CS244 Lecture 2

The Design Philosophy of the DARPA Internet Protocols [Clark 1988]

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Context: David D. Clark (MIT)

- Chief Protocol Architect for the Internet from 1981.
- Continues to be a network visionary today.
- At the time of writing (1987)…
  - (Almost) no commercial Internet
  - 1 yr after Cisco's 1st product, IETF started
  - Number of hosts reaches 10,000
  - NSFNET backbone 1 year old; 1.5Mb/s

The Design Philosophy of the DARPA Internet Protocols [Clark 1988]

Goal 0: An "effective" technique for multiplexed utilization of existing interconnected networks.

Goal 1: Internet communication must continue despite loss of networks or gateways.

Goal 2: The Internet must support multiple types of communication service.

Goal 3: The Internet architecture must accommodate a variety of networks.

Goal 4: The Internet architecture must permit distributed management of its resources.

Goal 5: The Internet architecture must be cost effective.

Goal 6: The Internet architecture must permit host attachment with a low level of effort.

Goal 7: The resources used in the internet architecture must be accountable.

Goal 0: An effective technique for multiplexed utilization of existing interconnected networks

Led to: Different networks connected together by packet switched, store-and-forward routers/gateways

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Q. Why interconnect *existing* networks and not design a new overall network from scratch?

Q. Why was packet switching picked for multiplexing? What were the choices?

What you observed

- "Even within my own lifetime, I've seen dialup, DSL, broadband, gigabit ethernet and the rise of LTE cellular networks. These different mediums are all able to connect to the Internet because IP is the lean-core that appeals to the lowest common denominator.", Andrew

Goal 1: Internet communication must continue despite loss of networks or gateways.

1. "Entities should be able to continue communicating without having to re-establish or reset the high level state of their conversation."
2. "The architecture [should] mask completely any transient failure."

Leads to:

1. "Fate-sharing" model - only lose communication state if the end-host is lost.
2. Stateless packets switches => datagrams

Q. What alternative design could there be?

Q. How does the Internet do this?

Q. Would a "dedicated" new network have been more reliable?

What you said

- "I would imagine that a similar problem must have been proposed when designing the initial Internet as well: what if our adversarial country started to flood our Internet routers and hosts?", Koki

Other goals

Goal 4: The Internet architecture must permit distributed management of its resources

Q. Does the Internet accomplish this?

Goal 5: The Internet architecture must be cost effective.

Q. Is it cost effective?

Goal 7: The resources… must be accountable

Q. What does this mean?

Q. What would such a network look like?

Minimum Assumptions of interconnected networks

1. Can transport a datagram
2. …of reasonable size
3. …with reasonable chance of delivery

Interesting comments:

- Reliability and qualities of service were not built in because they would require too much change.
- Datagram as a building block, not as a service.

More discussion questions

1. Originally TCP+IP were joined, but were later split.
   Q: Why?

2. "It proved more difficult than first hoped to provide multiple types of service without explicit support from the underlying network"
   Q. Why? What has happened since?

More discussion questions

Interesting comment: "The most important change in the Internet…will probably be the development of a new generation of tools for management of resources..."

Q. Has this happened?

What is missing from the list?

"I felt the paper was lacking in one key area: analysis of goals that *could* have been viewed as important enough to include in the original design priorities, but ultimately did not make the cut. (Examples might include long-term scalability to billions or trillions of connected nodes, or network security -- authenticating and authorizing the nodes that connect to the network.", Ryan

What is missing from the list?

- "Revisiting the design, I believe the most important piece that we missed was programmability. There was no consideration of making any part of the network programmable. The requirements of the network were distilled to the basics and ultimately hard wired in the design.", Praveen

What you said

- "It seems like the focus of networking networking research and innovation over the past decade plus has been on this issue of efficient resource allocation at scale (the SDN control plane abstraction, etc). Clark was prescient to point out the management issue, but mistaken in the belief that it would be addressed within a few years as it is a problem that continues to burden networks.", Travis

Author's conclusion

- "Datagram" good for most important goals, but poor for the rest of the goals.
- Processing packets in isolation, resource management, accountability all hard.
- Anticipates flows and "soft-state" for the future.