Detecting DNS Root Manipulation

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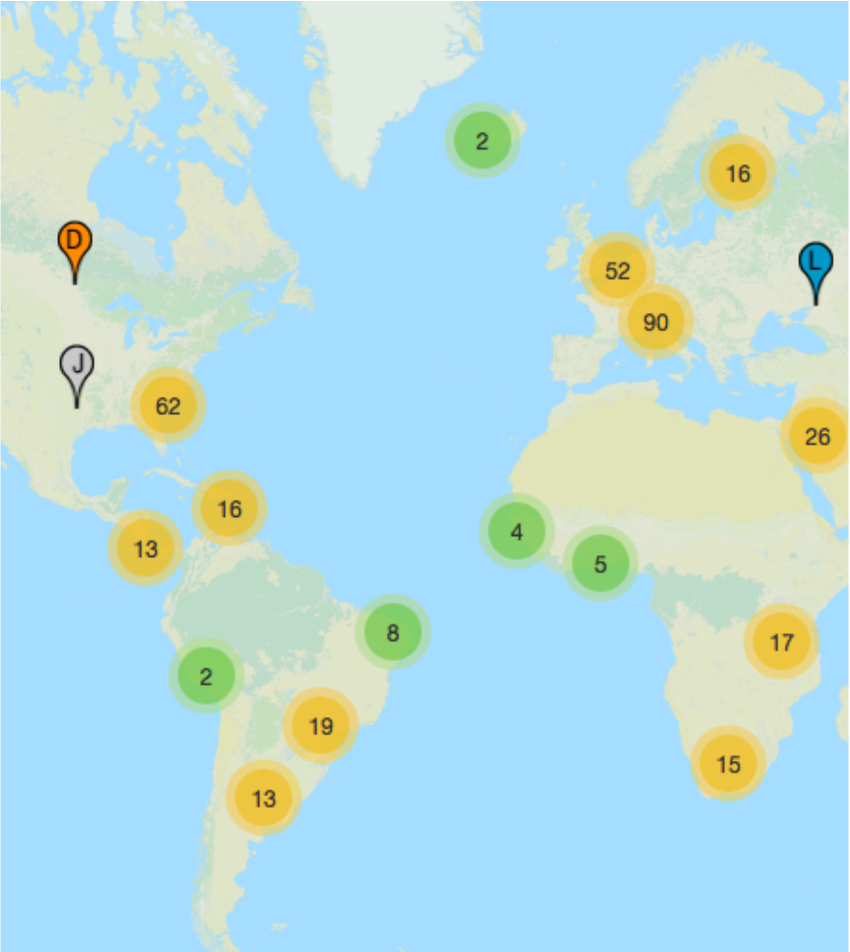
Motivation

- DNS is critical infrastructure
  - The Internet needs DNS
  - The DNS root is part of this infrastructure
- But can users talk to the real DNS root?
  - Implications for security and Internet governance

What is the DNS root?

