DNS-OARC

Domain Name System Operations Analysis and Research Center

UNIVERSITY OF AMSTERDAM

Defragmenting DNS

Determining the optimal maximum UDP response size for DNS

Security and Network Engineering

University of Amsterdam

Axel Koolhaas & Tjeerd Slokker, Augustus 2020

Supervision by Willem Toorop

Background

- EDNS(0) are extension mechanisms for DNS, and the current default
  - EDNS has UDP Message Size, communicating response size capability

- The Internet is a network of networks
  - Not every network has the same Maximum Transmission Unit (MTU)

Background

- Path MTU Discovery (PMTUD) discovers Path MTU between two nodes
  - PMTUD is flawed, due to conservativity and failing ICMP messages

- Fragmentation occurs when a packet exceeds the PMTU
  - IP fragmentation introduces fragility to DNS
  - ICMP messages cause problems for DNS servers since they are stateless

Introduction

- PMTUD is unreliable
- DNS is connectionless which causes problems with fragmentation of DNS packets

❖ We aim to suggest an optimal maximum EDNS message size for DNS

Research Questions

- What is the optimal EDNS message size to avoid IP fragmentation?
  - Is there a difference between IPv4 and IPv6 regarding PMTU sizes?
  - Which EDNS message size is best in terms of support for DNS stub resolvers?
  - Which EDNS message size is best in terms of support for DNS open resolvers?

Related Work

How many problems does fragmentation cause?

- Weaver, et al. showed that 9% of DNS resolvers don’t receive fragmented UDP datagrams [1]
- Van Den Broek, et al. expanded on this, showing that as much as 10.5% of all resolvers suffer from fragmentation-related connectivity issues [2]

Related Work

How can you measure the PMTU?

- Toorop used custom name servers experiment with different EDNS message sizes [3]
  - Different sub-domains produce different sized responses
- DNS-OARC used a custom DNS server and chained CNAME responses [4]
  - Server sends multiple replies, where each reply decreases in size.

❖ Both use custom name servers, decreasing reproducibility

Related Work

How can fragmentation in DNS be prevented?

- Fujiwara & Vixie wrote a RFC draft on fragmentation avoidance in DNS [5]
  - A suggestion is made on a possible maximum EDNS message size

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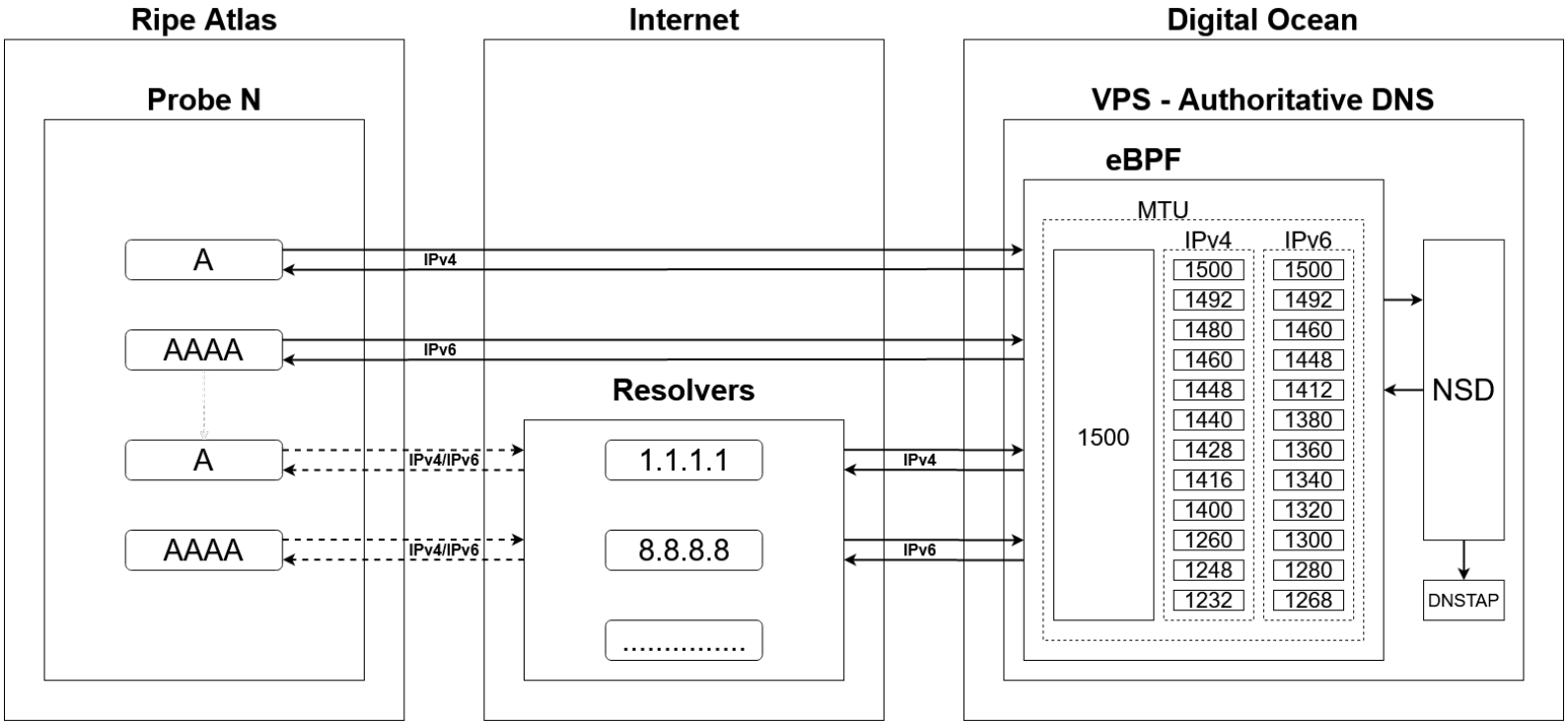
  - A suggestion is made on a possible maximum EDNS message size

