# CS 118 Discussion Week 1: A Brief Introduction to Networking



Slides by Eric Newberry (UCLA)

Winter 2021

# TA Introduction

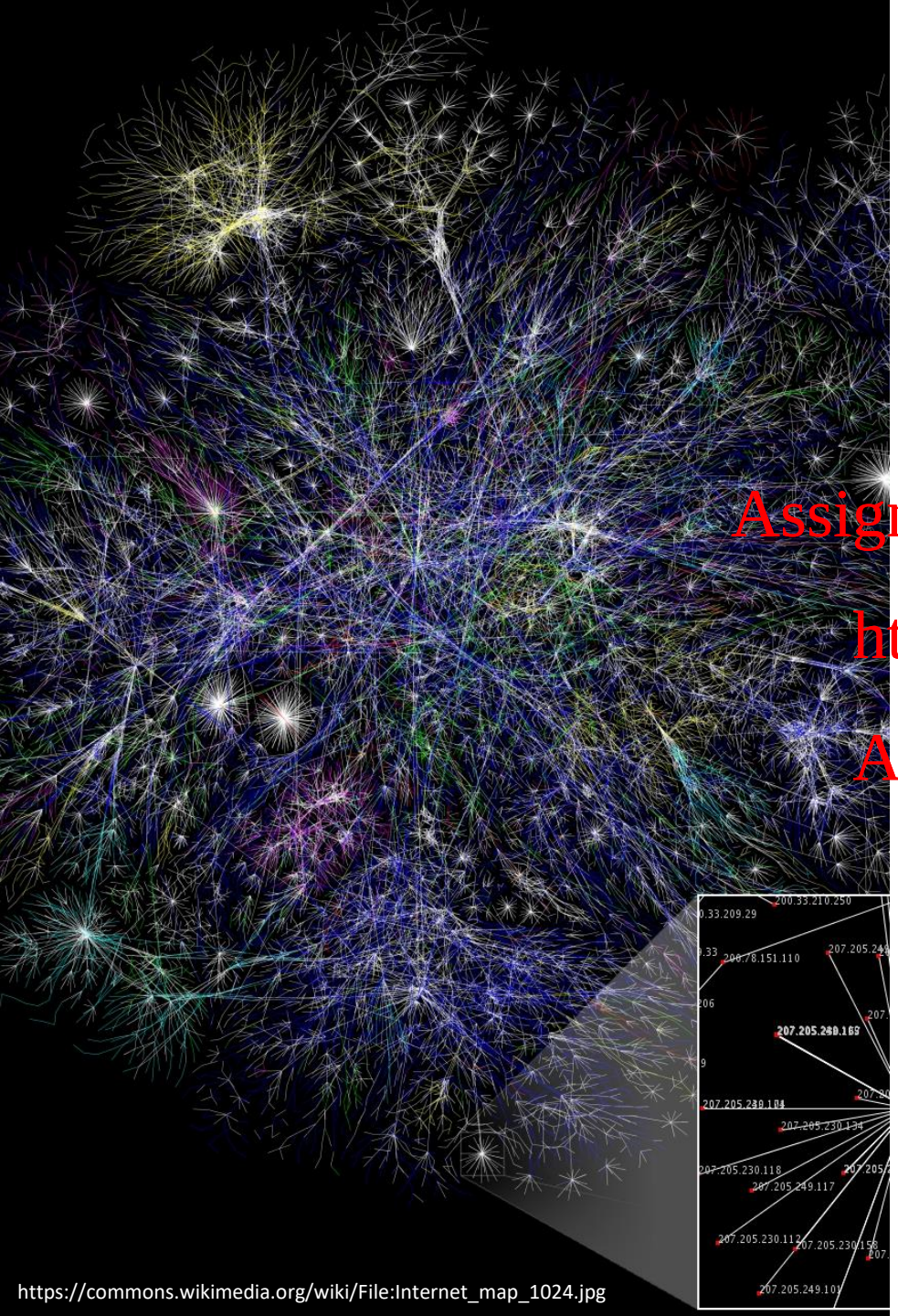
- Education
  - Ph.D. in Computer Science, UCLA, Started in January 2020
  - M.S. in Computer Science and Engineering, University of Michigan, 2020
  - B.S. in Computer Science, University of Arizona, 2018
- Research
  - Named Data Networking (NDN) with Prof. Lixia Zhang
  - Focusing on efficient packet forwarding implementations for NDN
  - Prior work on caching in NDN, software-defined NDN, and automotive network security (at Arizona and Michigan)
- Outside activities (aka when I'm not working or in class)
  - I read about history, read science fiction, and play video games of all sorts

