Reverse Paths Would Be Useful

Many distributed systems would benefit from reverse path information

- **Hubble** to isolate failures and group problems
- **iPlane**, Path-Stitching to provide more accurate path and property predictions
- Ark, etc., for more complete topologies
- Google to find inflated paths back from clients
- ISPs to find inflated paths back to customers
Current Tools Don’t Provide That Info

- ping, traceroute
  - Simple tools proven useful for many systems
  - Only provide forward path or round-trip info
- Existing one-way tools require control of both ends
  - RIPE’s TTM infrastructure
  - owping
- Vantage points could solve problems
  - Prober in every home?
Goals

- Techniques for reverse traceroute and one-way ping when we do not control destination
- Evaluate how often they work
- Demonstrate how they help us understand Internet
  - Systems from earlier slide: iPlane, topology, Google
  - Asymmetry
  - Daily reverse map from world back to PlanetLab

Preliminary/ongoing for now
Talk will focus on reverse traceroute
Reverse Traceroute Approach

- Exploit destination-based routing
- IP options carried over to response packets
  - Timestamp option (TS): time-query 4 ordered IPs
  - Record route option (RR): first 9 routers recorded
- Spoofing to overcome:
  - Lack of vantage points in most prefixes
  - Max 9 hops recorded with RR
  - Limited support/ filtering of options
Spoofing?? Isn’t that bad?

- We use only a restricted version
  - Only spoofing as nodes we control
  - Rate limit, restrict destinations (no broadcast IPs)
- Millions of spoofed probes sent to 10s of thousands of IPs, no complaints
- **Hubble** and this work show utility
- Lets us approximate:
  - Having control of destinations
  - One-hop detouring/ loose source routing
  - One VP sending to another, bouncing through dst
- Want reverse path from D back to S, but don’t control D
- Set of vantage points, some of which can spoof
- Traceroute from all vantage points to $S$
- Gives atlas of paths to $S$; if we hit one, we know rest of path
From all vantage points, ping D with TTL=8 to find those within 8 hops.

Record route does 9 hops, so these will give us return hop(s).
- From vantage point within 8 hops of D, ping D spoofing as S with record route option
- D’s response will contain recorded hop(s) on return path
Iterate, performing TTL=8 pings and spoofed RR pings for each router we discover on return path.
If no spoofing vantage points within 8 hops, consider set of routers directly connected to R3 (in pre-measured topology).

Use timestamp option to try to verify which is on return path.
Once we see a router on a known path, we know remainder
Techniques combine to give us complete path
We have additional techniques for inferring reverse hops
Preliminary results

- Spoofing gives a few extra hops to connect to measured paths
- End hosts like PL are a few extra hops from routers
- PL-PL measurements more likely to share paths (GREN)

Reverse paths from PL sites back to UW

Measurments:
- TR PL to UW
- RR PL to UW
- Spoofed RR as UW
- Pick dst, exclude site

How many hops back from dst need to be given before we can construct a complete path for rest of reverse TR?

Median: 3 vs 5
Reverse Path Summary

- Reverse path info can be very useful to systems
- Ongoing work on reverse traceroute and one-way ping for when we don’t control destination
- Preliminary results here and in Hubble show techniques can work

Limiting factors:
- Restricted support for options
- Current prober deployment
  - Need diverse paths back to our test sources
  - Need spoofing vantage points in diverse network locations
  - Any we can use?
Measurement Work at UW

- Real Internet-scale measurement-based systems
  - Hubble - Monitoring black holes on the Internet
  - iPlane - Providing Internet path and path property predictions

- Ongoing work
  - Reverse path techniques
  - Massive software prober deployment
  - Evaluating prober deployments
Massive Prober Deployment

- Goal: on-demand probes from any prefix
- Talking with RIPE Science Group about 3 tier brain/ controller/ prober architecture
- Different classes of probers operating under standard controllers
  - Super probers - TTM, PlanetLab
  - Hardware probers - simple USB dongles
  - Software probers - next slide
Software Probers: Incenting End-users

- Plan to develop software prober plugin
- Deploy in different vehicles that incent users to contribute measurements by providing benefit of measurements
  - BitTorrent client
  - Reliability-focused detouring - Firefox plugin
  - Apps built on iPlane predictions
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  - *Evaluating prober deployments*
Reviewers (properly) suspicious of PL

Actual (paraphrased) comments from reviews:

- “Needs evaluation of likely coverage of all paths in Internet given small size of PlanetLab”
- “Let me know how much of Internet is observable and suggest vantage points to improve coverage”
- “Oddities of Abilene are hard to reason about”
- “Including more text on limitations of PlanetLab”
- “Include discussion on how well you see this technique working in the global Internet.”
Assessing prober deployment

Previous work either focuses on:
- Measurements between vantage points
- Cumulative topology

Our focus:
- Paths to prefixes
Goals

Techniques to help with:

- node selection for a system: # and which
- node deployment: where to place new nodes
- assessing how set of vantage points represents overall diversity of paths and how results of a study would vary with a different deployment
Questions to answer

- Ideal is every end host. How close is our data to that? How much does spoofing help?
- Is PlanetLab limited primarily by # of sites or also by network locations of sites?
- How many vantage points do we "need?"
- How much does it help to select vantage points per target vs one set for all targets?
- How can we characterize which nodes are most useful to add?
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- Ongoing work
  - Reverse path techniques
  - Massive software prober deployment
  - Evaluating prober deployments

Would love to talk about or collaborate on any of this.