# COMPUTER NETWORKS

*CSCI 690 – NYIT*

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"Computer networks are like a good joke: if you have to explain it, it’s probably not funny anymore."

# Outline

- Network Design and Setup
- Communication Performance Analysis
- Routing Protocols
- Network Security Fundamentals
- Network Monitoring and Anomaly Detection

# Deliverables

Assignment – 1: QnA(Individual)

Project – 1: Exploring Networks(Individual)

Project – 2: TCP Protocol Behavior(Individual)

Term Project: Research Paper (Group)

Security News Presentation(Group)

# Cybersecurity News & Podcasts

https://public.govdelivery.com/accounts/USDHSCISA/subscriber/new?qsp=CODE_RED

https://www.sans.org/newsletters/

https://thecyberwire.com/podcasts/daily-podcast

https://darknetdiaries.com/




| Event | Contribution |
| --- | --- |
| Projects/Assignments(Individual) | 25 |
| Term Research Project(Group) | 20 |
| Quizzes | 10 |
| Midterm | 20 |
| Final | 25 |
| **Total** | **100** |

# Evaluation

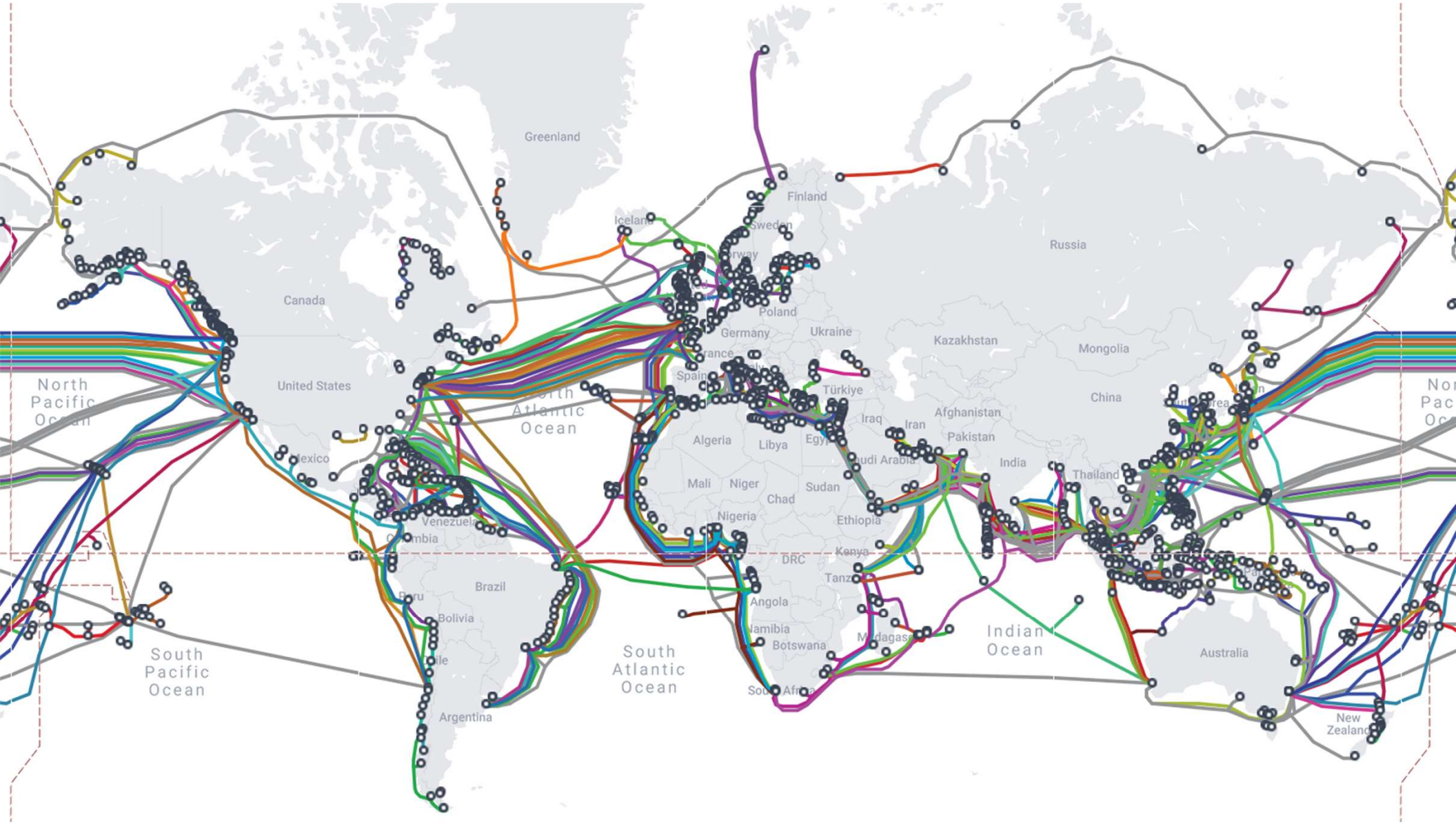
| | |
|---|---|
| A | **Masterful Performance:** The student demonstrates a profound understanding of cybersecurity concepts, exhibiting exceptional mastery of theoretical and practical applications. They consistently demonstrate innovative problem-solving skills, leveraging advanced knowledge to tackle complex security challenges. |
| B | **Proficient Performance:** The student can identify and describe security threats, design effective solutions, and demonstrate good problem-solving skills. However, may require additional guidance to develop more sophisticated problem-solving skills. |
| C | **Needs Improvement:** The student demonstrates a limited understanding of cybersecurity concepts, struggling to apply theoretical knowledge to practical scenarios. They may require additional support and guidance to develop a stronger grasp of security principles and practices. |
| F | **Unsatisfactory Performance:** The student demonstrates little understanding of cybersecurity concepts. They requires extensive remedial instruction to develop a foundational understanding of security principles and practices. |

