



**UC Berkeley EECS
Lecturer
Gerald Friedland**

The Beauty and Joy of Computing


Lecture #12 Internet I





Honeywell Lyric: Monitoring thermostats using the Internet.
http://www.youtube.com/watch?feature=player_embedded&v=WI-CgMLA5cY


Cool? (literally!)
But: Info sent to contractors so they can sell you products? So now they know when you are at home or not. Privacy?




Quick Question I


In the last 3 years, what was the longest time stretch you have ever been without Internet?


- Several hours
- 1-2 days
- More than 2 days
- Several weeks
- More than several weeks





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Quick Question II


What was the reasons for not having access to the Internet?


- Technical interruption
- In an area with no Internet
- Voluntary break
- Didn't bother having access
- Other



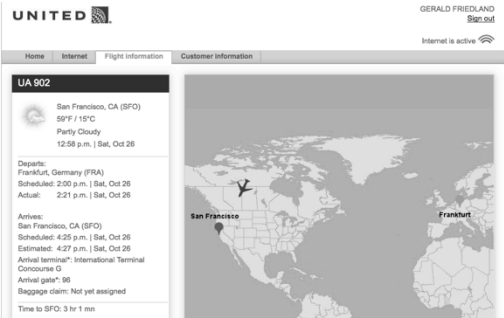



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Internet is pretty much everywhere!





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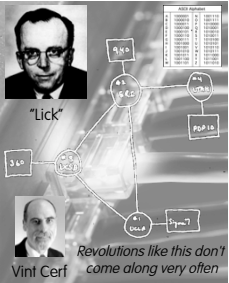





The Internet (1962)

www.computerhistory.org/internet_history


- Founders**
 - JCR Licklider, as head of ARPA, writes on "intergalactic network"
 - 1963 : ASCII becomes first universal computer standard
 - 1969 : Defense Advanced Research Projects Agency (DARPA) deploys 4 "nodes" @ UCLA, SRI, Utah, & UCSB
 - 1973 Robert Kahn & Vint Cerf invent TCP, now part of the Internet Protocol Suite
- Internet growth rates**
 - Exponential since start!



Revolutions like this don't come along very often



www.greatachievements.org/?id=3736
en.wikipedia.org/wiki/Internet_Protocol_Suite




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The basics of the basics

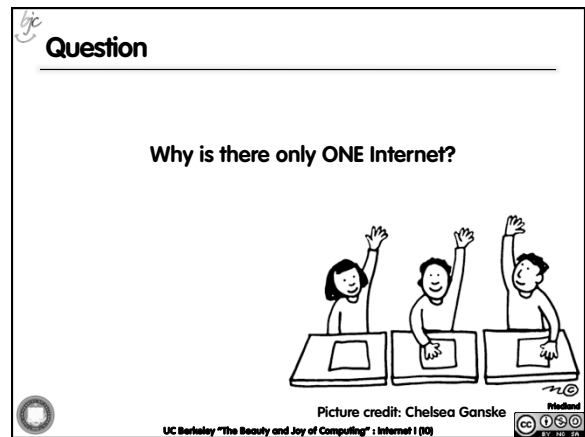
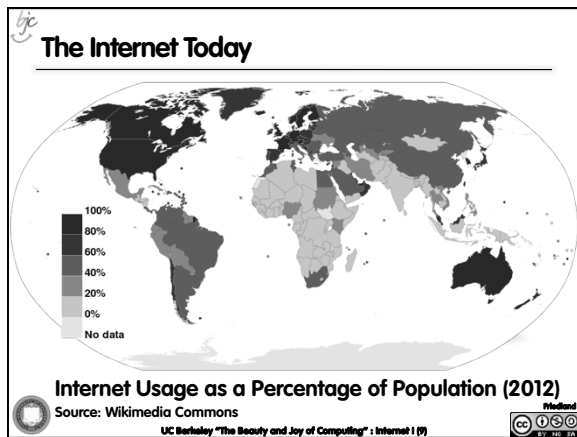
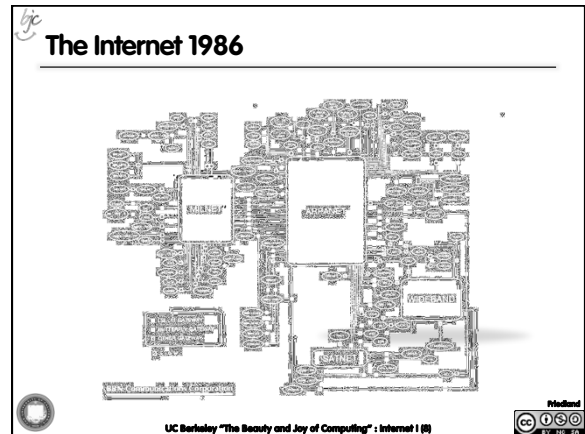
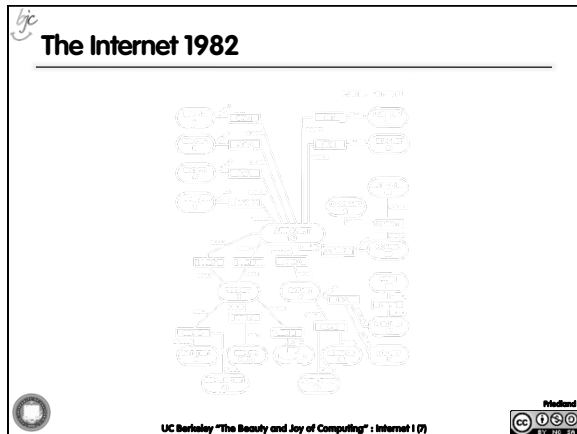


