Computer Networks & The Internet

Historical Overview

Primitive forms of data networks have a long history

- Smoke signals
- Telegraphy/telephone (19th century)

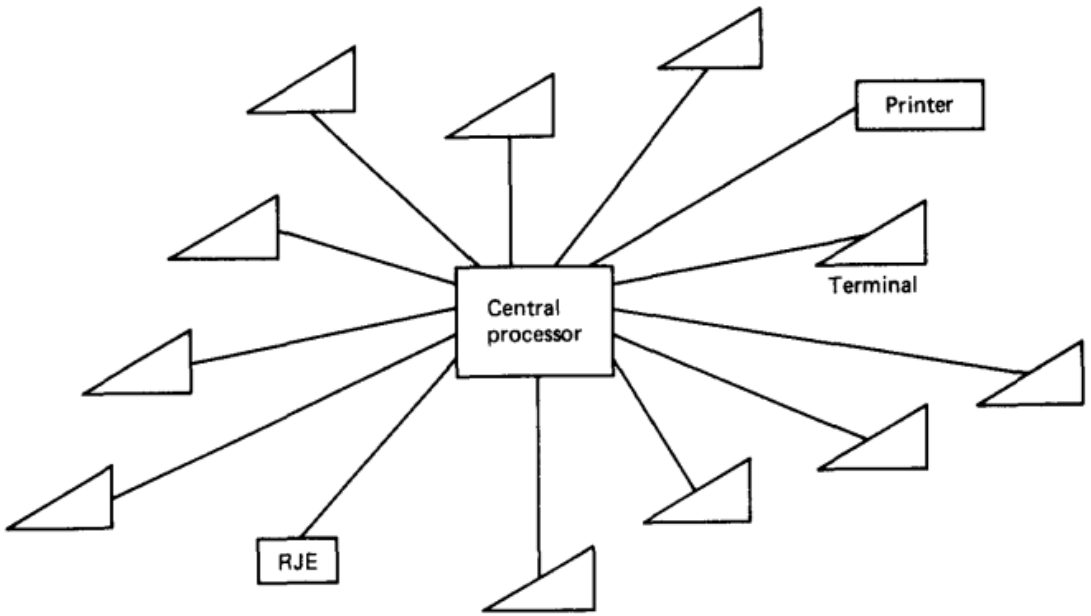
Our focus in this course is on computer data networks

Remote Terminal: 1950-1960

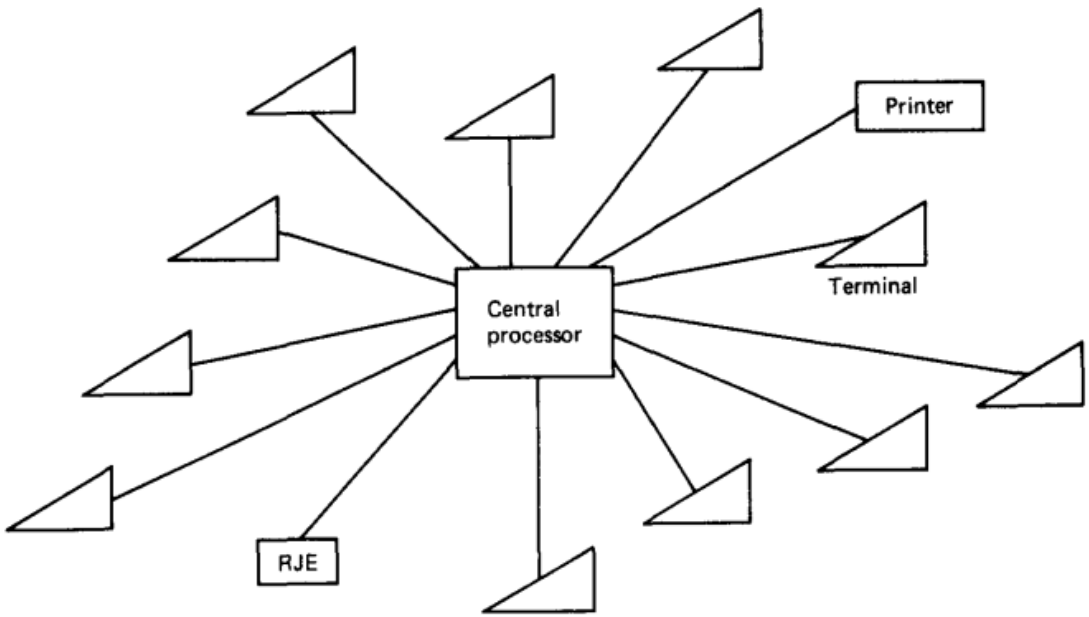
the era of expensive *supercomputers*

IBM 7094
2,000,000 $
$\rightarrow$ 45.66$/hour

Using time sharing operating systems for better utilization



Using time sharing operating systems for better utilization



Resembles a central computer with peripheral devices rather than a computer network