# Installations

- Wireshark
- VMWare/Virtualbox
- Distro: Linux-based

# Resources

- James F. Kurose and Keith W. Ross, *Computer Networking: A Top-Down Approach*, 8th edition, Pearson, 2020. (7th edition is ok) ISBN-13: 9780135928615.
- William Stallings, *Data and Computer Communications*, 10th edition, Pearson, 2014. ISBN-13: 9780137561704.
- Interactive end-of-chapter exercises, Supplement to Computer Networking: A Top-Down Approach, 8th edition.
- Behrouz A. Forouzan, *Data Communications and Networking*, 5th edition, McGraw Hill, 2012. ISBN-13: 9780073376226.
- A. Leon-Garcia and I. Widjaja, *Communication Networks: Fundamental Concepts and Key Architectures*, 2nd edition, Tata McGraw-Hill, 2004. ISBN-13: 978-0070595019.
- K. P. Murphy, *Probabilistic Machine Learning: An Introduction*. Cambridge, MA, USA: The MIT Press, 2022. ISBN-13: 978-0262046824. https://probml.github.io/pml-book/book1.html


Greenland
Canada
United States
Mexico
Venezuela
Brazil
Peru
Bolivia
Chile
Argentina
Iceland
Finland
Sweden
Poland
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Ukraine
Spain
Türkiye
Algeria
Libya
Egypt
Mali
Niger
Sudan
Chad
Nigeria
Ethiopia
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Botswana
Tanzania
Madagascar
Iraq
Iran
Afghanistan
Pakistan
Saudi Arabia
India
Thailand
Russia
Kazakhstan
Mongolia
China
Australia
New Zealand
North Pacific Ocean
South Pacific Ocean
North Atlantic Ocean
South Atlantic Ocean
Indian Ocean

Number of devices on Internet?

75 Billion, with a ‘B’, by 2026

# Ch – 1 Computer Networks & Internet

# Chapter 1: introduction

*Chapter goal:*

- Get "feel," "big picture," introduction to terminology
  - more depth, detail *later* in course
- Approach:
  - use Internet as example

*Overview/roadmap:*

- What *is* the Internet?
- What *is* a protocol?
- Network edge: hosts, access network, physical media
- Network core: packet/circuit switching, internet structure
- Performance: loss, delay, throughput
- Security
- Protocol layers, service models
- History

# The Internet: a "nuts and bolts" view

Billions of connected computing *devices*:

- *hosts = end systems*
- running *network apps* at Internet's "edge"

*Packet switches*: forward packets (chunks of data)