http://youtu.be/7_LPdtKXPC



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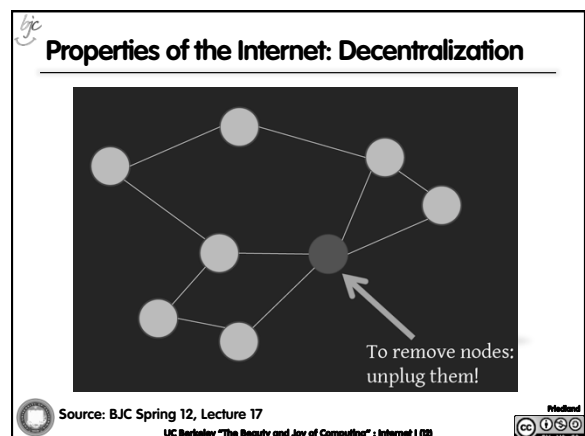




Growth of the Internet

- The major point in building networks is agreement.
- The Internet was build
 - using a decentralized architecture
 - using open protocols

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en.wikipedia.org/wiki/History_of_the_World_Wide_Web

The World Wide Web (1989)

- **Internet Engineering Task Force (IETF):**
 - Request for Comments (RFC)
- **World Wide Web Consortium (W3C)**
 - HTML
- **International Standards Organization (ISO)**
 - JPEG, MPEG
- **Institute of Electrical and Electronics Engineers (IEEE)**
 - WiFi

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en.wikipedia.org/wiki/Email

Email (1965)

- **Fundamentally changed the way people interact!**
- **1965: MIT's CTSS**
 - Compatible Time-Sharing Sys
- **Exchange of digital info**
 - Model: "Store and Forward"
 - "Push" technology
- **Pros**
 - Solves logistics (where) & synchronization (when)
- **Cons**
 - "Email Fatigue"
 - Information Overload
 - Loss of Context

How

- Alice composes email to bob@b.org
- Domain Name System looks up where b.org is
- DNS server with the mail exchange server for b.org
- Mail is sent to mx.b.org
- Bob reads email from there

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en.wikipedia.org/wiki/History_of_the_World_Wide_Web

The World Wide Web (1989)

- **"System of interlinked hypertext documents on the Internet"**
- **History**
 - 1945: Vannevar Bush describes hypertext system called "memex" in article
 - 1989: Tim Berners-Lee proposes, gets system up '90
 - ~2000 Dot-com entrepreneurs rushed in, 2001 bubble burst
- **Wayback Machine**
 - Snapshots of web over time
- **Today : Access anywhere!**

Tim Berners-Lee

World's First web server in 1990

Internet Donorily Blurring Host Count

Wayback Machine

www.archive.org

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en.wikipedia.org/wiki/History_of_the_web_browser

WWW Search & Browser (1993)

- **Browser**
 - Marc L. Andreessen and Eric J. Bina @ NCSA create Mosaic, 1st popular WWW browser
 - First Internet "Killer App"
 - Later: Netscape Navigator
 - Now IE (23%), Firefox (30%)
- **Search**
 - Before engines, there was a complete list of all servers!
 - 1993 Martijn Koster Aliweb is 1st web search engine
 - 1997 Stanford Sergey Brin and Larry Page develop Google's search, based on PageRank (each: \$16 Billion)

WEB BROWSER

Netscape

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en.wikipedia.org/wiki/Web_2.0

Web 2.0 : The Social Network (2004)

- **"...web development & design that facilitates interactive information sharing, interoperability, user-centered design and collaboration on WWW"**
 - Users change content via "architecture of participation"
- **Examples**
 - Web communities, apps, social networks, video & photo sharing, wikis, blogs, tweets, ...
- **"Take back the web!"**

Web 2.0

TIME

You.

