Introduction

CSE351

Computer Networks

CSE351: Computer Networks

Course Information

Course Code	CSE 35101
Course Title	Computer Networks
Year/Semester	2020/Spring
School	ECE
Course Classification	
Classroom/Class Time	106, T204 (Tue/Thu, 2:30-3:45pm)
Grading Type	Letter

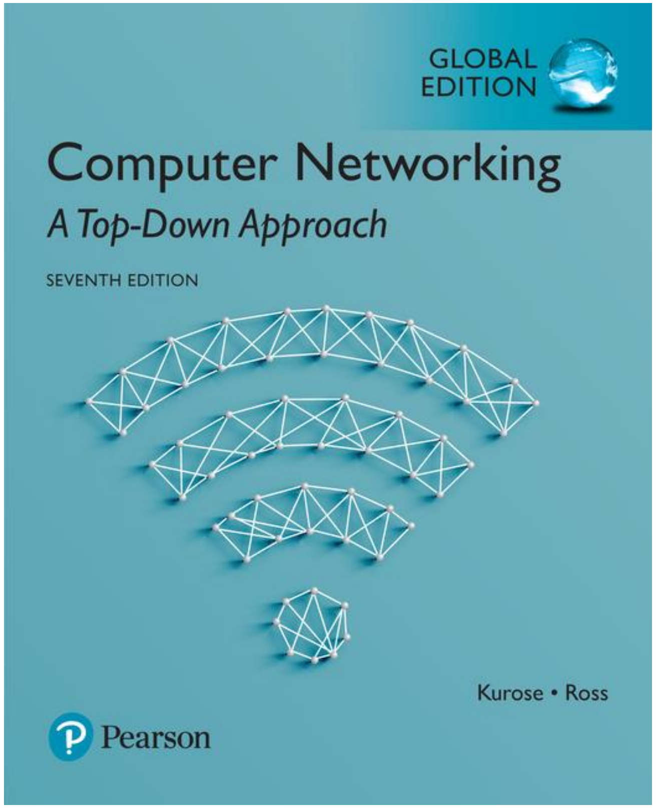
Instructor Information

Instructor	Youngbin Im
Office	106, 501-9
Telephone	2255
E-mail	ybim@unist.ac.kr
Office Hours	Wed 4:00pm – 5:00pm

Grading

Attendance (10 %)
Midterm (30 %), Final Exam (35 %)
Others (Assignment, Project, etc., 25%)

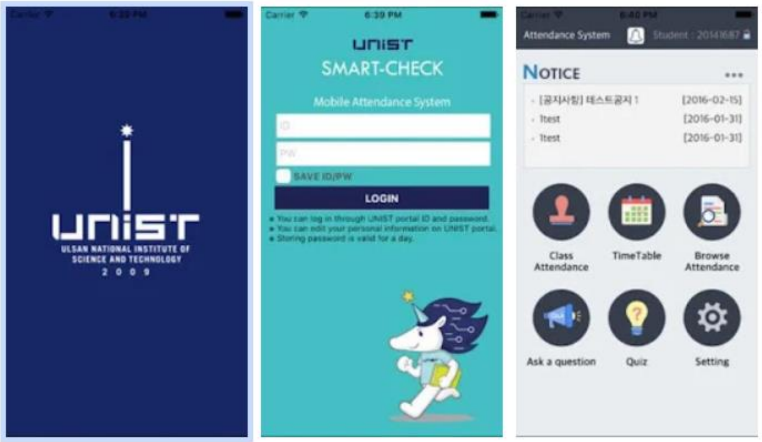
CSE351: Computer Networks



Computer Networking (7th Edition)
Jim Kurose, Keith Ross
Pearson

Attendance

- Online classes
  - BlackBoard Collaborate automatically checks the attendance
- Offline classes
  - Use UNIST Mobile Attendance System
  - Don’t forget to check your attendance
  - If it doesn’t work let me know after the class



First two weeks

- First week
  - The classes including attendance are substituted with homework. The details will be announced soon.
- Second week
  - No classes. Make-up classes at 14:30 on April 11 and at 14:30 on May 2.

Consequences of Plagiarism & Cheating

- An *official* ECE regulation on the Academic Integrity
  - On the 1st violation
    - **Zero grade on the item** involved (e.g., homework, midterm, etc.).
    - **Lower the final grade by at least one letter grade** (e.g., A0 → B0).
    - Attain **a "signed" personal letter from the student** stating this will not happen again, and he/she is well aware of consequence if it does.
    - **Provide a written report** of the student and violation **to School Head and ECE education committee**.
  - On the 2nd violation
    - **Give F on the course**.
    - **Share the identity of the student** with the entire faculty.
    - **Report to the University Student Scholarship Counseling Committee** (학생장학지도위원회) for further disciplinary action.

ABOUT ME

Education

B.S.

Computer Science,
Seoul National
University, 1999.3 ~
2006.8

Ph.D.

Computer Science,
Seoul National University, 2007.3 ~
2014.8

Advisor: Prof. Taekyoung Kwon

Professional Experiences

2003.6 ~ 2005.11 — CAR123
Software Developer
Develop ERP, customer systems

2011.6 ~ 2012.6 — Princeton University
Visiting Researcher
Advisor: Prof. Mung Chiang

2014.9 ~ 2015.3
Postdoctoral Researcher
Advisor: Prof. Taekyoung Kwon

2015.3 ~ 2019.7 — University of Colorado Boulder
Postdoctoral Researcher
Advisor: Prof. Sangtae Ha

2019.9 ~ current — UNIST Ulsan National Institute of Science and Technology
Assistant Professor

