Recursives in the Wild:
Engineering Authoritative DNS Servers

Moritz Müller[1,2], Giovane C. M. Moura[1],
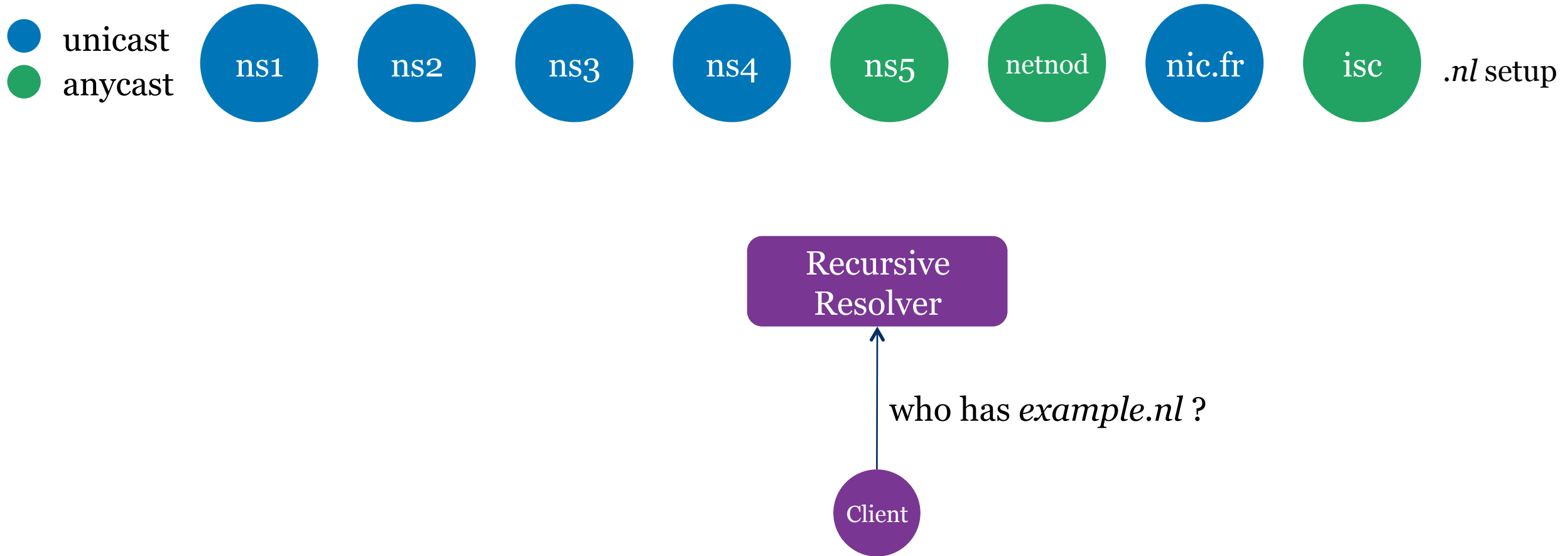
Ricardo de O. Schmidt[1,2], John Heidemann[3]

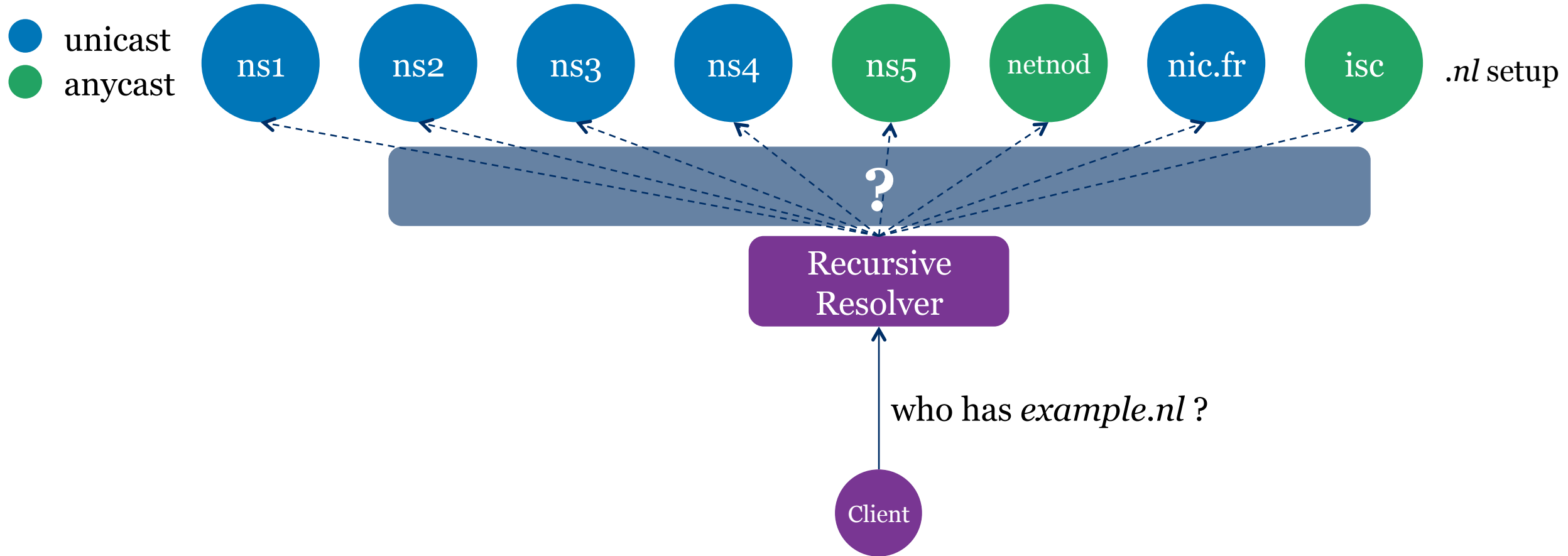[1]SIDN Labs, [2]University of Twente, [3]USC/Information Sciences Institute
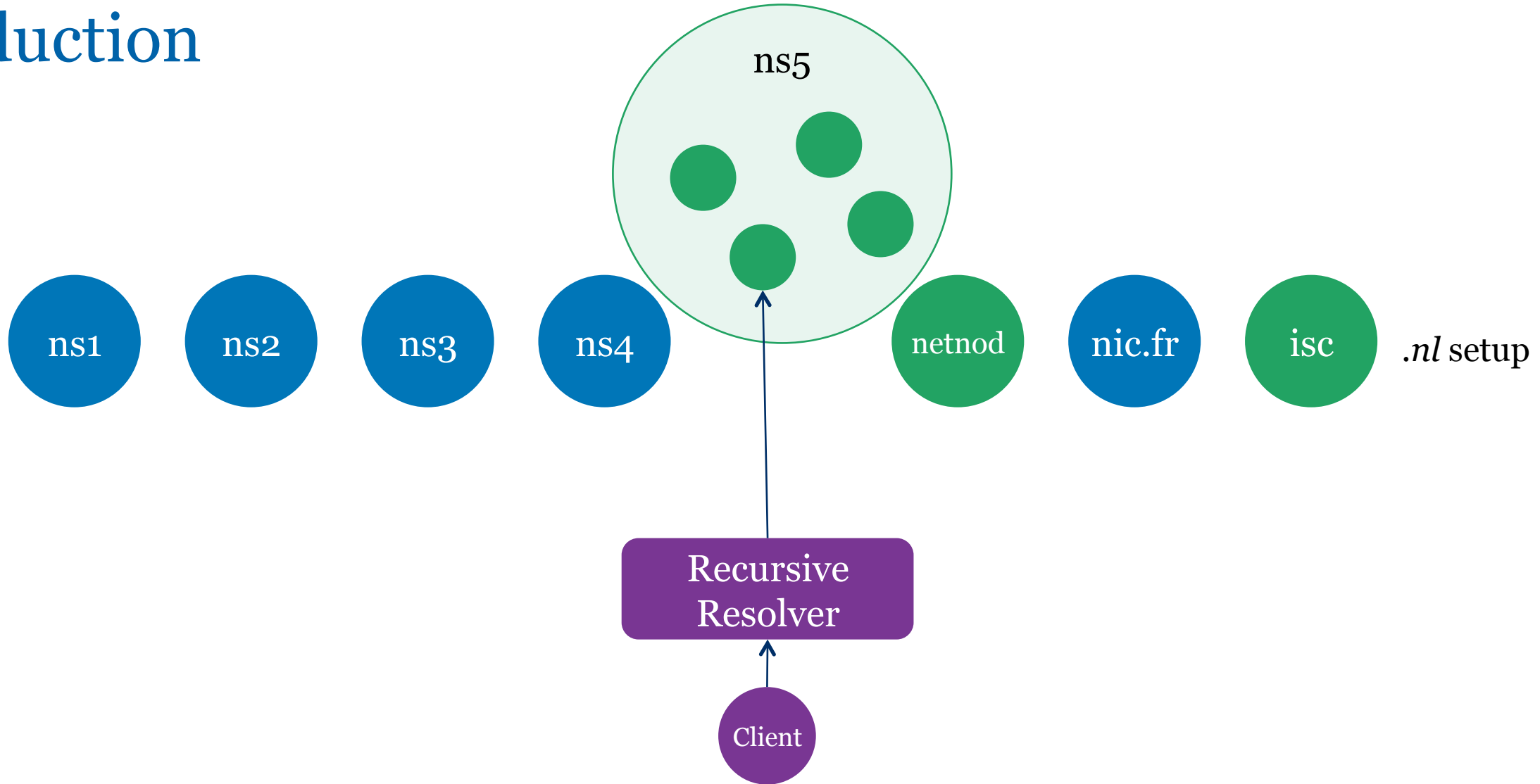
Introduction

Introduction

unicast
anycast

ns1 ns2 ns3 ns4 ns5 netnod nic.fr isc   .*nl* setup

Recursive Resolver

who has *example.nl* ?

