Measuring the Availability and Response Times of Public Encrypted DNS Resolvers

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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.
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.aladns.net/dns-query
  - https://doh.in.aladns.net/dns-query
  - https://dns.alekberg.net/dns-query
  - https://doh.nl.aladns.net/dns-query
  - https://dns.arapurayil.com/dns-query
  - https://dohtrial.att.net/dns-query
  - https://dns.alekberg.net/dns-query
  - https://doh.bortzmeyer.fr/dns-query
  - https://dns.civel.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://doh.dns.gegesschaft.ch/dns-query
  - https://doh.dns.gegesschaft.ch/dns-query
  - https://doh.ch.blahdns.com/dns-query
  - https://dns1.ryan-palmer.com/dns-query
  - https://doh.sh/dns-query
  - https://doh.therideman.name/dns-query
  - https://dns1.dnsencrypt.ca/dns-query
  - https://doh2.dnsencrypt.ca/dns-query
  - https://doh.dnsforfamily.com/dns-query
  - https://doh.dns-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.