Basics

- Circuit Switching vs Packet Switching

- Network metrics (BW, latency, etc)

- Layering (why, what are layers for, layers in Internet protocols, etc)
Internetworking (IP)
  ◆ Why? What problem solved?

End-to-end principle

How IP works
  ◆ Addressing, Error control, etc
Reliable communication

- Automatic Repeat Request
  - Sequence numbers
  - Stop-and-wait
  - Duplicate detection
  - Sliding window

![Diagram showing reliable communication process](image)
Reliable transmission

- When to retransmit
  - Timers
  - Fast retransmit

- Forward Error Correction (not ARQ)
  - Basic idea, when applicable?
Connections & Flow control

- Associating packets with processes
  - Port numbers, connection tuples

- TCP (connection-oriented)
  - Three-way handshake – connection establishment
  - Sender/receiver buffering & flow control
    » Purpose of flow control
    » Advertised window (how flow control is implemented)

- UDP (connectionless)
  - Applications that want more control (over retransmission or not, framing, flow control, scheduling, etc.)
Congestion control

- Queuing
  - Scheduling & buffer management
- Congestion control design issues
  - How to detect, how to control data rate, what data rate to use, how to ensure stability, etc.
- TCP congestion control
  - Window-based, congestion control – detects congestion via packet loss
  - AIMD adaptation (with fast recovery)
  - Slow start
  - Fast retransmit
Routing: distance vector

- Kinds of routing
  - Destination-based, source routing, virtual circuit
- Routing vs Forwarding

- Distance vector routing
  - Distributed Bellman-Ford Algorithm
  - Tell your neighbors everything you know
- Problems: count-to-infinity
  - Split horizon/poison reverse
- When to send route updates?
Routing: link state

- Tell everyone about your neighbors
  - Reliable flooding & link-state packets
- Djikstra’s algorithm
- Timestamps to reject old LSPs?
- What if router crashes?
Routing: inter-domain

- Routing between organizations
  - Policy-oriented not optimizing global metric
  - Autonomous systems (AS)
- BGP
  - Path-vector protocol
  - Per AS policy (which routes to accept/advertise)
  - BGP decision procedure
  - Example implementations of policy:
    » Localpref, AS path, lowest IGP cost
  - Peering vs Transit (routing economics)
Routing: multicast

- Why multicast?
- How to use
  - Host API, addressing
- IGMP
- Routing
  - Source-based vs shared-tree
    - Tradeoffs
    - DV: Reverse Path Flooding, Reverse Path Multicast (prune)
  - Tunnelling/Mbone deployment issues
Mobile IP

- Mobility problem
- Mobile IP
  - Home Agent & Mobile agent
  - How packet forwarding works during mobility
  - Performance/security

- Transport-level mobility
  - TCP migrate option
Domain Naming System (DNS)

- Distributed database
- DNS records
  - A, NS, CNAME, etc
- Primary/secondary servers
- Name resolution
  - Hierarchy of servers
- Name caching
HTTP/Web

- Basic protocol
  - GET & response
- Parts of HTTP transfer (DNS, TCP handshake, request per object, etc)
- Persistent connections
- Pipelining
- Caching mechanisms
  - Expires, If-Modified-Since request
**Load Balancing/CDN**

- Other applications
  - SMTP, Telnet, NFS

- Load balancing
  - How to replicate content, push vs pull
  - How to select replica (mechanisms & policy)
    » Routing, application-specific, using DNS

- CDN (Akamai example)
  - Use DNS to redirect requests for Web objects
  - Consistent hashing for matching object to servers
Peer-to-peer networks

- Lookup problem
- Centralized vs Distributed
- Flooding vs structured (routing)
  - Gnutella (flood request)
  - Freenet (non-deterministic routing table)
  - Chord (deterministic routing using consistent hashing)
Network Security I

- Kinds of security problems
- Channel security
  - Basic cryptography
    » Authentication, confidentiality, integrity
- Perimeter security
  - Firewalls
  - Intrusion-detection systems
- Protocol security
  - Misbehaving TCP + modified protocol
Network Security II

- Denial-of-service attacks
  - How they work
  - Estimating DoS attacks
    » Backscatter analysis

- Network worms
  - How they grow
  - How to defend against
Distributed Web Caching

- Where to cache
  - Host, proxy cache, server accelerator, server

- What to cache
  - Impact of object popularity
  - Impact of # of users
  - Sources of cache misses

- Prefetching
- Cooperative Web caching
- Consistency