RIPE NCC
RIPE NETWORK COORDINATION CENTER

Analysis of DNS4EU with RIPE Atlas

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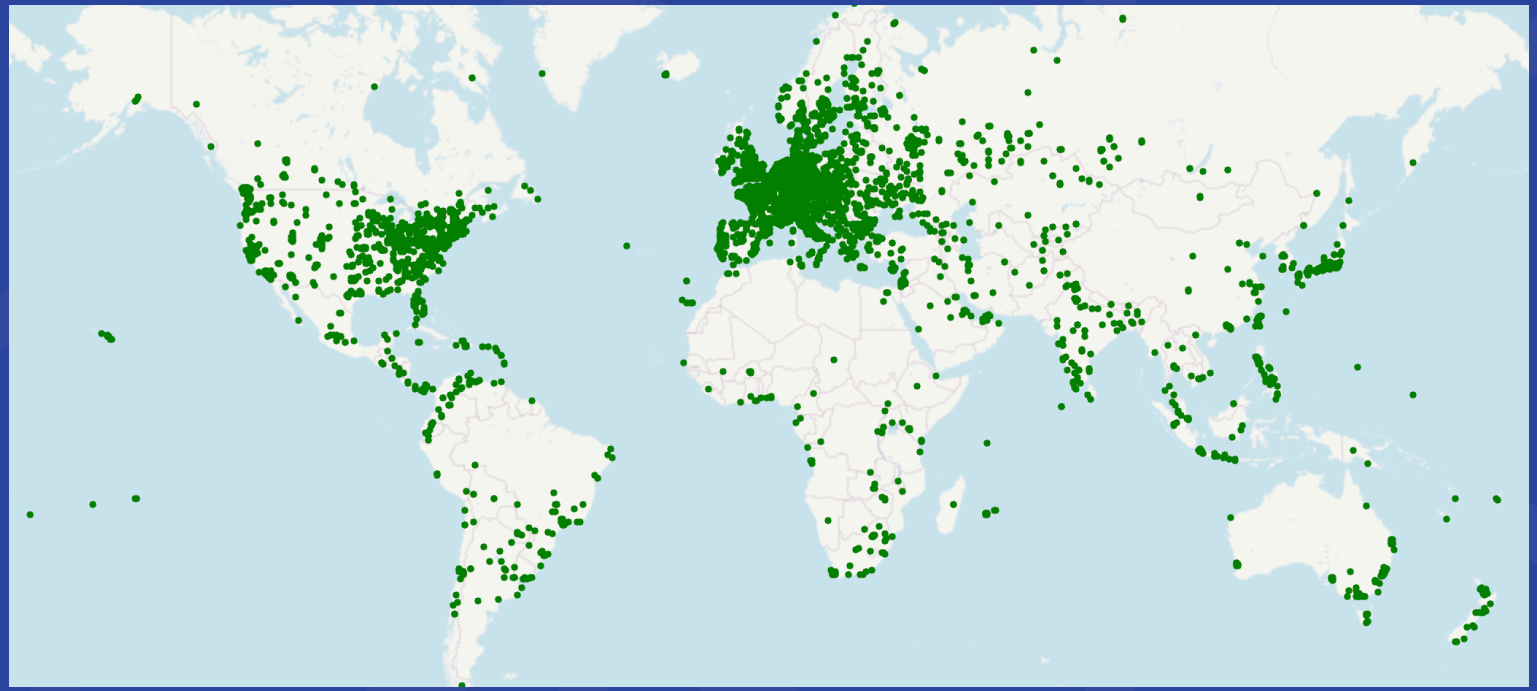
RIPE Atlas

What is RIPE Atlas?

RIPE Atlas is the RIPE NCC's main Internet data collection system. It is a global network of devices, called probes and anchors, that actively measure Internet connectivity. Anyone can access this data via Internet traffic maps, streaming data visualisations, and an API. RIPE Atlas users can also perform customised measurements to gain valuable data about their own networks.

