

Measuring the Availability and Response Times of Public Encrypted DNS Resolvers

Nick Feamster, Austin Hounsel, Ranya Sharma
University of Chicago
Princeton University

Contributions

- We developed and released an open-source tool for measuring encrypted DNS performance to replicate and extend these results, and to support further research on DoH performance.
- We measure DoH response times a large list of resolvers, including both mainstream DoH resolvers that are included in major browser vendors and a large collection of non-mainstream resolvers.
- We study how the performance of various DoH resolvers differ based on vantage point.
- The first study of DoH performance measurements for non-mainstream resolvers, as well as the first comparison of DoH performance across a variety of vantage points, for a large number of resolvers.

Context

Browser	Cloudflare	Google	Quad9	NextDNS	CleanBrowsing	OpenDNS
Chrome	✓	✓		✓	✓	✓
Firefox	✓			✓		
Edge	✓	✓	✓	✓	✓	✓
Opera	✓	✓				
Brave	✓	✓	✓	✓	✓	✓

- Modern browsers provide only a few choices for encrypted DNS resolver, which we define as mainstream resolvers.

Metrics

- **Availability:** Which DoH resolvers are active and responding to queries?
- **Latency:** What is the round-trip latency to each server?
- **DNS query response time:** What is the end- to-end time it takes for a client to initiate a query and receive a response?

Experiment Setup

- **Vantage Points:** Three global vantage points in Amazon EC2
 - Ohio, United States (North America)
 - Seoul, North Korea (Asia)
 - Frankfurt, Germany (Europe)
- **Queries:** google.com, netflix.com
- **Resolvers**

- <https://dns.google/dns-query>
- <https://dns.aa.net.uk/dns-query>
- <https://adfree.usableprivacy.net/dns-query>
- <https://dns.adguard.com/dns-query>
- <https://dns-family.adguard.com/dns-query>
- <https://doh.in.ahadns.net/dns-query>
- <https://doh.la.ahadns.net/dns-query>
- <https://doh.nl.ahadns.net/dns-query>
- <https://dns.alidns.com/dns-query>
- <https://dnsnl-noads.alekberg.net/dns-query>
- <https://dnsnl.alekberg.net/dns-query>

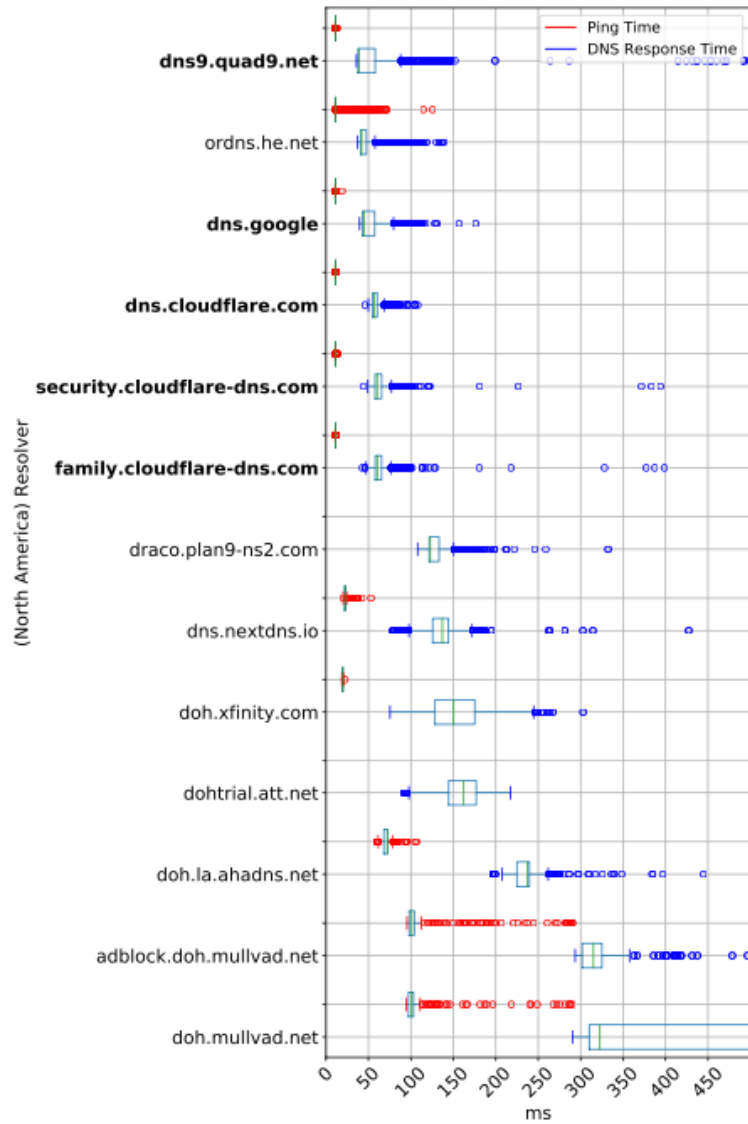
- <https://dns.arapurayil.com/dns-query>
- <https://dohtrial.att.net/dns-query>
- <https://dnses.alekberg.net/dns-query>
- <https://doh.bortzmeyer.fr/dns-query>
- <https://dns.circl.lu/dns-query>
- <https://doh.opendns.com/dns-query>
- <https://dns.cloudflare.com/dns-query>
- <https://family.cloudflare-dns.com/dns-query>
- <https://security.cloudflare-dns.com/dns-query>
- <https://odvr.nic.cz/dns-query>
- <https://dns.digitale-gesellschaft.ch/dns-query>
- <https://dns.digitale-gesellschaft.ch/dns-query>

