Welcome to

CS 3516:
Computer Networks

Prof. Yanhua Li

Time: 9:00am –9:50am M, T, R, and F
Location: AK219
Fall 2018 A-term

Chapter 1: roadmap

1.1 what is the Internet?

"nuts and bolts" view

service view

1.2 network edge

- end systems, access networks, links

1.3 network core

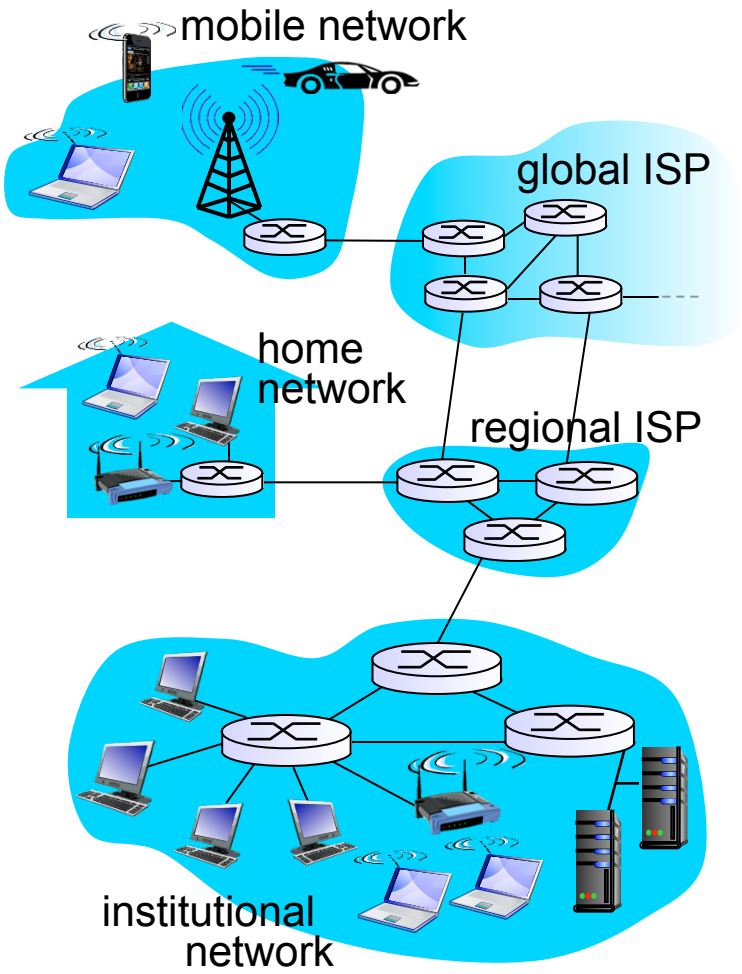
- packet switching, circuit switching, network structure

A closer look at network structure:

- *network edge:*
  - hosts: clients and servers
  - servers often in data centers

    - *access networks, physical media:* wired, wireless communication links

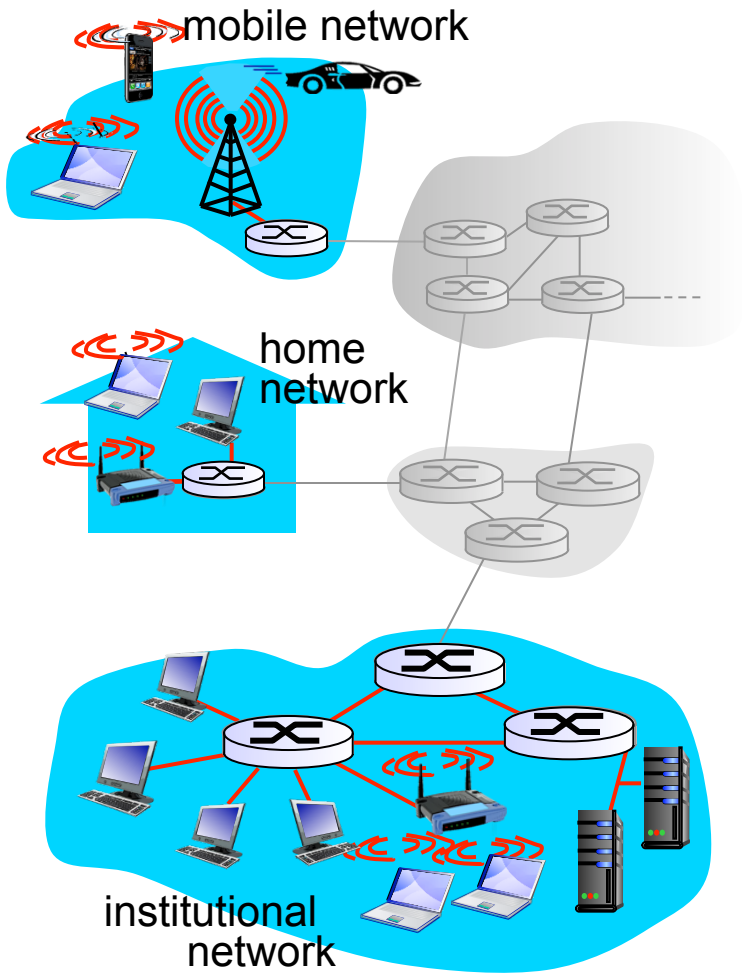
- *network core:*
  - interconnected routers
  - network of networks



