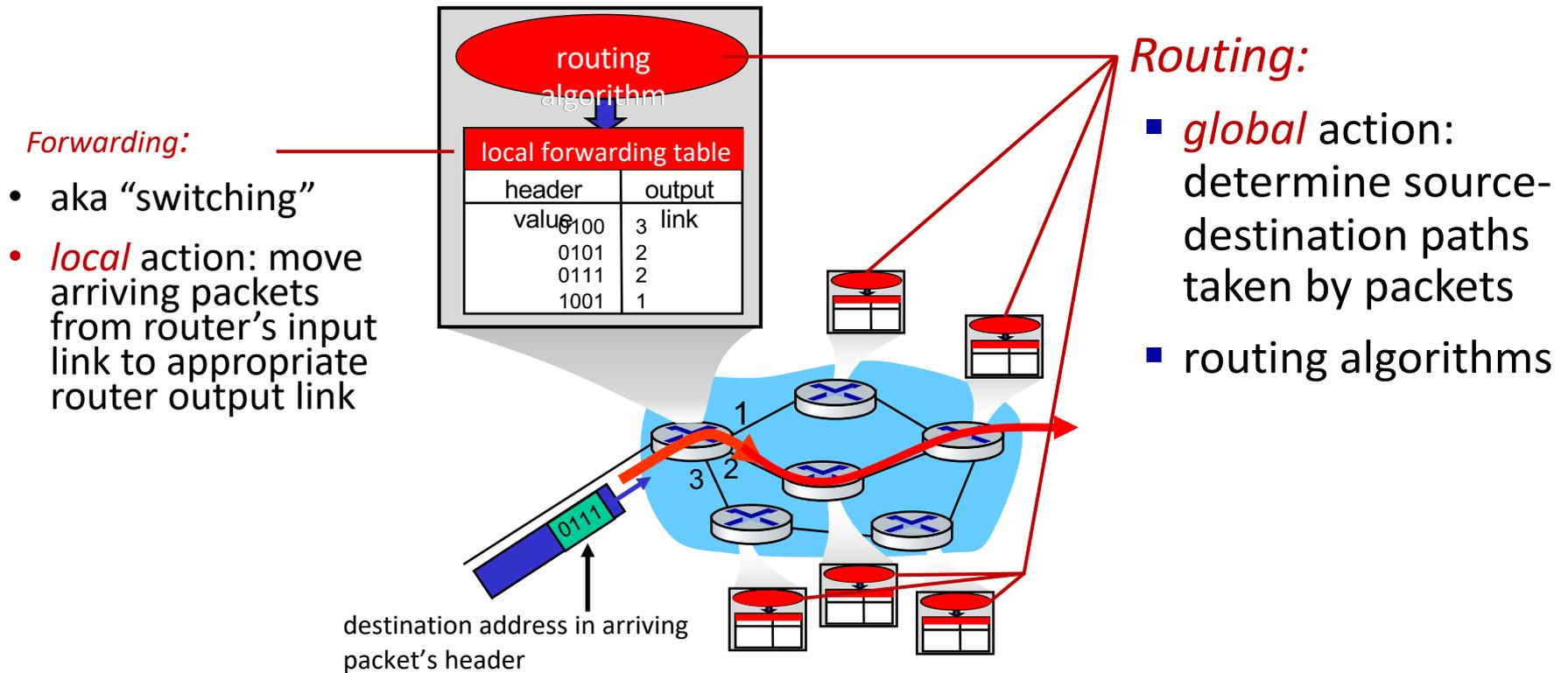data == "Who's there?";
Send(joke)

Rcv(data) &&
data == joke + " who?";
Send(punchline)