- <https://dns1.ryan-palmer.com/dns-query>
- <https://doh.sb/dns-query>
- <https://dns.therifleman.name/dns-query>
- <https://dns1.dnscrypt.ca/dns-query>
- <https://dns2.dnscrypt.ca/dns-query>
- <https://dns-doh.dnsforfamily.com/dns-query>
- <https://dns-doh-no-safe-search.dnsforfamily.com/dns-query>
- <https://dnsforge.de/dns-query>
- <https://dns.dnshome.de/dns-query>
- <https://doh.pub/dns-query>
- <https://doh-ch.blahdns.com/dns-query>

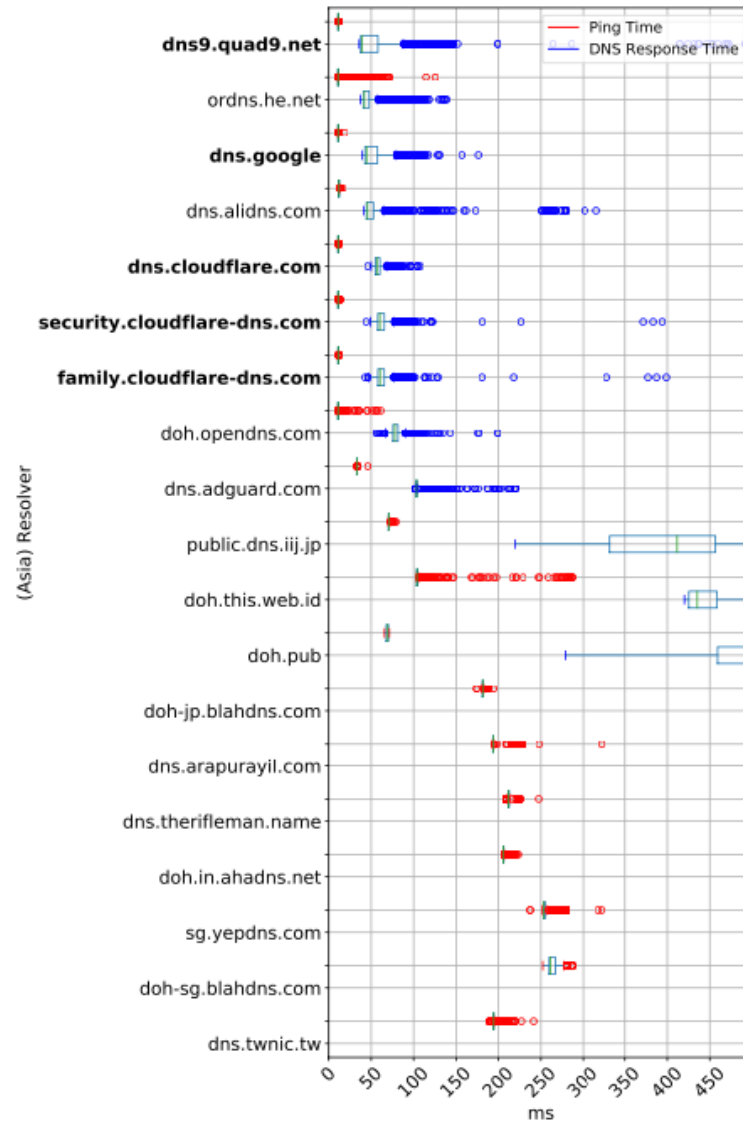
Are Non-Mainstream Resolvers Available?

