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

Before we start...

- How many DNS operators in the room?

- Role: point of view of a DNS operator that wants to reduce latency to its services

  - Why? : **Time (latency) is money**

    Many reports (google, amazon): report : high latency, less searches

    - Paper presented at ACM IMC2017 in London

Introduction

unicast
anycast

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

- Example of a DNS authoritative setup:

  8 authoritative name severs for the same zone (.nl)

  Could be the same for any second-level domain

- Redundancy for high availability

Introduction
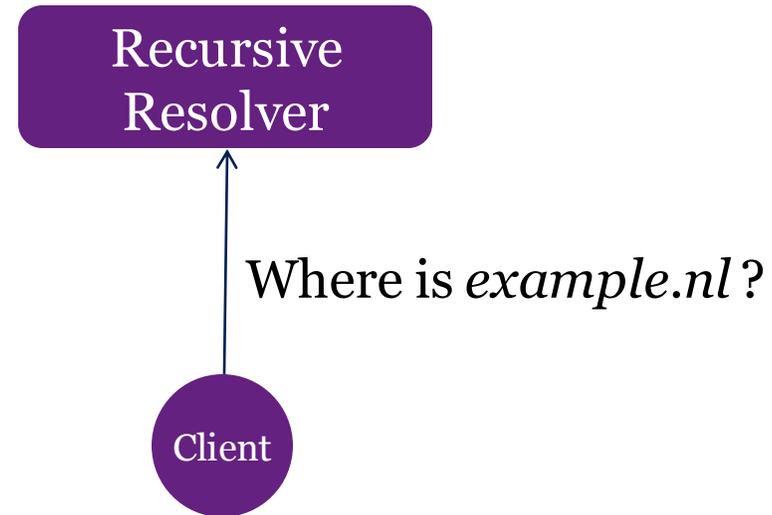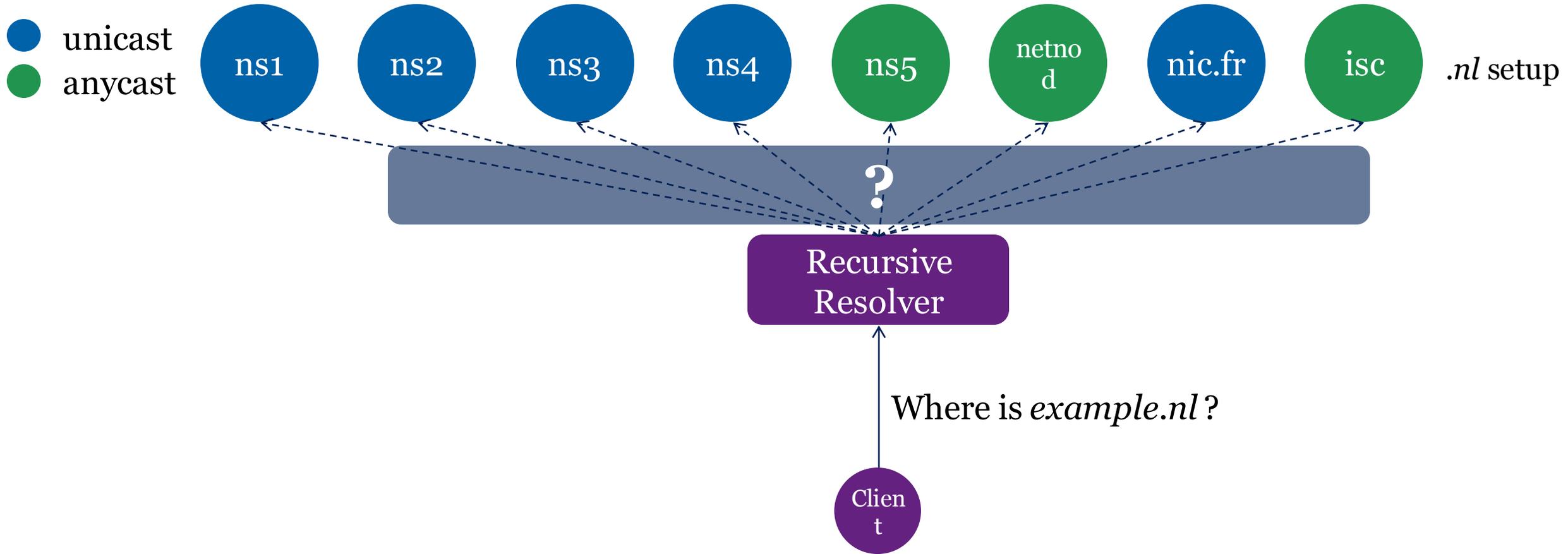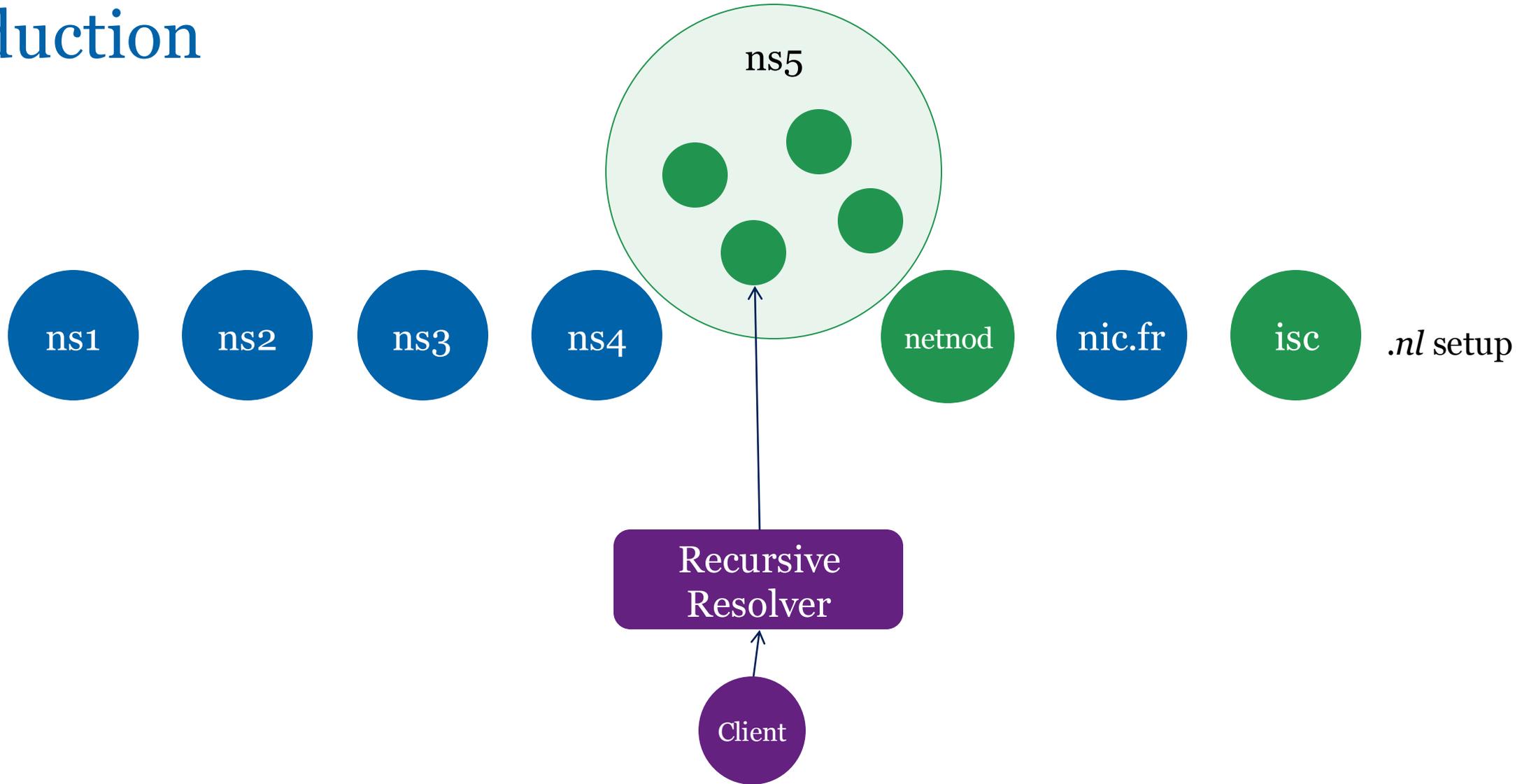
unicast
anycast

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

Recursive Resolver

Where is *example.nl* ?

Client

USC Viterbi
School of Engineering

UNIVERSITY OF TWENTE.

SIDN LABS

Introduction

unicast
anycast

ns1 ns2 ns3 ns4 ns5 netnod nic.fr isc

.nl setup

?

Recursive Resolver

Where is *example.nl* ?

