

CSCI-351

Data communication and Network

Lecture 2: History

What is a Comm. Network?

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2

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- What are nodes and links?
 - People and roads
 - Telephones and switches
 - Computers and routers

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- What are nodes and links?
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- What is a message?
 - Information

What is a Comm. Network?

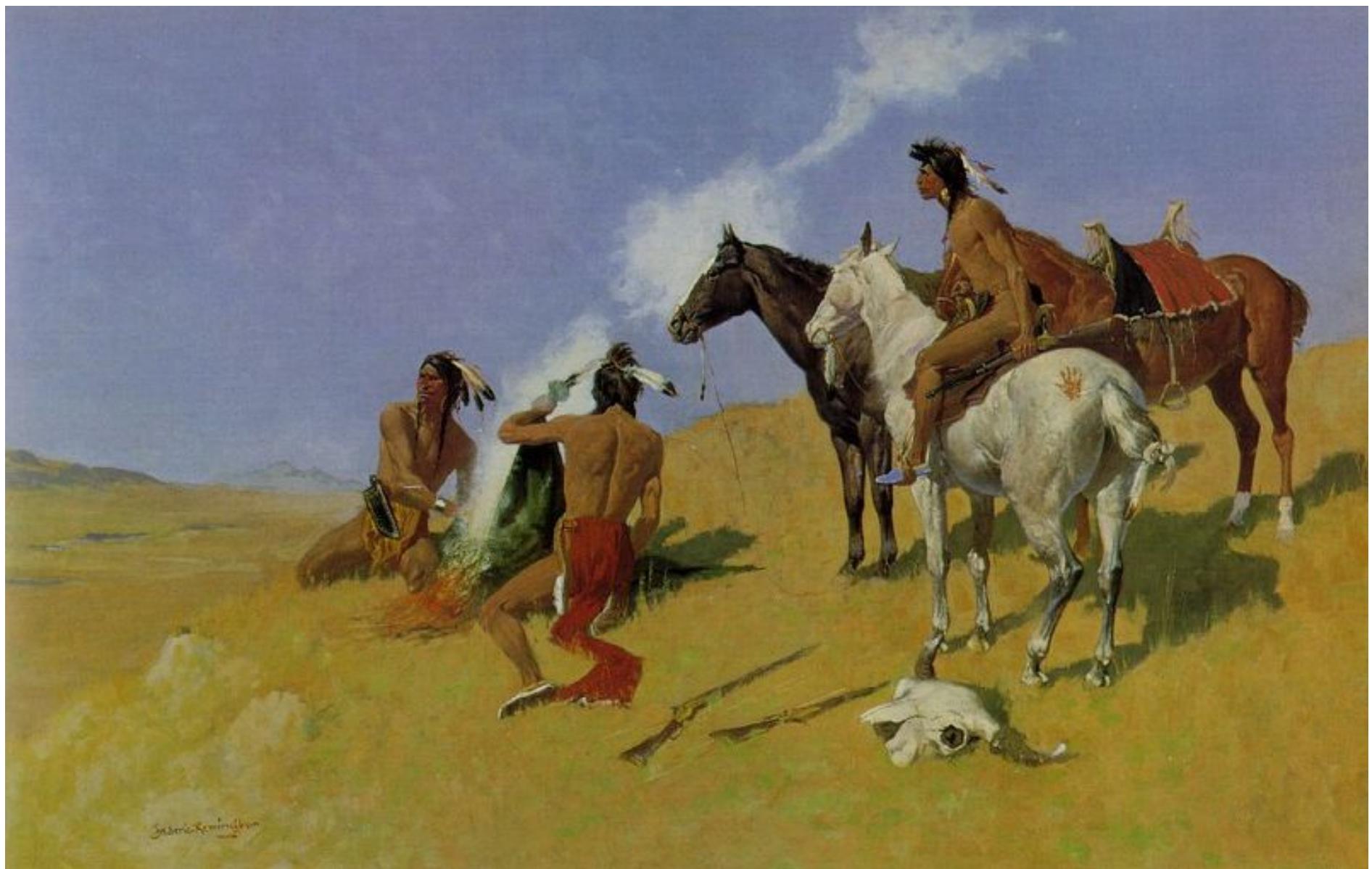
2

A communications network is a network of links and nodes arranged so that messages may be passed from one part of the network to another

- What are ~~Networked links~~ key for:
 - People and ~~Speed~~
 - Telephones and switches ~~Distance~~
 - Computers and routers
- What is ~~a message?~~
 - Information

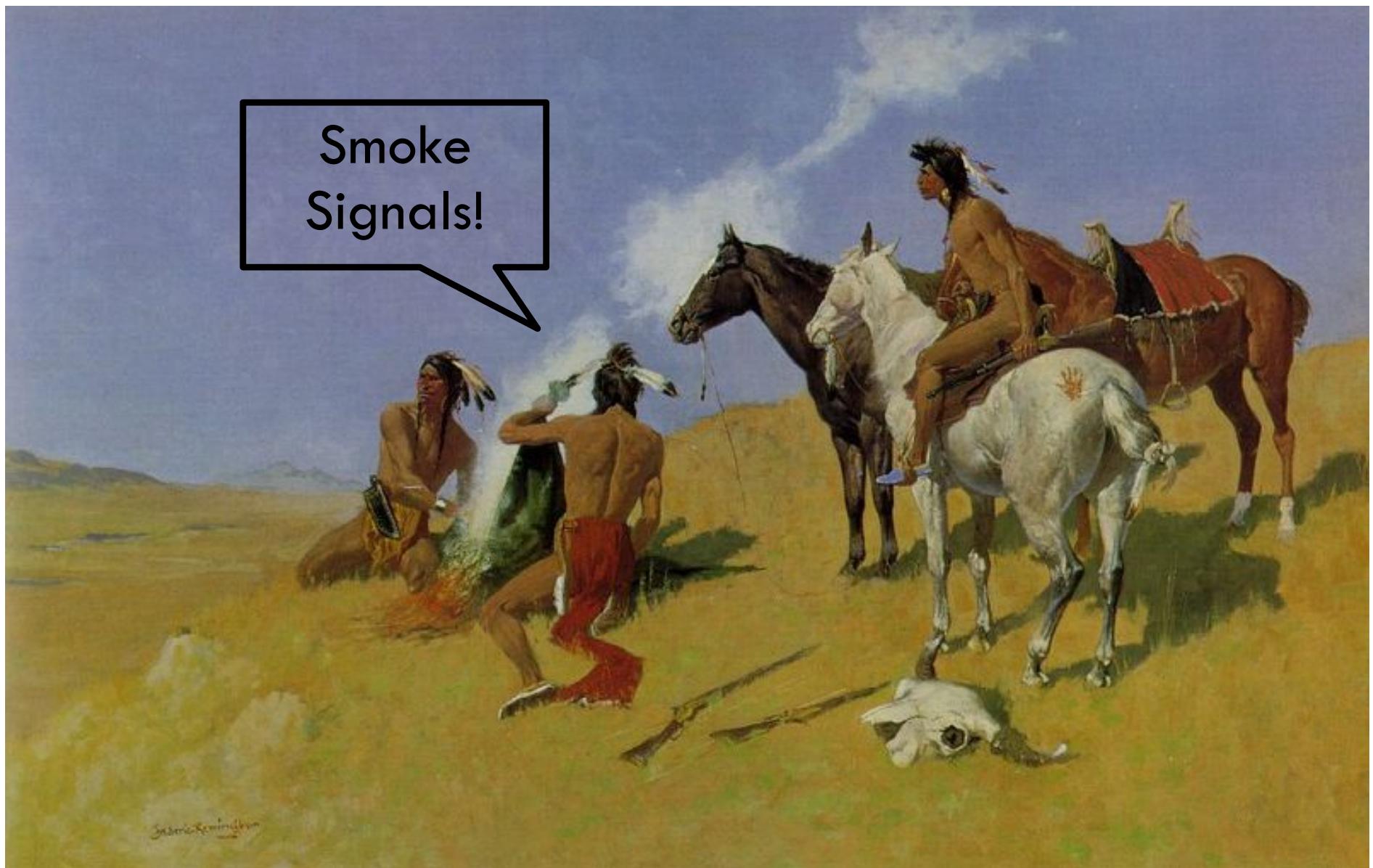
Networks are Fundamental

3



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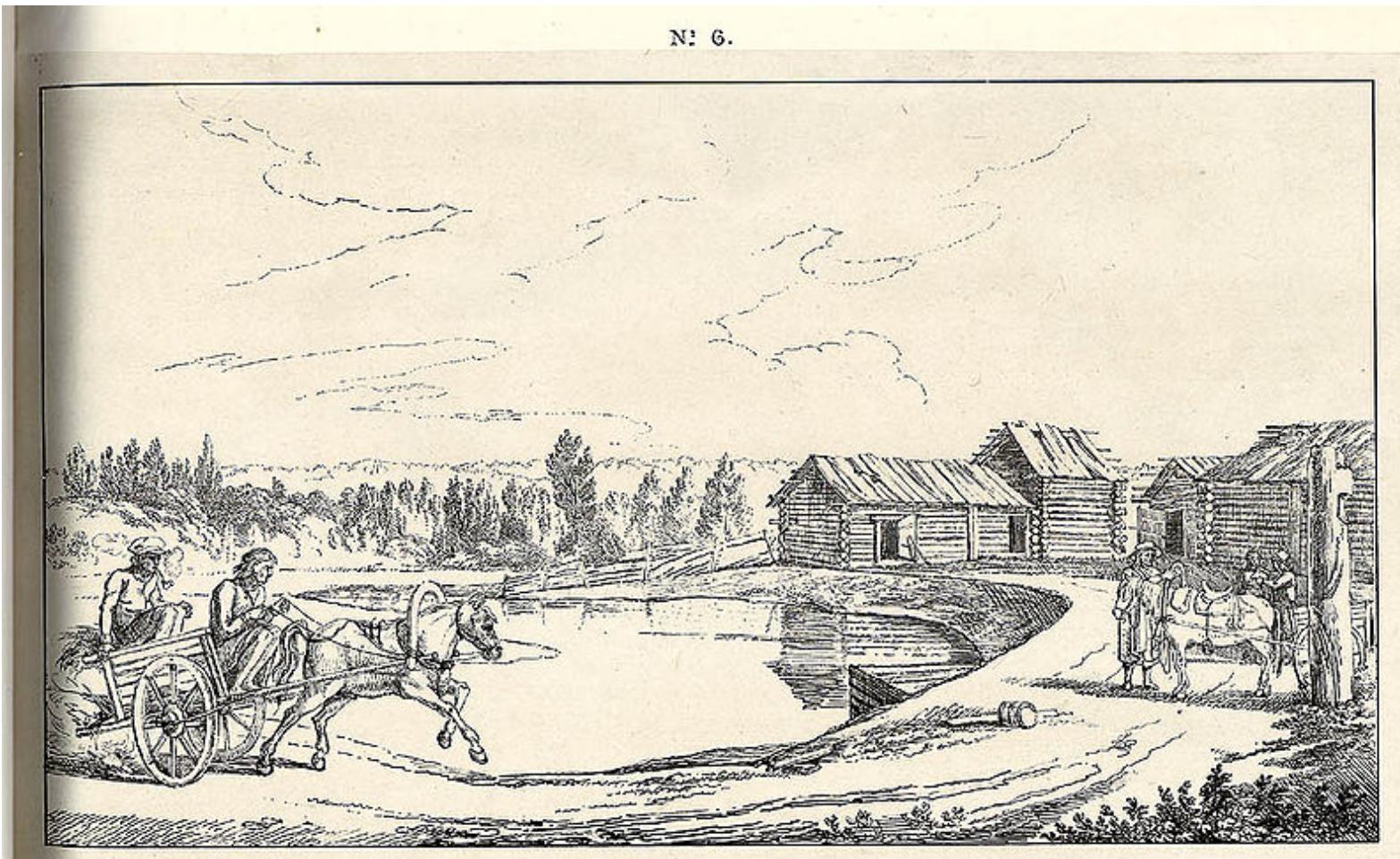
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Networks are Old

