Data-driven DNS anycast migration

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Agenda

1. Intro and background
2. Predictable automated deploy
3. Selecting a new BMaaS operator
4. Data-driven anycast deployment
5. Summary and conclusions

i3D.net SIDN

Quick introduction

- SIDN: TLD operator for .nl
- i3D.net: global infrastructure provider offering BMaaS & operating own carrier backbone



Photo by Unsplash

Intro and background

SIDN uses BMaaS to operate a global DNS anycast platform

- Presentation during DNS-OARC Belgrade in 2022
- Used Packet, later Equinix Metal
- Service discontinued as of mid 2026



Photo by Martin Fu on Unsplash

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Predictable deploy

DNS anycast components:

- Bare bones immutable OS plus containerized workloads
- Deployed quickly in parallel
- (amd64) Hardware independent
- Infra-as-code
- All nodes resemble each other: no configuration drift
- Reduce operational overhead
- Optimize for speed and flexibility

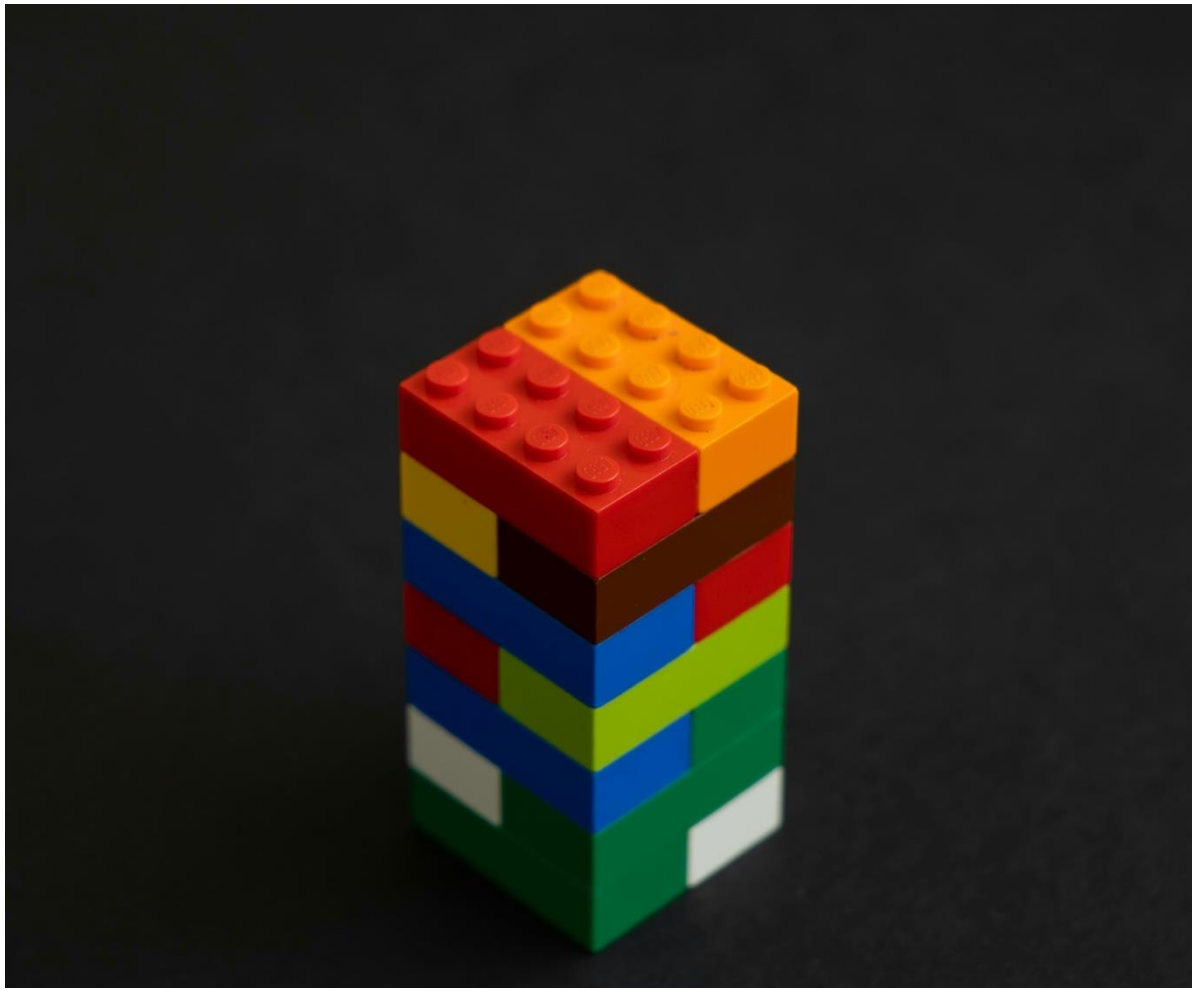

Photo by Abolfazl Ranjbar on Unsplash

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Selecting a new BMaaS operator

