Internet Technology

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# Baran, Davies, Clark & Roberts – Packets

- The concept came from Paul Baran (1962)
  - Working on a survivable network design under US Air Force contract
  - Data can be broken up into chunks (packets) and forwarded through mesh network
  - Packets include designation address and payload
  - Reliable delivery ensured by redundant paths & rerouting on link failure

- The name "packets" came from Donald Davies (1966)
  - Working at UK National Physics Laboratory
  - Independent development, but found Baran's work

- Implementation came from Larry Roberts (1969)
  - Working at US Defense Advanced Research Projects Agency (ARPA)
  - Got permission (and $) to build ARPANET
  - Used Baran/Davies packet-based design & external router concept from Wes Clark (IMP)

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ARPANET (1969-1983)

- Proved international packet-based networks would work

ARPANET GEOGRAPHIC MAP, OCTOBER 1980
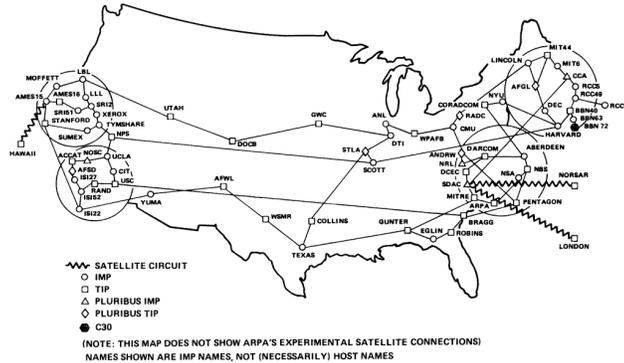
- But was a single network

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Pouzin - Datagram

- Louis Pouzin working at French national computing laboratory
  - Developed concept of "datagram" by extending packet concept
  - ARPANET packets followed paths defined by IMPs and depended on IMPs to reliably deliver the packets in order
  - Datagrams are packets but do not depend on the network for reliable delivery
    - Instead, connection end points are responsible for reliability and for controlling speed of data transfer
  - Datagrams can take any available path to destination
  - No state required in network
  - Provides a "bearer service" -
    - Hides network differences from applications
  - Minimizes required network functionality
  - Building block for different types of services
    - Interactive services, data transfer, voice, streaming services, …
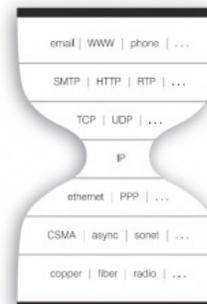
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Internet – Cerf & Kahn (1983-???)

- Bob Kahn working at ARPA, asked Vint Cerf to help develop an Internet Protocol
  - Extend ARPANET model to interconnect networks rather than computers
- Built on Pouzin's datagram concepts
- Developed TCP/IP (Transmission Control Protocol/Internet Protocol)
  - Datagrams include Internetwork addresses – address of node on another network
- Deployed on ARPANET in 1983 – start of the Internet

0 8 16 19 31				
Version	Header Length	Service Type	Total Length	
Identification			Flags	Fragment Offset
TTL		Protocol	Header Checksum	
Source IP Addr				
Destination IP Addr				
Options			Padding	

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End-to-End Model

- Natural result of datagram concept
- New applications "just work" as long as communications make use of Internet Protocol
  - Assuming the underlying network provides an adequate level of service
- "Permissionless innovation"
  - How the world wide web, Skype, You Tube, etc. were enabled

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Regulation Not Required For Operation

- Minimal record keeping required
  - Record protocol parameters (e.g., 25 means email)
  - Record IP address assignments (addresses must be unique)
  - Record domain name assignments (can only be one Harvard.edu)
  - Done by Internet Assigned Numbers Authority (IANA) (currently run by ICANN)

- Pair-wise agreements between ISPs for interconnection
  - Including what routing protocol to use
  - Including payments (if any)

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