The need for making computer networks

data sharing

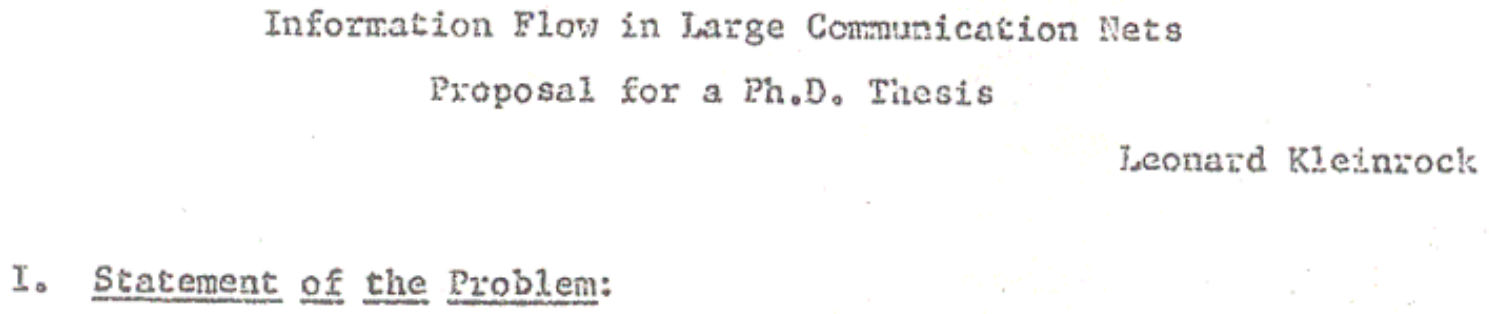
Program sharing

A way to solve hardware incompatibility

Computation resource sharing

Packet switch: 1960's

1961: Leonard Kleinrock PhD thesis



Information Flow in Large Communication Nets

Proposal for a Ph.D. Thesis

Leonard Kleinrock

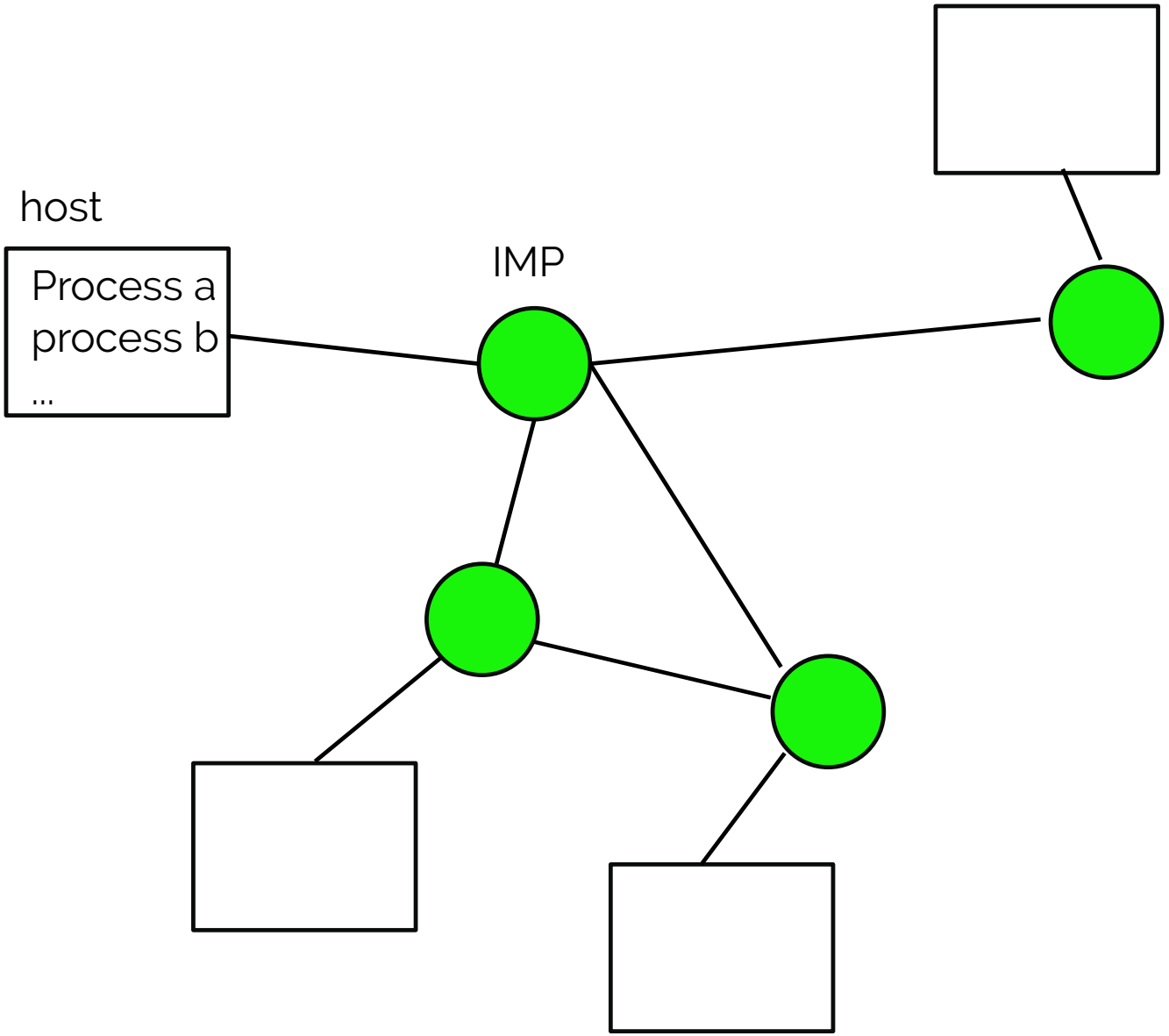
I. Statement of the Problem:

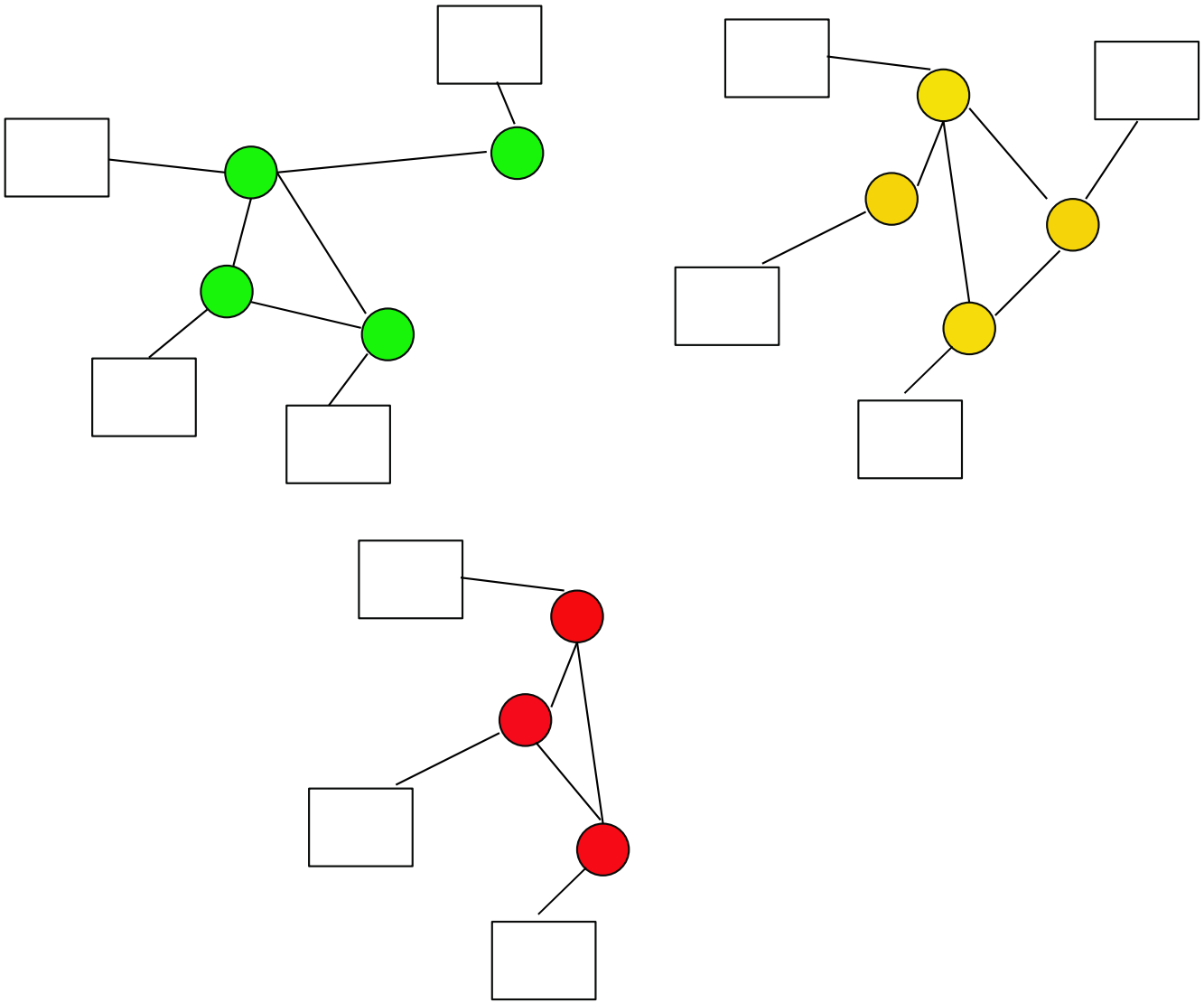
Using queuing theory, proved the effectiveness of the packet-switching approach for bursty traffic sources