Client

Introduction

unicast
anycast

ns5

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

Recursive Resolver

Client

Introduction

area relative to the number of _sites_

ns1 ns2 ns3 ns4 ns5 netnod nic.fr isc
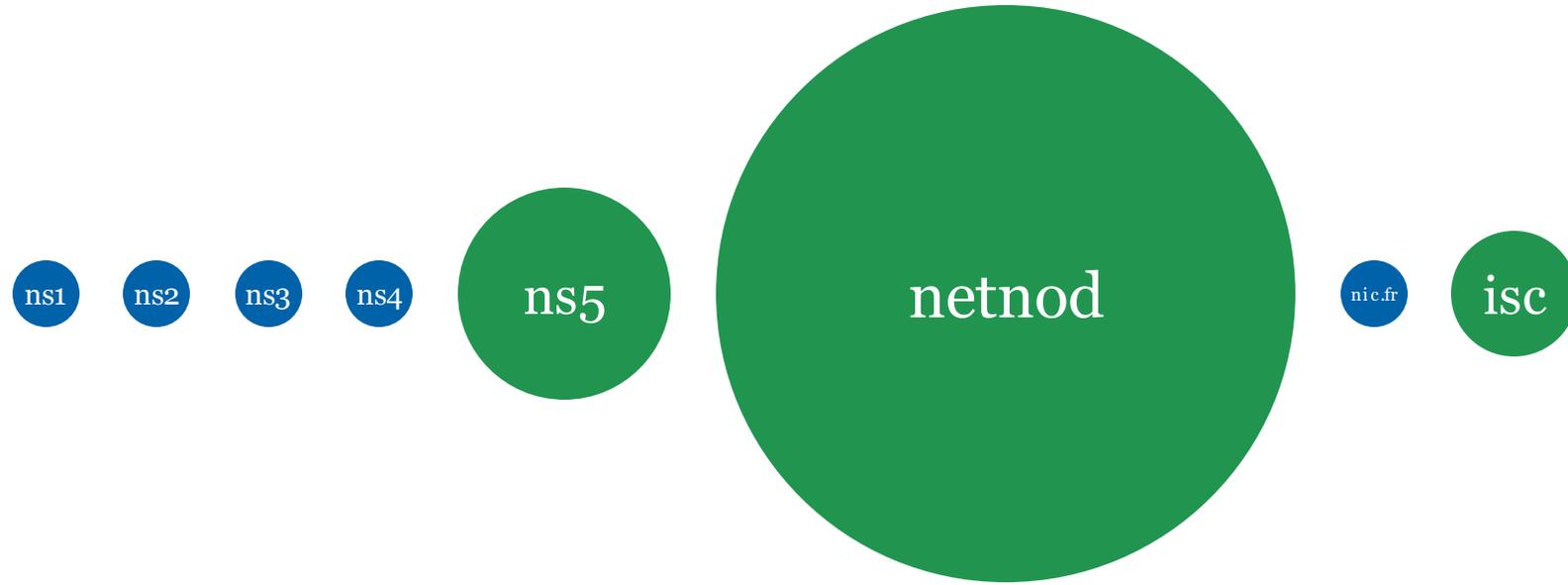
Introduction

area relative to the number of *sites*
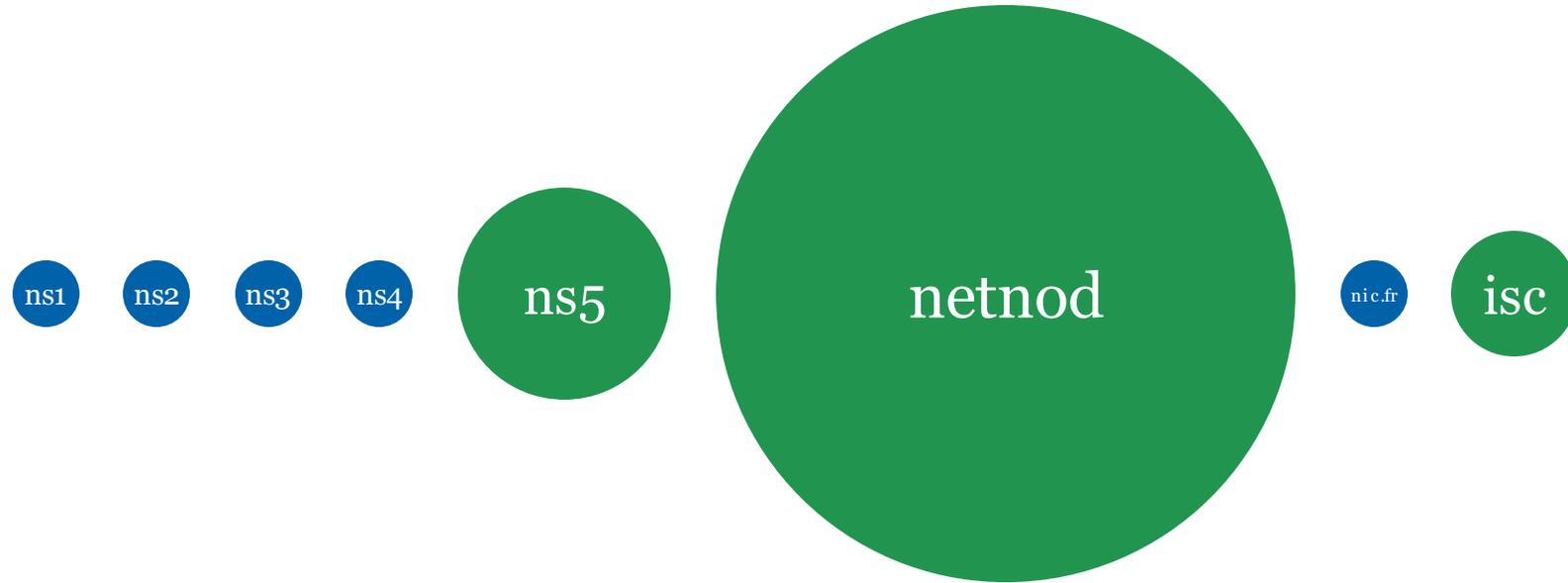
area relative to the number of *queries*

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

9

Why is that?

unicast (blue) / anycast (green)

.nl setup: ns1, ns2, ns3, ns4 (unicast) — ns5, netnod, nic.fr, isc (anycast)

Recursive Resolver

who has *example.nl* ?

Client

10
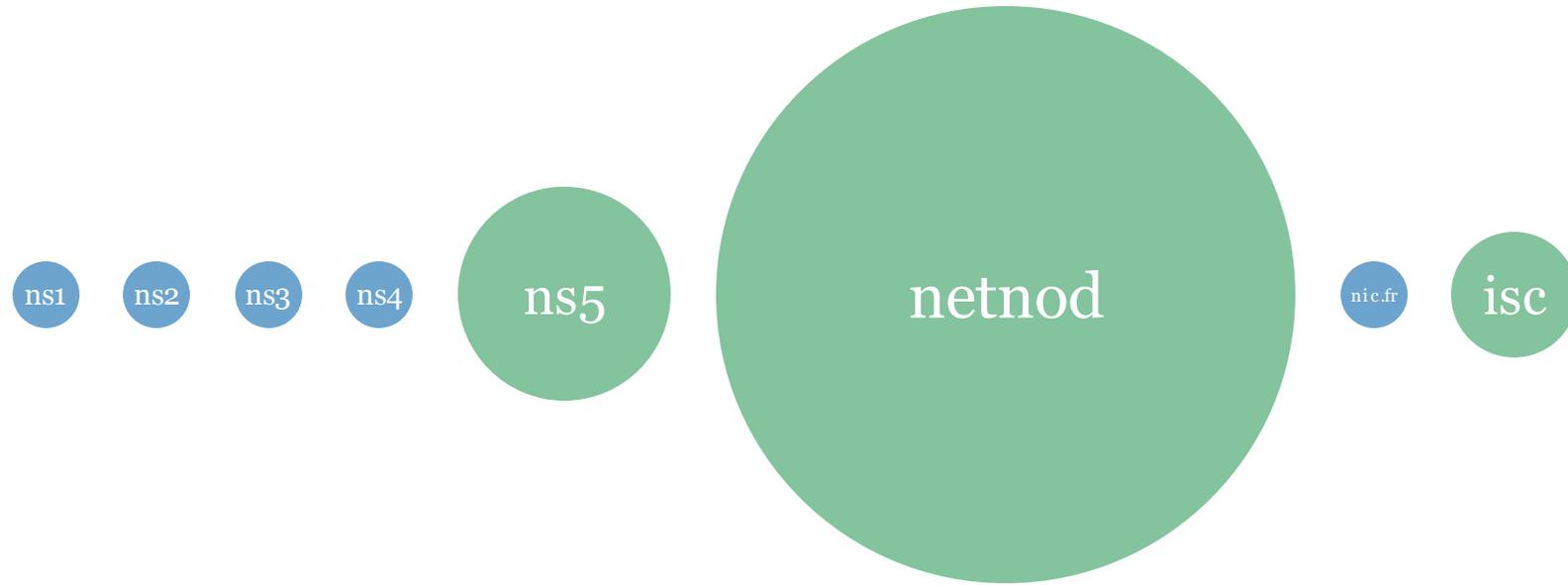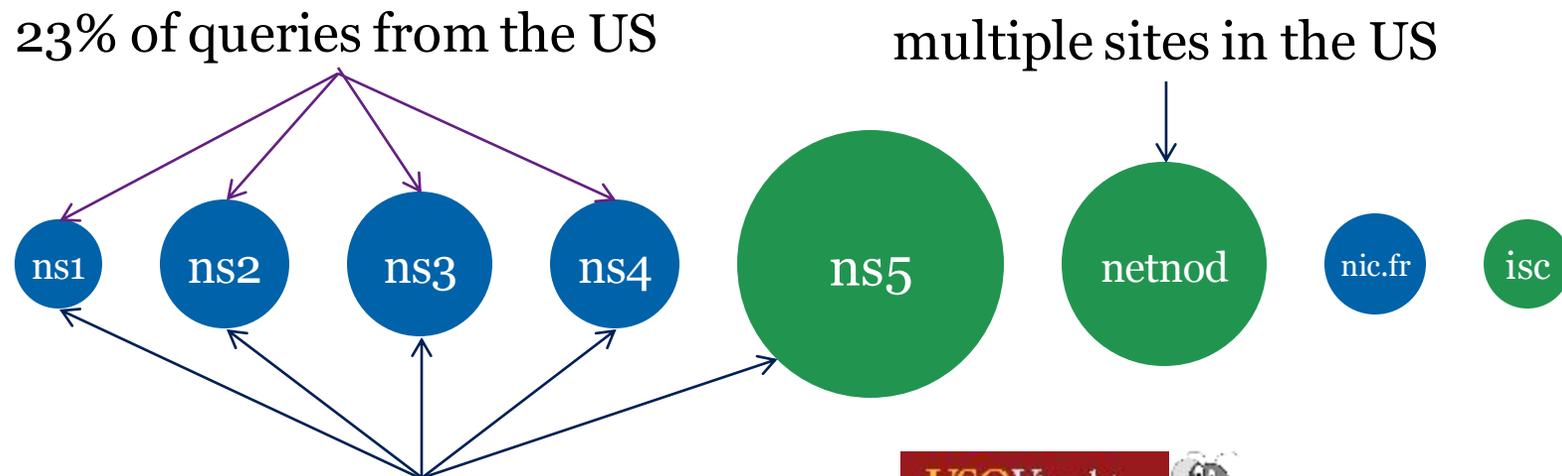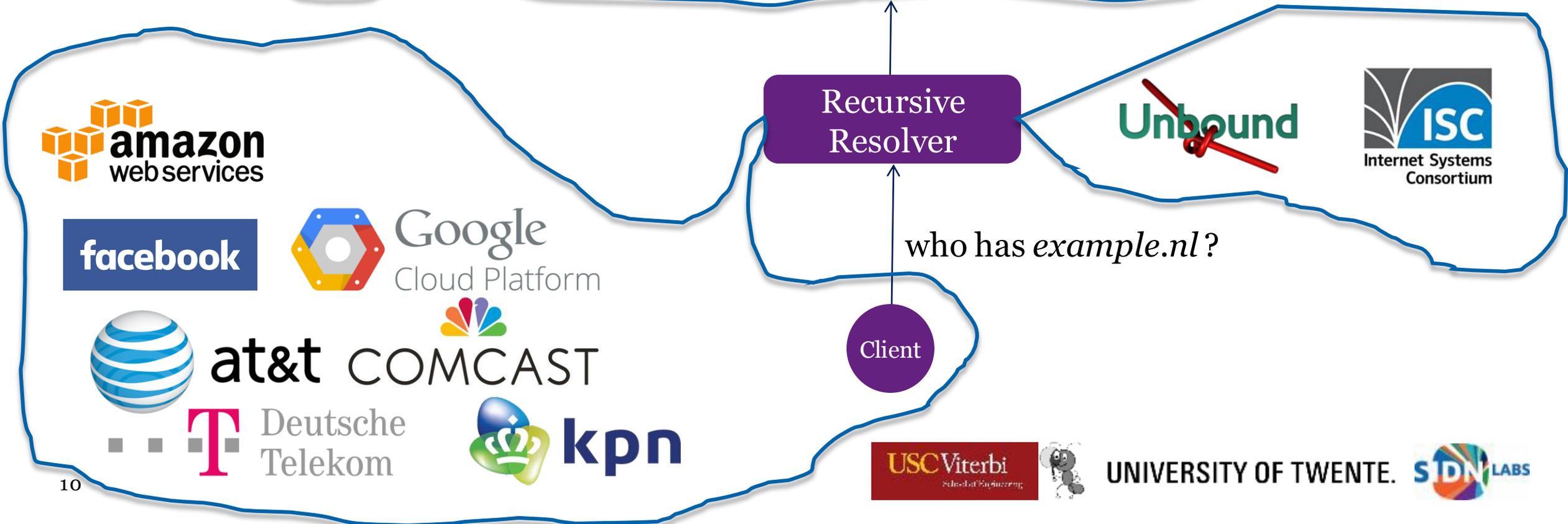
Research Questions