- Looking for a new partner with global presence
- Reserved capacity with scaling on-demand
- Advertise anycast prefixes using our own ASN
- Sovereignty discussion -> prefer European partner
- Selected i3D.net: experience with low-latency applications and global presence



Photo by Jametlene Reskp on Unsplash

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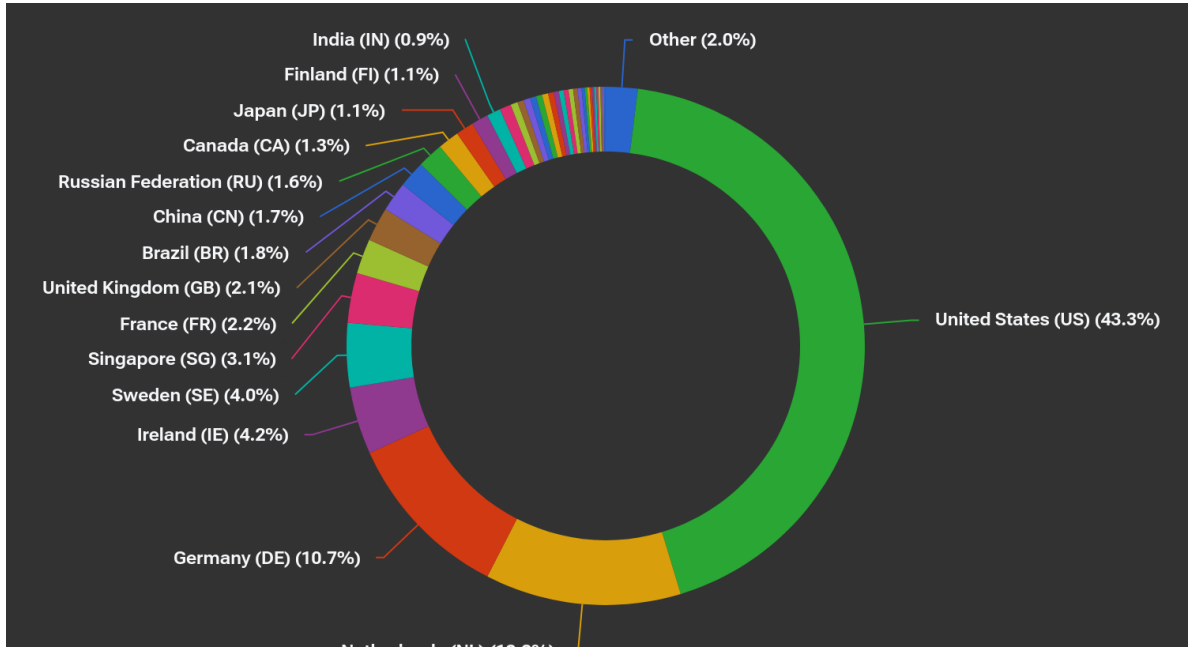
Which anycast locations do we choose?

- Deployment locations on Equinix largely based on (suspected) query origin with a pinch of gut feeling
- Query origins: mainly US & Europe
- Based on GeoIP data: how reliable?
  - Hint: it's decent, but far from perfect.
- Assemble a list of 230K v4 and 73K v6 resolvers pulled from actual .nl query data



