



The network is the computer.
- Sun Microsystems Motto

It's a mind-set, not a skill-set. Brilliance helps, but is not required.

Instead, adopt these mantras: be stubborn, bossy, lazy, obsessive, cynical, **plodding**, and importunate. Why? So you can use IT as a tool to do cool stuff...



Early Computer Networks

- Early machines were *stand-alone* machines.
- But people wanted to...
 - share data
 - share resources
- Growth
 - 1960s: some mainframes
 - 1980s: personal computers at home
 - 2000s: everything? mandatory?

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We'll pretty much skip directly to the internet.

Computer networks present:

Opportunities

- users can share files
- you only need 1 printer for a group of people
- you can communicate via email and ftp
- computing loads could be balanced between machines

Difficulties

- hackers can get shared files
- when the 1 printer goes down, everyone is toast
- you can send spam
- Security is a huge issue!



Distributed Network

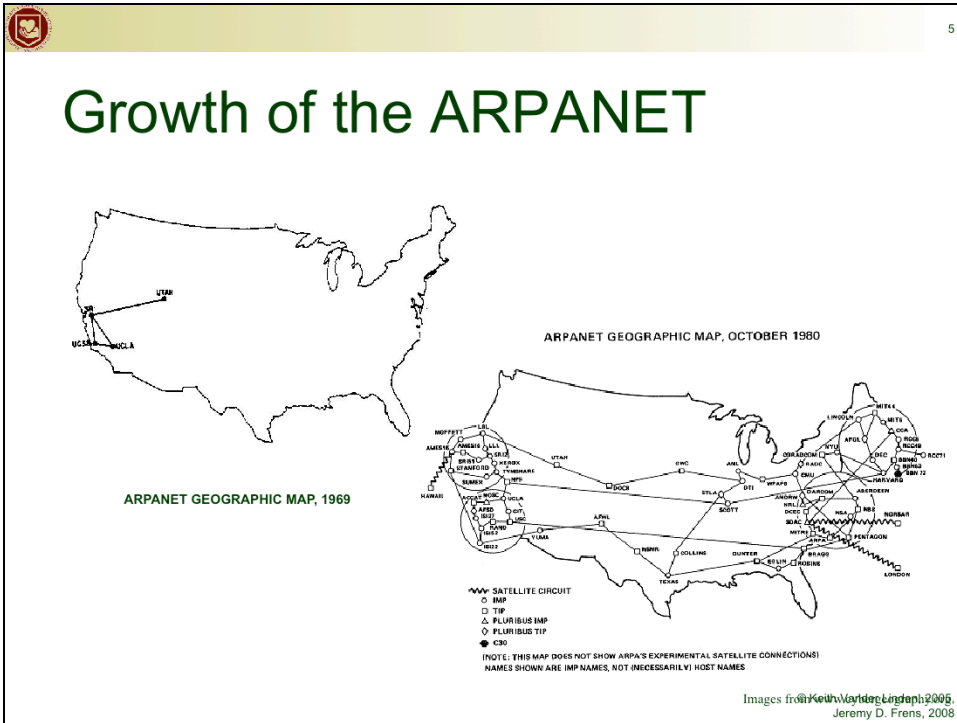
- No one computer is in charge of the Internet.
 - All computers are in charge!
 - Some take on more responsibilities.
- Computers are connected to each other in multiple ways.
- Each computer routes data closer to its destination.
 - Routers: extra routing responsibilities.



ARPANET

- 1969
- The DOD wanted a network that could handle computers that crashed regularly.

The DOD did not want a computer network in which communication lines could so easily be “disconnected”.



No, I won't try to get a map of the whole internet today!



Internet

- 1983
- ARPANET, CSNET & other networks combined to form the Internet.
- Network of independent, heterogeneous networks.
 - Within your network, use whatever protocol you want.
 - On the Internet, use TCP/IP

The internet is a network of networks, all using TCP/IP.