- *routers*, *switches*

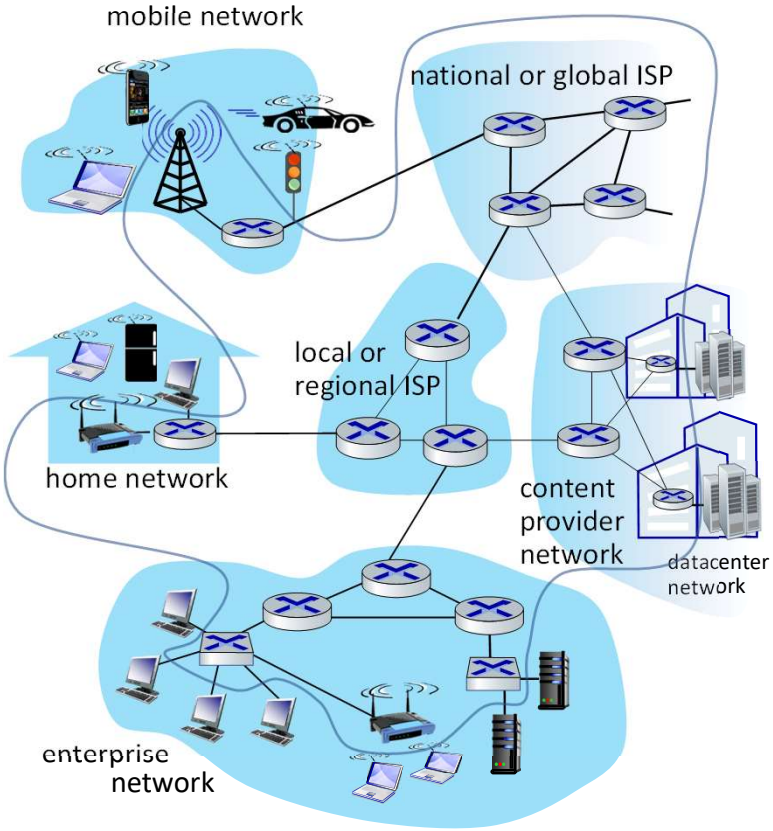
*Communication links*

- fiber, copper, radio, satellite
- transmission rate: *bandwidth*



*Networks*

- collection of devices, routers, links: managed by an organization



# “Fun” Internet-connected devices

Amazon Echo

Internet refrigerator

IP picture frame

Pacemaker & Monitor

Tweet-a-watt: monitor energy use

Web-enabled toaster + weather forecaster

Security Camera

Slingbox: remote control cable TV

AR devices

Internet phones

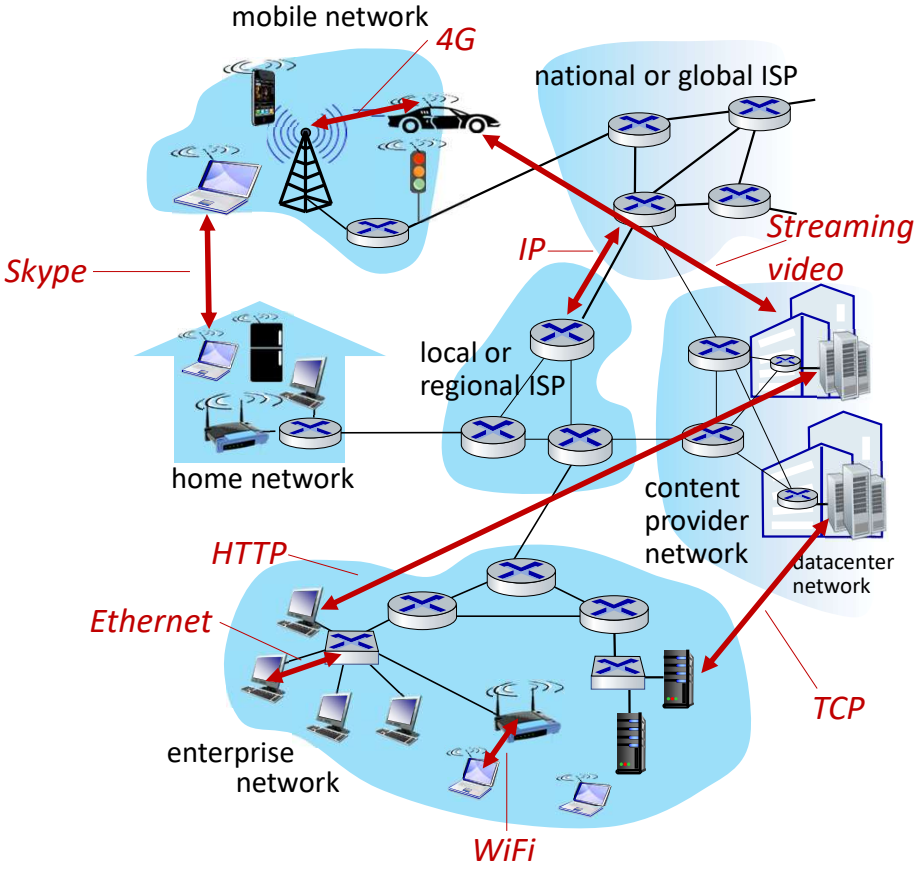
sensorized, bed mattress

Fitbit

*Others?*

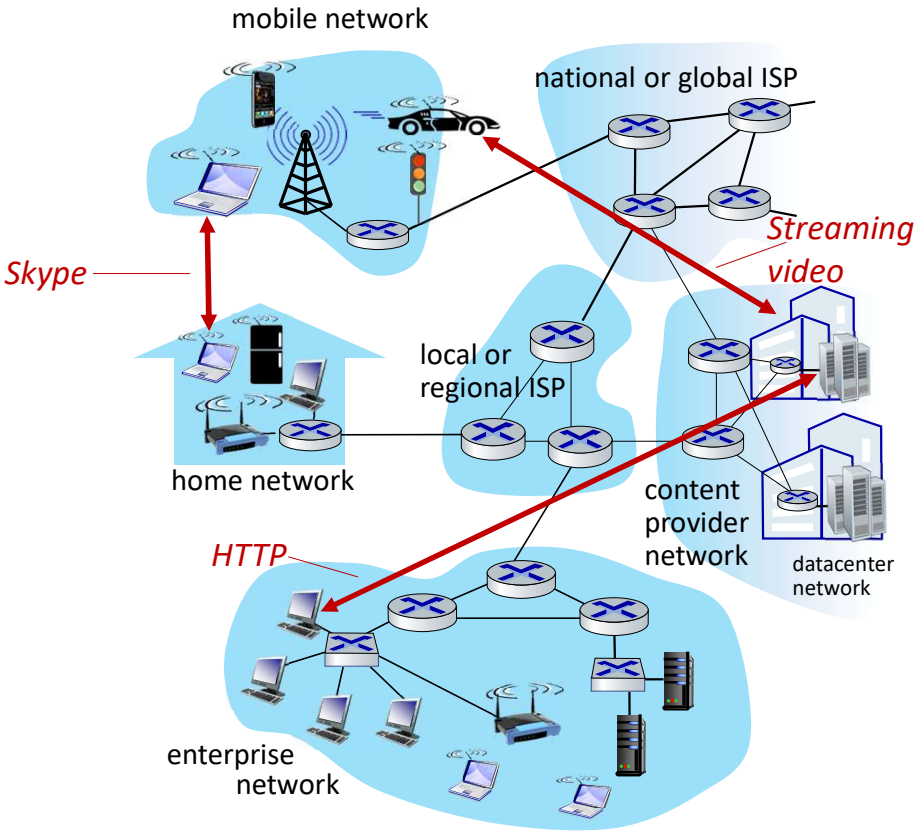
# The Internet: a "nuts and bolts" view

- *Internet:* "network of networks"
  - Interconnected ISPs
- *protocols* are *everywhere*
  - control sending, receiving of messages
  - e.g., HTTP (Web), streaming video, Skype, TCP, IP, WiFi, 4G, Ethernet
- *Internet standards*
  - RFC: Request for Comments
  - IETF: Internet Engineering Task Force



# The Internet: a "service" view

- *Infrastructure* that provides services to applications:
  - Web, streaming video, multimedia teleconferencing, email, games, e-commerce, social media, inter-connected appliances, …
- provides *programming interface* to distributed applications:
  - "hooks" allowing sending/receiving apps to "connect" to, use Internet transport service
  - provides service options, analogous to postal service



# What's a protocol?

*Human protocols:*

- "what's the time?"
- "I have a question"
- introductions

… specific messages sent

… specific actions taken when message received, or other events

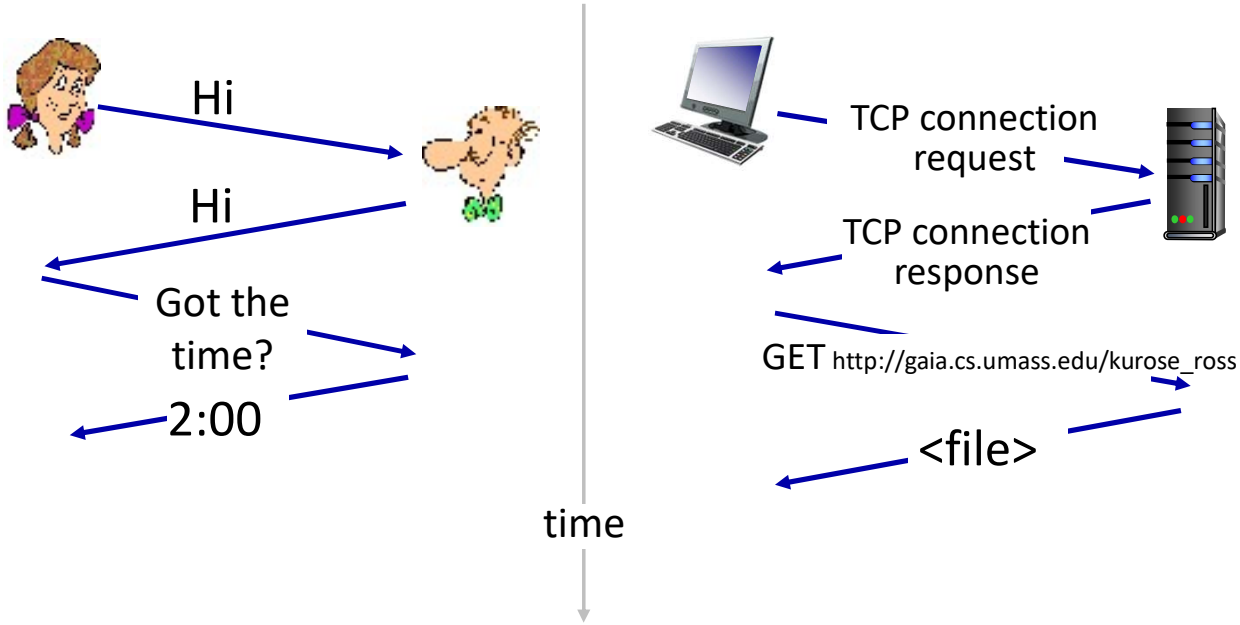
*Network protocols:*

- computers (devices) rather than humans
- all communication activity in Internet governed by protocols

*Protocols define the format, order of messages sent and received among network entities, and actions taken on msg transmission, receipt*

# What's a protocol?

A human protocol and a computer network protocol:




*Q:* other human protocols?

