Network Measurement
Research in SPYCE

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Cing: feasibility (2)

- Data: ~10k paths from 5 different sources
- Metric: fraction of nodes usable for tomography
- Results: ~50% nodes are usable, more difficult as distance from source increases, better when probing from multiple sources

Cing: accuracy

- Simulation study shows direct method is more accurate on average than indirect, but much better in worst case
- Real-world measurements show direct is more accurate than TTL-based (e.g. traceroute-like) methods

Cing applications: network modeling

Network protocol designers assume one bottleneck in path

Does model match reality?
- Not always: measurement study of 50k paths shows 10% of connections go through multiple bottlenecks
- Is there a problem?
  - Yes: simulation experiment shows "translation collapse" scenario, demonstrating tension between fairness and efficiency not foreseen by existing network models

Implications:
- Need to rethink simulation models, develop comprehensive benchmarking suite for protocol evaluation

Cing applications: overlay adaptation

One can override IP-level routing by sending packets through overlay nodes
- Useful for routing around broken or poorly-performing parts of the net (congestion, DoS, ...)
- cing can be used for fault diagnosis to improve overlay adaptation
- More accurate and timely fault diagnosis
- Scalable: less probes, time to locate fault compared to end-to-end/all-to-all probing
- Greater local autonomy: no need for cooperation, deployment of global diagnosis infrastructure

Work in progress

- Extended, hybrid direct-indirect technique
  - Combine ICMPTimestamps, TTL-expired RTT probes and indirect inferencing methods when pure direct approach cannot be used
- Preliminary results show 97% coverage
- Use cing for diagnosis and adaptation

Impact: Critical Infrastructure

- Networks are CI, and underlie other CIs
- Diagnosis, reconfiguration, recovery all important to survivable network CI
- cing provides autonomy and accuracy in network diagnosis
- Useful, for example, in detecting existence and location of DoS and DDoS: diagnosis

Impact: Software Quality

- cing is a novel diffuse computing approach to network measurement
  - Many cooperating components
  - Software part of SPYCElab toolkit
  - De-centralized, loosely coupled, and effective
- Approach is highly fault- and error-tolerant
- Example of "logical sandbox" characteristic of diffuse computing approach in SPYCE

Impact: DoD

- DoD has far-flung, complex networks
- Rapid deployment, diagnosis, reconfiguration
- cing-like approaches provide highly decentralized solutions even with partial information
- Crucial for Network Centric Operations and Warfare, as per JV 2010 / JV 2020

Highlights

- New network tomography method and tool (cing)
  - For directly measuring network-internal delays that does not require deployment of a wide-area measurement infrastructure
- Comparison with indirect methods
- Feasibility study
- INFOCOM 2003 paper
- Use of tool to evaluate network models
- MASCOTS 2003 paper
- Hybrid direct-indirect method to improve coverage
- Work in progress
- Use of tool for overlay adaptation and security
- Work in progress - see demo

Direct method (cing tool)

- Problem: Suppose we want to measure queuing delay between x and y on path P = x s d
  - Method: send pairs of ICMP Timestamp probes to routers
  - One observation:
    \[ \delta = t_d - t_i = t_{	ext{in}} + t_{	ext{out}} + \Delta_{\text{trans}} \]
  - Two observations:
    \[ \delta = t_d - t_i = \min(\delta_{\text{in}}, \delta_{\text{out}}) \]

Cing: feasibility

- 96% of nodes respond to Timestamp queries
- Irregular routing limits choice of nodes

Example: Path structure, Penn to Sprintlabs

Corresponding feasible measurement partitions, Penn to Sprintlabs

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