The instructor's station might have the address: pcnh180-1.calvin.edu. This is completely unique in the world.



Vinton Cerf (1943-)

TCP/IP

- 1973
- Co-invented with Robert Kahn
- TCP/IP – a suite of protocols, including:
 - Transmission Control Protocol
 - Internet Protocol
- Together, they form the basis of the internet.

Image from www.elsevier.com

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Transmission Control Protocol - rules for building and managing packets (chunks and reassembles)

Internet Protocol - rules for routing the packets

The basis of the internet for 2 reasons really:

packet switching

it was an **open-network architecture**, not a proprietary one.



Packet Switching

- Data is split up into small packets.
- Each packet is sent on its own to a nearby computer.
 - Not all packets take the same route!
- The packets are reassembled into the original data.
- If a packet goes missing, it's resent.

Packet switching is different from the explicit direct circuits used by the telephone system - if you are cut off there, you are cut off and need to re-establish a connection. In packet-switching, the packets just get re-routed. TCP/IP is one of the many packet switching protocols out there.

Note that this is very different from a centralized, switched telephone network.



Network Size

- Networks can be characterized by how large they are:
 - Local-Area Network (LAN)
 - Wide-Area Network (WAN)

Local Area Networks (*LAN*):

reach up to 1 mile – say for a single building or a campus
(Calvin is a LAN)

are relatively fast

Wide Area Networks (*WAN*):

can be global

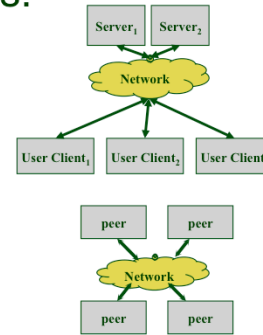
e.g., the internet is a WAN (but not the only one)

are relatively slower



Network Architectures

- Networks can be characterized by how they manage their resources.
- Common network architectures:
 - Client-Server
 - Peer-to-Peer

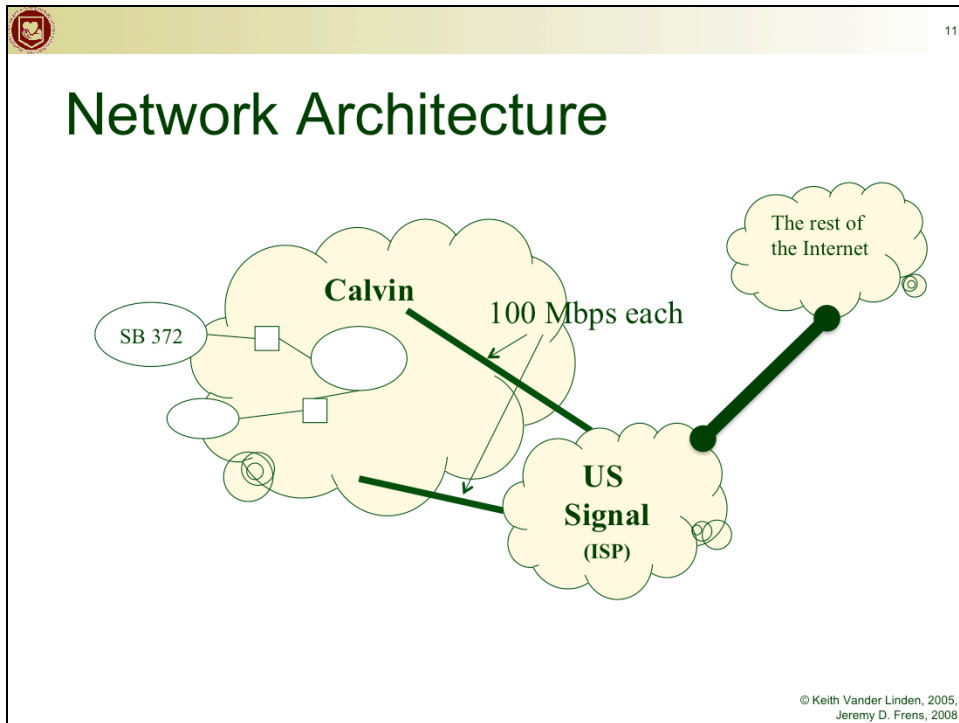


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Common network architectures:

Client-server – Separates front-end interfaces (clients) from centralized service providers (servers) – This is by far the most common architecture today.

