EECS 3213 Fall 2014

L1: Introduction to Communication Networks (Telegraph & Telephone)

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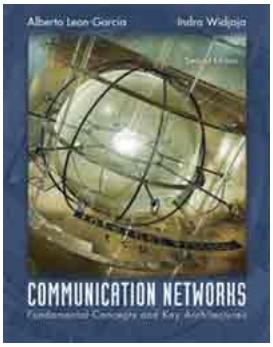
Outline

- Course texts, mark breakdown, topics
- Telegraph
  - A connectionless message-switching network
- Telephone
  - A connection-oriented circuit-switching network

Textbook & Topics

- Textbook: Communication Networks
- Ch. 1 – 8
  1. Network Introduction (1.1-1.2)
  2. Models, Layers and Applications (2.1-2.5)
  3. Digital Information & Transmission (3.1-3.9)
  4. Data Link Protocols (5.1-5.5)
  5. Multiple Access & LANs (6.1,6.2,6.6,6.7)
  6. Packet Switching (7.1-7.5)
  7. TCP/IP Architecture (8.1-8.6)

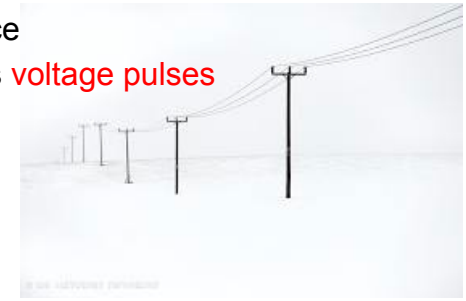


Overview

- Basic Internet operations and applications
  - structure, addressing, routing, DNS, HTTP, etc.
- Basic network principles
  - sharing, metrics, scalability
- Physical layer (communications THEORY!!!!)
  - signals, modulation, error detection, error correction, wires
- Data Link layer
  - Flow control, framing
- Medium Access Control
  - Dynamic medium control, ALOHA, Ethernet
- Network Layer
  - routing & IP
- Transport Layer
  - TCP

Telegraph

- 1850's text message service
- Tap on machine that sends voltage pulses



- A basic circuit…

Digital Communications (1850s style)

- Conceptually convert text into sequence of dots and dashes

	Morse Code		Morse Code		Morse Code		Morse Code
A	· —	J	· — — —	S	· · ·	2	· · — — —
B	— · · ·	K	— · —	T	—	3	· · · — —
C	— · — ·	L	· — · ·	U	· · —	4	· · · · —
D	— · ·	M	— —	V	· · · —	5	· · · · ·
E	·	N	— ·	W	· — —	6	— · · · ·
F	· · — ·	O	— — —	X	— · · —	7	— — · · ·
G	— — ·	P	· — — ·	Y	— · — —	8	— — — · ·
H	· · · ·	Q	— — · —	Z	— — · ·	9	— — — — ·
I	· ·	R	· — ·	1	· — — — —	0	— — — — —

Physical Signal Characteristics

- Ideal signal as a function of time

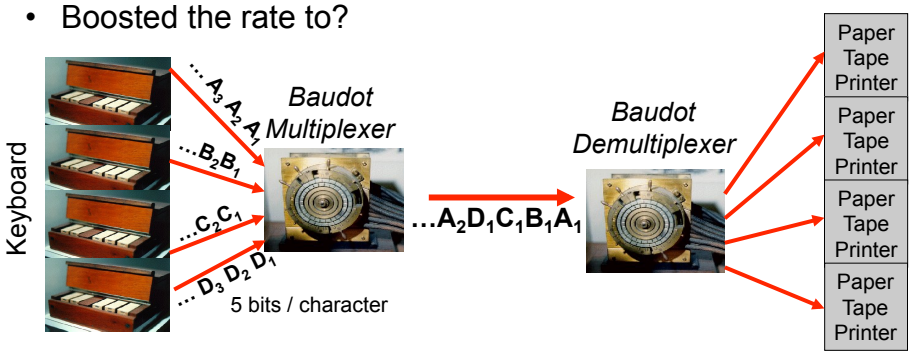
- What does it actually look like?
  - Intersymbol interfrence (ISI)

A Little Telegraph Quantification

- What was the data rate of this technology? (In bps)
  - Operators could send 30 words-per-minute (wpm)
    - Think of the dots/dashes as 1s/0s…
    - Or approximate the bits per character for constant length code

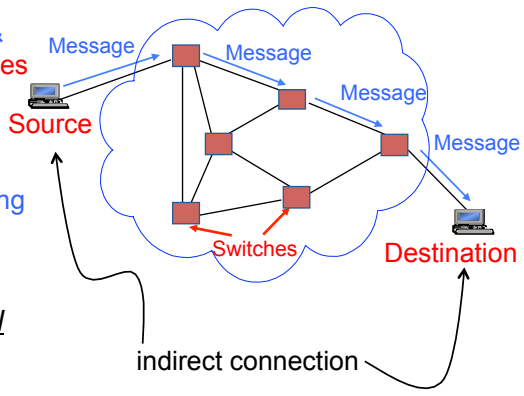
Multiplexing

- Baudot multiplexer let 5 operators use a line at the same time
- Boosted the rate to?



