The Introduction of TCP/IP at CERN

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TCP/IP and networking at CERN

This story spans half a century!

- *It is little known outside CERN - and even within it*
- *It came from a relatively unknown part of CERN*
- *… in fact, CERN didn't have the mandate to do this work*
- *… but it led to the Internet in Europe, the Web, the Grid*
- *… and finally to today's networked world …*

I will begin at the beginning…

Internet early timeline

- **ARPAnet project began: 1969**

  (but only a "mono-net", not an "inter-net")

- **TCP/IP specified: 1974-8 / introduced: 1983**

- **CERN TCP/IP introduction: 1984 – 1989**

  ➔ *today's talk is mostly about this* ⬅

- **CERN joined the Internet: January 1989**

TCP/IP basic principles

Came from much deep thought <u>and experiment</u>:

- Use *packet switching, not circuit switching* as for telephony
- Use *global numbering / naming* of processes/hosts/networks
- Use *layered protocols… but not excessively (see next slide)*
- ➔ *Provide IP datagrams on all networks and media* ⬅
- Use *best-effort IP delivery* plus smart routing algorithms
- Provide *IP fragmentation/reassembly*
- Use *end-to-end control (TCP)* to solve reliability issues
- Provide a standard *programming API ("sockets")*

A digression on layers

A major protocol-war battle was about layers:

- *ISO's proposed Open Systems Integration (OSI) model had 7 main layers (plus numerous sub-layers)*

- *OSI layers only communicated with their immediate neighbours, imposing multiple copying of data between layers*

- *TCP/IP has only 3 layers (below the application layer) and avoids copying between them:*

➔ **Link layer / IP network layer / TCP transport layer** ⬅

"If you know what you're doing, three layers is enough; if you don't, even seventeen levels won't help."

(quoted from): *"The Elements of Networking Style"* - Michael Padlipsky, 1985

A digression on standards

The protocol-war was also about standards:

- *ISO's style of standards development was top-down, driven by committees of experts meeting physically from time to time*
- *ISO standards were printed - for sale - and were expensive*
- *Internet standards were developed bottom-up and free on-line*
- *Internet documents were "Requests for Comment", and the standards were iterated using test implementations*

A disruptive victory of bottom-up over top-down

"We reject: kings, presidents, and voting. We believe in: rough consensus and running code."
- *Dave Clark, 24th IETF meeting, 1992*

Background: networking in the 1980's

At CERN we wanted to solve a technical problem
(sharing data between many different sorts of computers)

- *In 1983, after "STELLA", I joined SW Group under Les Robertson*
- *We looked around for heterogeneous solutions and found TCP/IP*
- *It was easy to find software and we began to install test versions*
- *Soon we connected mainframes (IBM-VM, Cray, DEC 9000); medium size computers (Vax-VMS, Unix); workstations (Apollo); IBM PC's, etc.*

- *It worked well but we were not supposed to go beyond "testing":*

➔ *we were forbidden to connect machines outside CERN* ⬅

We had hit a massive (but non-technical) wall!

Background: networking in the 1980's

The political, economic and social issues:

- ***Computer firms** were competing, incompatible, uncooperative*

- ***National telecom monopolies** had dominant power*

- ***Networking technologies** were slow, expensive, incompatible*

- *Paradigm was **circuit switching + charging by data volume***

  (TCP/IP uses best effort datagrams, lightweight accounting)

Background: networking in the 1980's

Political problems with our "technical" solution:

- *TCP/IP was US developed, not an "international standard"*
- *ISO, ITU did not talk to Internet standards bodies IETF, IAB*
- *TCP/IP was explicitly opposed by the European PTT monopolies*
- *TCP/IP was cheap and simple, but in fact DISRUPTIVE*
- *Rival solutions (eg ISO/OSI) had powerful supporters …*

… in fact a protocol war was being fought over them …

- *and crucially:*

CERN did not want to fight battles over networking

Background: networking in the 1980's

Another problem we faced:

TCP/IP implementations often depended on:

- *Programming in the C language*

- *UNIX based networking code*

… but both UNIX and C were <u>non-standard at CERN !</u>

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Inside CERN : 1980-90

The Political Order:

- **Physics**
- **Accelerators**
- ***THE REST (...... <u>Computing</u>)***

Order in Computing:

- **Big mainframes (IBM, etc)**
- **Big peripherals (Tape robots, etc)**
- ***THE REST (...... <u>Networking</u>)***

Order in Networking:

- **External (X.25, DECnet, SNA)**
- **Internal (CERNET, Ethernet)**

====> ***(<u>Internet + Distributed Computing</u>)*** <====

A little progress …

In early 1985, I was named "CERN TCP/IP Coordinator"

- *I had "no resources" but was supported by the Software Group*
- *CERN's main computer networking CS Group did not contribute*
- *I held weekly coordination meetings, distributed licences, etc.*
- *I managed all CERN's IP numbering (Network 100 !)*
- *The powerful LEP/SPS Controls Group adopted TCP/IP for LEP*
- *The LEP experiments inter-connected their CERN machines*
- *Many initial "testers" became enthusiasts …*

... but we were still forbidden to connect machines outside CERN

Life "underground" (1984-88)

Some ups and downs of working "bottom-up":

Downs:
- *It's unpleasant to be treated as an outlaw or a threat*
- *It's disappointing when the Division Leader writes (in 1987)*
  (quote): "The TCP/IP networking is not a supported service"

Ups:
- *Working informally like this was perfectly in the Internet spirit*
- *I began teaching TCP/IP and network programming,*
  both inside CERN and internationally …

Finally, very good news…

In late 1988, CERN accepted ISO/OSI would not arrive and allowed Internet connections outside CERN

- *The CERN CS Group took over TCP/IP support*
- *Interestingly, IBM helped by paying for CERN's USA link*
- *CERN rapidly became a main European Internet centre*
- *The decision enabled CERN to adopt Internet standards for email, file and database sharing, remote login, RPC, etc …*

- *… and it led to the Internet in Europe, the Web, the Grid …*
- *… and finally to today's networked world …*