Research Experiences by Areas

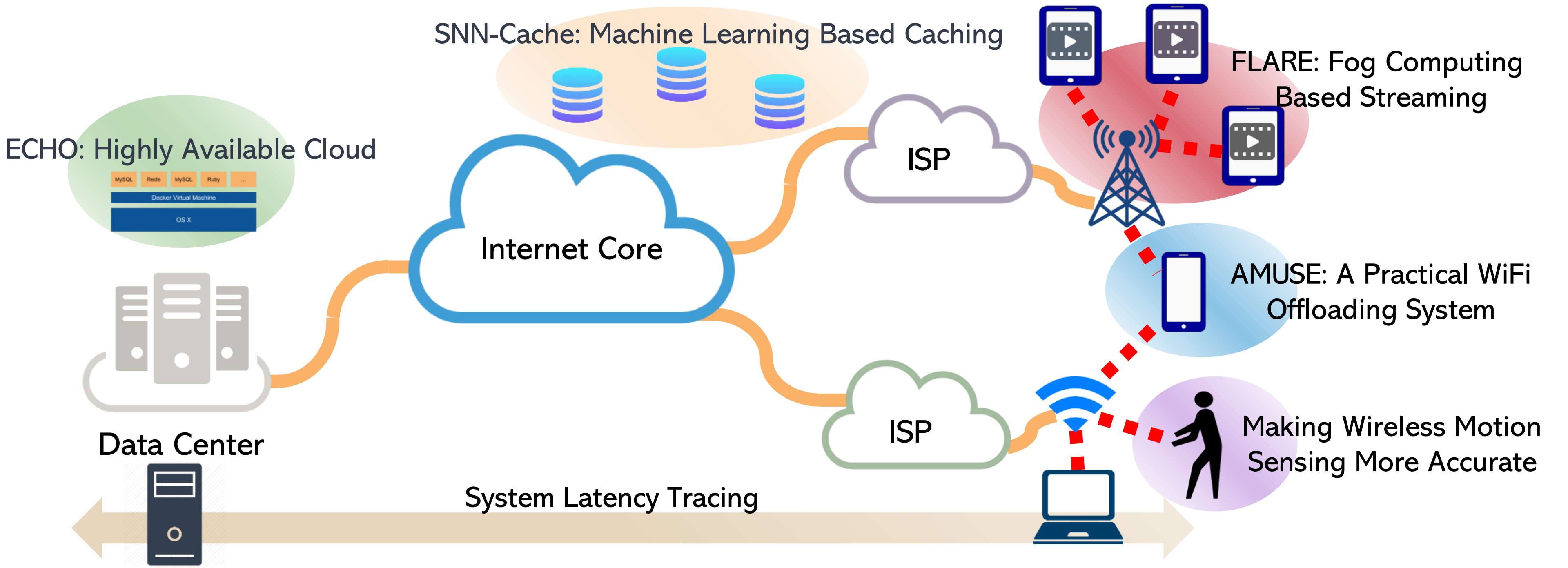
Large-Scale Network Systems

- FluidMem: Full Flexible and Fast Memory Disaggregation for the Cloud (ICDCS 2020)
- SPARCLE: Stream Processing Applications over Dispersed Computing Networks (ICDCS 2020)
- Learning the Optimal Protocol Selection (ICNP 2019)
- System Latency Tracing (EuroSys 2019)
- ECHO: Highly Available Cloud (ICDCS 2019)
- SNN-Cache: Machine Learning Based Caching (CISS 2018)
- FLARE: Fog Computing Based Streaming (ICDCS 2017)
- TUBE: Time Dependent Pricing System for Wireless (SIGCOMM 2012)

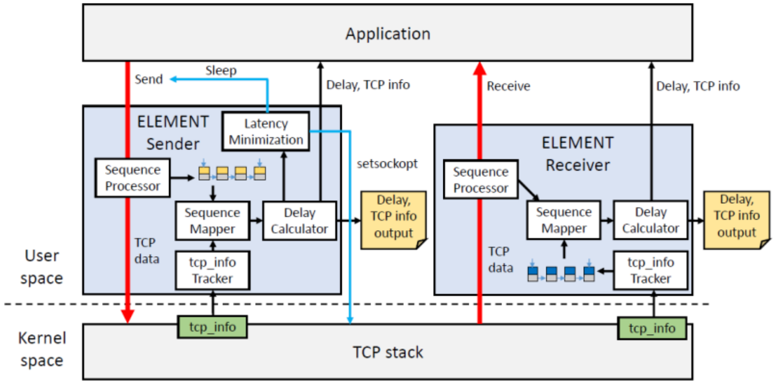
Next Generation Wireless Networking and Sensing Systems

- This is Your President Speaking: Spoofing Alerts in 4G LTE Networks (MobiSys 2019 Best Paper Award)
- CASTLE: Distributed Scheduling for Cellular Data Transmissions (MobiSys 2019)
- Making Wireless Motion Sensing More Accurate (SenSys 2017)
- AMUSE: A Practical WiFi Offloading System (INFOCOM 2013, TMC 2016)

Research Experiences by Topics



Large-Scale Network Systems

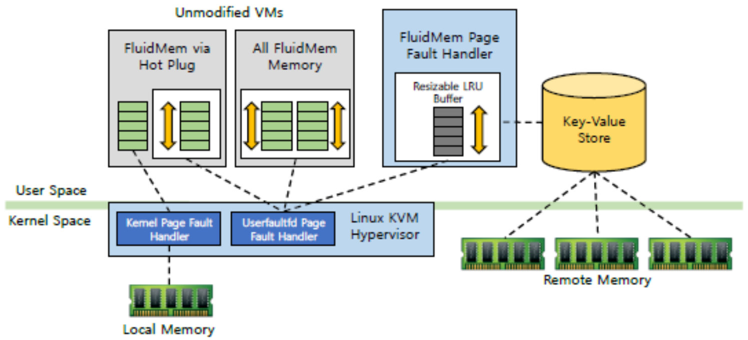


System Latency Tracing (EuroSys 2019)

- Present ELEMENT, a latency diagnosis framework that decomposes end-to-end TCP latency into endhost and network delays
- Implement a user-level library that uses ELEMENT to minimize delays

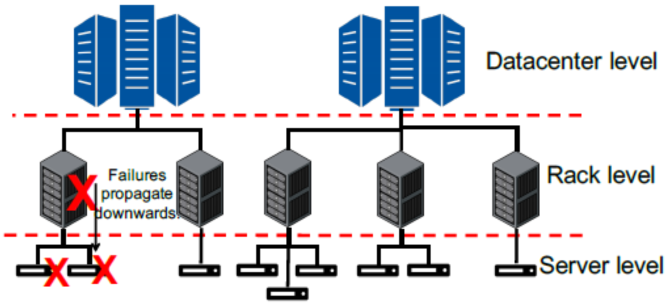
FluidMem: Full Memory Disaggregation for the Cloud (ICDCS 2020)

- Present a new approach to memory disaggregation called FluidMem that leverages the user-fault mechanism to achieve full memory disaggregation in software



UNIST ULSAN NATIONAL INSTITUTE OF SCIENCE AND TECHNOLOGY

Large-Scale Network Systems

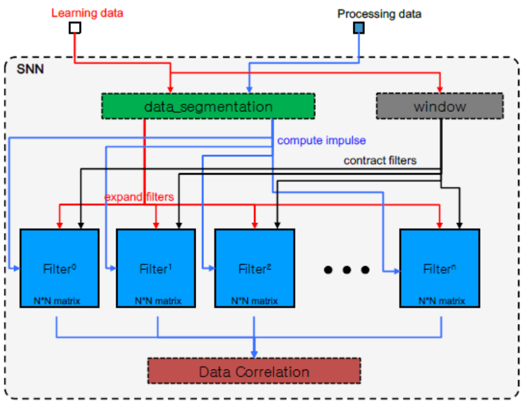


ECHO: Highly Available Cloud (ICDCS 2019)

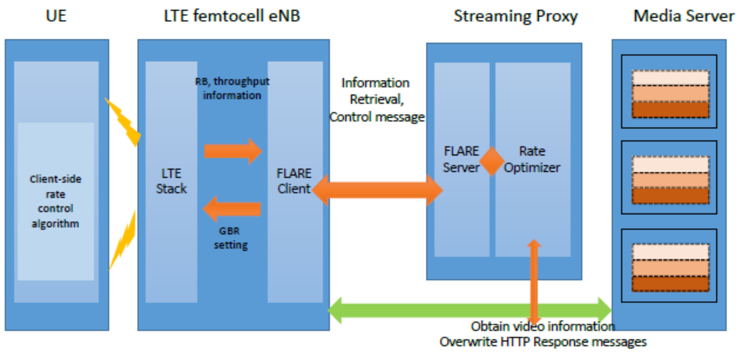
- A cloud resource management system that overbooks backup VMs by optimizing the overbooking rate tradeoff between availability and utilization

