Should a load-balancer choose the path as well as the server?

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Can’t choose path :’( 
Outline and goals

- A new architecture for distributed load-balancing
  - joint (server, path) selection
- Demonstrate a nation-wide prototype
- Interesting preliminary results
OpenFlow Controller

OpenFlow Protocol (SSL)

Control Path

Data Path (Hardware)
Software Defined Networking

Network OS

OS
Custom Hardware
Feature
Feature

OS
Custom Hardware
Feature
Feature

OS
Custom Hardware
Feature
Feature

OS
Custom Hardware
Feature
Feature
Load Balancing is just Smart Routing
Load-balancing as a network primitive
Aster*x Controller
Joint selection of Server and Network Path

http://www.openflow.org/videos
So far...

- A new architecture for distributed load-balancing
  - joint (server, path) selection
- Aster*x – a nation-wide prototype
- Promising results that joint (server, path) selection might have great benefits
What next?
How big is the pie?

Characterizing and quantifying the performance of joint (server, path) selection
Load-balancing Controller

MININET-RT
Load-balancing Controller
Parameters

Topology

- Intra-AS topologies
  - BRITE (2000 topologies)
  - CAIDA (1000 topologies)
  - Rocketfuel (~100 topologies)
- 20-50 nodes
- Uniform link capacity
Parameters

Servers
- 5-10 servers
- Random placement

Service
- Simple HTTP service
- Serving 1 MB file
- Additional server-side computation
Parameters

Clients

- 3-5 client locations
- Random placement

Request pattern

- Poisson process
- Mean rate: 5-10 req/sec
Load-balancing strategies?
Design space

Simple but suboptimal

Complex but optimal

Disjoint-Shortest-Path

Disjoint-Traffic-Engineering

Joint
Anatomy of a request-response

Client → Load-Balancer → Server

- Request
- Choose
- Deliver
- Retrieve
- Response 1st byte
- Response last byte
- Last byte ack
Disjoint-Shortest-Path

- CDN selects the least loaded server
  - Load = retrieve + deliver
- ISP independently selects the shortest path
Disjoint-Traffic-Engineering

- CDN selects the least loaded server
  - \( \text{Load} = \text{retrieve} + \text{deliver} \)
- ISP independently selects path to minimize max load
  - Max bandwidth headroom
Single controller jointly selects the best (server, path) pair

Total latency = retrieve + estimated deliver
Disjoint-Shortest-Path vs Joint

Disjoint-Shortest-Path performs ~2x worse than Joint
Disjoint-Traffic-Engg. vs Joint

*Disjoint-Traffic-Engineering* performs almost as well as *Joint*
Is Disjoint truly disjoint?

Client Load-Balancer Server

Response Time

Request

Choose

Retrievel

Response 1st byte

Response last byte

Last byte ack

Deliver

Server response time contains network information
The bottleneck effect

A single bottleneck resource along the path determines the performance.
The CDN-ISP game
The CDN-ISP game

- System load monotonically decreases
- Both push system in the same direction
Summary of observations

- Disjoint-SP is ~2× worse than Joint
- Disjoint-TE performs almost as well as Joint
  (despite decoupling of server selection and traffic engineering)
- Game theoretic analysis supports the empirical observation
Conclusion

- A new architecture for distributed load-balancing
  - joint (server, path) selection
- Aster*x - a nation-wide prototype
- Interesting preliminary results
- Future – application to other contexts and applications
Let’s chat more!
Extra slides...
Sample topologies

BRITE

CAIDA