4

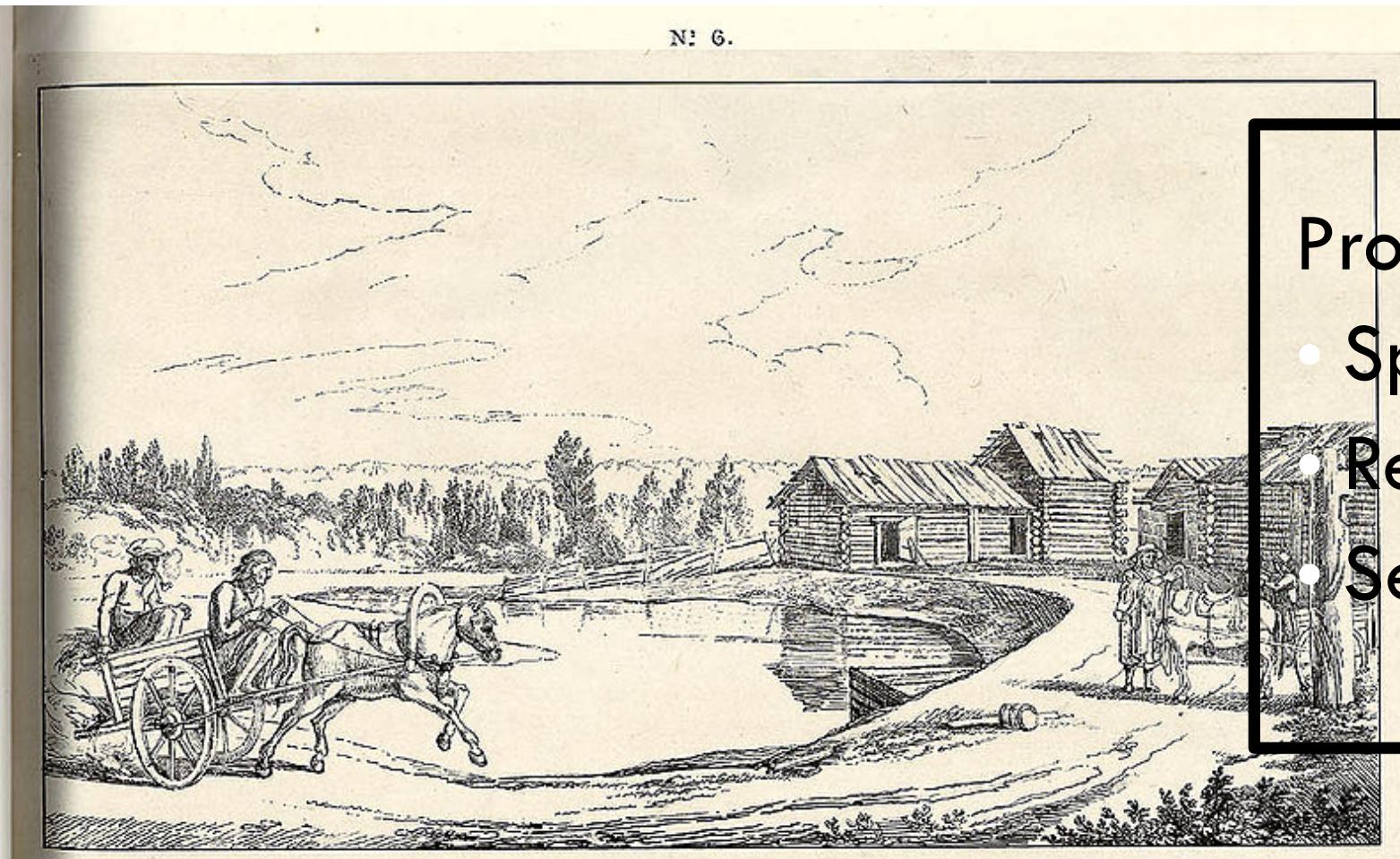
- 2400 BC: courier networks in Egypt
- 550 BC: postal service invented in Persia



Networks are Old

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Problems:

- Speed
- Reliability
- Security

Towards Electric Communication

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- 1837: Telegraph invented by Samuel Morse
 - Distance: 10 miles
 - Speed: 10 words per minute
 - In use until 1985!

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A •

B ..

C ...

D

E

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- Next generation: binary encoding

A •— B —... C —•—• D —•• E •

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Higher compression =
faster speeds

- Next generation: binary encoding

A •-

B -...

C -•-

D -•

E •

Telephony

6

- 1876 – Alexander Graham Bell invents the telephone

Telephony

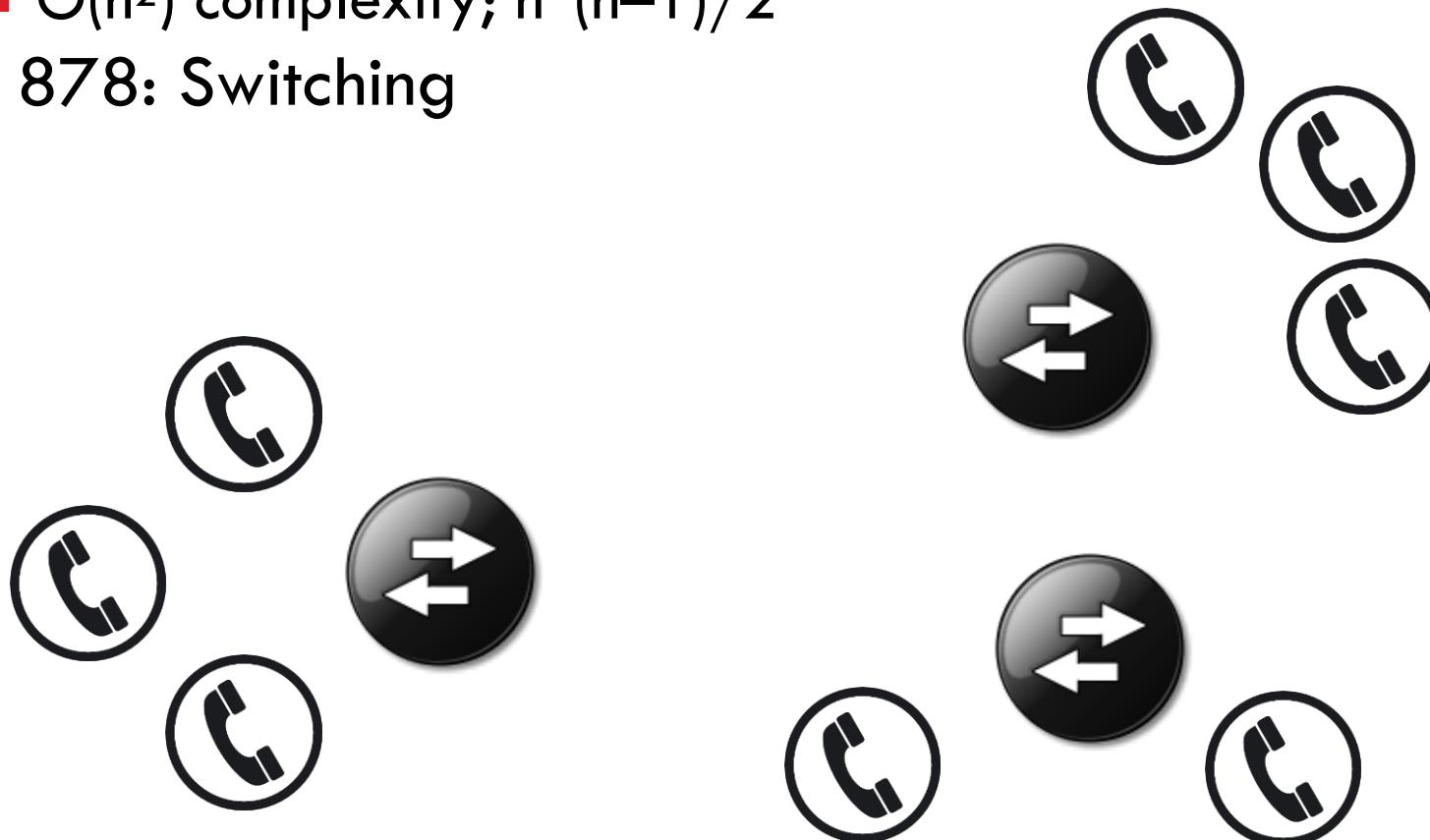
6

- 1876 – Alexander Graham Bell invents the telephone
- Key challenge: how to scale the network?
 - ▣ Originally, all phones were directly connected
 - $O(n^2)$ complexity; $n*(n-1)/2$