- 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 DNS 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)

Measurement Design
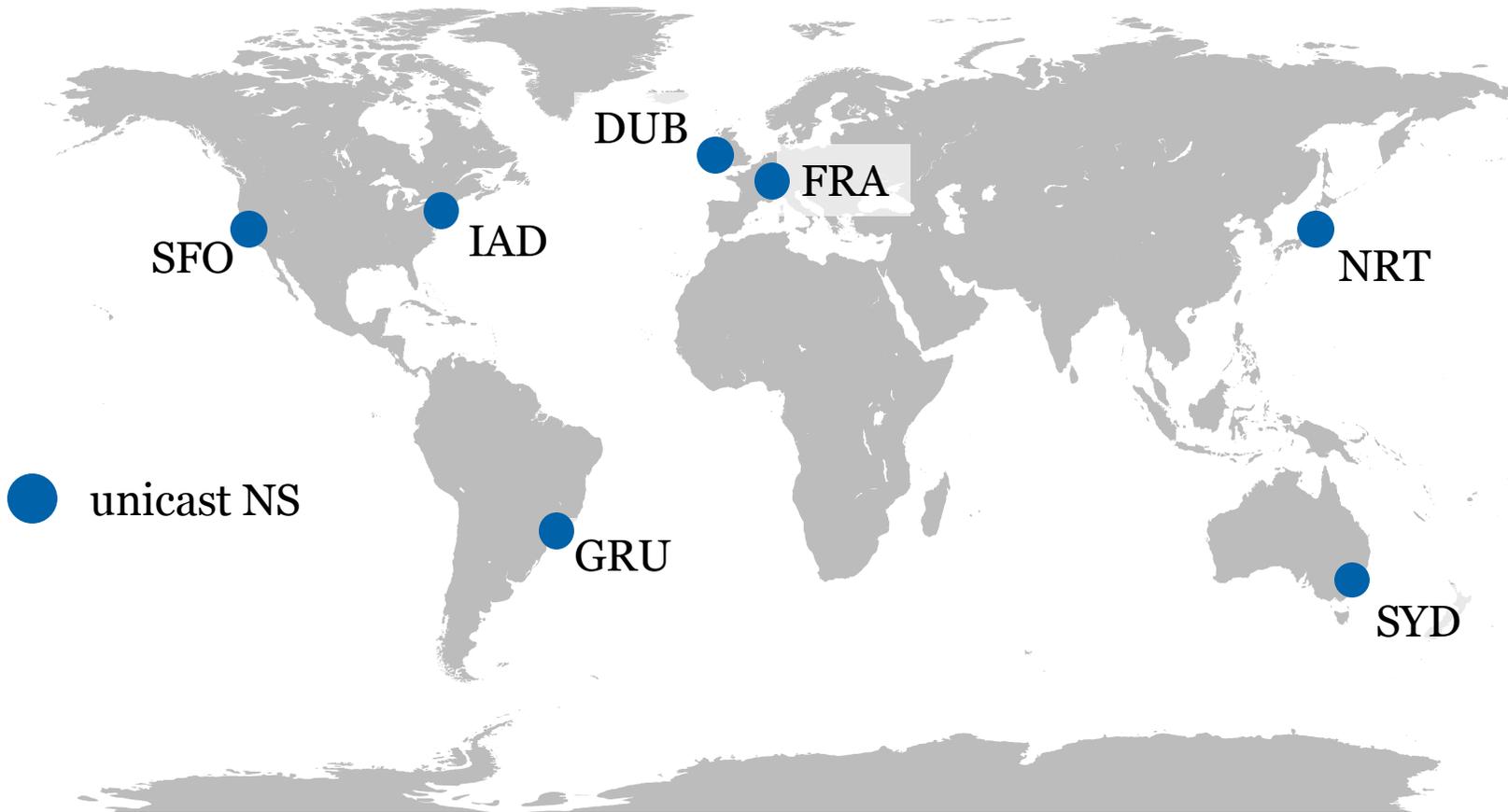
unicast NS

Map markers: SFO, IAD, DUB, FRA, NRT, GRU, SYD

7 measurement 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)

USC Viterbi
School of Engineering

UNIVERSITY OF TWENTE. SIDN LABS

Measurement Design

7 measurement 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)

Map labels: DUB, FRA, IAD, SFO, NRT, GRU, SYD
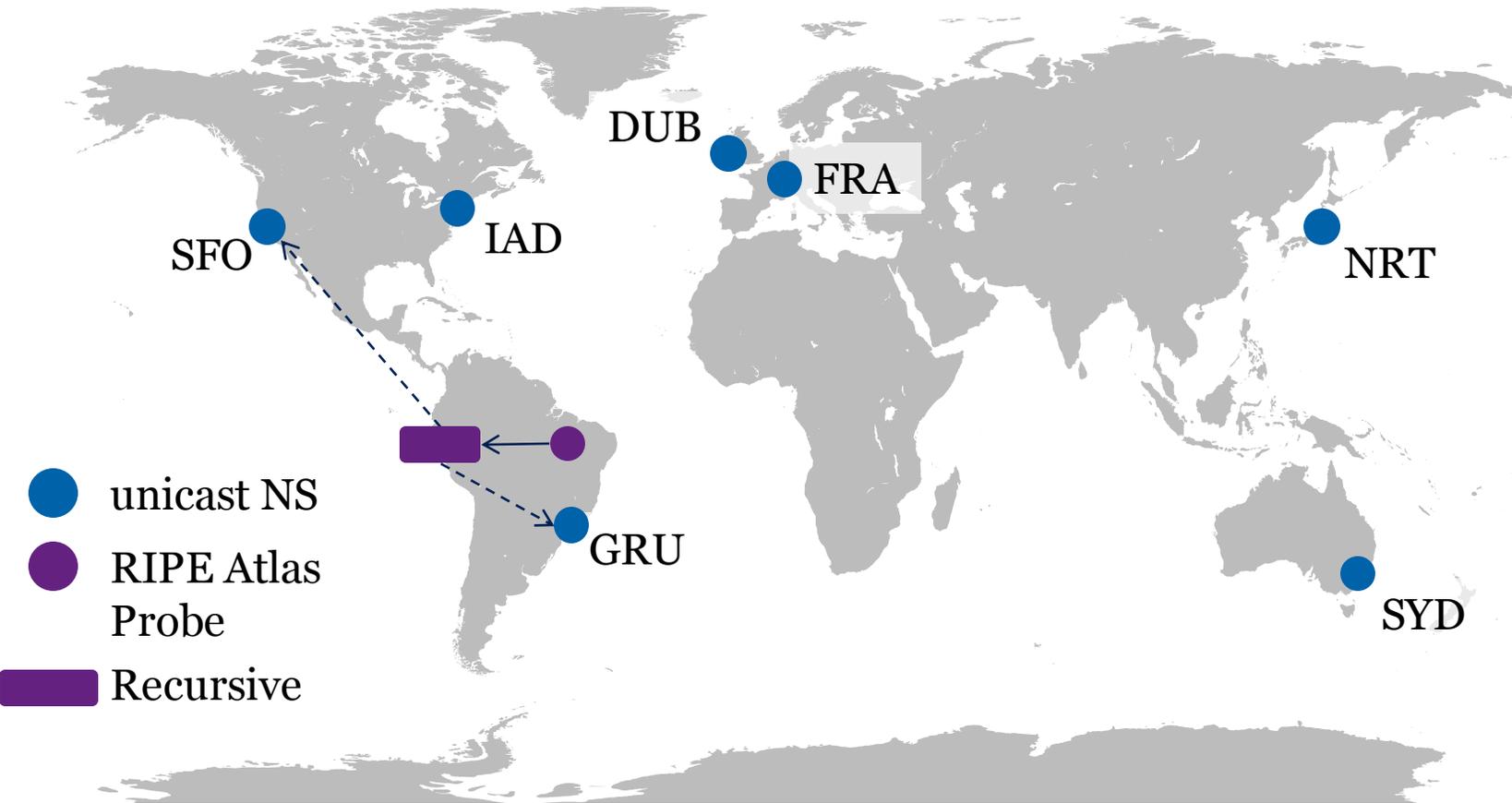
Legend:
- unicast NS
- RIPE Atlas Probe
- Recursive

1 hour each measurement, ever 2 min

~9000 Ripe Atlas probes from ~2500 ASes

USC Viterbi — School of Engineering

UNIVERSITY OF TWENTE.