RIPE Atlas Probes distribution

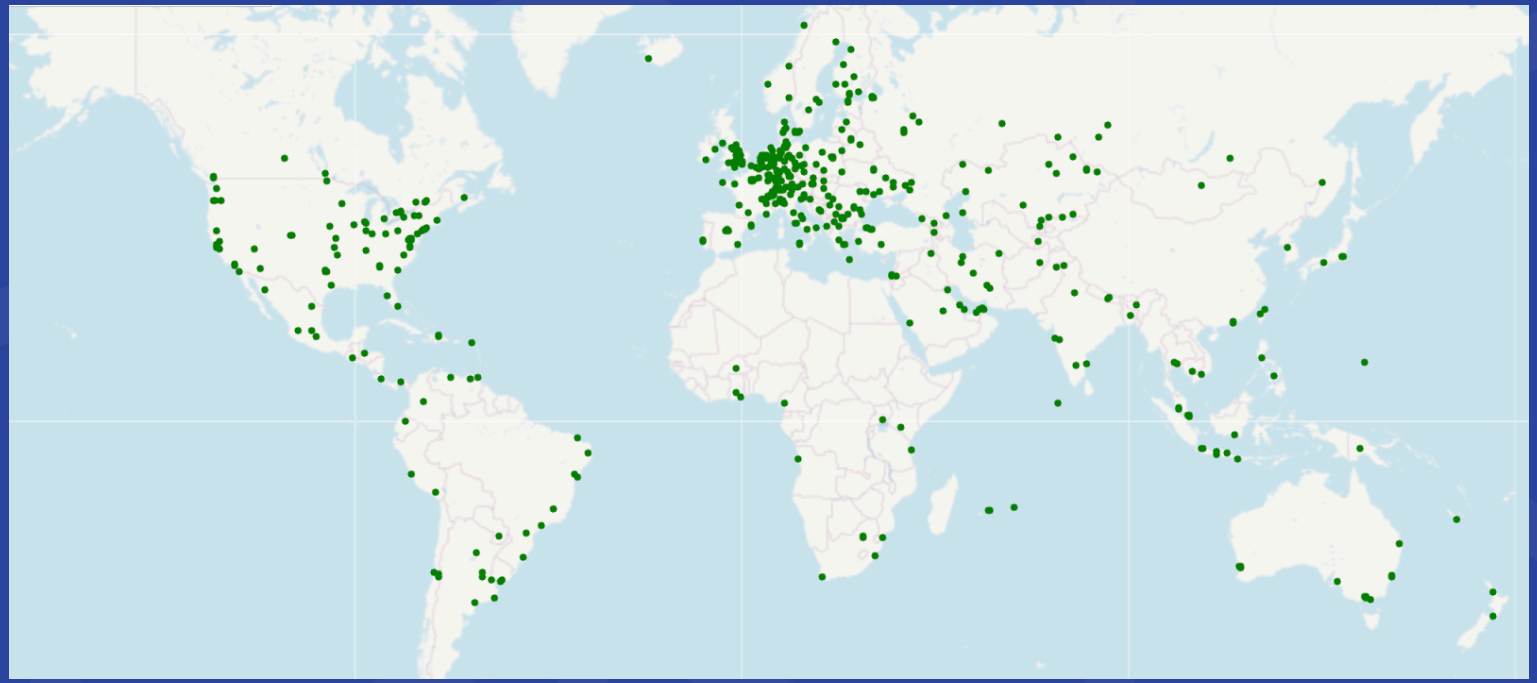


All over the globe

13000+ probes

177 countries

RIPE Atlas Anchors distribution



All over the globe

1000+ anchors

103 countries

DNS4EU

History

2022

- The European Commission selected the DNS4EU consortium and launched the project

2023

- The project entered the kickoff, design, and infrastructure build phase

2025

- DNS4EU was publicly launched as a European privacy-focused DNS service

2026

- The project moved into expansion, stakeholder engagement, and DNS4GOV development

Goals

EU digital sovereignty

> EU-hosted infrastructure

> Privacy and GDPR compliance

DNS-layer threat protection

Government and critical infrastructure support

Services

Day 0

- Unfiltered public resolver
- Ad-filtering profile
- Child-protection profile
- Combined ad-filtering + child-protection profile

Later addition

- Added a Protective service profile to block access to known malicious and fraudulent domains

Protocols

Dual stack

- All services support both IPv4 and IPv6

Transport

- Classical DNS over UDP and TCP
- DoH
- DoT

Methodology

Measurements

From

- EU Counties
- Ukraine + Moldova
- USA
- Japan
- Australia

Five random probes per country

To

- Unfiltered service
- Ad-filtering
- Child protection
- Ad-filtering + Child protection

Types

- RTT (ping)
- DNS
- TLS

What

- Requests for “joindns4.eu"

When

- Summer 2025
- Re-check: Spring 2026

Two time ranges

The main part

- 11/06/2025 to 31/05/2026
- Soon after the announcement that the public service has gone live
- The main objective was to examine the service parameters and their **trends at the initial stage**
- 34062629 measurements in total

A small verification update

- 06/04/2025 to 12/04/2025
- Quick comparison with the main part
- Parallel measurements of other public DNSes
- 12652 measurements

What is NSID?