Telephony

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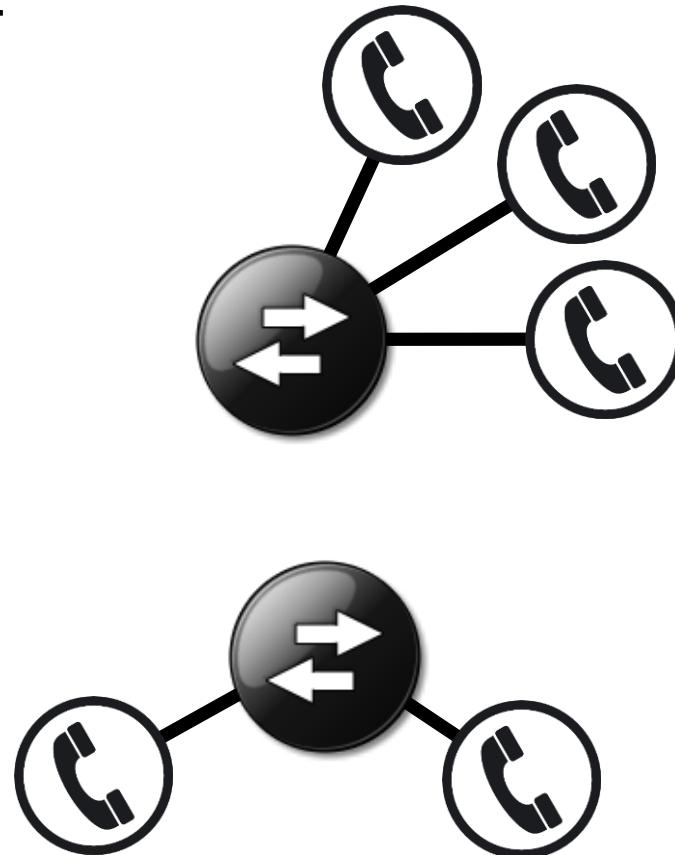
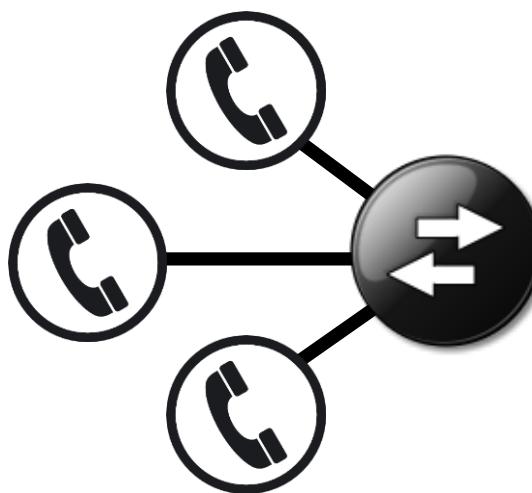
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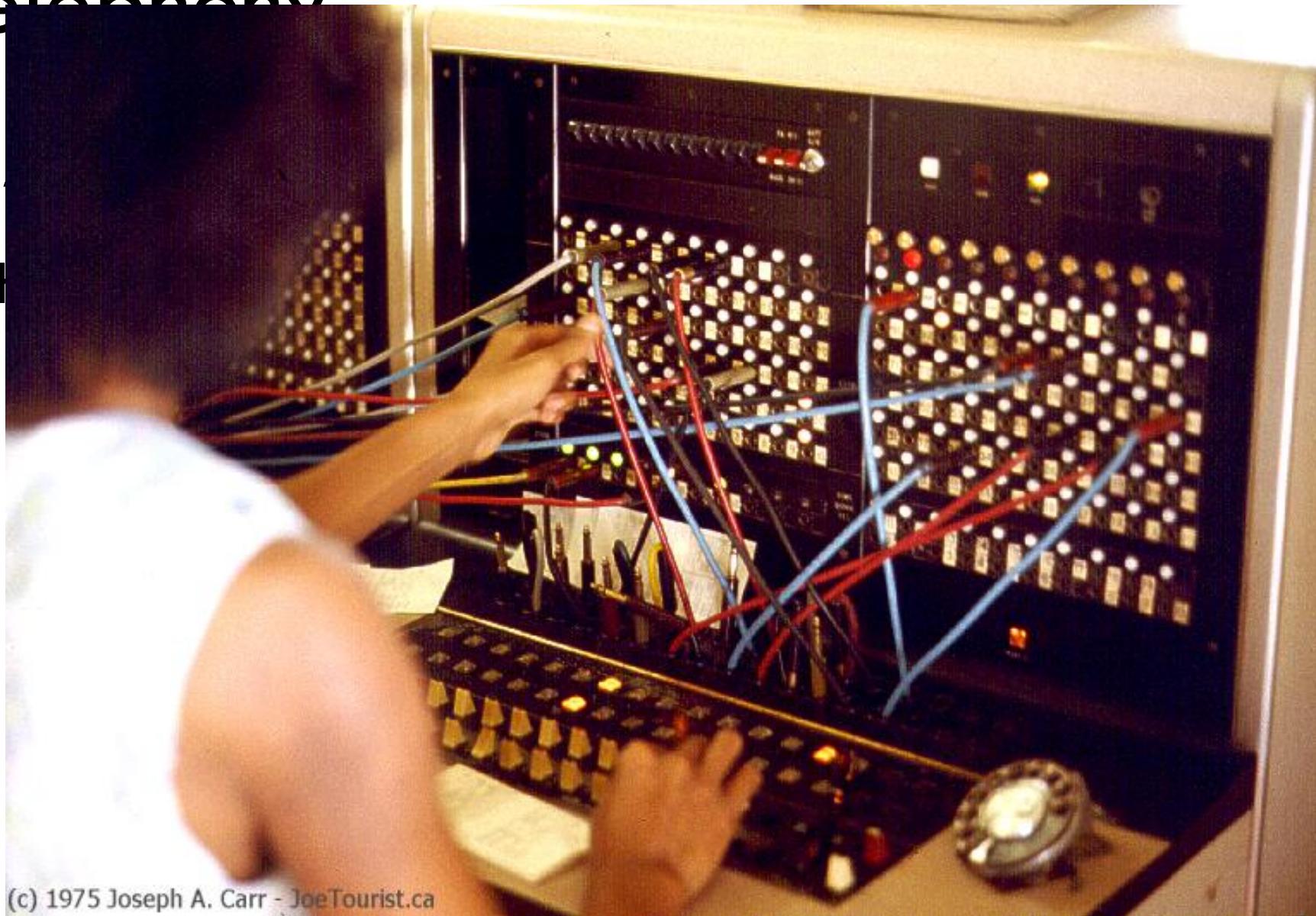
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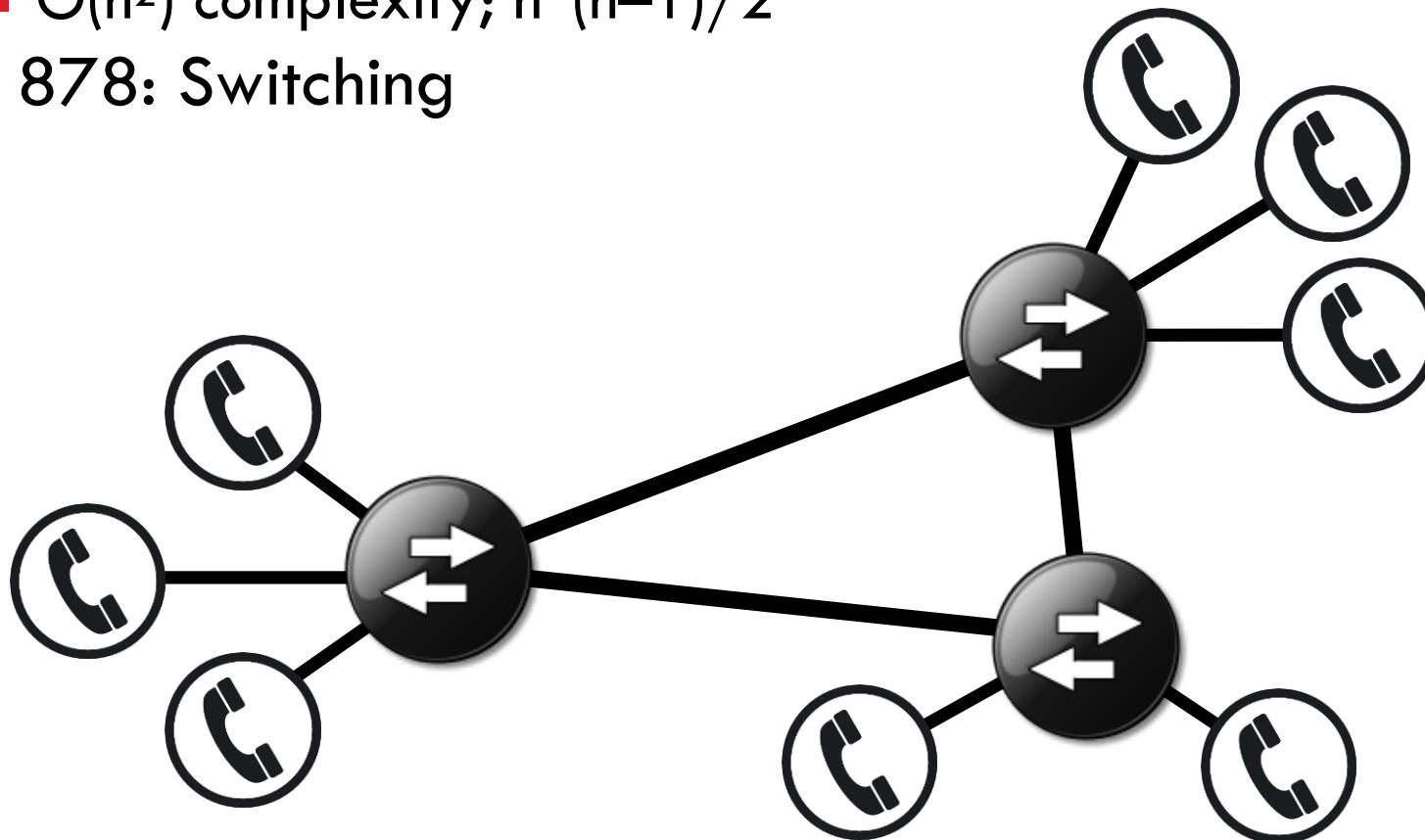
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Telephony

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Advantages

Key challenge: how to scale the network?