SIDN LABS

13

Do recursives query all authoritatives?
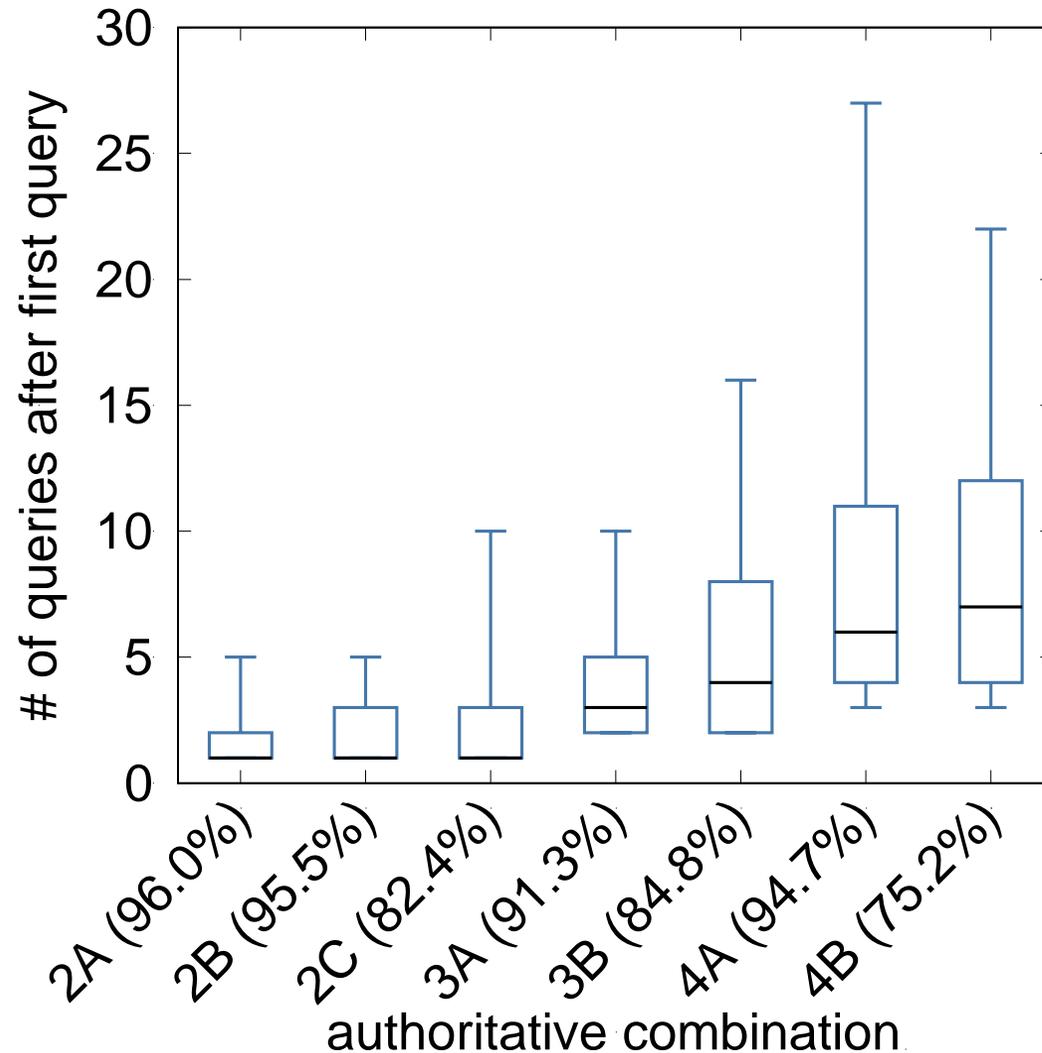
- Majority will quickily query ALL authortitatives
- Meaning "one bad apple may spoil the whole bunch" ?
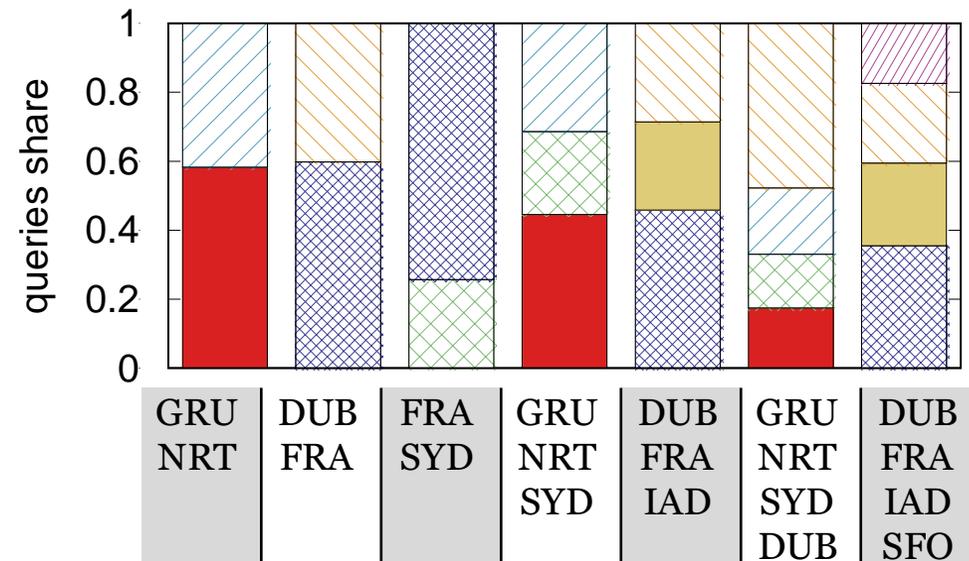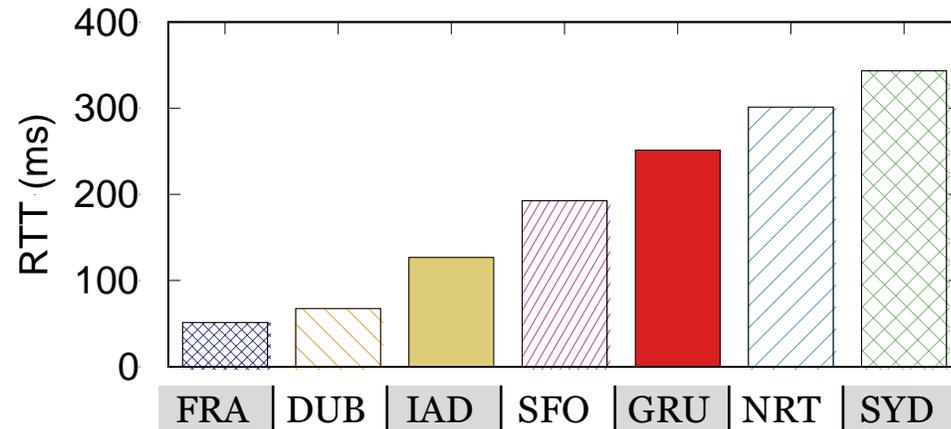
USC Viterbi
School of Engineering

UNIVERSITY OF TWENTE.

SIDN LABS

How do recursives distribute their queries over time?

How do recursives distribute their queries over time?
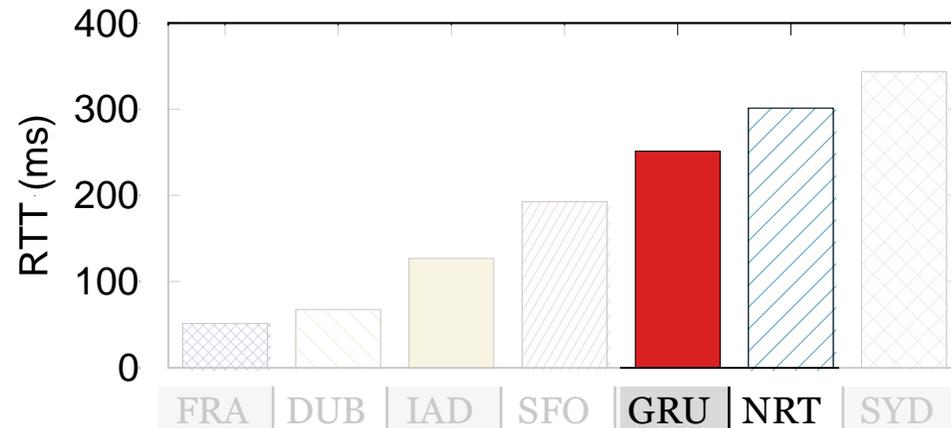
- Authoritatives with similar latency get similar number of queries
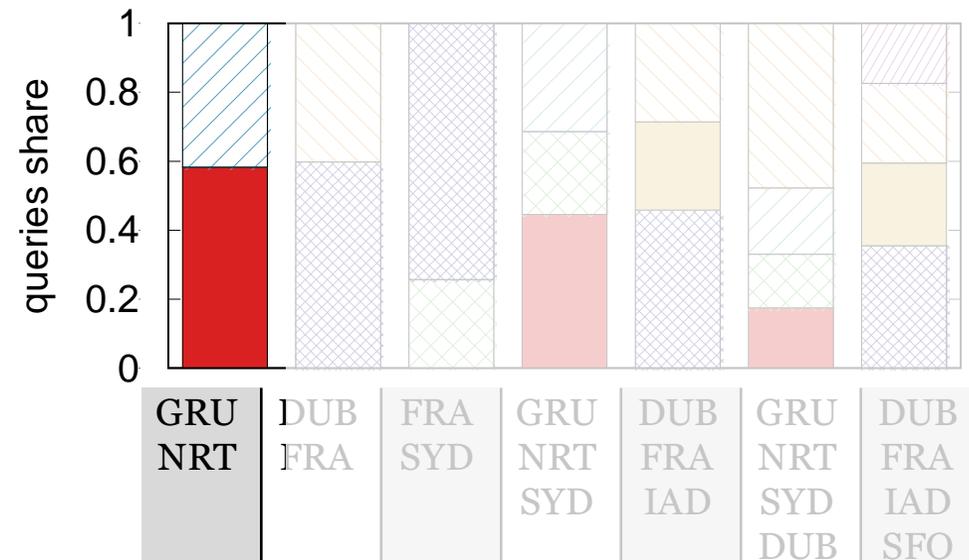
How do recursives distribute their queries over time?
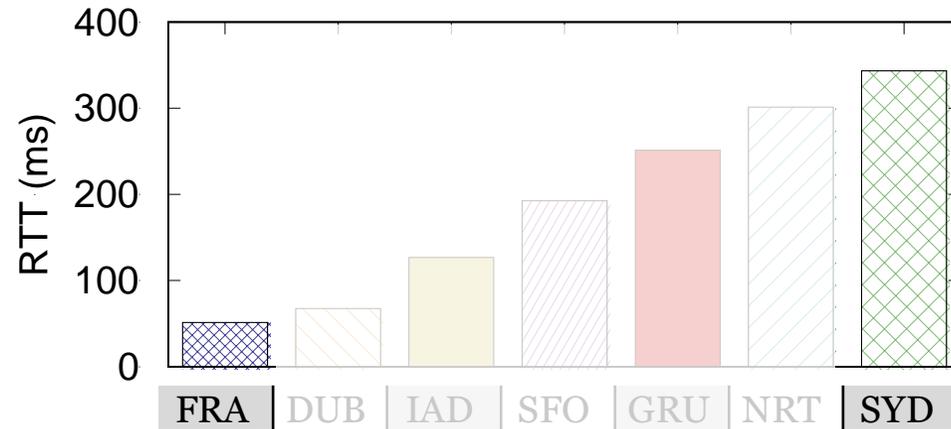
- Authoritatives with similar latency get similar number of queries

