Communications Network Design

lecture 01

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October 27, 2011

Introduction

What, When, Where, How, Who, Why

Why do we need design

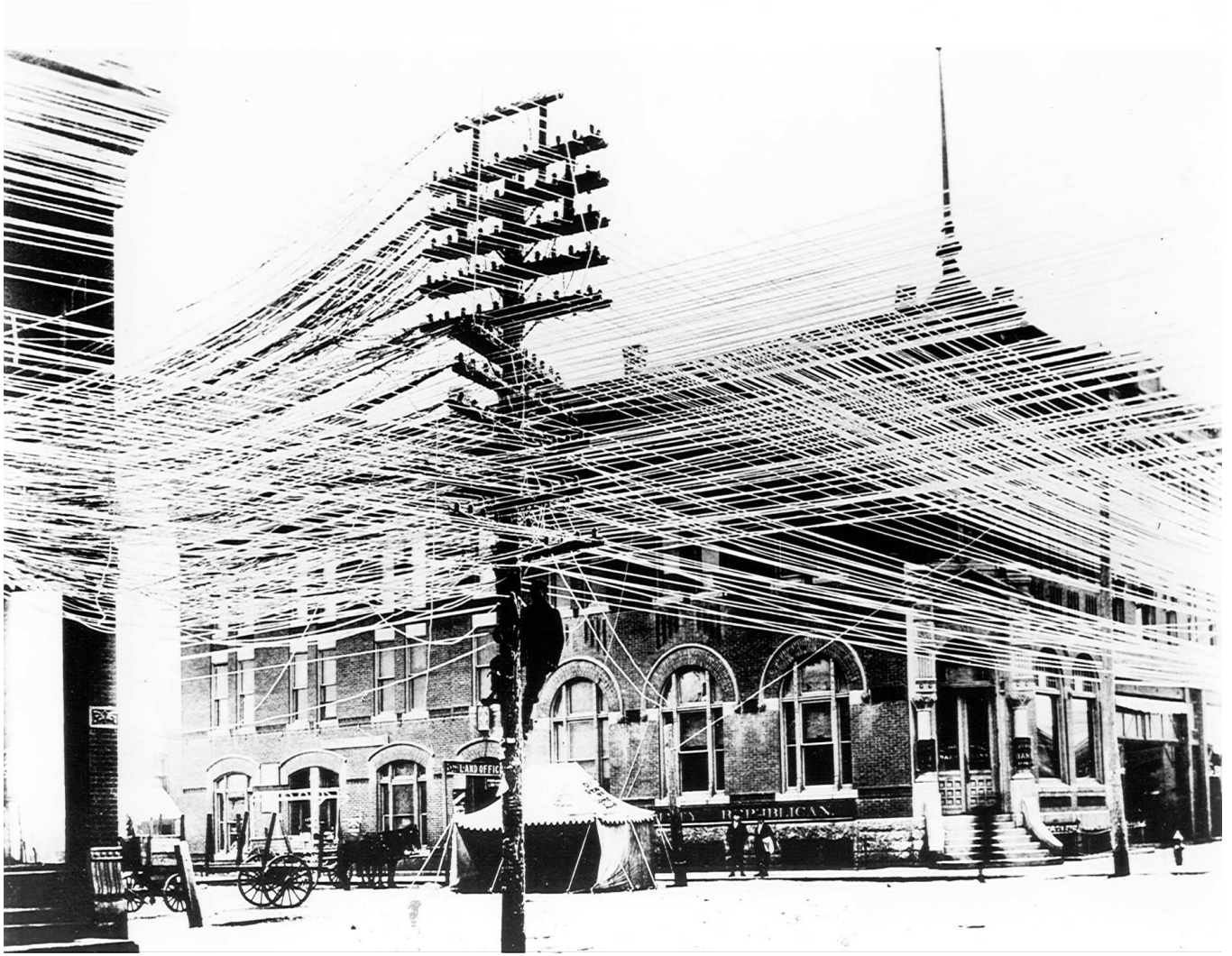
?

I don't know how any of the stuff works that is involved with telephone networks, let alone what works in any computer network.

former Chief Executive of a major Australian Telco

... Without Design

Pratt, Kansas



http://www.bellsystemmemorial.com/oldphotos_6.html

Motivation

- Telecommunications industry in the US in 1997
  $256 billion industry [1]
- Compare to other US industries [1]
  - Motion picture industry: $63 billion
  - TV: $37 billion
  - Newspapers: $55 billion
  - Radio: $14 billion
- Telstra 2005, [2]
  - property, plant, equipment >$22 billion
- National Broadband Network, 2009
  - $4.7 billion public investment (+ private)

What if you could save 1%?

