Teaching Network Architecture through Case Studies

Dan Massey — Colorado State University

Christos Papadopoulos — Colorado State University
Lan Wang — University of Memphis
Beichuan Zhang — University of Arizona
Lixia Zhang — UCLA

Why Teach Architecture?

- Today's Students Are Tomorrow's Network Architects
  - New advances at all layers, from optical and wireless to new applications
  - Increased awareness of security concerns
  - Scaling, policy, social/regulatory and economic concerns
  - Future Internet must address these challenges through evolution of current design or a new revolution
- Today's Courses Focus On How Things Are Done
  - Important to know how things are done in the Internet
  - But also need to ask why things are done
  - Can only expect a better network architecture if students are taught to analyze the design constraints and understand design trade-offs.

Teaching Objectives

- New Architectures Don't Fall From The Sky.
  - Claim there is no single "break through" moment
  - Architecture develop over a series of ideas
  - Show seminal papers influence evolution
- Architecture Involves Trade-Offs.
  - Consider what the architecture aims to achieve
  - Claim can't meet all goals
  - Large part of design is making smart trade-offs

Teaching Strategy

- Add To Already Limited Course Time
  - Aim to add architecture to standard networking courses
  - Already overloaded with more topics than one can cover
- Essential to Discuss More Than One Architecture.
  - Clearly Need to cover the Internet Architecture
  - Can't consider trade-offs and designs with only one example
  - Our choice is Named Data Networking (NDN)
    - Delete the concept of a location!
- Cover Five Papers For Each Architecture
  - Essential to include multiple papers and show evolution of ideas

Internet Architecture (1/2)

1. *"On Distributed Communications Networks" by Paul Baran*
   - *Early pioneer in using redundancy to survive loss*
   - *Introduces dynamically routed packets*
2. *"A Protocol for Packet Network Interconnection" by Cerf and Kahn*
   - *Classic paper introduces* gateways for interconnection and retransmission windows
   - Thin waist idea of putting only the minimal requirements into interconnection layer.
3. *“End-to-end Arguments in System Design" by Saltzer, Reed, and Clark*
   - Introduce the End to End Principle for System Design
   - To build Baran’s redundant dynamic network that survives massive disruptions, seems wise not to place a tremendous amount of state in middle of the network.

Internet Architecture (2/2)

4. *"The Design Philosophy of the DARPA Internet Protocols" by Clark*
   - Must identify the design objectives and prioritize the objectives.
   - First: function despite loss of networks/gateways (Paper 1 by Baran)
   - Second, support multiple types of services (Paper 3 on End to End)
   - Third, accommodate a variety of networks (Paper 2 by Cerf/Kahn).
5. *"Watching the Waist of the Protocol Hourglass" by Steve Deering*
   - Not paper but an IETF Plenary Talk
   - Thin IP waist was key to achieving our design goals.
   - Modifications are best suited to the ends, rather than bloating the middle with more and more features and expanding the thin waist.
   - Very entertaining summary and look forward at the IP hourglass design

Named Data Architecture (1/2)

1. *"Multicast routing in internetworks and extended LANs" by Deering and Cheriton*
   - *Applications that must send the same data to multiple destinations.*
   - *Locate or query content when the exact location of that content is unknown.*
2. *"A Reliable Multicast Framework for Light-weight Sessions and Application Level Framing" by Floyd, Jacobson, McCanne, Liu, Zhang*
   - Receiver-based model of data reliability and application level naming.
3. *“Adaptive web caching: towards a new global caching architecture" by Michel, Nguyen, Rosenstein, Zhang, Floyd, and Jacobson*
   - A movement away from server locations and toward designs focused on the data itself.
   - Together these three papers establish the direction for the NDN model

Named Data Architecture (2/2)

4. *"Building Efficient Wireless Sensor Networks with Low-Level Naming" by Heidemann, Silva, Intanagonwiwat„ Govindan, Estrin, and Ganesan*
   - New architecture must be driven by some incentive
   - Claim Internet driven by processing power and move from supercomputer to PC
   - NDN is driven by content requests (Paper 3) and sensor networks (Paper 4)
5. *"Networking Named Content" by Jacobson, Smetters, Thornton, Plass, Briggs, and Braynard*
   - Architecture focused on what data is sought, not where data is located.
   - Retain thin-waist, end to end, and reliance on redundancy from Internet design
   - Packets have *no source address* and *no destination address*.
   - May or may not be the future, but more key point is challenges the students to think about a different architectural design.

Caveats And Next Steps

- Some Challenges to Overcome
  - Students may view the Internet papers as “old and dated”
    - Students excited about 4G, but read papers in terms of bits per second
  - Students may view papers as philosophical rather than technical
    - Lots of design ideas, but no specific packet format or protocol state machine
  - Need to stress the design ideas (why), not the details (how)
- Some Advantages to Gain
  - Students better understand how the Internet evolved
  - Students can better understand how it can evolve in the future
  - Students are challenged to think big and invent new designs

Questions?

education@named-data.net