

History of Networking; Network Building Blocks

CS 640, 2015-01-20

Introduction

- How I got interested in networking -- writing a network stack for Embedded Xinu which runs on wireless routers
- Networking research
 - Network management -- how are networks designed and changed? how do management practices impact the frequency/severity of failures?
 - Middleboxes -- what are mboxes? how do we scale them? how do we make them distributed?
 - Software-defined networking -- write control programs to decide how data is forwarded through a network, rather than having network devices run distributed control protocols; how do we verify the correctness of these control programs?
 - Cloud measurement -- what web services are hosted in clouds? what features are used and what is the geo-diversity? how are CDNs used alongside clouds?
 - Accurately measuring cellular network performance; improving wireless network throughput by removing redundant data from traffic; quantify how handheld devices use networks differently than non-handheld devices

****What networks do you use?**

- CS department
- Campus -- wireless and wired
- Data center -- CS department, campus, cloud (e.g., Amazon EC2),
- Internet -- composed of many provider networks (e.g., WiscNet, Level3, Internet2, AT&T, Charter)
- Cellular network
- Home network
- Telephone network
- Cable network
- Content distribution network -- images, video
- Peer-to-peer network
- Social network

Syllabus

- Course website -- schedule
- TA -- Srini Ravichandran
- Book
- Grading

- Piazza

Network Building Blocks

- Play a game similar to Scattergories
 - You want to list things that fall into a certain category
 - You earn points for items that no one else has on their list
 - You'll compare lists in small groups first, then we'll try to compare as a class
- Pull out a piece of paper
- List physical and conceptual components of networks -- e.g., wireless access point, website address; includes anything you think we might talk about this semester

History of networking -- how did we get to where we are today?

- Communication before computer networks
 - At a very basic level, a network is a system for exchanging messages
 - 2400 BCE: carrier system
 - July 26, 1775: United States Postal Service was established by the Second Continental Congress with Benjamin Franklin as the first Postmaster General
 - 1838: First commercial telegraph allowed messages to be exchanged between two points in the city of London 13 miles apart
 - Samuel Morse simultaneously sent the first telegraph in the United States; Alfred Vail, his assistant, developed Morse code
 - 1876: First telephone conversation between Alexander Graham Bell and his assistant, Thomas A. Watson
 - 1895: First commercial radio capable of transmitting 1.5 miles was invented by Italian inventor Guglielmo Marconi
 - 1927: First working television with electronic scanning of both the pickup (i.e., video camera) and display devices was invented by Philo Farnsworth
- Computer Networks
 - Motivation was to enable remote use of computers
 - Based on 1960s telephone network, which performs circuit switching
 - A circuit is a dedicated communication channel, composed of a sequence of dedicated physical wires
 - Telephone switchboard -- originally circuits were established by manually connecting wires
 - Circuit switching is inefficient because only two endpoints at a time can communicate over the channel
 - Late 1950s and early 1960s: ideas for packet switching
 - Packet switching breaks a message into pieces (packets) and multiplexes packets from several endpoints over the same communication channel
 - 1961: Leonard Kleinrock published a paper that showed packet switching was effective for bursty traffic -- when two endpoints were not using the communication channel, other pairs of endpoints could send packets

- 1967: Paul Baran had been developing packet switching as Rand Institute and published his work; US Department of Defense wanted a robust communication system
- 1967-169: Team lead by Vint Cerf and Bob Kahn developed the ARPAnet (Advanced Research Projects Agency Network)
 - First network switches built by BBN using the Internet Message Processor (IMP)
 - First 4-node packet switched was built -- switches were deployed at Utah, UCLA, UCSB, and Stanford
- 1972: ARPAnet had grown to 15 nodes
 - Network control protocol was the first end-to-end communication protocol -- defined by RFC0001; allowed endpoints to send a message and let the network worry about what path to take to get it there
- 1972: Ray Tomlinson invented email; first network application; used the end-to-end communication protocol
- 1973: Bob Metcalf invented Ethernet -- a standard for wiring and signaling that is still used today (with some updates)
- 1974: Vint Cerf and Bob Kahn developed an open architecture for the Internet
 - Internet Protocol (IP) and Transmission Control Protocol (TCP)
- 1979: Internet (formerly the ARPAnet) had 200 nodes
- 1989: Internet had 100K nodes
 - Much growth was fueled by connecting universities -- Larry Landweber from UW-Madison was an important part of this
 - Need for improvements
 - TCP improvements by Van Jacobson to address congestion
 - Domain Name System (DNS) developed to provide an easier way to identify nodes
- 1991: Tim Bernes-Lee invented the Web by creating the Hypertext Transfer Protocol (HTTP)
- 1993: Mark Andreessen invented MOSAIC, the first graphical browser
- 1998: Google was incorporated; Napster peer-to-peer network for file sharing started
- 2000s: social networks, gaming, streaming media
- 2008: OpenFlow protocol was designed by Nick McKeown, leading to software-defined networking (SDN)
- 2????: You invent the next big thing for networking