Wider Motivation

More than just telephone networks ...

"Close roads to clear traffic gridlock"

Bernard Lane, The Australian, 17-02-2005

- postal network
- more sinister networks
  - al-Qaeda
  - Mafia
- transportation network
  - road
  - rail
  - truck

Focus

- data networks
- main example: the Internet
  - made up of lots of components
  - we'll look at specific design problems within this context
- many techniques have MUCH wider applicability

Course objectives

Objectives: At the end of this subject the students should be able to:

- analyse the features of a network design problem:
  - objectives (e.g. cost minimization)
  - constraints (e.g. technological limits)
  - properties of each
- understand what data is needed/available
- choose suitable algorithm for solving the problem
- understand the limits of methods, and inputs, and therefore critically interpret the output

Not covered

- **Stochastic modelling:** see "Modelling Telecommunication Traffic (APP MTH 4012)", or "System Modelling and Simulation (APP MTH 4004)"
- **Pricing:** Lots of work on this (e.g. Paris Metro pricing, and Frank Kelly's proportional fairness)
- **Protocol design:** e.g. framing and encapsulation, TCP congestion control design, or Ethernet details.
- **Network Administration:** e.g. how to configure Cisco routers (this is not a CCNA course).
- **Physical Networks:** e.g. RF, error correction, Shannon and Nyquist limits, compression, ...
- **Multimedia or Design of Web Pages:** application layer, client-server, ...
- **Security:** encryption, ...

A Brief History of Networking

"Those who do not study history are doomed to repeat it."

Georges Santayana

A brief history of networking

An outline:

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

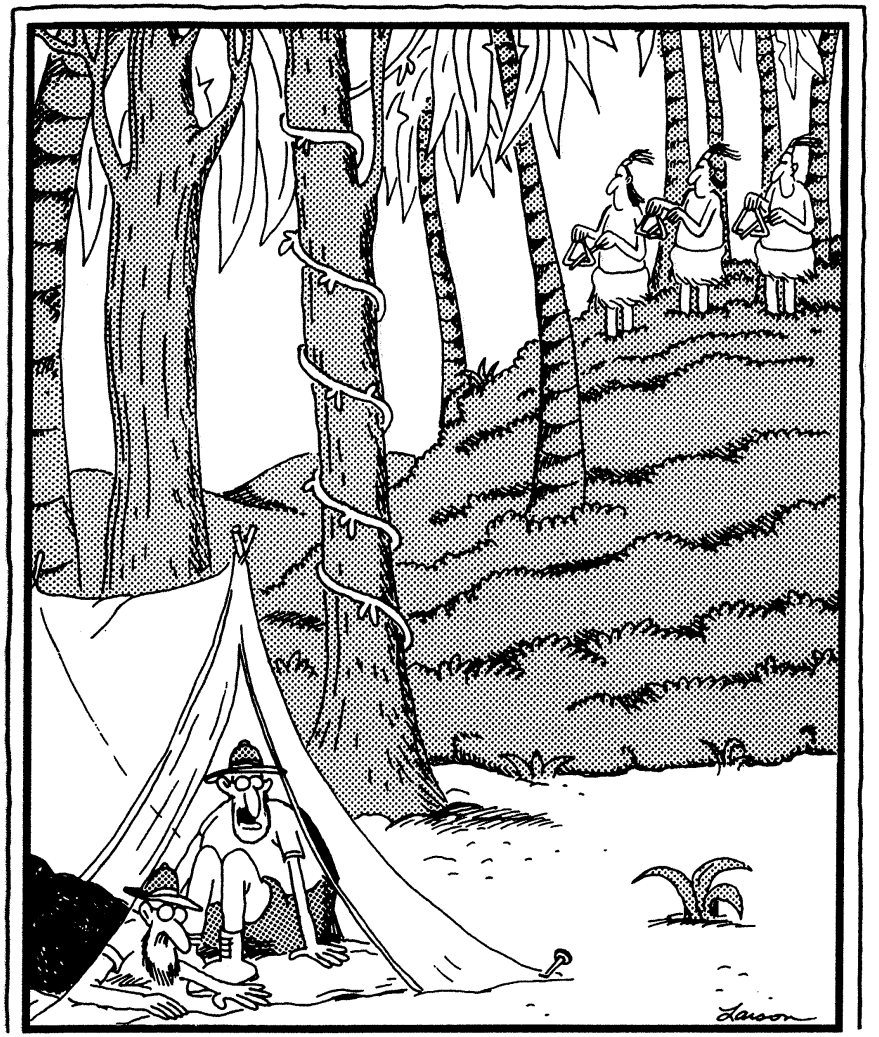
More detailed telephony timelines can be found at
http://www.telephonetribute.com/timeline.html
http://www2.fht-esslingen.de/telehistory/

