Recursives in the Wild: Engineering Authoritative DNS Servers

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Introduction

unicast

anycast

ns1
ns2
ns3
ns4
ns5
netnod
nic.fr
isc

.Go to the tab Start.

Here you will find two buttons as shown below. By means these buttons you can easily switch between text levels.
Introduction

Recursive Resolver

who has example.nl?

Client

unicast
anycast
ns1 ns2 ns3 ns4 ns5 netnod nic.fr isc

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.net setup

ns1

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unicast

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Recursive Resolver

Through these buttons, you can easily switch between text levels.
Introduction

- **ns1**
- **ns2**
- **ns3**
- **ns4**
- **netnod**
- **nic.fr**
- **isc**

.**nl setup**

**unicast**

**anycast**

Recursive Resolver

Client

by means of these buttons you can easily switch between text levels.
area relative to the number of sites
Introduction

area relative to the number of sites

area relative to the number of queries
Introduction

area relative to the number of sites

area relative to the number of queries

23% of queries from the US

located in the Netherlands

multiple sites in the US
Research Questions

• How do recursive resolvers select authoritative name servers?

• [1] says, most *implementations* prefer faster responding authoritatives

• but what is the overall behaviour *in the wild*?

• To improve performance, how should operators design their authoritatives?

Measurement Design

Setups:
- GRU+NRT
- DUB+FRA
- FRA+SYD
- GRU+NRT+SYD
- DUB+FRA+IAD
- DUB+GRU+NRT+SYD
- DUB+FRA+IAD+SFO

IPv4 only (for now)
Measurement Design

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IPv4 only (for now)
How do recursives distribute their queries over time?

![Graph showing RTT (ms) and queries share over locations.]

**Graph 1:**
- **RTT (ms):** The graph shows the round-trip time in milliseconds (ms) for different locations.
- **Locations:** FRA, DUB, IAD, SFO, GRU, NRT, SYD.

**Graph 2:**
- **Queries share:** The graph illustrates the distribution of queries share over time for various locations.
- **Locations:** GRU, NRT, FRA, SYD, DUB.
How do recursives distribute their queries over time?

- Authoritatives with similar latency get similar number of queries
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- Larger difference leads to larger preference
How do recursives distribute their queries over time?

- Authoritatives with similar latency get similar number of queries
- Larger difference leads to larger preference
- Authoritatives that respond faster are in general preferred
- Confirms previous work, but now in the wild
How do *individual* recursives distribute their queries?
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1. Go to the tab Start.
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How do *individual* recursives distribute their queries?

[Graph showing fraction of queries across EU, DUB, SYD, and FRA over recursives (x100).]
How do *individual* recursives distribute their queries?

![Graph showing query distribution across different regions (EU, UK, US, AUS), with labels for NRT, GRU, DUB, FRA, SYD, and the x-axis representing recursives (x100)].

- **EU**: NRT > GRU
- **UK**: NRT > DUB > FRA
- **US**: SYD > FRA
- **AUS**: NRT > GRU > DUB > FRA

**Legend**:
- NRT: Light Blue
- GRU: Pink
- DUB: Beige
- FRA: Dark Blue (gradually lighter)
- SYD: Green

**Notes**:
- By using the buttons, users can easily switch between text levels.
How do *individual* recursives distribute their queries?

[Diagram showing the distribution of queries across different regions (NRT, GRU, DUB, FRA, SYD) over a range of recursives (x100).]
How do *individual* recursives distribute their queries?

Up to 69% of resolvers have a weak preference (60% to 90% of their queries to one NS)
How do *individual* recursives distribute their queries?

Up to 37% of resolvers have a strong preference (more than 90% of their queries to one NS)
How do *individual* recursives distribute their queries?

Some resolvers always prefer the slower NS
Validation: Authoritatives in Production

- Root: +60% query at least 6 servers
- .nl: +90% query at least 4 servers
- Overall confirms the observations from our test bed

Root Servers (10 out of 13)

.nl Servers (4 out of 8)
Measurement Summary

- Distribution is inversely proportional with the median RTT
- Recursives prefer faster responding authoritatives
- But they also query slower authoritatives from time to time

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- Additional findings:
  - Lower RTT becomes more relevant if competing NSes are closer (<150 ms)
  - Stronger preference when querying more frequent (< 10min interval)
Recommendations for DNS Operators

• The slowest authoritative limits the response time of a DNS service

• **Recommendation:**
  
  • Use anycast on *all* your name servers
  
  • Anycast sites need to be well connected with good peering

→ Based on this work .nl is replacing unicast NSes with anycast
Data Sets

All data sets (but one) available:
https://ant.isi.edu/datasets/dns/index.html#recursives
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Questions?

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Additional Slides
Does preference change for distant recursives?

- VPs in EU reach Frankfurt 13 ms faster than Dublin
- Thus, they clearly prefer Frankfurt
- VPs in Asia reach Frankfurt 20 ms faster, but distribute their queries almost equally
  - Lower RTT becomes more relevant if competing authoritatives are closer to the recursive
How does query frequency affect the results?

- A higher query frequency leads to a stronger preference.
- However, preference persists even after the default timeout of resolvers like Bind and Unbound.
Do recursives query all authoritatives?

Yes, the majority of resolvers query every authoritative