Final Exam

- When: May 8 (Fri) 10-12pm

- Where: Zoom meeting (link on Canvas)

- Open-book and open-notes

- Office hours in the final week: TW 2-3 pm

- Course evaluations end on Apr 30
  - Gibson → "course evaluations"

Final Grades

- Grades will not be curved

- Undergraduate students may choose to receive a letter grade or P/U
  - The P/U option does not apply to graduate students and undergraduate students taking the course for credit in a 4+1 masters program

Final Review

■ Topics covered

- Introduction: [KR 1.1-1.5]

- Statistical multiplexing and queues: discrete probability and [SY 3.1-3.4]

- Application layer: [KR 2.1-2.2, 2.4-2.5, 2.7] [SY 8.2-8.3]

- Transport layer: [KR 3.1-3.7.1] [SY 2.1-2.2]

- Network layer: [KR 4.1-4.3, 5.1-5.4]

- Link layer: [KR 6.1-6.4.3, 6.7]

Introduction

- **Network edge:** hosts/switches/links, services, protocols, access networks

- **Network core**

  - circuit switching: multiplexing (FDM, TDM)

  - packet switching: store-and-forward, statistical multiplexing

- **Performance measures:**

  - Four types of delays

  - Queueing and packet loss

  - Throughput

Statistical Multiplexing and Queues

- Discrete probability

- Statistical multiplexing
  - The Chernoff bound

- Discrete-time Markov chains
  - state transition diagram, transition probability matrix
  - irreducible/aperiodic chains, stationary distributions, local balance equations

- Queues: Geo/Geo/1, Little's law

Application layer

- **Basic principles**
  - client-server vs. peer-to-peer, addressing (IP address & port)
  - transport service requirement of various applications
  - services provided by Internet: TCP, UDP

- **Important applications and protocols**
  - Web and HTTP: non-persistent vs persistent HTTP, request/response, cookies, web caches
  - Domain Name System (DNS): name resolution procedures, four types of DNS records
  - Peer-to-Peer File Sharing: BitTorrent, file distribution (CS vs. P2P), ~~structural P2P File sharing~~

Transport layer

- Transport-layer services
  - service model, multiplexing/demultiplexing

- Connectionless Transport: UDP
  - checksum

- Principles of reliable data transfer
  - ~~rdt 1.0-3.0, GBN, SR~~

- Connection-Oriented Transport: TCP
  - reliable data transfer, flow control, connection setup

- TCP congestion control
  - throughput, fairness

- Network Utility Maximization
  - ~~Convex optimization~~, NUM, proportional fairness, max-min fairness

Network layer

- Forwarding
  - Longest-prefix matching
  - Router: crossbar switching, queueing, packet scheduling
  - IPv4: datagram format, fragmentation, addressing, subnets
  - DHCP, NAT, IPv6

- Routing
  - Link state routing
  - Distance vector routing
  - ~~OSPF, BGP~~

Link layer

- error detection & correction

  - Parity checks, checksum, ~~CRC~~

- multiple access

  - Slotted ALOHA, ALOHA, CSMA/CD, ~~taking-turn protocols, DOCSIS~~

- local area networks

  - MAC addresses, ARP, Ethernet

- a day in the life of a web request