Protocols

- Receiver
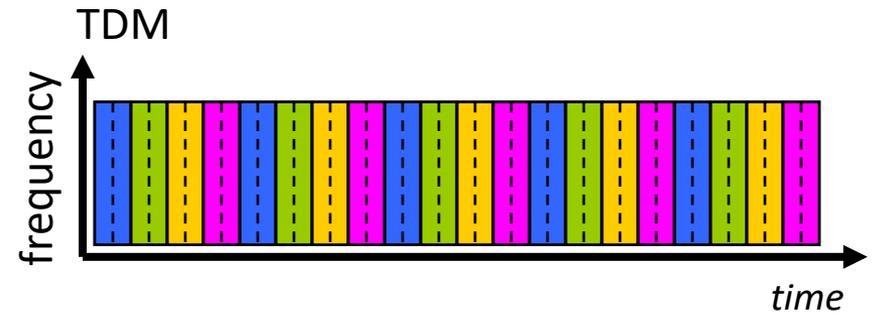

Rcv(msg1) &&
msg1 == "Knock, knock";
Send("Who's there.")

Rcv(msg2)
Send(msg2 + "who?")

Rcv(msg3)
ε
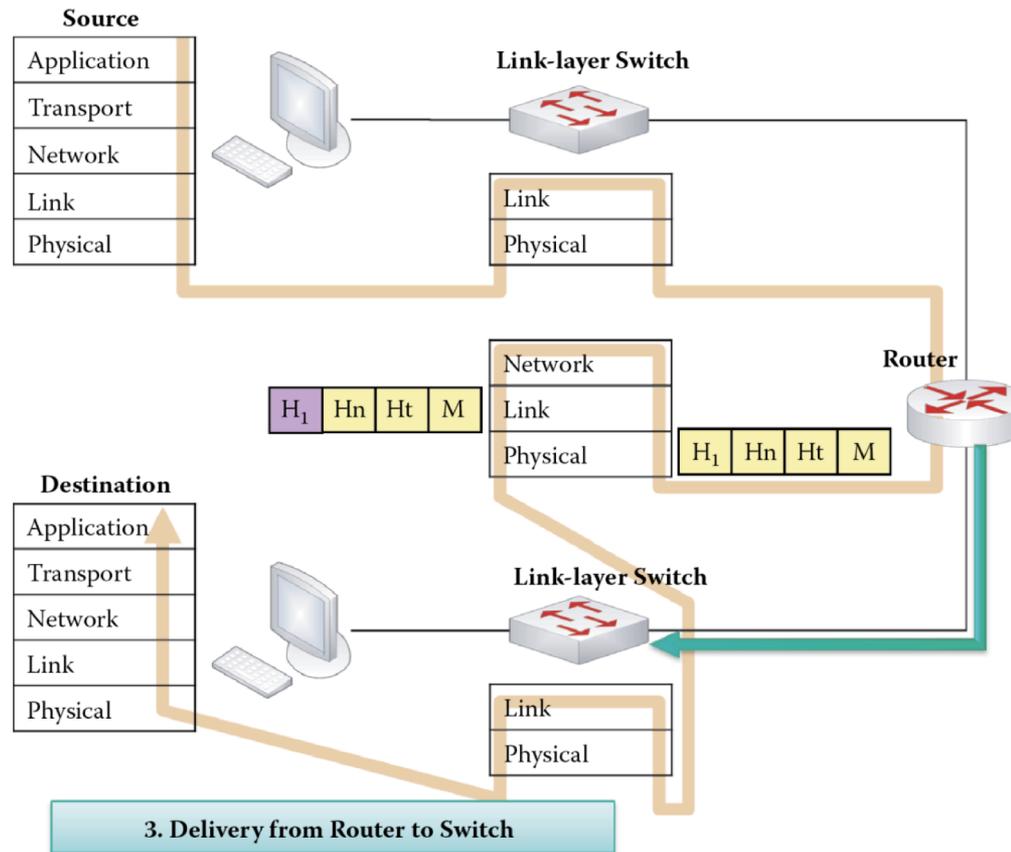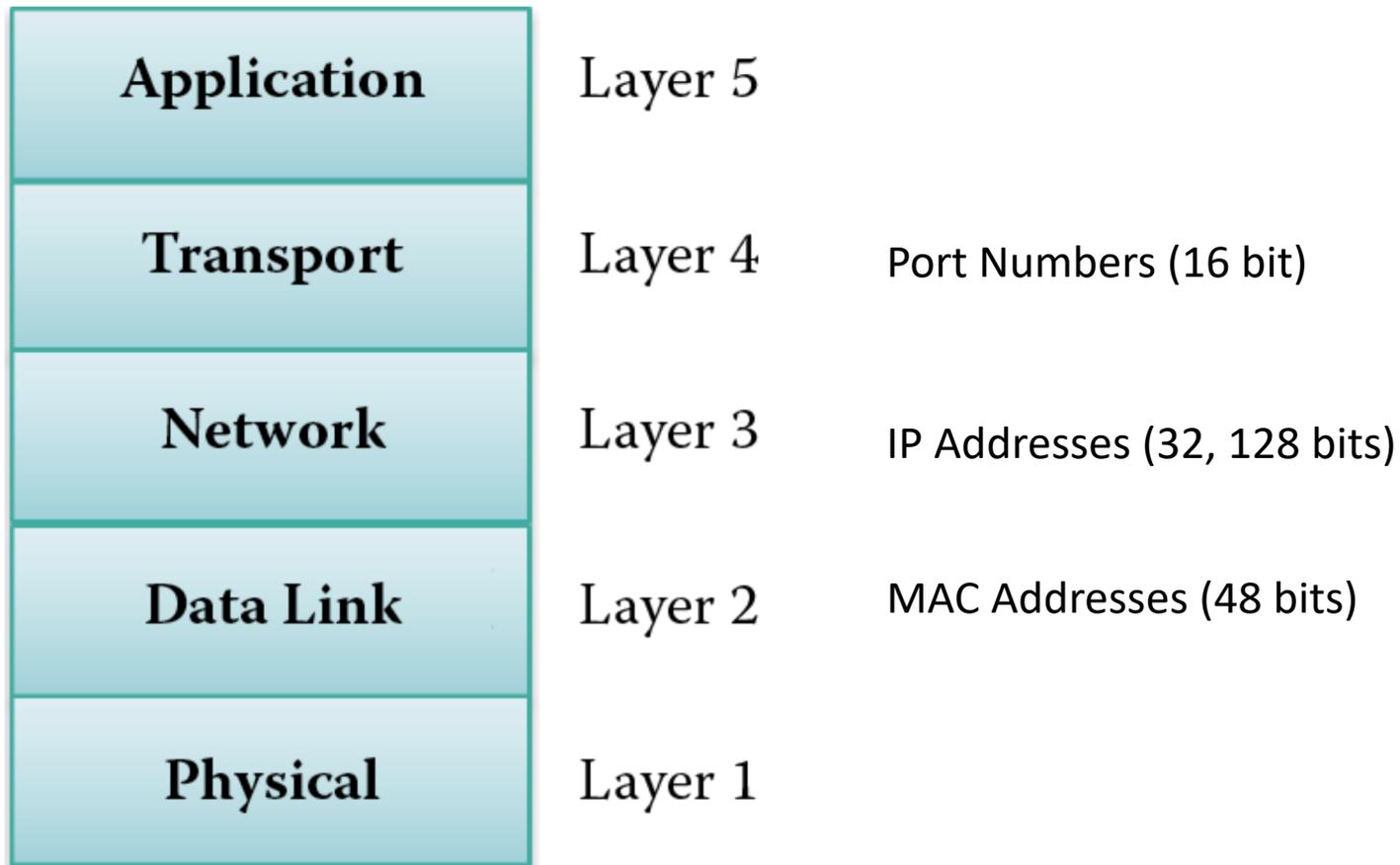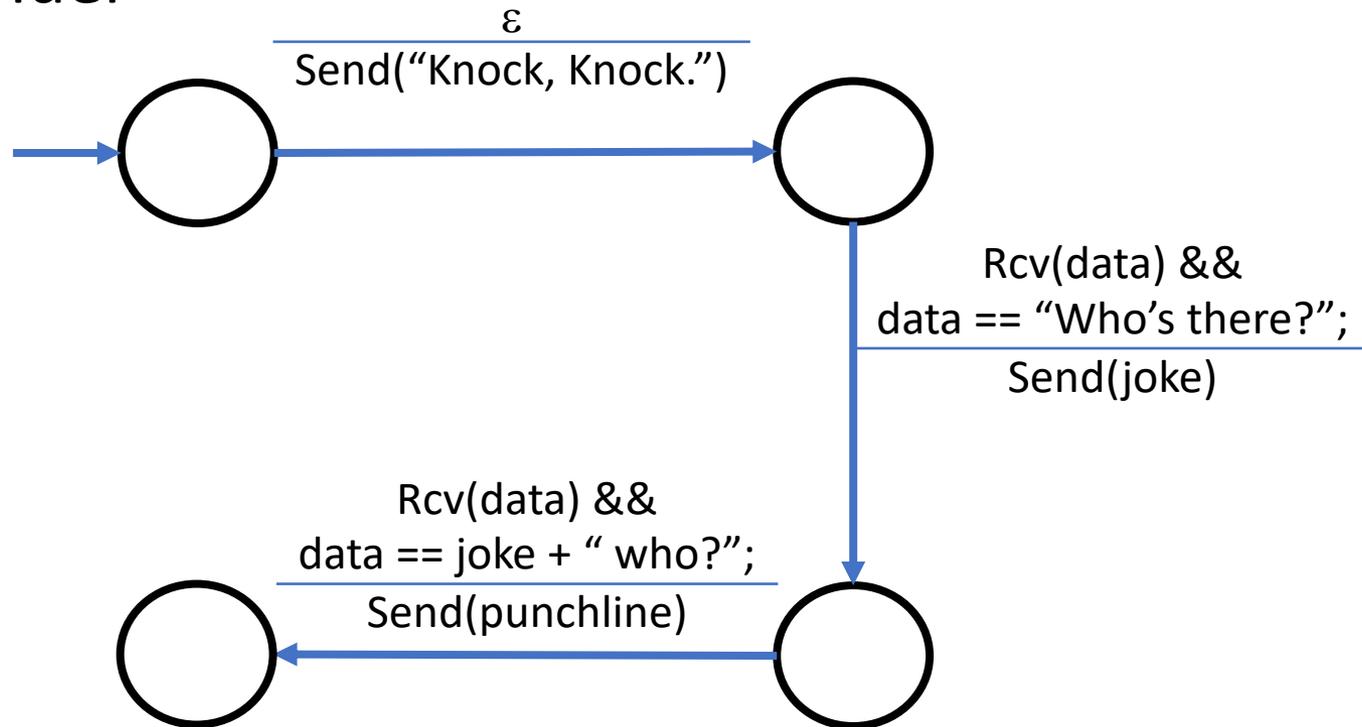