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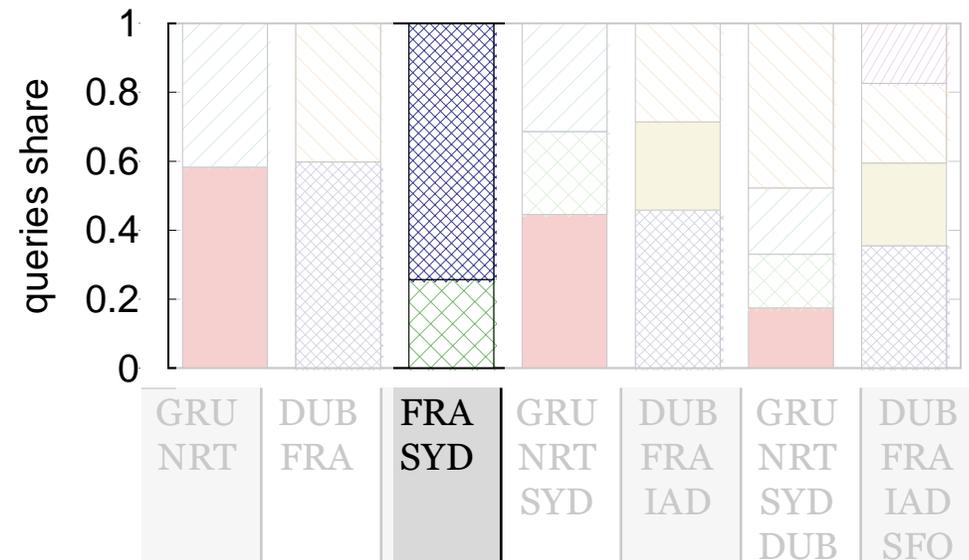
How do recursives distribute their queries over time?
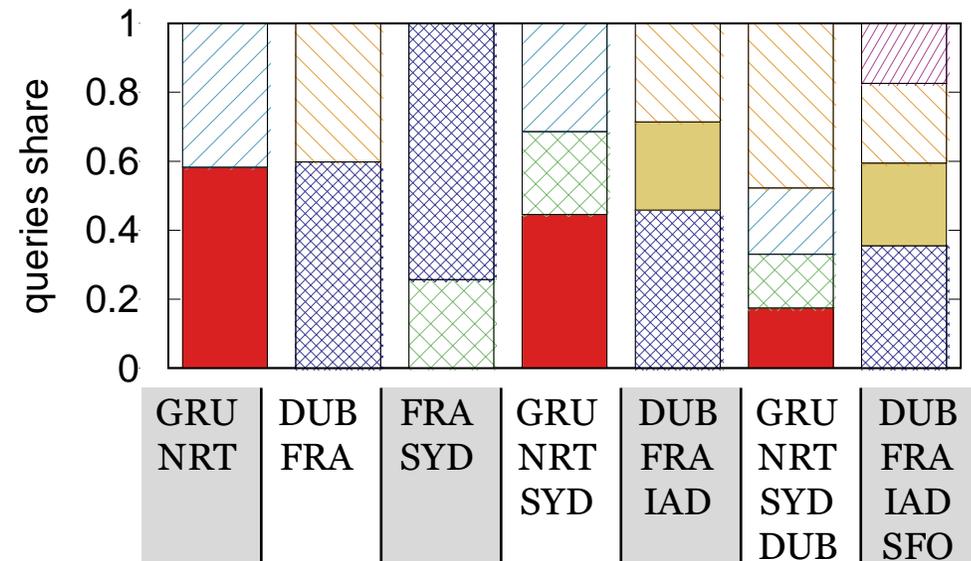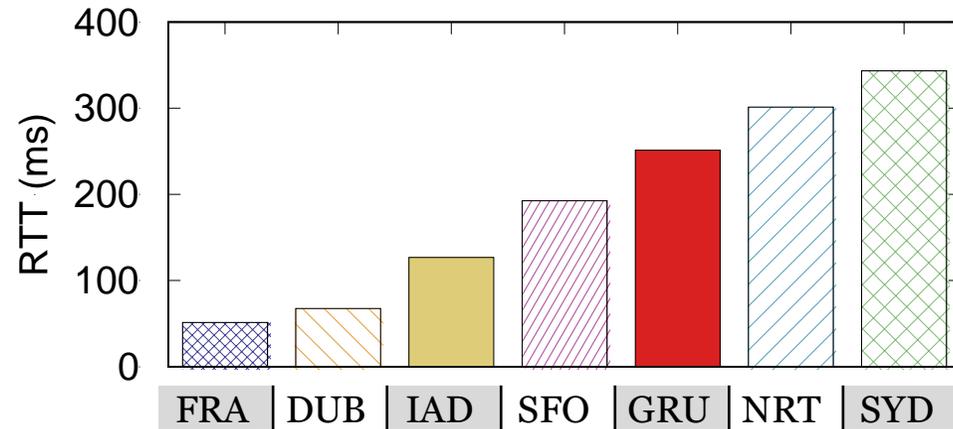
- Authoritatives with similar latency get similar number of queries