# Chapter 1: roadmap

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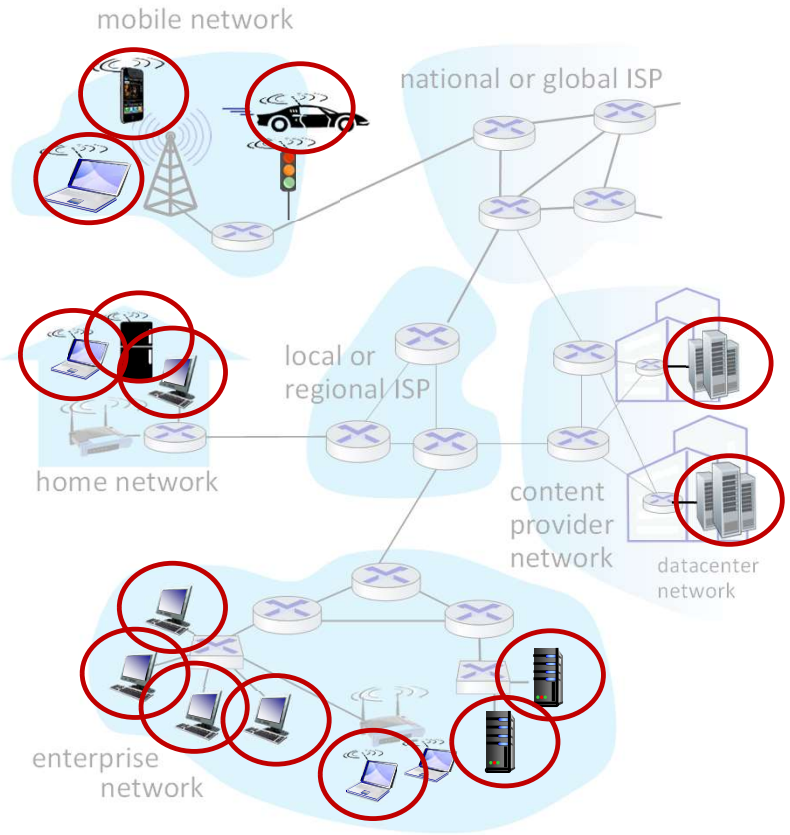
# A closer look at Internet structure

## Network edge:

- hosts: clients and servers
- servers often in data centers



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Network edge:

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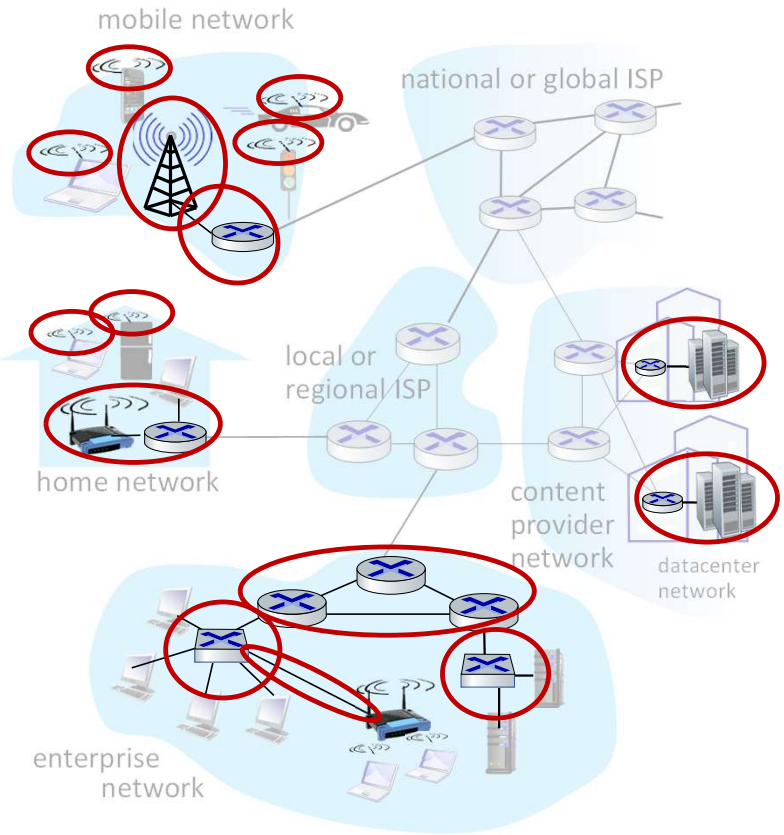
- servers often in data centers

Access networks, physical media:

- wired, wireless communication links



# A closer look at Internet structure

Network edge:

- hosts: clients and servers
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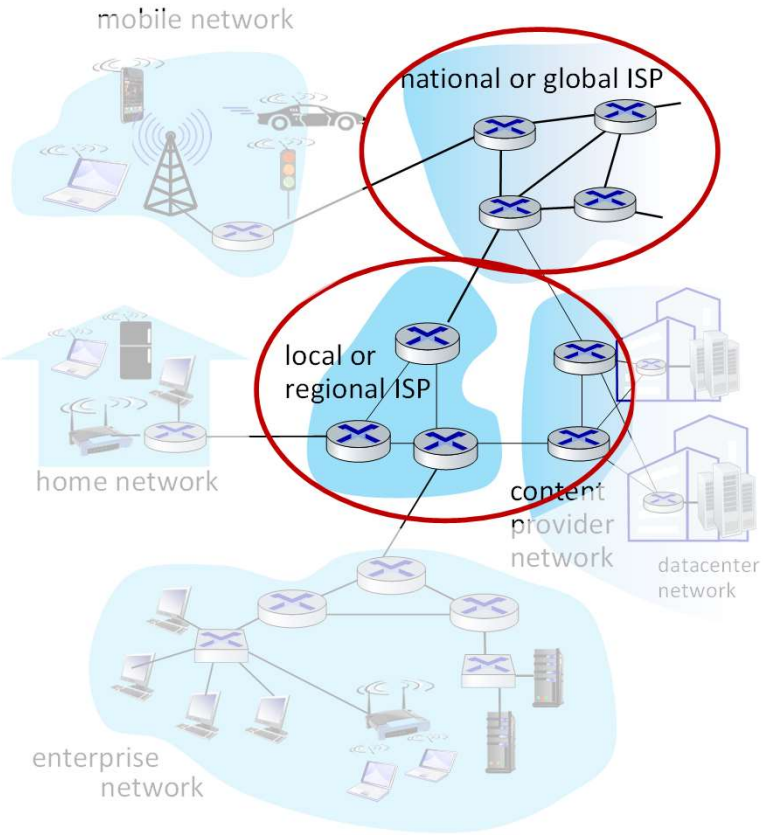
Access networks, physical media:

- wired, wireless communication links

Network core:

- interconnected routers
- network of networks



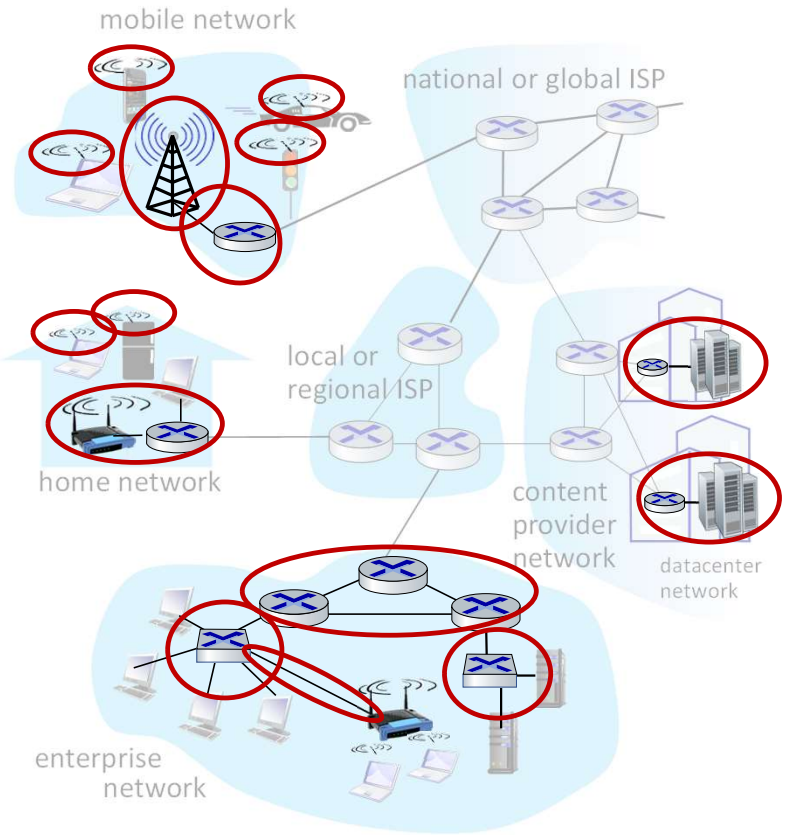
# Access networks and physical media

*Q: How to connect end systems to edge router?*

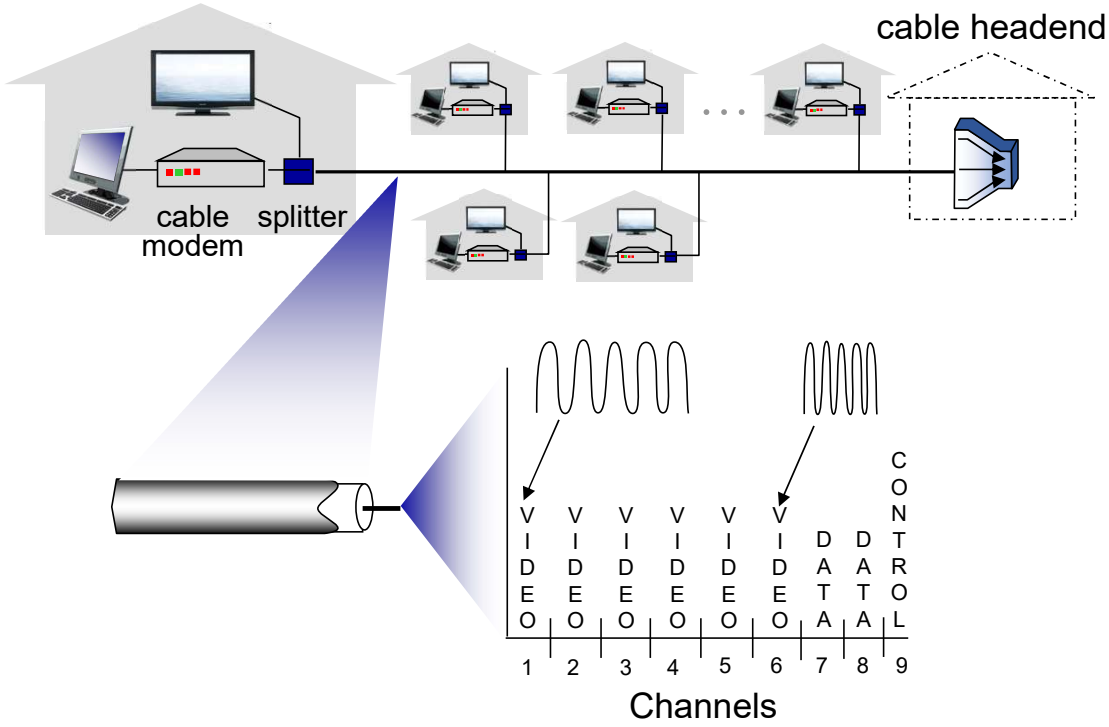
- residential access nets
- institutional access networks (school, company)
- mobile access networks (WiFi, 4G/5G)

*What to look for:*

- transmission rate (bits per second) of access network?
- shared or dedicated access among users?