Originally, all phones were directly connected

Switching mitigates complexity

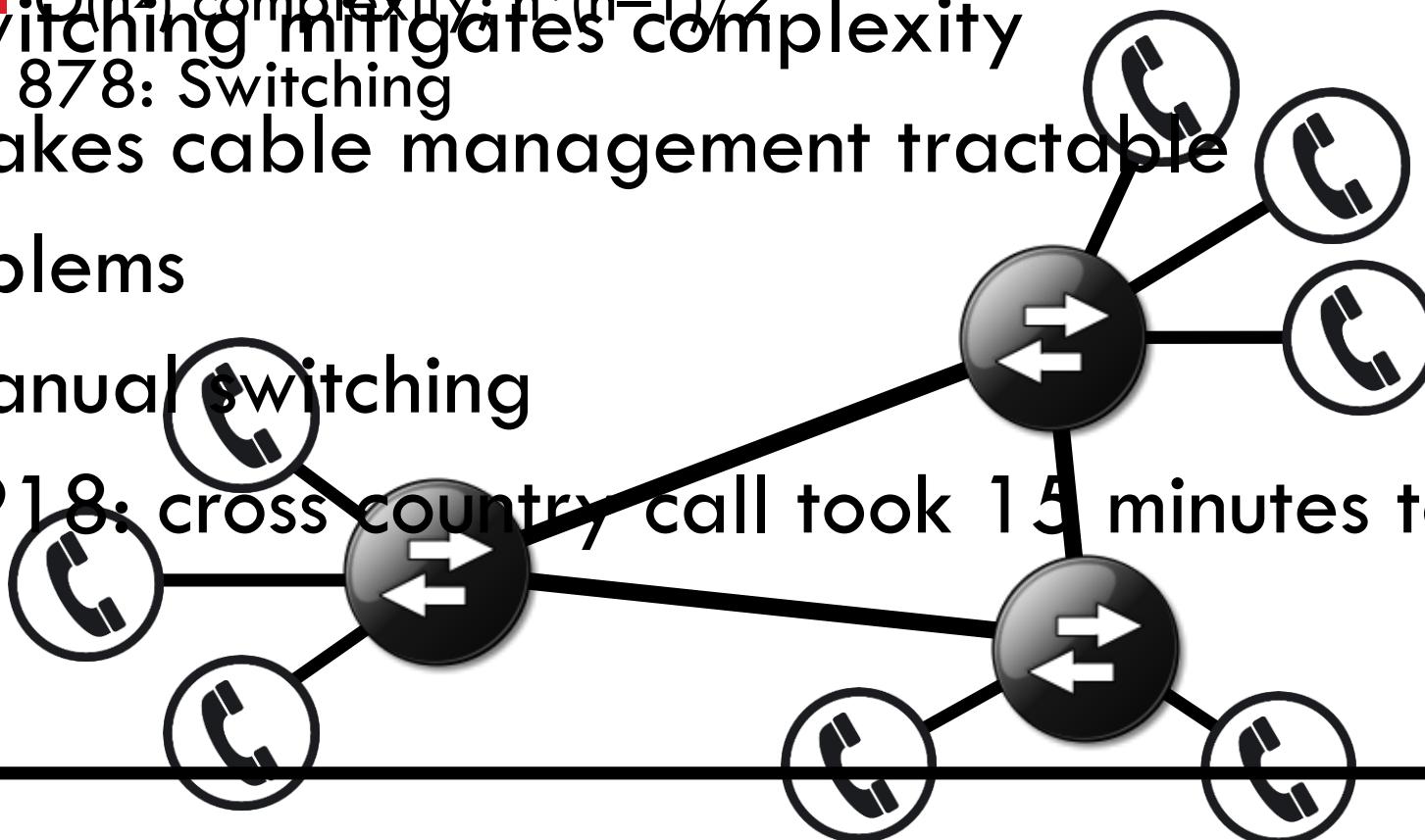
1878: Switching

Makes cable management tractable

Problems

Manual switching

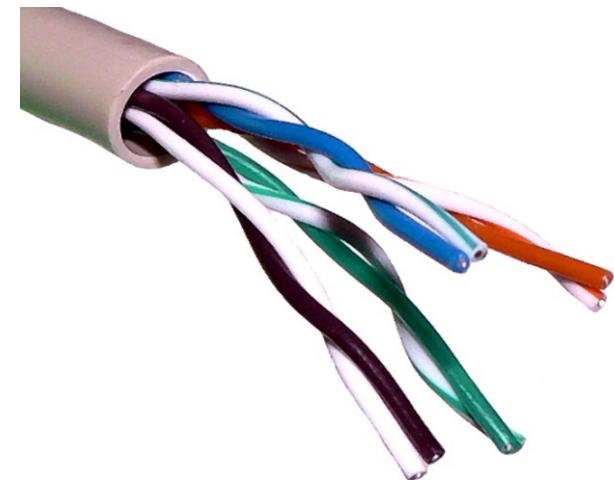
1918: cross country call took 15 minutes to set up



Growth of the Telephone Network

7

- 1881: Twisted pair for local loops
- 1885: AT&T formed
- 1892: Automatic telephone switches
- 1903: 3 million telephones in the US
- 1915: First transcontinental cable
- 1927: First transatlantic cable
- 1937: first round-the-world call
- 1946: National numbering plan



at&t

Crazy idea: Packet switching

8

- Telephone networks are circuit switched
 - Each call reserves resources end-to-end
 - Provides excellent quality of service
- Problems

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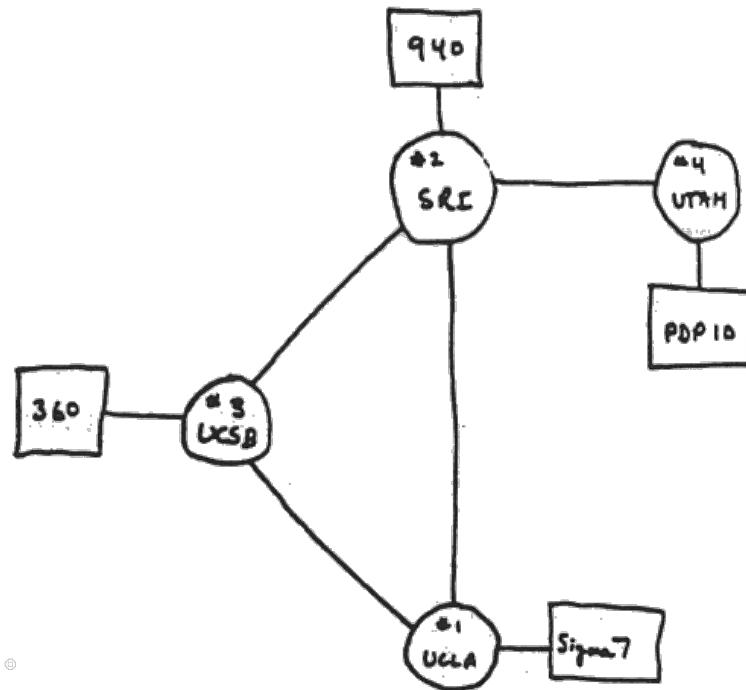
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 - ▣ Complex network components (per circuit state, security)
- Packet switching
 - ▣ No connection state, network is store-and-forward
 - ▣ Minimal network assumptions
 - ▣ Statistical multiplexing gives high overall utilization

The World's Most Successful Computer Science Research Project

9



THE ARPA NETWORK

DEC 1969

4 NODES

FIGURE 6.2 Drawing of 4 Node Network
(Courtesy of Alex McKenzie)

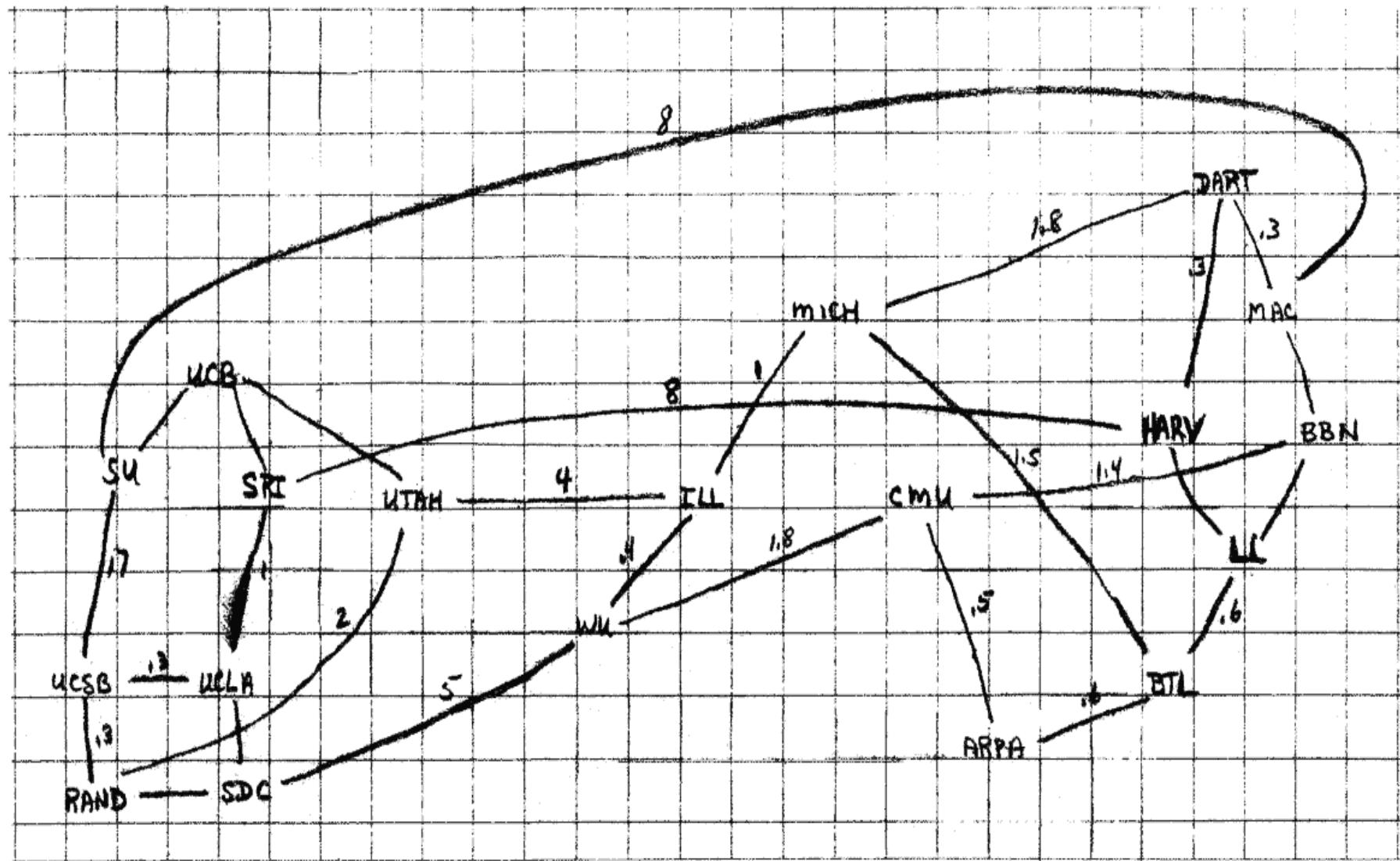
History of the Internet

10

- 1961: Kleinrock @ MIT: packet-switched network
- 1962: Licklider's vision of Galactic Network
- 1965: Roberts connects computers over phone line
- 1967: Roberts publishes vision of ARPANET
- 1969: BBN installs first InterfaceMsgProcessor at UCLA
- 1970: Network Control Protocol (NCP)
- 1972: Public demonstration of ARPANET
- 1972: Kahn @ DARPA advocates Open Architecture
- 1972: Vint Cerf @ Stanford writes TCP