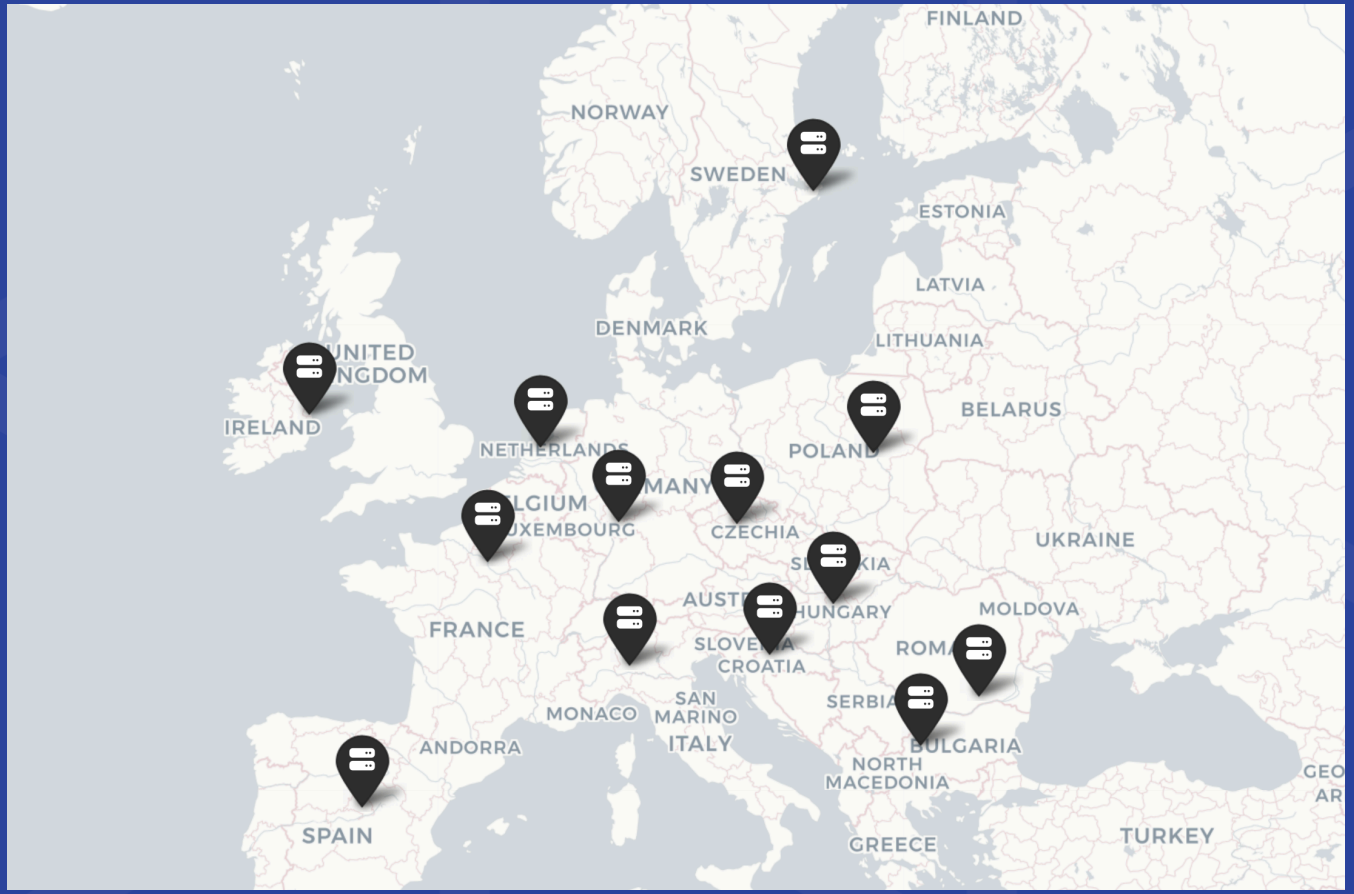
- RFC5001
  - “an EDNS option […] identifying the name server”
  - “The OPTION-DATA for the NSID option is an opaque byte string, the semantics of which are deliberately left outside the protocol”
- Public resolvers usually use NSID both for internal and external purposes

DNS4EU

- Supports NSID and has a simple label semantics
- Has a location coded inside the NSID label (based on IATA codes)
  - Example: dns4eu-ams-01

We will use NSID to group the results when applicable

Servers geography



NSIDs

Primary NSIDs

- dns4eiu-mil-01 - typo, was fixed later
- dns4eu-ams-01 - Amsterdam
- dns4eu-ath-01 - Athene
- dns4eu-buc-01 - Bucharest
- dns4eu-bud-01 - Budapest
- dns4eu-dub-01 - Dublin
- dns4eu-fra-01 - Frankfurt
- dns4eu-mad-01 - Madrid
- dns4eu-mil-01 - Milan
- dns4eu-par-01 - Paris
- dns4eu-prg-01 - Prague
- dns4eu-sof-01 - Sofia
- dns4eu-sto-01 - Stockholm
- dns4eu-waw-01 - Warsaw
- dns4eu-zag-01 - Zagreb

Secondary

- **Cloudflare-like**: 1051m8, 123m41, 439m10, 439m11, 439m13, 439m16, 439m19, 439m2, 439m20, 439m24, 439m4, 439m6, 439m7, 439m9, 5000}, 607m1, 607m10, 607m11, 607m13, 607m14, 607m15, 607m16, 607m17, 607m19, 607m2, 607m3, 607m4, 607m5, 607m6, 607m7, 607m8, 607m9, 673m1, 673m3, 673m5, 673m6, 673m7, 74m161, 951m1, 951m115, 951m2, 951m24, 951m75, 951m76, 951m77, 951m80
- austx-dns-cac-300, austx-dns-cac-301, austx-dns-cac-302, austx-dns-cac-303, austx-dns-cac-304, austx-dns-cac-305, austx-dns-cac-306, austx-dns-cac-307, austx-dns-cac-308, austx-dns-cac-309, austx-dns-cac-310, austx-dns-cac-311, austx-dns-cac-312
- dnsadl03.island.aussiebb.io, dnsadl04.island.aussiebb.io, dnsadl05.island.aussiebb.io, dnsadl06.island.aussiebb.io, dnsmel03.island.aussiebb.io
- QCH0-01, QCH0-03, QCH0-05
- **IBM-like**: res210.qotp2, res210.qotp2.rrdns.pch.net, res700.qotp2, res701.qotp2, res701.qotp2.rrdns.pch.net
- snavtx-dns-cac-300, snavtx-dns-cac-301, snavtx-dns-cac-302, snavtx-dns-cac-303, snavtx-dns-cac-304, snavtx-dns-cac-305, snavtx-dns-cac-306, snavtx-dns-cac-307, snavtx-dns-cac-308, snavtx-dns-cac-309, snavtx-dns-cac-310, snavtx-dns-cac-311, snavtx-dns-cac-312

