What this course is about

What are the underlying concepts and technologies that make the Internet run?

First/introductory course in computer networking

- Learn basic networking technologies & principles
- Develop network programming skills
Course Workload

- Reading assignment for every lecture
- Weekly homework assignment
  - Assigned every Thursday (except the 10th week)
  - Due 6:00pm the following Thursday to TA's mailbox; homework solutions posted Friday morning.
- Two programming projects
  - Check class website for details
- Midterm and final exams
- Last but not least: Classroom participation

Grading breakdown

- Homework: 20%
- Projects: 30%
- Midterm: 20%
  - Thursday, May 8th
- Final exam: 30%
  - 3:00-6:00PM, Saturday June 7th
**Course Policies**

- no late turn-in is accepted for credit
- no make-up exams
- no misconduct

**Lets have a shared understanding**

- Why are you here?
- The goal in next 10 weeks
- What I can help
- Whose fault would it be, if you:
  - failed to understand the lecture material
  - failed to turn in an assignment on time
  - fell to sleep in class
  - Missed one of the exams
Lecture Teaching

- "Taking notes in class helps me understand better"
- So posted lecture notes will be like this

### Slide title
- Client communicates with the server through the net
- *(your notes go here)*

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**Part I: Introduction**

**Today's goal:**
- get context, overview, “feel” of networking
  - more depth, detail *later* in course

**Overview:**
- what's the Internet
  - network edge, network core, access net, physical media
- **Circuit switching vs. packet switching**
- Protocols, protocol layers
- Performance measure: data loss, delay

Assignment: Read chapter 1
What’s the Internet: “nuts and bolts” view

- **hosts (end-systems):**
  - PCs, workstations, servers, PDA’s, phones, toasters...
  - Send/receive data, but do not forward

- **Connected to networks made of:**
  - **communication links**
    - fiber, copper, radio, satellite
  - **routers:** forward chunks of data (packets) through a network

- **running network applications**
  - WWW, email, games, e-commerce, file sharing (MP3)

A closer look at network structure:

- **network edge: end systems (hosts)**
  - run application programs at “edge of network”
  - client/server model
A closer look at network structure:

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- **access networks**
  - Physical media, communication links

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Access Networks

- **Campus:** local area network (LAN)
  - Ethernet: 10 Mbps, 100 Mbps, Gigabit Ethernet

- **wireless LANs:**
  - radio spectrum replaces wire
  - wider-area wireless access: CDPD—wireless access to Internet via cellular network

- **Dialup via modem, ADSL**
  (asymmetric digital subscriber line)
A closer look at network structure:

- **network edge**: end systems (hosts)
  - run application programs at "edge of network"
  - client/server model
- **access networks**
  - Physical media, communication links
- **network core**:
  - mesh of interconnected routers
  - network of networks
  - **the fundamental question**: how is data transferred through the net?
    - Circuit switching
    - Packet switching

How multiple data transfers share the same network

**Circuit Switching vs. Packet Switching**

- **Circuit switching**
  - dedicate link bandwidth & switch capacity to each "call"
  - Requires call setup
  - Guaranteed performance
- **Packet switching**
  - Packet: small chunks of data
  - Send packets as soon as link available
  - switch receives a full packet then forwards it towards the destination
Circuit Switching: FDM and TDM

FDM
- Example: 2 users
  ![FDM Diagram]

TDM
- ![TDM Diagram]

Packet Switching: Statistical Multiplexing

- Store-and-forward
- Packet switch can temporarily buffer up packets
  - Introduce queueing delay
  - Packets get dropped when the queue is full
Packet switching versus circuit switching

Example: how many users can share a 1 megabits/sec (1 Mbps) link?

- each user:
  - 100,000 bits/sec when “active”
  - active 10% of time
- circuit-switching:
  - 10 users
- packet switching:
  - 35 users: \( \text{Prob}(n > 10) < 0.0004 \)

A number of issues related to packet switching:
- How does a router figure out where to forward packets?
- What if packets get lost? Or get garbled along the way?

Tentative Course Schedule:
- Introduction (2 lectures, textbook: Chapter 1)
- Network applications (3 lectures, Chapter 2)
  - Socket programming (1 lecture)
- Transport protocols (3~4 lectures, Chapter 3)
  - Midterm exam (in class)
- Network protocols (4 lectures, Chapter 4)
- Link Layer: LANs (3 lectures, Chapter 5)
- Network Security (1 lecture, Chapter 7)
  - Review for final exam
Or more intuitively

Week 1

Link layer (week 8-9)

Transport (week 4-5)

Applications (week 2-3)

network layer (week 6-7)

my computer

server

What to do after this class

- Take a look at the course homepage
- Finish reading assignment before next lecture
- Food for thought:
  - What makes the Internet so popular these days?
  - What's lay ahead?
- Interesting articles on Internet histories
Packet Switched Networks

Network protocols govern all communication activities in a network.

What's a protocol?

Got the time?
2:00pm
One example: send email

dave@cs.ucla.edu → jim@cs.ucla.edu

Organization of air travel

- ticket (purchase)
- baggage (check)
- gates (load)
- runway takeoff
- airplane routing

- ticket (complain)
- baggage (claim)
- gates (unload)
- runway landing
- airplane routing

❖ a series of steps
**Distributed implementation of layer functionality**

- Departing airport
  - ticket (purchase)
  - baggage (check)
  - gates (load)
  - runway takeoff
  - airplane routing

- Arriving airport
  - ticket (complain)
  - baggage (claim)
  - gates (unload)
  - runway landing
  - airplane routing

**Intermediate air traffic sites**

- airplane routing

**Internet protocol stack**

- application
- transport
- network
- link
- physical
One example: send email

Dave's computer

Jim's computer

Protocol layering and data
Protocol header: one examples

Link layer: Ethernet frame format

Data Delivery Performance

- 3 basic measurements
Packet Losses

- Loss due to congestion
- Loss due to transmission errors
- Wireless links

Throughput

- Throughput over a single link
  - Point-to-point
  - Multi-access

- Throughput between two end hosts
Delay in packet-switched networks

4 sources of delay at each hop
- nodal processing: \[ \text{Transmission} = \frac{L}{R} \]
- Queueing
- Propagation \[ = \frac{d}{s} \]

Example: one hop delay

total delay \( (A \rightarrow B) \) = \[ 1ms \times 2 + 1ms + 0.5ms = 3.5ms \]
- Queuing delay =
- transmission delay =
- Propagation delay =
Network latency

- Time to send a packet from point A to point B
  - sum of delays across each hop along the path

- RTT: round-trip-time

Packet-switching: store-and-forward

- Takes L/R seconds to transmit (push out) packet of L bits on to link of R bps
- Entire packet must arrive at router before it can be transmitted on next link: store and forward
- Ignore propagation delay
Packet-switching: store-and-forward

Example 2:
- A sends 5 packets to B
- L = 8000 bits, R = 2 Mbps
  - Ignore propagation delay
- How long does it take starting from A sending the first bit of first packet till B receives the last bit of the last packet?

Bandwidth, transmission delay, and propagation delay

(bandwidth \times delay) product: amount of data "in-the-pipe"