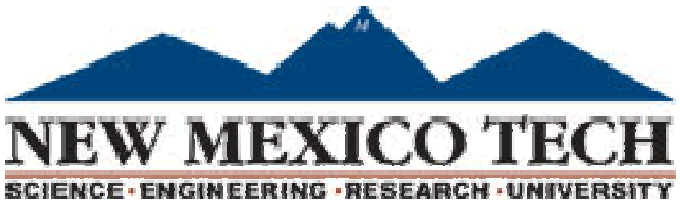
Overview of Computer Networks (1)

Dr. Jun Zheng

CSE353 Intro to Comptuer Networks

8/19/2021



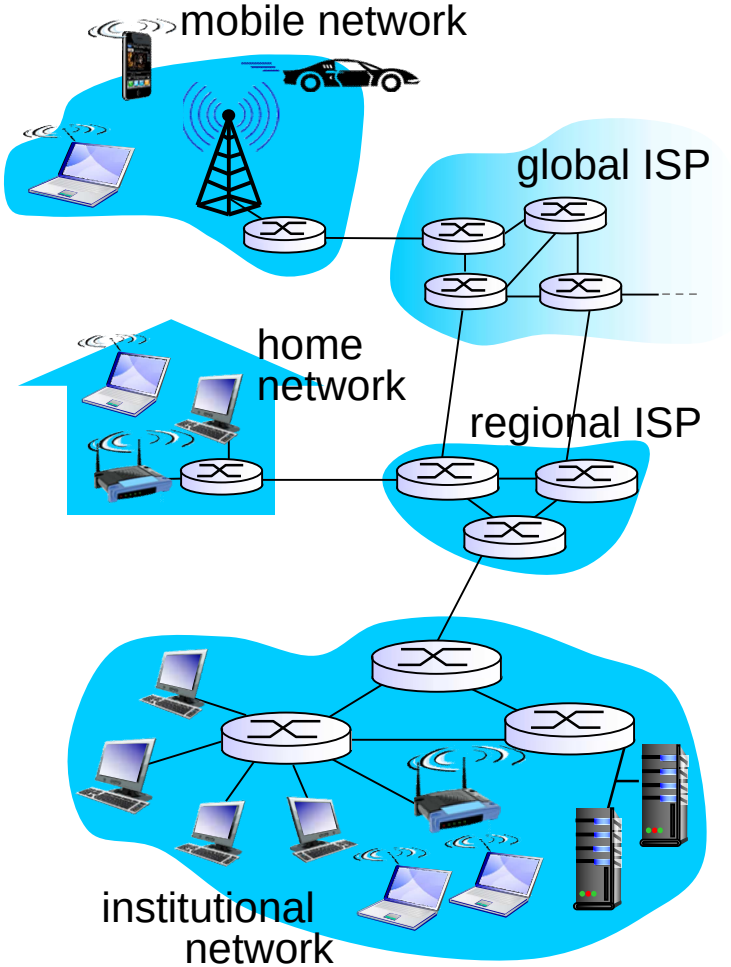
Wireshark Lab 1

- In this first Wireshark lab, you'll get acquainted with Wireshark, and make some simple packet captures and observations.
- Answer the lab questions and upload your answer in Canvas.
- Due 8/26 before class.