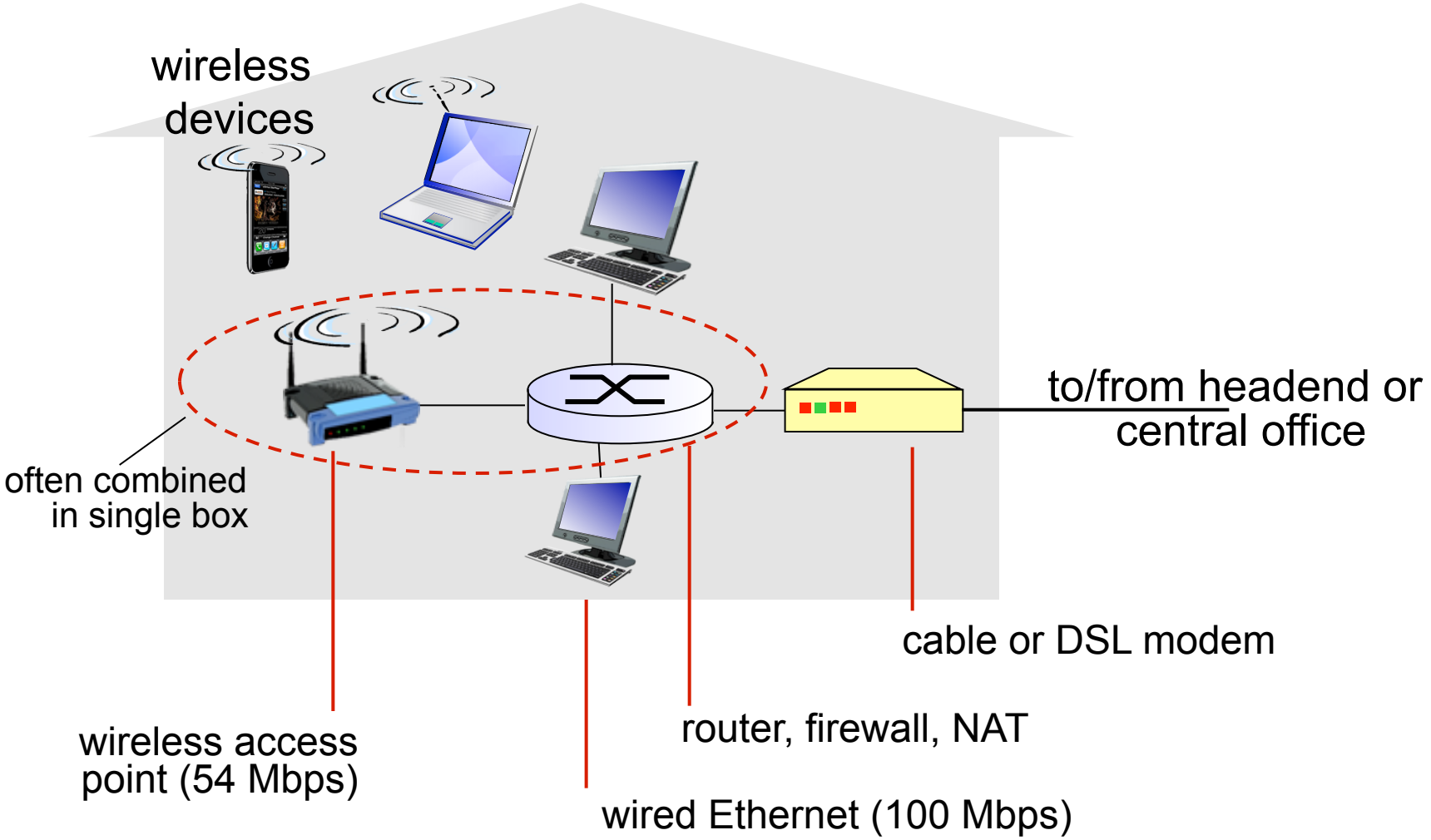
Access networks and physical media

Q: How to connect end systems to edge router?

- residential access nets
- institutional access networks (school, company)
- mobile access networks



Access net: home network



Chapter 1: roadmap

1.1 what is the Internet?

