



Fixing the Internet: 1987 Predictions vs. Reality

SIGCOMM99 Tutorial on the
Technical History of the Internet

Bob Braden
USC/ISI

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Talk-within-the-talk:

Future Developments in the Internet (One person's View)

Bob Braden, USC/ISI

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Future Developments in the Internet

- A. Add Internet Multicasting
- B. Crinkle the Internet Address Space
- C. Add “Soft State” to Gateways
- D. Provide for Operation and Management
- E. Provide Higher Network Speeds
- F. Improved Transport Protocols
- G. Progress on User Protocols
- H. Transition to ISO Protocols



A. ADD INTERNET MULTICASTING

- o Multicasting is a facility available on many LANs -- broadcasting to a particular subset of the connected hosts.
- This subset is called the Multicast Group.
- o Multicasting is a powerful tool for building distributed application systems (e.g. NETBIOS)
- o Internet multicasting -- group may span the Internet



B. CRINKLE THE INTERNET ADDRESS SPACE

- o Present “flat” address space leads to serious performance problems as Internet grows towards 1000 networks
(... AND BEYOND!)

Introduce some form of hierarchical routing
-- “AREA ROUTING”



C. ADD “SOFT STATE TO GATEWAYS

- o **OBJECTIVE:**
Improve performance of the Internet gateway system while preserving the dynamics which provide robustness and survivability.
- o **PERFORMANCE ISSUES ARE:**
 - “Real-time” traffic (e.g., packet voice)
 - Controlling congestion
 - Protection from bad host behavior
 - Choosing appropriate network paths
 - Handling bandwidth mismatches



D. PROVIDE FOR INTERNET OPERATIONS AND MANAGEMENT

- o There will be multiple operational organizations for the Internet; DARPA + NSF Internet: 6-12 NOC's
Will have multi-NOC fault-isolation and monitoring tools
- o **RE-ENGINEERING INTERNET TO IMPROVE STABILITY AND SIMPLIFY OPERATION -- CONTROLLED REDUCTION OF SYSTEM DYNAMICS.**
 - Packet barriers and filters
 - Internet congestion control



E. HIGHER NETWORK SPEEDS

- o T1 will replace 56KB on most long-haul links of the Internet.
- o Higher speeds will soon become available experimentally.



F. IMPROVED TRANSPORT PROTOCOLS

- o There is **MORE** to learn about TCP (and its close relatives) !!

There will be a “reliable datagram” transport protocol suitable for transaction-mode services.

- o There will be new transport protocols appropriate for effective use of high-bandwidth paths



G. PROGRESS ON USER PROTOCOLS

- o Authentication and Privacy features
- o Multi-media Mail increasingly important
- o Production-oriented services like RJE, background file transfer
- o Network file system protocols
- o RPC and transaction protocols



H. TRANSITION TO ISO PROTOCOLS

- o Can think of as natural evolution from R&D prototype (TCP/IP) to re-engineered standard (TP4/CLNP)
- o No magic!

THIS WAS THE END OF THE UNIFORM TALK



Score Sheet

- o Got it essentially **RIGHT**:
 - Higher network speeds
 - Growth
 - Hierarchical Internet addressing
 - Lots of engineering for [routing] stability
- o Got it **COMPLETELY WRONG**:
 - o Transition to ISO/OSI protocols
 - o [Internet standard] application protocols --
 - > Transaction transport protocol
 - > Network file system protocol
 - > RJE, BFTP



Mixed bags [1]

- o **IP Multicasting**
 - Routing much harder than we thought; still not settled.
 - Multicast is still not widely supported
- o **Transport protocols**
 - Major progress in understanding TCP
 - TCP extended for high-bandwidth[*delay] paths.
 - No rival to TCP emerged
 - No “reliable datagram” protocol emerged



Mixed Bags [2]

- o **Authentication and Privacy (Security)**
 - Lots of progress, but slower and harder than I expected.
 - o **Network Management**
 - [Standard] network mgt protocols successful but seem (to me) primitive.
 - Multi-AD fault isolation and monitoring tools did not emerge; only ping and traceroute.
- A triumph of engineering over CS**



Mixed Bags [3]

- o **Soft State in Gateways**
 - First of all, they are called “routers” now.
 - Realtime flows: led to Int-Serv & RSVP
 - Congestion control is E2E and stateless (unless you think of RED as router state) in the network.
 - ‘Protection from bad host behavior’ is an unsolved and increasingly oppressive problem
 - Bandwidth mismatches are still resulting in tinkering around the edges of TCP spec.



Predictions about the Internet in 2011

You must be kidding...