Histories of computing and computer networks
http://en.wikipedia.org/wiki/Computing_timeline
http://www.isoc.org/internet/history/

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 [3]
  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



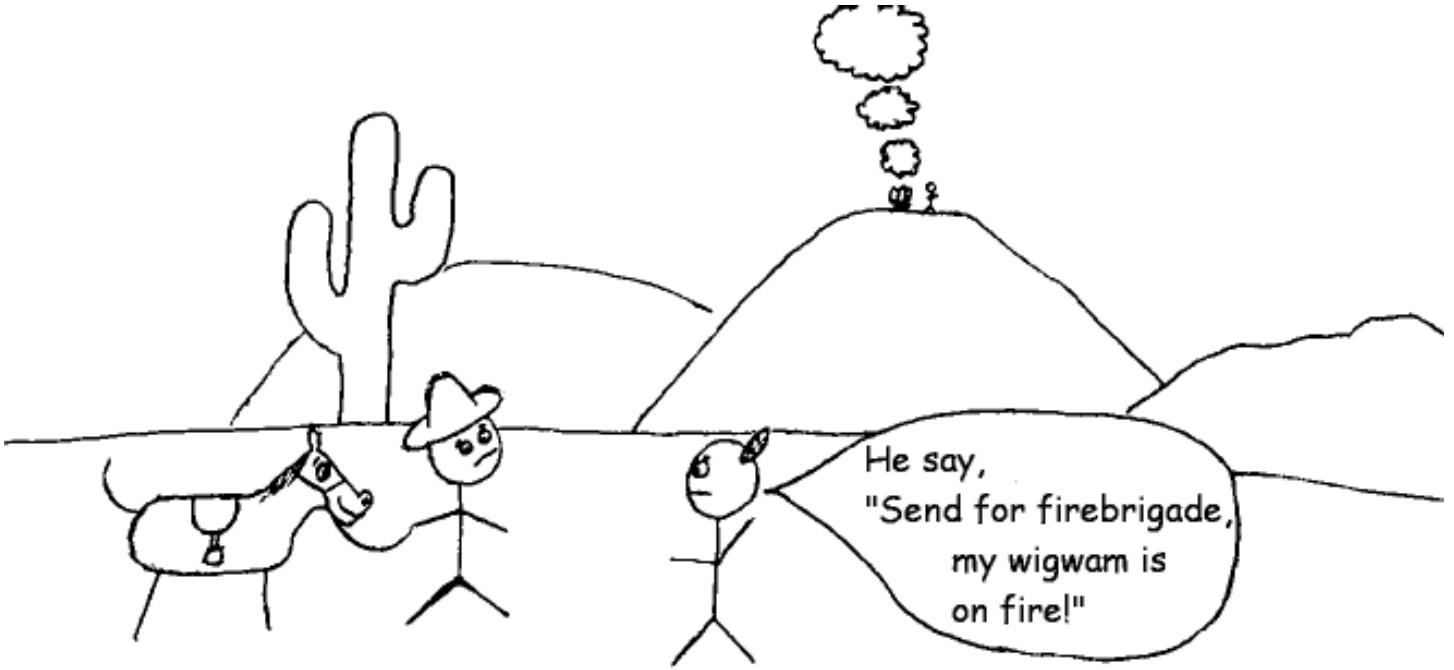
"Wait, Morrison! … It's OK—those are jungle *triangles*!"