Disappeared in 2026

NSID population by projects

DNS4EU

- 14 primary NSIDs were used by Atlas probes in EU

Google

- 22 NSIDs were used by Atlas probes in EU

Cloudflare

- 3595 NSIDs were used by Atlas probes in EU

IBM

- 45 NSIDs were used by Atlas probes in EU

Results

Errors

Summary

- Types of errors: almost only **timeouts** (cut-off: 5 seconds)
- Subtle amount of other network issues
- **No DNS errors**, whether temporary (SERVFAIL) or permanent (NXDOMAIN)

Summer 2025

- DNS4EU, percentage: 7.84%

Spring 2026

- DNS4EU, percentage: 11.23%
- Google DNS, percentage: 10.42%
- Cloudflare DNS, percentage: 10.60%
- IBM DNS, percentage: 10.14%

Filtering price

Ads-free service

- IPv4, Median diff (ms) : 0.0
- IPv6, Median diff (ms) : 0.0

Children-safe

- IPv4, Median diff (ms) : 0.0
- IPv6, Median diff (ms) : 0.0

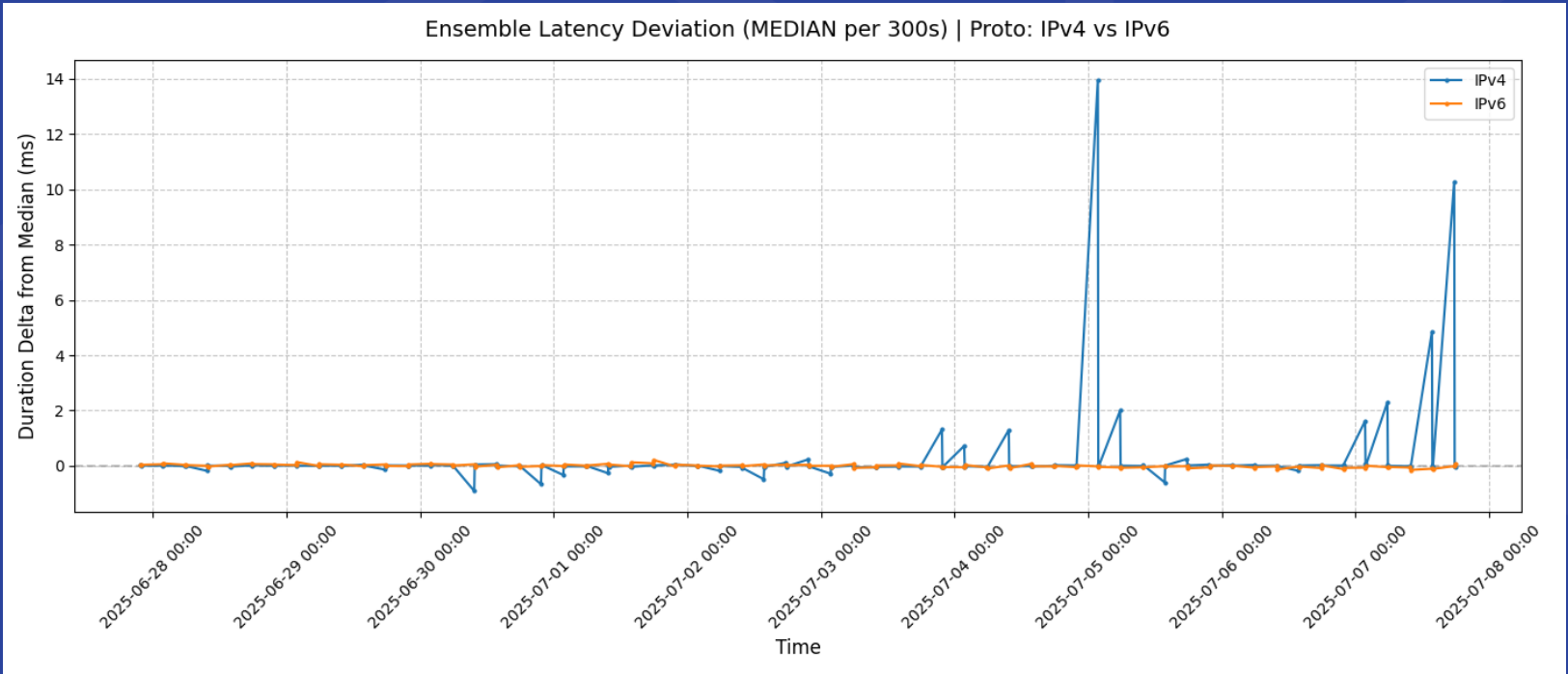
Combined

- IPv4, Median diff (ms) : 0.0
- IPv6, Median diff (ms) : 0.0

Filtering is free here

IPv4 vesus IPv6

Fluctuations



IPv4 vesus IPv6

Who is faster?