# Course Logistics

- My office hours are Wednesdays, 3-5pm PST
  - https://ucla.zoom.us/j/99586525253?pwd=RVJ4Nzl6QVVMSE9zR0RKbW94ZitxQT09
- Email: enewberry@cs.ucla.edu
  - If it requires an immediate response, please CC the professor (gpau@cs.ucla.edu) and the other TA (idellaverson@gmail.com)

# Course Introductions

- Name
- Major
- Year
- (optional) What's been your go to pastime in lockdown?

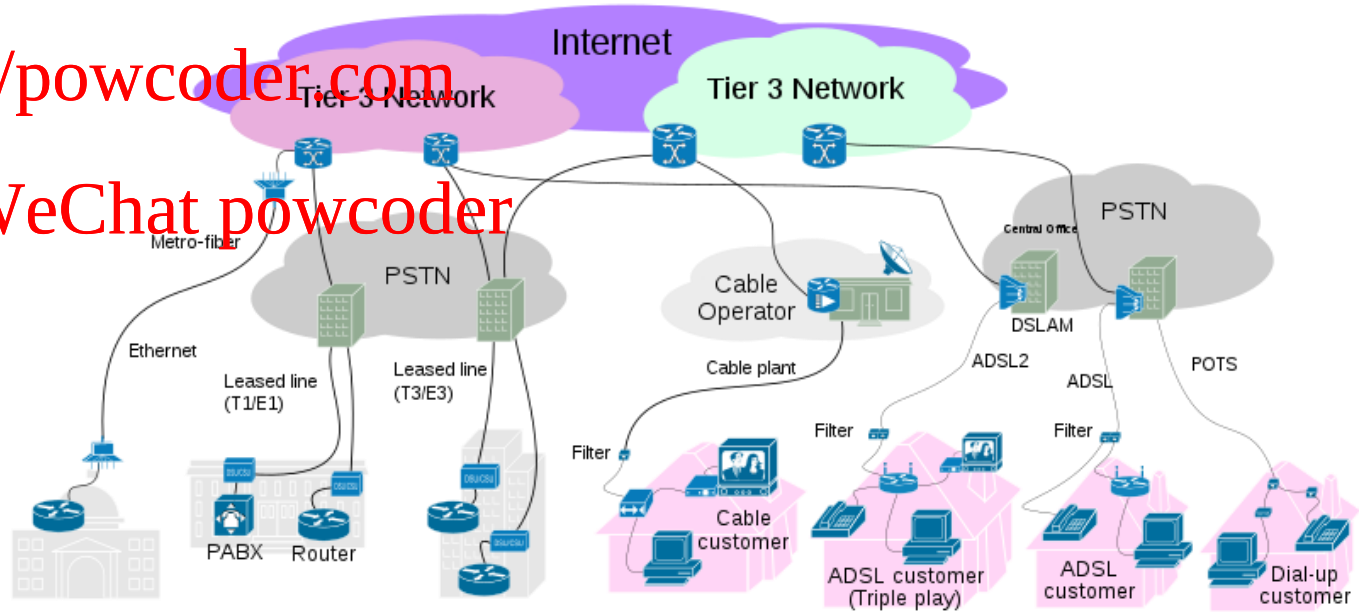


https://commons.wikimedia.org/wiki/File:Internet_map_1024.jpg

# Structure of the Internet

- Network of networks → hierarchical



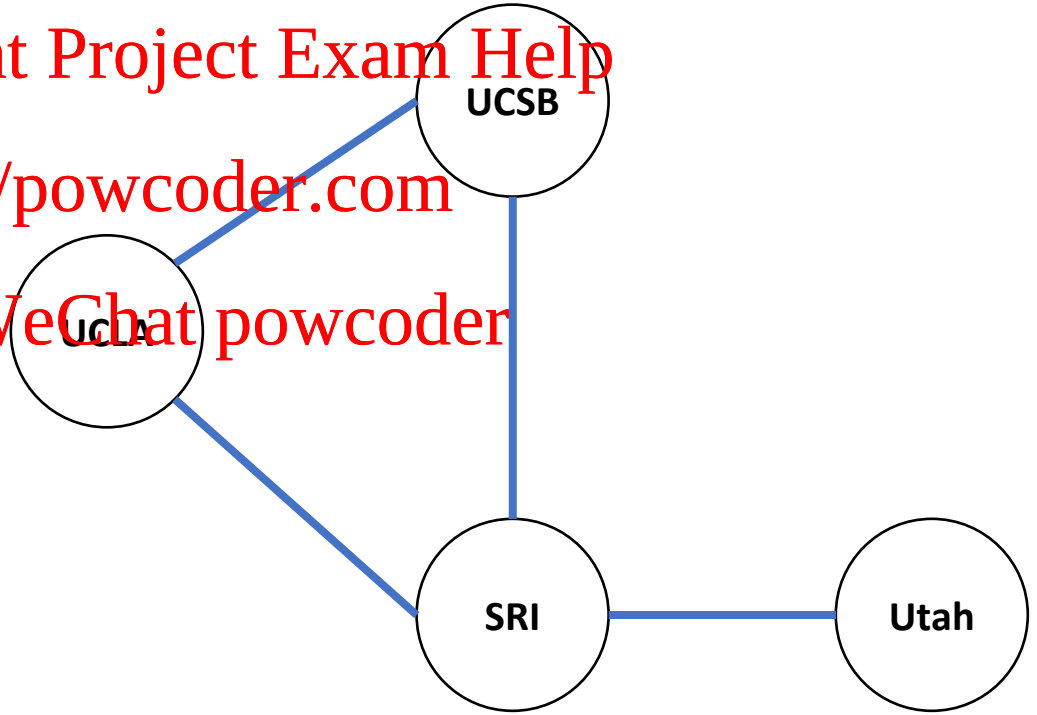



https://commons.wikimedia.org/wiki/File:Internet_Connectivity_Access_layer.svg

# A Brief Step Back in Time

- The first modern computer network was developed in the late 1960s
- ARPANET
- The story of “LO”

