

Information Theory and Networks

Lecture 2: A Brief History of Networks

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Part I

A Brief History of Telecommunications

You know what they say. Those of us who fail history, are doomed to repeat it in summer school.

Buffy (the Vampire Slayer), "After Life" (Season 6, Ep. 3), 2001

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2013-09-18

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Why bother?

- ideas have their time
 - most things are invented for a need
 - this gives insight into network design
- most things in networking are reinvented again and again
 - can save a lot of time if you already know the answer
- gentle introduction to some concepts

An outline

- 1 pre-industrial
- 2 19th century
- 3 early 20th century
- 4 computer networks
- 5 early 21st century (now)

An outline

- pre-industrial
- 19th century
- early 20th century
- computer networks
- early 21st century (now)

More detailed telephony time-lines can be found at

<http://www.telephonetribute.com/timeline.html>
<http://www2.fht-esslingen.de/telehistory/>

Histories of computing and computer networks

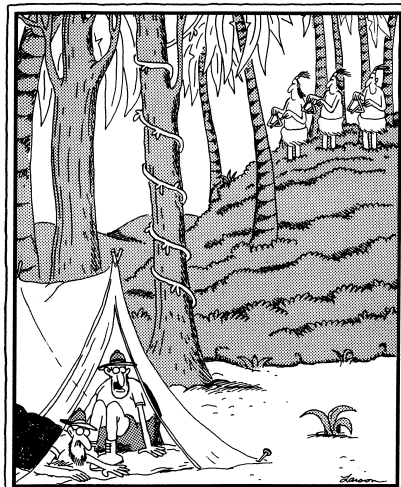
http://en.wikipedia.org/wiki/Computing_timeline
<http://www.isoc.org/internet/history/>
<http://www.onlineitdegree.net/>

Australian telecoms history

<http://www.caslon.com.au/timeline.htm>
<http://www.anu.edu.au/people/Roger.Clarke/II/OzIHist.html>

Pre-industrial

- Jungle drums
- Signal fires
1184 BC, fall of Troy [AesCE]
1588 AD, Arrival of Spanish Armada
- Carrier pigeons
700 BC, Olympic games
- Smoke signals
150 AD, Romans
- Semaphore
1791 AD, Chappe brothers
later used by Napoleon



"Wait, Morrison! ... It's OK—those are jungle triangles!"

Gary Larson, 1993

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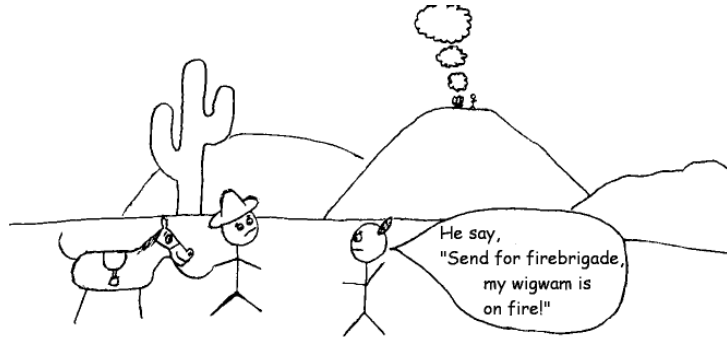
Marathon: One of the more famous events in early telecommunications occurred in September 490 BC. The Greeks defeated a much larger Persian army (numbering in the hundreds of thousands as compared to the Greeks who had more like 10,000 soldiers). An Athenian herald, Pheidippides, ran from Marathon to Athens to deliver the message "We were victorious!", following which he immediately died.

Most telecommunications providers would prefer not to die :-)

Pre-industrial

These had limitations

- Carrier pigeons: 1 short message per pigeon
- Signal fires: one bit per fire
- Semaphore: 15 characters per minute.



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19th century

Post office:

- British post office founded 1635.
- modern postoffice 1840 (1st "penny black" in UK)
- send **content** as letter or parcel
- encapsulate package with address on the front
- send to local postoffice
- each postoffice determines next postoffice
- final postoffice delivers to the address



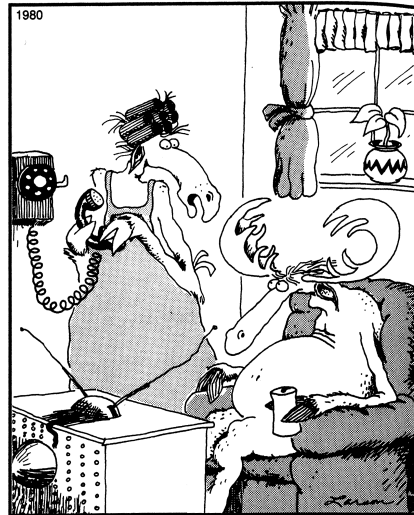
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http://www.bbc.co.uk/history/timelines/britain/vic_penny_black.shtml

19th century

Electronic communication:

- telegraph
 - ▶ invented 1753
 - ▶ Morse code 1835
 - ▶ take off 1838
 - ▶ 1st transatlantic line 1866
- radio (Marconi, 1896)
- telephone
 - ▶ A.G. Bell
 - ▶ filed patent Feb. 14, 1876, 3 hours before Elisha Gray



"It's the call of the wild."