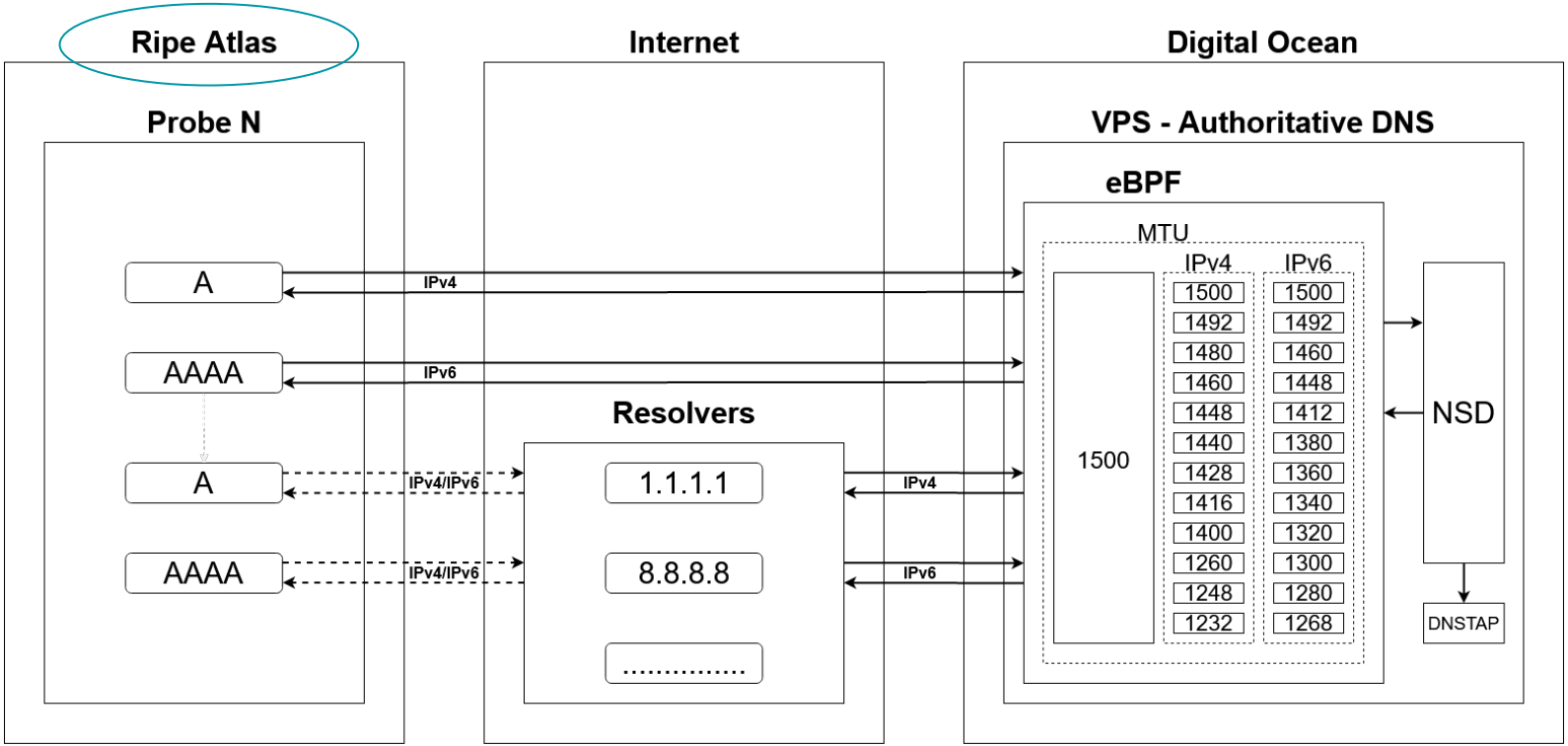
❖ Topical subject!