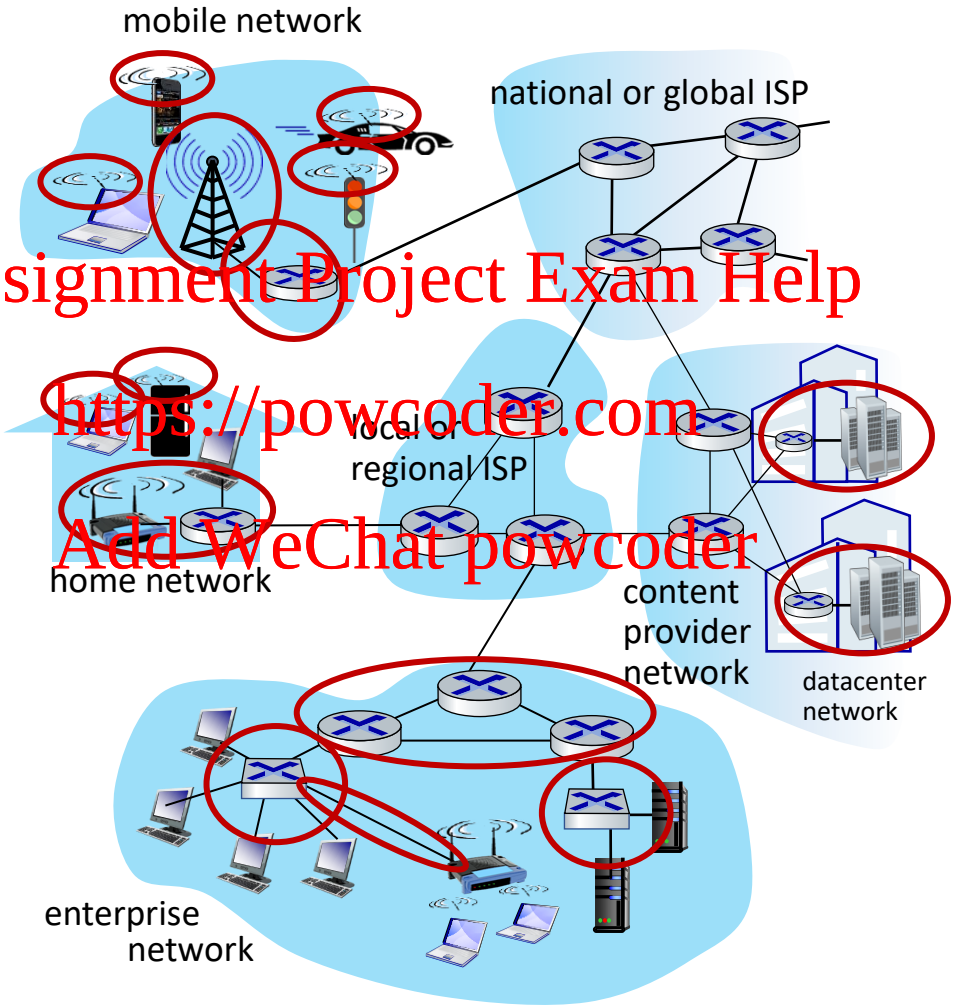




# Structure of the Internet

- The “edge”
  - End devices such as desktops, laptops, smartphones, game consoles, tablets, IoT devices, etc.
- The “core”
  - Networks that interconnect large, geographically disparate networks
  - Made up of internet service providers (ISPs)
- “Access networks”
  - How the edge reaches the core
  - E.g., DSL, cable, fiber to the home, 4G, 5G, WiFi, Ethernet

# Access Networks



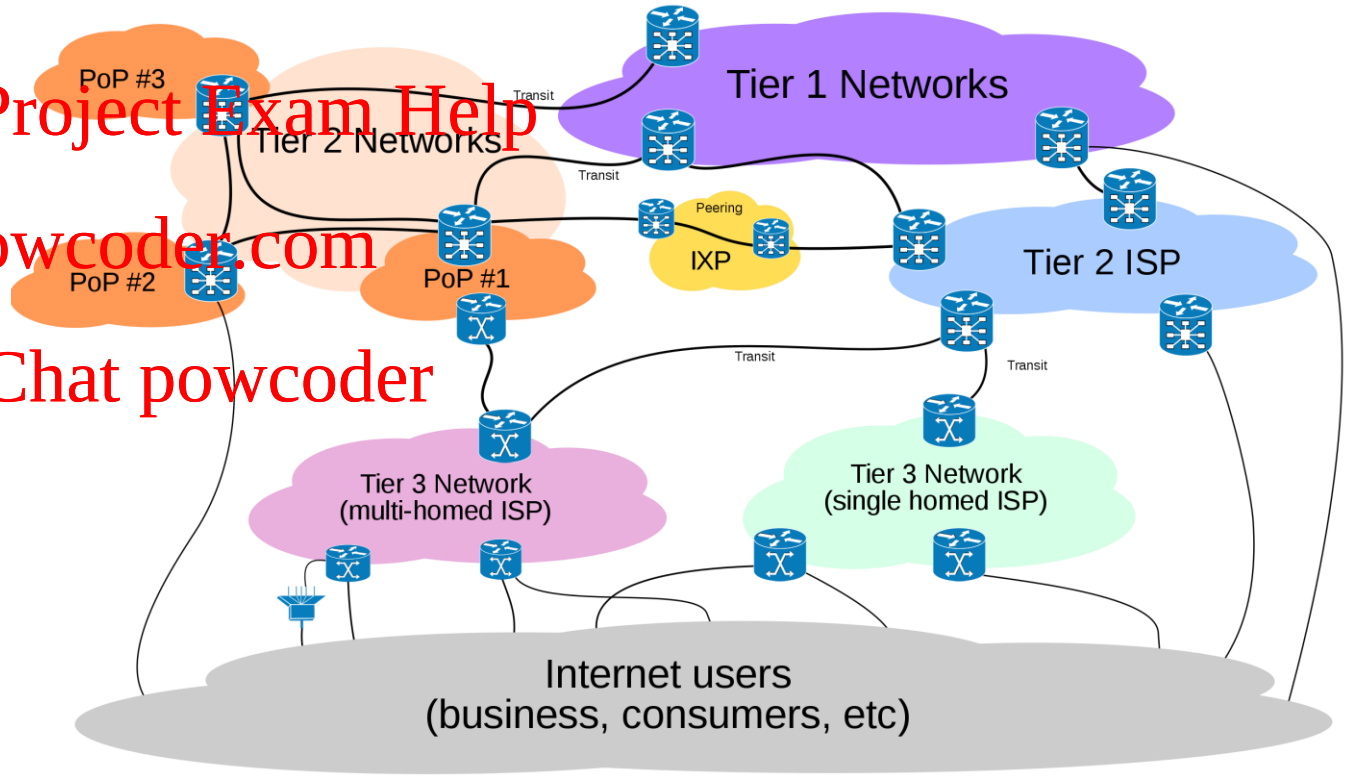
# Are these “access networks”?