Gary Larson, 1993

Pre-industrial

These had limitations

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



19th century

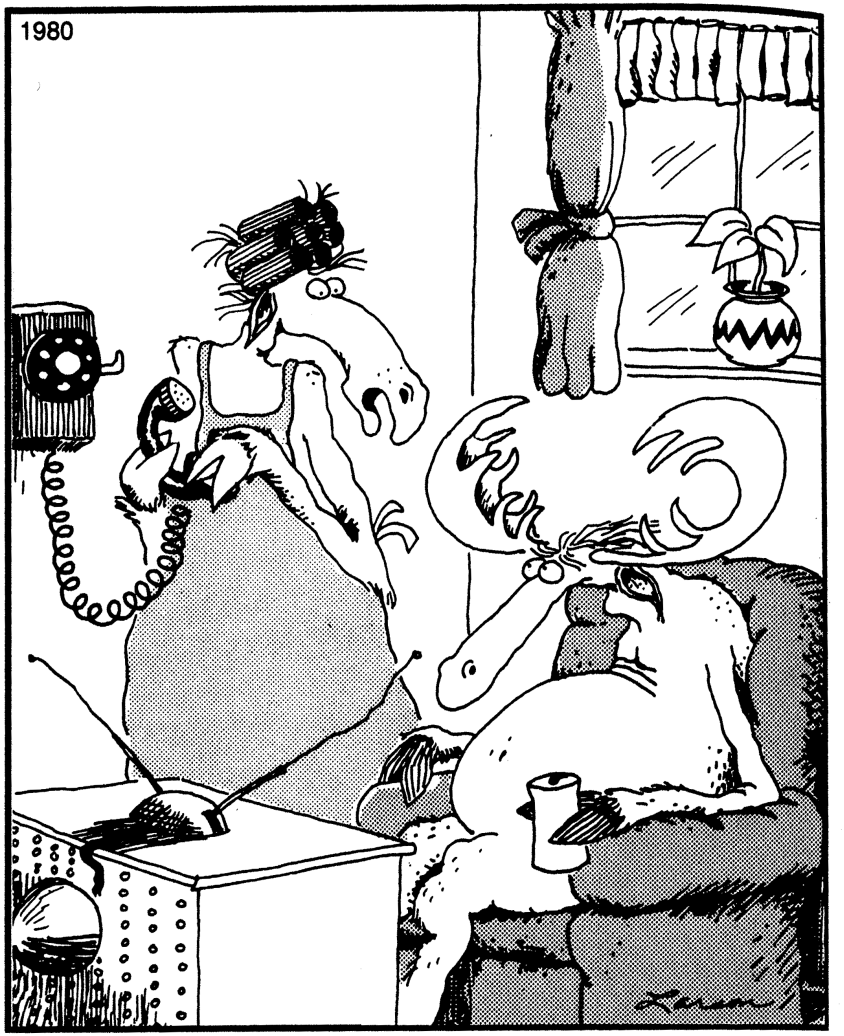
Post office:

- 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

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

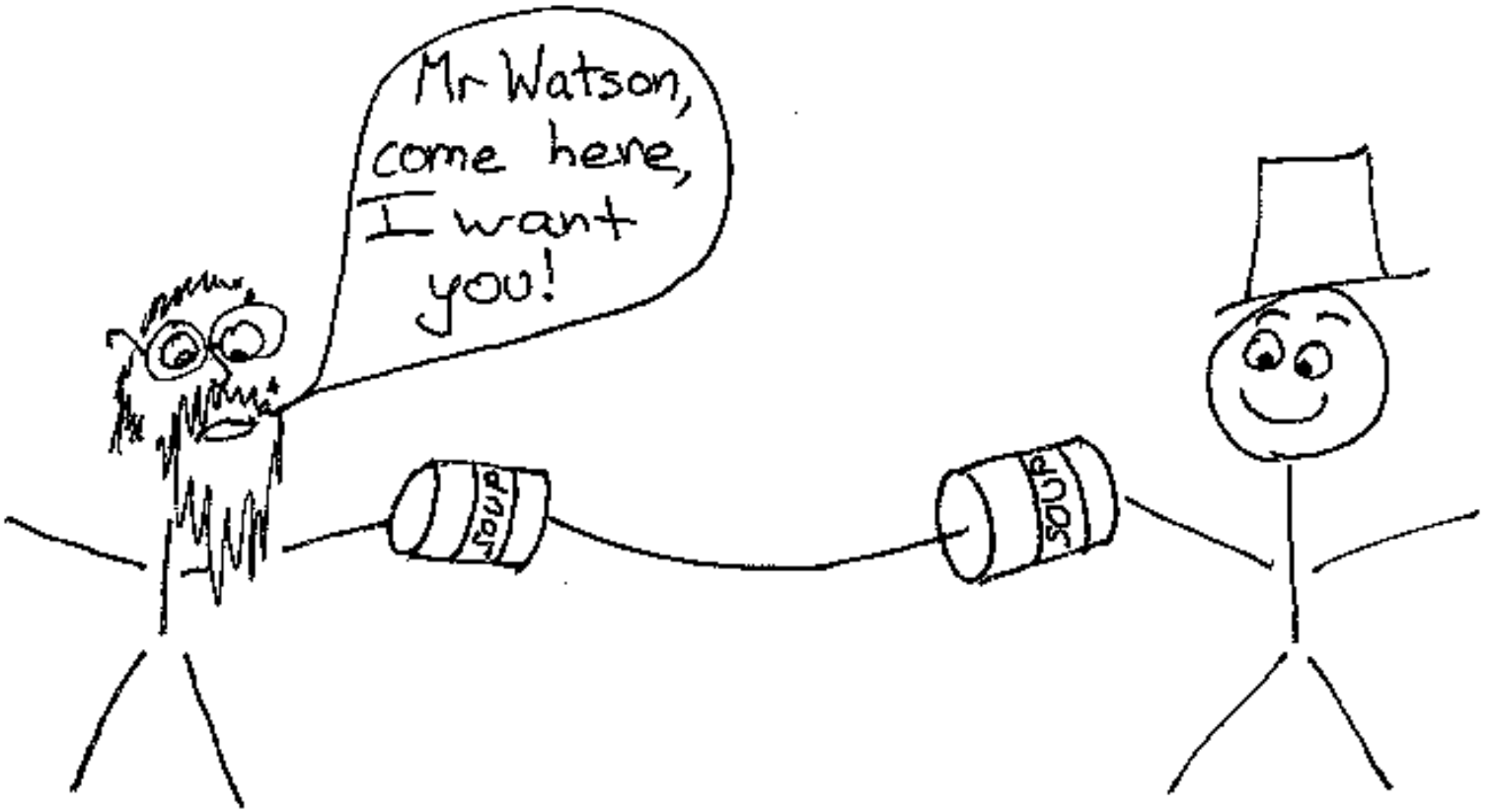


"It's the call of the wild."

Gary Larson, 1980

19th century

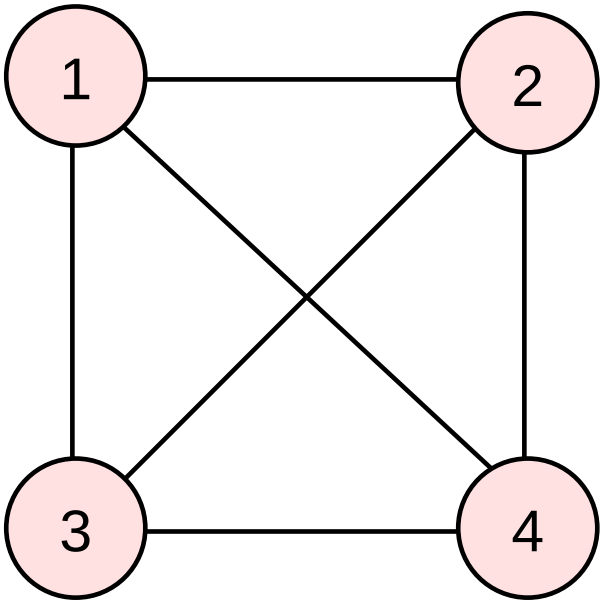
Simple telephone: connects two points with a wire



