Distributed computing
- a historical perspective -

(Talk 1/3) :

TCP/IP

Ben Segal / CERN, Geneva
b.segal@cern.ch
www.cern.ch/ben

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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 Internet in Europe, the Web, and the Cloud***

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**

  ** ***and a co-specifier is online with us today !!!***

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

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

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

ARPAnet showed the way to an Internet !

**(for which we can thank Vint Cerf et al.
for their work beginning in 1974)**

Interlinking of Computer Networks

Proceedings of the NATO Advanced Study Institute
held at Bonas, France, August 28 - September 8, 1978

edited by

KENNETH G. BEAUCHAMP
director of computer services
University of Lancaster, U.K.

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/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")***

<u>INTER - NETWORKING NEEDS IP !!!</u>

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."

"*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 different sorts of computers)

- ***In 1983 we looked around for 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

More problems with our "technical" solution:

- ***TCP/IP was US developed, not an "international standard"***
- ***ISO, ITU did not even talk to Internet standards bodies IETF, IAB***
- ***TCP/IP was explicitly opposed by the European PTT monopolies***
- ***TCP/IP was cheap and simple, in fact DISRUPTIVE !!***
- ***There were alternative solutions with powerful supporters,***

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

- ***and crucially:***

CERN did not want to fight battles over networking

Inside CERN : 1980-90

The Political Order:

- Physics
- Accelerators
- ***THE REST*** **(…… *Computing*)**

Order in Computing:

- Big mainframes (IBM, etc)
- Big peripherals (Tape robots, etc)
- ***THE REST*** **(…… *Networking*)**

Order in Networking:

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

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

Now for some good news…

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 Group did not cooperate***
- ***I held weekly coordination meetings, distributed licences, etc.***
- ***I managed all CERN's IP numbering (Network 100 !)***
- ***The LEP experiments inter-connected their CERN machines***
- ***The powerful LEP/SPS Controls Group adopted TCP/IP for LEP***
- ***Many initial "testers" became enthusiasts …***

… we were taking the first steps towards the dream of:

Distributed Computing

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 demeaning 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 …***

(…including to one particular student…)

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

Finally, very good news…

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

- ***The CERN Networking 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 …***

… in other words for …

Distributed Computing

The "particular student" I mentioned ...

… was Tim Berners-Lee …

- ***He came to CERN as a Fellow in 1984 (after a short stay in 1980)***
- ***We met in 1985 - he asked for advice on his (official) RPC project***
- ***Taught him TCP/IP and network programming***
- ***Helped him design HTTP by showing him RFC's (NNTP, FTP)***
- ***Helped him get a NeXT machine for his "unofficial" project (1990)***
- ***Wrote a reference for his CERN indefinite contract (1990)***
- ***Helped him get student collaborators (N. Pellow, J-F. Groff)***

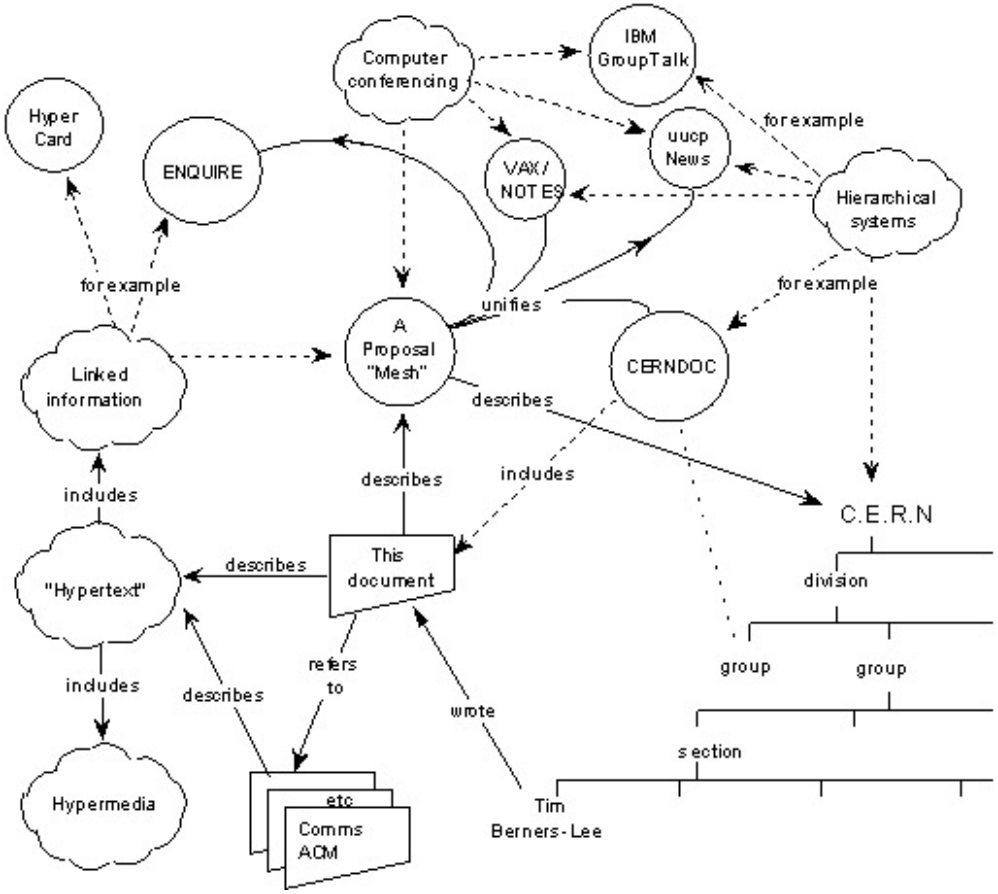
… and his WWW invention of course changed the world …