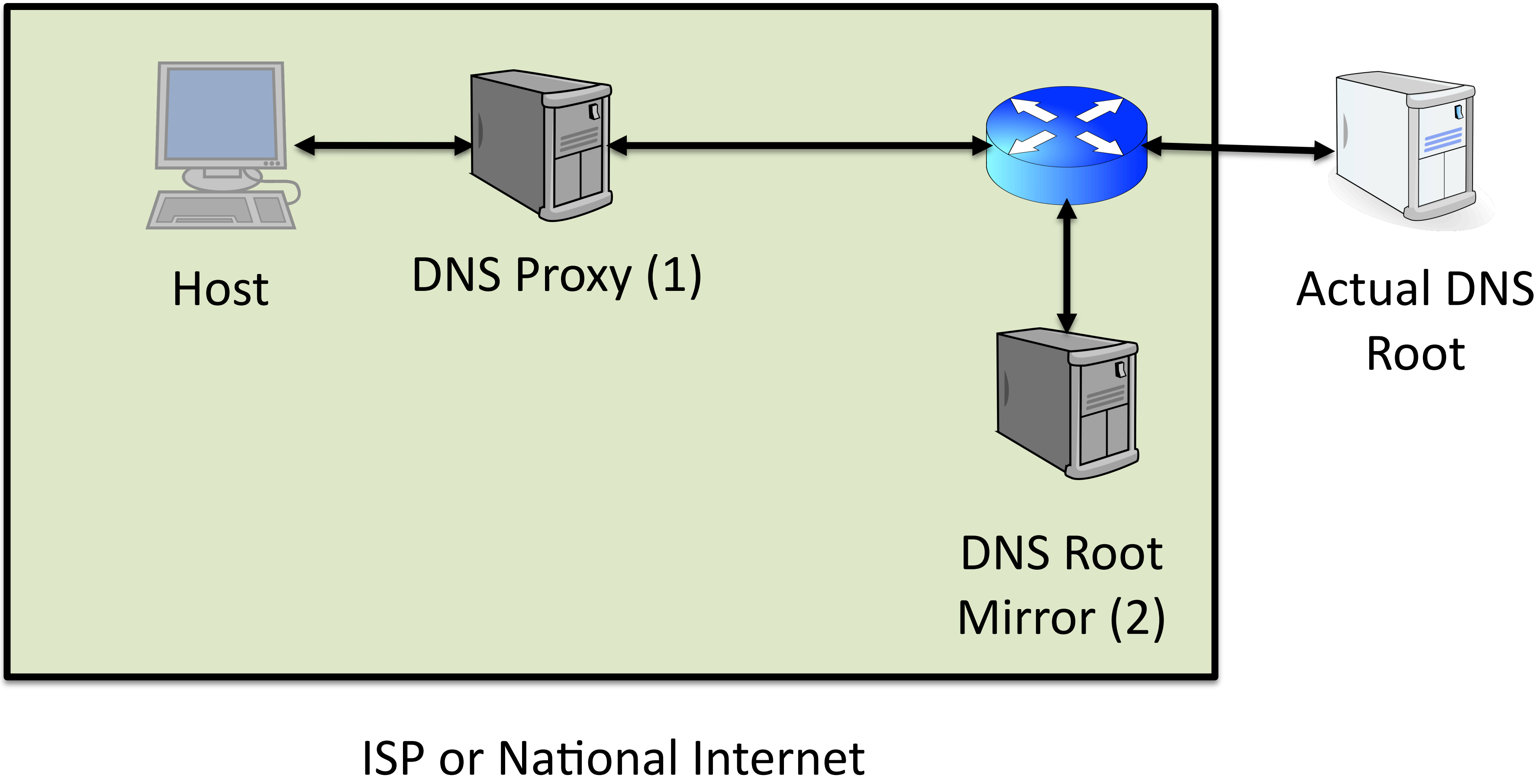


- DNS root is top of hierarchy
- 13 logical servers
- Servers anycasted to varying degrees
  - L root has 144 instances
  - B root has one instance

Do we care about unauthorized roots?

- We care because DNSSEC is not enough
  - DNSSEC only provides integrity, not availability
- **Censorship** is an attack on availability
  - Countries can and do attack DNS
- Masquerading roots affect **Internet Governance**
  - Countries could create their own version of DNS

What are we looking for?



Problem Statement

- Problem:
  - Can users talk to the real DNS root?

- Solution:
  - Collect data from a large set of users
  - Look for anomalous response times and server identities
  - Focus on B root because there is only 1 instance

Outline

- Motivation
- Dataset and Methods
- Results

Dataset

RIPE Atlas

Measurements	Dates	Manipulation that can be Detected
Ping	July 6-13, 2014	Proxies and root mirrors
HOSTNAME.BIND	July 22, 2014	Proxies and root mirrors
Traceroutes	July 6, 2014	Root mirrors

BGP

Measurements	Dates	Manipulation that can be Detected
RIPE RIS	July 6-13, 2014	Root mirrors
RouteViews	July 7, 2014	Root mirrors

Methods

- Response time
  - Did the response beat the speed of light?
  - Use RIPE Atlas pings
- Server identity
  - Is the user talking to the real root?
  - Use RIPE Atlas HOSTNAME.BIND queries, traceroutes, and BGP data