NEW MEXICO TECH
SCIENCE · ENGINEERING · RESEARCH · UNIVERSITY

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



NEW MEXICO TECH
SCIENCE · ENGINEERING · RESEARCH · UNIVERSITY

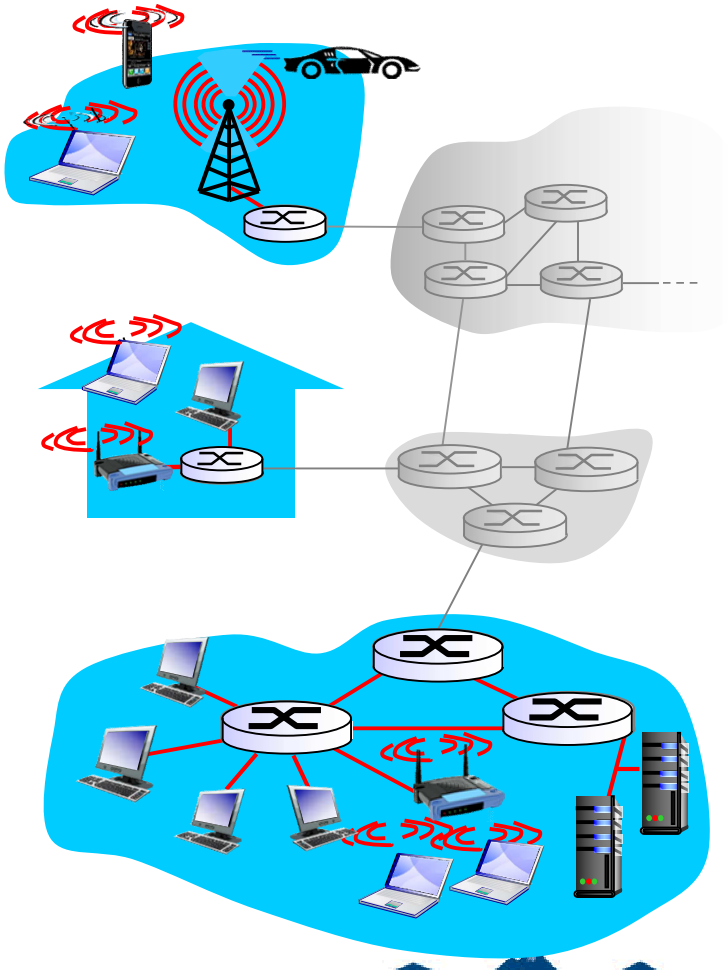
Access Networks and Physical Media

Q: How to connect end systems to edge router?

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

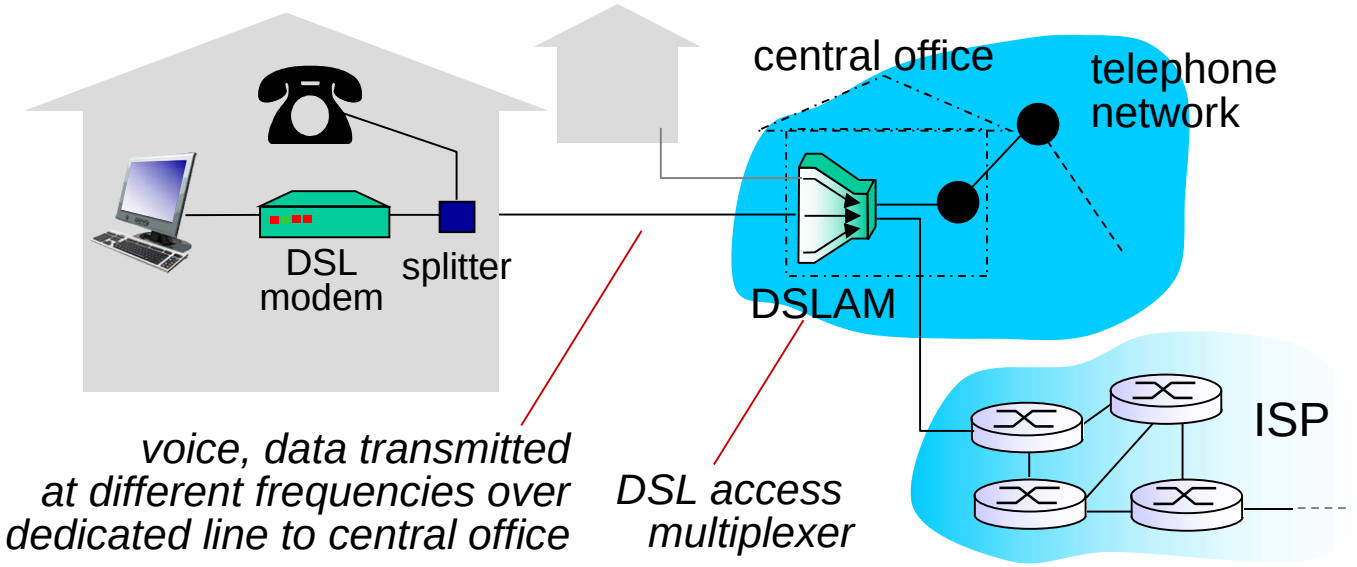
keep in mind:

- bandwidth (bits per second) of access network?
- shared or dedicated?