Client

3

Introduction

Introduction

ns5

unicast
anycast

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Recursive Resolver

Client

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Introduction

area relative to the number of *sites*

ns1　ns2　ns3　ns4

ns5

netnod

nic.fr

isc

Introduction

area relative to the number of *sites*

ns1 · ns2 · ns3 · ns4 · ns5 · netnod · nic.fr · isc

area relative to the number of *queries*

ns1 · ns2 · ns3 · ns4 · ns5 · netnod · nic.fr · isc

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Introduction

area relative to the number of *sites*

ns1 ns2 ns3 ns4 ns5 netnod nic.fr isc

23% of queries from the US

multiple sites in the US

area relative to the number of *queries*

ns1 ns2 ns3 ns4 ns5 netnod nic.fr isc

located in the Netherlands
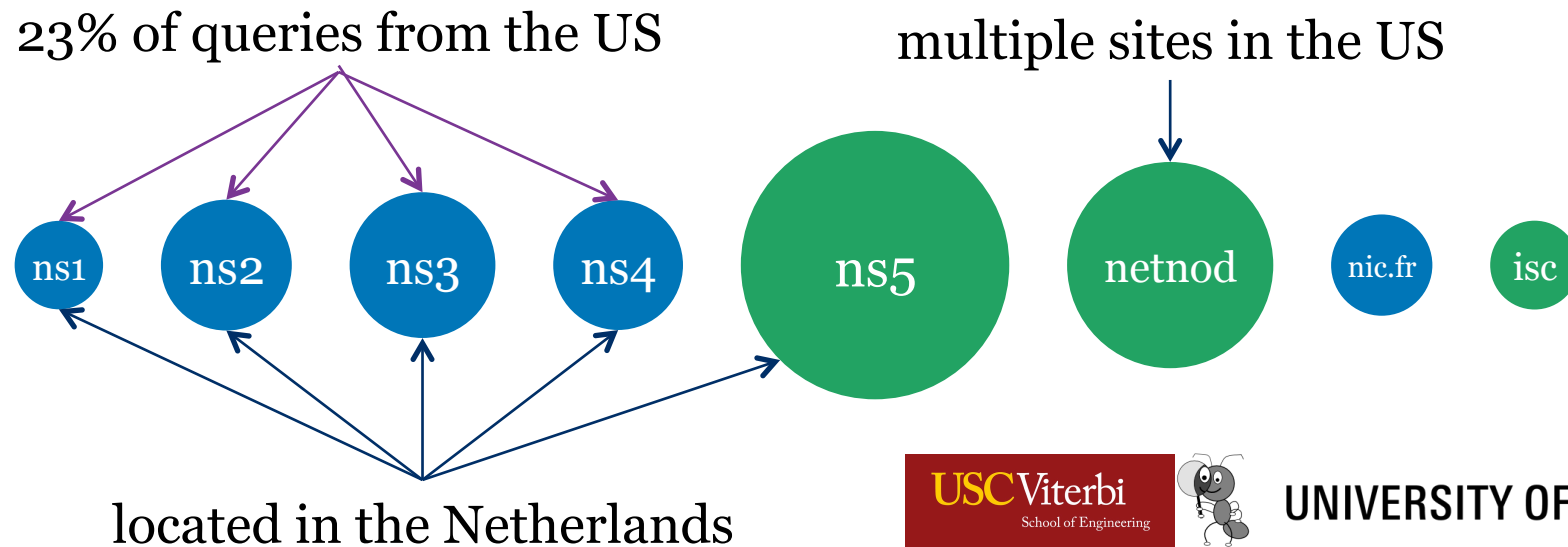
Research Questions

- 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?

[1] Yu, Y., Wessels, D., Larson, M., and Zhang, L.
Authority Server Selection in DNS Caching Resolvers.
SIGCOMM Computer Communication Review 42, 2 (Mar. 2012), 80–86.

Measurement Design
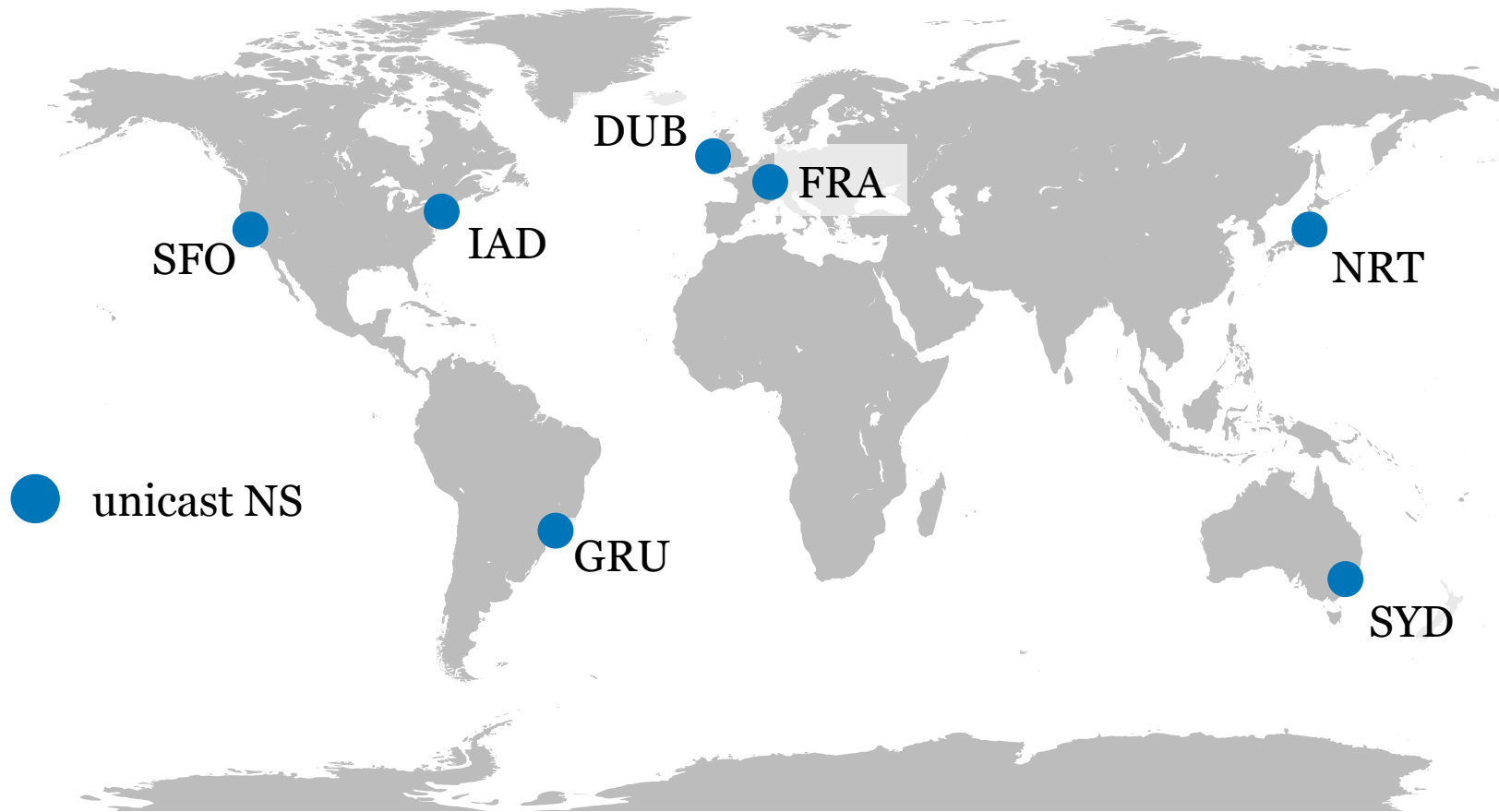
Setups:

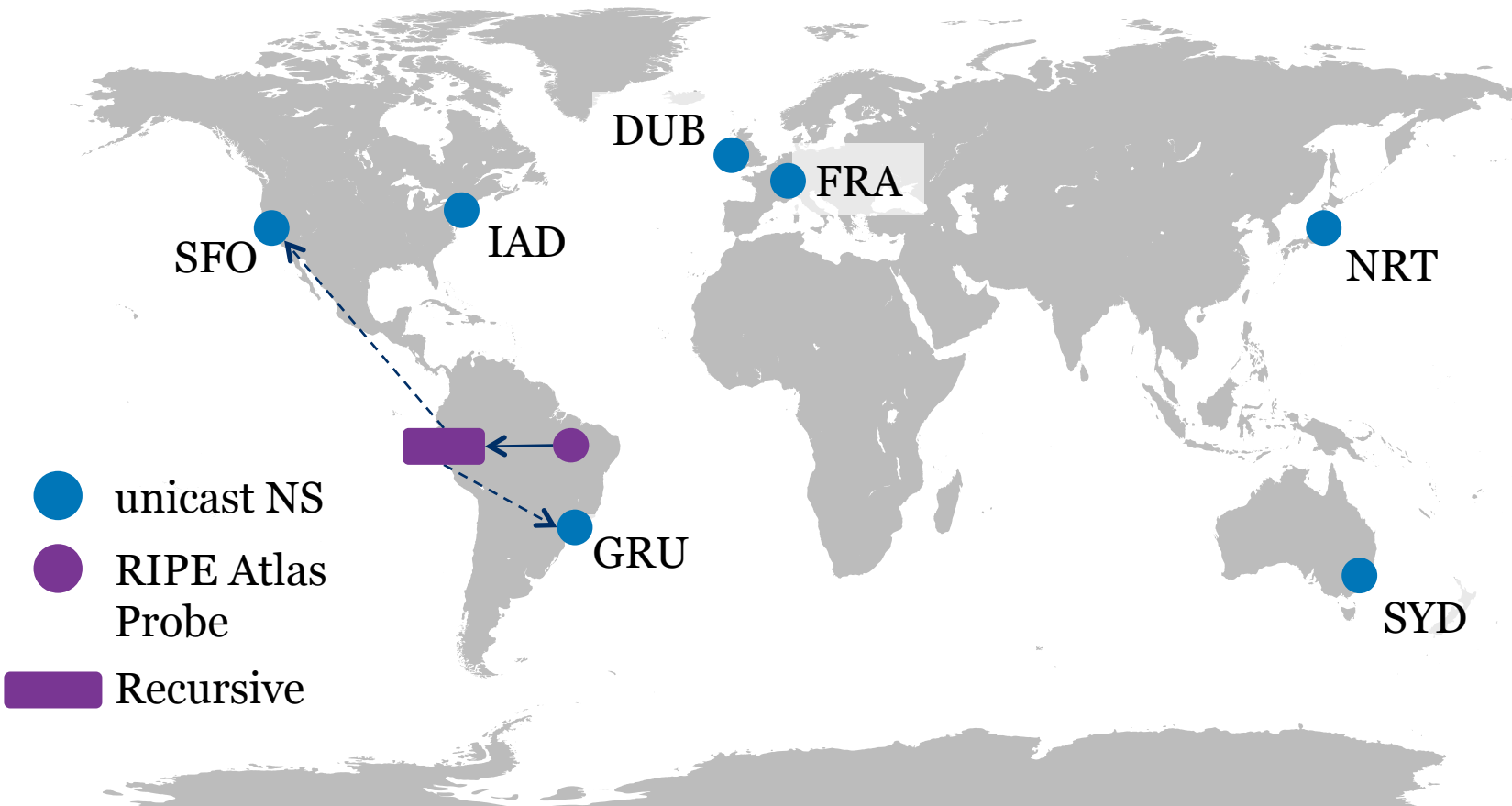GRU+NRT

DUB+FRA

FRA+SYD

GRU+NRT+SYD

DUB+FRA+IAD

DUB+GRU+NRT+SYD

DUB+FRA+IAD+SFO

IPv4 only (for now)

Measurement Design

Legend:
- unicast NS
- RIPE Atlas Probe
- Recursive

Setups:

GRU+NRT

DUB+FRA

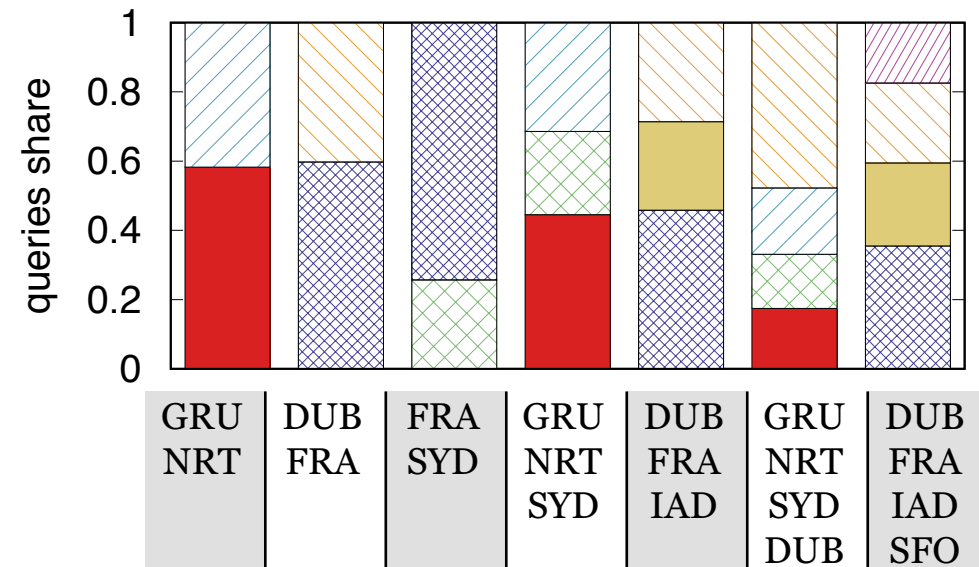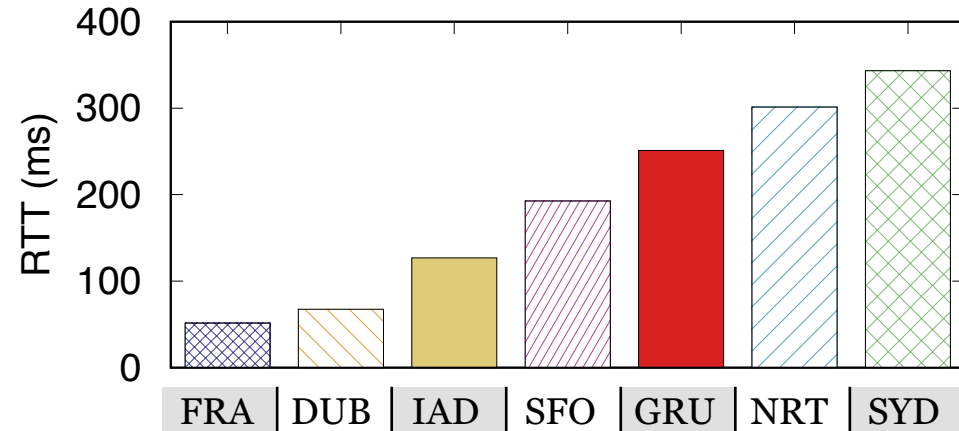FRA+SYD

GRU+NRT+SYD

DUB+FRA+IAD

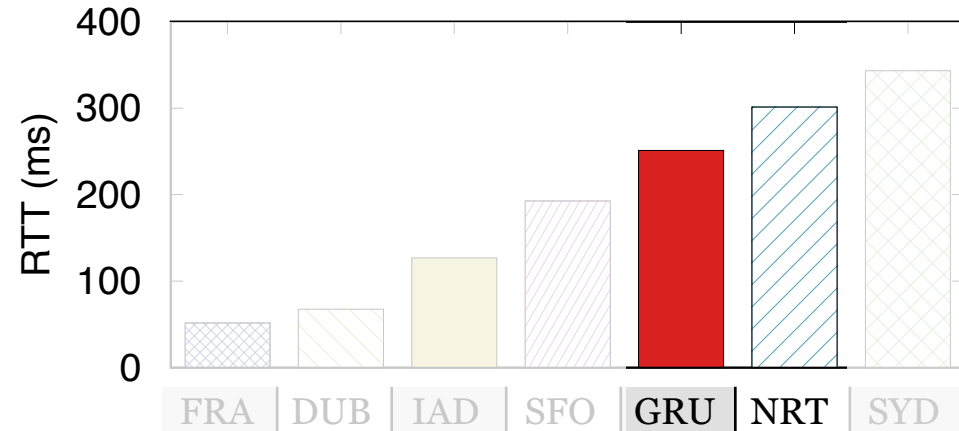DUB+GRU+NRT+SYD

DUB+FRA+IAD+SFO

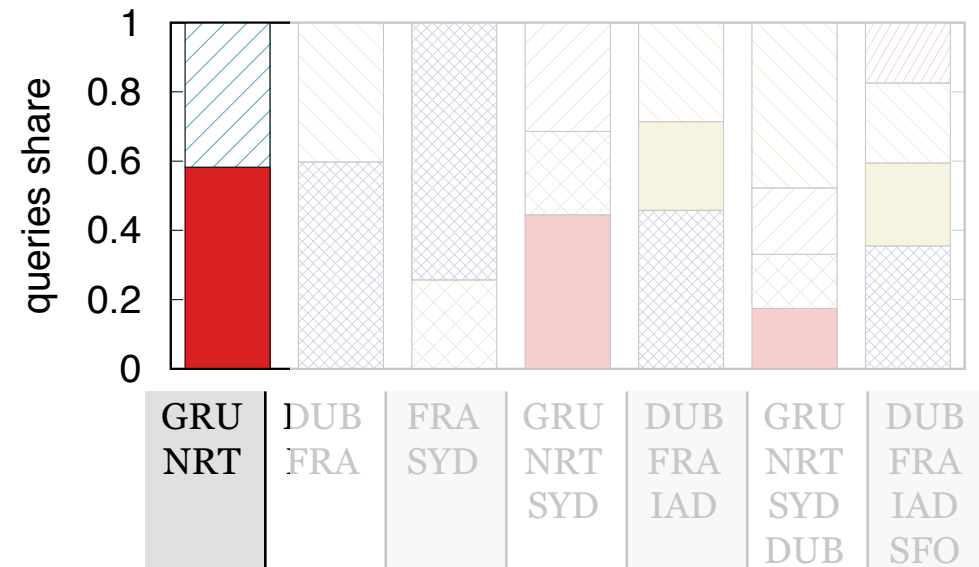IPv4 only (for now)