Response time

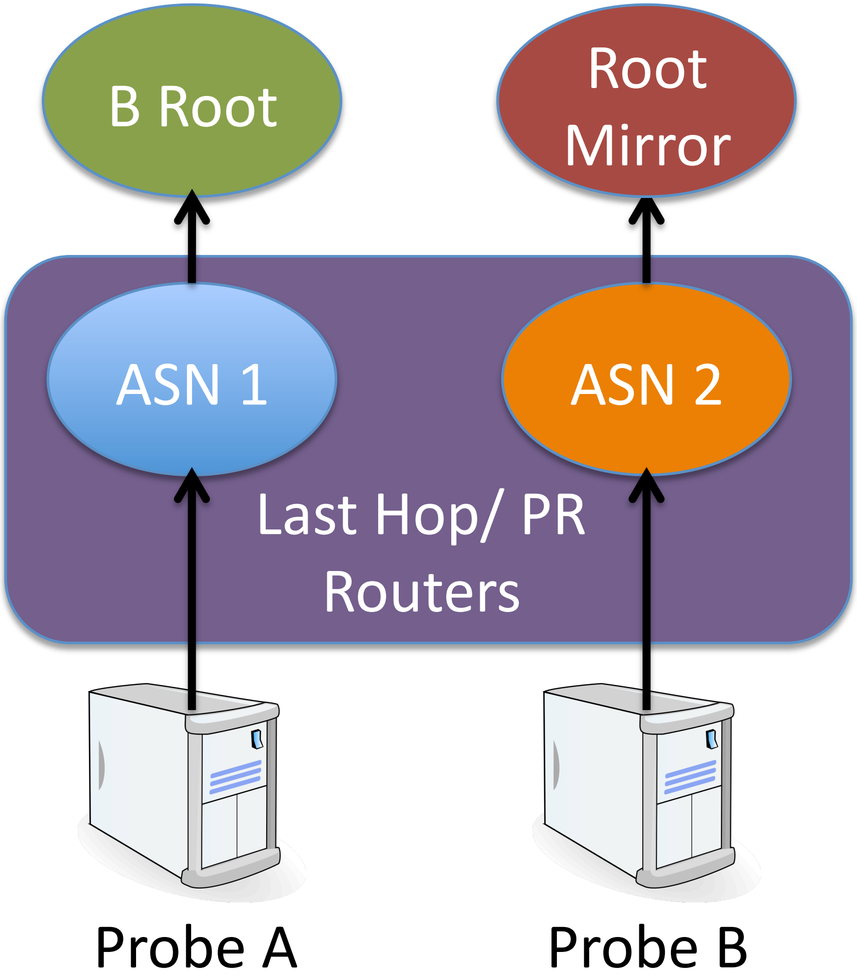
- Did the response beat the speed of light?
  - Geolocate probes with RIPE and MaxMind
  - Find the minimum RTT from a week of pings for each probe from RIPE Atlas
  - Compare all responses from a region with expected RTT and look for outliers

Server identity: HOSTNAME.BIND

- Does the server identity match B root?
  - Collect server identity and DNS response time
  - Compare HOSTNAME.BIND identity to expected value for B root
- Compare ping and DNS response times
  - Expect DNS and ping response time to be similar
  - If DNS response time is substantially lower, then DNS proxy in use