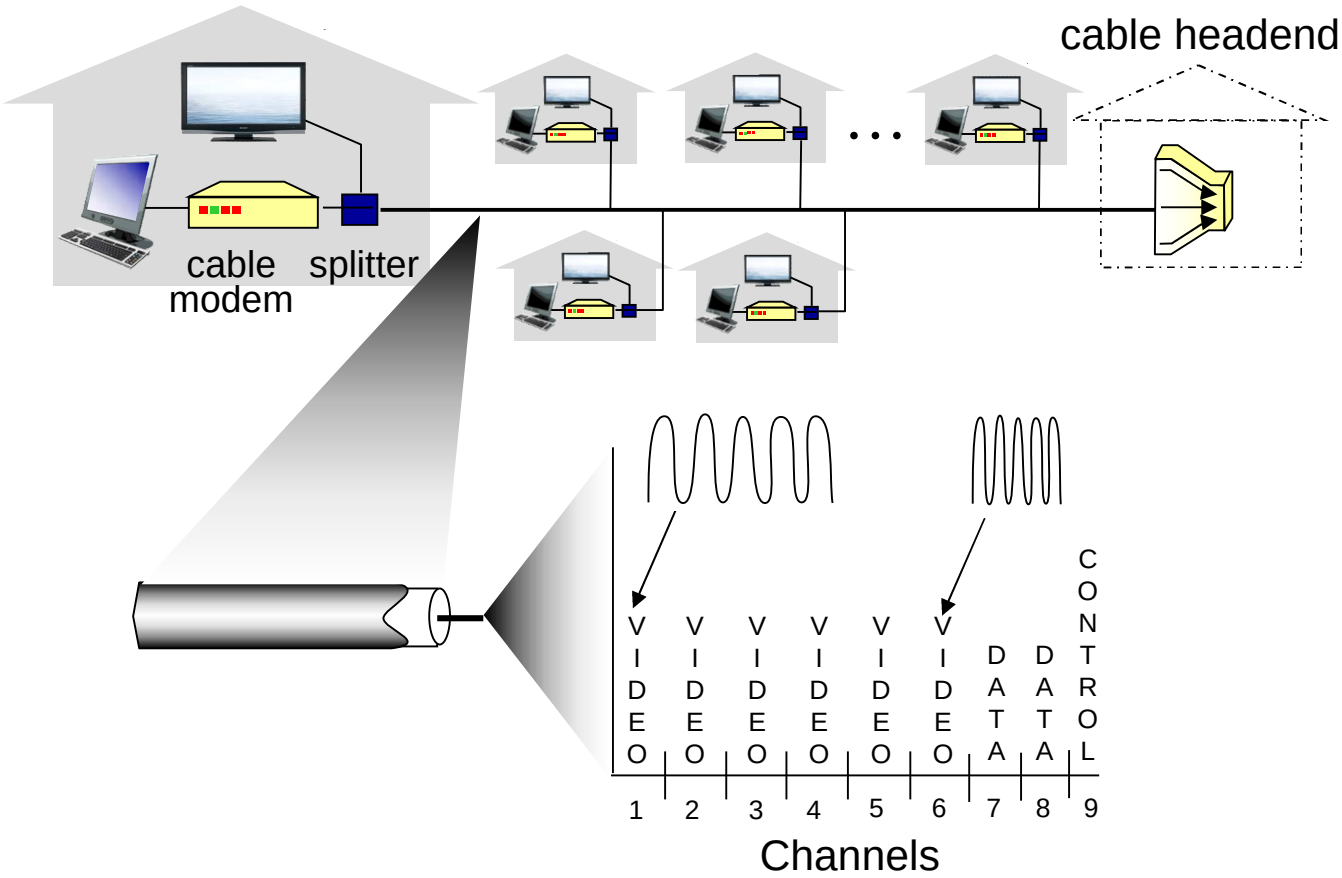
NEW MEXICO TECH
SCIENCE · ENGINEERING · RESEARCH · UNIVERSITY

Access Net: Digital Subscriber Line (DSL)



- use *existing* telephone line to central office DSLAM
  - data over DSL phone line goes to Internet
  - voice over DSL phone line goes to telephone net
- < 2.5 Mbps upstream transmission rate (typically < 1 Mbps)
- < 24 Mbps downstream transmission rate (typically < 10 Mbps)

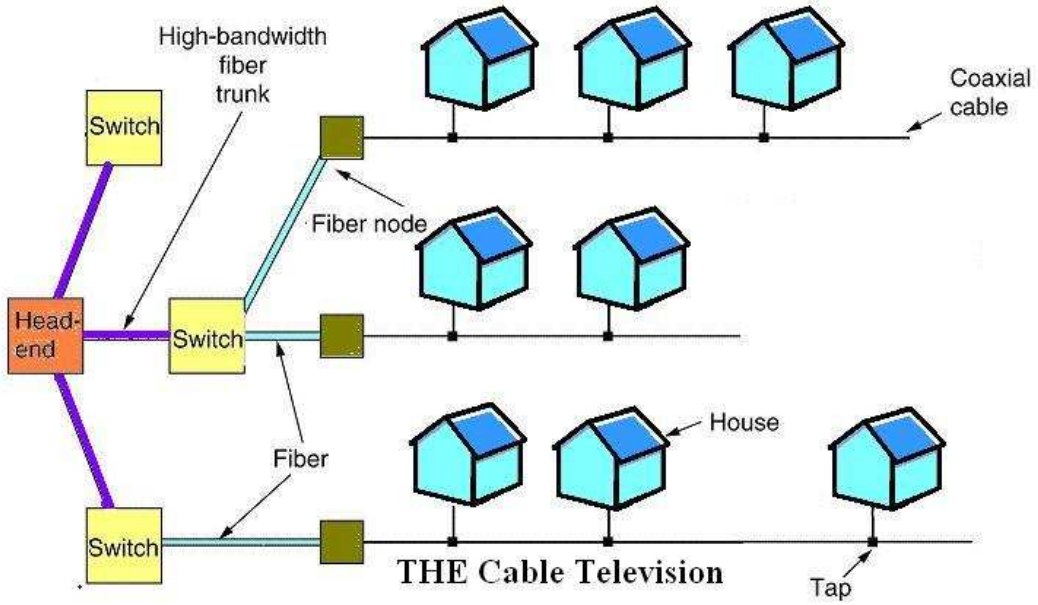
Access Net: Cable Network



- *frequency division multiplexing:* different channels transmitted in different frequency bands