Peer-to-peer – used direct network connections between egalitarian client/servers (clervers!?)



The internet is a network of heterogeneous networks, as can be seen in this myopic, SB372-centric view of the internet.

LANS (circles at Calvin, including SB 372)

Switches connect computers all with the same domain (i.e. Calvin is all 153.106.xx.xx)

Routers link one (potentially incompatible) network to another (little boxes). They can also have additional responsibilities like firewalls and other policy implementation

Modems (little circles): From Wikipedia: A **modem** (**modulator-demodulator**) is a device that modulates an analog signal carrier to encode digital information, and also demodulates such a carrier signal to decode the transmitted information. The goal is to produce a signal that can be transmitted easily and decoded to reproduce the original digital data.

Internet Service Provider

Servers: deliver content

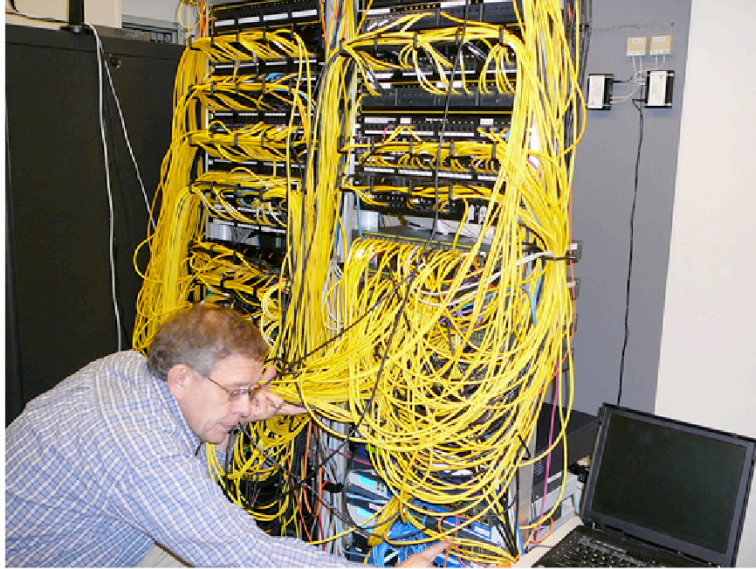


Calvin's Network

- Dual 100 Mbps fiber connections to/from US Signal
- 400 switches
- Distribution closets in all buildings – with big one in Bolt-Heyns-Timmer
- All data through a “packet shaper”, “intrusion prevention device”, and “external firewall”.



Calvin's Network



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Network Technologies

- Copper wire
 - coaxial or twisted pair (telephone wire, cat5/ ethernet cable)
- Fiber-optics
- Wireless technology
 - Radio Frequency (RF)
 - Infrared radiation
 - Microwave

Fiber is cheaper to fabricate, but requires a laser (expensive). Breaks easily without protection, but works better for long distances.

Thus, **copper** is still common (more durable, works well for local connections)

RF is nice, but there are limited radio frequencies to use (this is what WIFI works with though)

infrared is restricted to a single room, and is still slower than the others (remote controls)

microwave can't penetrate metal either, and are potentially dangerous to humans



Network Connections

- Computers on a Network, connect via a *NIC*.
- Other computers connect to a *POP* using:
 - *Modem* (modulator/demodulator)
 - *ISDN* - digital telephone service (up to 128 Kb/s)
 - *DSL* - similar to ISDN (up to 1.5 Mb/s upload)
 - *Cable modem* - standard cable lines (up to 1 Mb/s)

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Computers on a Network, connect via a Network Interface Card (*NIC*)
high-speed connection to a LAN

Connecting to a Network point of presence (POP):

Modem (modulator/demodulator)

digital to analog telephone signals (up to 56 Kb/s)

connects to an *Internet Service Provider* (ISP)

Other technologies:

ISDN - digital telephone service (up to 128 Kb/s)

DSL - similar to ISDN (up to 1.5 Mb/s upload)

Cable modem - standard cable lines (up to 1 Mb/s)

ISDN/DSL are used because we're stuck presently with twisted pair technology.