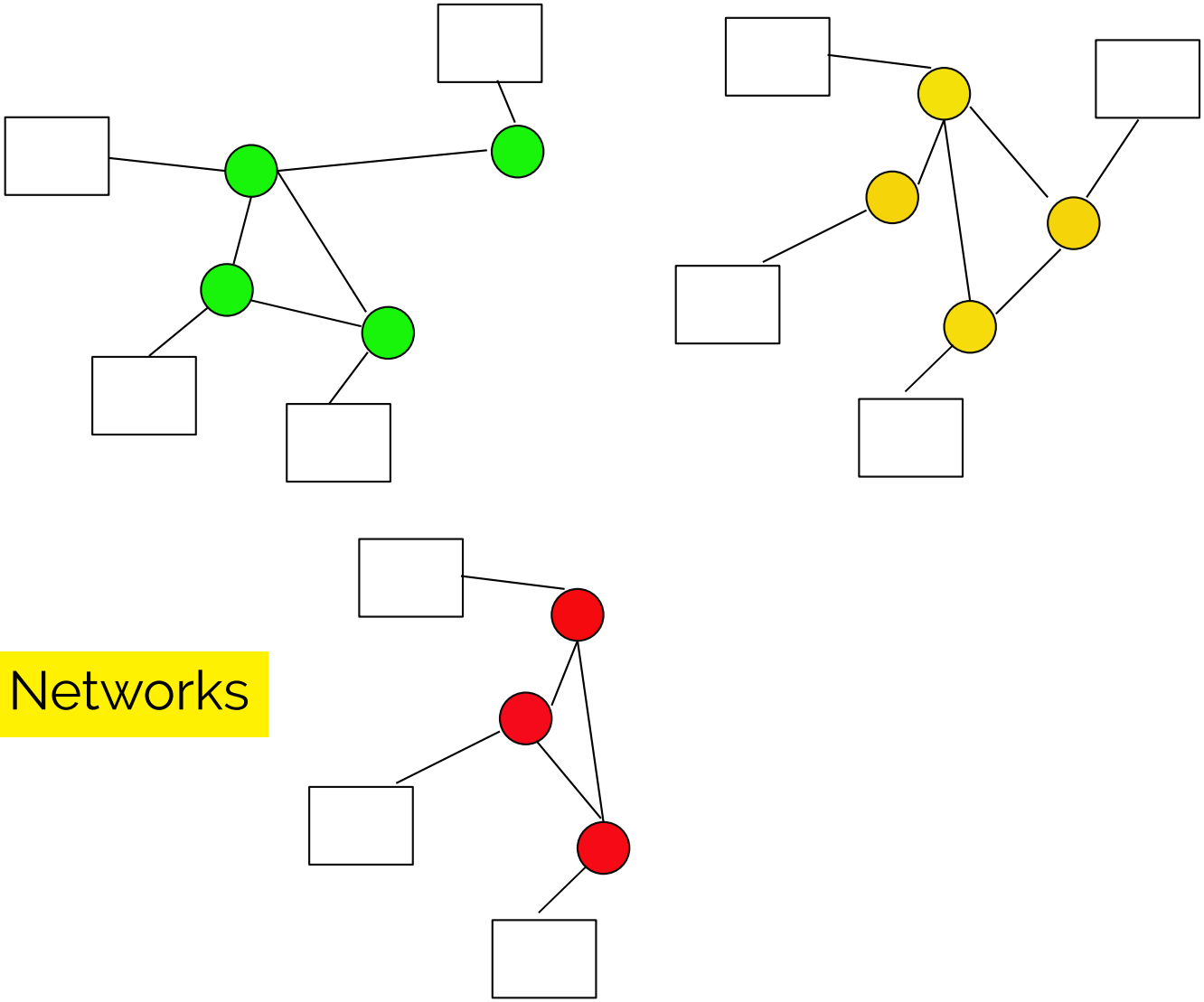
1969: ARPANET

the first packet switch (Interface Message Processor, IMP) was installed at UCLA under Kleinrock's supervision, and three additional packet switches were installed shortly thereafter at the Stanford Research Institute (SRI), UC Santa Barbara (UCSB), and the University of Utah