"nuts and bolts" view

service view

1.2 network edge

- end systems, access networks, links

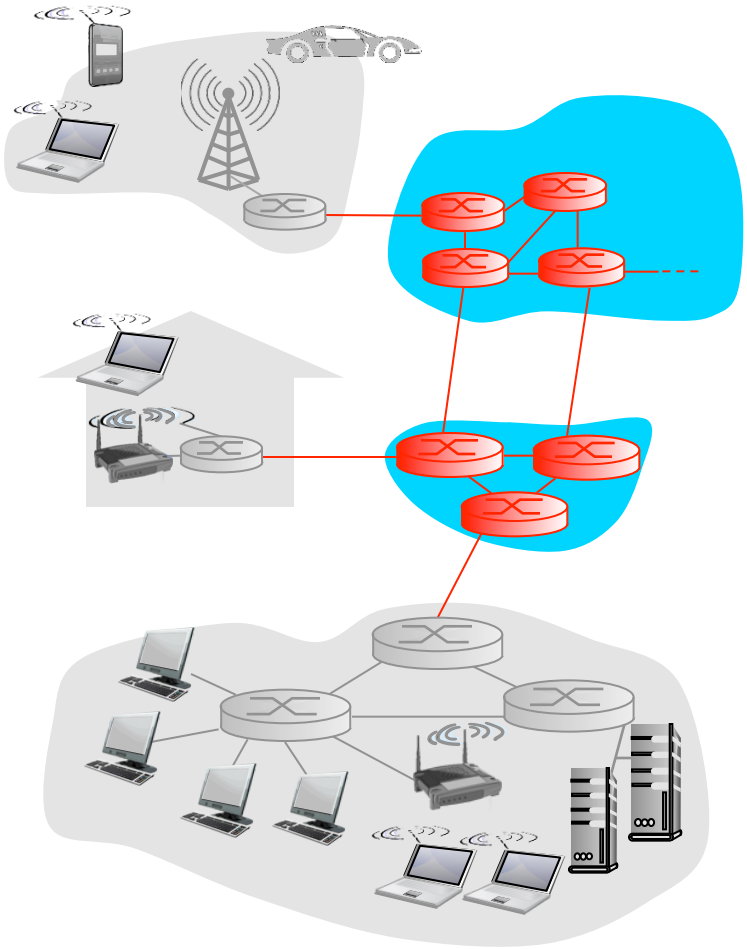
1.3 network core

- packet switching, circuit switching, network structure

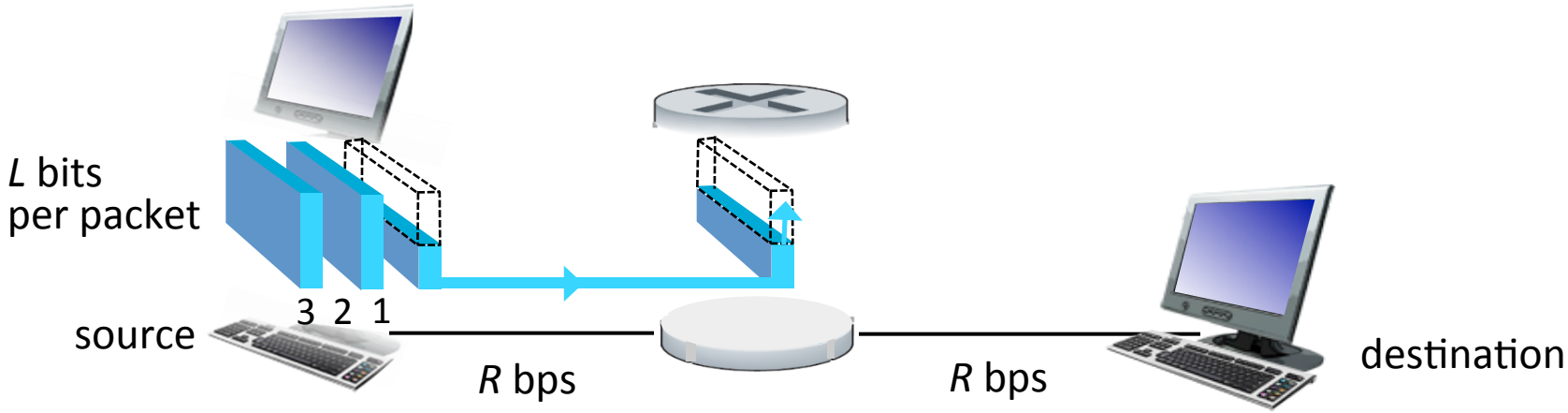
The network core

mesh of interconnected routers with three key aspects in network core

- Link: Switching, Resource allocation (chp 1.3)
- Node: Routing & Forwarding (to be discussed in Network layer chp 4)
- Network: Network Core Structure / Management / Coordination (chp 1.3)



Packet-switching: store-and-forward



- takes *L*/*R* seconds to transmit (push out) *L*-bit packet into link at *R* bps
- *store and forward:* entire packet must arrive at router before it can be transmitted on next link
- end-end delay = 2*L*/*R* (assuming zero propagation delay)

one-hop numerical example:

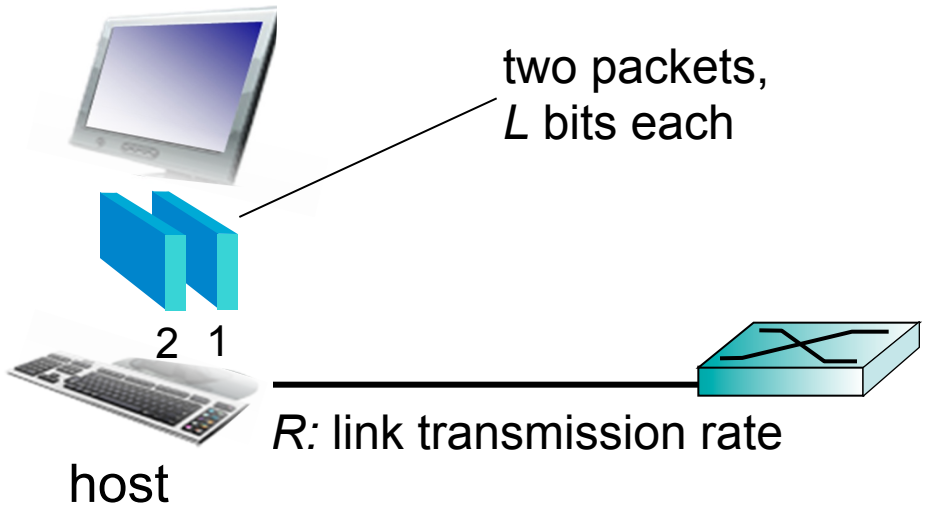
- *L* = 7.5 Mbits
- *R* = 1.5 Mbps
- one-hop transmission delay = 5 sec

more on delay shortly …

Host: sends *packets* of data

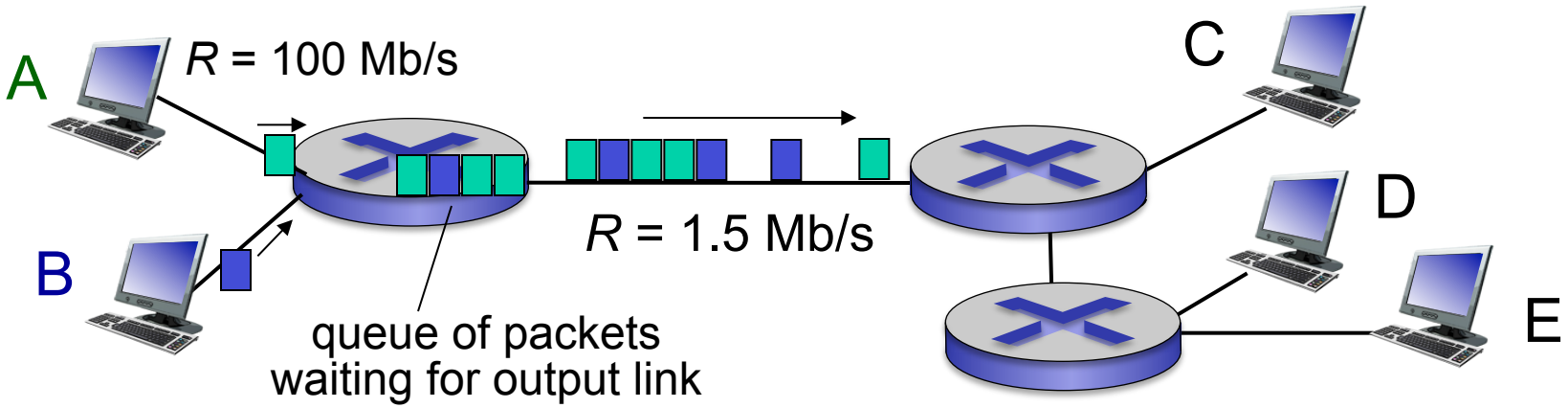
host sending function:

- takes application message
- breaks into smaller chunks, known as *packets*, of length *L* bits
- transmits packet into access network at *transmission rate R*
  - link transmission rate, aka link *capacity, aka link bandwidth*



$$\text{packet transmission delay} = \text{time needed to transmit } L\text{-bit packet into link} = \frac{L \text{ (bits)}}{R \text{ (bits/sec)}}$$

Packet Switching: queueing delay, loss



queuing and loss:

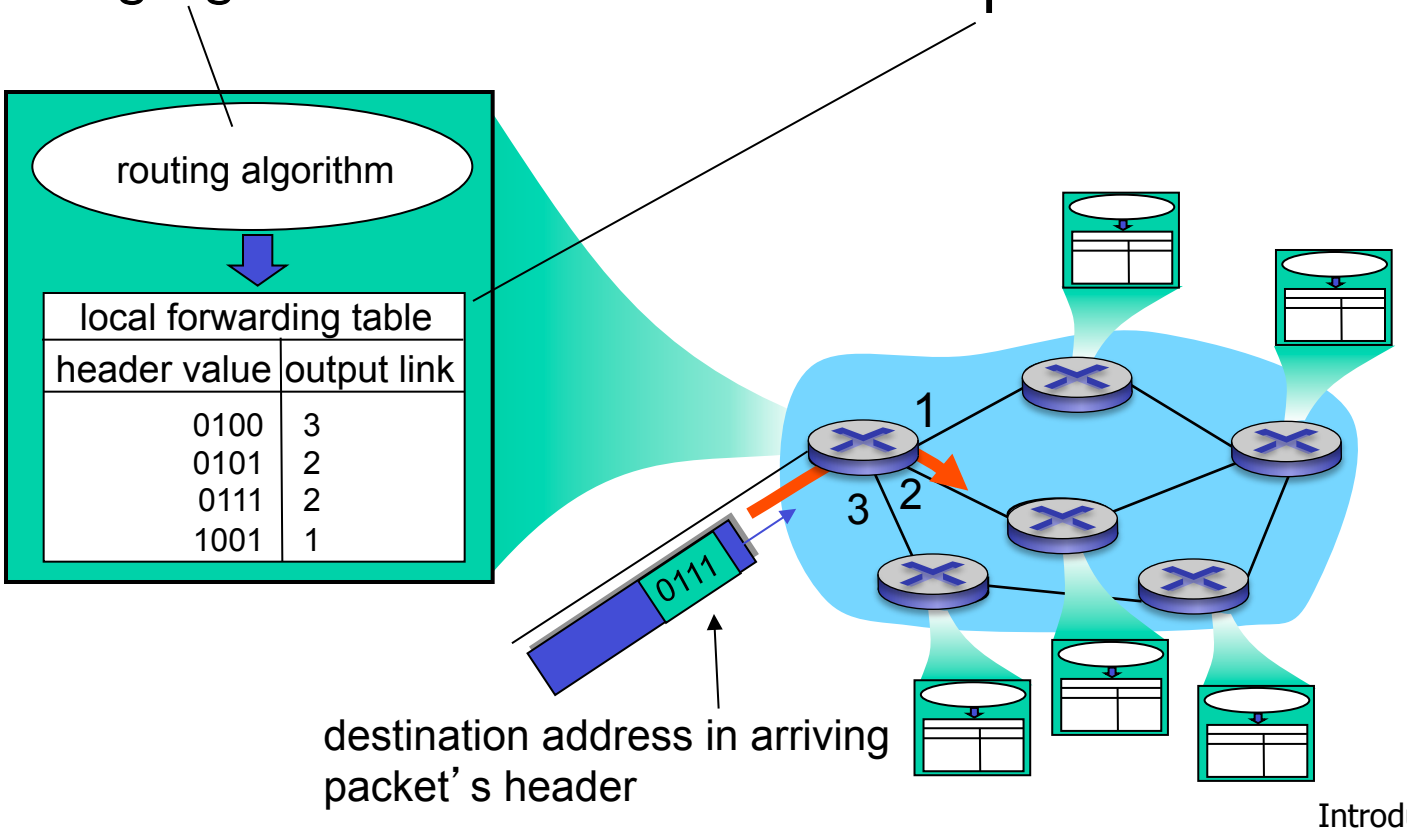
- if arrival rate (in bits) to link exceeds transmission rate of link for a period of time:
  - packets will queue, wait to be transmitted on link
  - packets can be dropped (lost) if memory (buffer) fills up

Two key network-core functions

routing: determines source-destination route taken by packets

- *routing algorithms*

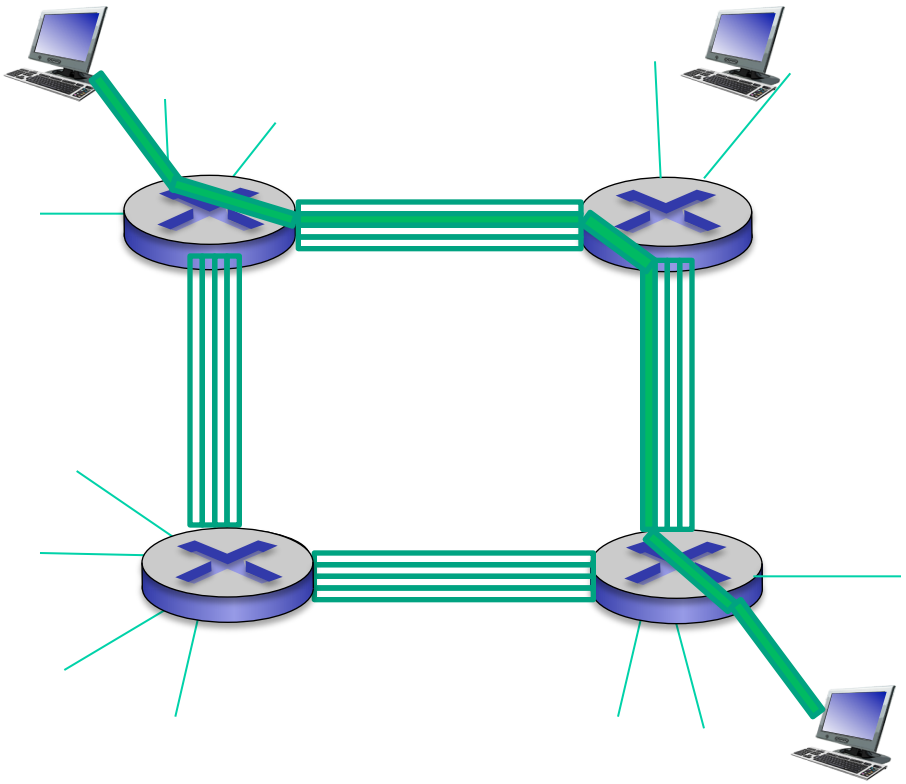
forwarding: move packets from router's input to appropriate router output