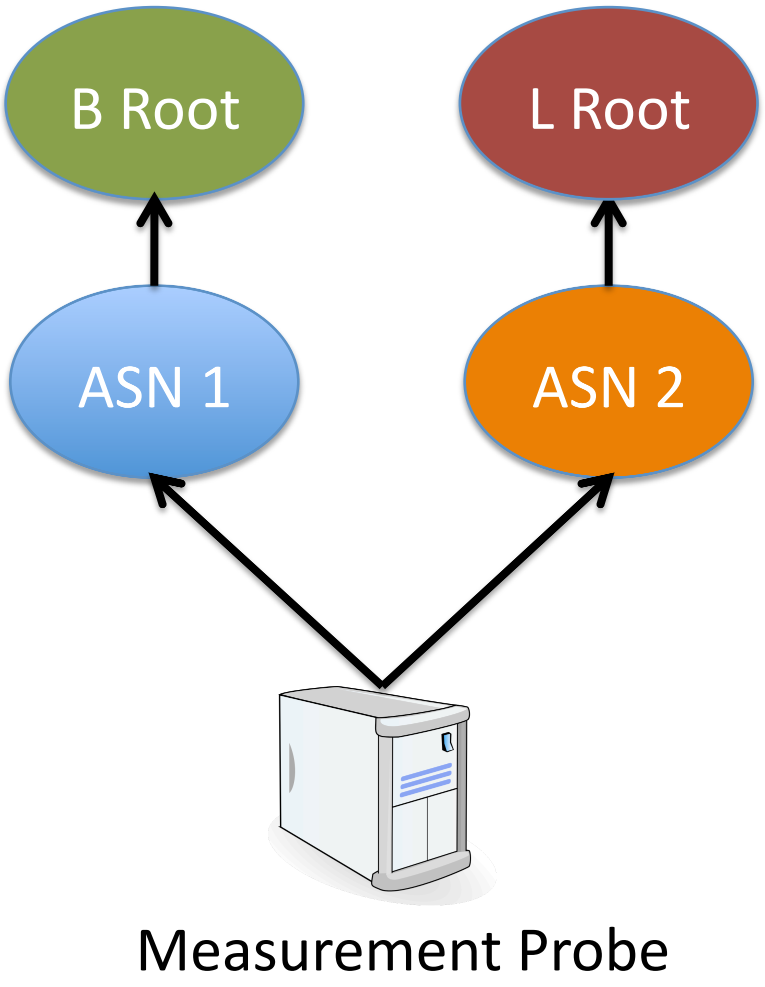
Server identity: traceroutes

- Hypothesis: root mirrors may have different last hop (Penultimate Router or PR)
  - Extract and compare the last hop/ PR from traceroutes



Server identity: traceroutes cont.

- Hypothesis: an ISP may redirect multiple root addresses to the same instance
  - Compare the similarity in paths to different roots



Server identity: BGP

- What if an ISP tried used BGP to redirect to their root mirror?
  - – What if their route was propagated?
- Is anyone doing a prefix hijack on B root?
  - – Collected RIBS from RouteViews and updates and RIBs from RIPE RIS
  - – Looked for unexpected announcements for B root's prefix

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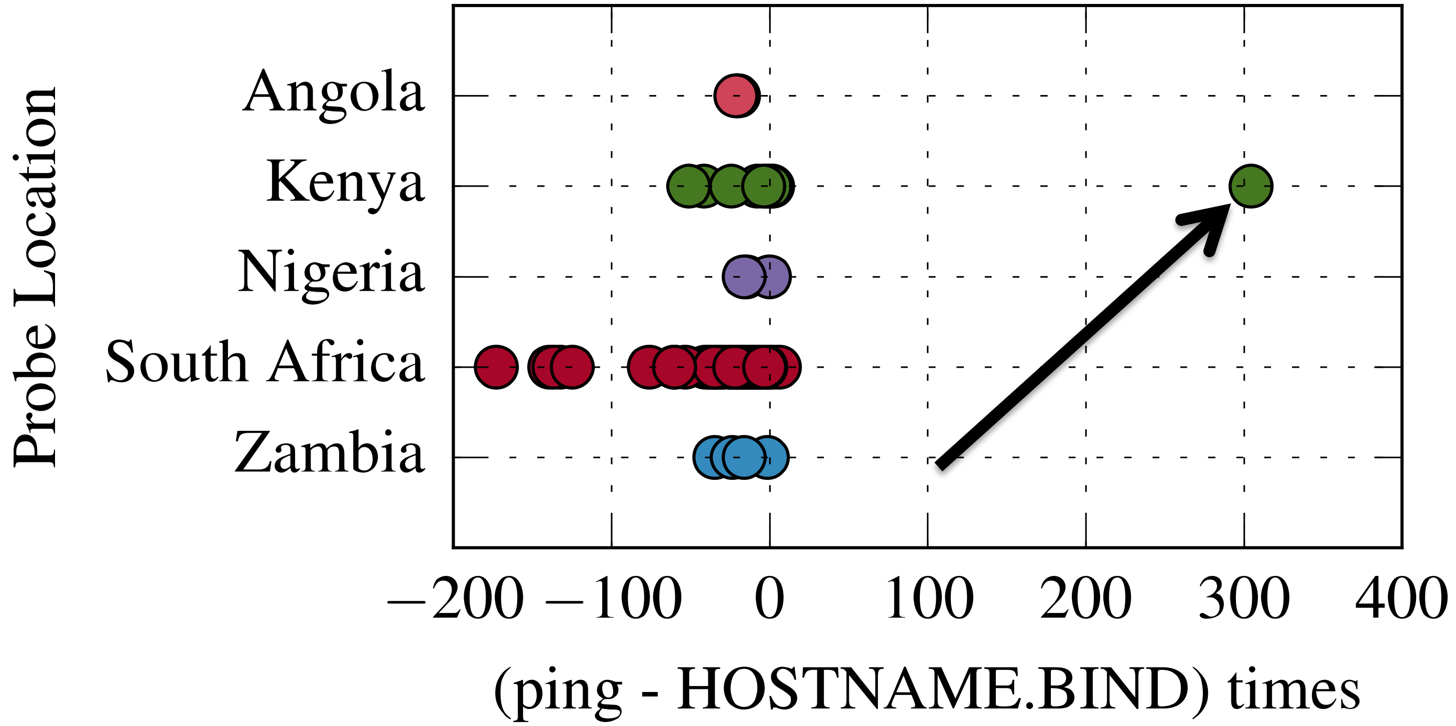
Comparing HOSTNAME.BIND responses

