

The Internet: A Wonderful Accident

Reflections on the History and Future of the Internet
(from a technical perspective)

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The Internet: A Wonderful Accident

- Designed as a network for researchers in the 60's and 70's
- Now an essential infrastructure for the “network society”
- It was never designed for that role....
- A better internet is urgently needed

Development of communication networks

- Telephone network
 - Designed for voice, circuit switched, connection oriented, focus on path, required very reliable components, central control
- Cable TV networks
 - Broadcasting over coax cable, designed as a one to many infrastructure
- Internet
 - Designed for data communication, packet switched, connection less, focus on end points, no central management
- 2019: 50 year ARPANET, 30 year WWW, 25 year AMS-IX

Development of Packet switching

- 1969 ARPANET first demo of an open-access packet ***network***
 - Initial version of ARPANET was developed on the ideas of Donald Davies
 - connection oriented, IMP subnet, NCP in hosts
- 1972 CYCLADES by Louis Pouzin at IRIA was the first to be designed as an ***internetwork*** based on an end-to end architecture
 - connection less, datagrams, layered structure, Transport Service (TS) in hosts
- 1972 Start of International Packet Networking Group, INWG
- 1974 TCP article in IEEE TC by Bob Kahn and Vint Cerf “A Protocol for Packet Network Interconnection”

Development of the Internet

- Consensus building was difficult but succeeded in Dec. 1975: INWG 96
- DARPA decided to continue along the lines of the 1974 IEEE publication
- INWG work continued in ISO, TC97 SC's 6 and 16 as well as the CCITT

- 1980 “final” TCP/IP specification
- 1983 ARPANET was based on TCP/IP
- 1986 start of NSFnet
- 1986 first congestion collapse occurred, patching began

So what went wrong?

- ARPANET was setup for a closed group of researchers, in particular to give them terminal access to remote computers
- TCP/IP was a much more powerful protocol than NCP and worked fine over the connection oriented network services of the IMPs
- ARPANET gradually had grown bigger and IMPs were faced out
- TCP/IP had become both the Internetwork layer and the network layer

ARPANET had lost the internetwork layer!

- But so what?
- ARPANET as well as the resulting NSFnet were in fact prototypes for a limited group of research organisations for a limited set of tasks
- The Internet would soon be replaced by networks based on the international standards developed in ISO and CCITT, the TCP/IP based networks would only be needed for an interim period
- Even the US believed this

However

- The international standardisation efforts produced too little too late
- TCP/IP code became freely available, started to be used in networks everywhere
- These networks emerged into the global Internet we have today
- Which is now used for many things it was never designed for

Some major flaws for its current use

- Wrong naming and addressing model
- Wrong congestion control
- No security mechanisms

- Complex patches were and are constantly needed
- Engineers have done a remarkable job to get the Internet going

The Internet is clearly not future proof

- Difficult to support mobility, multi-homing and quality of service
- Difficult to support real-time and low latency applications
- IPv6 and NATs complicate the situation even further
- And so does the move of voice and streaming video towards IP

Why were ISO and CCITT not able to fix this?

- It was clear that TCP/IP had severe limitations and the technical knowhow how to build better networks already existed
 - Conflicting interests among the major players
 - Slow progress resulting in overly complex solutions
 - Very poor initial interworking between different implementations
- PTT networks failed. Early 90's we ran out of X.25 speed, end 90's out of ATM
- Users were left in the cold and started using what was freely available, first locally and finally worldwide, TCP/IP had won the war

Why is the IETF not able to fix this?

- Insisting on backwards compatibility, fear for a clean slate solution
 - *Nevertheless they created IPv6 which is not backwards compatible, it is a different network with still most of the fundamental flaws of IPv4*
- Backwards compatibility will never remove fundamental flaws
 - *'A hardened piece of junk propagates all through the system', Barton*
- Vested interest in current network by active participants

What role played The Netherlands

- In 1982 EUnet started with its central node at CWI in Amsterdam
- 25 April 1986 .nl assigned to CWI
- In 1986 SURF provided seed money to start RARE, now called GEANT, that offered a home to kickstart Ebone and the RIPE NCC
- 17 November 1988 CWI gets connected status to the Internet
- The Dutch Government took a pragmatic position
- Dutch PTT was open for experimentation, also for international connections
- NIKHEF and SURFnet started exchange points in Amsterdam which evolved into the AMS-IX
- 2STiC: *Security, Stability and Transparency in inter-network Communication*

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- A new joint research programme to increase the security, stability and transparency of internet communications, see: www.2stic.nl
- By developing and evaluating new types of internet that will complement and co-exist with the current Internet to support 21st century applications
- Experimenting with and contributing to emerging internet architectures, such as SCION, NDN and RINA
- Operating a national programmable network based on P4 switches
- Long-term objective is to establish a centre of expertise in the field of trusted and resilient internets
- Current participants: SIDN Labs, the University of Twente, the University of Amsterdam, SURFnet, NLnet Labs and TUDelft

Conclusion

- TCP/IP brought us a wonderful Internet
- Current Internet is no longer fit for purpose
- A new architecture is needed sooner rather than later
 - We know how to build better internets
 - The technology to do so exists
 - Societal awareness for a better internet is growing fast
- So the momentum is there, let's do something about it