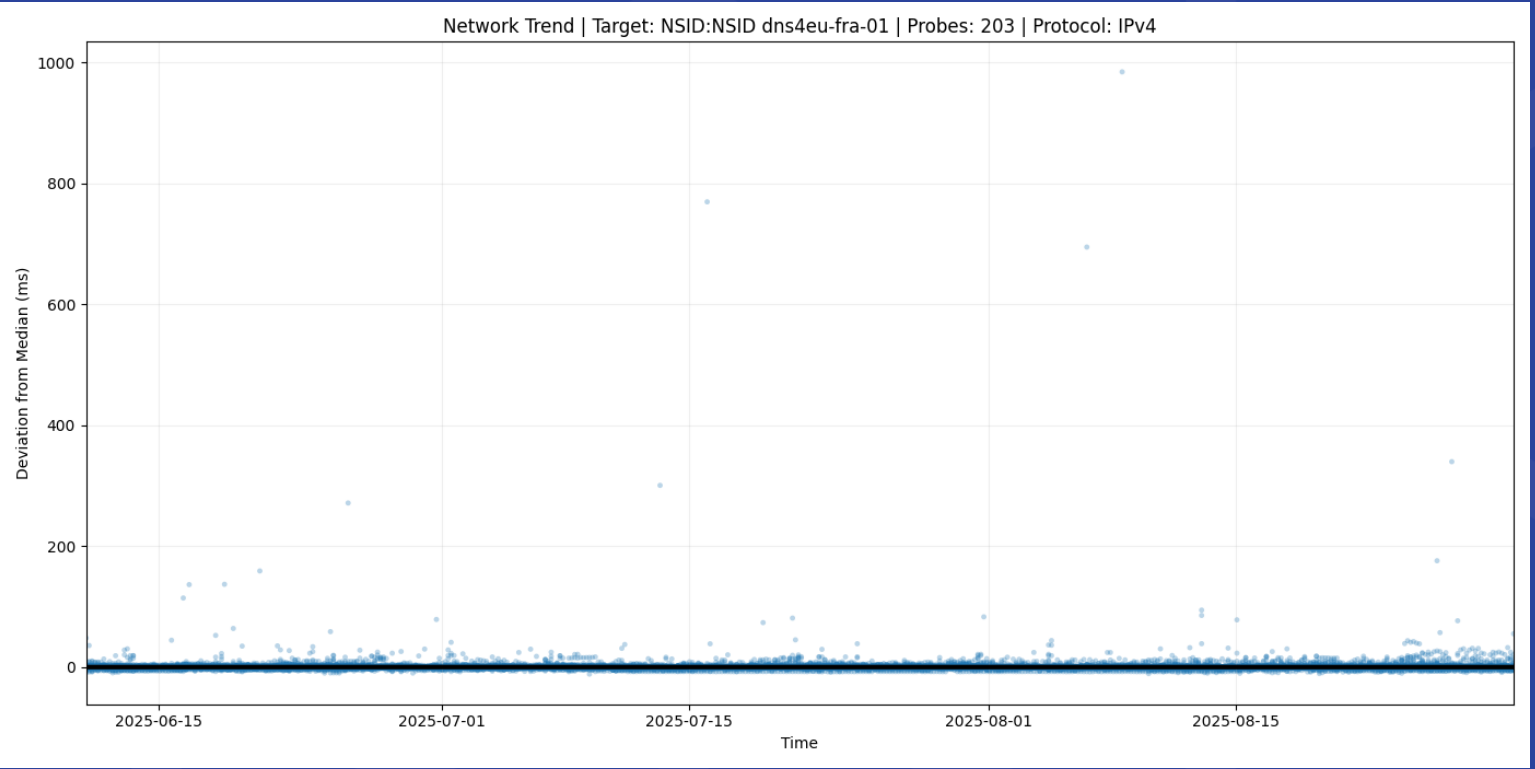
- IPv4 won the race in 50,8%

Who is more reliable?

- IPv4 error rate: 2.0%
- IPv6 error rate: 23,9%

- Top Errors: timeout, operation not permitted, network unreachable
- Top Errors: timeout, network unreachable