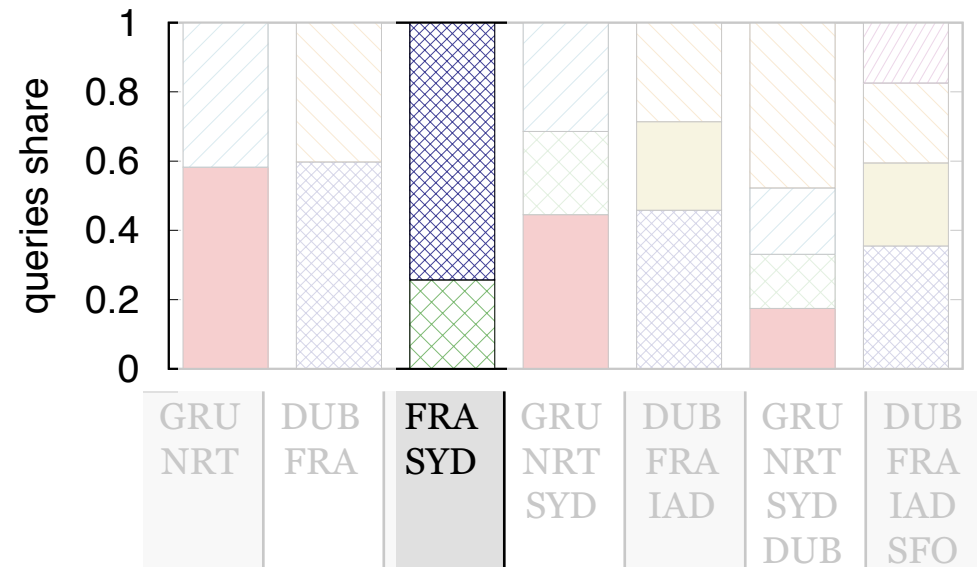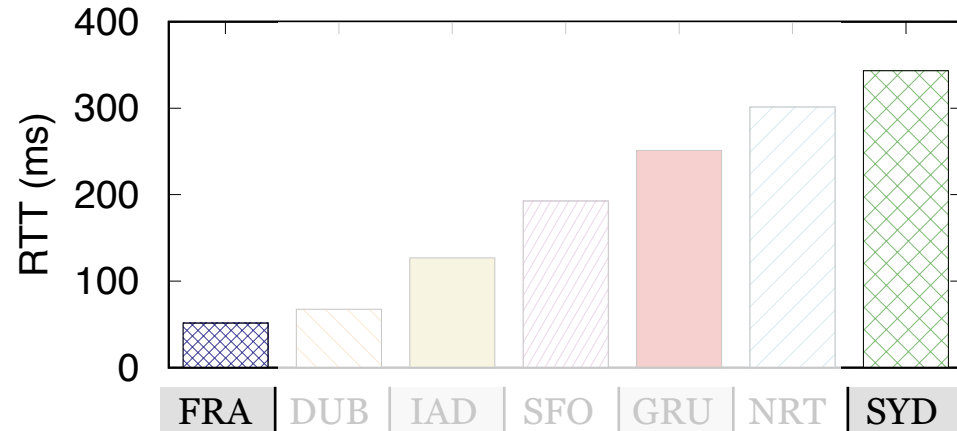# How do recursives distribute their queries over time?

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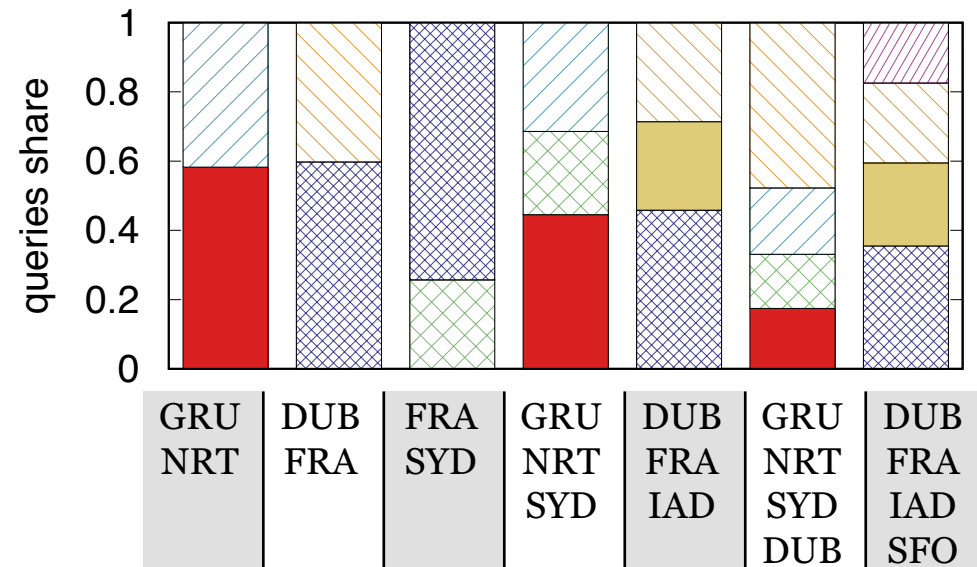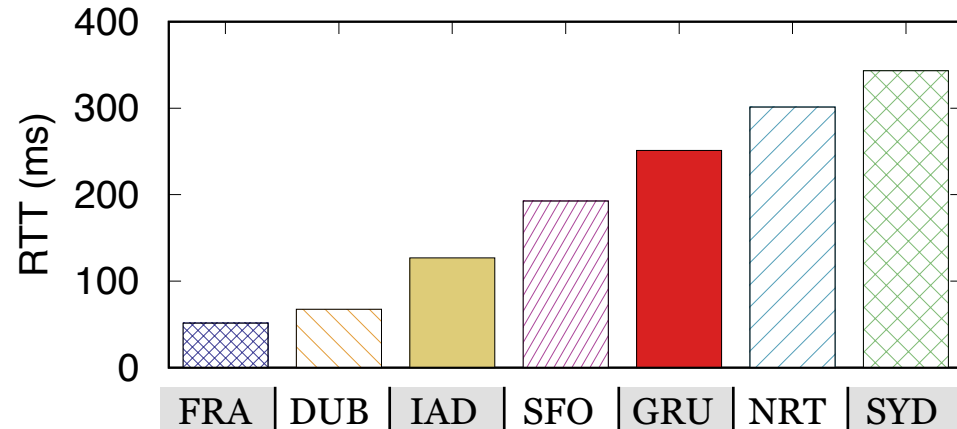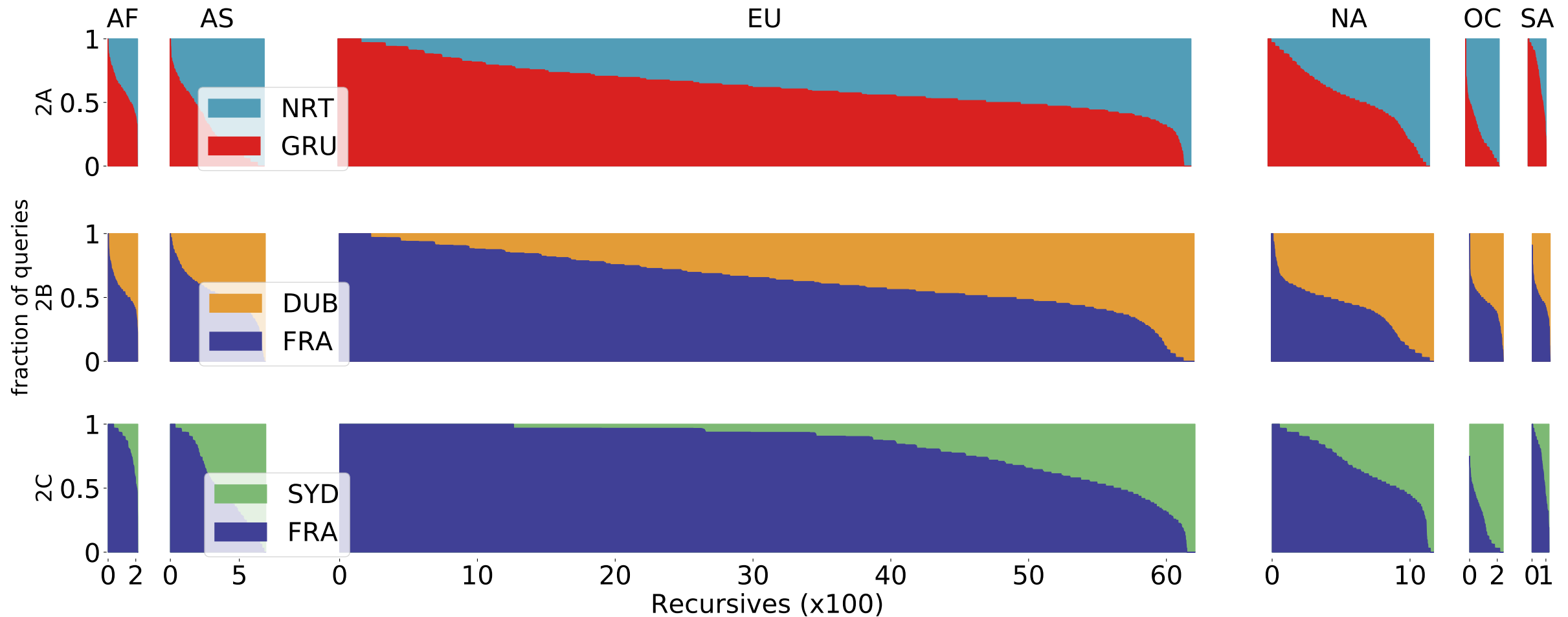
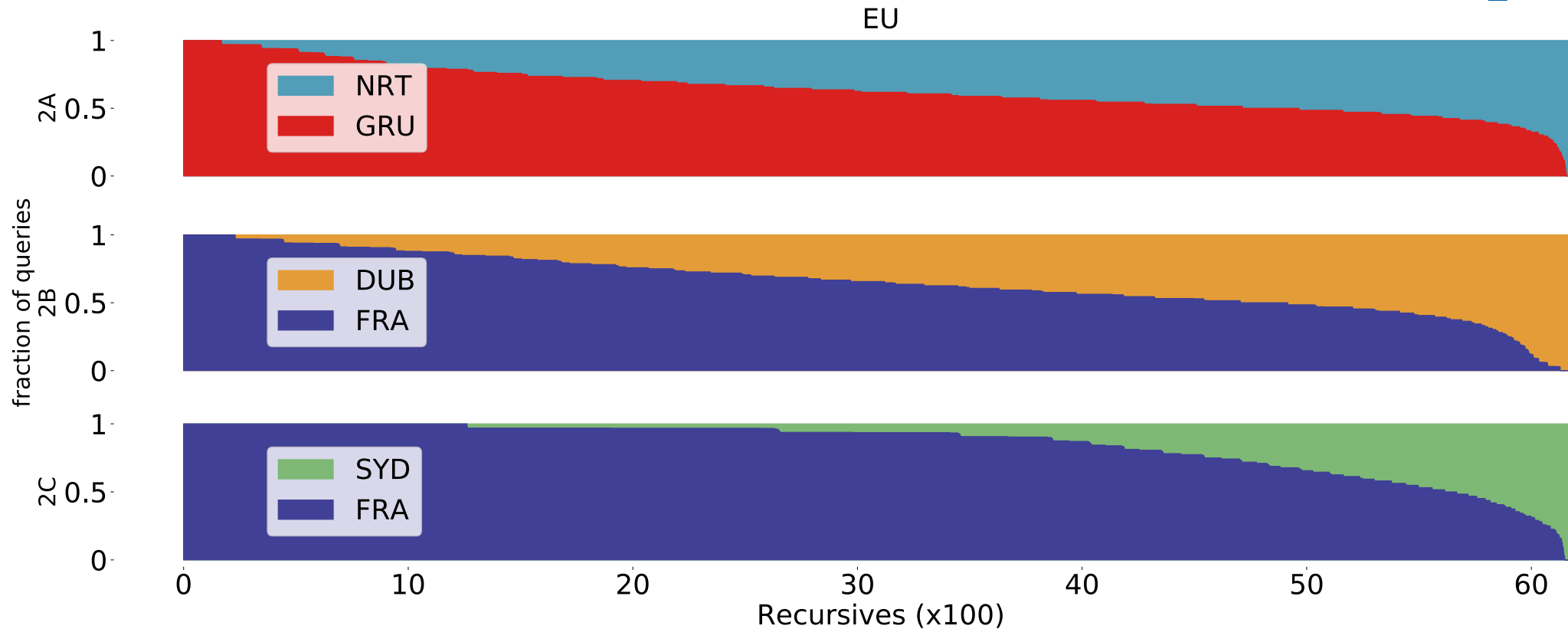# How do recursives distribute their queries over time?