Error	Count % of All Responses	
Couldn't Connect to Server	47,377	7%
HTTP Error Status	38,475	5.7%
Couldn't Decode Response	26,686	4%
SSL Connect Error	17,720	2.6%
Couldn't Resolve the Resolver's Domain Name	8,864	1.3%
SSL Certificate Error	4,465	0.7%
Other Error	234	< 1%
SSL Timeout	27	< 1%
Error in the HTTP/2 Framing Layer	2	< 1%
Successful Responses	531,528	78.7%
All Errors	143,848	21.3%

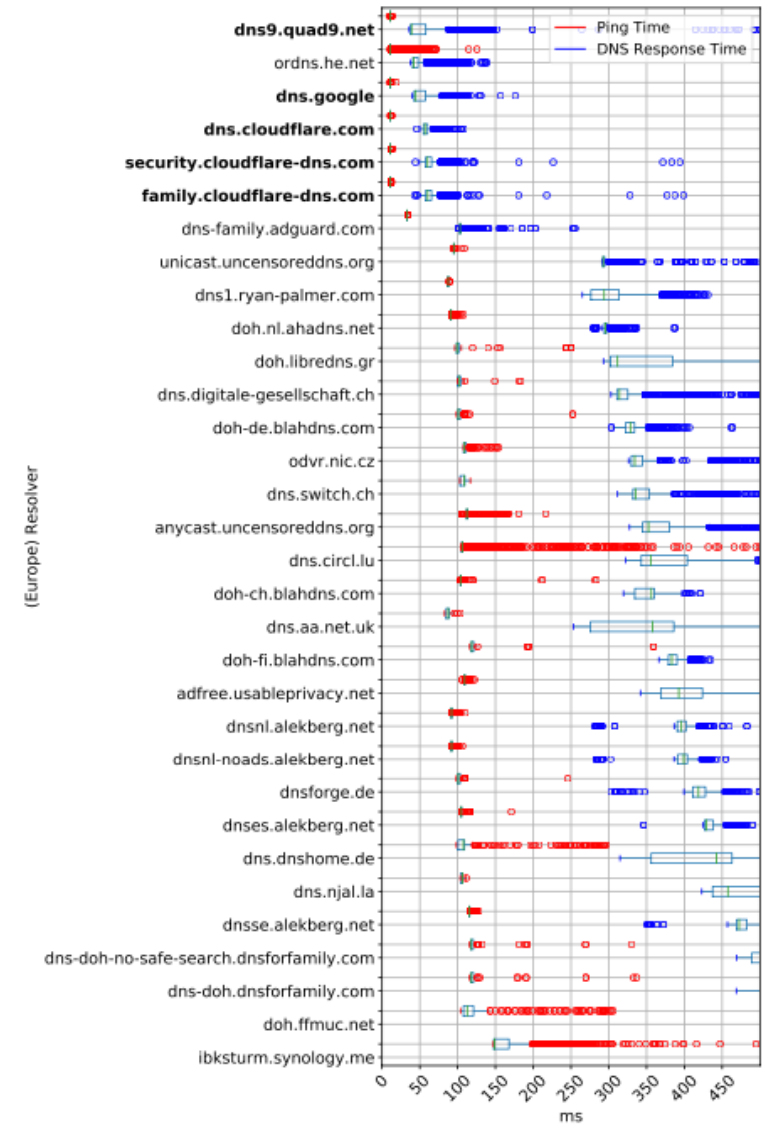
How Do Non-Mainstream Resolvers Perform?



(a) North America (Local).