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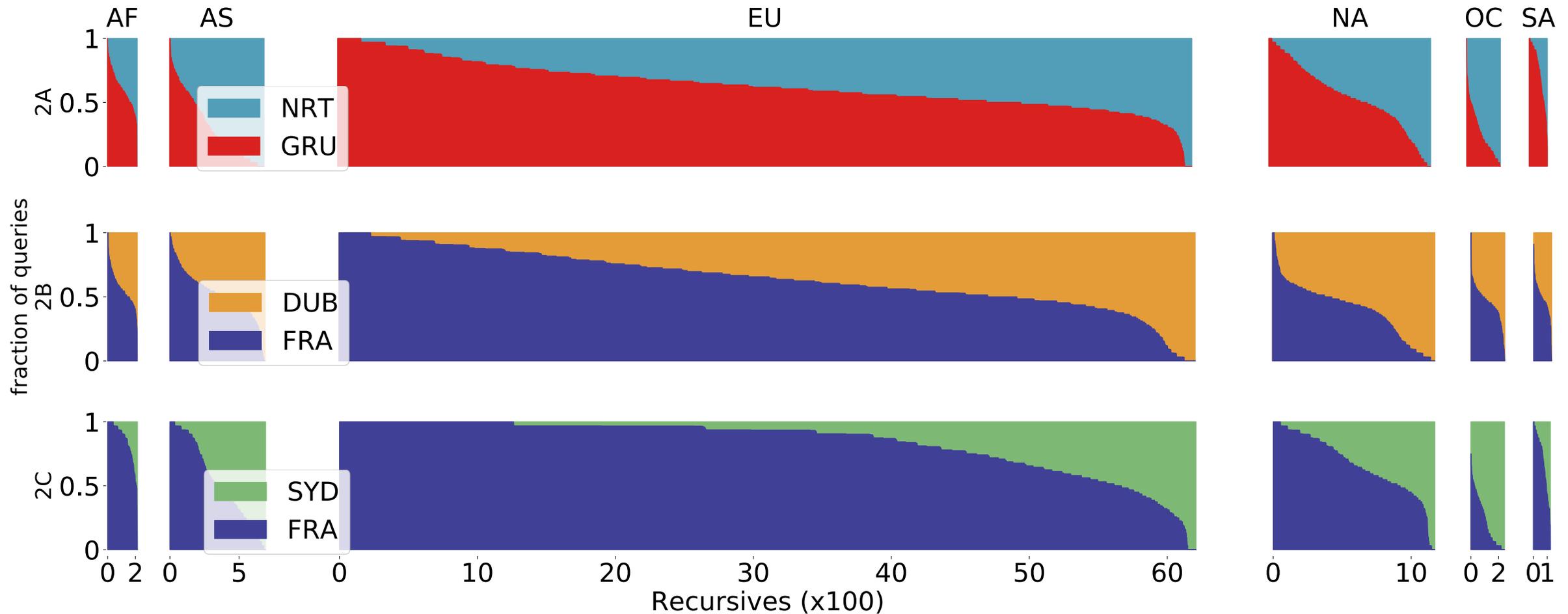
How do *individual* recursives distribute their queries?
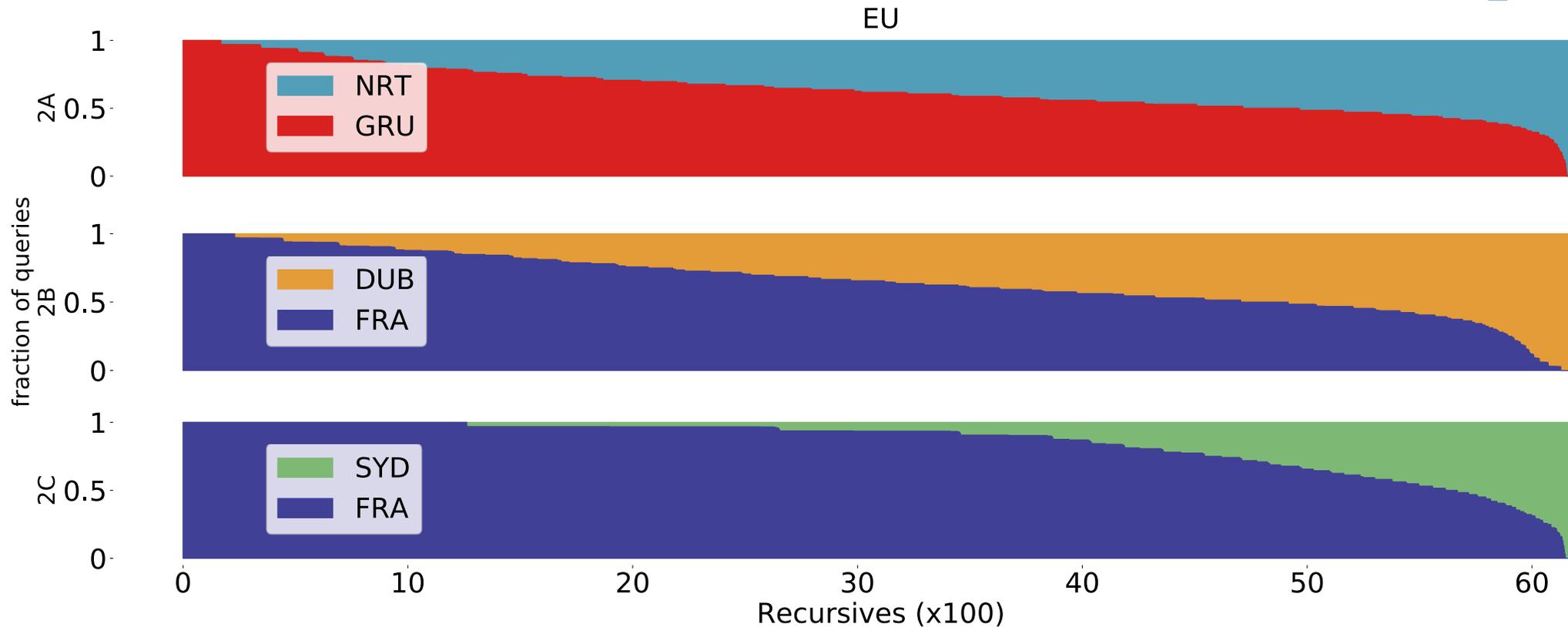
How do *individual* recursives distribute their queries?
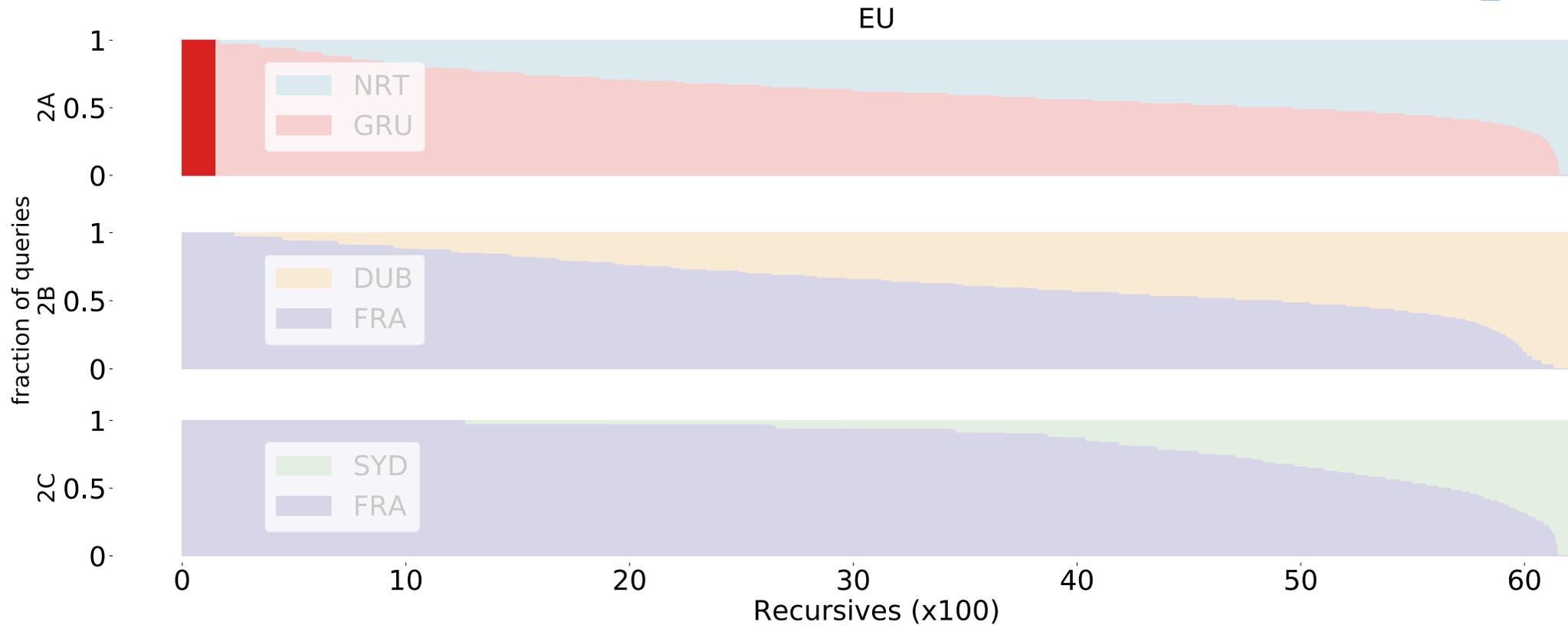
How do *individual* recursives distribute their queries?
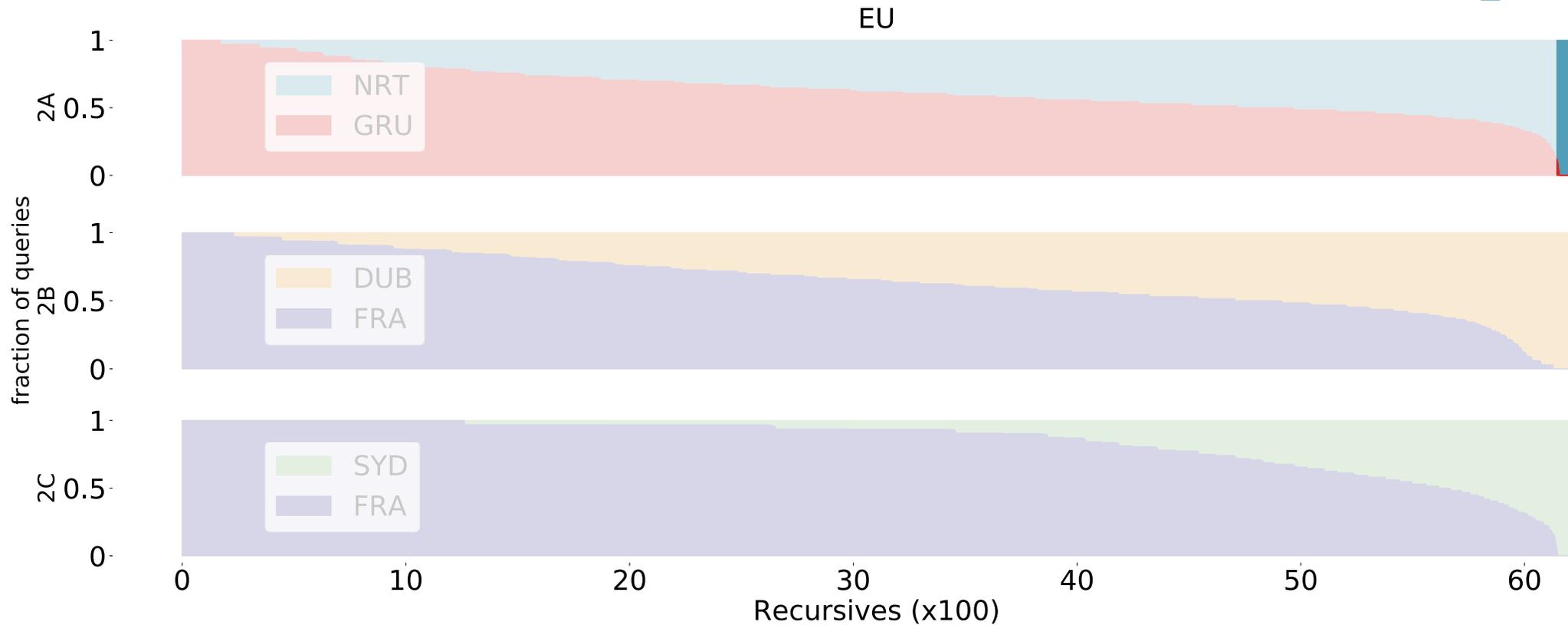
How do *individual* recursives distribute their queries?
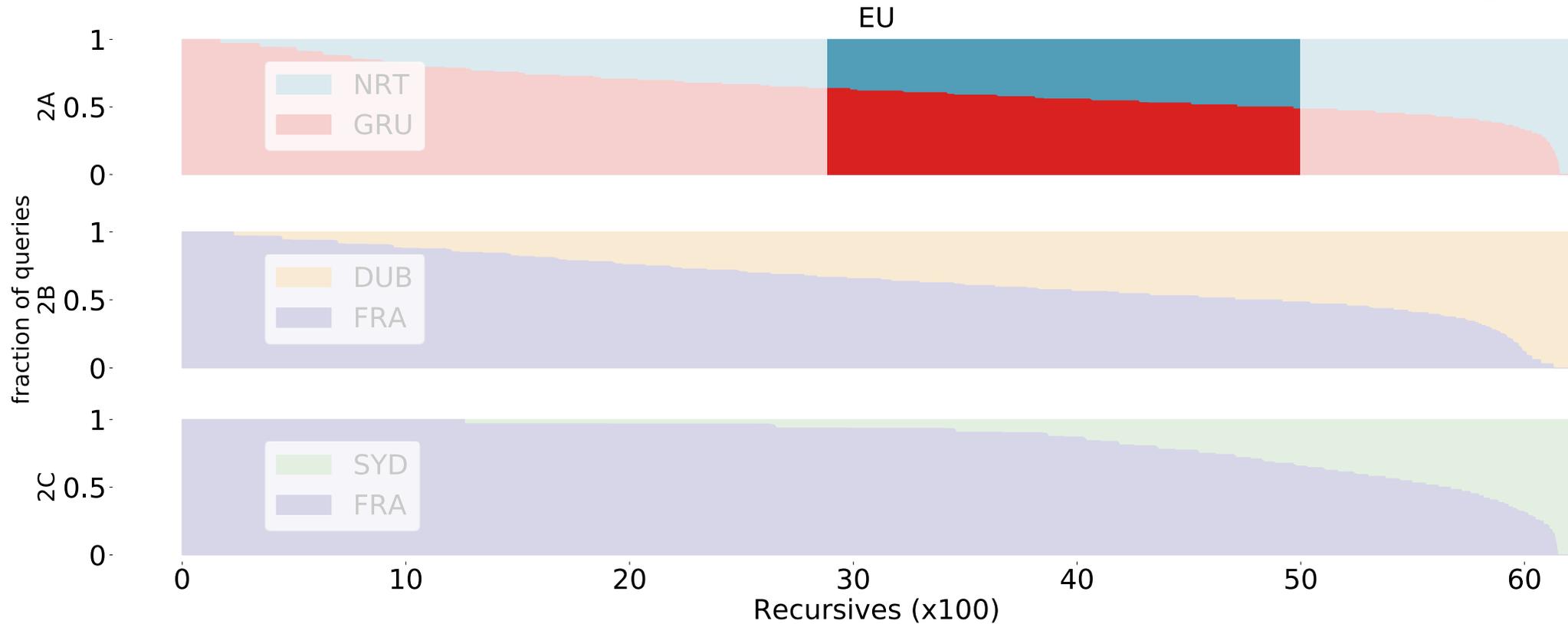
How do *individual* recursives distribute their queries?
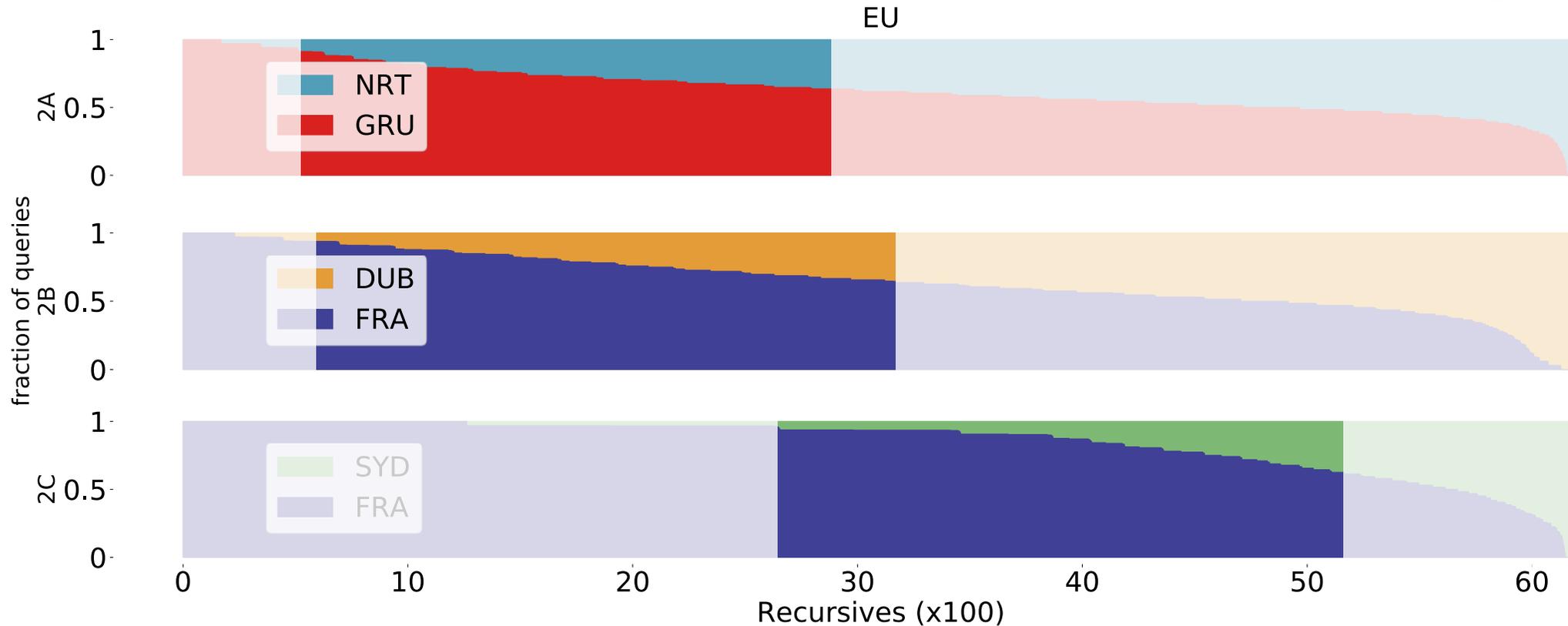
Up to 69% of resolvers have a weak preference (60% to 90% of their queries to one NS)