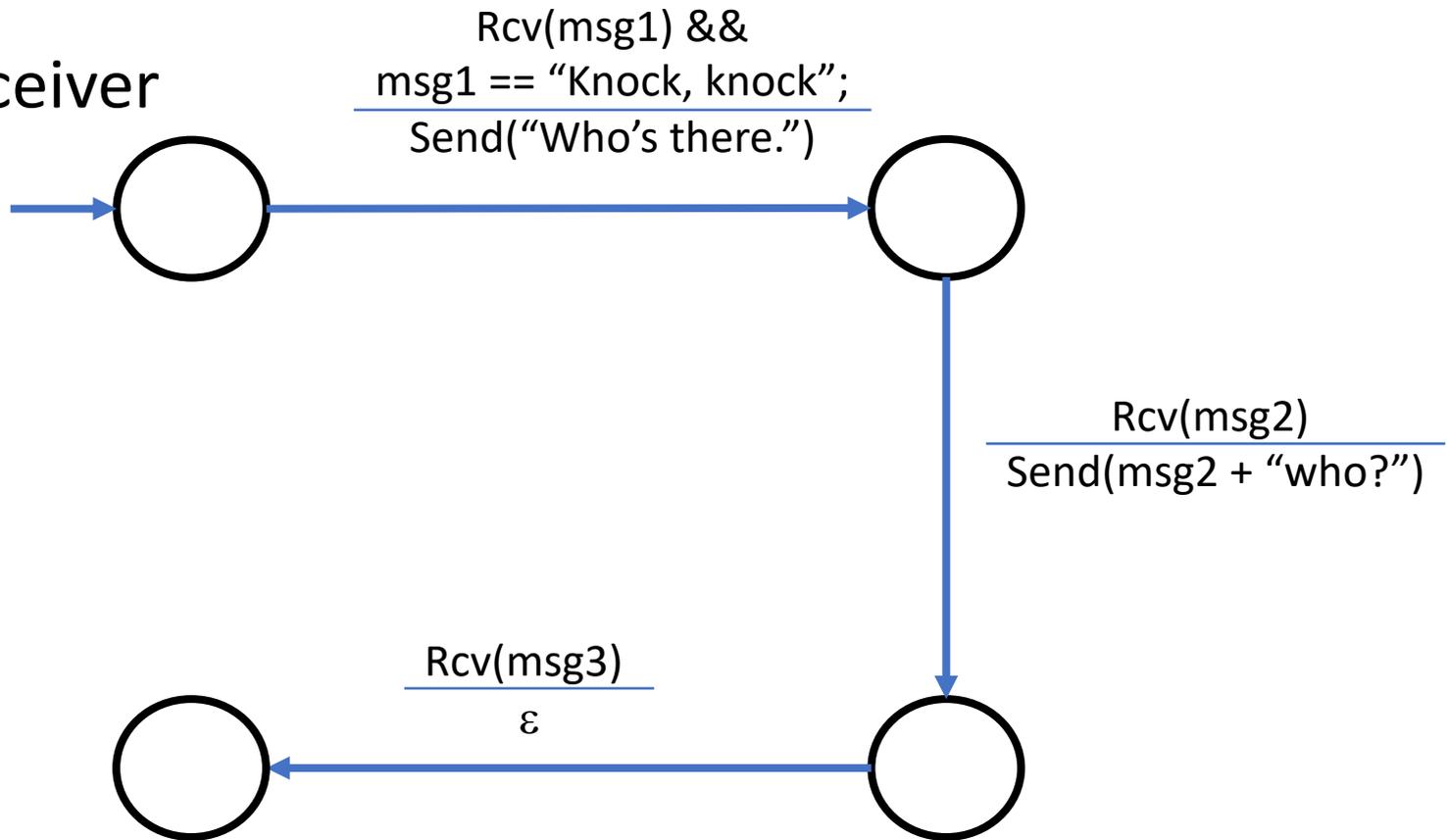
Two key network-core functions