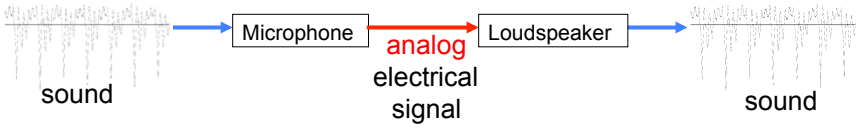
Message Switching

- "Vast" *network of stations* arose
  - Operator examines source & destination address and routes the message to next most reasonable switch
  - store-and-forward : examine message in full before sending to next node (as opposed to cut-through)
- Transmission by *occasional connections* referred to as message-switching



The Telephone

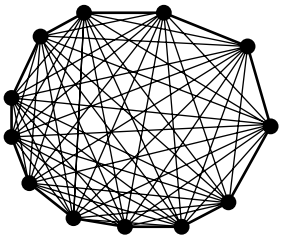
- ~ 30 years after telegraph (1876 Bell's patent)
- Direct conversion of sound pressure to an electrical analog

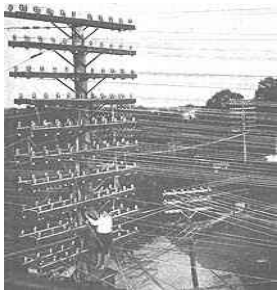


- No need for digital translation, a direct end-user service
  - Plug and play
- Rough data rate? Shannon's Theorem

The Telephone "Network"

- Originally sold in pair
  - What's the problem with this?

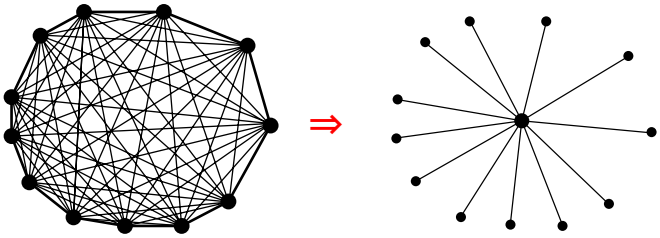




- *N* users requires *????* connections
- 1000 users ⇒ 499,500 connections

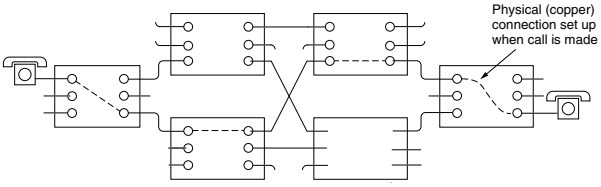
The Telephone Network

- The birth of the switching office (and *Bell Telephone Company*, 1877)…a wiring hub

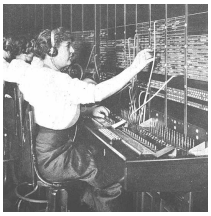


- Run a wire between the customer and the telephone company switching office
- Now only need *N* connections to central office (CO) (aka end office or local central office)

The Switch



Human Switch

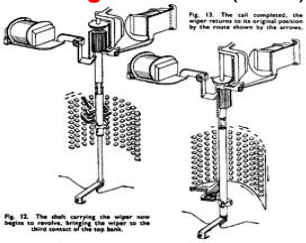


verbal instructions

Circuit Switching
(contrast with
message switching)