- 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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EU

fraction of queries

2A
- NRT
- GRU

2B
- DUB
- FRA
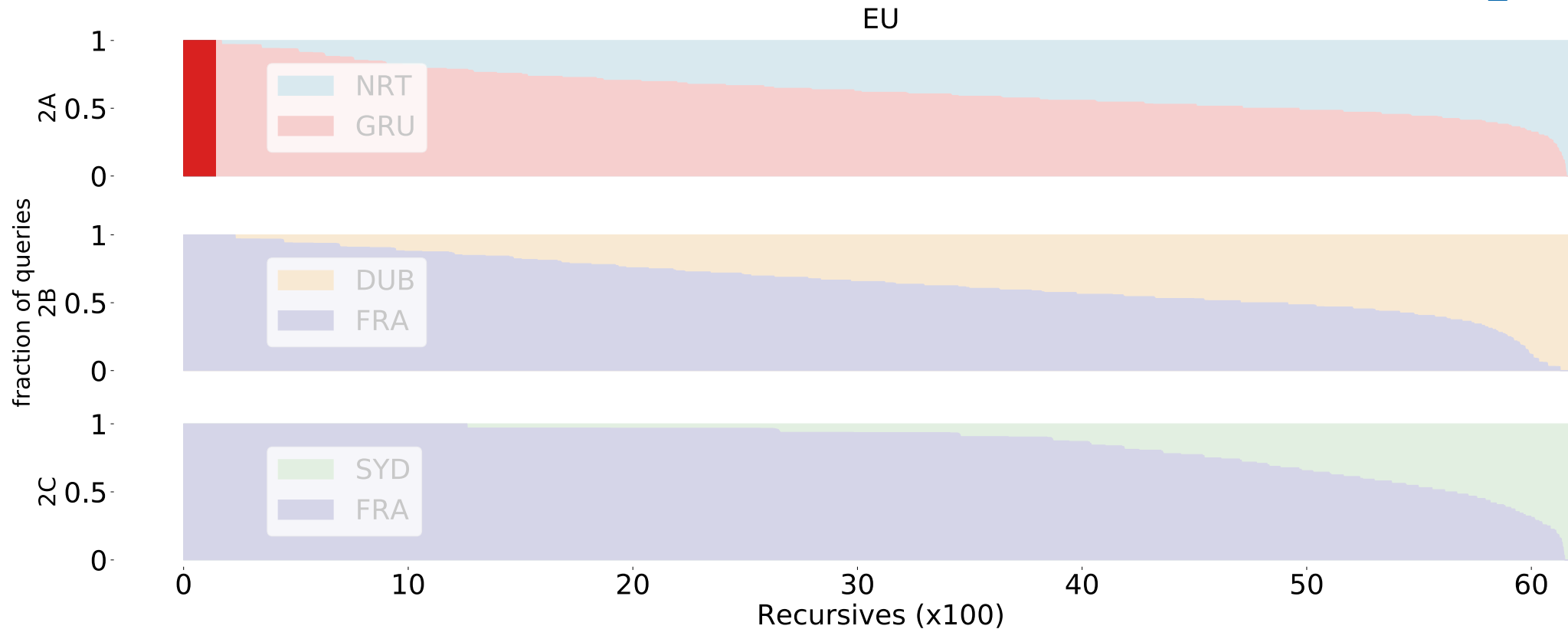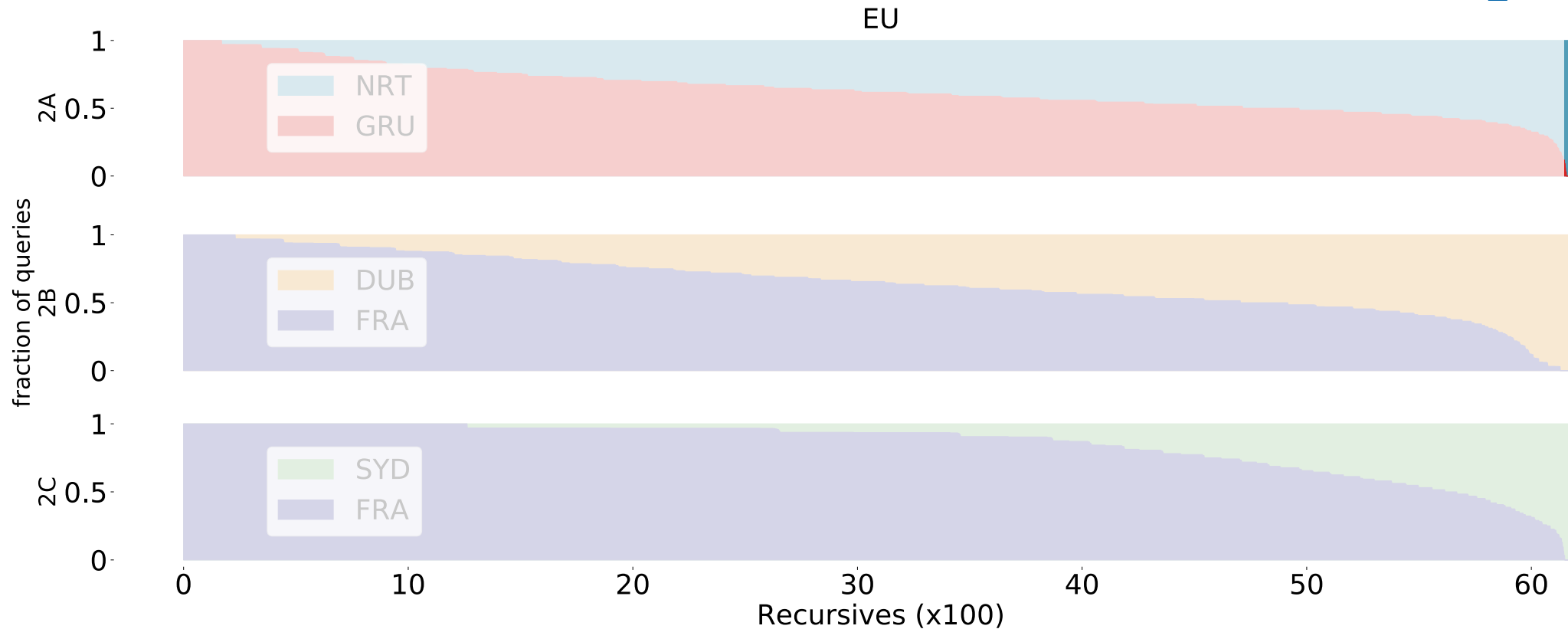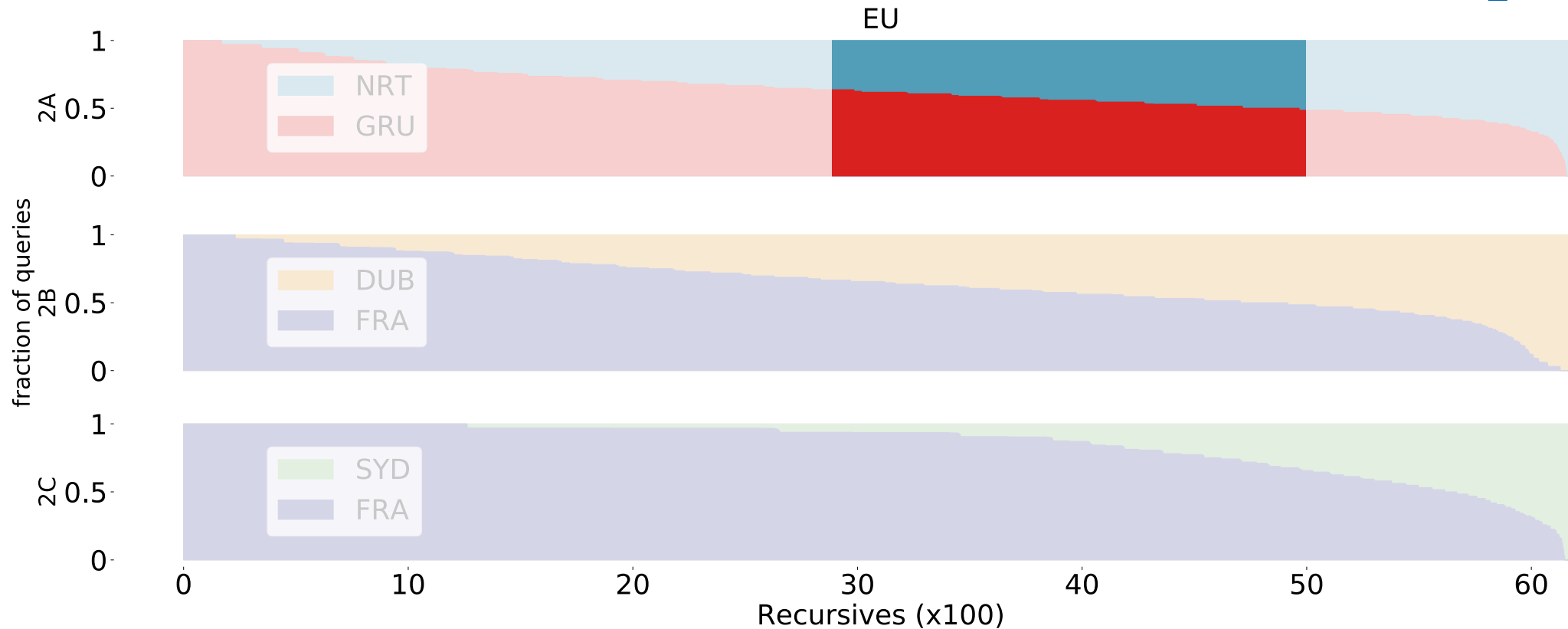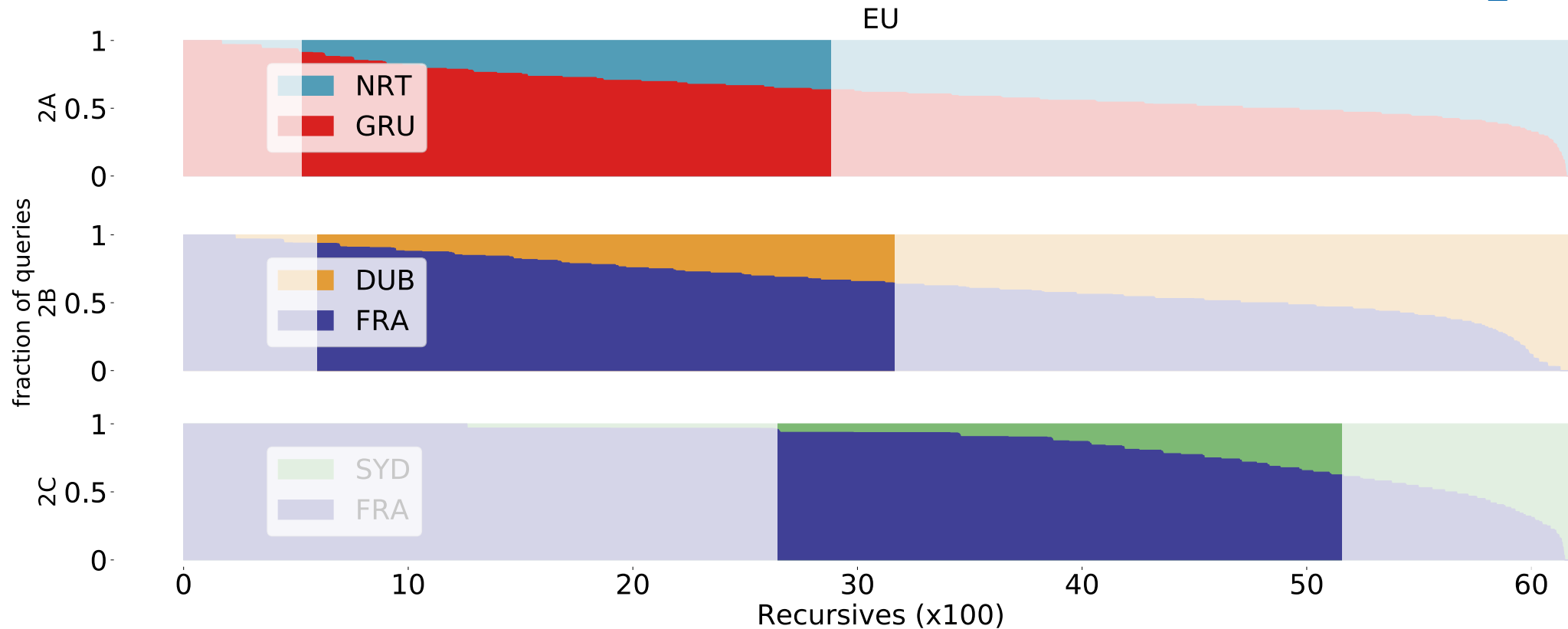
2C
- SYD
- FRA

Recursives (x100)

How do *individual* recursives distribute their queries?

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Up to 69% of resolvers have a weak preference
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How do *individual* recursives distribute their queries?

