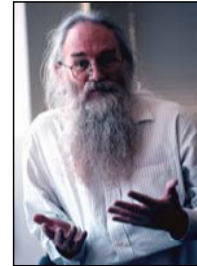


Internet History

Why are we here?



*“ARPAnet is a network of computers.
The Internet is a network of networks.
An interplanetary net would be a
network of Internets.”*

**The sky is the limit – Vinton G. Cerf
Creator of the Internet**

Before Arpanet



- **1957**
 - ◆ The USSR launches Sputnik
 - ◆ Leads to "Sputnik Shock" in USA
- **1958**
 - ◆ US Congress Funds the *Advanced Research Projects Agency (ARPA)*
 - Basically for space and computer research
 - ◆ ARPA placed under DoD
 - ◆ Space research is spun off to a separate organization: "NASA"
 - ◆ ARPANET design discussions started

In 1957 the USSR launched Sputnik, the first artificial earth satellite. In response, the United States formed the Advanced Research Projects Agency (ARPA) within the Department of Defense (DoD) to establish US lead in science and technology applicable to the military. The Cold War with his atomic menace lead the military to new technologies. The electronic communication was one of the important technologies. But there was one big problem with this kind of communication, if one communication-point went down, the whole communication stops. The design of the ARPANET began.

The Pioneers



- **Paul Baran**
 - ♦ **Research on reliability of the US telephone network in case of nuclear attacks**
 - ♦ **1964 "On Distributed Communication" released (RAND corp.)**
 - ♦ **Described the idea of packet switching in a decentralized network (actually for AT&T)**
- **Donald Watts Davies**
 - ♦ **English physicist, study on distributed network nodes with partial redundant links**
 - **Support from telephone companies**
 - ♦ **Also idea of packets and packet switching**

Paul Baran's Life:

Born 1926 in Poland

Got to USA in 1928

Drexel University, good mathematical education there

Completed study in 1949 as electrical engineer

Employed by Eckert-Mauchly Computer Corporation, where he tested tubes and germanium diodes for the first commercial produced computer

Went to Hughes Aircraft, analyzed radar data and attended courses at UCLA on computer and transistors

Master of Engineering in 1959

Went to RAND Corporation – Computer Science and Mathematics Department

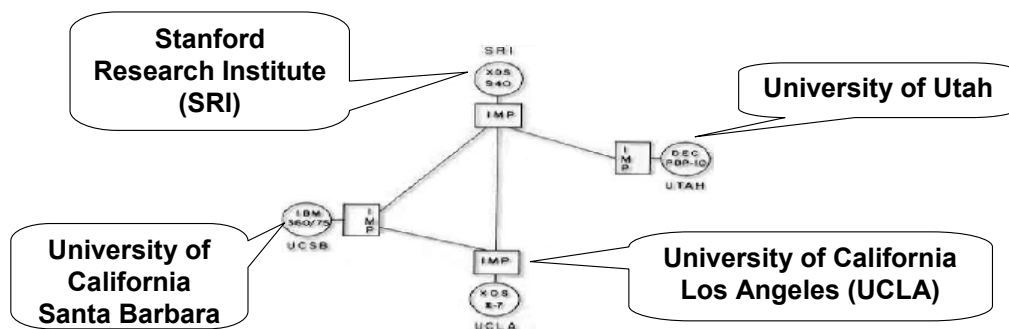
Research on reliability of the US telephone network in case of nuclear attacks (NOT on computer networks as widely assumed!)

AT&T did not take this serious

Birth Of The Arpanet



- **1. Sept. 1969 – The Birth of the Arpanet**
 - ♦ First packet-switched network
 - ♦ Connected UCLA, SRI, UCSB, UTAH
 - ♦ Using predecessors of Routers:
Interface Message Processors (IMPs)



