pcp: Internet Latency Estimation using CDN Replicas

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Problem

- Low latency communication is important for interactive applications
  - online video games
  - augmented reality
  - video chat
  - cloud-based voice recognition

- Small communication delays result in a user-perceived loss of responsiveness.

- Late packets cost CDN providers
Possible Solutions

- Ways to reduce application communication latency
  - nearby servers
  - nearby users.
- Solutions exist but suffer from shortcomings:
  - Incomplete coverage of the IP space
  - Predictions based on stale network measurements
  - Do not solve both clustering and server selection problems
Contributions

To address these issues we:

1. Extensively evaluate currently available tools for server selection, clustering, and latency estimation.
2. Introduce Ping through CDN Proxies (pcp)
3. Evaluate the effectiveness of pcp using Dasu Networking Testbed and Seattle Networking Testbed
   - Dasu and Seattle are publicly available and offer hosts in last mile networks
Related Work

- ping
- Traceroute-based Tools
- IP Geolocation Databases
- Network Coordinate Systems
- Leveraging Current Internet Infrastructure
- Integration with Network Infrastructure
Related Work

ping
Related Work

Traceroute-based Tools

http://www.paris-traceroute.net/
Related Work

IP Geolocation Databases

Related Work

Network Coordinate Systems

Related Work

Leveraging Current Internet Infrastructure

King

Leveraging Current Internet Infrastructure

CRP

Integration with Network Infrastructure

- EDNS: being adopted, does not work well in cellular networks
- Namehelp: does not address the client clustering problem
- CloudGPS: relies on active probing and AS topology information
To overcome the difficulties associated with Internet latency estimation we introduce Ping through CDN Proxies (pcp). The three primary goals of pcp:

1. **accuracy**
   - Accurate latency estimation
   - Competitive Internet end-point selection
   - High coverage of IP space

2. **scalability**
   - Lack of dedicated probing traffic

3. **maintainability**
   - Does not require infrastructure dedicated to measurements
▶ Clients report latency information about CDNs that they contact

▶ pcp builds a virtual topology of the network based on the measurements

▶ Latency is estimated using shortest path found between two clients in the graph using Dijkstra’s algorithm

Graph of simple network containing 5 clients and 3 CDN servers
Example

Diagram showing the interaction between different CDN services and devices. The diagram illustrates the flow of data between devices and CDNs with indicated latencies.
L(c_1, c_4) = L(c_1, cdn_1) + L(cdn_1, cdn_2) + L(cdn_2, cdn_3) + L(cdn_3, c_4)
Coverage percentage of `pcp` on networks with various numbers of hosts
Evaluation

CDFs of latency estimation between clients

Seattle

Dasu
CDFs of latency estimation between clients and PlanetLab servers
CDFs of Intra-cluster Latency (of size 10)

Seattle

Dasu
CDFs of latency to closest PlanetLab server

Seattle

Dasu
A closer look at server selection with pcp:

CDN$_2$ is the closest CDN to $C_1$ but the latency is overestimated and CDN$_1$ is returned instead.
After evaluating the effectiveness of pcp we expect that it will:

1. Provide an accurate, scalable, and long-lived solution for Internet latency estimation
2. Improve interactive and real-time application responsiveness through better end-point selection
Conclusions

- **pcp** is a viable solution for
  - Internet latency estimation
  - End-point selection

- **pcp** offers
  - Accurate latency estimation between end-hosts
  - Better coverage of the IP space than similar tools
  - Maintainability
  - Scalability

- **Future work**
  - Explore potential P2P implementations for **pcp**
  - Research better ways for **pcp** to utilize direct measurements to improve server selection results.
Code available at: https://github.com/msu-netlab/pcp