EU

2A — NRT / GRU

2B — DUB / FRA

2C — SYD / FRA

fraction of queries
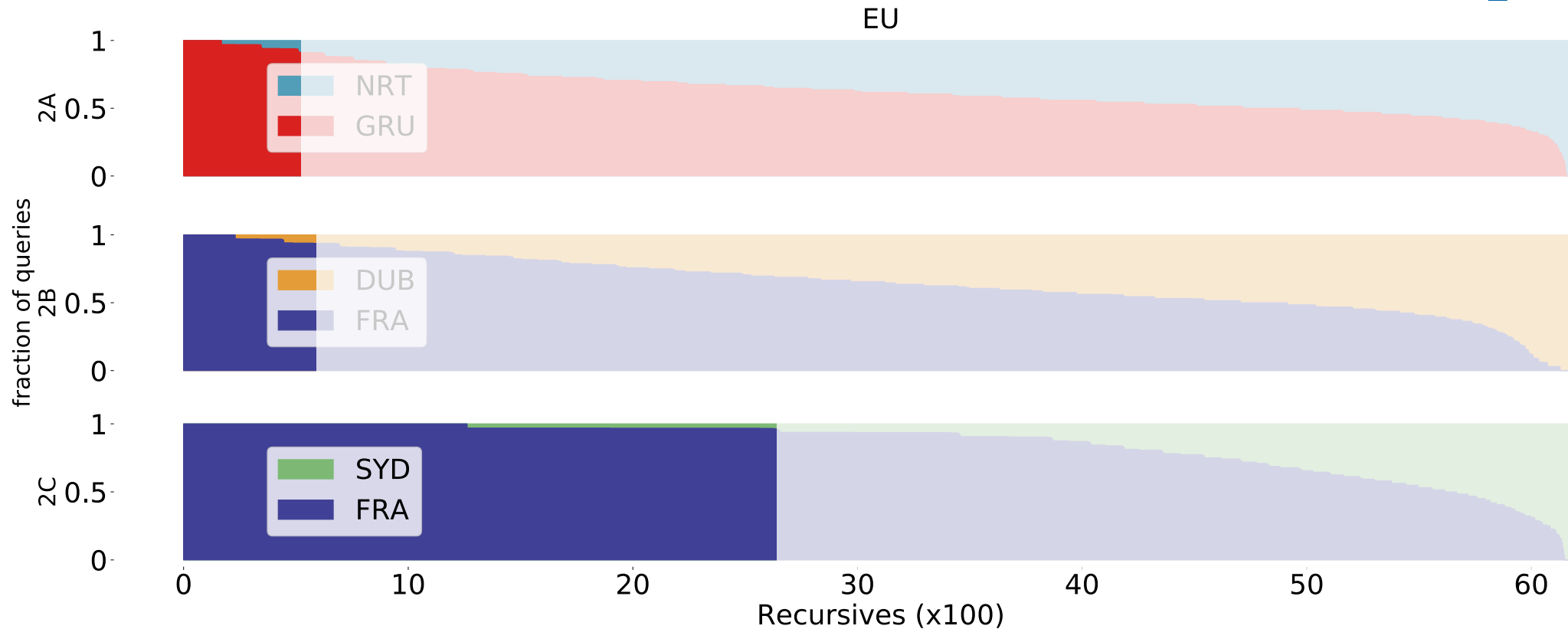
Recursives (x100)

Up to 37% of resolvers have a strong preference
(more than 90% of their queries to one NS)

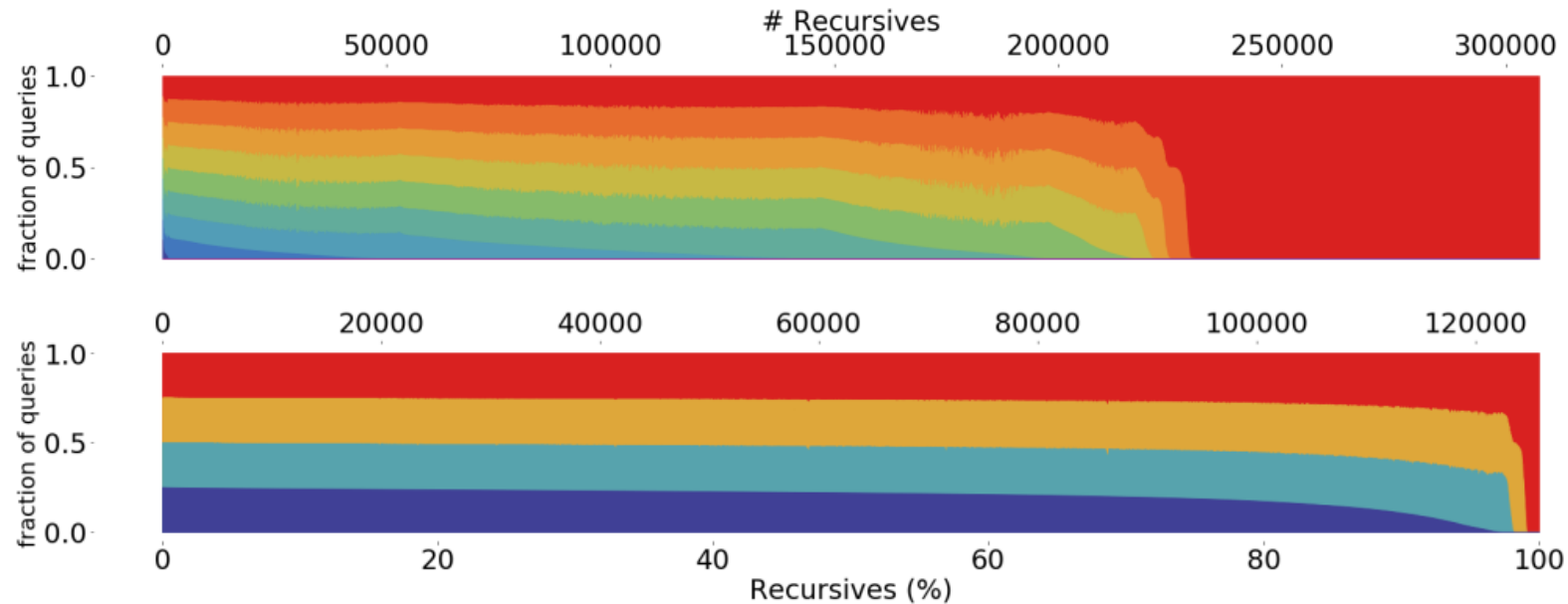# How do *individual* recursives distribute their queries?
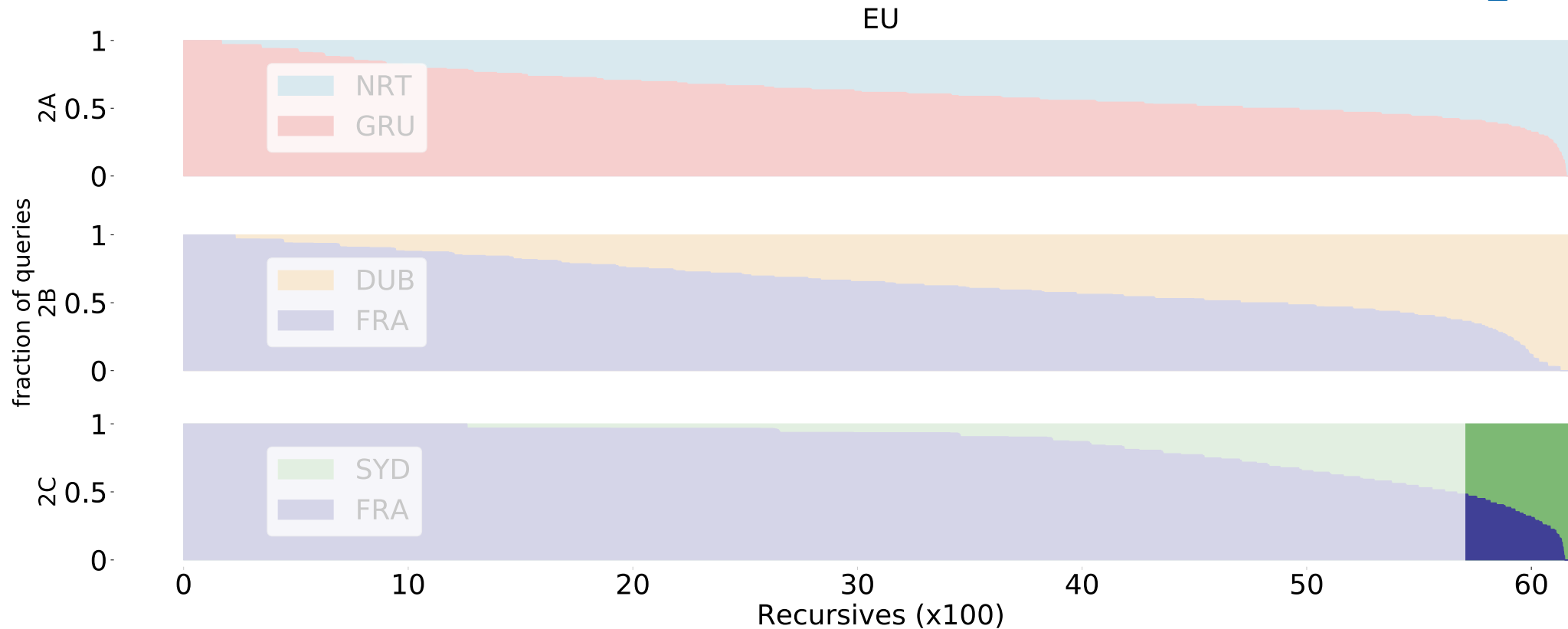
Some resolvers always prefer the slower NS

Validation: Authoritatives in Production

Root Servers
(10 out of 13)

.nl Servers
(4 out of 8)

- Root: +60% query at least 6 servers

- .nl: +90% query at least 4 servers

- Overall confirms the observations from our test bed

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

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Data Sets

All data sets (but one) available:

https://ant.isi.edu/datasets/dns/index.html#recursives

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Questions?