“broadband” refers to high-speed (> 1Mbps) internet connections



Internet Services

- The Internet supports a variety of information services.
- These services *use* the Internet.
- Examples:
 - World Wide Web (http)
 - Email
 - Skype
 - FTP/SFTP

The internet now supports a vast array of programs/systems, called services.

The Web is an Internet service that supports the sharing of hypermedia. **Internet != WWW**

Email is a service for exchanging mail messages.

FTP/SFTP is a service for moving data between machines



Inclusiveness of the Web

- How “world-wide” is the web?
- How could we make it more international?
- How inclusive or *intrusive* should it be?

Given the English-centric nature of the web, one might more accurately call it the ***Western-wide web***.

Digital divide – the WWW is hard to access in:

- the developing world
- the non-western world
- underprivileged social classes
- the disabled community

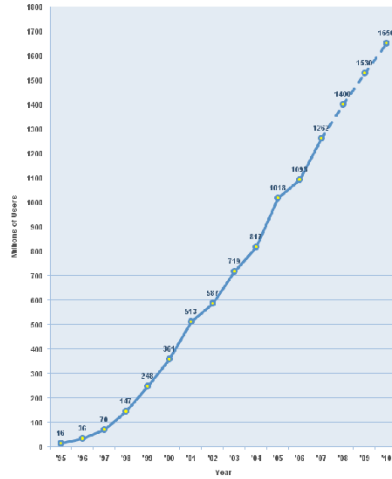
What could we do to help bridge this divide?

- Unicode
- internationalized domain name resolution
- better translation tools
- better international/disabled design and testing



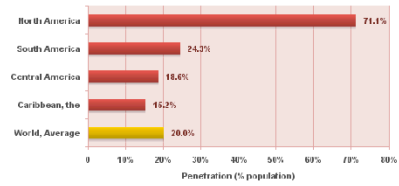
Growth of the Internet

Internet Users in the World
Growth 1995 - 2010



Source: www.internetworldstats.com - January, 2008
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Internet Penetration Rate in the Americas
December 2007



Source: Internet World Stats - www.internetworldstats.com
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penetration (% of population)

<http://www.internetworldstats.com/stats.htm>



Malware

- malicious software: “software to infiltrate a computer system without the owner’s informed consent” [wikipedia]
 - definition based on the user’s *intent* or *motive*
 - Note: God judges us based on our *motives*.
- includes computer viruses, worms, trojan horses, rootkits, spyware, dishonest adware, crimeware, etc.

What kinds of data:

- internet usage patterns
- credit cards (even with encryption)
- informational databases
- proprietary systems or information
- passwords

how can they be compromised:

- copying
- hacking into protected sites
- sniffed in various ways
 - packet-sniffers
 - carnivore
 - companies monitoring stuff
- cookies
- identity theft



Malware (cont)

- virus: attached to an existing program, does damage to files, and copies itself.
- worm: unattached, damages the network, and copies itself.
- trojan horse: opens up a “backdoor” to the system for future unauthorized access; non-replicating.
- spyware: collects info about users.
- crimeware: for identity theft.



Privacy and the Internet

- The internet never sleeps, it never forgets and it doesn't always tell the truth.
 - phishing schemes
- The internet makes information more vulnerable to improper use.
- What can be done about this?
- "...be shrewd as snakes and as innocent as doves." - Matthew 10:16

Privacy is somewhat of a fallacy on the internet.

What to do:

privacy legislation

proper security

ethical behavior.