6.033 - Networking: Introduction
Lecture 8
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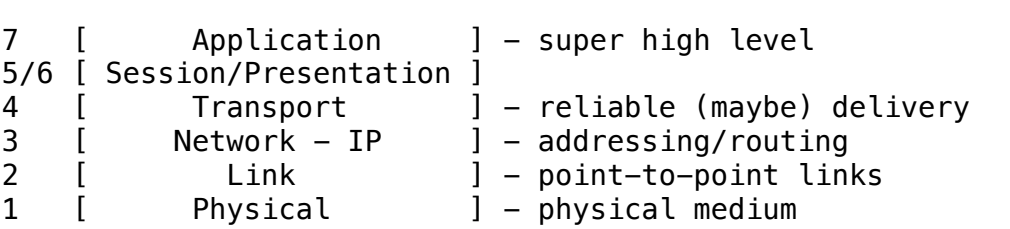
0. Welcome to networking
  - How networks work is a big part of systems
  - Network = source of failure for many systems. Why?
  - Today: intro to network / history of Internet. Look for common themes that you'll see over and over.
  - Don't worry about details of specific protocols today; we'll delve into those later on.

1. General networks
  - Model networks as graphs. Endpoints on outskirts, switches (a type of "middlebox") in the middle. Edge = direct connection between two nodes (perhaps a wire, perhaps not)
  - Problems:
    - Addressing
    - Naming
    - Routing
    - Transport
  - For small networks:
    - Naming/addressing: Just assign each node a unique name
    - Routing: A common protocol is link-state routing. Nodes flood the network with advertisements, use those advertisements to infer the topology, and run Dijkstra's algorithm on that topology. This protocol is run repeatedly to catch failures.
    - Transport: Lots of questions here. One problem to think about is reliability: what do we do when a packet gets dropped? Simple reliable transport: sender numbers its packets, receiver sends acknowledgements for packets. If sender doesn't receive an acknowledgement within a "reasonable" amount of time, it resends the packet.
  - In 6.033, we care mostly about the Internet. The Internet is not a "normal" network

2. The Internet, Pre-1993
  - Launch of Sputnik => creation of ARPA (now DARPA)
  - 1970S: ARPAnet. Started small. Combined addressing and transport. Began to grow by connecting existing networks
    - Using hosts.txt, distance-vector, sliding-window, etc.
  - 1978: Decide to make the Internet flexible. Encourages a layered model. Typical model:



- Ideally, layering lets us swap out protocols. E.g., link-state (a layer-3 protocol) can run over whatever physical layer.
- ~1983: TCP, provides reliable transport. No congestion control. Now apps don't have to reimplement reliable delivery.

3. Growth => Change
- 1978-79: Link-state routing, EGP. More scalable routing.
- 1982: DNS. More scalable naming. Also enabled growth through distributed management.

4. Growth => Problems
- Mid 80s: Congestion collapse. So many packets in network, but none were useful. TCP added a congestion control mechanism (more on this next week).
  - Why add it to TCP, not as a separate layer? It was already hard to add a new layer, even in the 80s.
- Early 90s: Policy routing. Internet was beginning to be commercialized, parts of it didn't want to provide transit to commercial transit. Policy routing (BGP) is a means to do this.
  - Notice: commercialization is causing problems.
- Addressing. Assign addresses in chunks of different sizes. "Class B" chunks -- 65K -- are typically "just right", and we ran out of those. The protocol CIDR was developed to divide these up.
  - Most interesting thing about CIDR: that it was possible to make this change at all. Changing addressing => changing switches. Happened because all switches were made by Cisco and forwarding was done in software.

5. The Internet, post-1993
- 1993: Commercialization. Changes stopped. "New technologies essentially get deployed for reasons of fear or greed." (http://www0.cs.ucl.ac.uk/staff/M.Handley/papers/only-just-works.pdf)

6. Problems we deal with today
- DDoS: send a lot of traffic to one machine to consume its resources. Hard to prevent. Internet wasn't designed with accountability in mind.
- Security: Internet was not designed for security. DNS, BGP, etc., have no secure infrastructure
- Mobility: No one every imagined this
- Address Space Depletion: IPv4 -> IPv6
- Congestion control: should probably change given the changes we've seen in the Internet (more about this later)

7. So what's new on the Internet?
- Lots. P2P, wireless, mobile, streaming, cloud computing, datacenter networks, security threats/defenses..
- Almost everything happens on the Internet today! Crazy.

- We expect to see continued changes: massive growth, software-defined networks, sensors, robots, embedded devices, privacy, censorship

8. Recurring themes
   - Layering and hierarchy (particularly hierarchy as a means of addressing scale)
   - Scalability: If enforcing modularity was the theme of the first part of 6.033, scalability is the theme of the second part.
   - Performance/efficiency: As the Internet grew, performance requirements informed its (re-)design.
   - Diversity of Applications: As the Internet grew, more and more applications used it. These applications have different demands: some care about throughput, some care about latency, some care about both, some need reliability, some don't, etc. We have to build a network that works for all of them.
   - Money: Because people pay to use the Internet, designing protocols can sometimes be trickier than it "should" be.
   - End-to-end argument: what part of the network should implement what features (endpoints, middleboxes, etc.)?