Methodology



Platform to perform measurements with

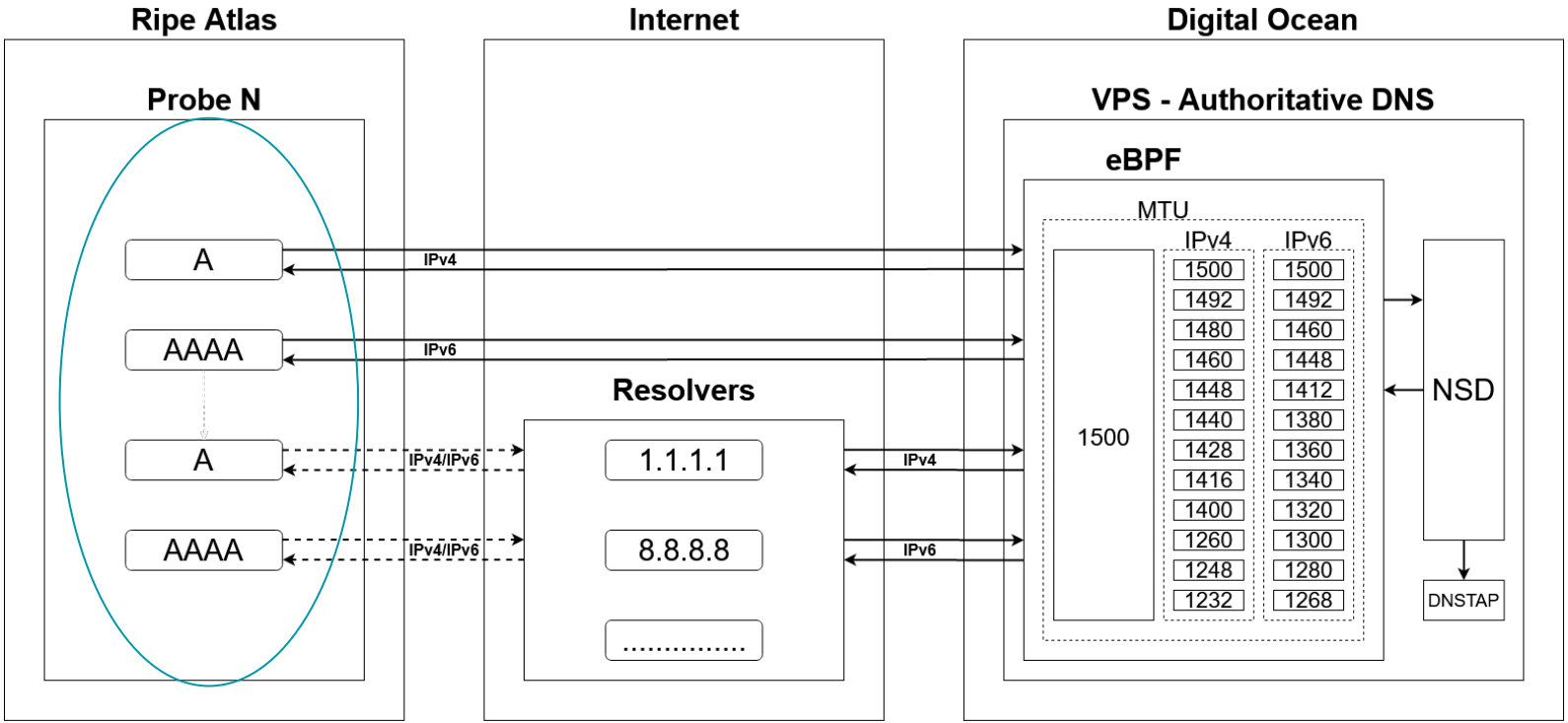
Methodology



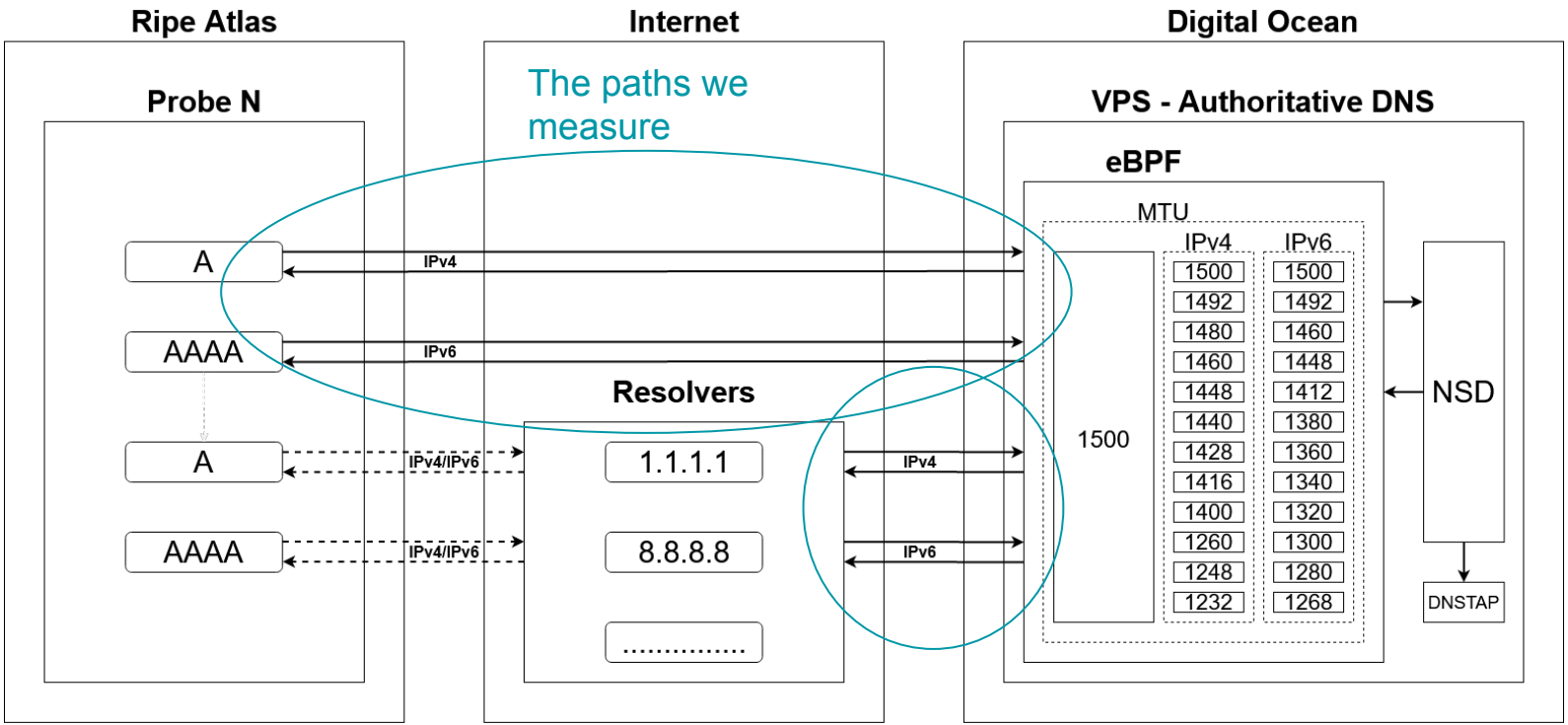