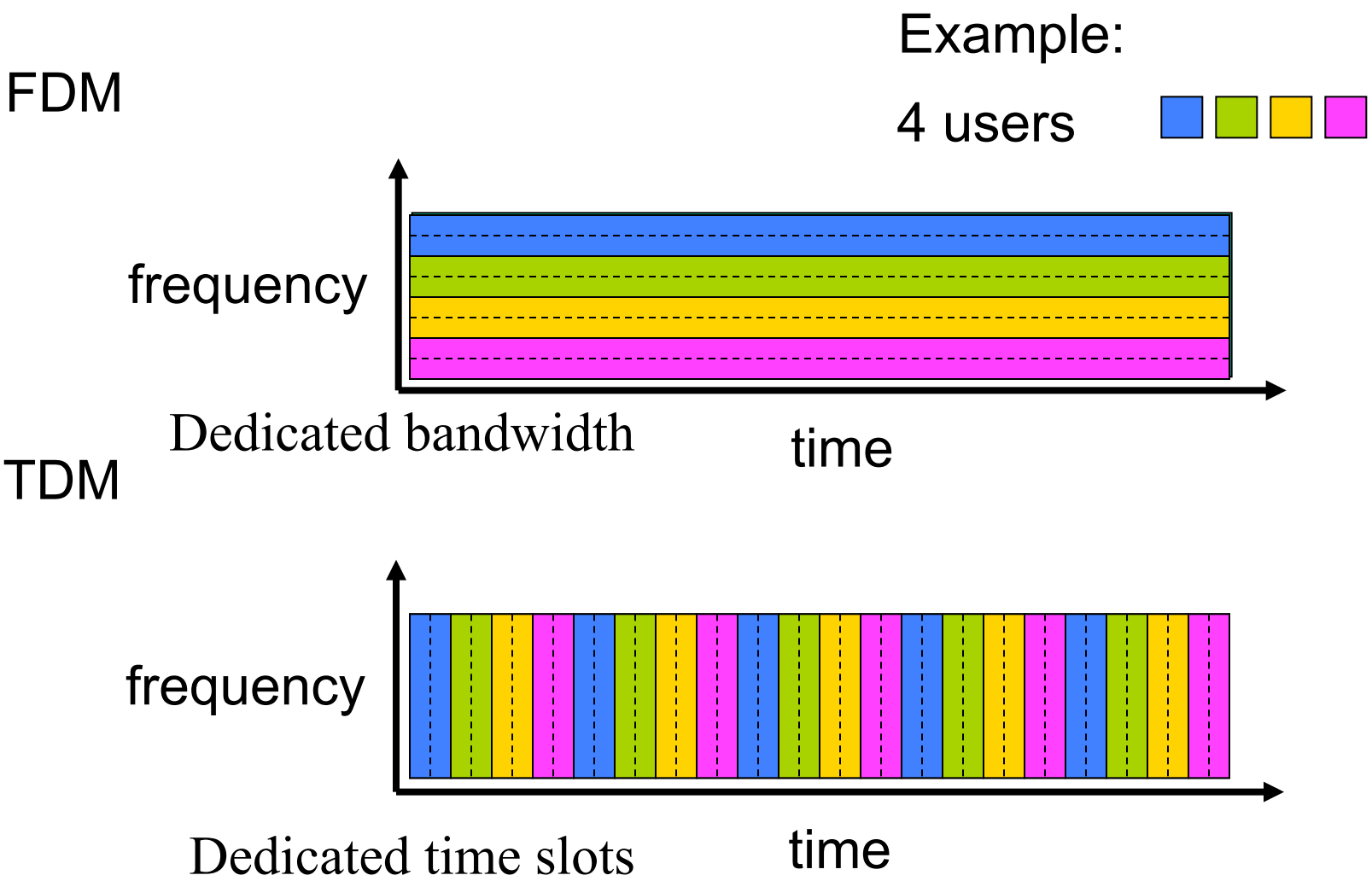
Alternative core: circuit switching

end-end resources allocated to, reserved for "call" between source & dest:

- in diagram, each link has four circuits.
  - call gets 2nd circuit in top link and 1st circuit in right link.
- dedicated resources: no sharing
  - circuit-like (guaranteed) performance
- circuit segment idle if not used by call *(no sharing)*
- commonly used in traditional telephone networks



Circuit switching: FDM versus TDM



Analogy to Road Networks

End systems=buildings

Packet switches=intersections

Links=road segments

Packet switching versus circuit switching

is packet switching a "slam dunk winner?"