The ARPANET in December 1969


host
Process a
process b
...
IMP

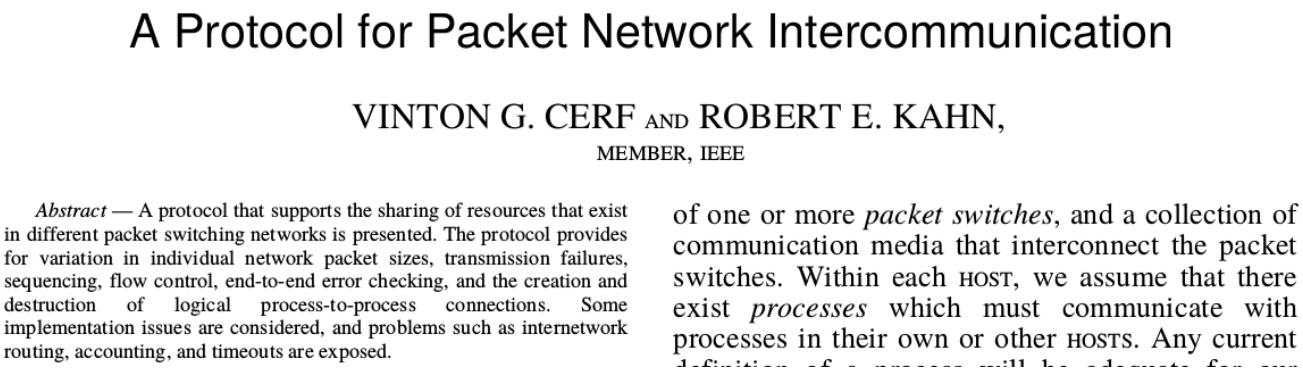




Disjoint Networks

Internetting: 1970's

1974: Vinton Cerf and Robert Kahn paper



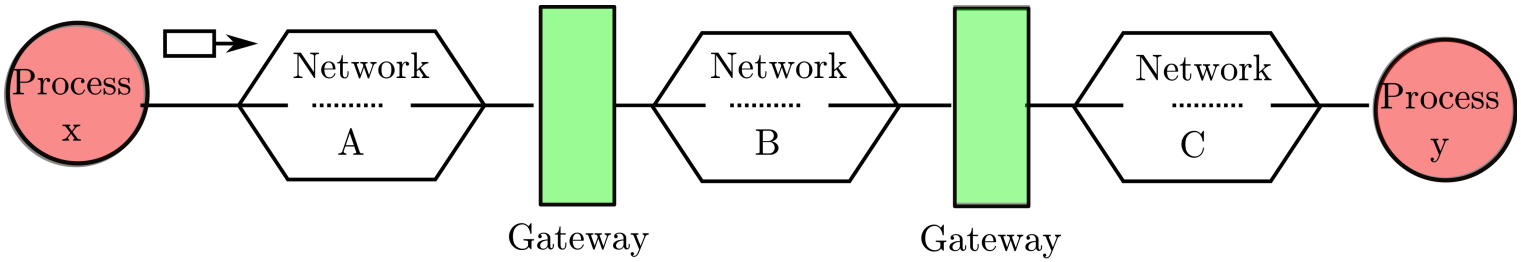
A Protocol for Packet Network Intercommunication