Four separate Atlas measurements

Methodology

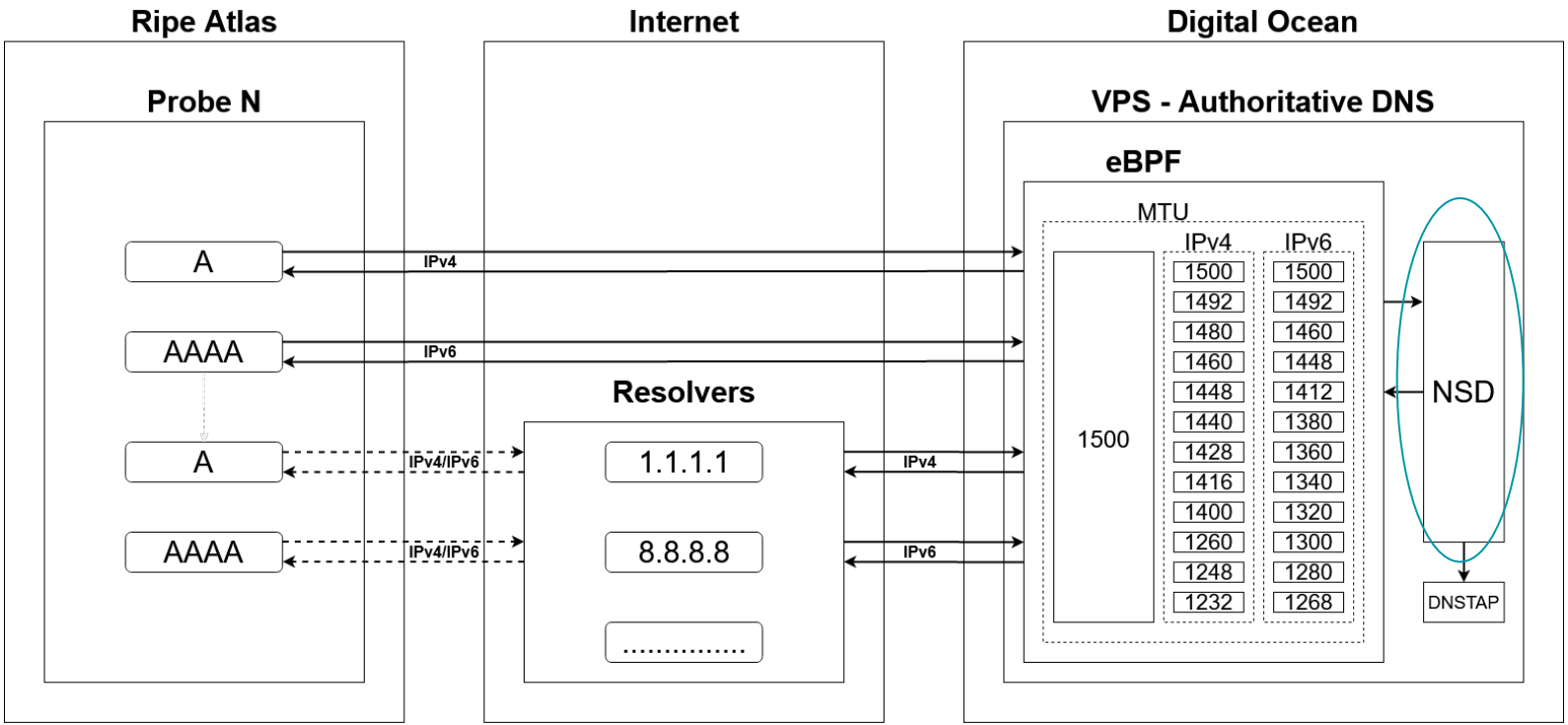
Special thanks to
Emile Aben for creating the queries!