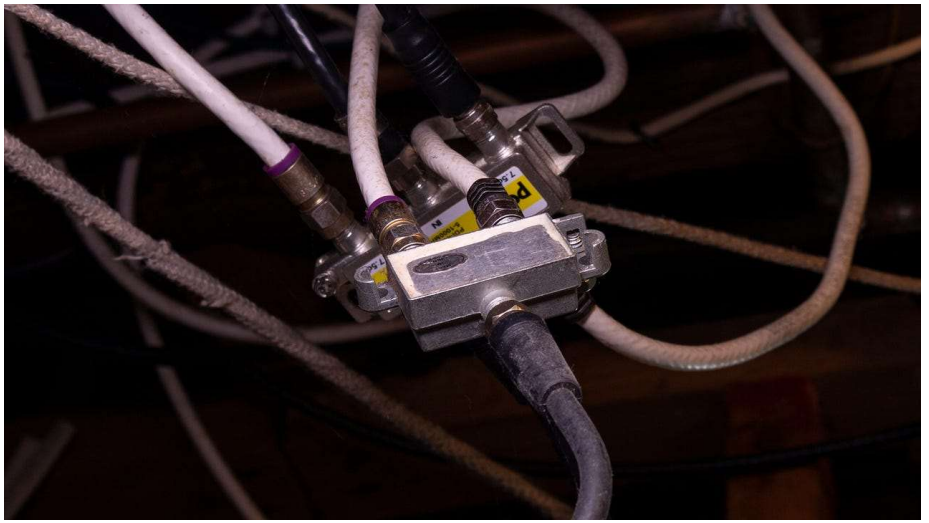


# Access networks: cable-based access




*frequency division multiplexing (FDM):* different channels transmitted in different frequency bands


Y15B
MG



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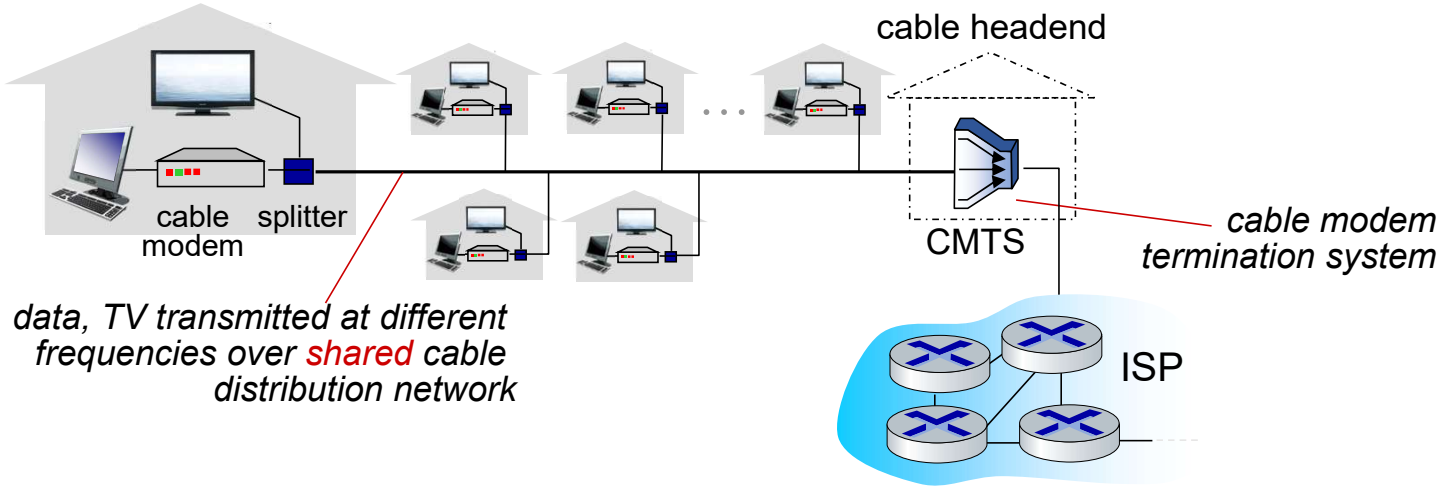
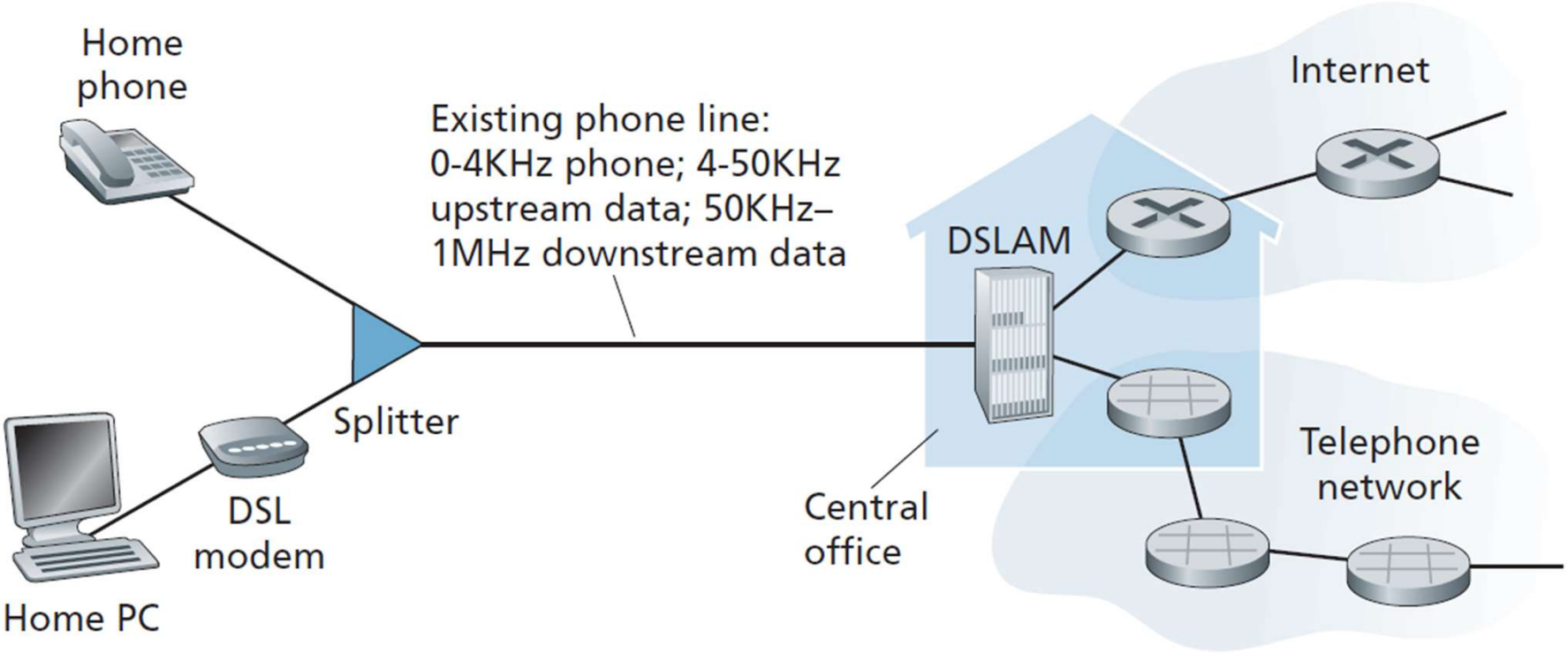
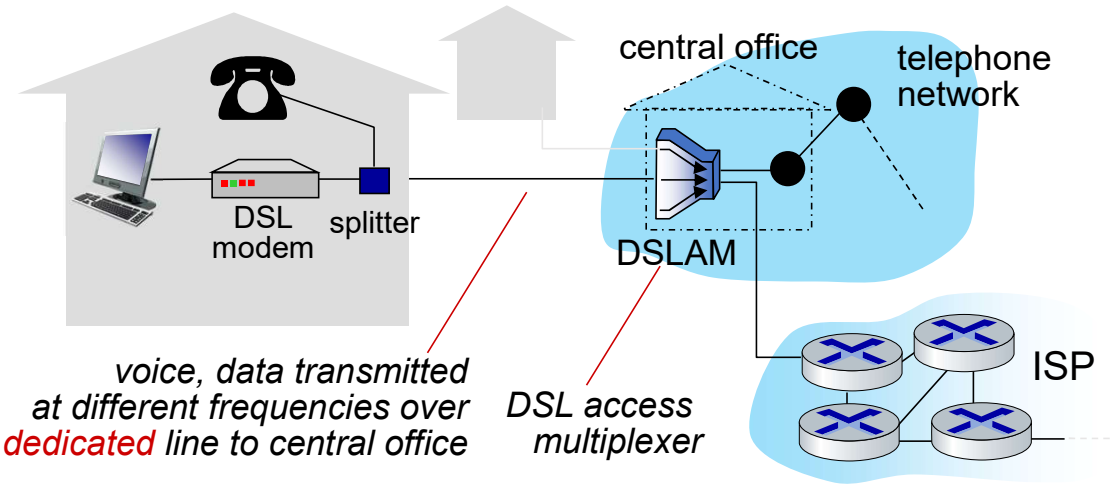