VINTON G. CERF AND ROBERT E. KAHN,
MEMBER, IEEE

Abstract — A protocol that supports the sharing of resources that exist in different packet switching networks is presented. The protocol provides for variation in individual network packet sizes, transmission failures, sequencing, flow control, end-to-end error checking, and the creation and destruction of logical process-to-process connections. Some implementation issues are considered, and problems such as internetwork routing, accounting, and timeouts are exposed.

of one or more *packet switches*, and a collection of communication media that interconnect the packet switches. Within each HOST, we assume that there exist *processes* which must communicate with processes in their own or other HOSTS. Any current

A protocol that supports the sharing of resources that exist in different packet switching networks.



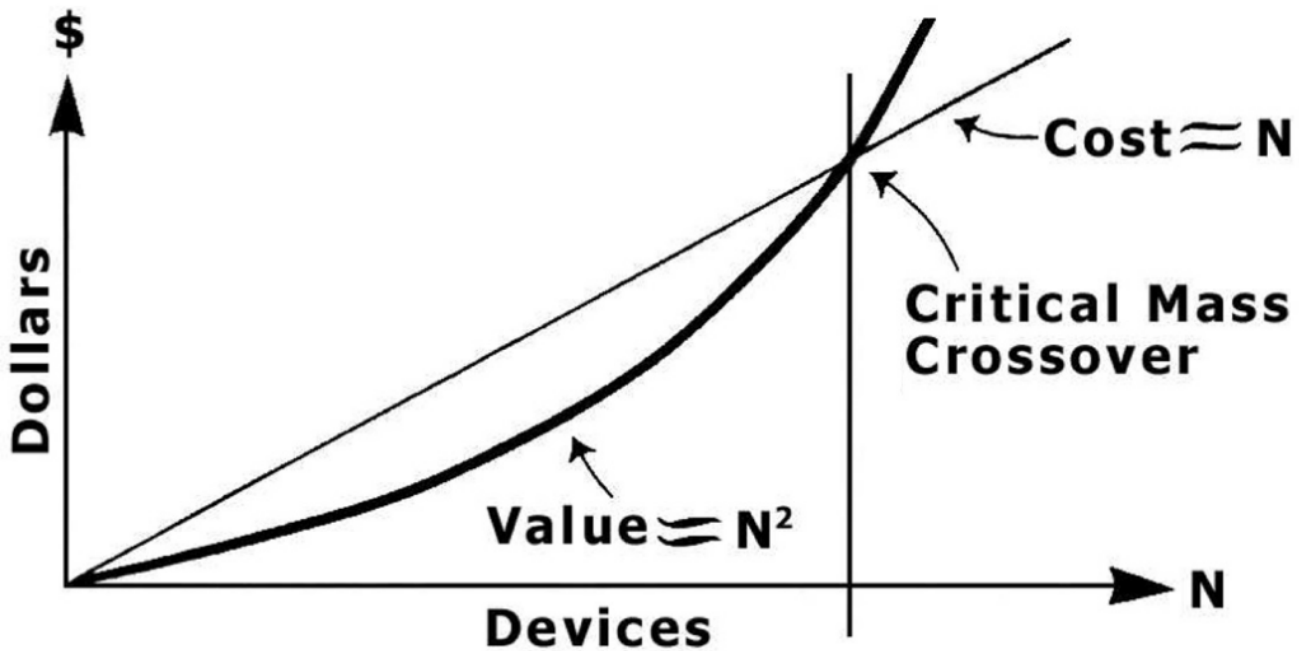
Gateways

interfaces between networks
Technology/protocol adaption (dual stack)