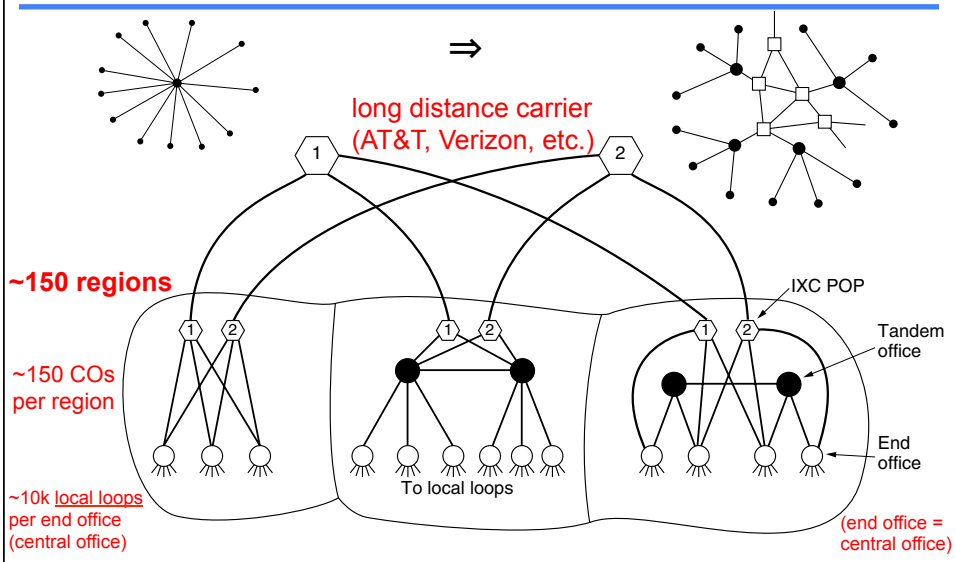
now all digital

Strowger Switch (1888)



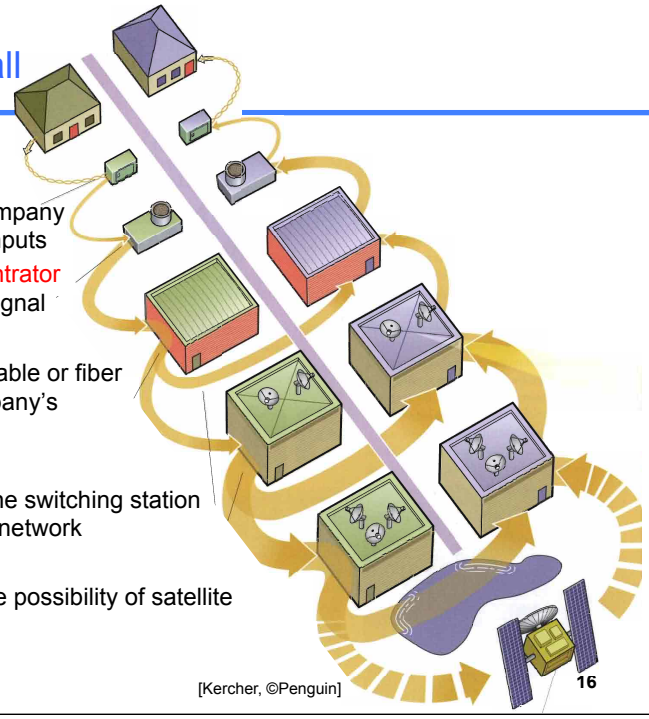
number dialed

Telephone Network Hierarchy



Path of a Call

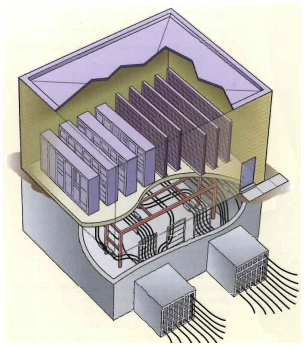
- Phone signal out on copper pair
- To local phone company box with 100s of inputs
- To a digital concentrator that digitizes the signal
- Then via coaxial cable or fiber to the phone company's switching station
- Then perhaps to the switching station of a long distance network
- And so on, with the possibility of satellite transmission



[Kercher, ©Penguin]

Switching Station

- New York has 80 for 8,000,000
  - About 100,000 lines served by a station



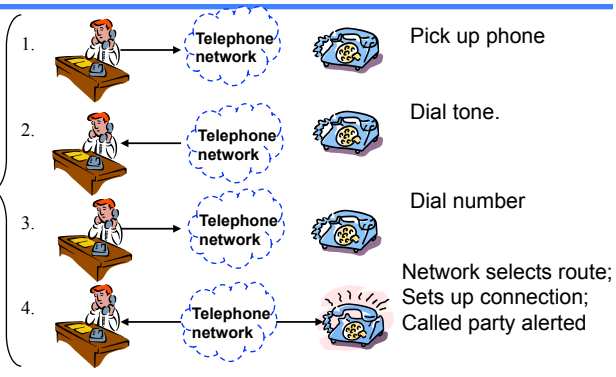
[Kercher, ©Penguin]

Three Phases of a Connection

1. Connection set up

connection oriented: *a network that establishes a connection before transmitting information*

circuit switching: *formation of dedicated path between source and destination*



2. Information transfer

3. Connection release

Digitization of the Telephone Network

- Pulse Code Modulation
  - 64 kbps uncompressed voice signal (8-bit sample every 125 μs)
- Time Division Multiplexing (TDM)
  - Put multiple signals on the trunk
  - T1 carrier method sends a signal from one of 24 messages every 125 us
  - (24*8+1)/125 us = 1.544 Mbps
- Digital Switching (no analog conversion)
  - No need to go back to analog at switch
- Optical Transmission
  - 10^{12} bps!!!