Methodology



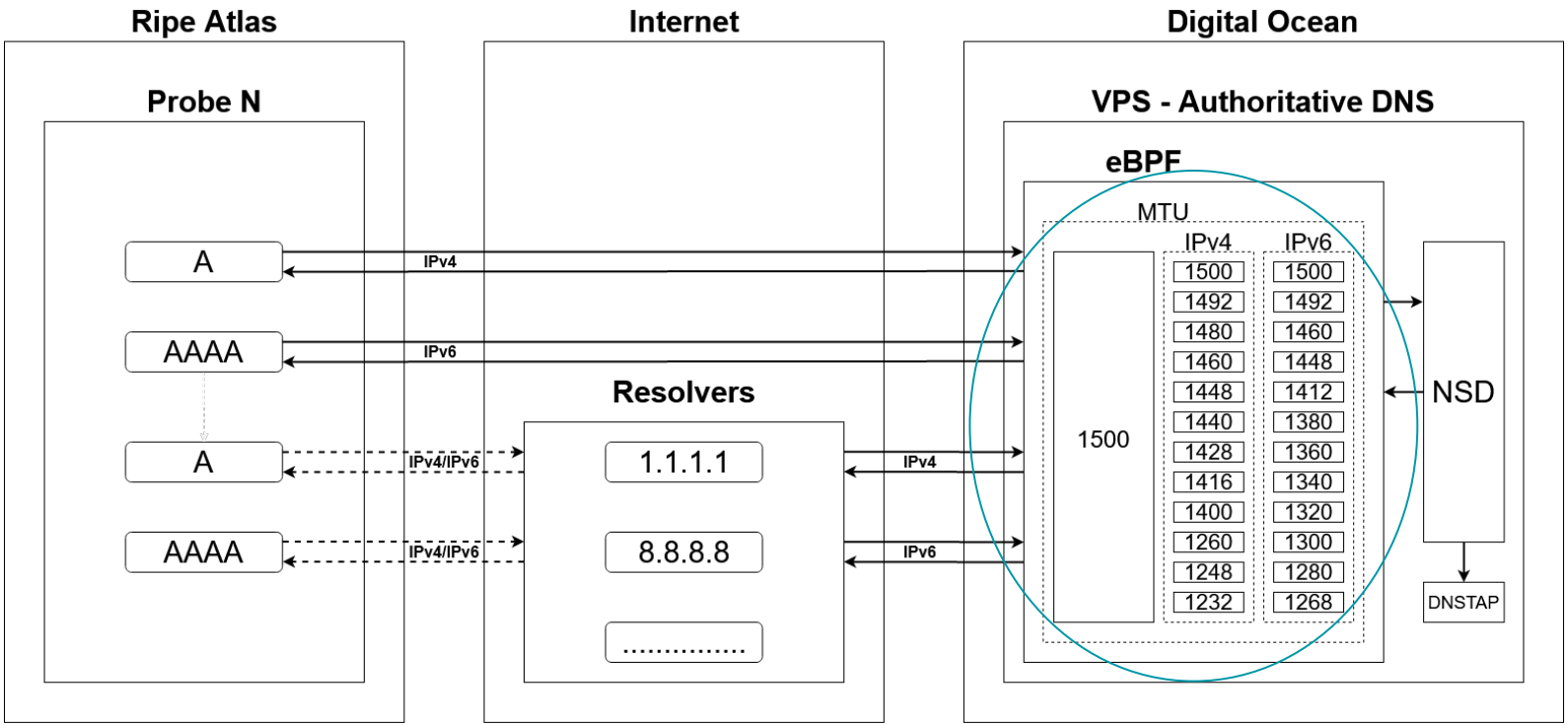
Methodology



Done in collaboration with Toorop and Carpaij

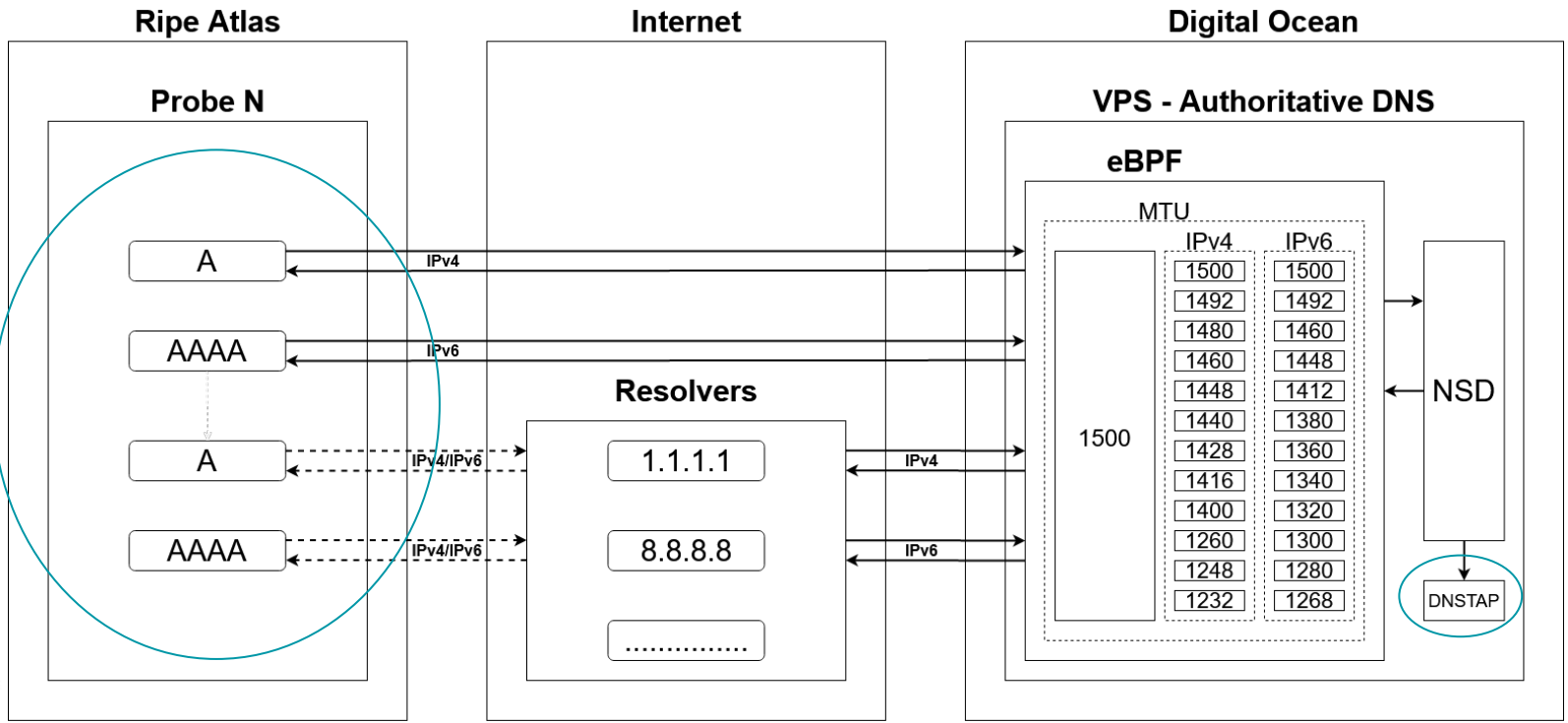
Methodology

Solution to universal query

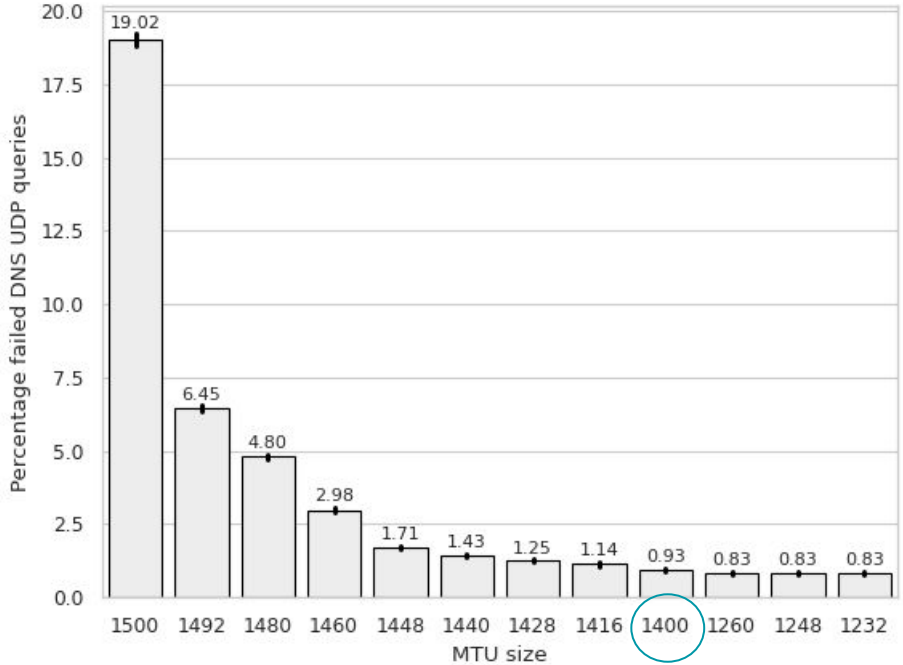


We aggregate our results from the Atlas API and dnstap logs

Methodology



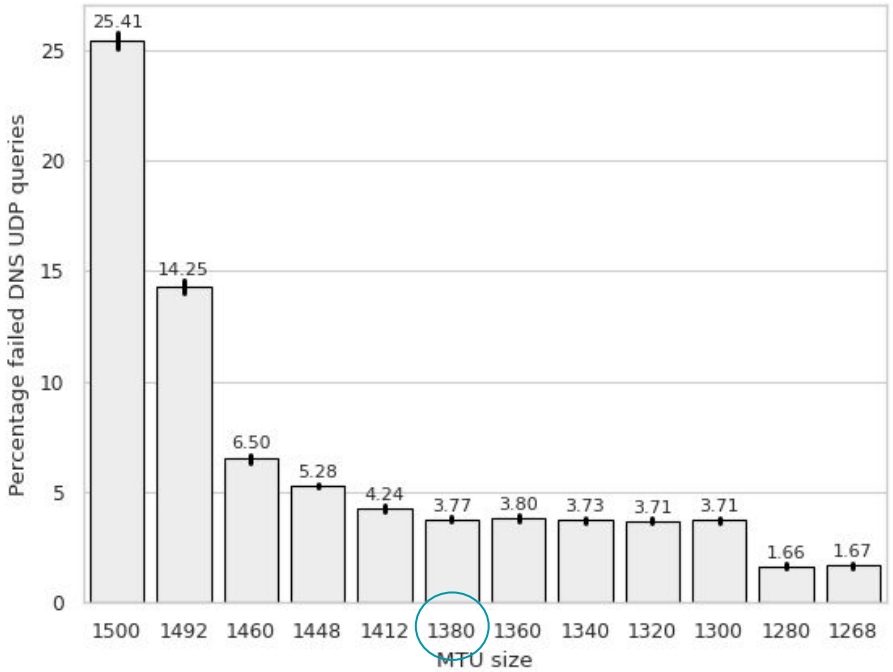