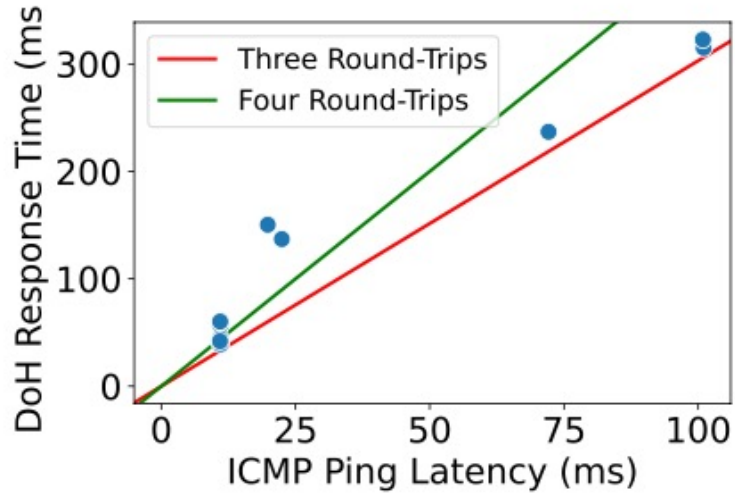


(b) Asia.

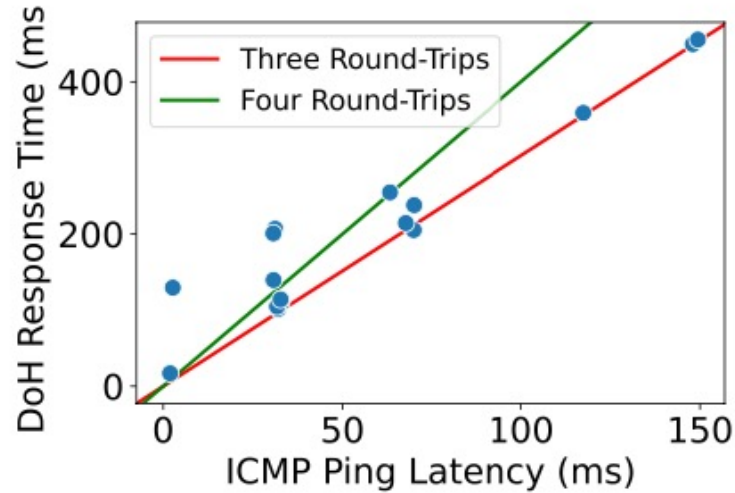


(c) Europe.

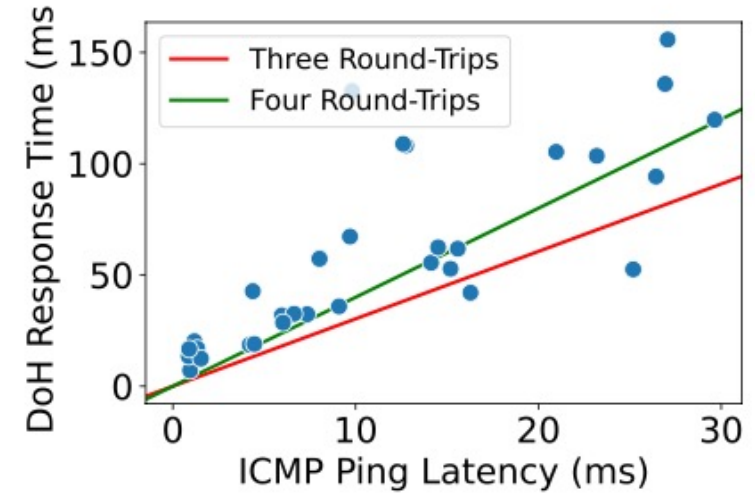
Median DoH Query Response Times vs. Latency



(a) Ohio (Local).



(b) Seoul (Local).



(c) Frankfurt (Local).

Conclusion

- Non-mainstream resolvers have higher median response times than mainstream ones, particularly if the resolvers are not local to the region.
- Most mainstream resolvers appear to be replicated and provide better response times across different geographic regions
- A local non-mainstream resolver can exhibit equivalent performance as compared mainstream resolvers (e.g., ordns.he.net in North America, dns.alldns.com in Europe, and doh.libredns.gr in Europe).
- There is an opportunity to invest in deploying and maintaining reliable, performant, global encrypted DNS infrastructure operated by a greater diversity of organizations