NEW MEXICO TECH
SCIENCE · ENGINEERING · RESEARCH · UNIVERSITY

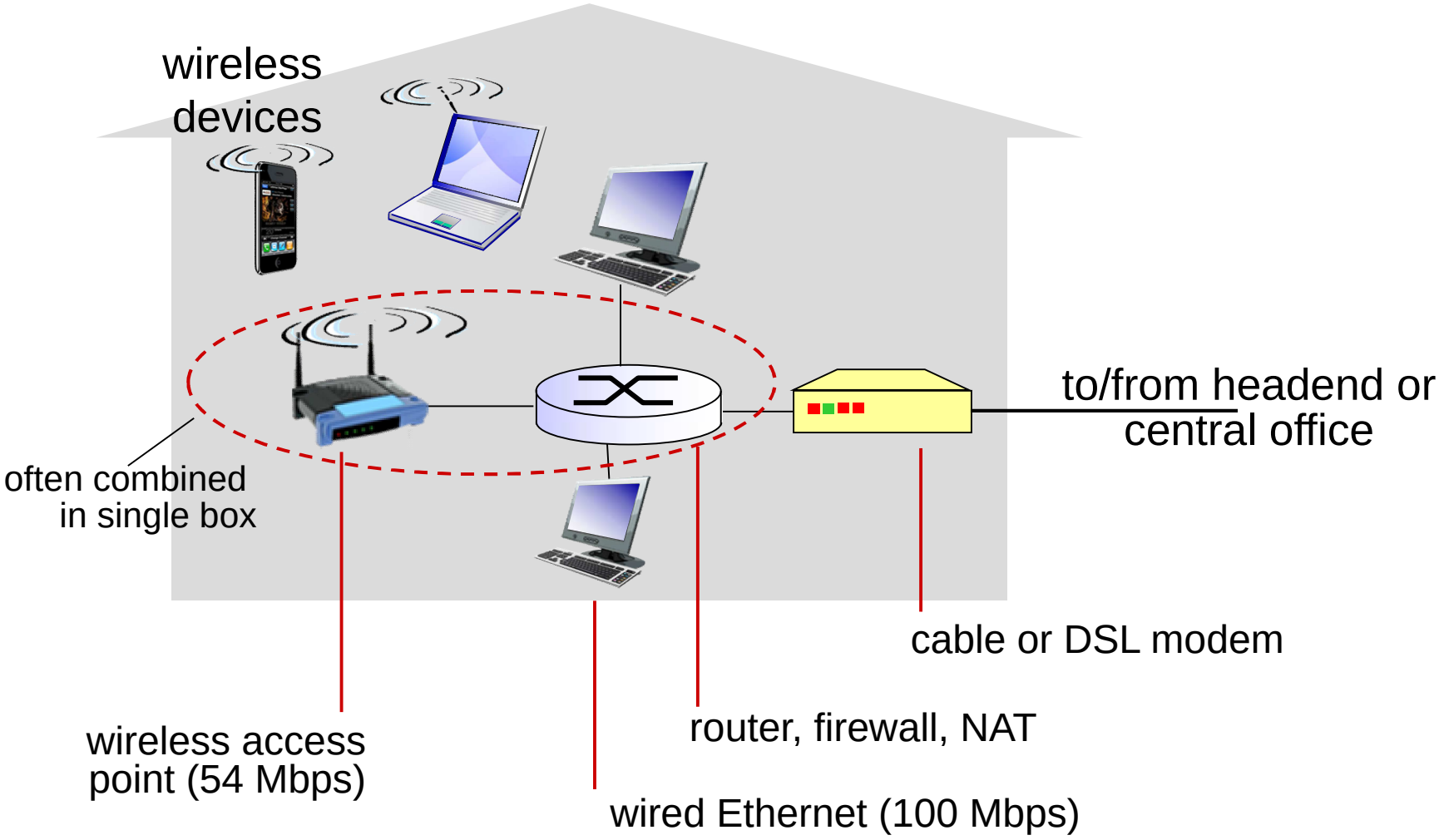
Access Net: Cable Network



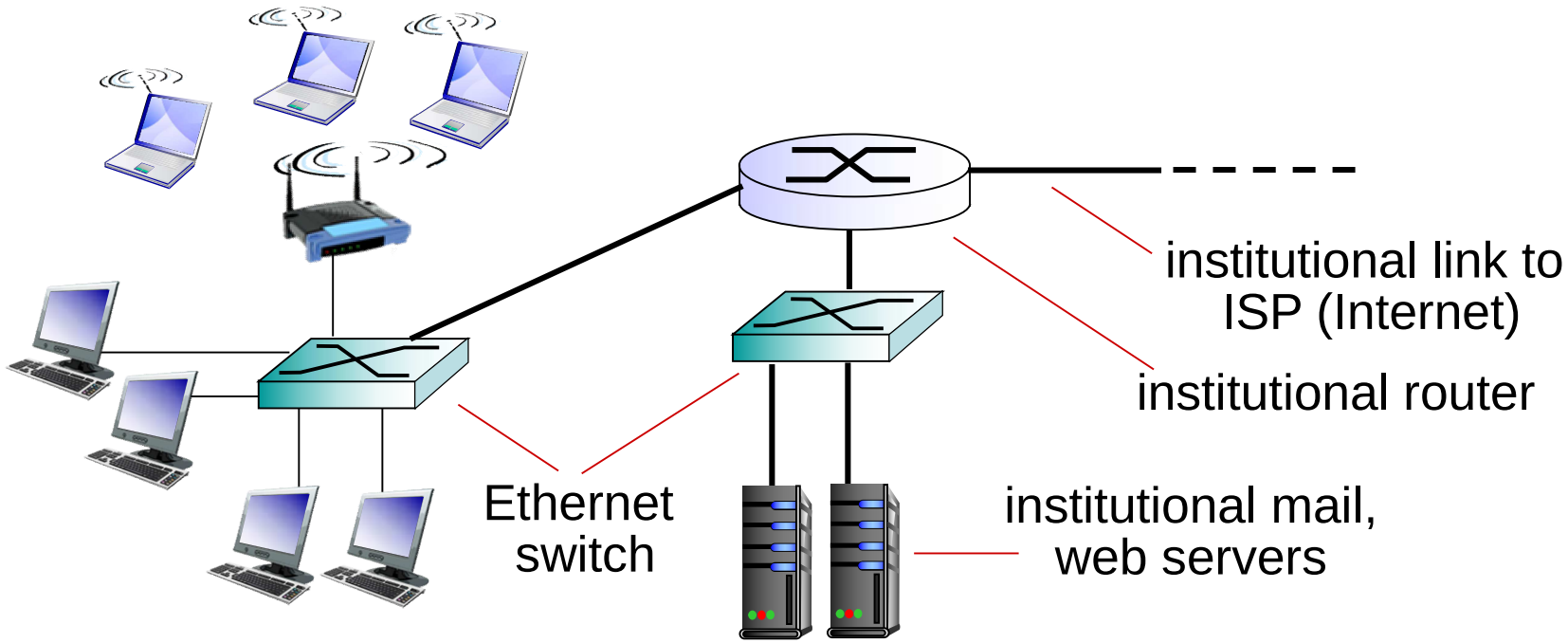
- HFC: hybrid fiber coax
  - asymmetric: up to 30Mbps downstream transmission rate, 2 Mbps upstream transmission rate

NEW MEXICO TECH
SCIENCE · ENGINEERING · RESEARCH · UNIVERSITY

Access Net: Home Network



Enterprise Access Networks (Ethernet)



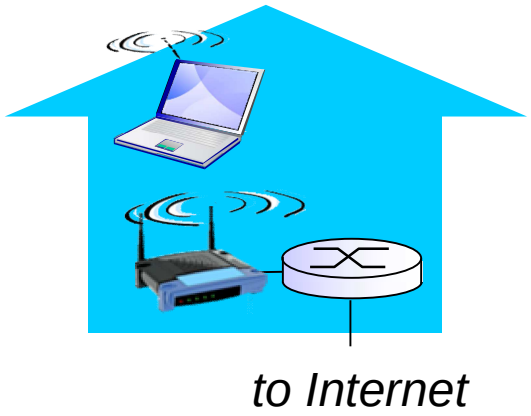
- typically used in companies, universities, etc
