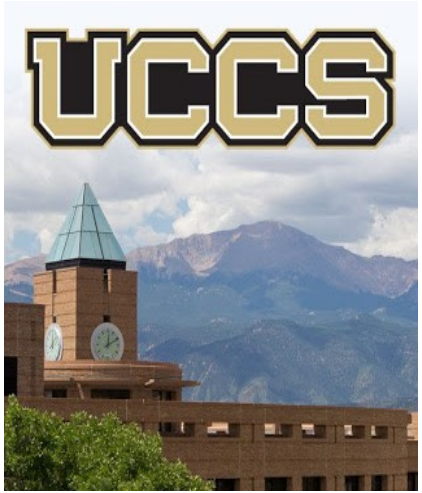

Unit 01.01.01
CS 5220:
COMPUTER COMMUNICATIONS

Evolution of Communication Networks

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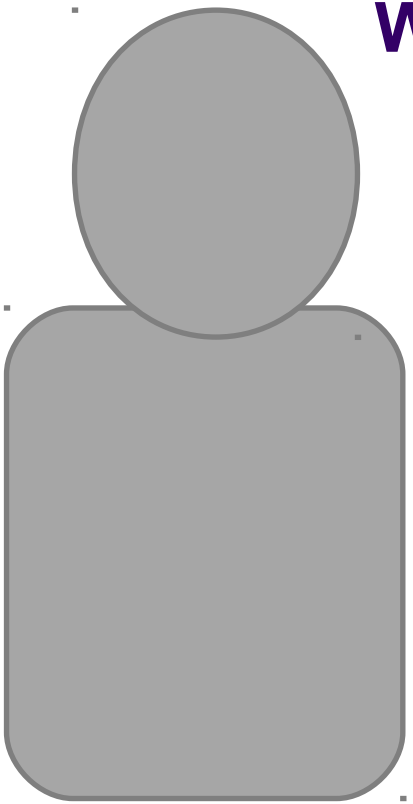
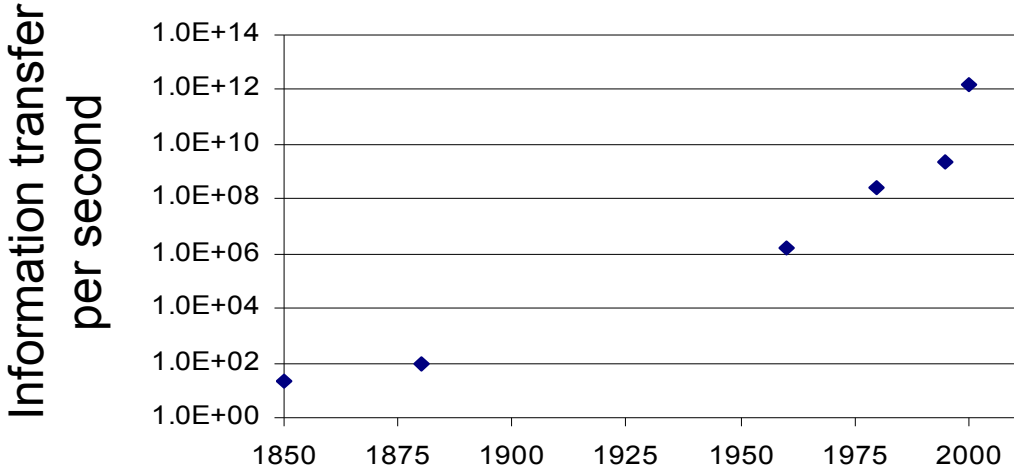
What is a Communication Network?



- The equipment (hardware & software) and facilities that provide the basic communication service

- Facilities
  - Copper wires, optical fiber …
- Equipment
  - Routers, servers, switches, …

Network Architecture Evolution



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Telegraph networks

Telephone networks

Internet, Optical & Wireless networks

Next Generation Internet

Telegraph Networks

- Telegraph: a message is transmitted across a network using signals
  - Drums, beacons, mirrors, smoke, flags, semaphores…
  - Electricity, light