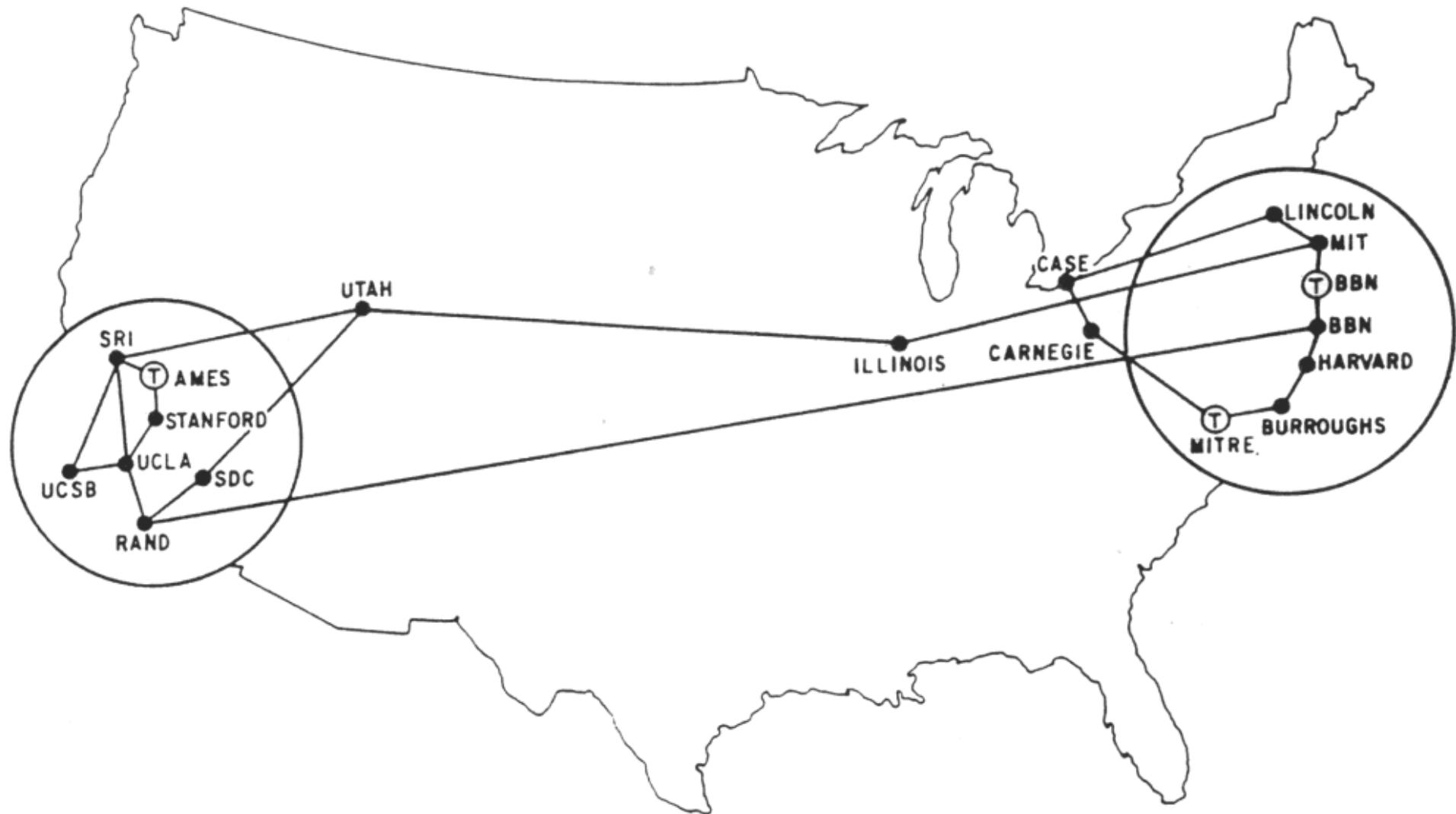
The 1960s

11



1971

12

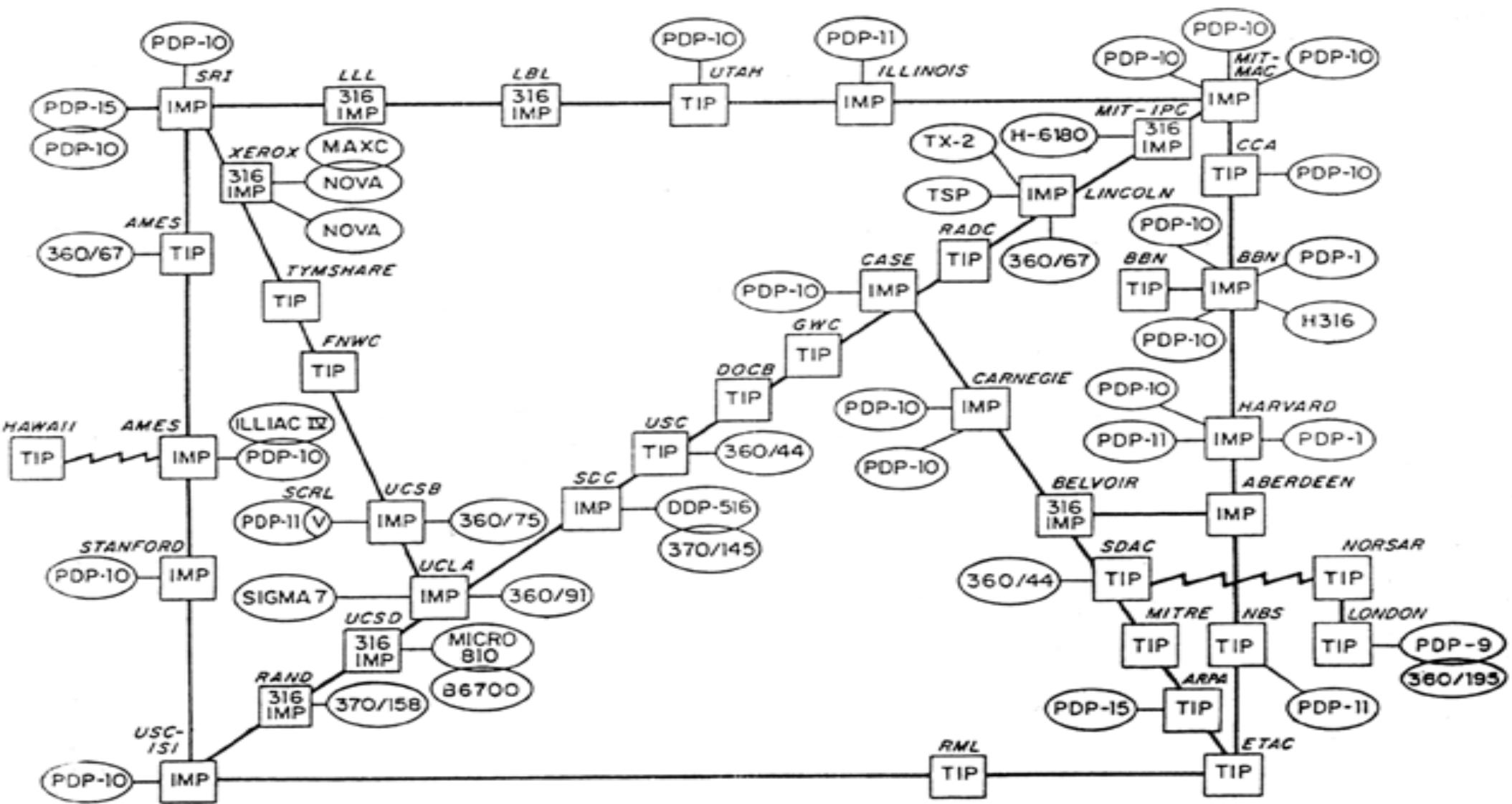


MAP 4 September 1971

1973

13

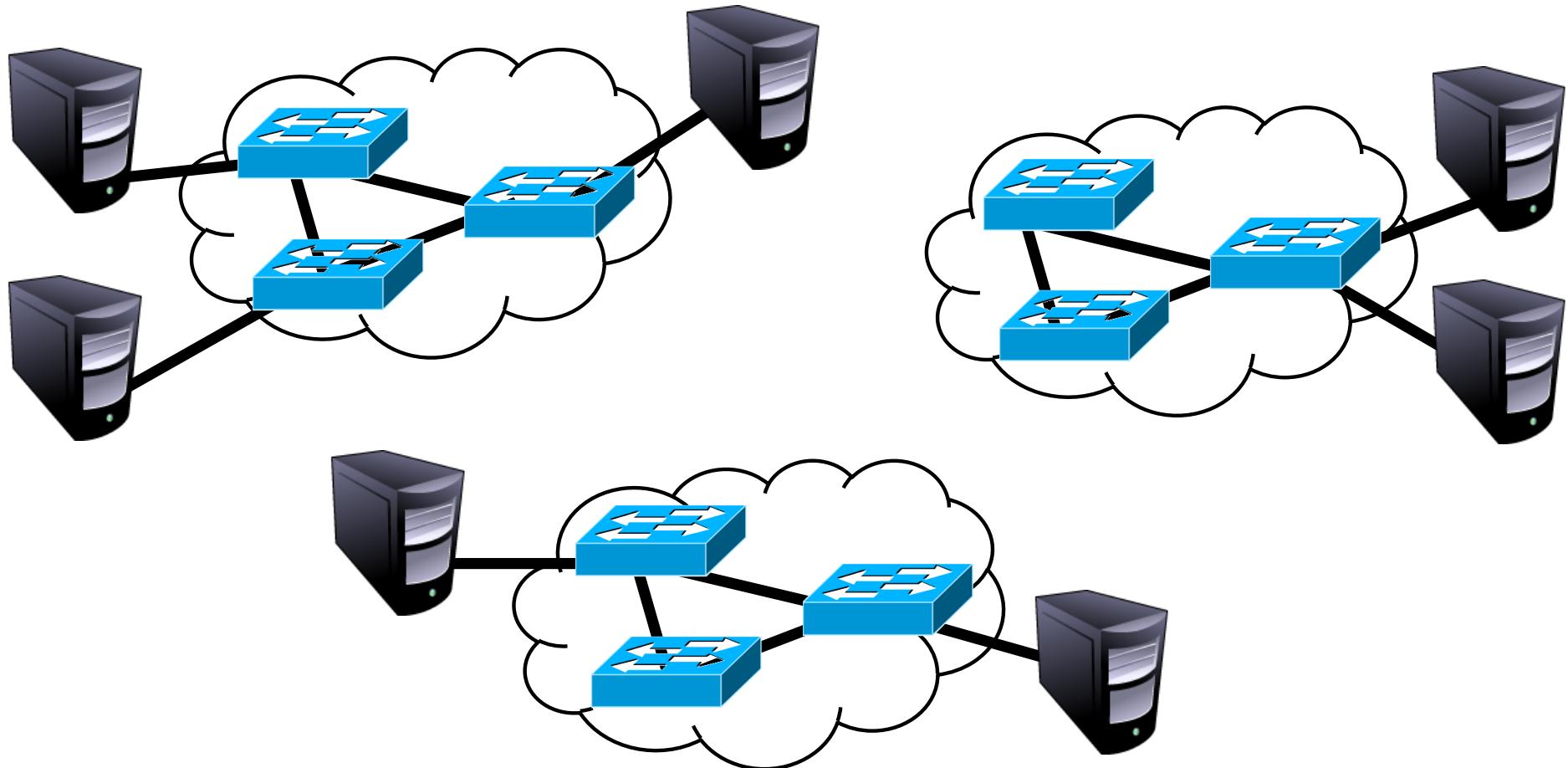
ARPA NETWORK, LOGICAL MAP, SEPTEMBER 1973



Growing Pains

14

- Problem: early networks used incompatible protocols



Kahn's Ground Rules

15

1. Each network is independent, cannot be forced to change
2. Best-effort communication (i.e. no guarantees)
3. Routers connect networks
4. No global control