Results IPv4 Stub Resolver



Note: this is the EDNS message size, so MTU minus IP and UDP headers

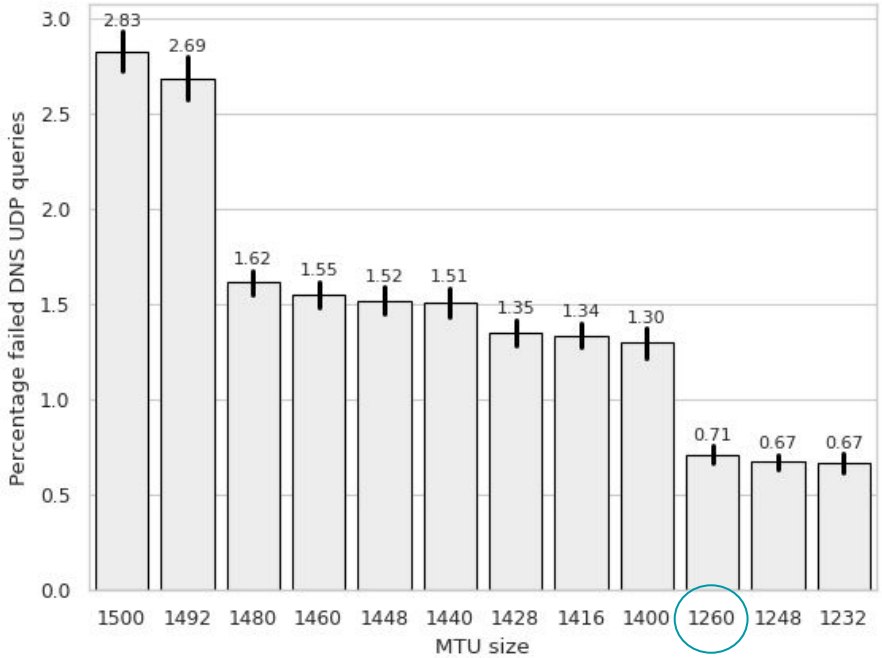
	Stub	**Resolver**
IPv4	1372	
IPv6		

Results IPv6 Stub Resolver



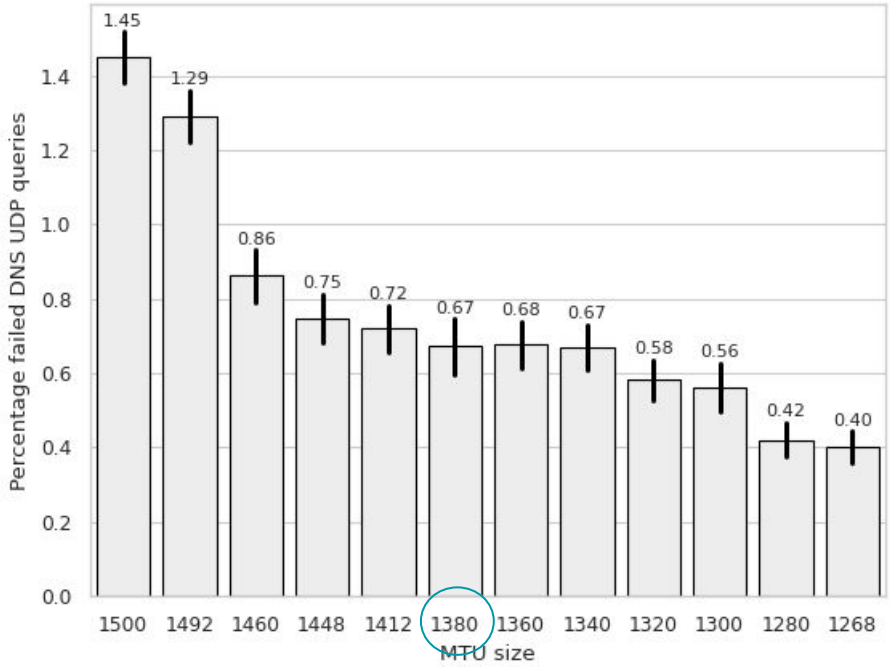
	Stub	Resolver
IPv4	1372	
IPv6	1332	

Results IPv4 Resolver



	Stub	Resolver
IPv4	1372	1232
IPv6	1332	

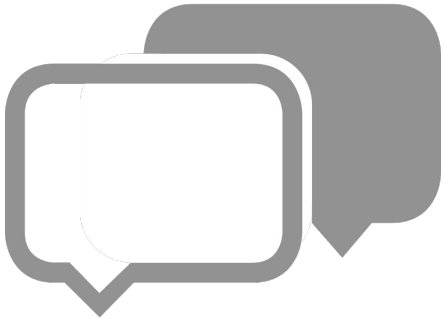