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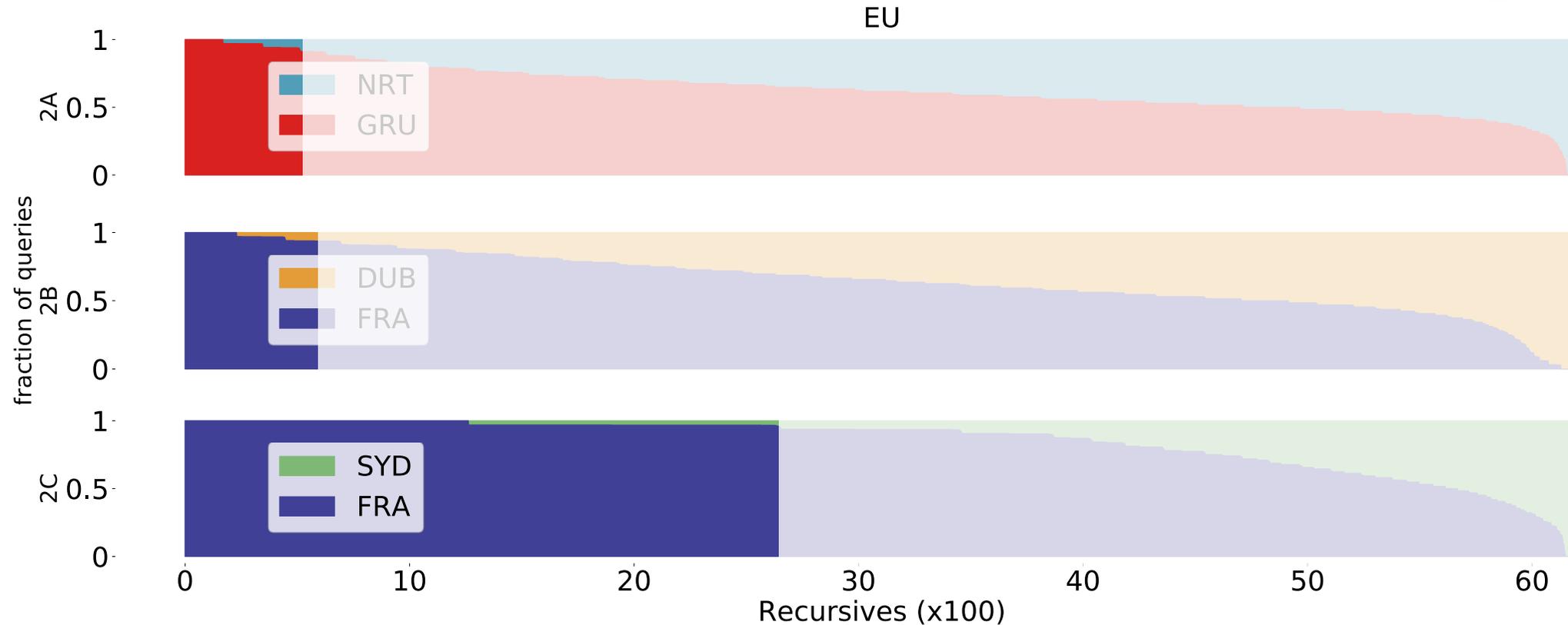
Up to 37% of resolvers have a strong preference (more than 90% of their queries to one NS)