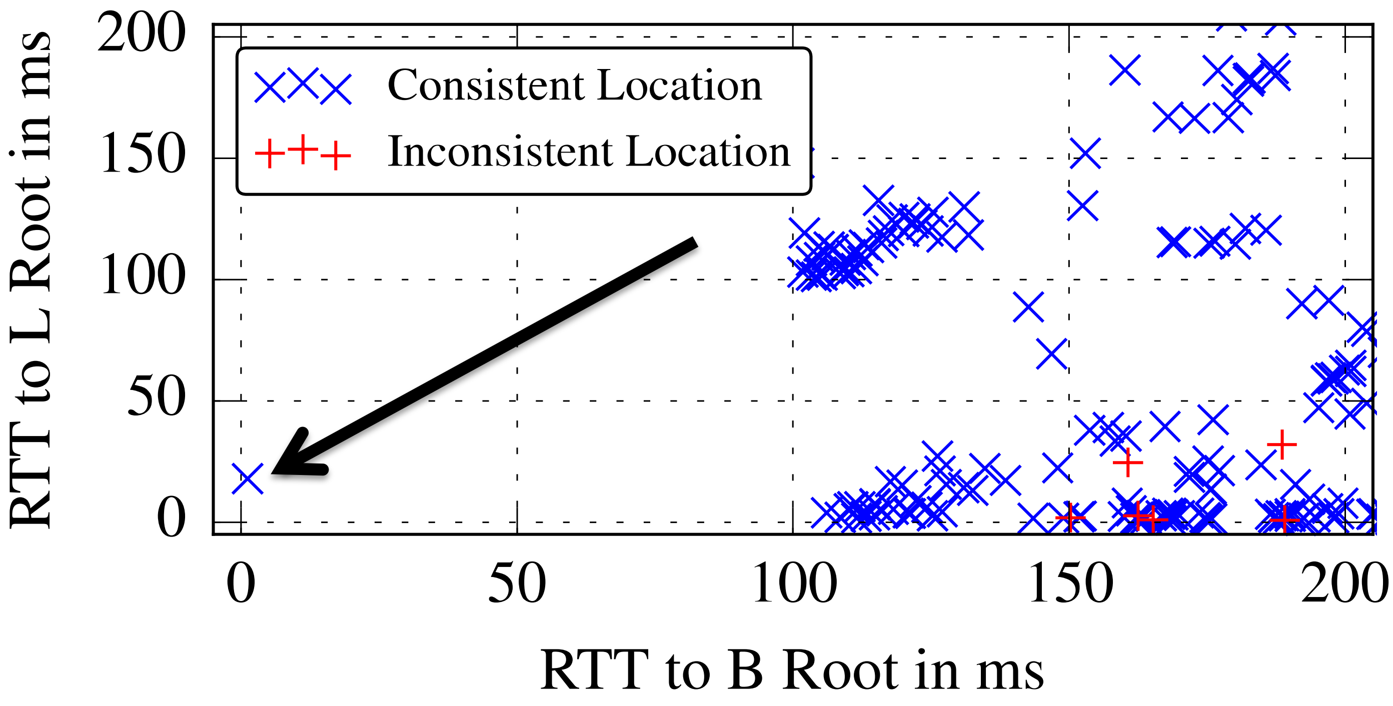
- We saw 11 anomalous responses
  - B root responses have the form *b[0-9]*
  - 3 responses with no answer, 3 with name of ISP, and 5 other responses
- What is the purpose of the DNS proxy?
  - Servers identifying with the ISP may be intended to improve performance
  - Other servers appear to be placed by end user, e.g. in one ISP, 1/4 probes had a DNS proxy