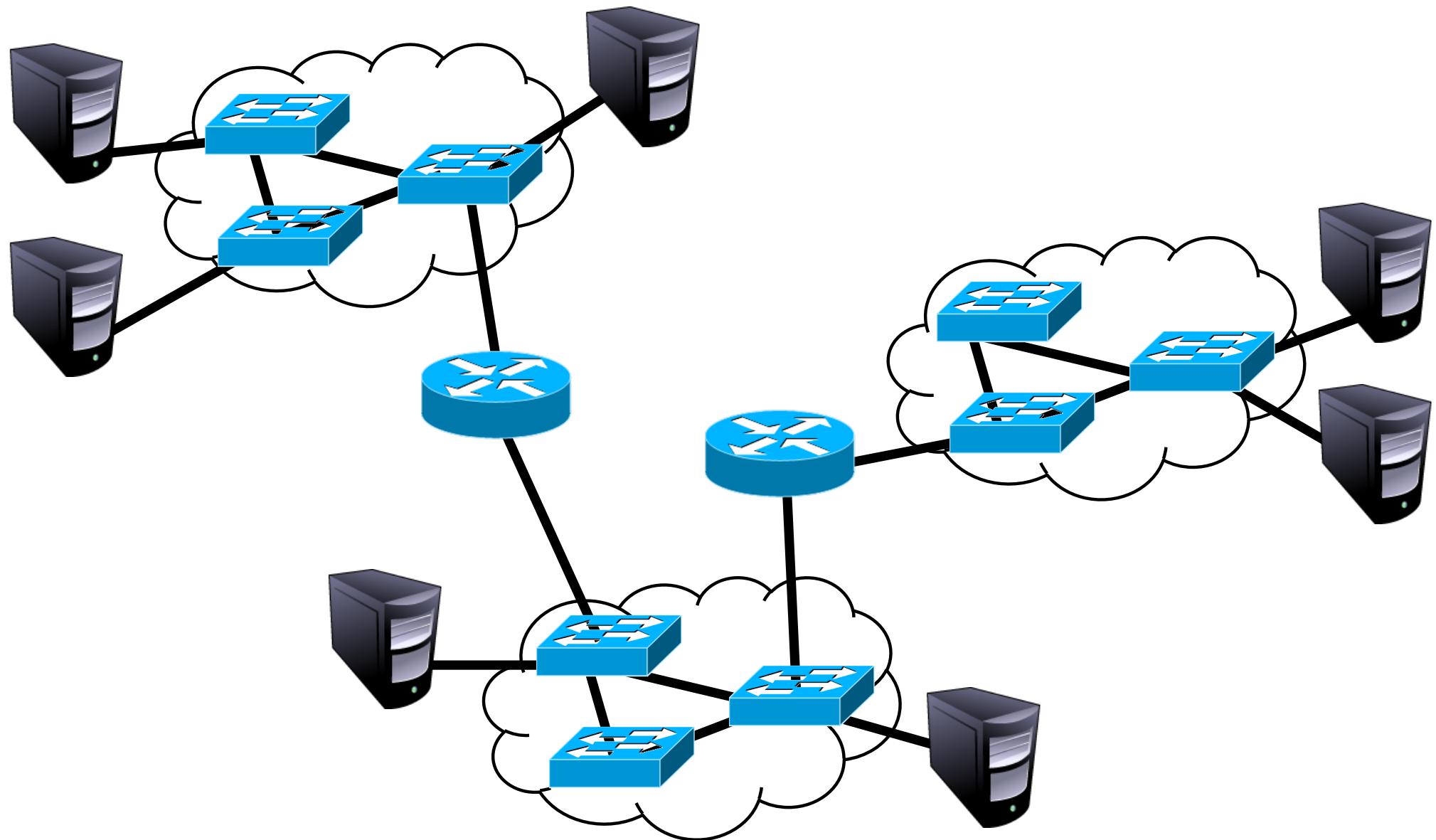
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- Principles behind the development of IP
 - Led to the Internet as we know it
 - Internet is still structured as independent networks