Source: i3D.net, based on GeoIP enriched IPFIX data

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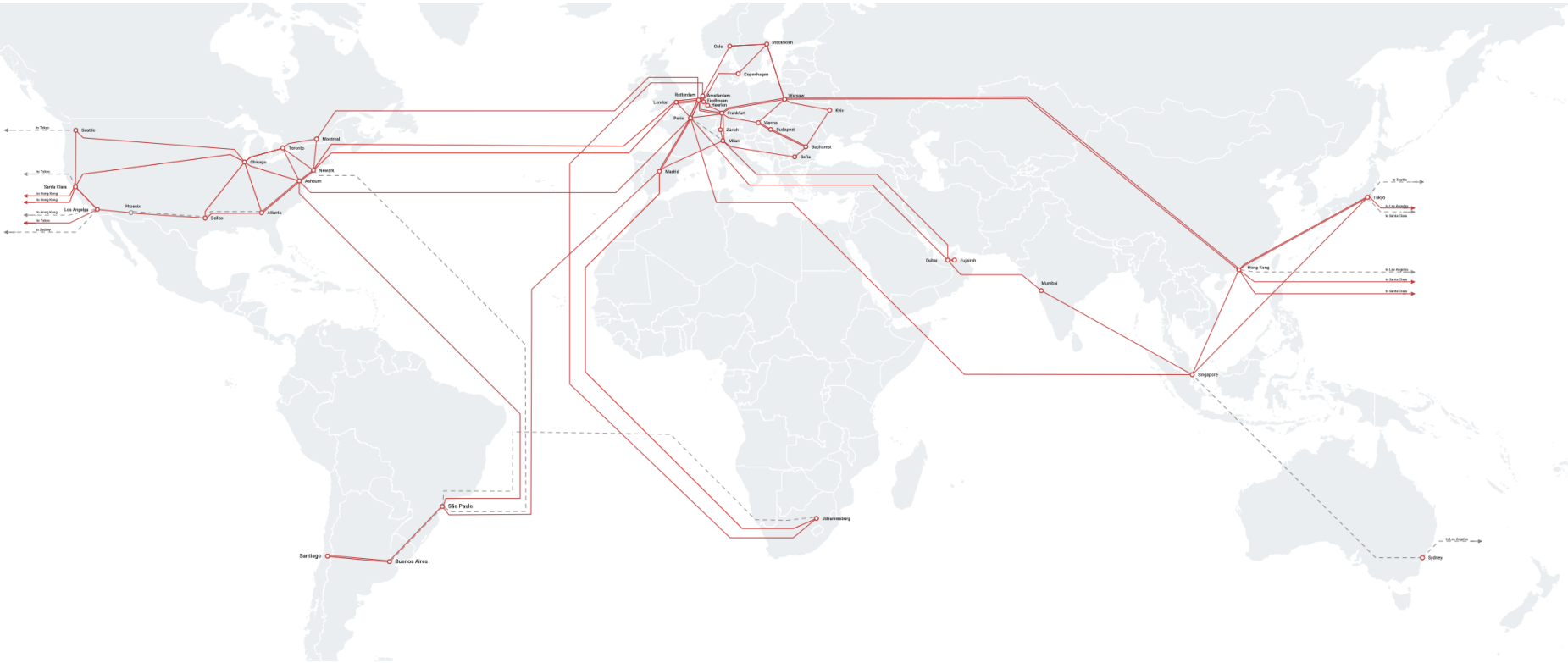
Which anycast locations do we choose?

- Feed resolver list to Manycastr® and do unicast ping sweep
- Collect data from all possible deployment locations and aggregate
- Backbone links allow use of peerings in adjacent metro areas



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Measuring predicted latency

- Measure the latency from all possible anycast PoPs to all resolvers
- Simulate anycast site selections and compute expected latency using unicast ping
- Optimize for median resolver latency weighted by nr queries by deploying in locations close to query origin
- Optimize for resiliency by deploying multiple nodes in busy locations

Ping RTT	Site A	Site B	Site C	Site D	…
Client 1	14.3ms	65.6ms	22.1ms	**6.7ms**	…
Client 2	**21.0ms**	84.1ms	9.2ms	26.1ms	…
Client 3	40.5ms	9.3ms	38.5ms	**31.1ms**	…
…	…	..	…	…	…