Forwarding:

- aka "switching"
- *local* action: move arriving packets from router's input link to appropriate router output link

routing algorithm

local forwarding table	
header value	output link
0100	3
0101	2
0111	2
1001	1

1

3 2

0111

destination address in arriving packet's header

Routing:

- *global* action: determine source-destination paths taken by packets
- routing algorithms
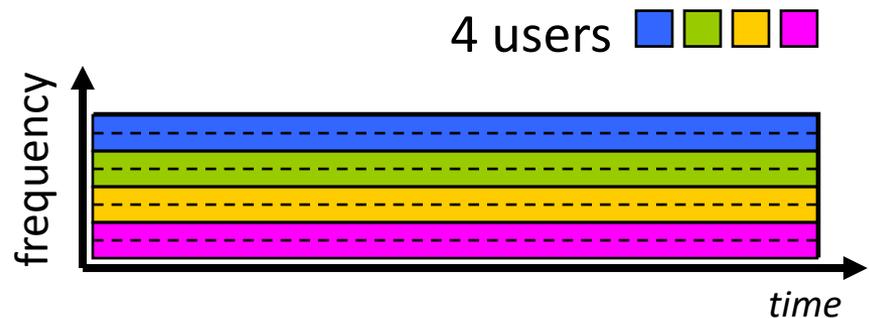
Packet v. circuit switching
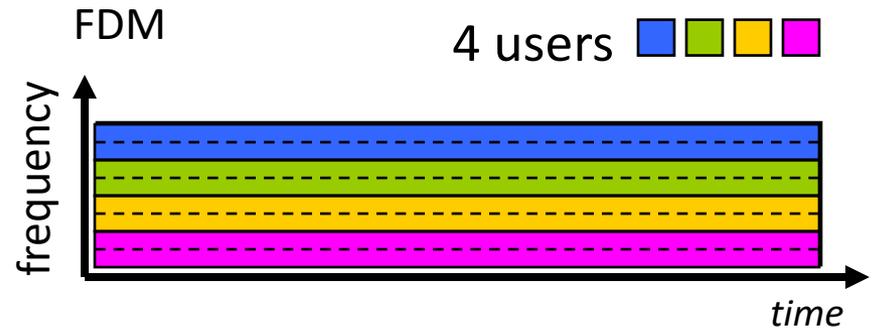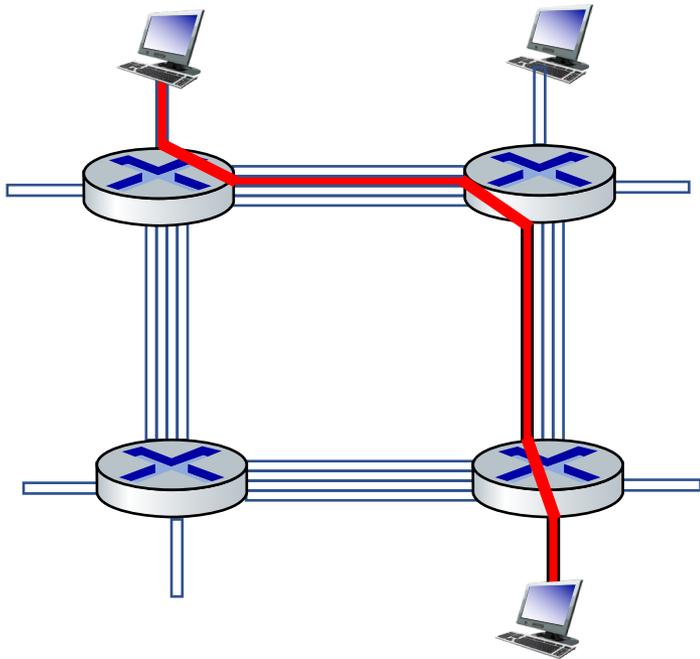
Circuit switching: FDM and TDM

Frequency Division Multiplexing (FDM)

- optical, electromagnetic frequencies divided into (narrow) frequency bands
  - each call allocated its own band, can transmit at max rate of that narrow band
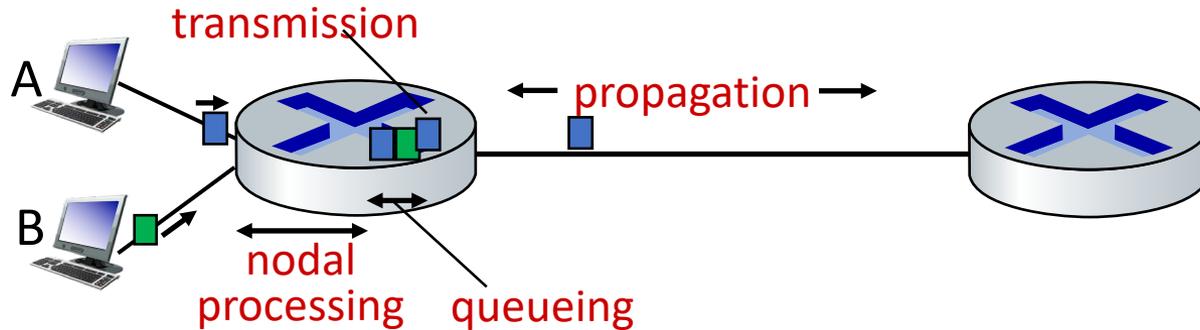
Time Division Multiplexing (TDM)