- Your home network (WiFi, routers, and connected devices)?
  - Not quite! It includes all of the above except your connected devices.
- Your local ISP?
  - No, they would be part of the core
- DSL or Cable link between your home and your local ISP?
  - Yes!

# Providing Structure to the Internet

- "Network of networks"
- You connect to your ISP
- Your ISP connects to other ISPs
- Some ISPs only have other ISPs as customers



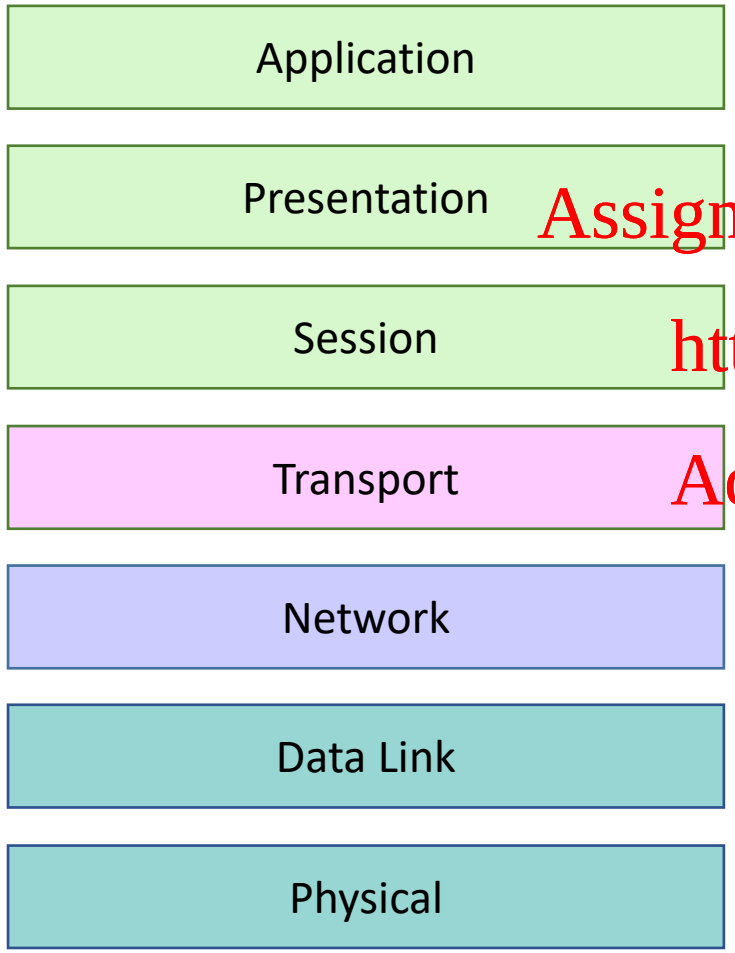



https://commons.wikimedia.org/wiki/File:Internet_Connectivity_Distribution_%26_Core.svg