"You" – Time's 2006 Person of the Year

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en.wikipedia.org/wiki/IP_addresses

IP Addresses

An IPv4 address (dotted-decimal notation)

172 . 16 . 254 . 1

↓ ↓ ↓ ↓

10101100.00010000.11111110.00000001

One byte=Eight bits

Thirty-two bits (4 x 8), or 4 bytes




- **Split: First part network, second part computer indicated by /bits: e.g. 192.168.1.103/16**
- **2³² = 4 billion unique numbers (world population 7 billion)**

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Count

Take a moment and count: How many Internet-connected devices do you own?

- a) 0
- b) 1
- c) 2-5
- d) 5-10
- e) More than 10



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- a) 0
- b) 1
- c) 2-5
- d) 5-10
- e) More than 10



Problem: No more IP addresses left...

The graph illustrates the depletion of free IP addresses over time. The Y-axis represents the number of free IP addresses (I/R) from 0 to 160. The X-axis represents the date from 1996 to 2014. The 'IANA' line shows a steady decline from approximately 145 in 1996 to about 10 in 2014. The 'RIR pool + IANA' line shows a similar decline but at a slower rate, reaching about 15 by 2014. The unlabeled line shows a more rapid decline, reaching about 10 by 2014.

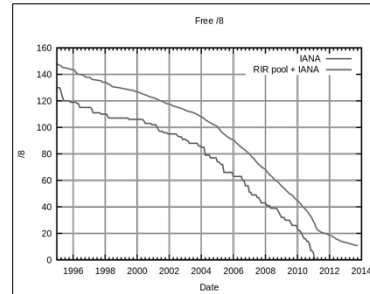
Date	IANA	RIR pool + IANA	Unlabeled
1996	145	145	145
2000	135	135	135
2004	125	125	125
2008	115	115	115
2012	105	105	105
2014	10	15	10

Source: Wikimedia Commons

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Weekend

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Solution: IPv6

An IPv6 address (in hexadecimal)

2001:0DB8:AC10:FE01:0000:0000:0000:0000

↓ ↓ ↓ ↓ [Zeros can be omitted]

2001:0DB8:AC10:FE01::

1000000000000100001001010110001001010000010000111111100000001
00

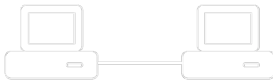
- $2^{128} = 3.403 \times 10^{38}$ unique addresses
- Issue: Adoption still in progress
- Workaround exists: NAT (Network Address Translation)

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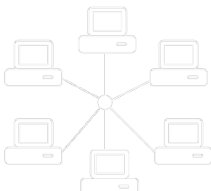
- # Summary and Outlook
-
- The Internet is setup for growth using open standards
 - It is highly failure tolerant due to decentralization
 - However, issues arise with trying to improve it.
- Internet II (later):
- Routers
 - Internet Protocols
 - Vulnerabilities of the Internet
 - More on Social Implications
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- **More on Social Implications**

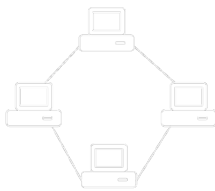
Network Topologies




Point-to-Point (Peer-to-Peer)




Starnet/Arcnet



Token Ring




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Starnet/Arcnet

Token Ring

Network Topologies II



The diagram illustrates the Ethernet (Bus) network topology. It features a central horizontal line representing the bus. Five computer icons are connected to this bus: two are connected to the top of the bus, and three are connected to the bottom. All computers share the same communication channel.

Ethernet (Bus)


- Most prevalent network today
- Wireless networks = Ethernet topology!

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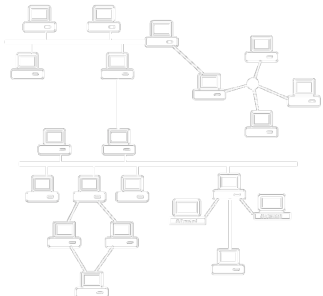
Standard
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Ethernet (Bus)

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
Network Topologies III



An internet

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IP Address Allocation


IANA (Internet Assigned Numbers Authority) allocates network addresses to entities by delegating to RIRs (Regional Internet Registries).

IANA-reserved private IPv4 network ranges

	Start	End	No. of addresses
24-bit block (/8 prefix, 1 × A)	10.0.0.0	10.255.255.255	16 777 216
20-bit block (/12 prefix, 16 × B)	172.16.0.0	172.31.255.255	1 048 576
16-bit block (/16 prefix, 256 × C)	192.168.0.0	192.168.255.255	65 536

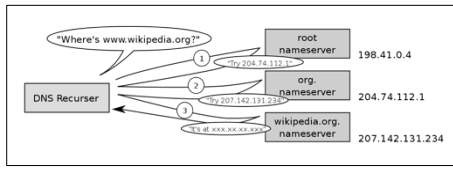
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Domain Name Service

DNS is used to resolve names to IP addresses in a decentralized manner



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