- time divided into slots
- each call allocated periodic slot(s), can transmit at maximum rate of (wider) frequency band (only) during its time slot(s)

4 users
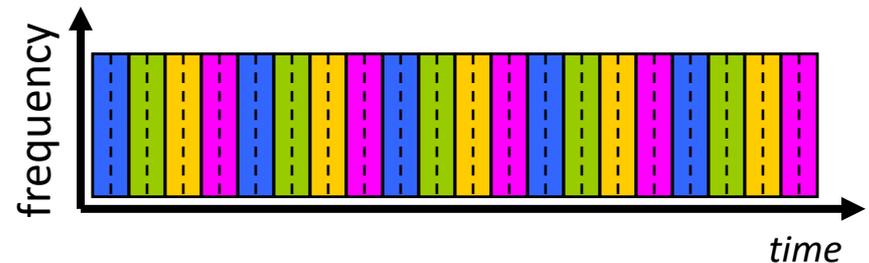
Packet delay: four sources

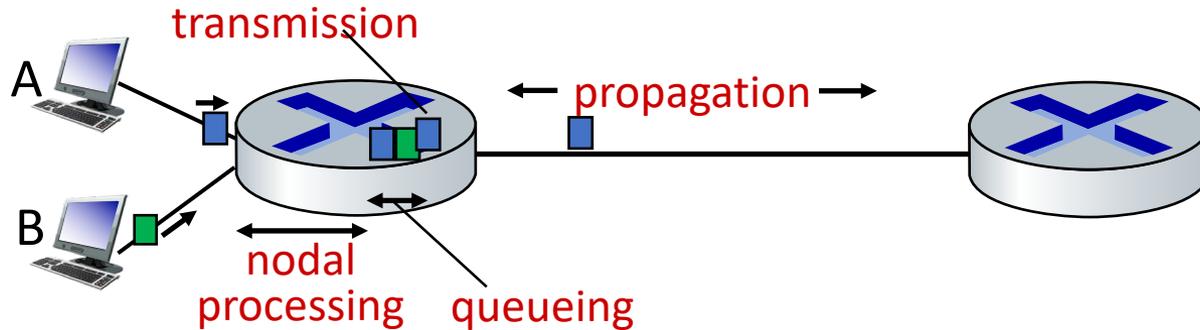$$d_{nodal} = d_{proc} + d_{queue} + d_{trans} + d_{prop}$$

d_{proc}: nodal processing
- check bit errors
- determine output link
- typically < microsecs

d_{queue}: queueing delay
- time waiting at output link for transmission
- depends on congestion level of router

Packet delay: four sources

$$d_{\text{nodal}} = d_{\text{proc}} + d_{\text{queue}} + d_{\text{trans}} + d_{\text{prop}}$$

d_{trans}: transmission delay:

- L: packet length (bits)
- R: link *transmission rate (bps)*
- $d_{trans} = L/R$

d_{prop}: propagation delay:

- d: length of physical link
- s: propagation speed ($\sim 2 \times 10^8$ m/sec)
- $d_{\text{prop}} = d/s$

d_{trans} and d_{prop}
very different

TCP v UDP (Transport Services)

Transmission Control Protocol

- Reliable

- Connection Oriented

- Flow Control

- Congestion Control

User Datagram Protocol

- Connectionless

- Best Effort