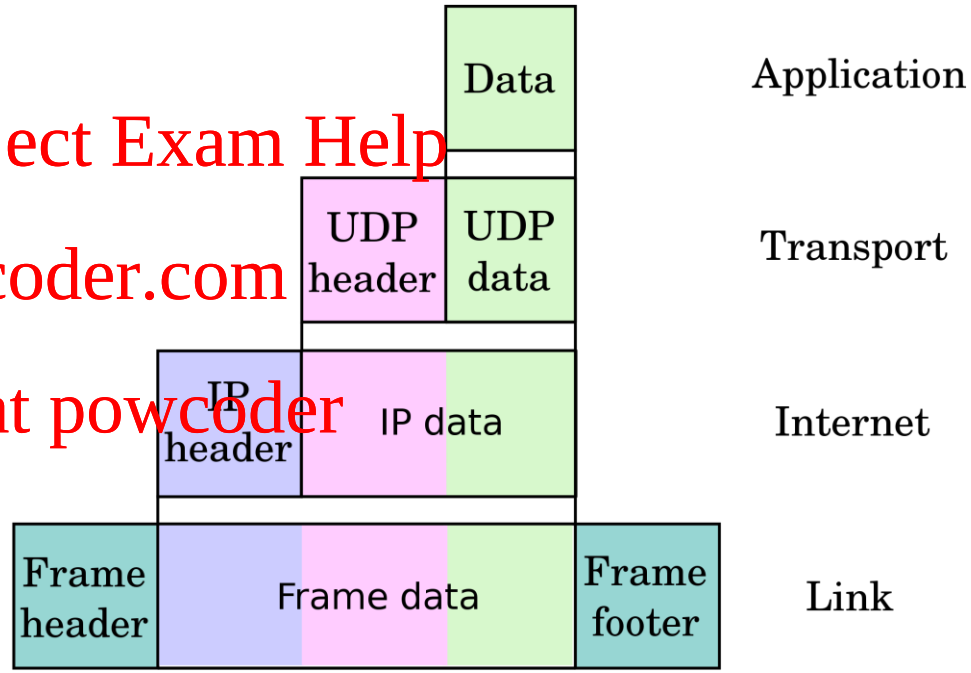
# Packets

- We have to share the network with other devices
- However, reserving network resources is too complex and inflexible
- → Split data stream into “packets” and send via “packet switching”

# Layering and Encapsulation






https://commons.wikimedia.org/wiki/File:UDP_encapsulation.svg

# Layering: Why Bother?

- Different layers have different responsibilities
- Can use different protocols at one layer without needing to change protocol at another layer