Gary Larson, 1980



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In 1876, Bell and his financial backer, G.G. Hubbard, offered Bell's patent to the ancestor of Western Union. Their committee to investigate the patent reads in part:

"The Telephone purports to transmit the speaking voice over telegraph wires. We found that the voice is very weak and indistinct, and grows even weaker when long wires are used between the transmitter and receiver. Technically, we do not see that this device will be ever capable of sending recognisable speech over a distance of several miles.

"Messer Hubbard and Bell want to install one of their "telephone devices" in every city. The idea is idiotic on the face of it. Furthermore, why would any person want to use this ungainly and impractical device when he can send a messenger to the telegraph office and have a clear written message sent to any large city in the United States?

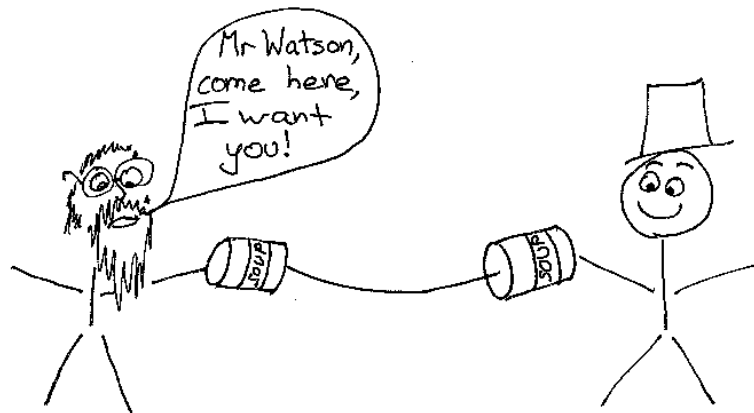
"The electricians of our company have developed all the significant improvements in the telegraph art to date, and we see no reason why a group of outsiders, with extravagant and impractical ideas, should be entertained, when they have not the slightest idea of the true problems involved. Mr. G.G. Hubbard's fanciful predictions, while they sound rosy, are based on wild-eyed imagination and lack of understanding of the technical and economic facts of the situation, and a posture of ignoring the obvious limitations of his device, which is hardly more than a toy... .

"In view of these facts, we feel that Mr. G.G. Hubbard's request for \$100,000 of the sale of this patent is utterly unreasonable, since this device is inherently of no use to us. We do not recommend its purchase."

The amusing thing about this letter, in retrospect, is that Bell obtained controlling interest in Western Union by 1882!

19th century

Simple telephone: connects two points with a wire



Reportedly, the first words over the telephone came when Bell spilled some acid on his pants, whereupon he call "Mr. Watson, come here, I want you!"



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Towards modern telephony

- switching
 - ▶ electronic switch (instead of electromechanical)
 - ▶ 4ESS (like a building)
<http://www.att.com/history/nethistory/switching.html>
- networks become hierarchical
 - ▶ long distance versus local
- reliability and redundancy become important
 - ▶ alternate routing
- billing systems
 - ▶ harder than you think!
- massive capacity increases
 - ▶ fibre optics
 - ▶ better transmission techniques (e.g., DSL)

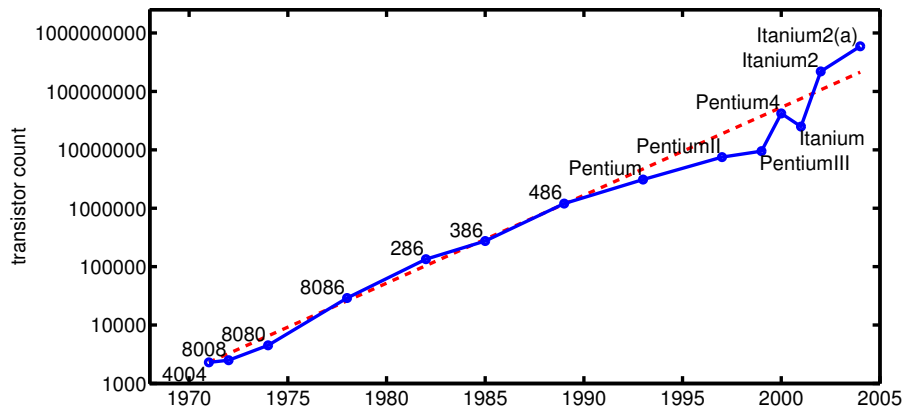
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Moore's Law

Moore's law: the speed of digital hardware increases by a factor of two every 18 months, or the number of transistors on a chip doubles, or the cost halves [Moo65].