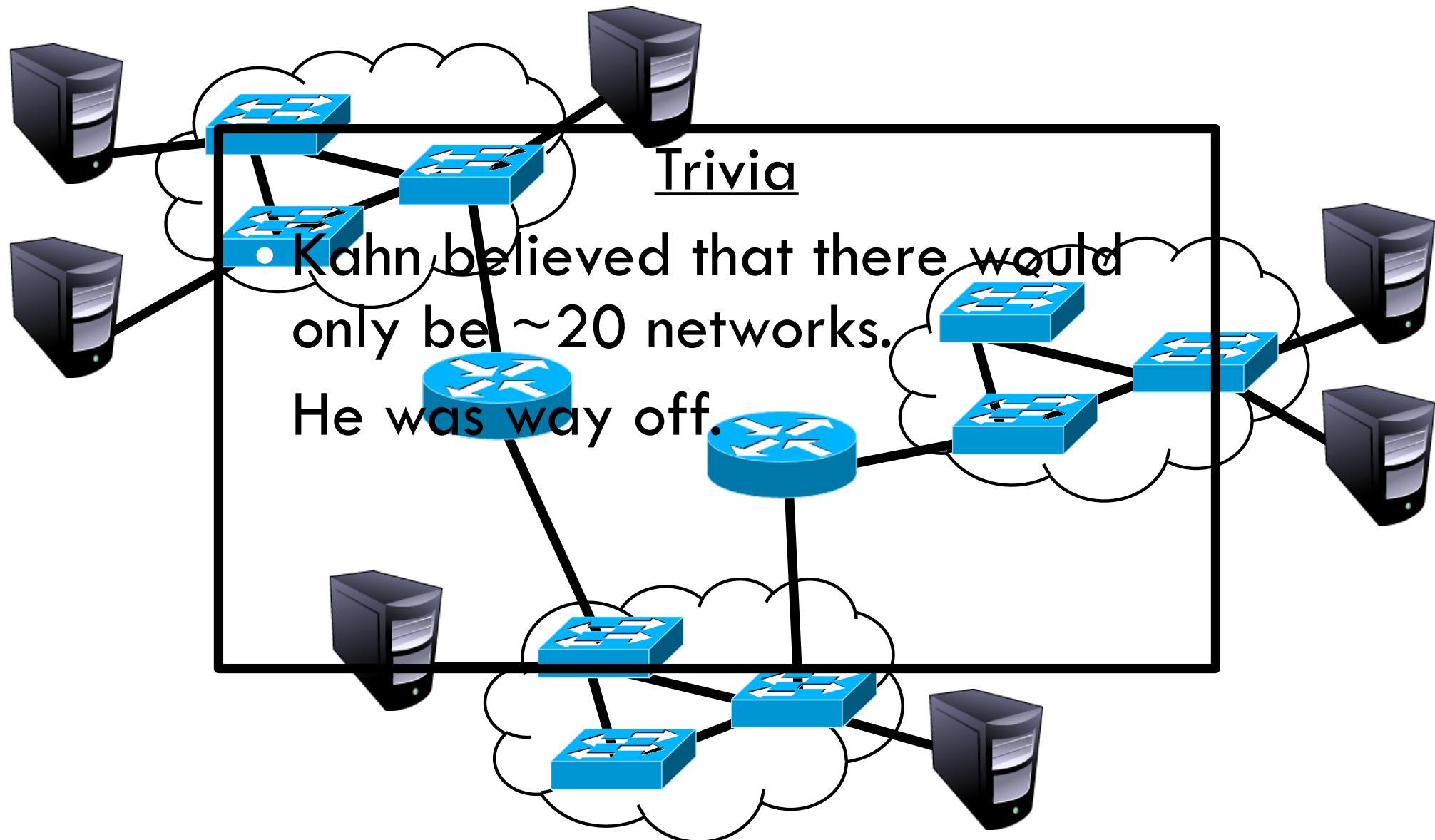
The Birth of Routing

16



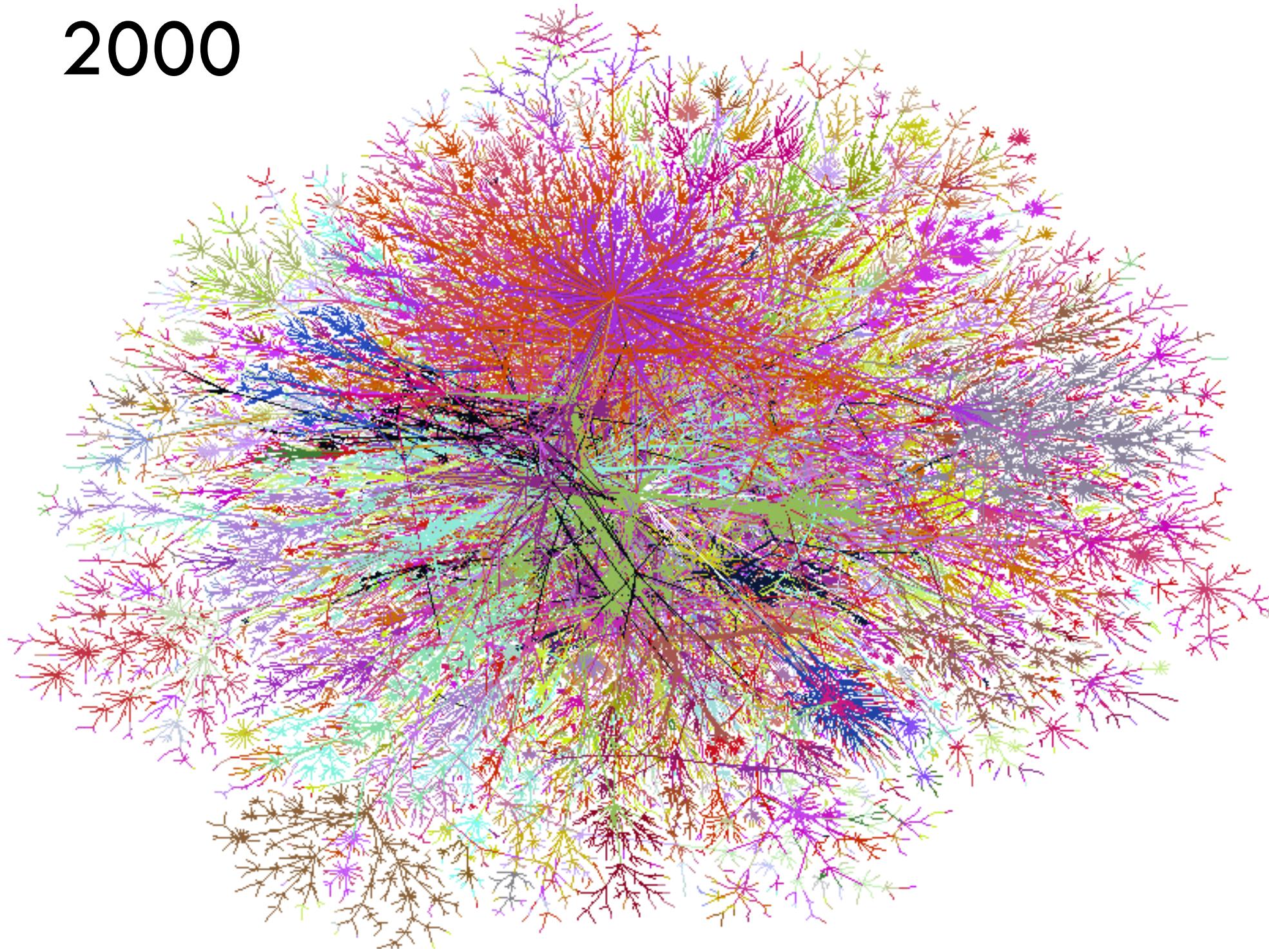
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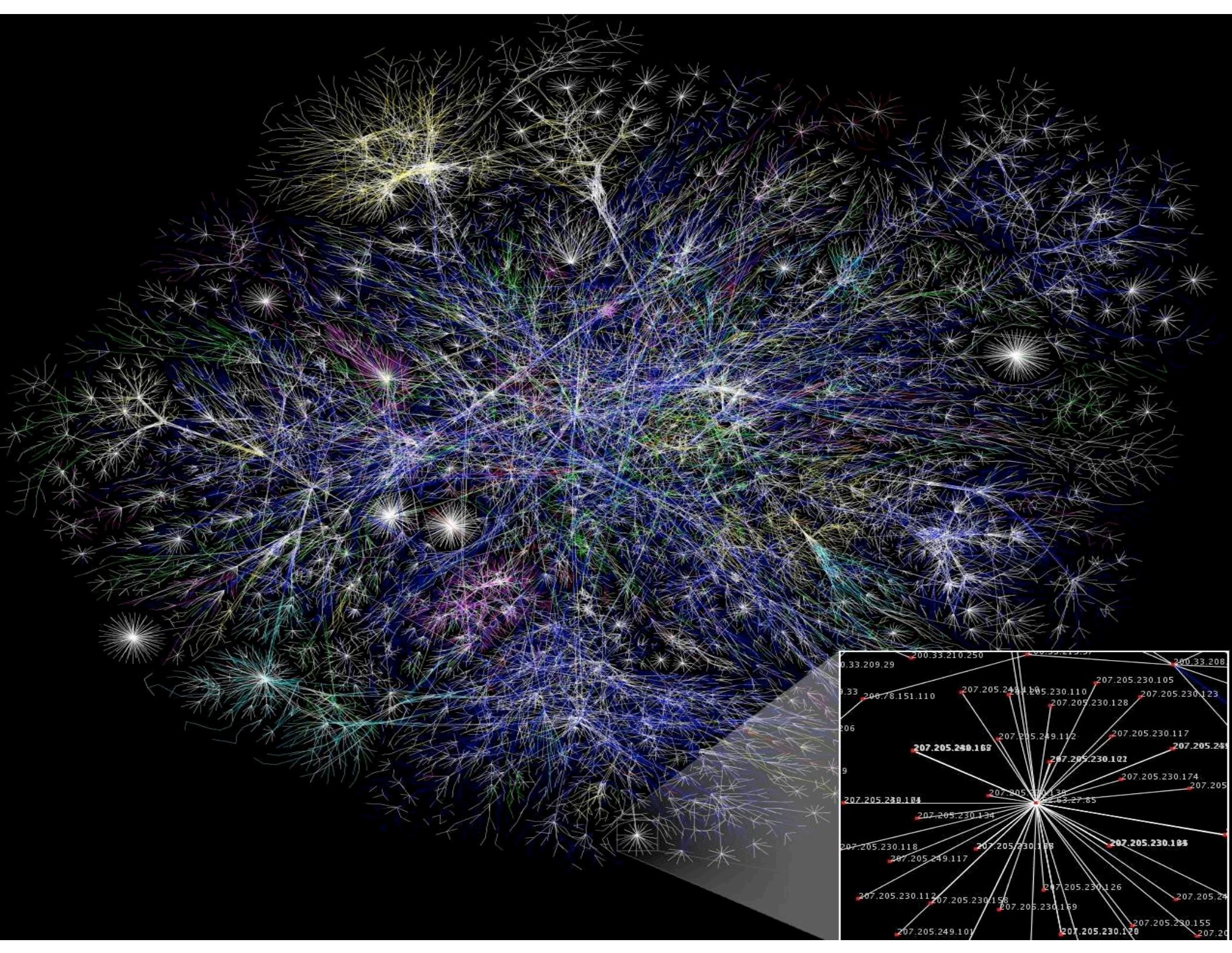
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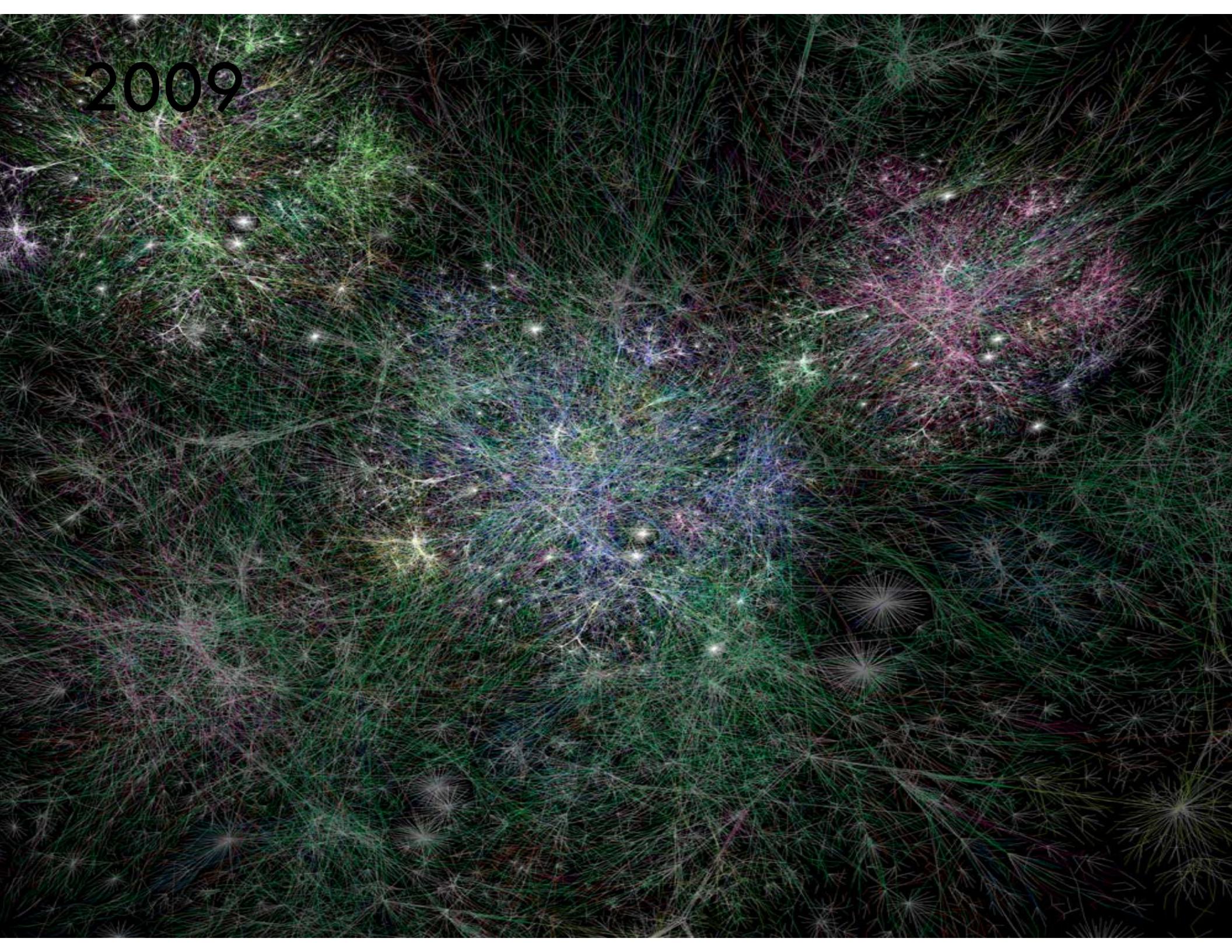
2000

17





2009



More Internet History

20

- 1974: Cerf and Kahn paper on TCP (IP kept separate)
- 1980: TCP/IP adopted as defense standard
- 1983: ARPANET and MILNET split
- 1983: Global NCP to TCP/IP flag day
- 198x: Internet melts down due to congestion
- 1986: Van Jacobson saves the Internet (BSD TCP)
- 1987: NSFNET merges with other networks
- 1988: Deering and Cheriton propose multicast
- 199x: QoS rises and falls, ATM rises and falls
- 1994: NSF backbone dismantled, private backbone
- 1999-present: The Internet boom and bust ... and boom
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Internet Applications Over Time

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- 1972: Email
- 1973: Telnet – remote access to computing
- 1982: DNS – “phonebook” of the Internet
- 1985: FTP – remote file access
- 1989: NFS – remote file systems
- 1991: The World Wide Web (WWW) goes public
- 1995: SSH – secure remote shell access
- 1995-1997: Instant messaging (ICQ, AIM)
- 1998: Google
- 1999: Napster, birth of P2P
- 2001: BitTorrent
- 2004: Facebook
- 2005: YouTube
- 2007: The iPhone
- ~2018: tons of applications

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What is next?

Takeaways

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- Key concepts have existed for a long time
 - Speed/bandwidth
 - Latency
 - Switching
 - Packets vs. circuits
 - Encoding
 - Cable management
 - Multiplexing
 - Routing

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 - Promise of free (\$) and free (freedom) communication
 - Shrunk the world

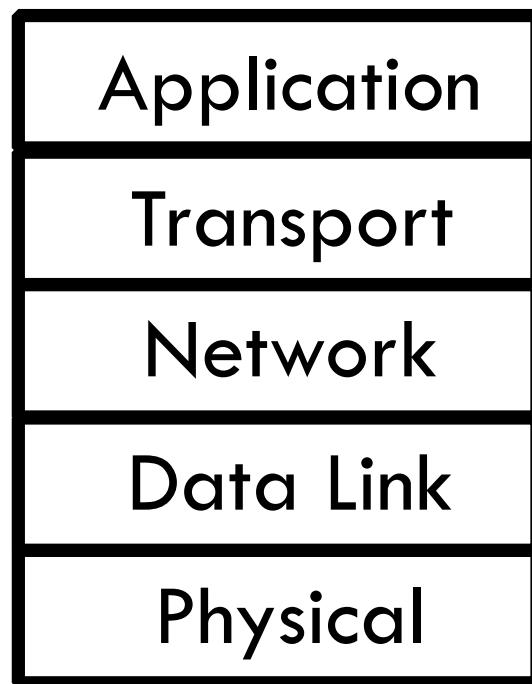
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- What made the Internet so successful? Stay tuned!