  - 10 Mbps, 100Mbps, 1Gbps, 10Gbps transmission rates
  - today, end systems typically connect into Ethernet switch

Wireless Access Networks

- shared *wireless* access network connects end system to router
  - via base station aka "access point"

wireless LANs:

- within building (100 ft)
- 802.11b/g (WiFi): 11, 54 Mbps transmission rate



wide-area wireless access

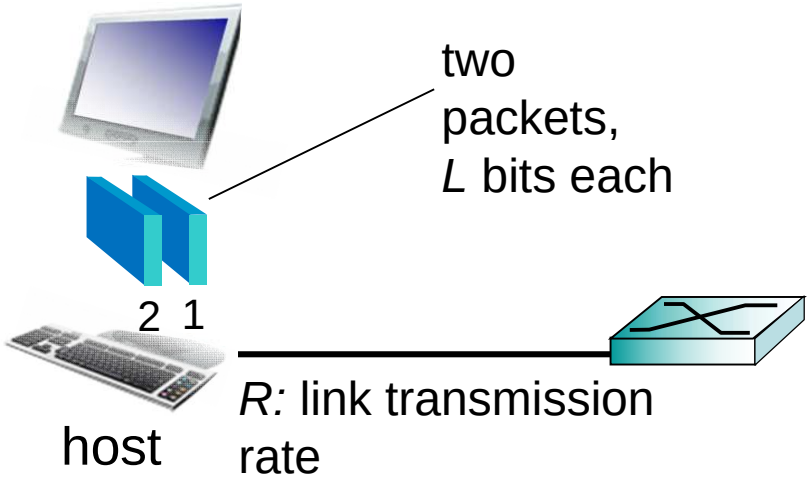
- provided by telco (cellular) operator, 10's km
- between 1 and 10 Mbps
- 3G, 4G: LTE