  - Don't want network layer to need to understand how your application works to operate correctly
  - Don't want to have to change application when using Wi-Fi instead of wired
  - Protocols evolve and change over time (e.g., IPv4 → IPv6 at network layer)

# Routing and Forwarding

- Routing: how do I reach the final destination of this packet?
- Forwarding: knowing the above, which of my neighbors do I send the packet to next?



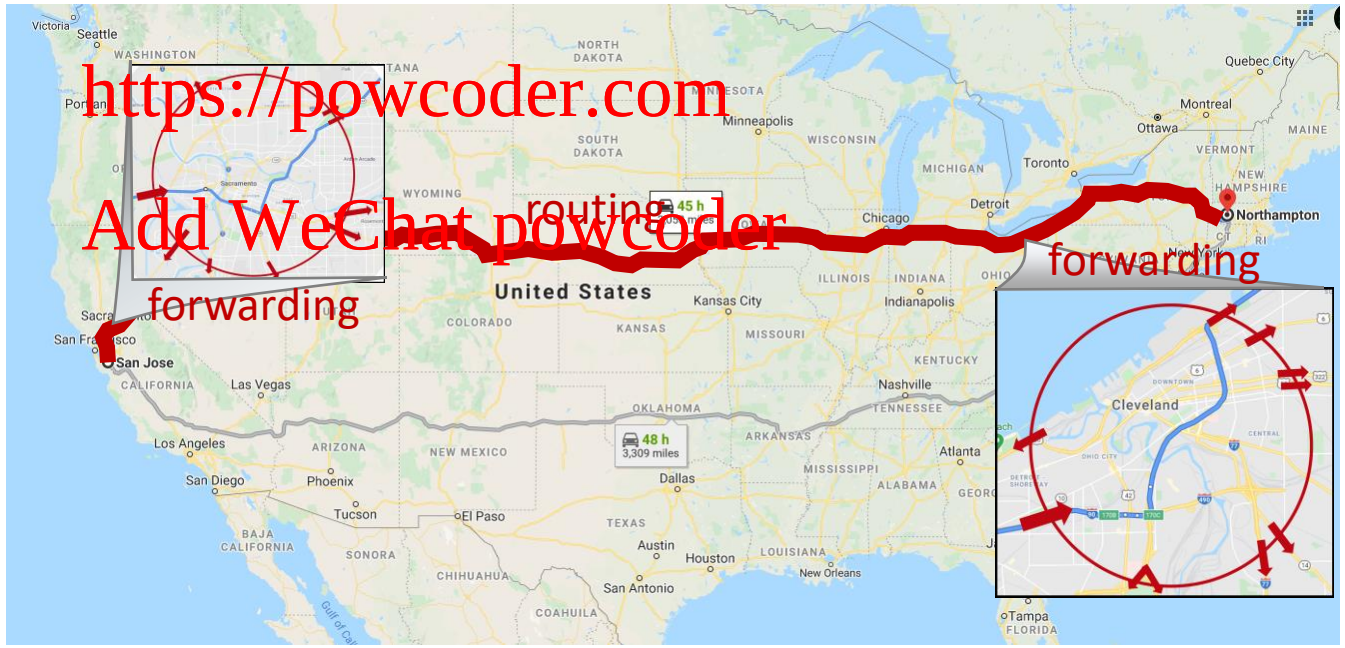
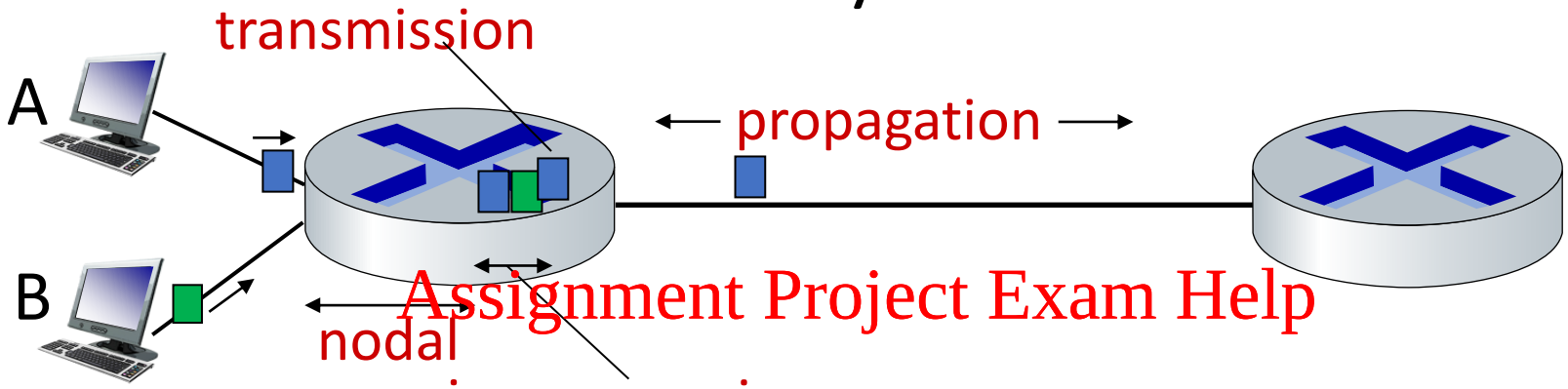