Regression over the time



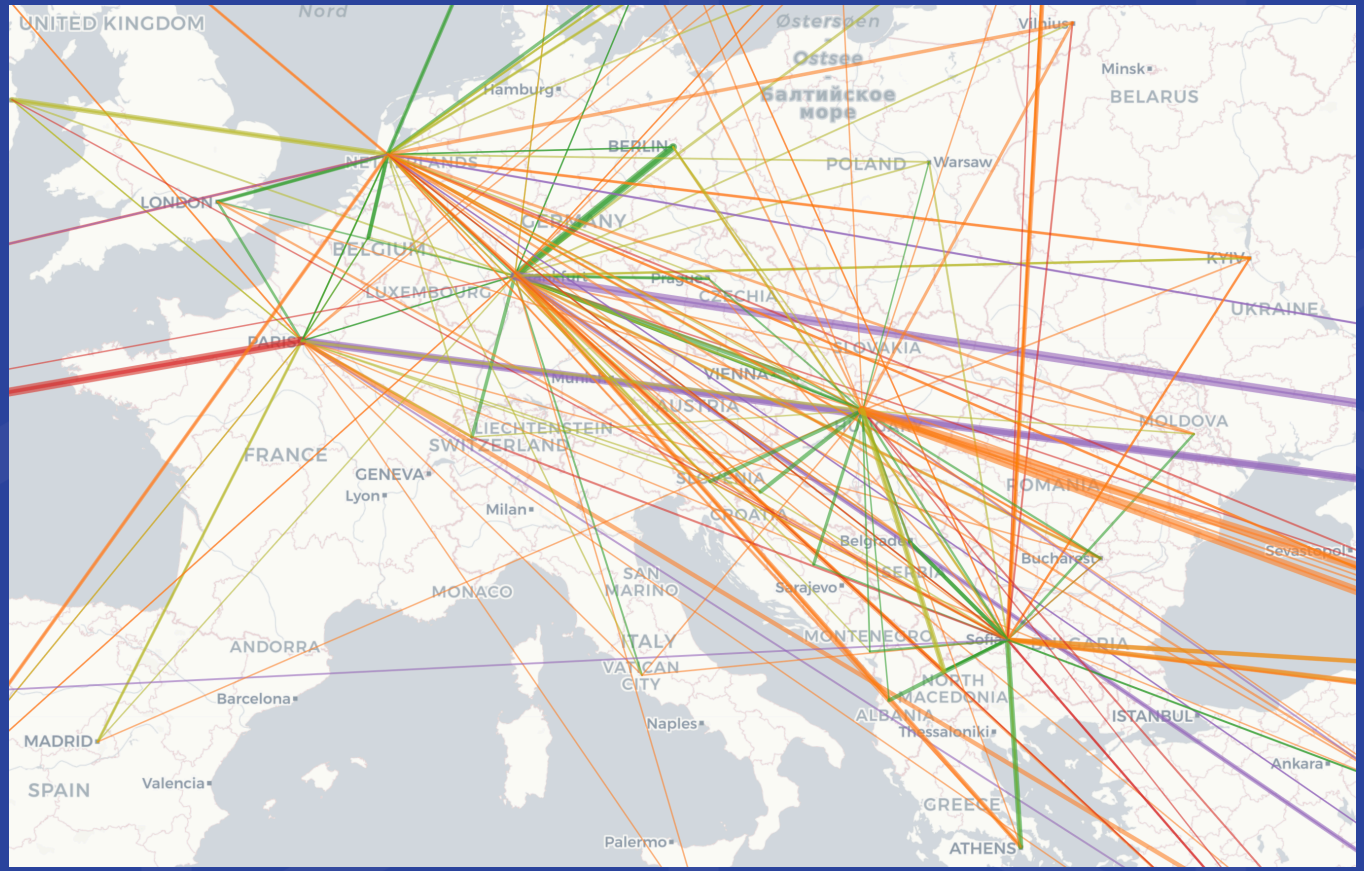
2025:

Same picture for all servers

2026 verification:

No substantial changes

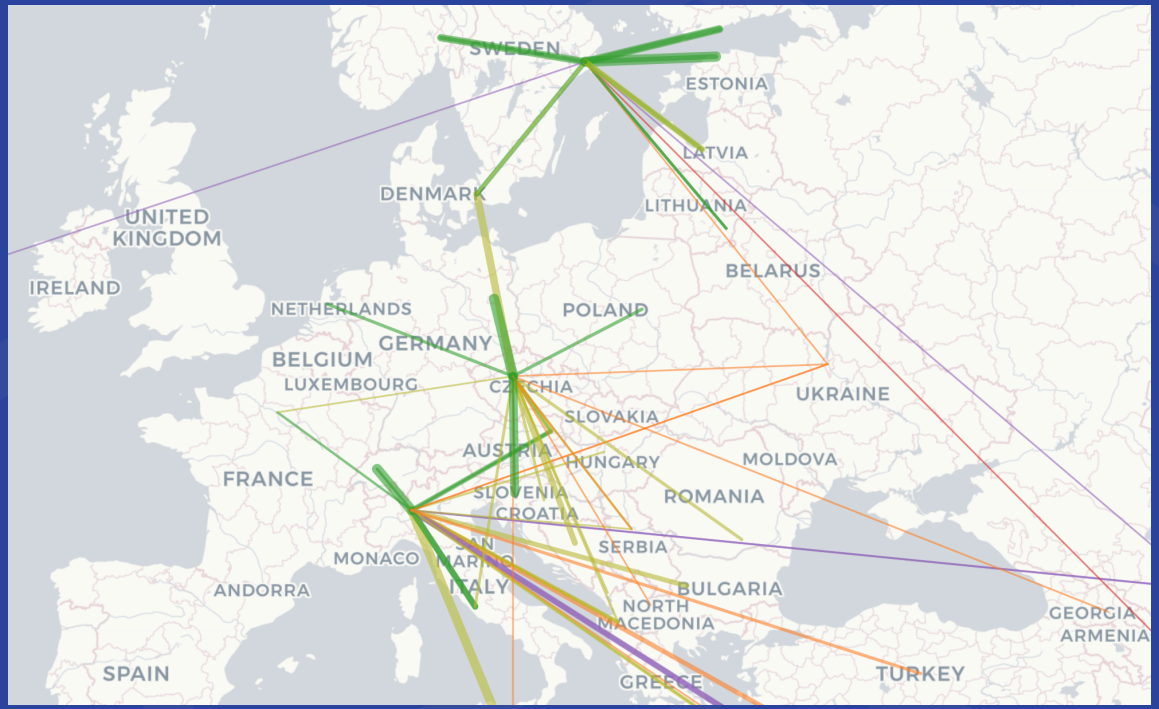
Geographical coverage: from the servers perspective



Main servers:

Frankfurt
Amsterdam
Budapest
Paris
Sofia

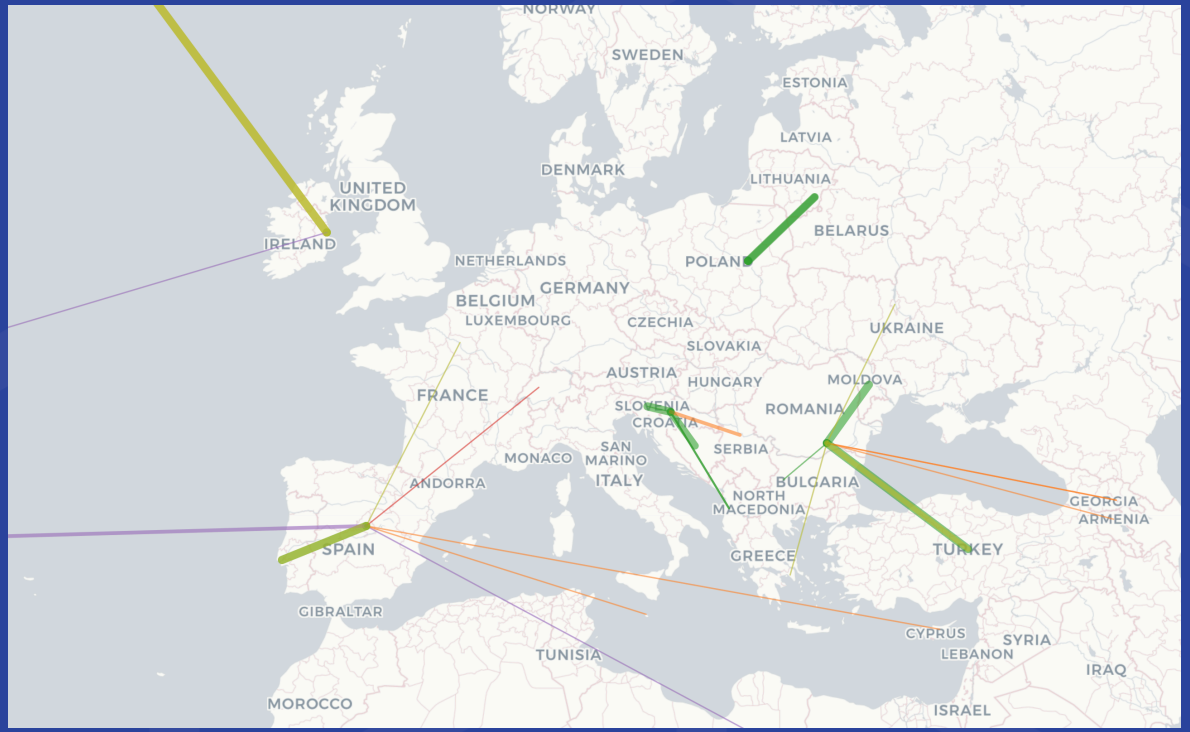
Geographical coverage: from the servers perspective



Servers with the moderate geographical reach:

Milan
Stockholm
Prague

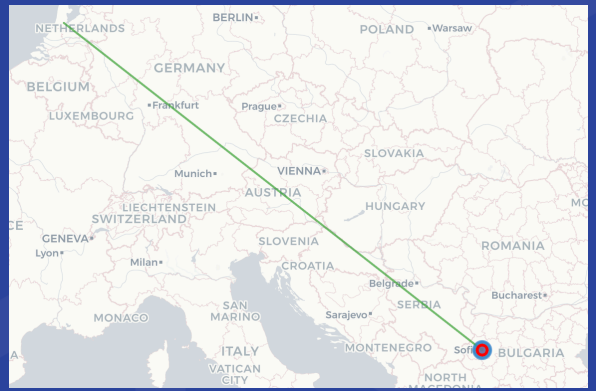
Geographical coverage: from the servers perspective



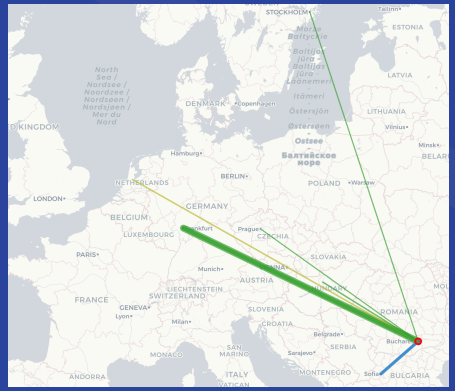
Servers with the limited geographical reach:

Bucharest
Dublin
Madrid
Warsaw
Zagreb

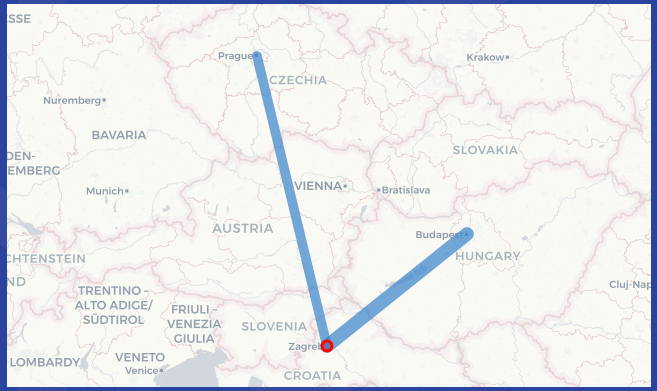
Who is serving South Europe?