NEW MEXICO TECH
SCIENCE · ENGINEERING · RESEARCH · UNIVERSITY

Host: Send 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*



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

NEW MEXICO TECH
SCIENCE · ENGINEERING · RESEARCH · UNIVERSITY

Physical Media

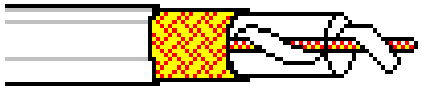
- bit: propagates between transmitter/receiver pairs
- physical link: what lies between transmitter & receiver
- guided media:
  - signals propagate in solid media: copper, fiber, coax
- unguided media:
  - signals propagate freely, e.g., radio

- twisted pair (TP)
  - two insulated copper wires
    - Category 5: 100 Mbps, 1 Gpbs Ethernet
    - Category 6: 10Gbps

Physical Media: Coax, Fiber

coaxial cable:

- two concentric copper conductors
- bidirectional
- broadband:
  - multiple channels on cable
  - HFC



fiber optic cable:

- glass fiber carrying light pulses, each pulse a bit
- high-speed operation:
  - high-speed point-to-point transmission (e.g., 10's-100's Gpbs transmission rate)
- low error rate:
  - repeaters spaced far apart
  - immune to electromagnetic noise

Physical Media: Radio

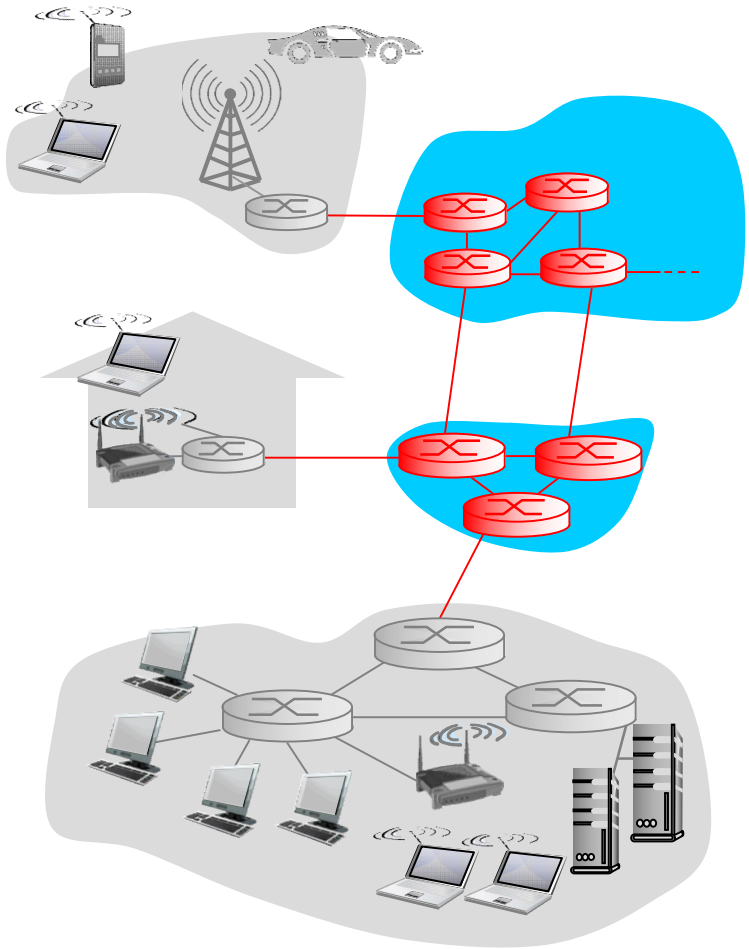
- signal carried in electromagnetic spectrum
- no physical "wire"
- bidirectional
- propagation environment effects:
  - reflection
  - obstruction by objects
  - interference

radio link types:

- terrestrial microwave
  - e.g. up to 45 Mbps channels
- LAN (e.g., WiFi)
  - 11Mbps, 54 Mbps
- wide-area (e.g., cellular)
  - 3G cellular: ~ few Mbps
- satellite
  - Kbps to 45Mbps channel (or multiple smaller channels)
  - 270 msec end-end delay
  - geosynchronous versus low altitude