- HFC: hybrid fiber coax
  - asymmetric: up to 40 Mbps – 1.2 Gbs downstream transmission rate, 30-100 Mbps upstream transmission rate
- network of cable, fiber attaches homes to ISP router
  - homes *share access network* to cable headend

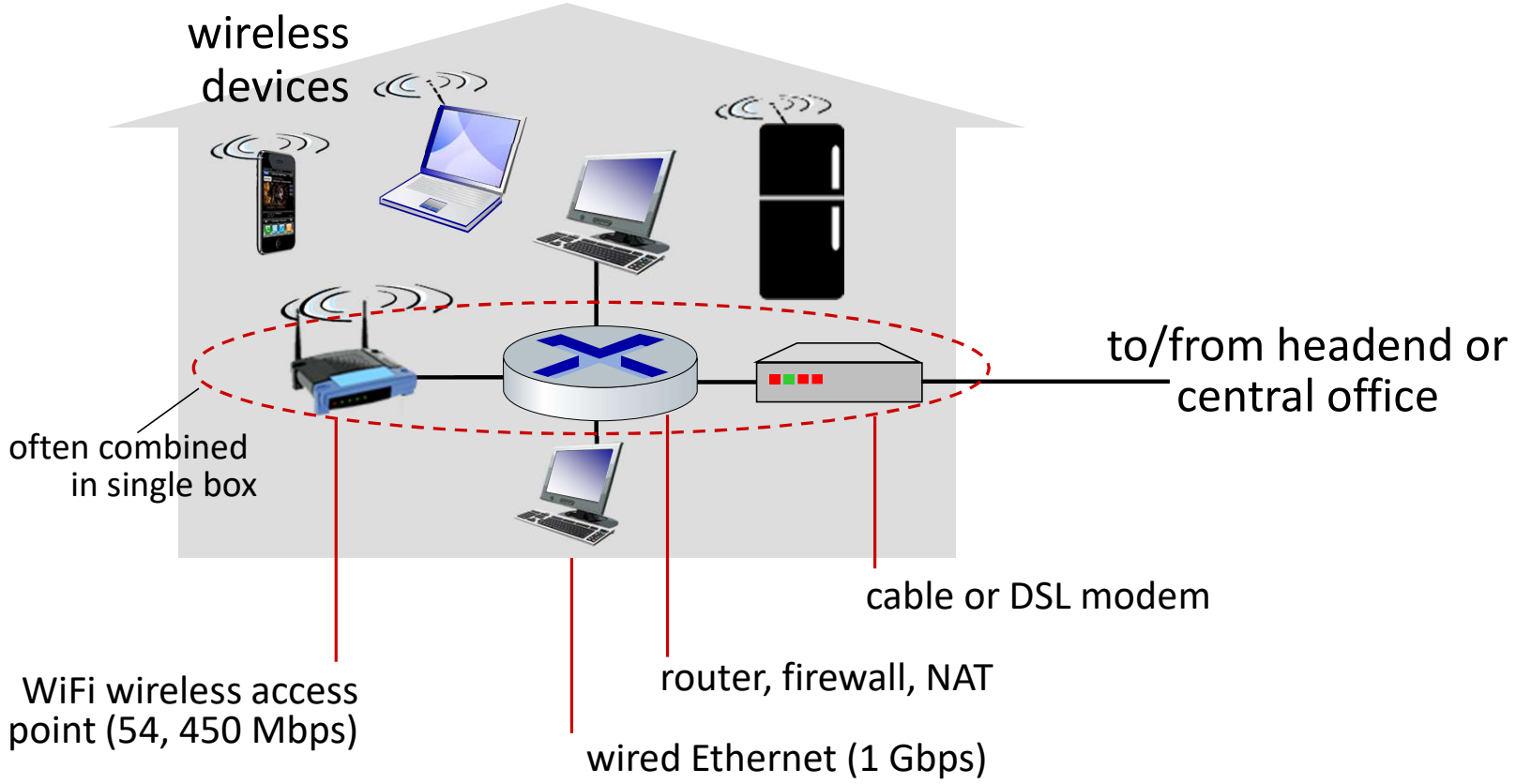

Home
phone
Existing phone line:
0-4KHz phone; 4-50KHz
upstream data; 50KHz–
1MHz downstream data
Internet
DSLAM
Splitter
DSL
modem
Home PC
Central
office
Telephone
network