Bulgaria serves itself



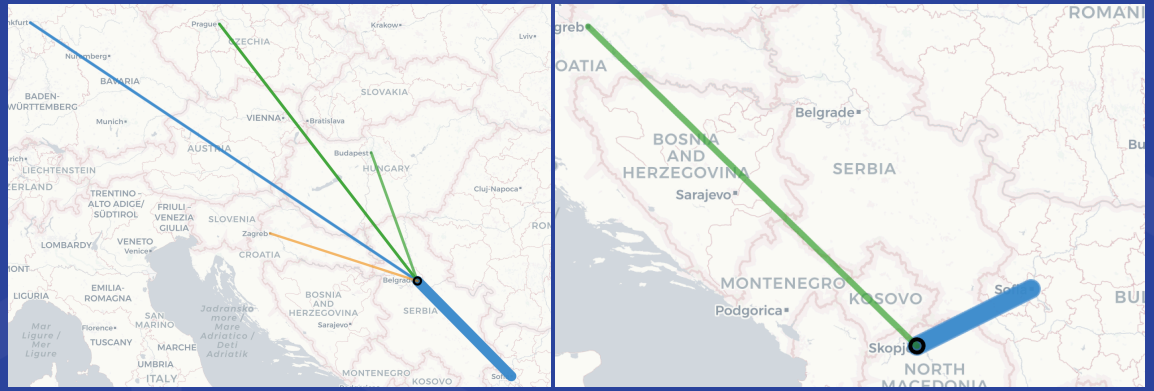
Romania heavily relies on Germany



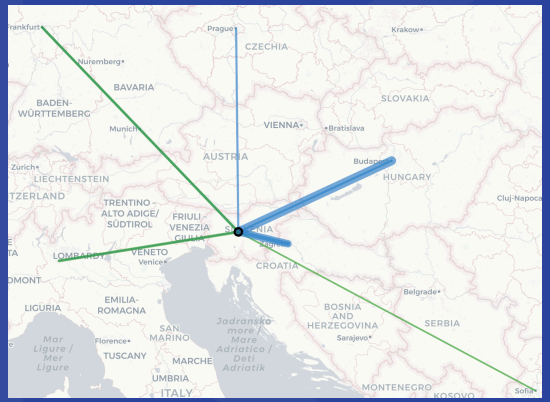
Croatia massively goes to Czech Republic and Hungary

Countries with own DNS4EU servers

Who is serving South Europe?

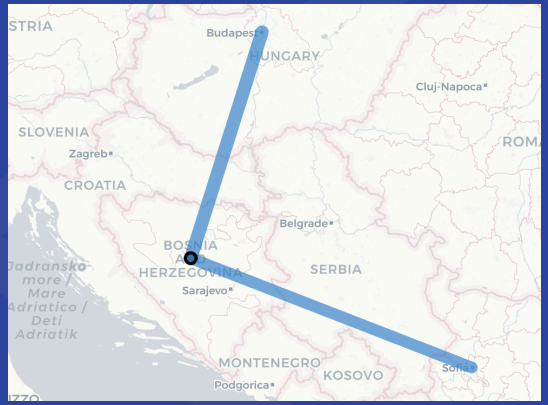


Serbia and North Macedonia send requests to Bulgaria

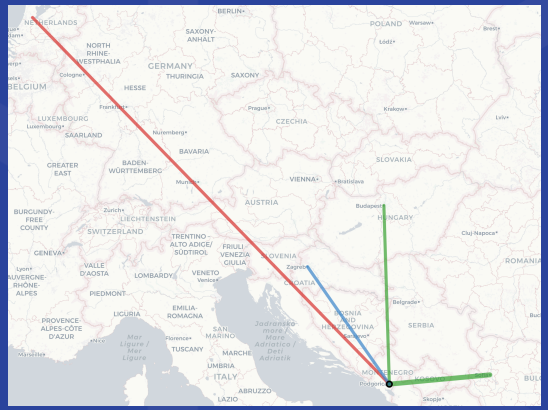


Slovenia prefers Hungary

Who is serving South Europe?



Bosnia and Herzegovina splits load between Bulgaria and Hungary



Montenegro demonstrates no preferences

Persistence of server selection

How faithful is a probe to the selected server?

dns4eu-waw-01	99.91
dns4eu-mad-01	96.52
dns4eu-sto-01	93.65
dns4eu-dub-01	91.52
dns4eu-par-01	84.79
dns4eu-ams-01	82.66
dns4eu-fra-01	81.46
dns4eu-mil-01	81.16
dns4eu-prg-01	**81.07**
dns4eu-buc-01	**79.9**
dns4eu-bud-01	**79.59**
dns4eu-sof-01	**77.99**
dns4eu-zag-01	**65.93**

In the SEE region, fidelity isn't exactly in the best of shape

Role of the server in Sofia

- Bulgaria serves the South of Europe - good
- Bulgaria serves the Caucasus countries - expectable
- Bulgaria sometimes serves the United States - acceptable (no DNS4EU in USA)
- But serving other countries looks a bit suboptimal

Conclusions and observations

- The project is already quite mature
- It features high-quality functionality
- Bulgaria contributes a lot, being a regional leader
- However, its coverage in Europe still lags behind that of US services
- The implementation of the BGP anycast requires further attention
- As does IPv6 support

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Questions?
Comments?

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