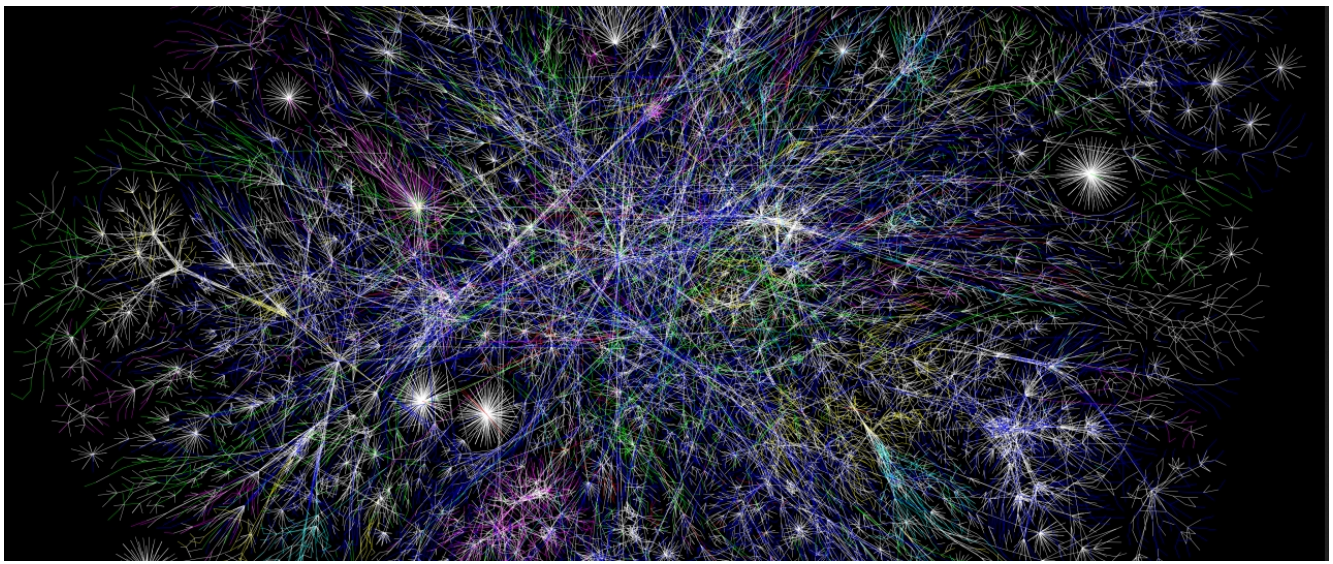
Foundations of **TCP/IP** protocols.

Since then, ...

Metcalfe's law

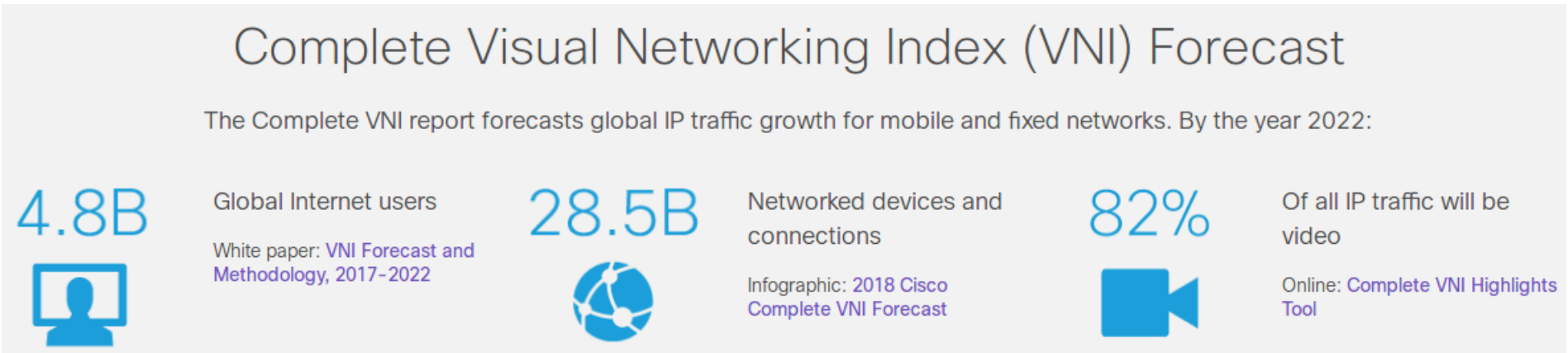


Since then, ...