Results IPv6 Resolver



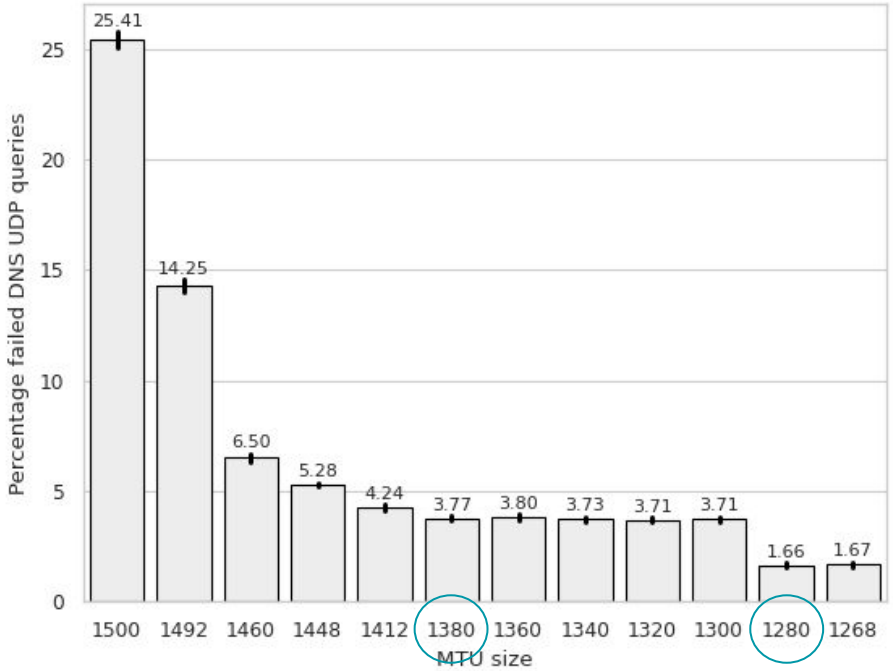
	Stub	Resolver
IPv4	1372	1232
IPv6	1332	1332

Discussion - Results

- MTUs 1500 & 1492 stand out
- IPv6 Stub
- IPv4/6 Resolvers



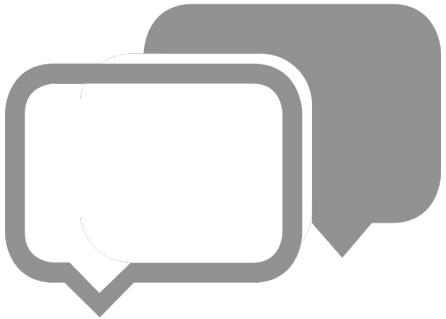
Results IPv6 Stub Resolver



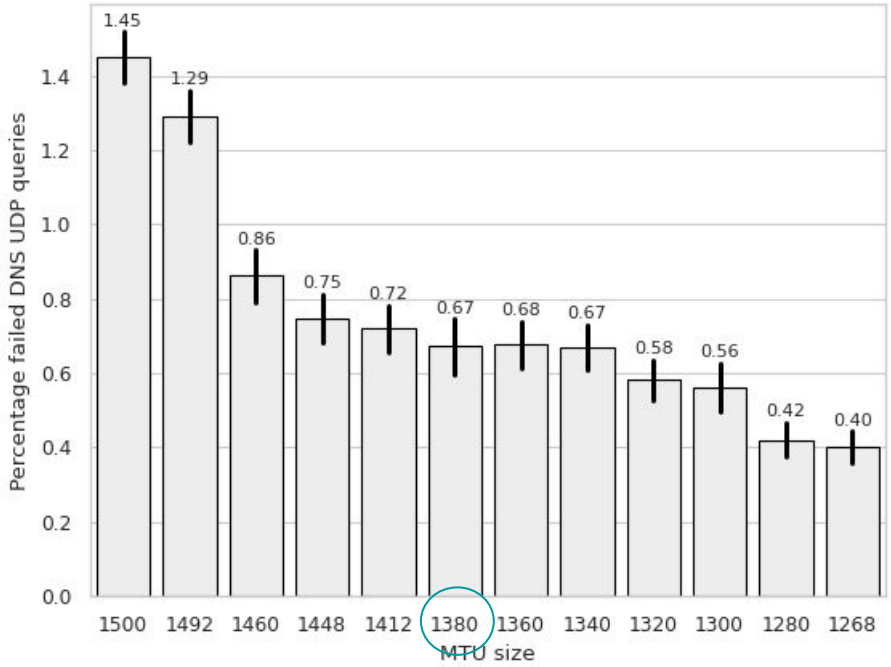
	Stub	Resolver
IPv4	1372	
IPv6	1332/1232	