- Pros: great for bursty data (advantages)
  - resource sharing
  - simpler, no call setup
- Cons: excessive congestion possible:
  - packet delay and loss
  - protocols needed for reliable data transfer, congestion control

Q: human analogies of reserved resources (circuit switching) versus on-demand allocation (packet-switching)?

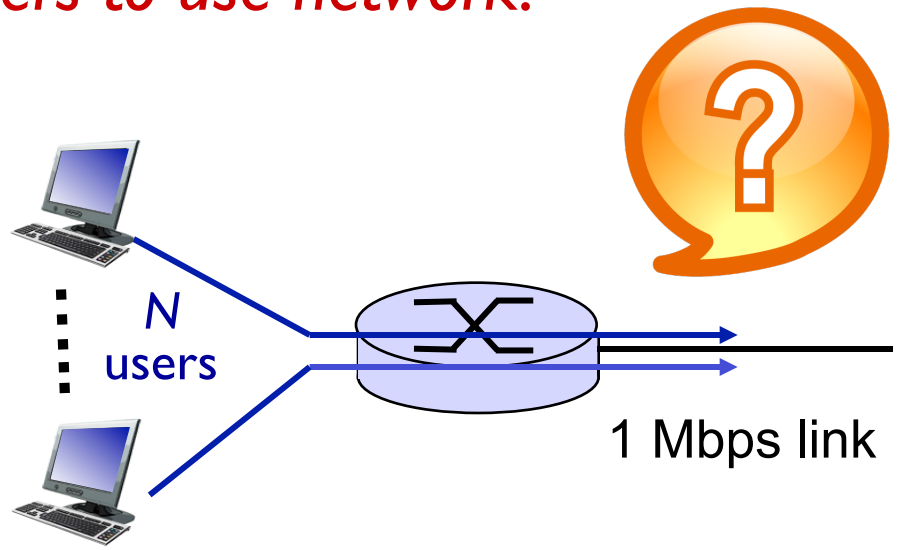
Like parking lots.

Packet switching versus circuit switching

packet switching allows more users to use network!

example:

- 1 Mb/s link
- each user:
  - 100 kb/s when "active"
  - active 10% of time



- *circuit-switching:*
  - 10 users
- *packet switching:*
  - with 35 users, probability > 10 active at same time is less small

Q: probability of $u_1, u_2, \ldots, u_{10}$ are active, and u_{11}-u_{35} inactive?

