Computer Networks
Final Review

- IP, routing, protocol implementation
- transport layer, TCP, reliable transmission, flow and congestion control
- lower layers, including wireless and Aloha, Ethernet, learning bridges, switches
- basic issues

Internet IP Layer

- responsible for unreliable end-to-end packet delivery
- IP: header, IPv6, configuration, interface(s)
- ICMP: error reporting, problem discovery (ping, traceroute)
- SLIP: framing
- Routing: packet forwarding, RIP, OSPF, BGP
- Protocol Implementations

Exactly what happens when an IP packet is received over Ethernet?

- hardware checks CRC and destination address
- interrupt handler dispatches to the IP module
- variety of checks, including IP version, header length, and header checksum
- IP destination address lookup:
  - is it for local delivery? If so, check protocol, port number(s), match an existing socket, and deliver to the application
  - otherwise, check (routing cache and) routing table, obtain interface and next hop: gateway if given, otherwise destination address
- decrement TTL/Hop Limit
- if necessary, queue for transmission on the selected interface

Forwarding a Packet over Ethernet

- given destination address D from the IP header
- if D matches a local network, use D as next hop H
- otherwise, convert D to a next hop H through either the routing cache or the routing table (or drop the packet)
- if outgoing interface is Ethernet, check ARP table for translation for H
  - if no translation, broadcast ARP request for H and wait for response
- create an Ethernet frame using the MAC address given by ARP, and give to NIC for transmission
- recycle buffer space

Transport Layer

- TCP, UDP, demultiplexing (port numbers)
- sockets/WinSock APIs
- headers, pseudo-header for end-to-end reliability
- reliable transmission: sequence numbers and acks
- flow control: stop-and-wait, sliding windows, sequence number wrap-around
- congestion control: additive (linear) increase/multiplicative decrease, AIMD
- three-way handshake, connection closing

Data Link Layer

- framing, addresses, and access control
  - hard problem: how do you share a medium, without any centralized control?
  - answers often involve some loss of performance (compared to theoretical bandwidth)
- wireless and Aloha
- Ethernet: header, hubs, switches, speed ranges, half and full duplex, collision detection, binary exponential backoff
- learning bridges/switches, spanning trees, comparison of routing and switching, wormhole routing
- serial lines, SLIP

Networking Issues

- connectivity
- performance: bandwidth/throughput, latency/RTT
- error rate and correction: where do you put the redundancy?
- encryption, authentication, data encoding and compression
- network models: OSI, TCP/IP

Potential Futures

- how fast can we go?
- wireless: 802.11 and cellular. What are the limits?
- fragmentation of the Internet: intranets, firewalls, NAT, ...
- no longer much of a question: when (if ever) will we switch to IPv6?
- does the Web look like television? what will replace the Web and the Internet, and when?
- peer-to-peer networks