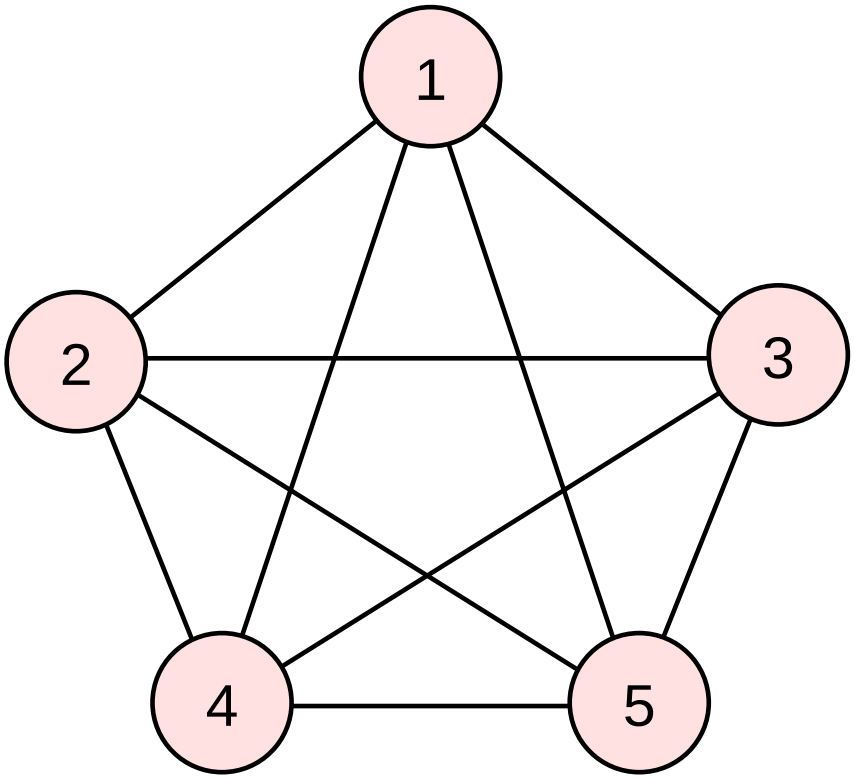
Reportedly, the first words over the telephone came when Bell spilled some acid on his pants, whereupon he call "Mr. Watson, come here, I want you!"