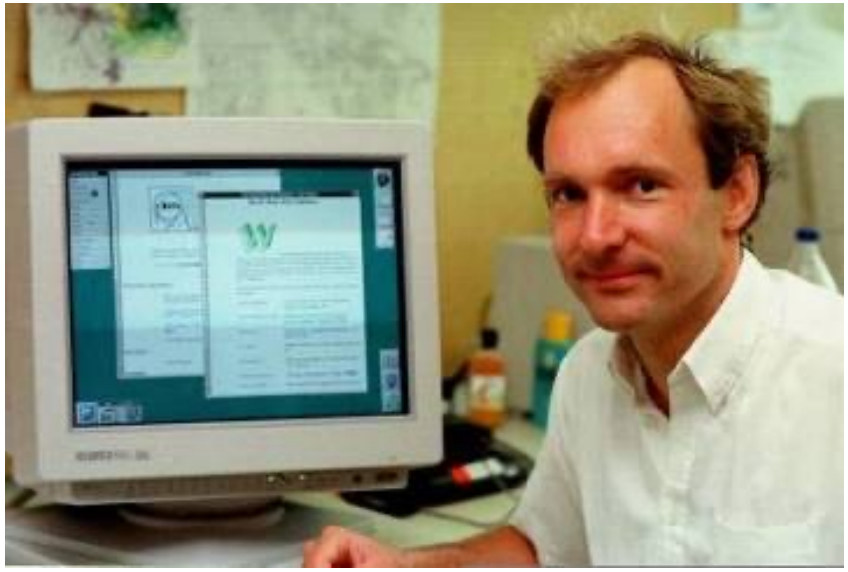
Maria Dimou will speak more about this in Talk No. 2

"Vague but exciting"

(reaction of Mike Sendall to the 1st proposal by Tim Berners-Lee, March 1989)

… and hopefully Tim is online with us today !!!





Distributed computing progresses…

By 1989 we realised that the mainframe model for physics production computing was not scalable…

- ***Networked nodes of powerful workstations could do better***
- ***The system would look like a distributed Cray supercomputer***
- ***We developed an architecture for it and prototyped it in 1990***
- ***By 1992 it had clearly succeeded and was then widely adopted***

The system was called "SHIFT"

(for: Scalable Heterogeneous Integrated FaciliTy)

and led directly to Grid and Cloud computing

The SHIFT Team in 2001
with the Computerworld Honors Award

Les Robertson and Frédéric Hemmer will speak more about this in Talk No. 3

And finally … about Innovation

One or two gifted people are often the most effective:

•*TCP/IP*	*(2)*	•*WWW*	*(1)*
•*Unix*	*(2)*	•*Linux*	*(1)*
•*Google*	*(2)*	•*AWS*	*(1)*
•*HP*	*(2)*	•*Ethernet*	*(1)*
•*Intel*	*(2)*	•…	

But true innovation is unpredictable, usually involves chance / coincidence, and overall remains a mystery

"History does not crawl, it jumps…"

Nassim Nicolas Taleb, 2007

"***Black Swan*: *The Impact of the Highly Improbable***"

The next two talks:

Talk 2

CERN evolves: Email, EU projects, the Web

Maria Dimou

Talk 3

Via "SHIFT" and the Grid to the Cloud

Les Robertson and Frédéric Hemmer