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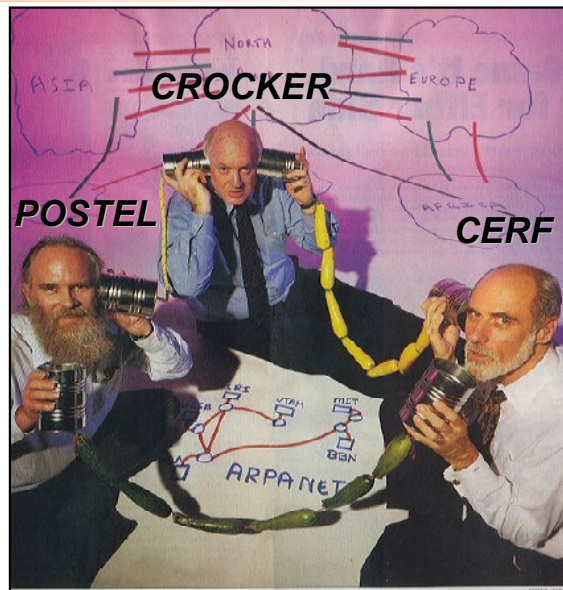
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The physical network was constructed in 1969, linking four nodes: University of California at Los Angeles, SRI (in Stanford), University of California at Santa Barbara, and University of Utah. The network was wired together via 50 Kbps circuits. The first IMP's based on computers of the types Honeywell DDP-516 and Forts. The IMP's are the predecessors of "routers" and serve for the connection between the different computers. The first hosts were computers from IBM, DEC and SDS, and all running different operation systems.

The Fathers



- Jon Postel
- Steve Crocker
- Vinton Cerf



Newsweek, Aug 8, 1994

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Jon Postel, Steve Crocker and Vinton Cerf working for the UCLA and developed the packet switching principle of the ARPANET.

Birth Of The Arpanet



- **1969**
 - ♦ Bell Labs created ESS-1, the first switch
- **1970**
 - ♦ Arpanet use the **Network Control Protocol (NCP)**
- **1971**
 - ♦ Arpanet connects 15 sites including universities and research organizations
 - ♦ Birth of TELNET and FTP
- **1972**
 - ♦ Ray Tomlinson created first email program
 - ♦ ALOHAnet connected to the Arpanet

In 1969 Steve Crocker writes the first RFC to establish a way to document and to discuss the new upcoming technologies.

The NCP was the first protocol which connect all hosts in the ARPANET and in July 1970 the NCP protocol was standardize with the help of the RFCs. The ARPANET began to grow and connects 15 hosts:

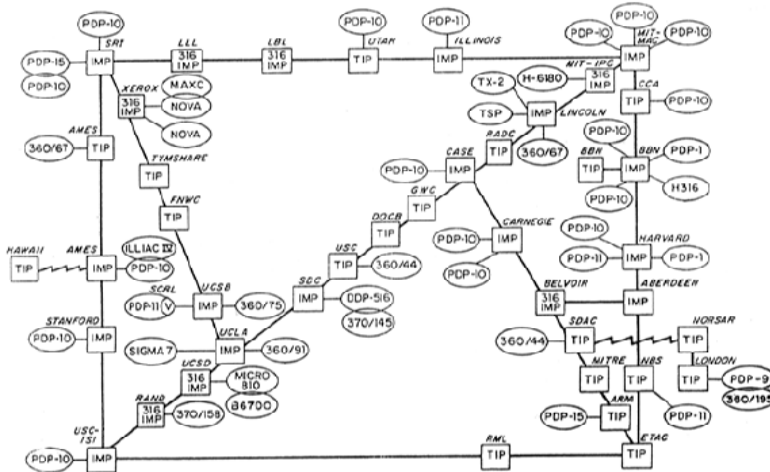
- University of California at Los Angeles (UCLA)
- Stanford Research Institute (SRI)
- University of California at Santa Barbara (UCSB)
- University of Utah
- Bolt Beranek and Newman (BBN)
- Massachusetts Institute of Technology (MIT)
- RAND Corporation
- SDC
- Harvard
- Lincoln Labs
- Stanford
- University of Illinois at Urbana Champaign (UIUC)
- Case Western Reserve University (CWRU)
- Carnegie Mellon University (CMU)
- NASA-Ames

The development was going on and new protocols and systems were created (TELNET, FTP, EMAIL).

Birth Of The Arpanet



- 1973
 - ◆ Arpanet comprises 35+ hosts



Source: Cybergeography

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In 1973 a multiplication of the existing IMPs began. The old DDP-516 computer changes to a Honeywell 316 and got the name "Terminal IMP" (TIP).

