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.alahdns.net/dns-query
- https://doh.la.alahdns.net/dns-query
- https://doh.n.l.alahdns.net/dns-query
- https://dns.alidns.com/dns-query
- https://dnsl-noouds.alekberg.net/dns-query
- https://dnsl.alekberg.net/dns-query
- https://dnsl.arapurayil.com/dns-query
- https://dnsltrial.att.net/dns-query
- https://dnss.alekberg.net/dns-query
- https://doh.bortzmeyer.fr/dns-query
- https://dns.civcl.in/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://dvnr.nic.cz/dns-query
- https://dns.digitale-gesellschaft.ch/dns-query
- https://dnsl.digitale-gesellschaft.ch/dns-query
- https://dnsl1.ryan-palmer.com/dns-query
- https://doh.sb/dns-query
- https://dns.the rifleman.name/dns-query
- https://dohs1.dnsencrypt.ca/dns-query
- https://dohs2.dnsencrypt.ca/dns-query
- https://dohs-doh.dnsforfamily.com/dns-query
- https://dnsforge.de/dns-query
- https://dohs.dnshome.de/dns-query
- https://doh.pub/dns-query
- https://doh-ch.blahdns.com/dns-query
Are Non-Mainstream Resolvers Available?

<table>
<thead>
<tr>
<th>Error</th>
<th>Count % of All Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Couldn’t Connect to Server</td>
<td>47,377</td>
</tr>
<tr>
<td>HTTP Error Status</td>
<td>38,475</td>
</tr>
<tr>
<td>Couldn’t Decode Response</td>
<td>26,686</td>
</tr>
<tr>
<td>SSL Connect Error</td>
<td>17,720</td>
</tr>
<tr>
<td>Couldn’t Resolve the Resolver’s Domain Name</td>
<td>8,864</td>
</tr>
<tr>
<td>SSL Certificate Error</td>
<td>4,465</td>
</tr>
<tr>
<td>Other Error</td>
<td>234</td>
</tr>
<tr>
<td>SSL Timeout</td>
<td>27</td>
</tr>
<tr>
<td>Error in the HTTP/2 Framing Layer</td>
<td>2</td>
</tr>
<tr>
<td>Successful Responses</td>
<td>531,528</td>
</tr>
<tr>
<td>All Errors</td>
<td>143,848</td>
</tr>
</tbody>
</table>
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.