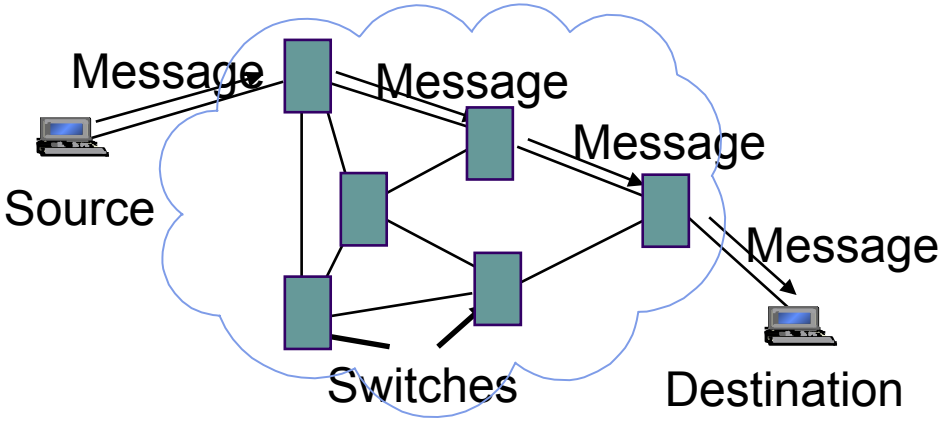
Digital Communications

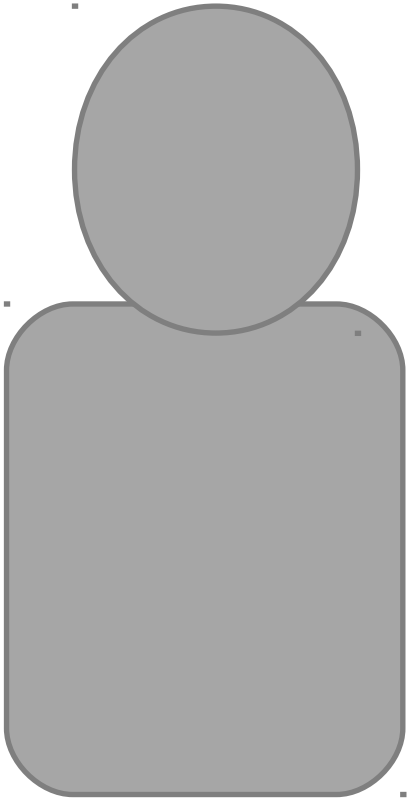
- Morse code converts text message in sequence of dots & dashes
- Use transmission system designed to convey dots and dashes

	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	— — — — —

Electric Telegraph Networks

- Electric telegraph networks exploded
  - Message switching & Store-and-Forward operation
  - Key elements: Framing, Multiplexing, Addressing, Routing, Forwarding



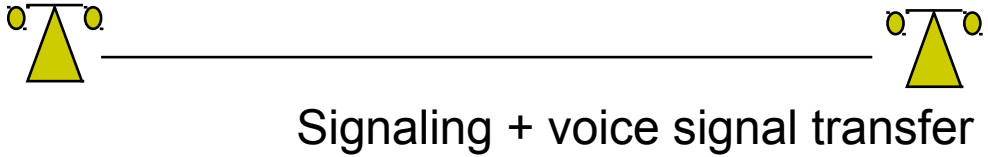


Elements of Telegraph Networks

- Digital transmission
  - Text messages converted into symbols
  - Transmission system designed to convey symbols
- Multiplexing
  - *Framing* needed to recover text characters
- Message Switching
  - Messages contain source & destination *addresses*
  - *Store-and-Forward: m*essages forwarded hop-by-hop across network
  - *Routing* according to destination address

Bell's Telephone

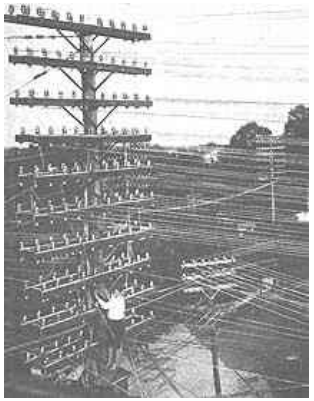
- Alexander G. Bell (1876) working on harmonic telegraph to multiplexing discovered voice signals can be transmitted directly
  - Microphone converts voice pressure variation into *analogous* electrical signal
  - Loudspeaker converts electrical signal back into sound
- Basic telephone service involves two-way, real-time transmission of voice signals across a network
  - Signaling required to establish a call

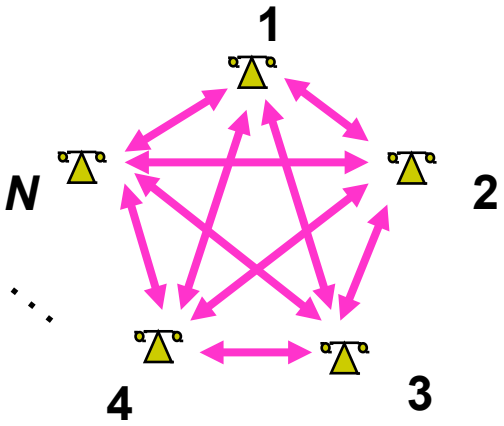


Signaling + voice signal transfer

The N^2 Problem

- Initially, p2p direct communications - for *N* users to be fully connected *directly*
  - Requires too much space for cables
  - Inefficient & costly since connections not always on