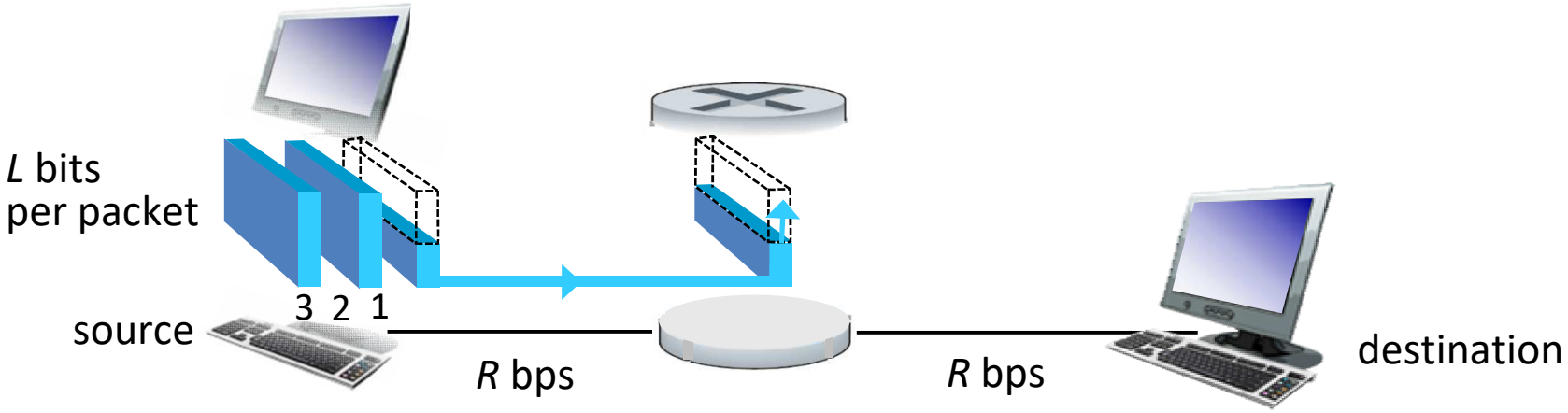
The Network Core

- mesh of interconnected routers
- packet-switching: hosts break application-layer messages into *packets*
  - forward packets from one router to the next, across links on path from source to destination
  - each packet transmitted at full link capacity



NEW MEXICO TECH
SCIENCE · ENGINEERING · RESEARCH · UNIVERSITY

Pakcet-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

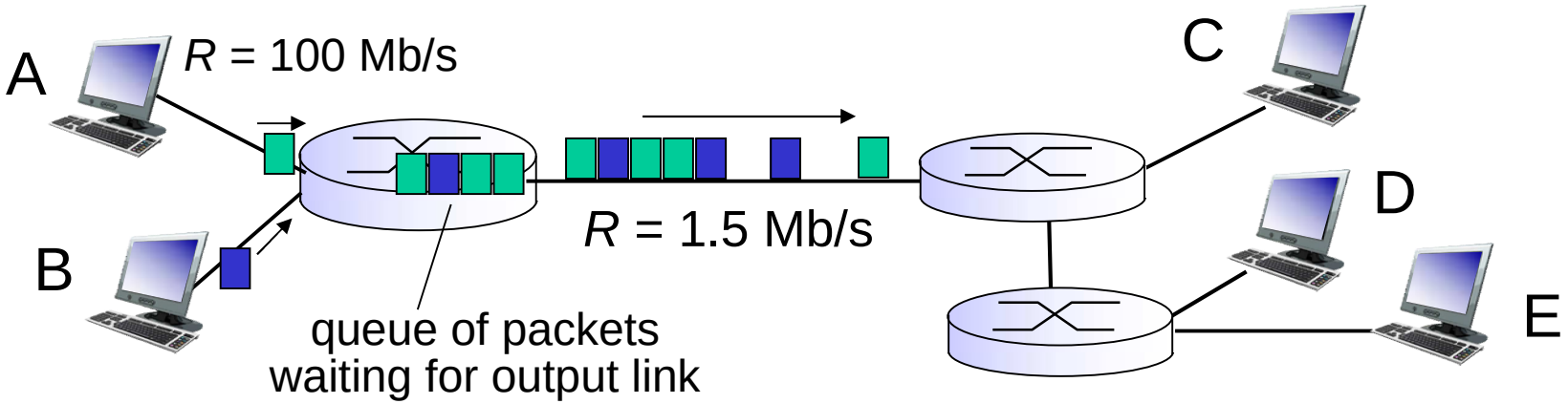
one-hop numerical example:

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

end-end delay = $2L/R$ (assuming zero propagation delay) } more on delay shortly …

NEW MEXICO TECH
SCIENCE · ENGINEERING · RESEARCH · UNIVERSITY

Packet-Switching: Queuing Delay, Loss



queuing and loss:

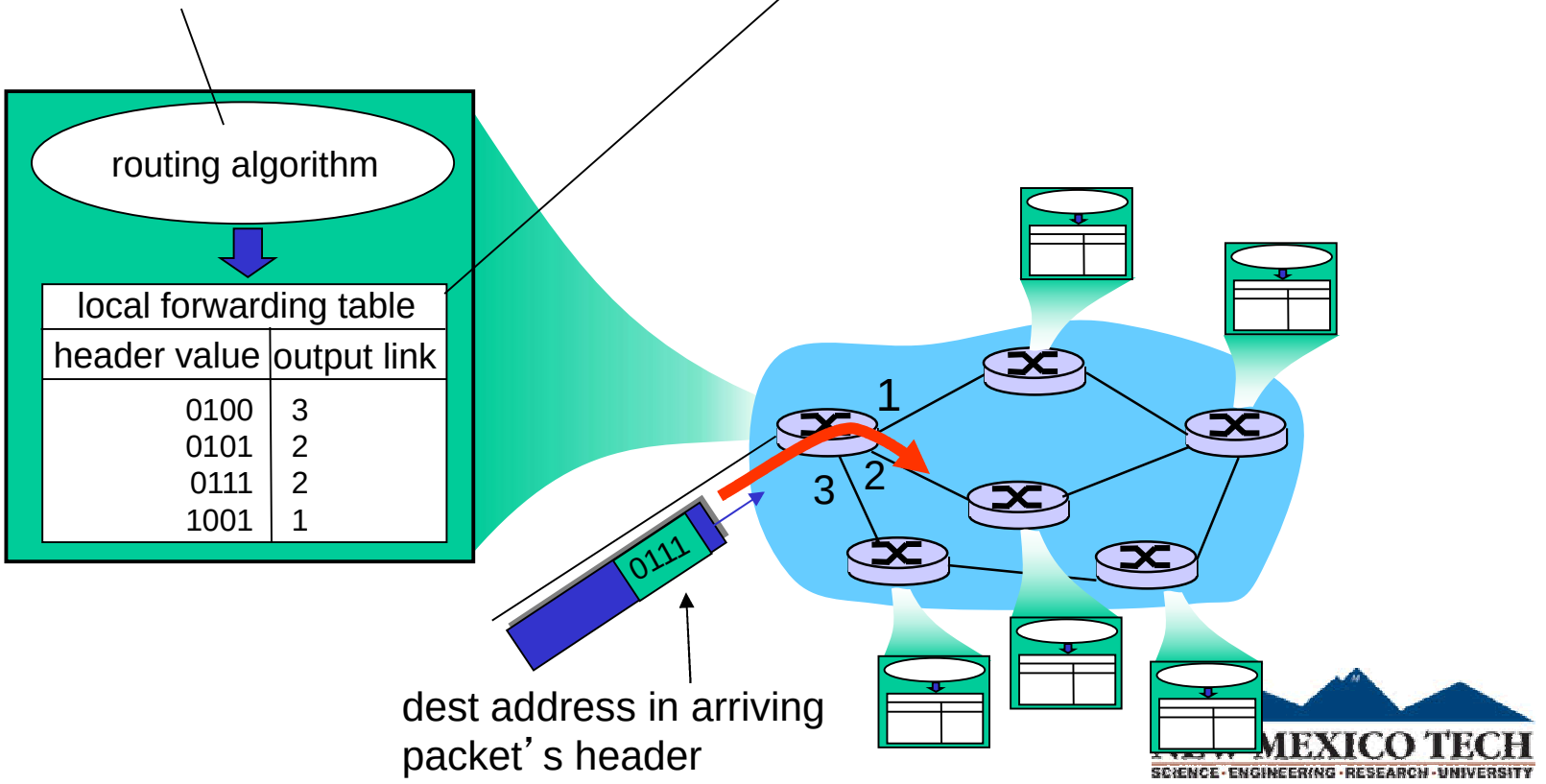
- If arrival rate (in bits) to link exceeds transmission rate of link for a period of time:
  - packets will queue, wait to be transmitted on link
  - packets can be dropped (lost) if memory (buffer) fills up

Two Key Network Core Functions

routing: determines source-destination route taken by packets

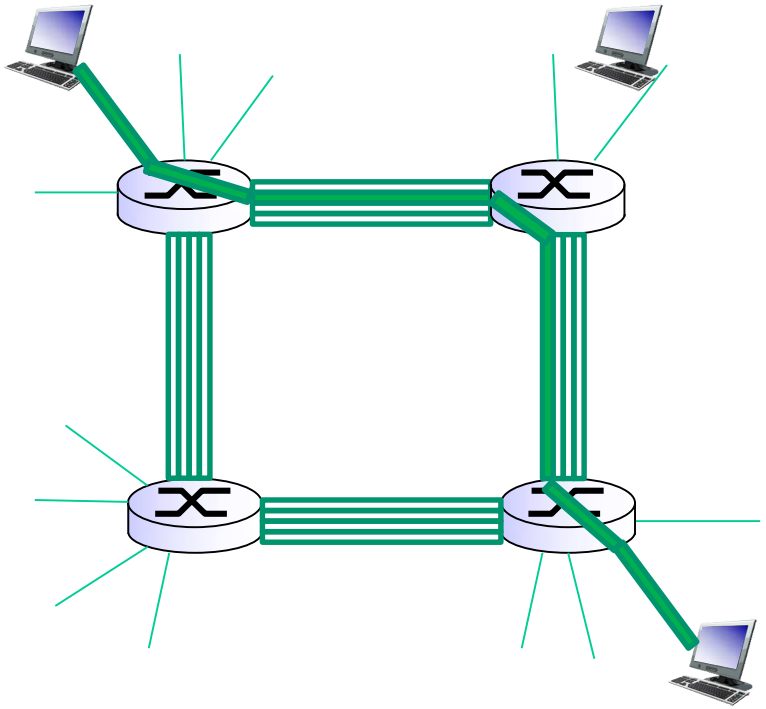
- *routing algorithms*

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



NEW MEXICO TECH
SCIENCE · ENGINEERING · RESEARCH · UNIVERSITY