Partial (30% class C) map of the Internet, 2005

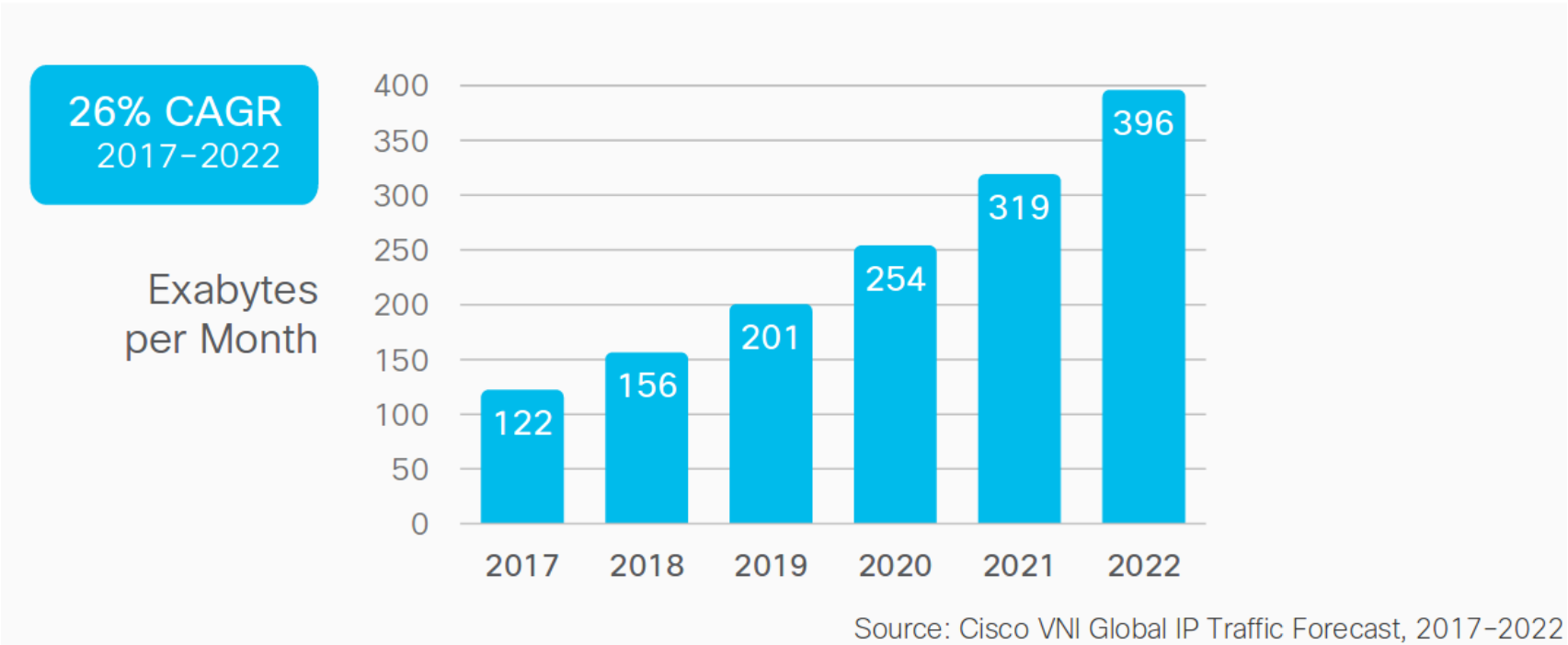
Since then, ...



https://www.cisco.com/c/en/us/solutions/service-provider/visual-networking-index-vni/index.html

Since then, ...

Cisco VNI forecasts 396 EB per month of IP traffic by 2022



Source: Cisco VNI Global IP Traffic Forecast, 2017–2022

1 Exabyte	1,000 Petabytes or 250 million DVDs	**5 Exabytes** A transcript of all words ever spoken **100 Exabytes** A video recording of the all the meetings that took place last year across the world **150 Exabytes** The amount of data that has traversed the Internet since its creation **175 Exabytes** The amount of data that will cross the Internet in 2010 alone

Since then, Many ...

- **Protocols/applications**
  - HTTP, FTP, SMTP, BitTorrent, TCP, UDP, DNS, DHCP, ARP, RIP, OSPF, ...
- **Networks**
  - Social Networks, Sensor Networks, IoT, CDN, wireless (Ad hoc, WiFi, 3G/4G/5G, ...)
- **Standardization bodies**
  - IETF, IRTF, IEEE, 3GPP, ETSI, IANA, ITU-T
- **Companies**
  - Google, Facebook, Amazon, Uber, Cisco, RealteK, ...
- **Research activities**
  - Queue theory, Optimization, Stochastic, Signals & systems, Coding, Cryptography, Control theory, Game theory, ...
  - ACM/IEEE conferences/journals: CCS, INFOCOM, ICC, GLOBECOM, NSDI, SIGCOM, NDSS, ... Transactions on communications/Networking/...

Leonard Kleinrock
(1934-present)

Distinguished Professor of Computer Science at UCLA

Pioneered the mathematical theory of packet networks

Sent the first message between two computers on a network