SNN-Cache: Machine Learning Based Caching (CISS 2018)

- SNN: a practical machine learning-based relation analysis system, which can be used in different areas
- SNNCache: leverage SNN to utilize the inter-relationships among sequenced requests in caching decision



Large-Scale Network Systems



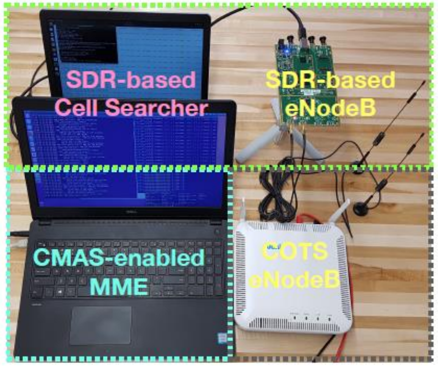
FLARE: Fog Computing Based Streaming (ICDCS 2017)

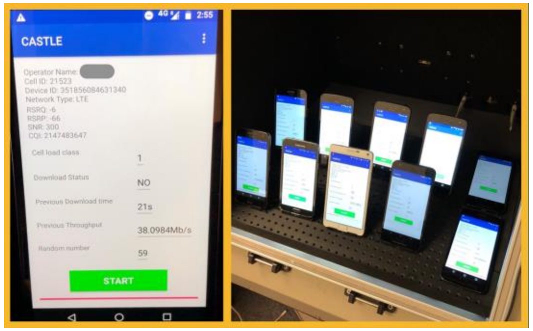
- A coordinated HAS solution for the fog computing that optimizes the total utility while maintaining stable video quality and supporting user-/device-specific needs

Next Generation Wireless Networking and Sensing Systems

This is Your President Speaking: Spoofing Alerts in 4G LTE Networks (MobiSys 2019 Best Paper)

- Investigate the details of Wireless Emergency Alert (WEA) protocol and develop and demonstrate the first practical spoofing attack



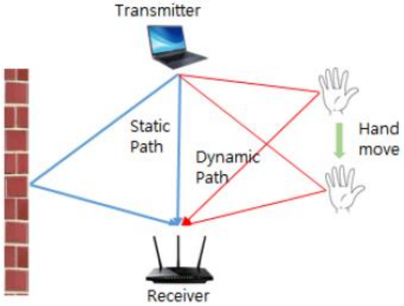


CASTLE: Distributed Scheduling for Cellular Data Transmissions (MobiSys 2019)

- Presents a fully distributed scheduling framework that jointly optimizes the spectral efficiency and battery consumption

Making Wireless Motion Sensing More Accurate (SenSys 2017)

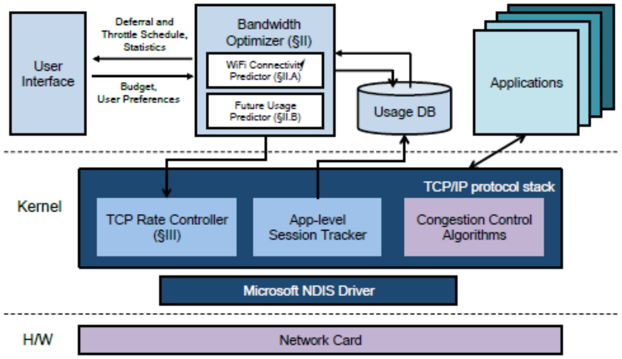
- Propose an effective phase noise calibration technique which can be broadly applicable to COTS WiFi based motion sensing

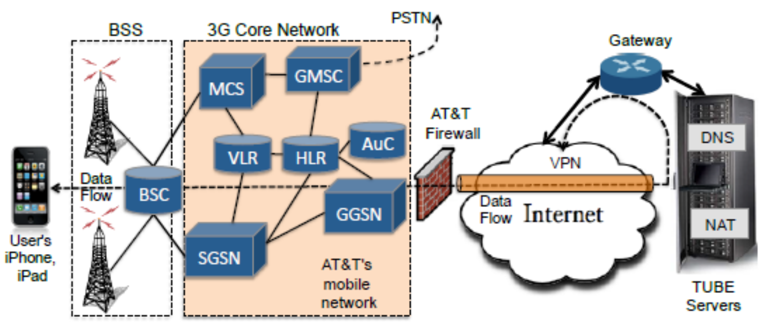


Next Generation Wireless Networking and Sensing Systems

AMUSE: A Practical WiFi Offloading System (INFOCOM 2013, TMC 2016)

- A practical, cost-aware WiFi offloading system that exploits a user's delay tolerance and offloads satisfying her throughput-delay tradeoffs and data budget constraints





TUBE: Time Dependent Pricing System for Wireless (SIGCOMM 2012)

- An end-to-end system for offering time-dependent pricing to users
- Offer lower prices in less congested periods, encouraging users to shift some traffic to less congested periods

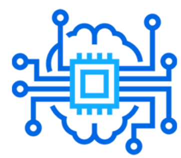
Research Topics

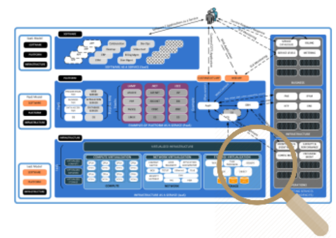
Diagnosis and Management Framework for Large-scale Systems

01

- Data center systems are becoming larger and more complex
- Existing logging and management systems are coarse grained

- Develop AI-based in-depth diagnosis and management framework





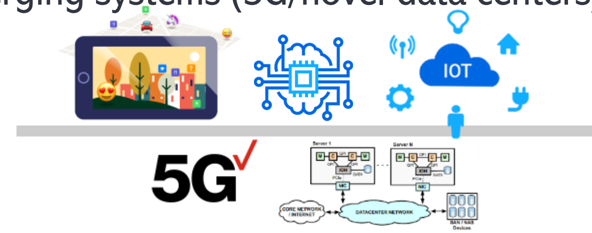
- Impact on application performance and management quality of data center companies

NAVER LG U+ amazon Microsoft Azure

Research Topics

Architecting Emerging Applications and Systems

- Better support the emerging applications (VR/AR/AI/IoT) in emerging systems (5G/novel data centers)



- Architect the related techniques for novel applications
- Improve the architecture, platform of data centers for new applications

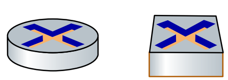
- Impact on application providers and ISPs, data center companies

INTRODUCTION

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)

