Declarative Networking

Mothy

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Off the top of my head…

- Running packet networks remains a complex and difficult problem.
- Despite ~25 years of research, no abstractions have emerged to modularize the problem.
- I find this astonishing. Can someone correct me?
It’s not all been wasted...

- Lots of measurement
  - \(\Rightarrow\) lots and lots of data now
- Understand “network level” well
  - TCP, BGP, Malware, etc.
- Plenty of control mechanisms
  - DCAN, RCP, 4D, etc., etc.

- Hypothesis: for IP at least, we as researchers already understand this well enough to abstract and uplevel.
- Can we just move on?
Mental exercise

• For a moment, try to forget everything you know about BGP, OSPF, IS-IS, DVMRP, etc., etc.

• Take a deep breath or two.

• Doesn’t that feel good?
A different abstraction

• The set of routing tables in a network represents a \textit{distributed data structure}

• The data structure is characterized by a set of ideal \textit{properties} which define the network
  - Think in terms of structure, not protocol

• \textit{Routing} is the process of maintaining these properties in the face of changing ground facts
  - Failures, topology changes, load, policy...
Routing and Query Processing

• In database terms, the routing table is a view over changing network conditions and state

• Maintaining it is the domain of distributed continuous query processing
Distributed Continuous Query Processing

• Relatively new and active field
  - SDIMS, Mercury, IrisLog, Sophia, etc., in particular PIER
  - ⇒ May not have all the answers yet

• But brings a wealth of experience and knowledge from database systems
  - Relational, deductive, stream processing, etc.
Goal: a constrained declarative language for network specification

• Higher-level view of routing properties
  - More than simply a configuration language

• Modular decomposition of function

• Static analysis for:
  - Optimization techniques
  - Safety checking

• Dynamic optimization
  - C.f. eddies, etc.
Other advantages

• Can incorporate other knowledge into routing policies
  - C.f. Jennifer’s examples, and beyond
  - E.g. Physical network knowledge

• Naturally integrates *discovery*
  - If you buy Paul’s argument

• Also provides an abstraction point for such information
  - Knowledge itself doesn’t need to be exposed.
What are we doing, then?

- Express network properties in DataLog
  - Preliminary to better languages
- Execute specifications to maintain routing and discovery
- Two directions / implementations:
  - IP Routing (SIGCOMM 2005)
  - Overlays (under submission)
Why overlays?

- **Overlays in a very *broad* sense**
  - Any application-level routing system
  - Email servers, multicast, CDNs, DHTs, etc.

- **Ideal test case**
  - Clearly deployable short-term
  - Defers interoperability issues

- **The overlay design space is wide**
  - → ensures we cover the bases

- **Testbed for wider applicability**
A Declarative Overlay Engine: “P2”

- Everything is a declarative query
  - Overlay construction, maintenance, routing, monitoring
- Queries compiled to software dataflow graph and directly executed
- System written from scratch (C++)
  - Deployable (PlanetLab, Emulab)
  - Already has reasonable performance for deployed overlays
Software Dataflow Graph
Example: Chord in 33 rules
Comparison: MIT Chord in C++
Conclusion

• An abstraction and infrastructure for radically rethinking networking
  - One possibility: System R for networks
• Where does the network end and the application begin?
  - E.g. can run queries to monitor the network at the endpoints
  - Integrate resource discovery, management, routing
  - Chance to reshuffle the networking deck
Thanks.