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Intel's pages on Moore's law:

- <http://www.intel.com/technology/mooreslaw/index.htm>
- <ftp://download.intel.com/research/silicon/moorespaper.pdf>

Other links to Moore's law:

- http://en.wikipedia.org/wiki/Moore's_law
- http://www.thocp.net/biographies/papers/moores_law.htm
- http://www.firstmonday.org/issues/issue7_11/tuomi/
- <http://www.hyperdictionary.com/computing/moore'slaw>
- <http://www.physics.udel.edu/wwwusers/watson/scen103/intel.html>
- <http://www.ziplink.net/~lroberts/Forecast69.htm>

Gilder's Law

Gilder's law: theoretical transmission capacity of a link increases by a factor of two every 12 months.

- <http://www.seas.upenn.edu/~gaj1/promise.html>
- <http://www.dtc.umn.edu/~odlyzko/doc/tv.internet.txt>
- <http://telecomvisions.com/articles/beyondip/>
- transmission capacity is still behind storage
 - ▶ 2000, backbones in US carried 144 PB/year, total disk capacity 3000 PB
 - ★ it would take 20 years to carry all the data
 - ▶ 2005, 100 GB disk is common, 1.5 Mbps
 - ★ it would take 6 days to carry all the data
 - ▶ network is catching up?

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"I returned, and saw under the sun, that the race is not to the swift, nor the battle to the strong, neither yet bread to the wise, nor yet riches to men of understanding, nor yet favor to men of skill; but time and chance happeneth to them all."

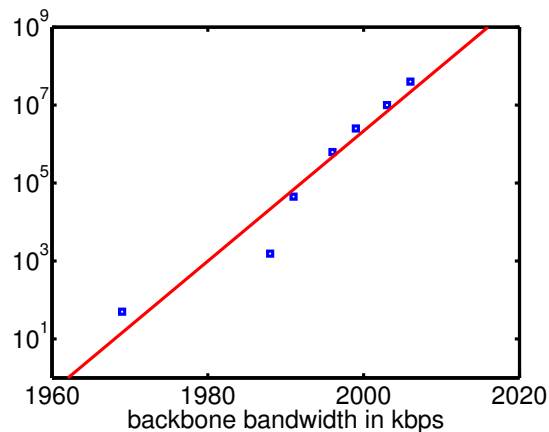
Ecclesiastes 9:11

The race is not always to the swift, nor the battle to the strong, but that's the way to bet.

Anon

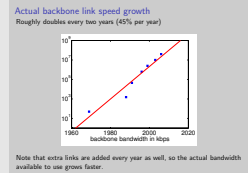
Actual backbone link speed growth

Roughly doubles every two years (45% per year)



Note that extra links are added every year as well, so the actual bandwidth available to use grows faster.

Actual backbone link speed growth



- 1969: 50kbps
- 1988: NSFNET backbone upgraded to T1 (1.544Mbps)
- 1991: NSFNET backbone upgraded to T3 (44.736Mbps)
- 1996: MCI upgrades Internet backbone 622Mbps
- 1999: MCI/Worldcom begins upgrading the US backbone to 2.5 Gbps (OC48)
- circa 2003: 10 Gbps (OC-192)
- circa 2006: 40 Gbps (OC-768)

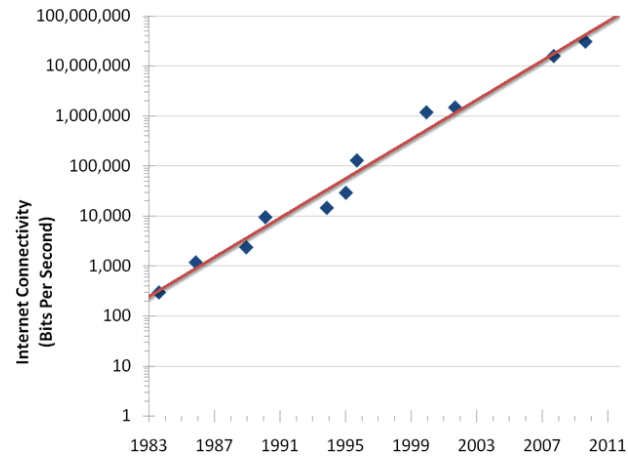
Backbone speeds are behind limits of transmission tech.

<http://www.zakon.org/robert/internet/timeline/>

Access-link speeds

Nielsen's Law of Internet (Access) Bandwidth

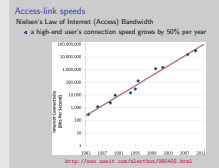
- a high-end user's connection speed grows by 50% per year



<http://www.useit.com/alertbox/980405.html>



Access-link speeds



A lot of these improvements come from better coding and transmission approaches. That's one of the things we will touch on in this course.

Further reading I

- Aeschylus, *Agamemnon*, <http://classics.mit.edu/Aeschylus/agamemnon.html>, 458 B.C.E.
- Gordon E. Moore, *Cramming more components into integrated circuits*, *Electronics* **38** (1965), no. 8.