Dumb network design

One link between every pair who wish to speak



N=4
L=6

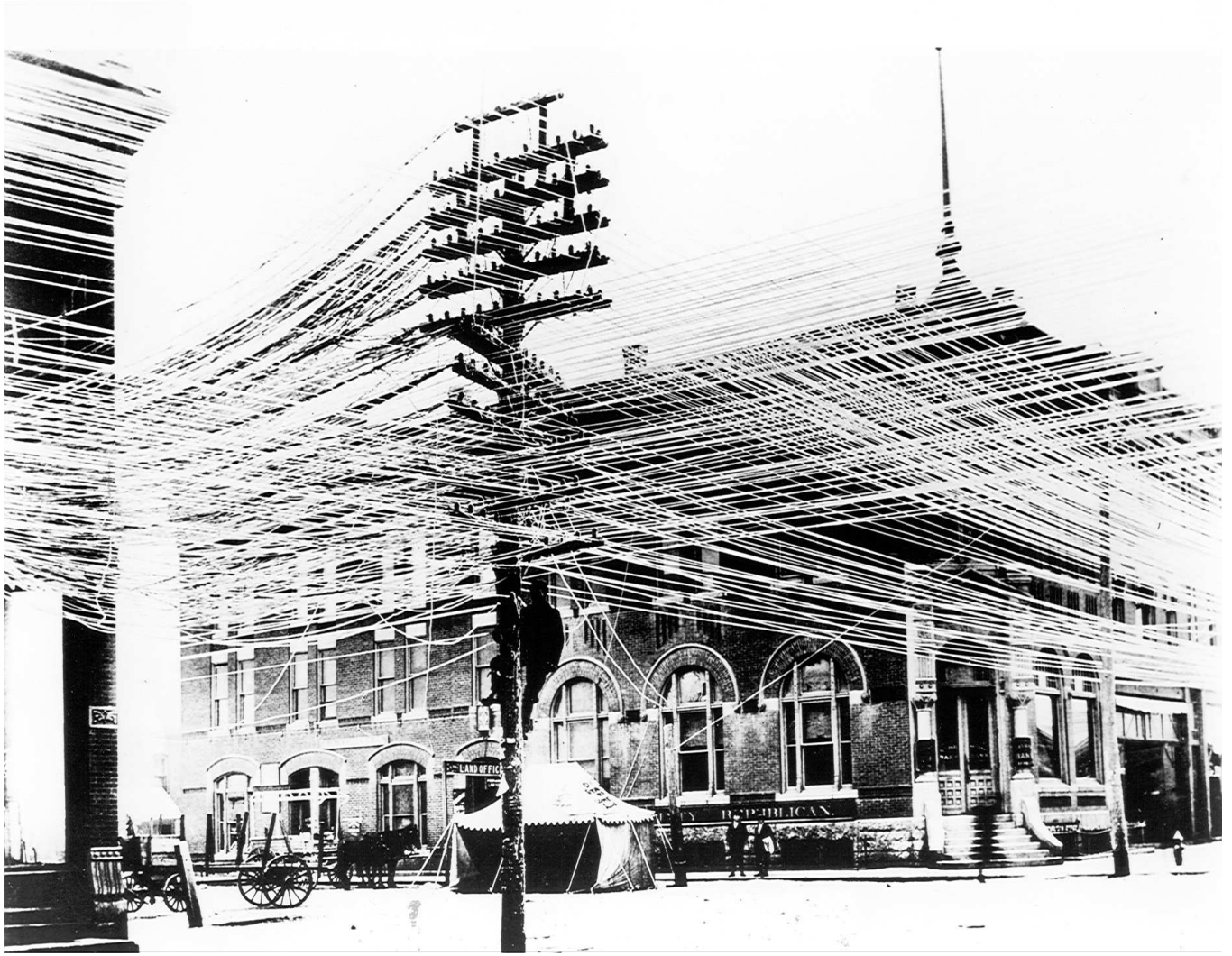


N=5
L=9

N nodes, then we have L=N(N-1)/2 links

Dumb network design

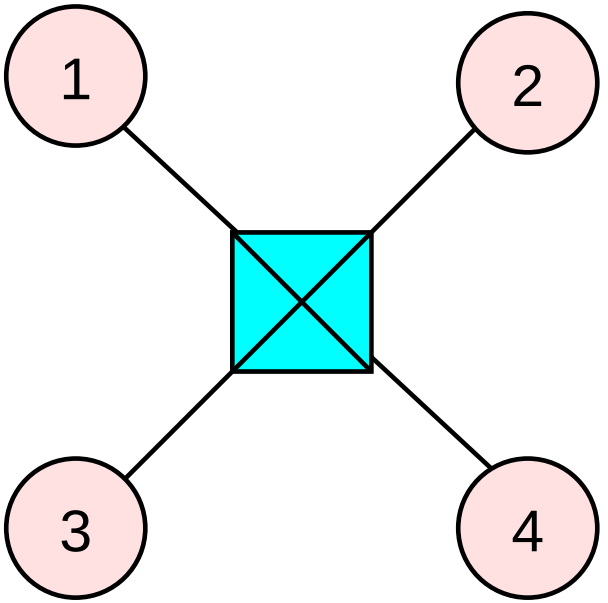
Pratt, Kansas



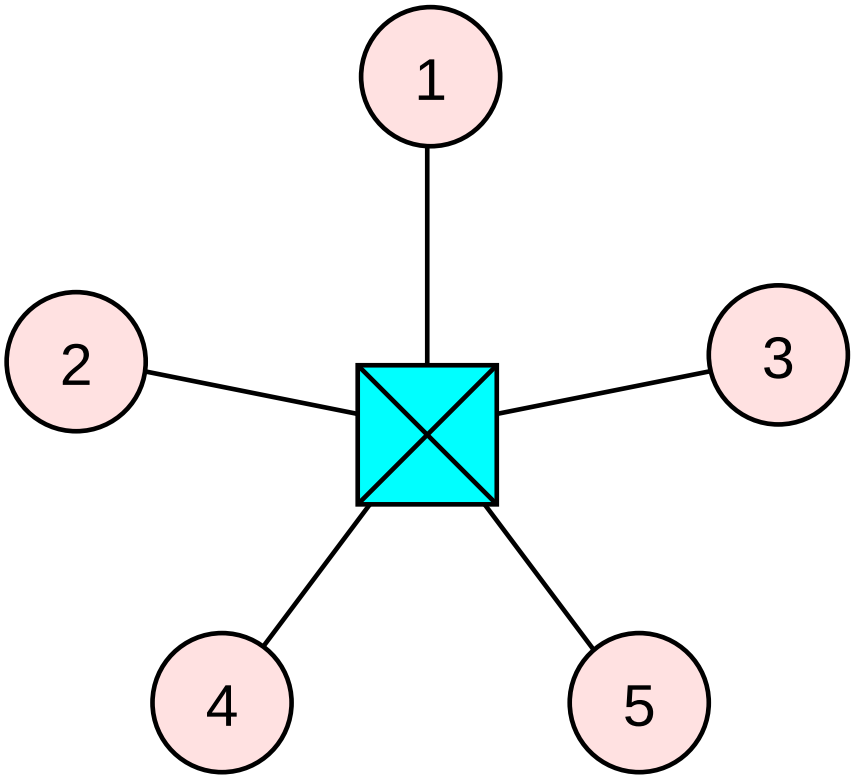
http://www.bellsystemmemorial.com/oldphotos_6.html

A switch

What if each person has one wire to a **switch**.