Detecting DNS proxies



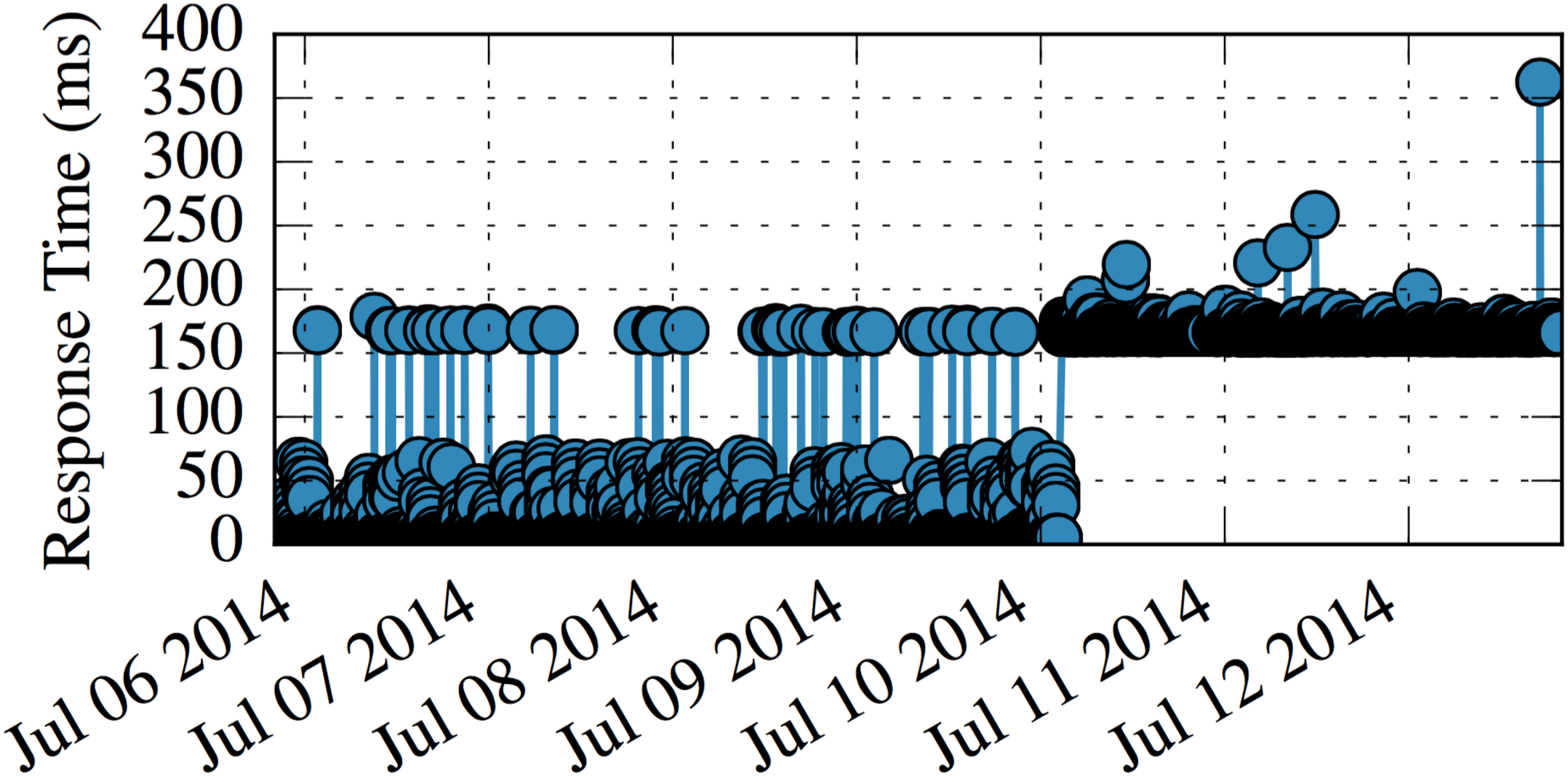
The outlier with a much smaller DNS response time is a DNS proxy

Detecting unauthorized roots



The outlier with a much smaller ping time is a DNS root mirror

Detecting root mirrors is not easy



Results summary

Analysis Method	Manipulation Found
HOSTNAME.BIND	10 DNS proxies and 1 root mirror
DNS and ping response time	10 DNS proxies
Ping response time	1 root mirror
Traceroute penultimate routers	No evidence of manipulation
Traceroute path sharing	No evidence of shared paths between roots
BGP hijack analysis	No evidence of hijacks

