CS 268: Future Internet Architectures

Ion Stoica
May 6, 2003

Project Reports

- At most 10 pages
- Single column
- At least 11pt font size
- Deadline May 15, midnight

Final Exam: Example Question 1

- **Overlay/DHT**
  - Show that the path length in CAN is O(d*n1/d), where d is the number of dimensions and n is the number of nodes
  - Describe two optimizations to CAN to reduce routing latency.

Final Exam: Example Question 2

- **Multicast**
  - What are the pros and cons of IP Multicast compared to application-layer multicast?
  - Describe the technical problems that prevent SRM/RLM from scaling to millions of receivers.

$\frac{c}{r\sqrt{s}}$

Final Exam: Example Question 3

- **TCP Congestion Control**
  - A TCP flow's throughput is approximately $\frac{c}{r\sqrt{s}}$, where *c* is a constant, *r* is the round trip time, and *s* is the probability that a segment is lost. Assuming that the probability of packet loss is *p*, and each segment is split into *n* fragments, what is the TCP throughput?
  - What are the pros and cons of explicit and implicit signals for congestion?

Key Question

- How can we as researchers/engineers influence the evolution of the Internet again?

How to Answer this Question

- Understand the new realities and try to predict where the Internet is heading to
- The two papers
  - The days when all players had a common goal are gone, and that the new environment where different players have often conflicting goals is here to stay
  - Internet should provide only one basic service: connectivity for which there is no business model, hence treat the Internet as a publicly supported & controlled utility

Tussles

- The process by which players with different interests act to achieve those interests
- Accept the reality that the players have often conflict interests and try to leverage or at least accommodate it

Design Principles

- Design for variation in outcome not for a particular outcome
  - Modularize the design along tussle boundaries
  - Design for choice

Modularize along Tussle Boundaries

- Functions that are within a tussle space should be logically separated from functions outside of that space
- Examples
  - DNS, QoS

Design for Choice

- Design protocols such that to allow parties to express preferences about the parties they interact with
- Examples
  - Mail server

Design Implications

- Design open interfaces – allow different parties to compete providing the same interface
- Desirable properties of open interfaces
  - Visible exchange of value → allow parties with compatible interests (e.g., provider/customer) to achieve equilibrium
  - Exposure of cost of choice → allow parties to make "intelligent" choices
  - Visible (or not) of choices made → realize that choices made public can be different from choices made in secret
  - Tools to isolate and resolve faults/failures

Economics

- Goal: create premises for investment
- Drivers of investment: greedy and fear
  - Greedy: invest in the hope to maximize revenues
  - Fear driven by the competition, which in turn is driven by the ability of customers to have choices

Examples

- Lock-in from IP addressing
  - Solution: made it easy for a host to change addresses and use multiple addresses
- Value pricing
  - Solution: aid consumers to bypass the controls of the producers
- Residential broadband access
  - Solution: design residential access facility that supports competition. Who is going to deploy this facility?
- Competitive wide area access
  - Solution: allow consumers to control the path of their packets at the level of providers. Need payment mechanisms?

Trust

- Users should be able to choose with whom to interact, and the level of transparency they offer to other users
- Question: who is controlling the policy? Users or network administrators?
- We cannot fully address this question but we should
  - Provide maximum flexibility to users in setting policies
  - Allow users to select third party entities to mediate the interaction (e.g., PKI)
- Recognize that technical solutions are note enough!
  - E.g., how to avoid eavesdropping?

Openness

- We need to strive for open interfaces → lead to competition, innovation
- In internet this means simple service, i.e., transparent packet carriage → allow to deploy new protocols without having to modify the network

Important Side Discussions

- Mechanisms vs. policies
- The role of identity
- The future of end-to-end arguments

Internet as Public Utility

- Assumption: Internet should provide basic connectivity → no business model for this
- Conclusions/Solutions:
  - Evolve internet into a publicly supported & controlled utility (e.g., postal system, power grid distribution, public roads)
  - Grant monopoly subject to regulatory contracts
    - Universal service → reach everyone
    - Common carriage → common interface
    - No bundled services

Discussion…