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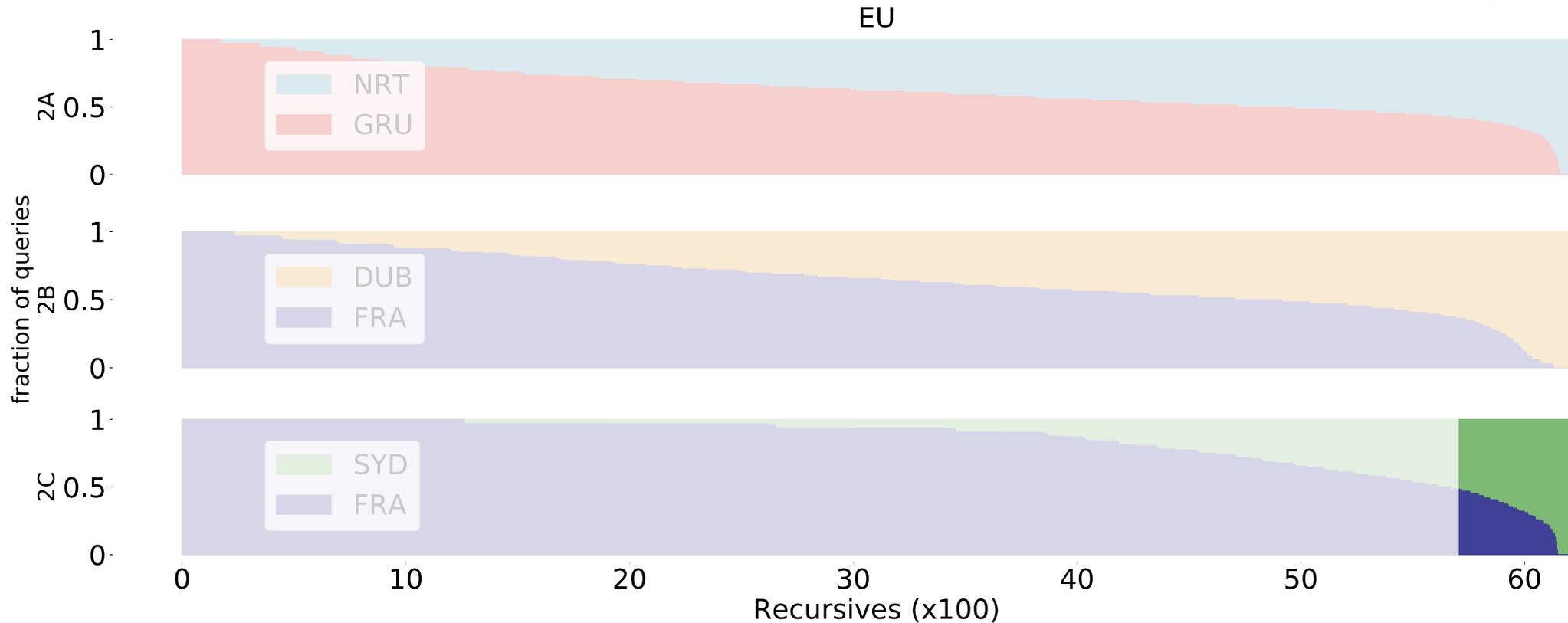
Some resolvers always prefer the slower NS

Validation: Authoritatives in Production

Root Servers
(10 out of 13)
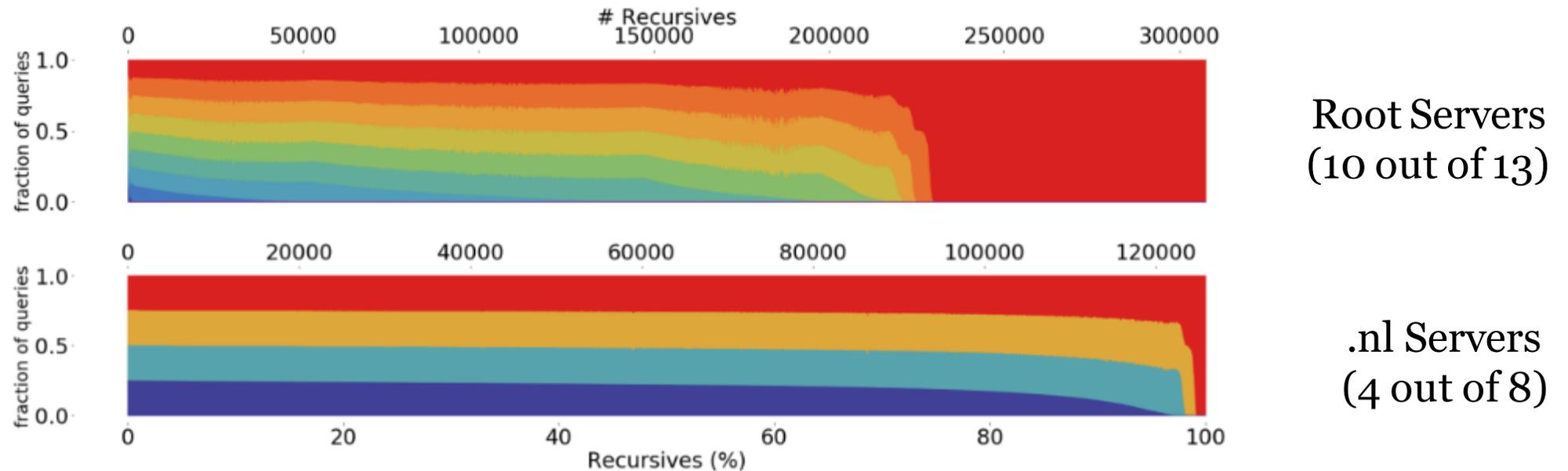
.nl Servers
(4 out of 8)

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

Measurement Summary

- Resolvers will query ALL your authoritative servers
- Distribution is inversely proportional with the median RTT
  - Recursives prefer faster responding authoritatives
  - But they also query slower authoritatives from time to time

- 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

Data Sets

All data sets (but one) available:

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

Yes, the majority of resolvers query every authoritatives

Paper available at: https://conferences.sigcomm.org/imc/2017/papers/imc17-final12.pdf

Giovane C. M. Moura

Questions?

Email: giovane.moura@sidn.nl

twitter: @giomourasec

Additional Slides

Does preference change for distant recursives?
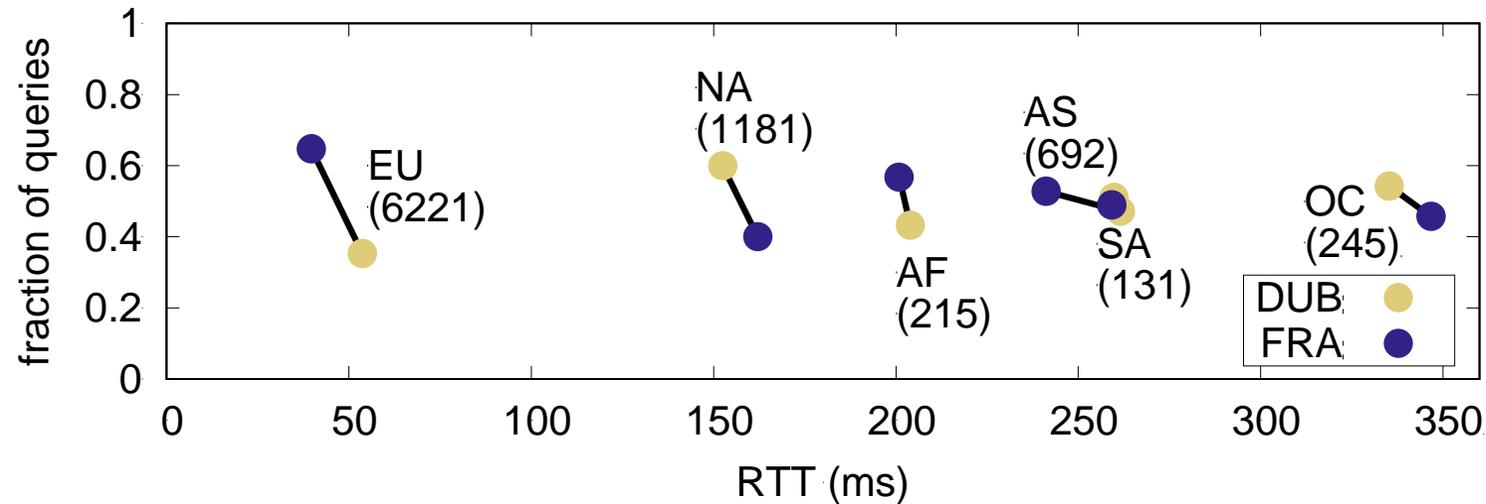
- VPs in EU reach Frankfurt 13 ms faster than Dublin

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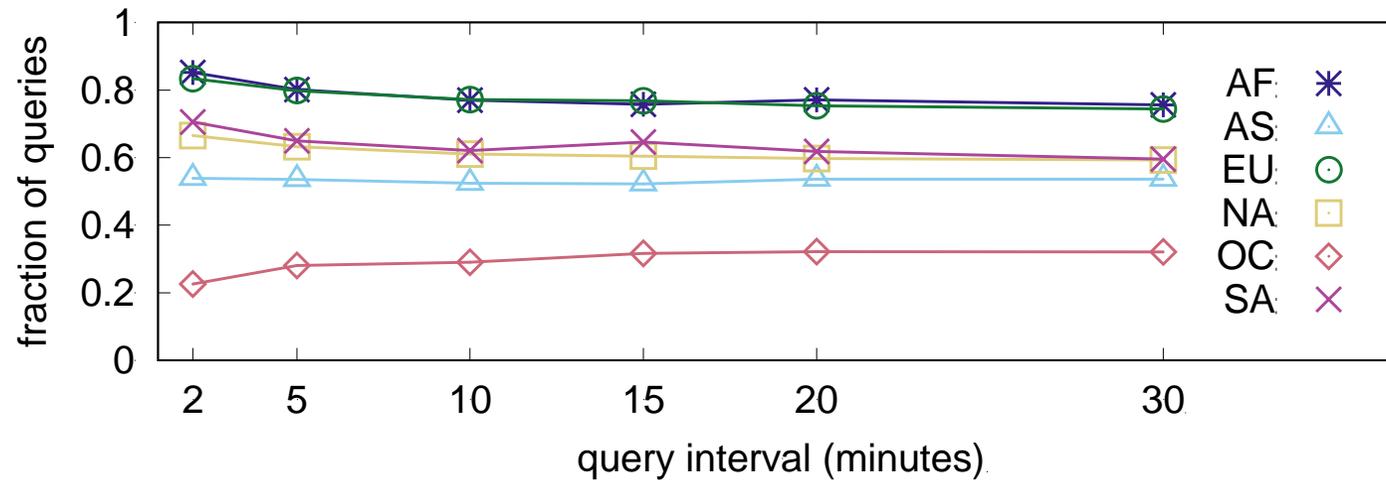
- A higher query frequency leads to a stronger preference
- However, preference persists even after the default timeout of resolvers like Bind and Unbound