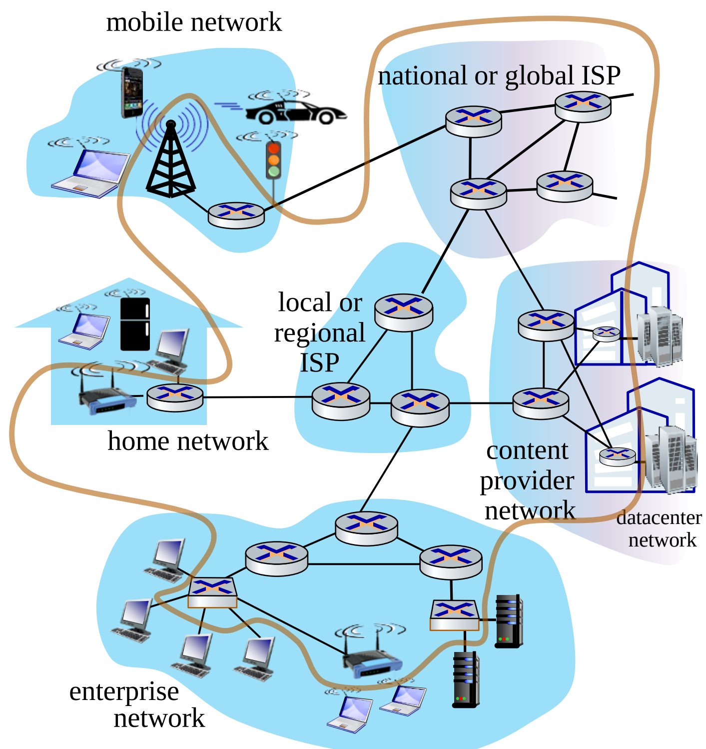
- *routers*, *switches*

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

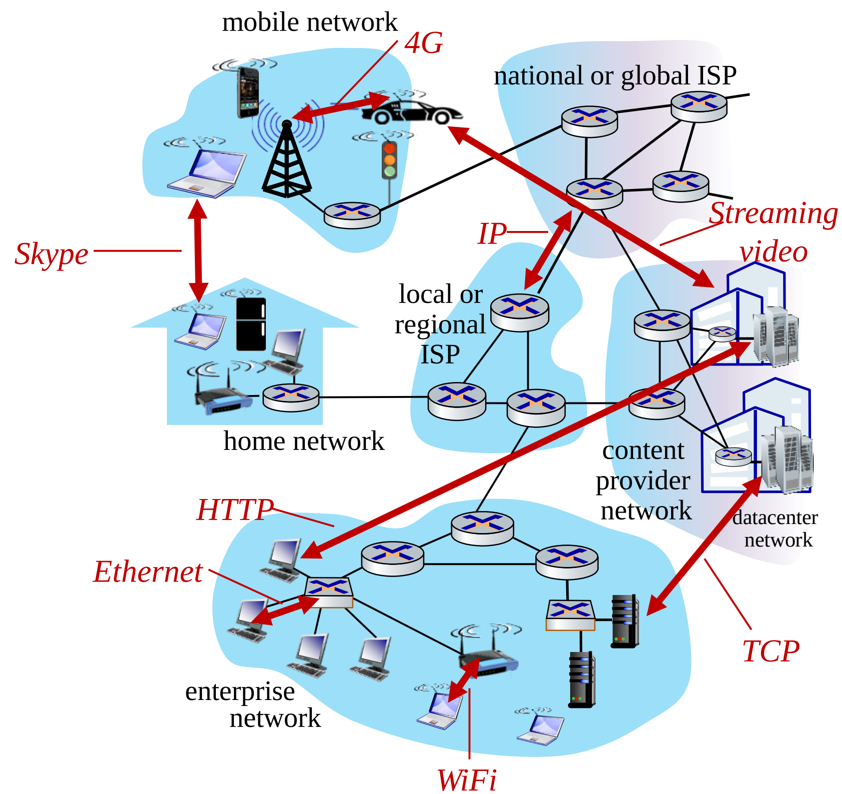
Others?

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

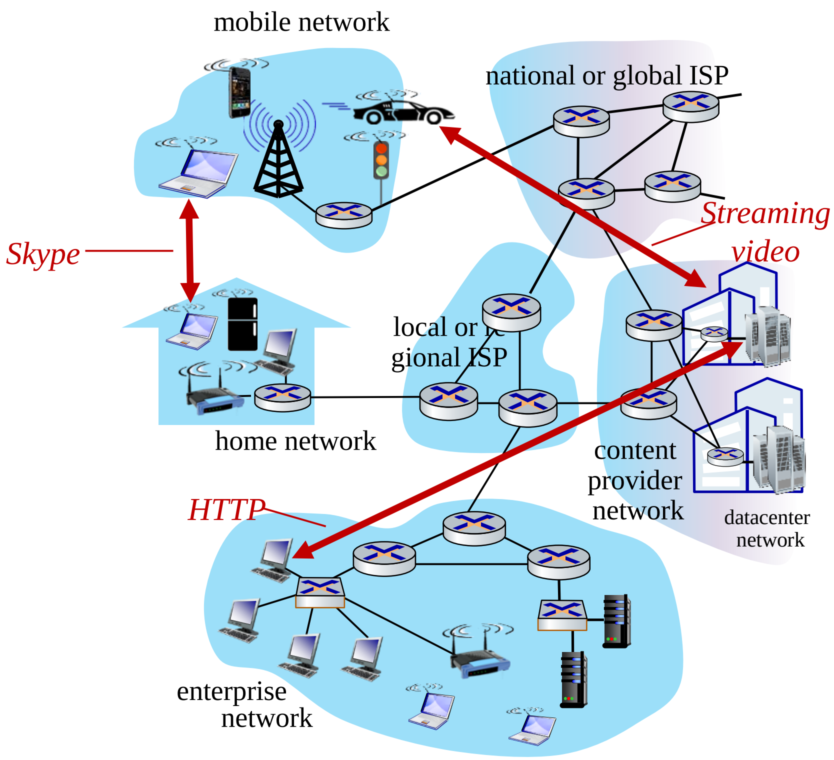
- *Internet standards*
  - RFC: Request for Comments
  - IETF: Internet Engineering Task Force



The Internet: a “Service” View

- *Infrastructure* that provides services to applications:
  - Web, steaming 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

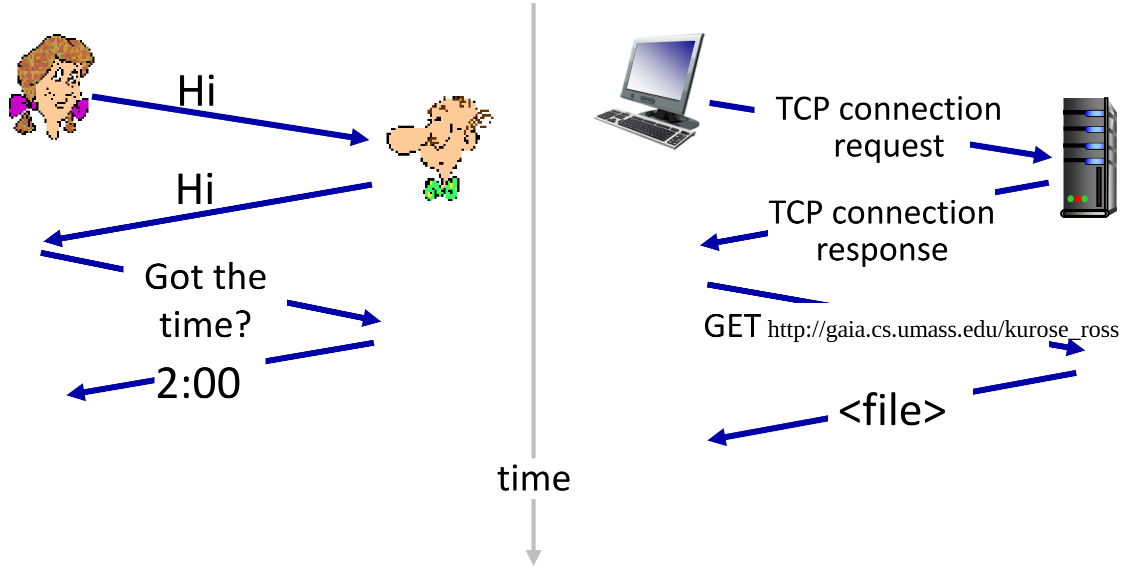
Network protocols:

- 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:

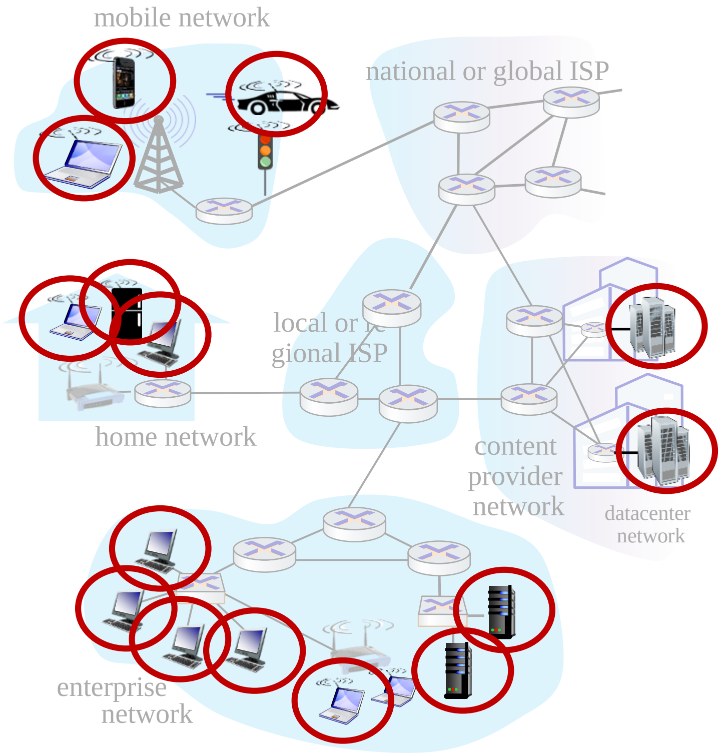


Q: other human protocols?

A Closer Look at Internet Structure

Network edge:

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



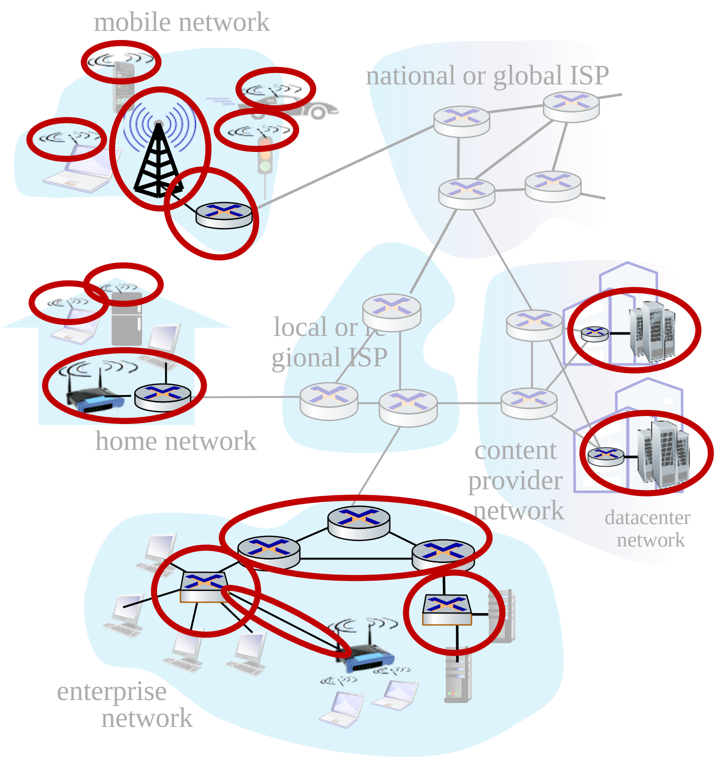
A Closer Look at Internet Structure

Network edge:

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

Access networks, physical media:

- □wired, wireless communication links



A Closer Look at Internet Structure

Network edge:

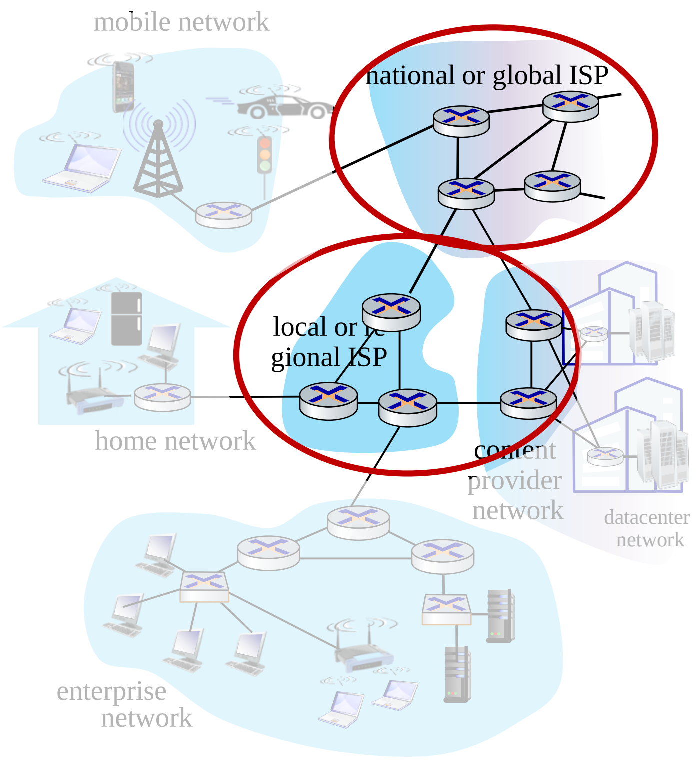
- hosts: clients and servers
- servers often in data centers

Access networks, physical media:

- wired, wireless communication links

Network core:

- interconnected routers
- network of networks



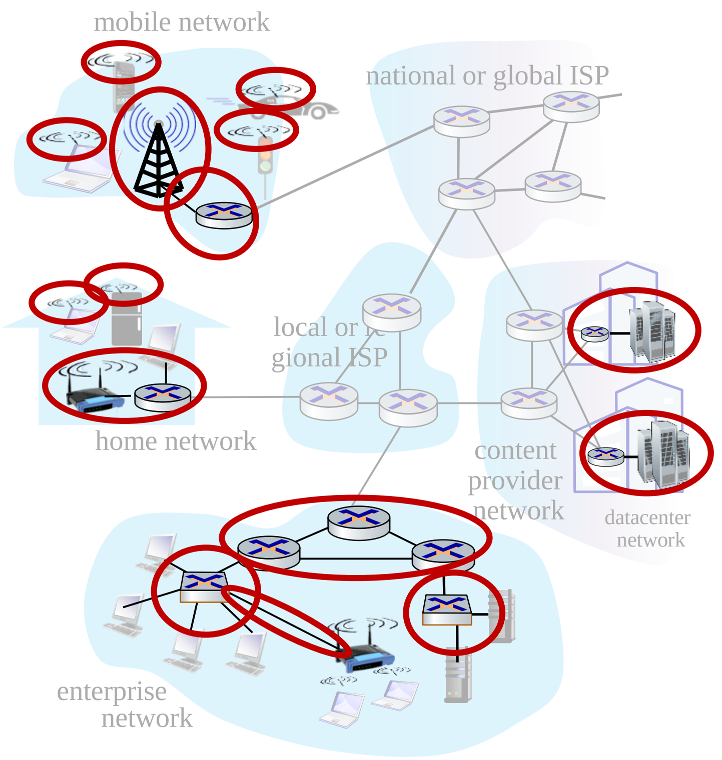
Access Networks and Physical Media

Q: How to connect end systems to edge router?

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

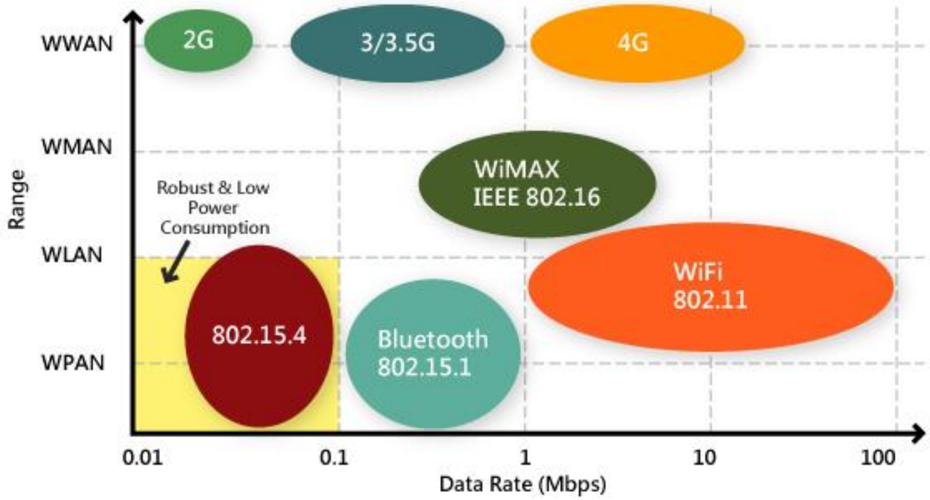
What to look for:

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



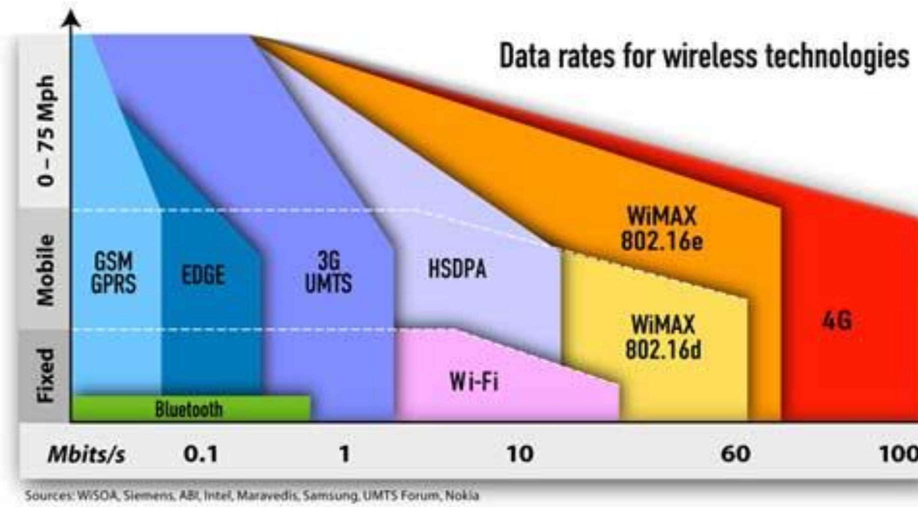
Network Edge -- Access Networks

Wireless Access Networks



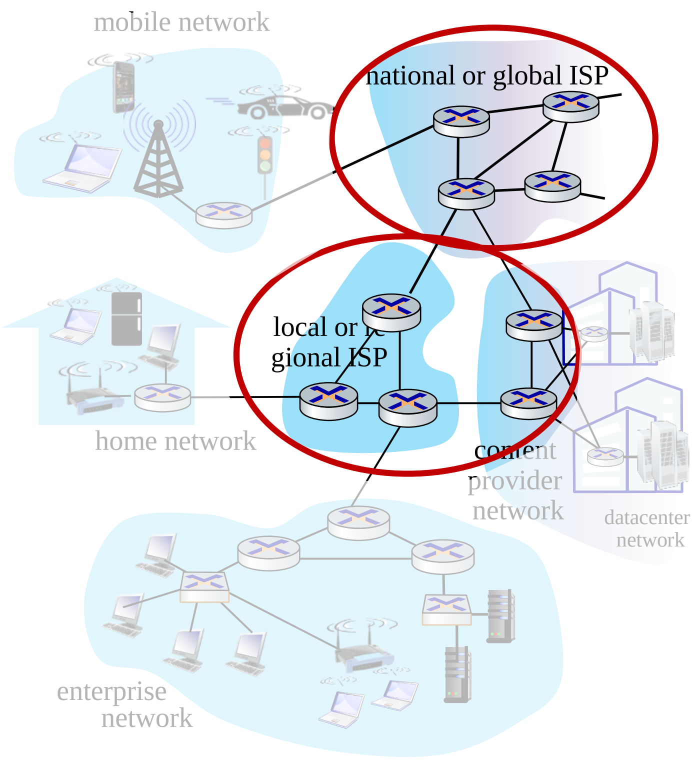
← Data rate vs. Range (coverage)