Conclusion

- Addressed important research question: DNS root manipulation
- Developed novel measurement techniques
- Analyzed data from RIPE Atlas to find 10 DNS proxies and 1 root mirror

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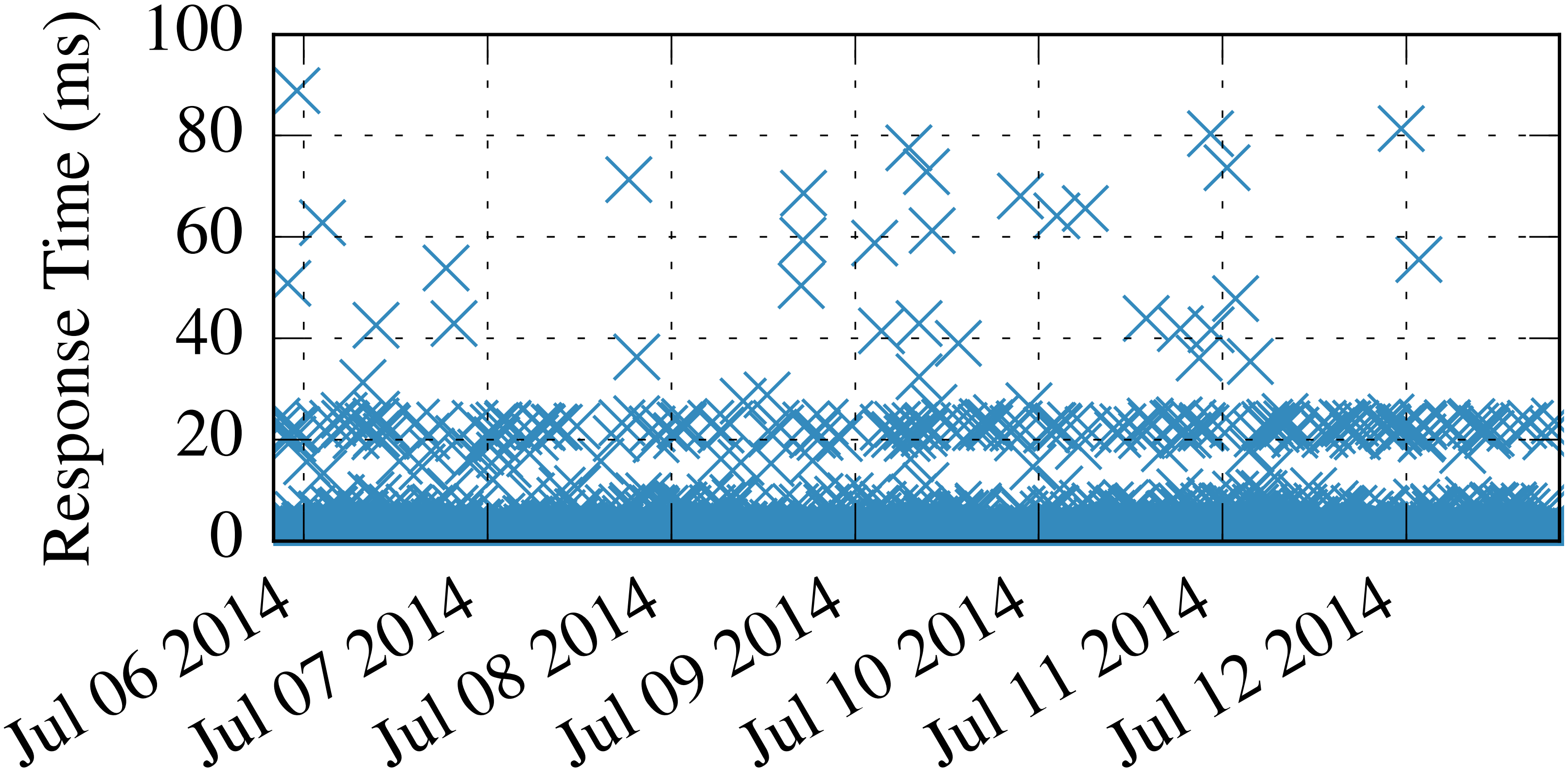
Root mirror pings


Response Time (ms)
Jul 06 2014
Jul 07 2014
Jul 08 2014
Jul 09 2014
Jul 10 2014
Jul 11 2014
Jul 12 2014