Discussion - Results

- MTUs 1500 & 1492
- IPv6 Stub
- IPv4/6 Resolvers



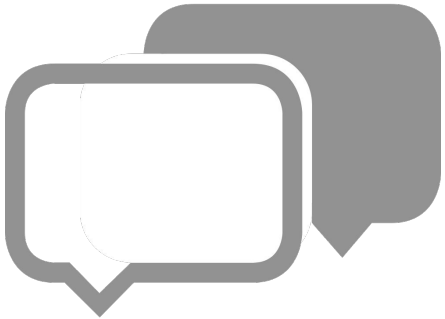
Results IPv6 Resolver



	Stub	Resolver
IPv4	1372	1232
IPv6	1332/1280	1332

Discussion - Limitations

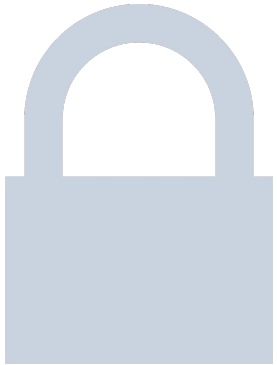
- MTU support Digital Ocean
- Dynamic paths
- Failing probes
- RIPE Atlas bias
- Measuring period



Conclusion

- Created publicly available reproducible environment [6]
- EDNS(0) message sizes

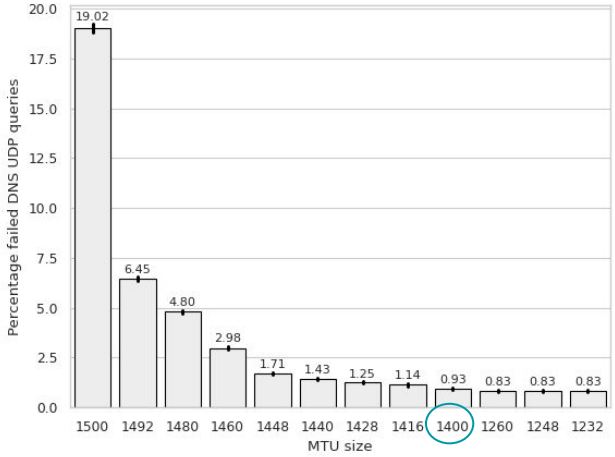
	Stub	**Resolver**
IPv4	1372	1232
IPv6	1332/1232	1332



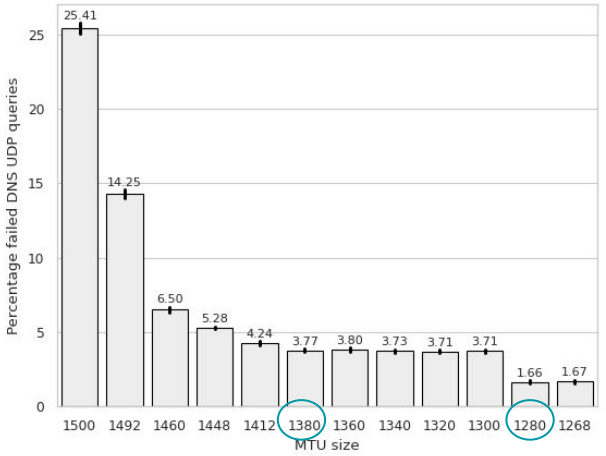
Future Work

- Spread of probes within ASs
- Failing probes
- Continuation

IPv4 Stub

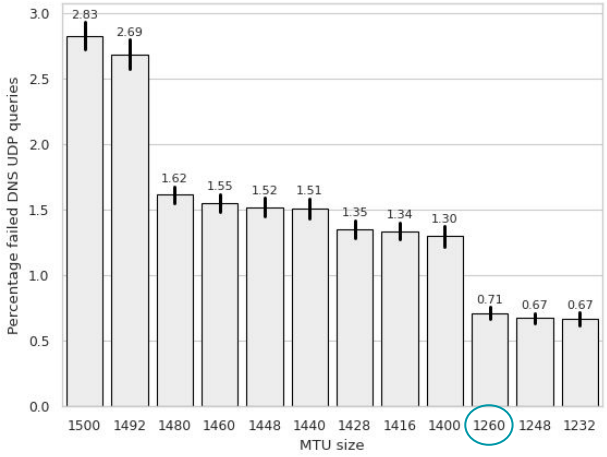


IPv6 Stub

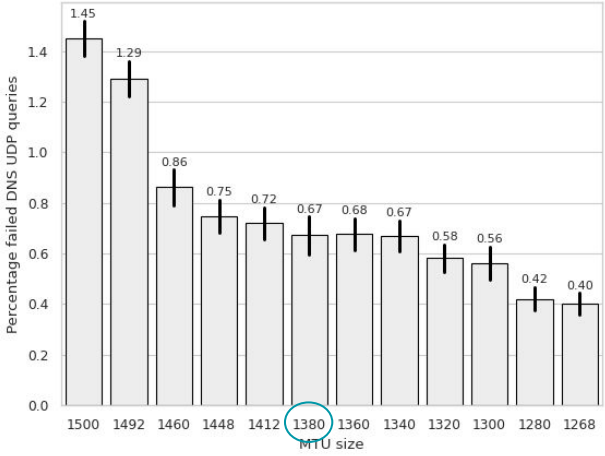


There is no single “magical” EDNS(0) message size for all DNS resolver implementations.

IPv4 Resolver



IPv6 Resolver



References

[1] - Weaver, N., Kreibich, C., Nechaev, B., & Paxson, V. (2011, April). Implications of Netalyzr's DNS measurements. In *Proceedings of the First Workshop on Securing and Trusting Internet Names (SATIN), Teddington, United Kingdom*.
[2] - Van Den Broek, G., van Rijswijk-Deij, R., Sperotto, A., & Pras, A. (2014). DNSSEC meets real world: dealing with unreachability caused by fragmentation. *IEEE communications magazine*, *52*(4), 154-160.
[3] - Toroop. (2013) https://medium.com/nlnetlabs/using-pmtud-for-a-higher-dns-responsiveness-60e129917665
[4] - OARC. https://www.dns-oarc.net/oarc/services/replysizetest
[5] - Fujiwara & Vixie. (2020) Fragmentation Avoidance in DNS
[6] - https://github.com/shoaloak/defragDNS