Data rate vs. Mobility (Speed) →



The Network Core

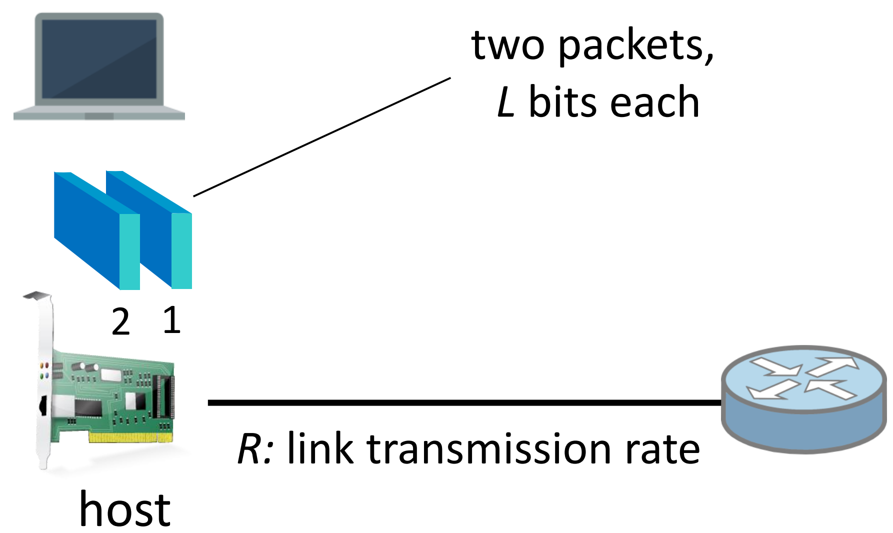
- mesh of interconnected routers
- packet-switching: hosts break application-layer messages into *packets*
  - forward packets from one router to the next, across links on path from source to destination
  - each packet transmitted at full link capacity



Network Core

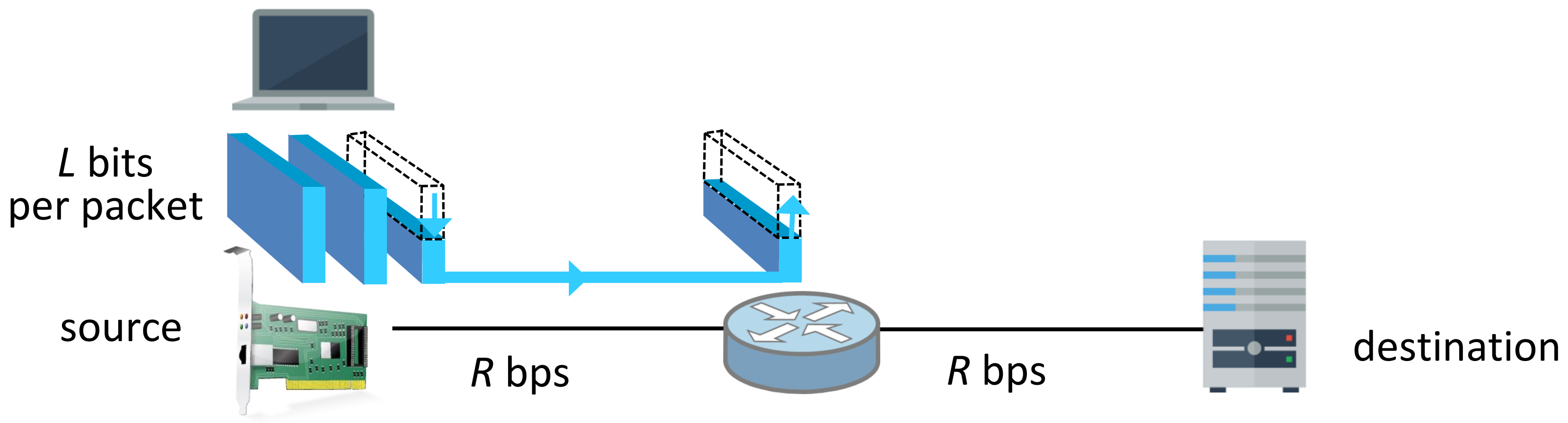
Data Transmission via *Packets*

- 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, a.k.a. 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: Store-and-Forward



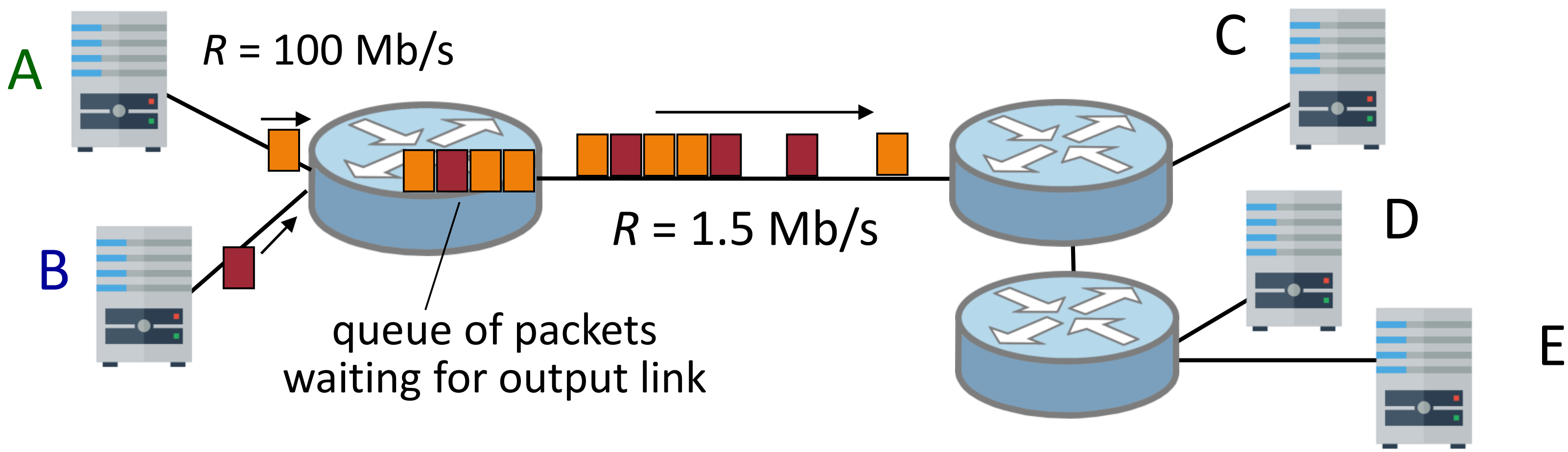
- takes L/R seconds to transmit (push out) L-bit packet into link at R bps
- *store and forward:* entire packet must arrive at router before it can be transmitted on next link

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)