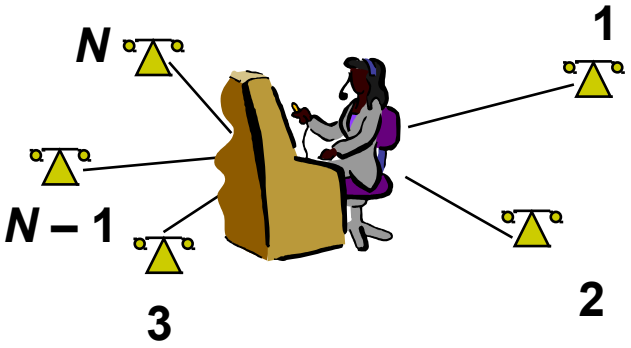


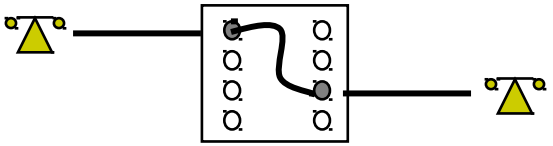
$N = 1000$

$N(N-1)/2 = 499500$

Circuit Switching is Connection-oriented

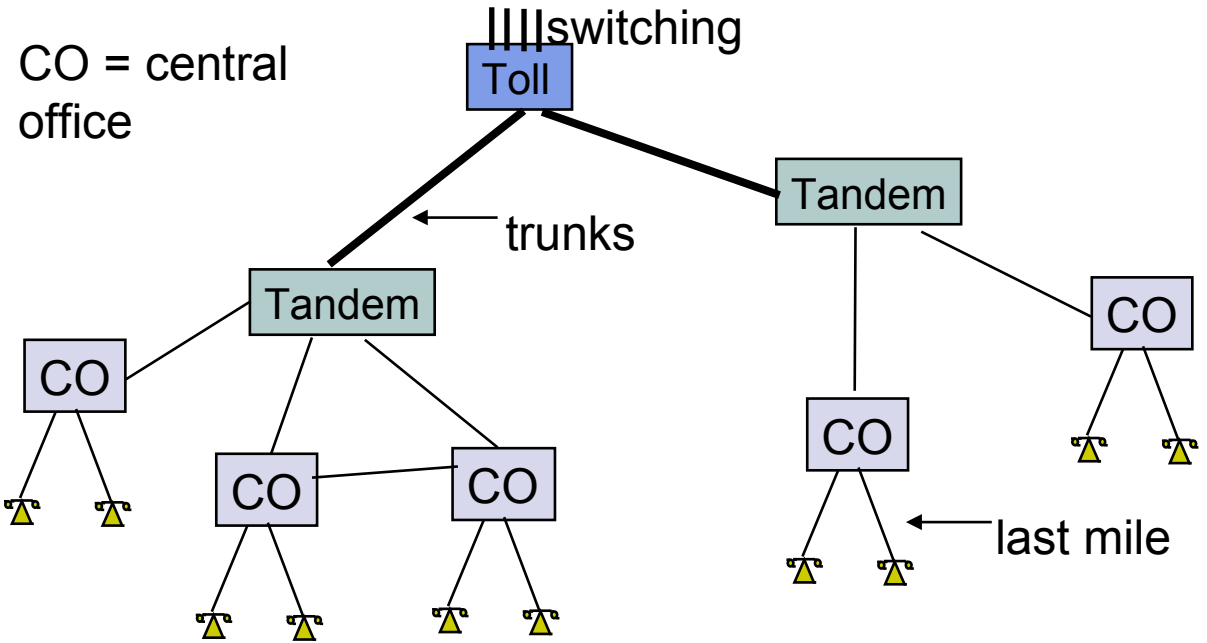
- Patchcord panel switch invented in 1878
- Operators connect users on demand
  - Establish *circuit* to allow electrical current to flow from inlet to outlet
- Only *N* connections required to central office

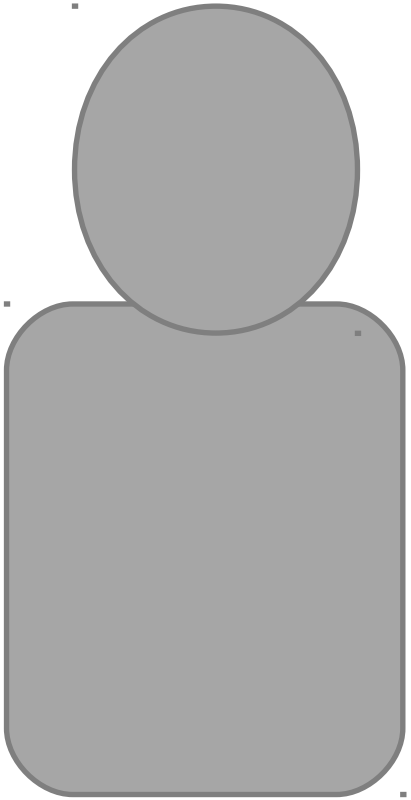




Hierarchical Tele-Network Structure

- End-to-end connection requires collaborative switching





Elements of Telephone Networks

- Digital transmission & switching
  - Digital voice; Time Division Multiplexing
- Circuit switching – Connection oriented
  - User signals for call setup and tear-down
  - Route selected during connection setup
  - End-to-end connection across network
  - Signaling coordinates connection setup
- Hierarchical Network Structure
  - Decimal numbering system
  - Hierarchical structure; simplified routing; scalability

Network Architecture Evolution

- Telegraph Networks
  - Message switching & store-and-forward
- Telephone Networks
  - Circuit Switching and connection oriented
- Computer Networks and the Internet
  - Packet switching
  - Virtual circuit switching
- Next-Generation Internet
  - ???

Summary of the Lesson

- History often repeats itself