Moritz Müller

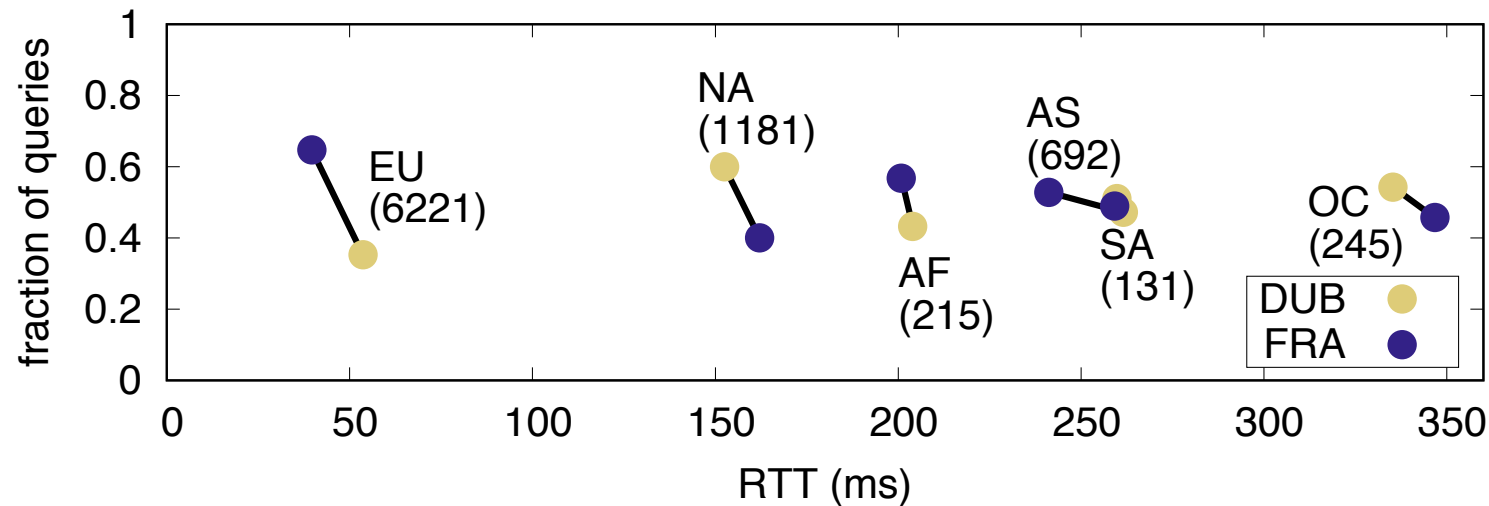email: moritz.muller@sidn.nl

twitter: @moritzcm_

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?
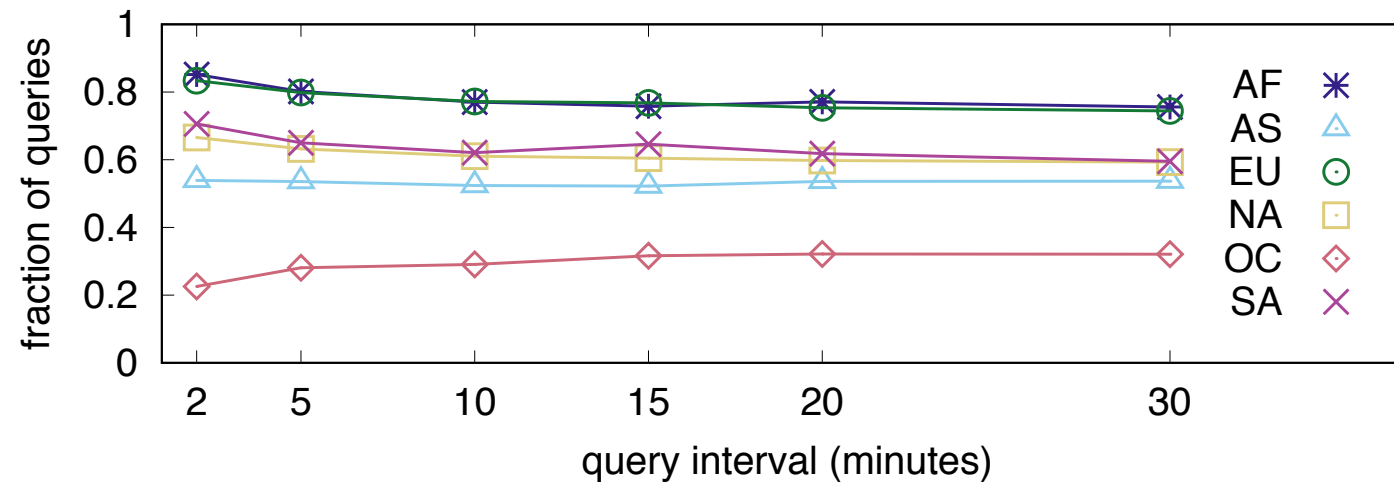
- A higher query frequency leads to a stronger preference

- However, preference persists even after the default timeout of resolvers like Bind and Unbound

Do recursives query all authoritatives?
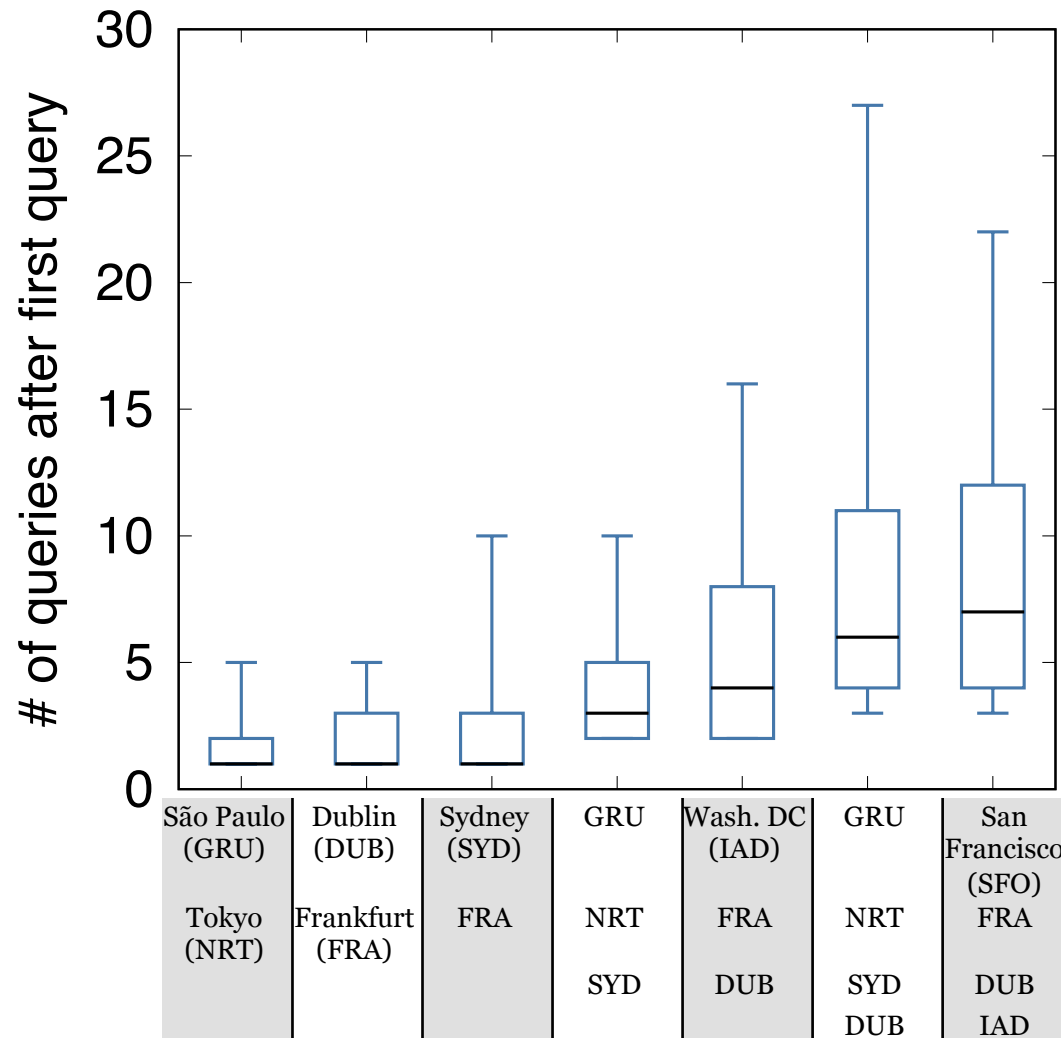
Yes, the majority of resolvers query every authoritative