Packet Switching: Queueing, Loss



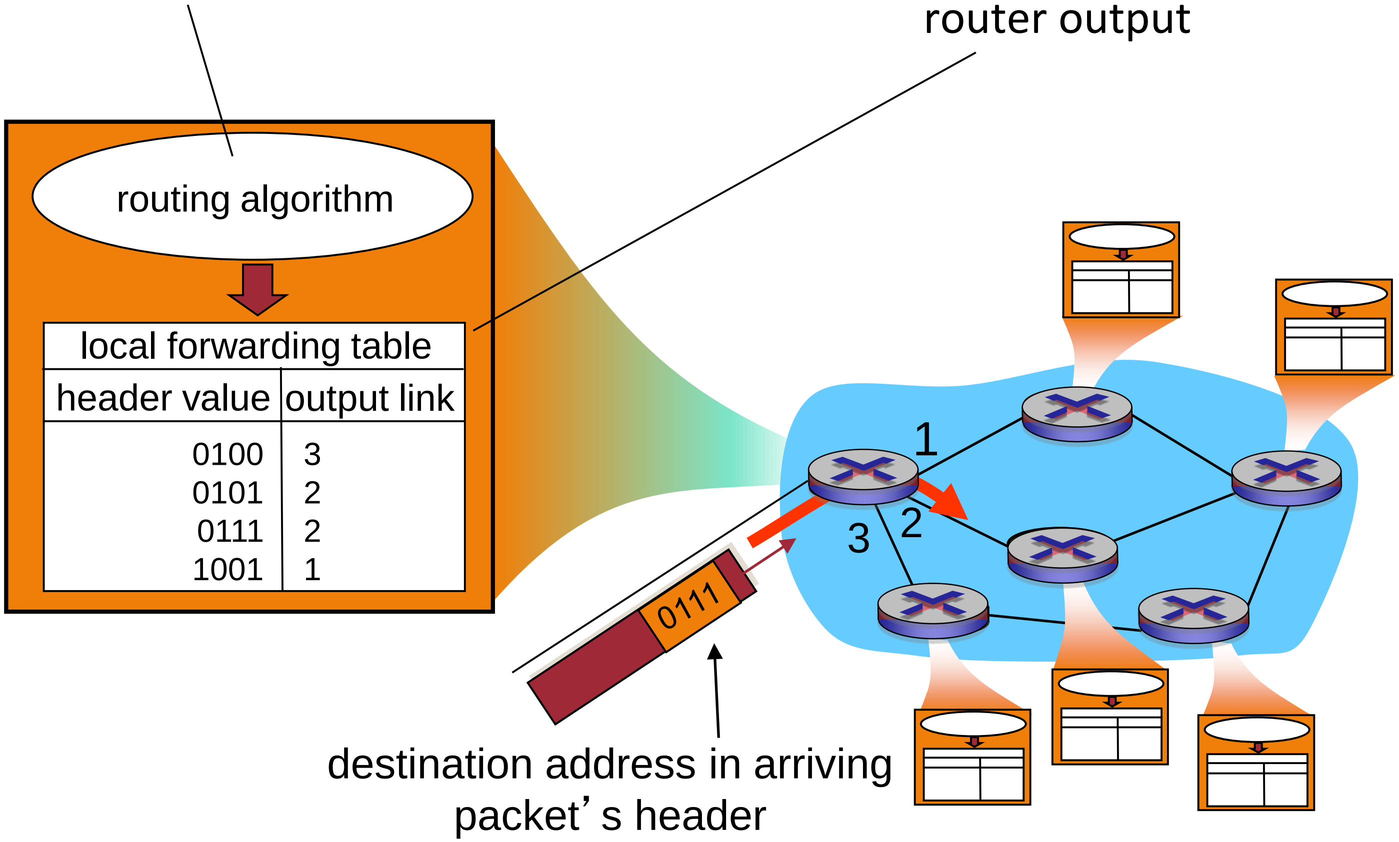
queuing and loss:

- 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

Packet Switching: Routing, Forwarding

routing: determines source-destination route taken by packets (by an algorithm)

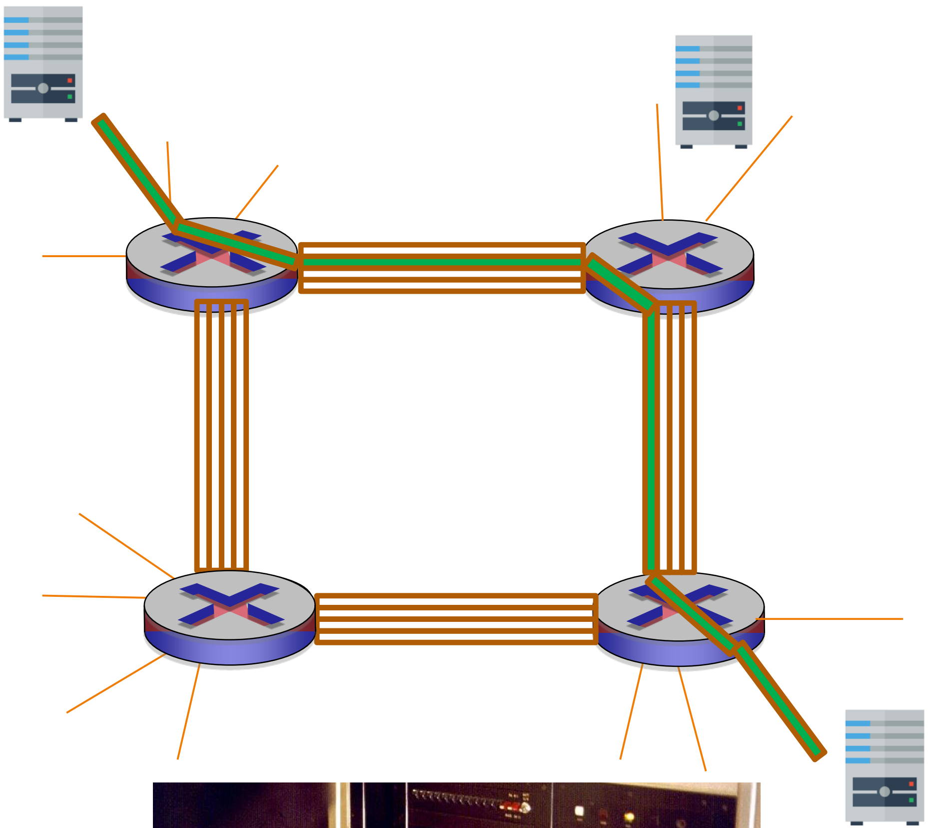
forwarding: move packets from router's input to appropriate router output

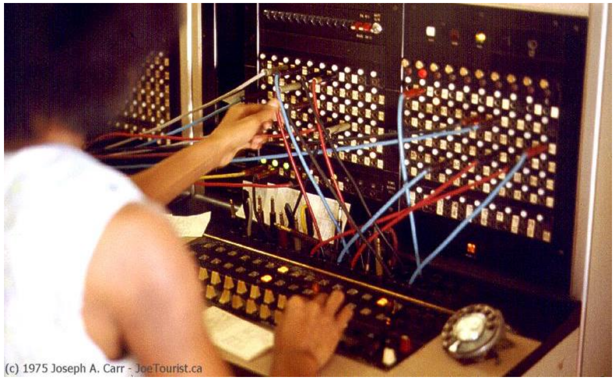


Circuit Switching

End-to-end resources allocated to, reserved for "call" between source and destination:

- 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 vs. Packet Switching

- Circuit Switching

  (e.g. Telephone Networks)

  - Easier to guarantee service quality
  - Routing can be done over longer time durations (call arrival and departure times)
  - Resources are dedicated for the entire duration of the call
  - Inefficient but suitable for smooth traffic (e.g., voice)
  - No packet loss (within the reserved resources)

- Packet Switching

  (e.g. The Internet)

  - Hard to guarantee service quality when resources are limited ➔ "Best effort"
  - Physical routing or switching needs to be done at line speed
  - Network is used on demand ➔ High network efficiency
  - Efficient and suitable for bursty traffic (e.g., file transfer)
  - Packets may be dropped