Early Problems



- Arpanet communicates with NCP but other networks use different protocols
- **1974 – The Transmission Control Protocol (TCP)**
 - ◆ TCP enabled the expansion from the Arpanet to a worldwide Internet
 - ◆ TCP means "Internet Architecture"

A new problem occurred. Other networks should be connected to the ARPANET. But every network uses a different protocol. Robert Khan and Vinton Cerf started to design a network overlapping protocol. In May 1974 a workgroup with the name "A Protocol for Packet Network Intercommunication" published, and in December the first RFC (RFC 675) "Specification of Internet Transmission Control Protocol" edited. TCP was created and enabled the expansion to a worldwide internet.

The Number of hosts arise to 62.

The Success of TCP/IP



- **1978**
 - ♦ TCP split into TCP and IP
- **1983**
 - ♦ Arpanet converts to TCP/IP
 - ♦ UNIX (v4.2 BSD) released – a kernel around TCP/IP !
 - ♦ Arpanet splits into Arpanet and MILNET
 - ♦ Internet Activities Board (IAB) founded

After 5 years of development on the TCP/IP protocol, it switched from a experimental to a operational protocol. To push the development on the TCP/IP protocol the Internet Configuration Control Board (ICCB) was created.

DARPA switched from the Arpanet architecture to the Internet architecture using **TCP/IP as base protocols**

Further Milestones



- **1984**
 - ♦ **Invention of the Domain Name System (DNS)**
 - **By Jon Postel and Paul Mockapetris**
- **1985**
 - ♦ **Symbolics.com is the first registered domain**

On 1st January 1983 NCP changed completely to TCP/IP.

The ARPANET works fine, but in 1983 the Department of Defense decided to create an own military network, called MILNET.

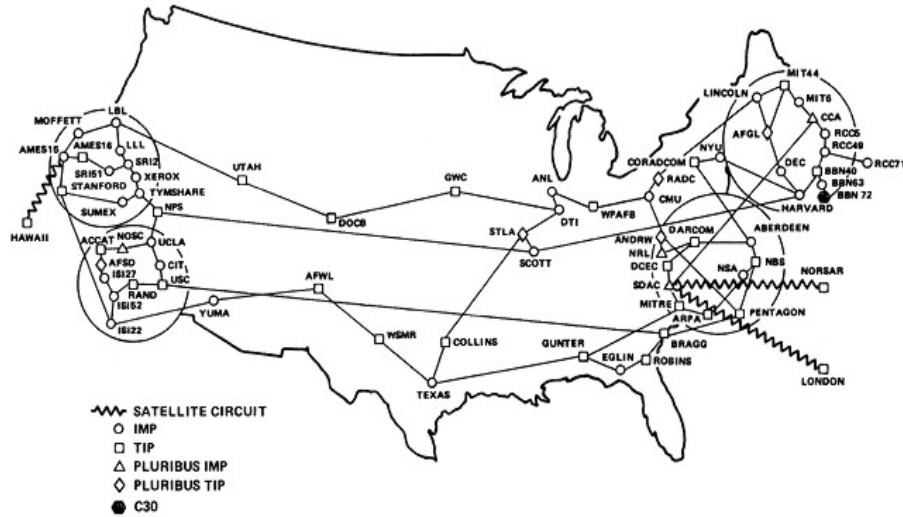
To push the development on the Internet the Internet Configuration Control Board (ICCB) was changed to the Internet Activities Board (IAB). Now the IAB has the function to control and edit the RFCs.

Because of the fast grow of the Internet (around 1000 hosts) the Domain Name System (DNS) was created. It took 2 years until all hosts were connected to the DNS.

1980's Topology



ARPANET GEOGRAPHIC MAP, OCTOBER 1980



Source: Cybergeography

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1986 the ARPANET enfolded over whole USA and parts of Europe.

Who Is Who?



- **J.C.R. Licklider (MIT, ARPA/IPTO)**
 - ♦ Memos about a global, distributed network and addressing
 - ♦ Vision of a universal network had a powerful influence
- **Robert Taylor (ARPA)**
 - ♦ Designed the ALTO workstation
- **Larry Roberts (ARPA)**
 - ♦ The principal architect of the Arpanet
- **Barry Wessler (ARPA)**
 - ♦ ARPA administrator

Who Is Who?