# Access networks: 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
- 24-52 Mbps dedicated downstream transmission rate
- 3.5-16 Mbps dedicated upstream transmission rate

# Access networks: home networks



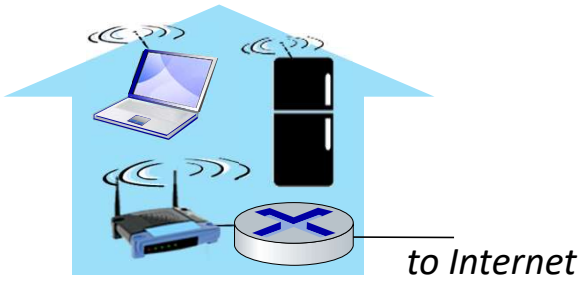
# Wireless access networks

Shared *wireless* access network connects end system to router

- via base station aka “access point”

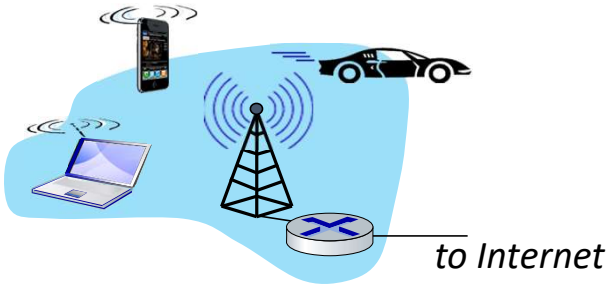
## Wireless local area networks (WLANs)

- typically within or around building (~100 ft)
- 802.11b/g/n (WiFi): 11, 54, 450 Mbps transmission rate

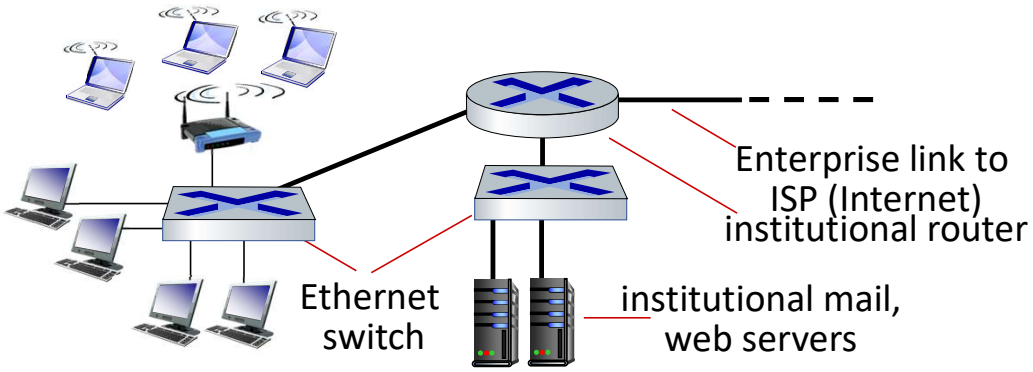



## Wide-area cellular access networks

- provided by mobile, cellular network operator (10’s km)
- 10’s Mbps
- 4G/5G cellular networks



# Access networks: enterprise networks

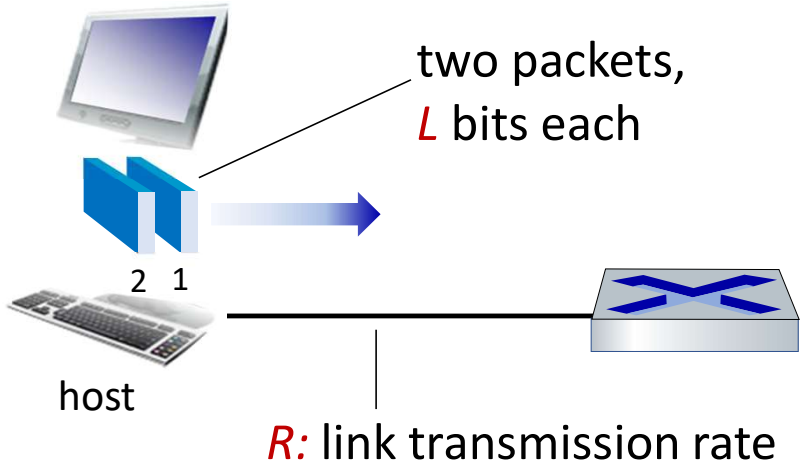



- companies, universities, etc.
- mix of wired, wireless link technologies, connecting a mix of switches and routers (we'll cover differences shortly)
  - Ethernet: wired access at 100Mbps, 1Gbps, 10Gbps
  - WiFi: wireless access points at 11, 54, 450 Mbps

# 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*



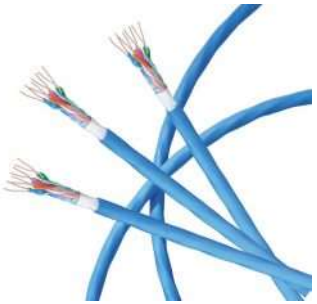

$$\text{packet transmission delay} = \text{time needed to transmit } L\text{-bit packet into link} = \frac{L \text{ (bits)}}{R \text{ (bits/sec)}}$$

# Links: 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 Gbps Ethernet
  - Category 6: 10Gbps Ethernet



# Links: physical media

## Coaxial cable:

- two concentric copper conductors
- bidirectional
- broadband:
  - multiple frequency channels on cable
  - 100's Mbps per channel

## Fiber optic cable:

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

# References


- https://gaia.cs.umass.edu/kurose_ross/wireshark.php
- Submarine Cable: https://www.submarinecablemap.com/
- NSA Top Secret Document: https://media.defense.gov/2021/Jul/15/2002763650/-1/-1/0/GREAT%20SEAL%20BUG.PDF/GREAT%20SEAL%20BUG.PDF