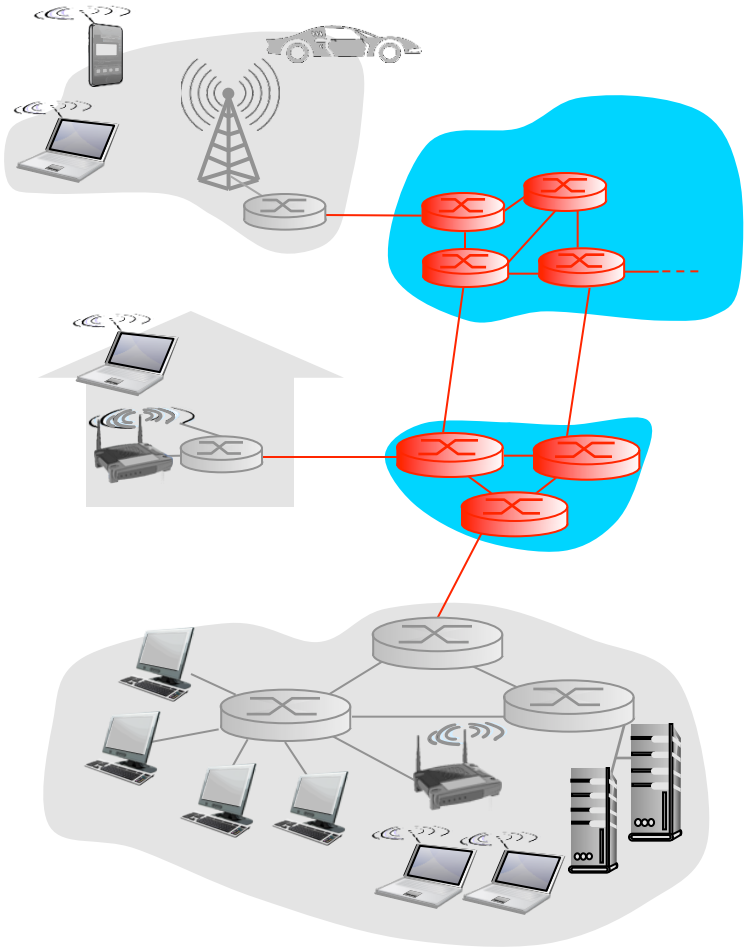
$(1/10)^{10}*(9/10)^{25}$

* Check out the online interactive exercises for more examples

The network core

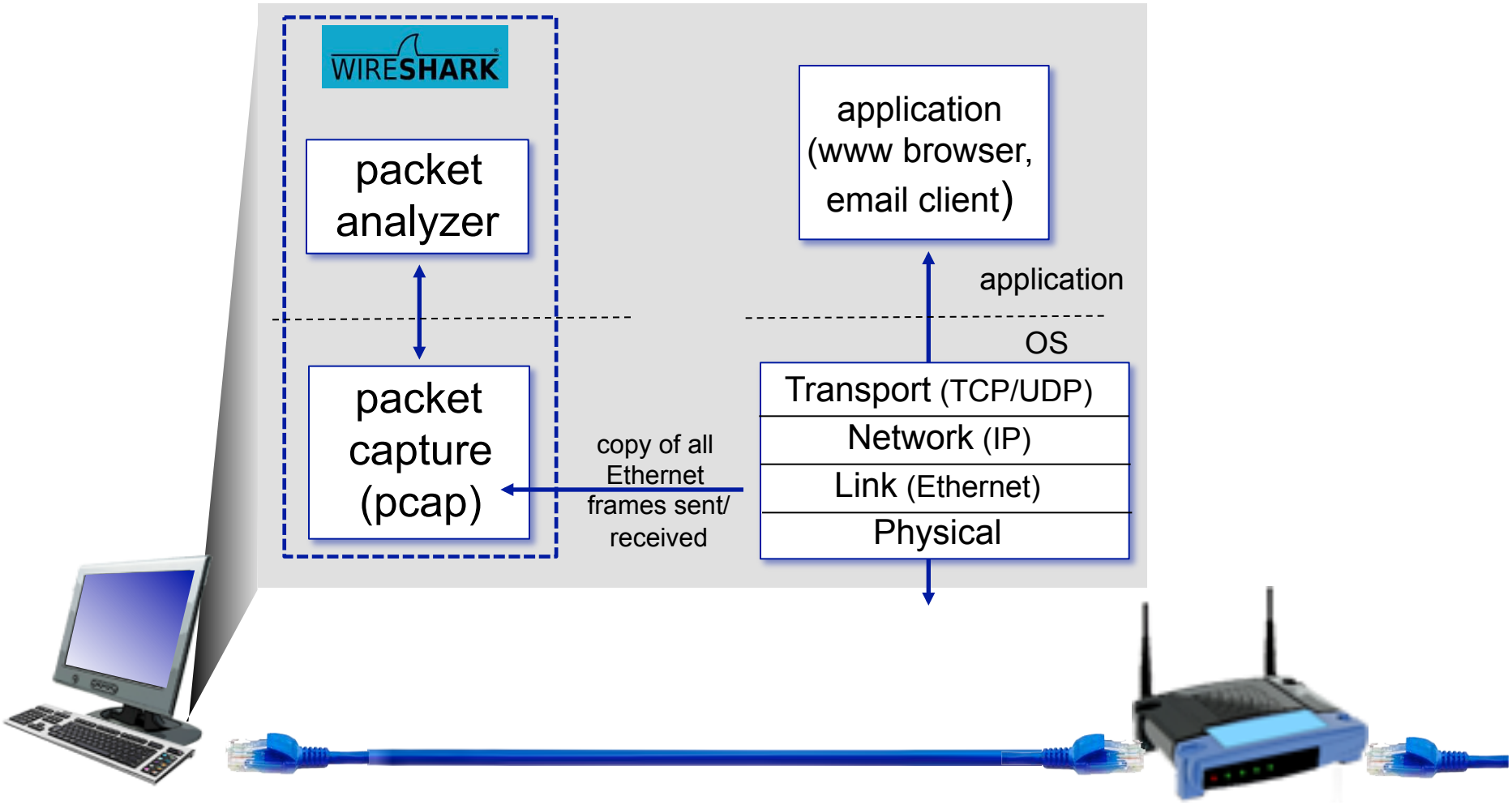
Three key aspects in network core

- Link: Switching, Resource allocation (chp 1.3)
- Node: Routing & Forwarding (to be discussed in Network layer chp 4)
- Network: Network Core Structure / Management / Coordination (chp 1.3)



Lab-assignment 1

http://users.wpi.edu/~yli15/courses/CS3516Fall18A/labs/Lab1/lab1.html


WIRESHARK
packet analyzer
packet capture (pcap)
copy of all Ethernet frames sent/ received
application (www browser, email client)
application
OS
Transport (TCP/UDP)
Network (IP)
Link (Ethernet)
Physical