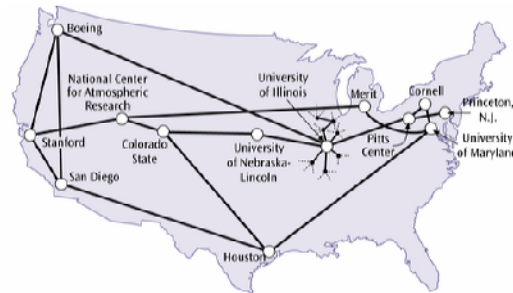


- **Wesley Clark** (Washington University)
- **Frank Heart, Robert Kahn, Dave Walden, Willy Crowther, Severo Ornstein et al (BBN)**
 - ◆ First packet switch
 - ◆ First router
 - ◆ First person-to-person network email
- **Leonard Kleinrock (UCLA) and Crocker, Postel, Kline, Braden, Cerf et al**
 - ◆ Principles of packet switching

NSFNET Backbone



- **1986**
 - ♦ National Science Foundation (NFS) creates the NSFNET Backbone
 - ♦ It connects Cornell, Princeton, UC-SD, Pitt and UI-UC with 56k Lines
 - ♦ Dramatic growth of hosts
 - February: 2000, November: 5000
- **1988**
 - ♦ Backbone is upgraded to T1 (1.544Mb/s)



Source: Cybergeography

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In 1986 the NFS created the NSFNET backbone to which each of the local networks could be attached. With this step the diffusion to a worldwide Internet began. In 1987 the number of hosts raised above 28000 and the 1000st RFC was published. The number of hosts grew and so the backbone was upgraded to a T1 connection in 1988 (Merit Network Inc., IBM and MCI were working on that update).

The NSFNET Backbone spanned over whole USA.

The Internet



- **1989**
 - ◆ Number of hosts exceeded 100,000 !
 - ◆ Reseaux IP Europeens (RIPE) founded
- **1990**
 - ◆ Arpanet Decommissioned
 - ◆ **Now officially called "Internet"**
 - ◆ First Internet provider, "The World" comes online

In 1989 two new organization were founded which should boost the development on TCP/IP and the Internet. The Internet Engineering Task Force (IETF) and the Internet Research Task Force (IRTF).

The WWW



- **1991**
 - ◆ **World Wide Web (WWW) Created by Tim Berners-Lee at CERN**
 - ◆ **NFSNet backbone upgraded to T3 (44.736Mbps)**
- **1992**
 - ◆ **Internet Society (ISOC) is chartered**
 - ◆ **Number of hosts exceeded 1,000,000**
 - ◆ **Term: “Surfing the Internet” coined by Jean Armour Polly**

The invention of the World Wide Web (WWW) had the most important impact to the Internet growth and development. WWW had been created by Tim Berners-Lee, a MIT graduate, working for the CERN in Switzerland. The first browser he wrote was called "Nexus" and was also capable to display inline graphics already.

Backbone networks from many different organizations had been created, such as General Atomics (CERFNet) and Performance Systems International (PSINet) and UUNET Technologies (AlterNet).

Upgrades of the initial modem-speed lines to T3 and more were made during the early 1990s.

With the help of the ISOC the development was going on and many new protocols, for example: Multipurpose Internet Mail Extensions (MIME), were created.

Etcetera



- **1993**
 - ♦ **Mosaic introduced first graphical Web browser**
 - ♦ **NSF specifies creations of Network Access Points (NAPs)**
 - **To allow Internet Service Providers (ISPs) to be connected to the backbone**
 - **Goal to privatize the Internet, become government independent**
- **1994**
 - ♦ **Four NAPs created: San Francisco, Chicago, Washington D.C., New Jersey**
- **1995**
 - ♦ **NSFNET Backbone was decommissioned**

In the following years the WWW significantly influenced the development of the Internet. Although only a few users could utilize this new service, many journalists paid great attention to WWW, and soon everybody wanted to "surf in the Internet". Also 1993 was a milestone in the history of the WWW, as NCSA released the first fully featured graphical web browser called "Mosaic". Later the famous Netscape Navigator was created upon this code.

In 1993 the WWW is only 0.1% of NSFNET Traffic

The NSP plan to change the backbone structure of the Internet and choose to leave the Internet. Instead of the backbone structure many independent Network Access Points should be created. On this NAP's regional networks can connect. The growth of the Internet was around 100% per year and so there where around 2 millions host and over 16000 networks connected each other.