N=4
L=4



N=5
L=5

N nodes, then we have L=N links

Switchboards

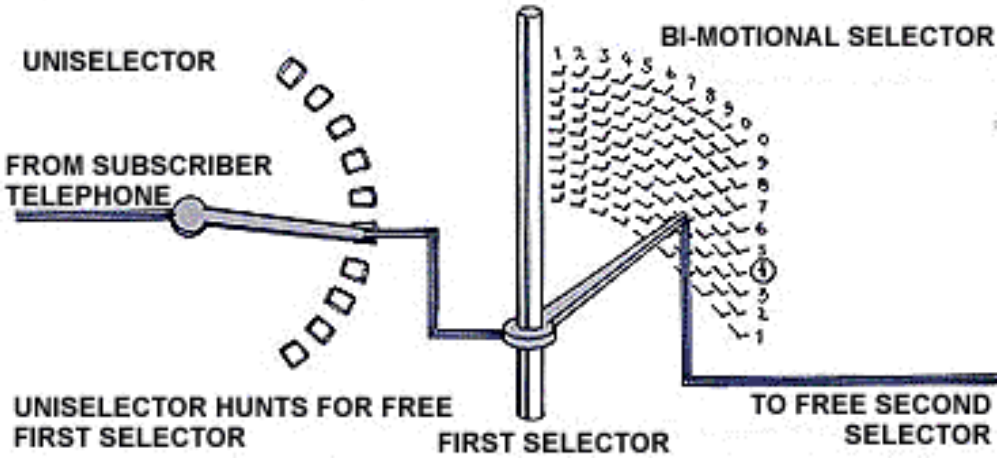
So switches are great, but what is a switch?

http://www.bellsystemmemorial.com/oldphotos_6.html

Electromechanical switch

Almon Strowger was an undertaker in Kansas City in the late 1800's

- http://www.strowger.com/history.html
- Company 'Strowger Automatic Telephone Exchange' in October 1891
- step-by-step electromechanical switch [4]



http://www.sigtel.com/tel_tech_sxs.html

Towards modern telephony

- switches get more complicated and sophisticated
  - electronic switch (instead of electromechanical)
  - 4ESS (like a building)
    http://www.att.com/history/nethistory/switching.html
- networks become hierachical
  - long distance versus local
- reliability and redundancy become important
  - alternate routing
- billing systems
  - harder than you think!

Some additional links

More detailed telephony timelines can be found at
http://www.telephonetribute.com/timeline.html
http://www2.fht-esslingen.de/telehistory/
http://www.webbconsult.com/hist-time.html
http://www.ieee.org/organizations/history_center/comsoc/timelines.html
http://williamstallings.com/Extras/Telecom.html
http://aronsson.se/hist.html

Histories of computing and computer networks
http://en.wikipedia.org/wiki/Computing_timeline
http://www.isoc.org/internet/history/
http://www.isoc.org/internet/history/brief.shtml
http://www.dei.isep.ipp.pt/docs/arpa.html
http://www.zakon.org/robert/internet/timeline/
http://en.wikipedia.org/wiki/History_of_the_Internet
http://goldenink.com/computersandnetworks.shtml
http://www.davesite.com/webstation/net-history.shtml
http://www.computerhistory.org/exhibits/internet_history/
http://www.tranquileye.com/cyber/
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

References

[1] A. M. Odlyzko, "The history of communications and its implications for the Internet." http://www.dtc.umn.edu/~odlyzko/doc/networks.html.

[2] "Telstra corporation limited — half-year report," 2005.

[3] Aeschylus, Agamemnon. http://classics.mit.edu/Aeschylus/agamemnon.html, 458 B.C.E.

[4] A. B. Strowger, "Automatic telephone exchange." United States Patent Office, patent no. 447,918, March 10th, 1891.