Image from main lecture slides

# Packet Queuing and Loss

- Routers can only process packets so quickly
- If packets come in faster than they can be sent out, they are queued
- If queue fills up, packets start being dropped!
- What do we do in the event of loss?
  - Try again! (aka retransmit)

# Sources of Packet Delay






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

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

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

$d_{queue}$: queueing delay
- time waiting at output link for transmission

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

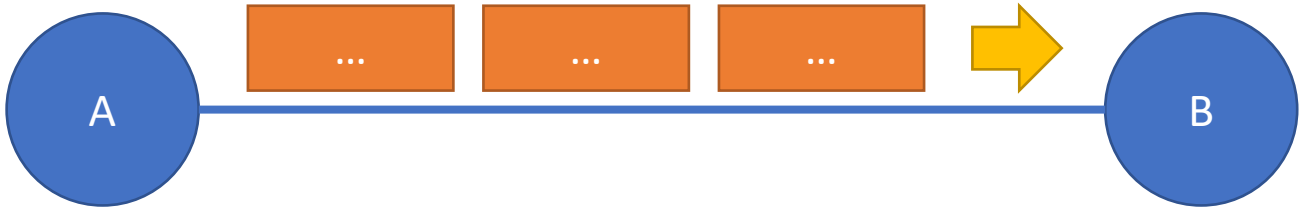
# Throughput

- Definition: Number of bits that can be sent from sender to receiver per unit of time (e.g., bits/second)
- End to end throughput constrained by throughput of “slowest” link
  - And by how much traffic other hosts are sending through the same link(s)

# Bandwidth-Delay Product

- How much data can be “in flight” on a given link in a given unit of time?
- Bandwidth (theoretical throughput of link, also in bits/second)
- BW x Round-trip delay





# Bandwidth-Delay Product

- Fiber-optic link:
  - Bandwidth: 10 Gb/s
  - Round-trip Delay: 25 µs (25 x 10^-6 seconds)
  - BDP:
- Slow DSL connection:
  - Bandwidth: 1 Mb/s
  - Round-trip Delay: 50 ms (50 x 10^-3 seconds)
  - BDP:

Questions?