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23



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24

Application

Transport

Network

Data Link

Physical



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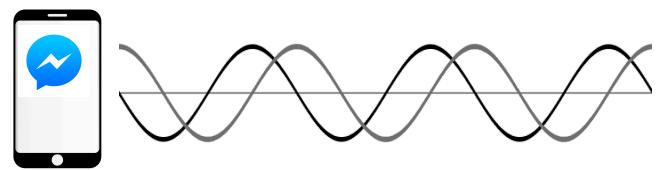
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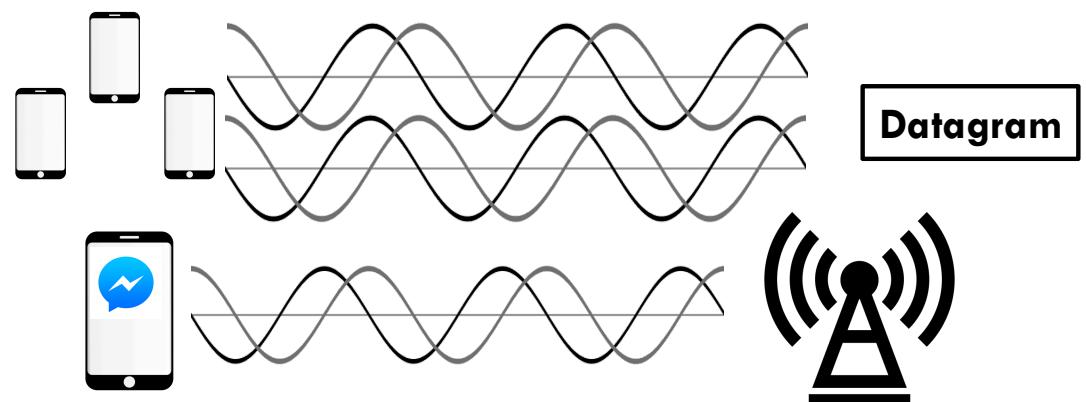
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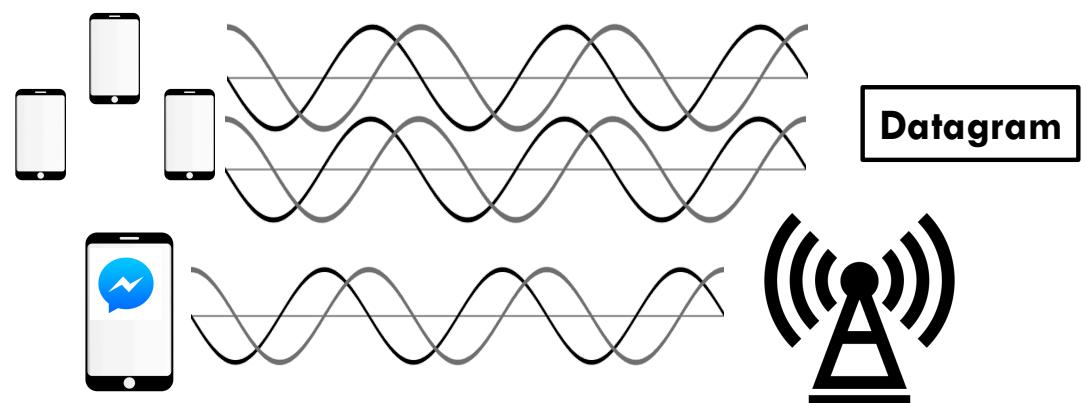
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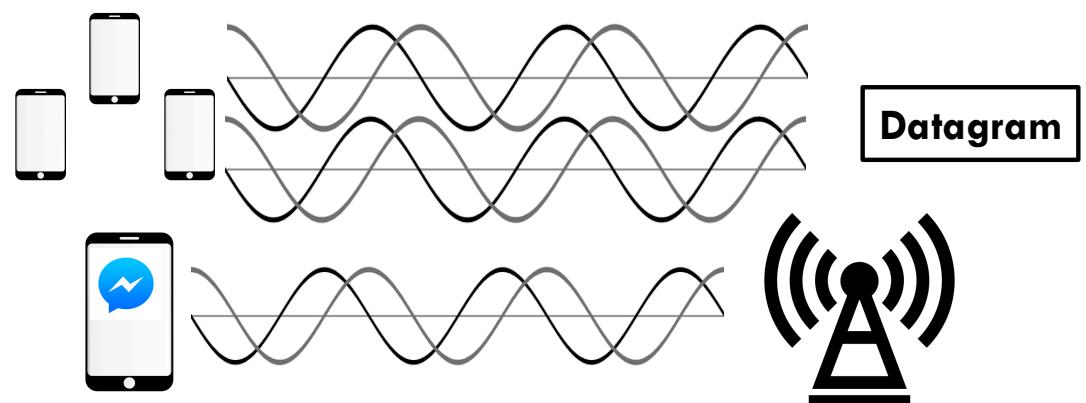
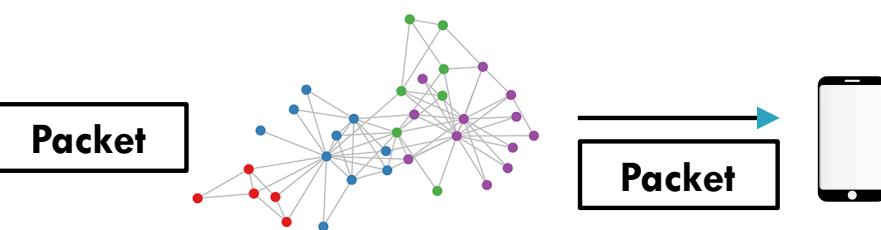
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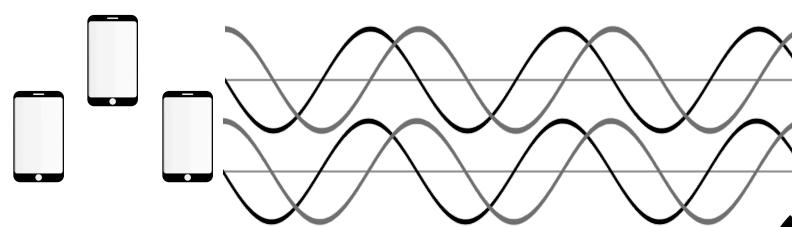
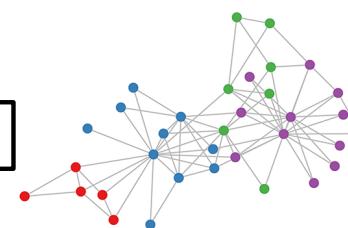
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Packet



Datagram



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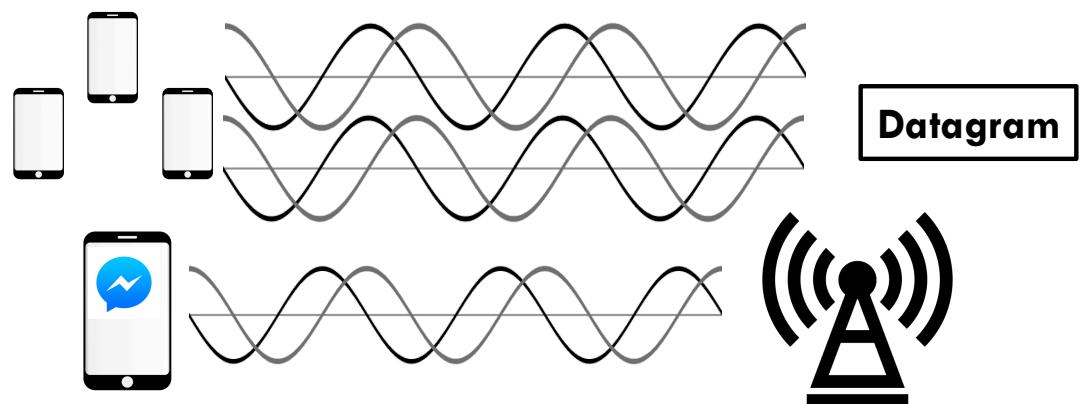
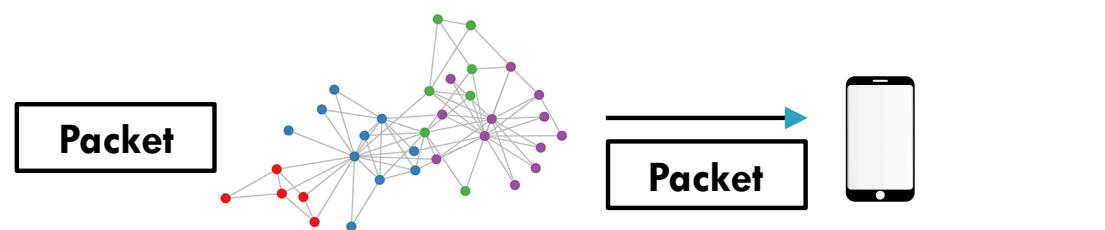
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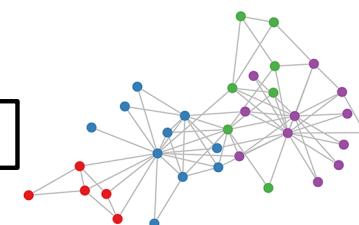
John: Hi there

Transport

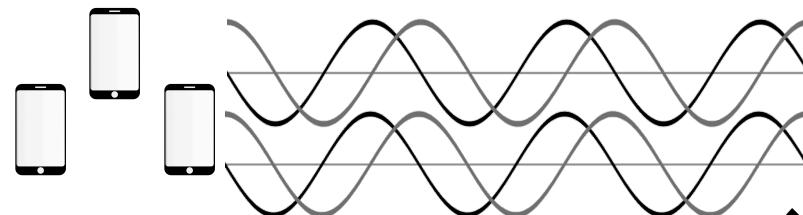


Network

Packet



Data Link



Datagram

Physical



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Which layer are you most interested in?

Application



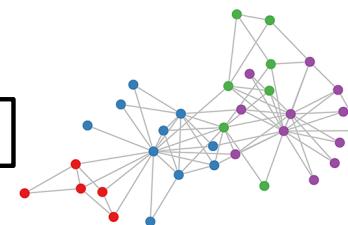
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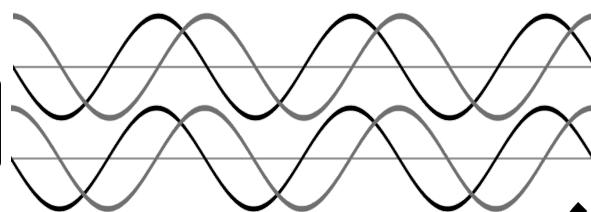
Packet



Packet



Data Link



Datagram

Physical



Physical

Data Link

Network

Transport

Application

No.	Date	Topic	Hw. Due	Proj. Due
01	08/28 TUE	Intro and Course Overview		
02	08/30 THU	History of the Internet		
03	09/04 TUE	Networking Architecture		
04	09/06 THU	Socket Programming		
05	09/11 TUE	Physical / Link layer 1		
06	09/13 THU	Link Layer 2	Hw. 1	
07	09/18 TUE	Bridging and Switching		Proj. 1 Milest
08	09/20 THU	Internet Protocol 1		
09	09/25 TUE	Internet Protocol 2	Hw. 2	Proj. 1
10	09/27 THU	NAT		
11	10/02 TUE	Intra-domain Routing		
12	10/04 THU	Inter-domain Routing	Hw. 3	
-	10/09 TUE	<i>No class—October Break</i>		
-	10/11 THU	<i>Midterm exam</i>		Proj. 2 Milest
13	10/16 TUE	Broadcast and Multicast		
14	10/18 THU	Transport Layer 1		Proj. 2
15	10/23 TUE	Transport Layer 2		
16	10/25 THU	Transport Layer 3		
17	10/30 TUE	Application Layer: DNS		
18	11/01 THU	Application Layer: HTTP	Hw. 4	
19	11/06 TUE	Client & Server and Peer-to Peer Network		Proj. 3 Milest
20	11/08 THU	CDN		
21	11/13 TUE	Network Security Basics		Proj. 3
22	11/15 THU	HTTPS	Hw. 5	
23	11/20 TUE	DNSSEC		
-	11/22 THU	<i>No class—Thanksgiving Holiday</i>		
24	11/27 TUE	TBD		
25	11/29 THU	TBD		Proj. 4 Milest
26	12/04 TUE	TBD		
27	12/06 THU	Final Reviews		
-	TBA	<i>Final exam</i>		Proj. 4