Source: sidnlabs.nl

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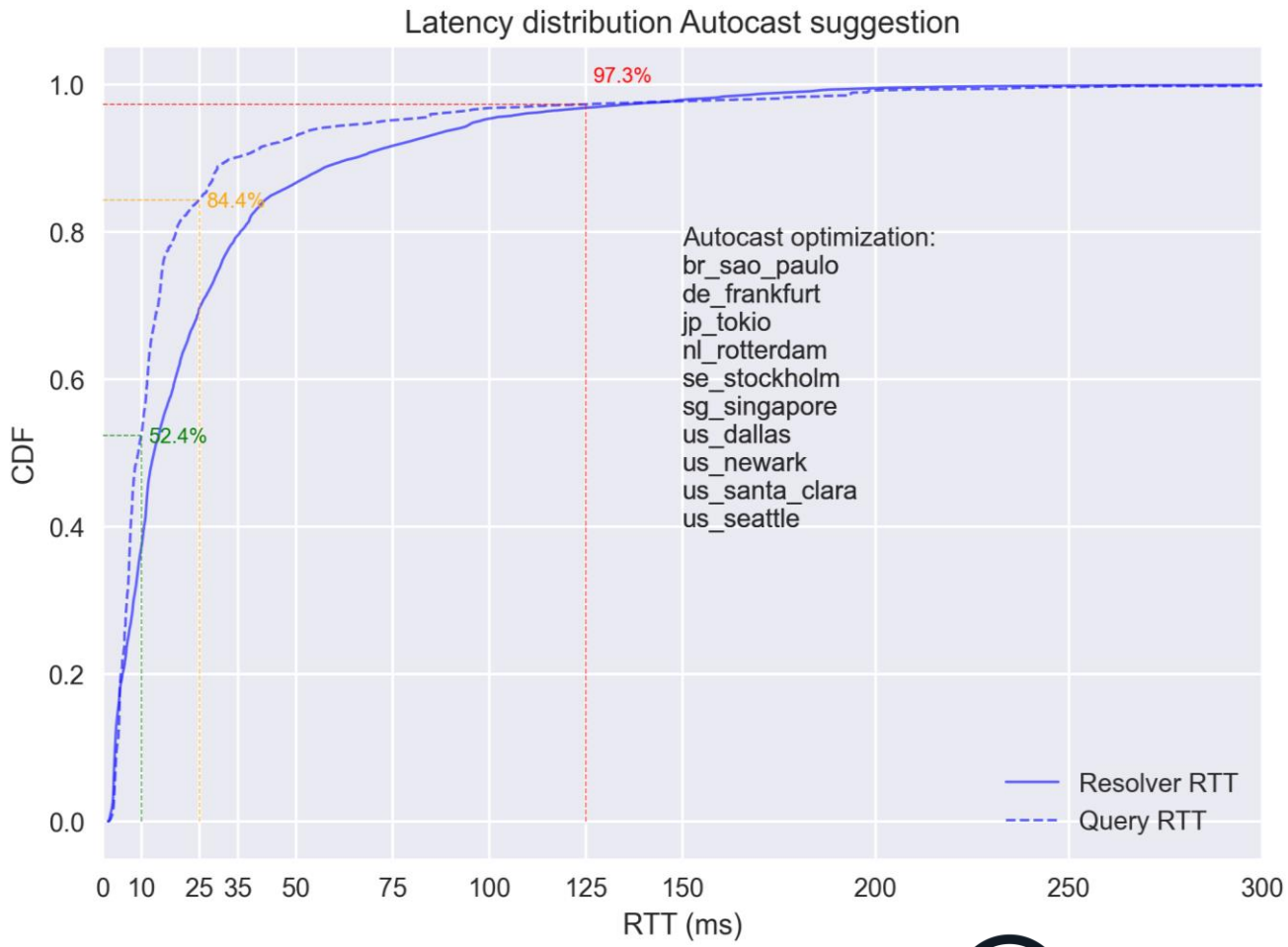
Putting it to the test

- 10 predicted optimal sites based on weighted RTT
- Changed Santa Clara and Seattle to LA and Chicago respectively
- Rerun test with anycast prefix
- Measure continuously using Tapdance



Source: sidnlabs.nl

Introducing Tapdance

- Query monitoring using dnstap: inside out vs outside in
- Combine ENTRADA and DSC approach to measuring RTT and catchment
- Track query counts per zone, query type, response, resolver etc.
- Enrich using GeoIP information
- No central processing: immediate results using InfluxDB & Grafana
- Source: codeberg.org/sidn/tapdance



Source: unsplash.com

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Deploy

- Build deployment pipeline using i3D.net's FlexMetal API
- Deploy and improve Tapdance
- Keep redeploying to optimize the process
- Perform dry-run with a different prefix



Source: pexels.com

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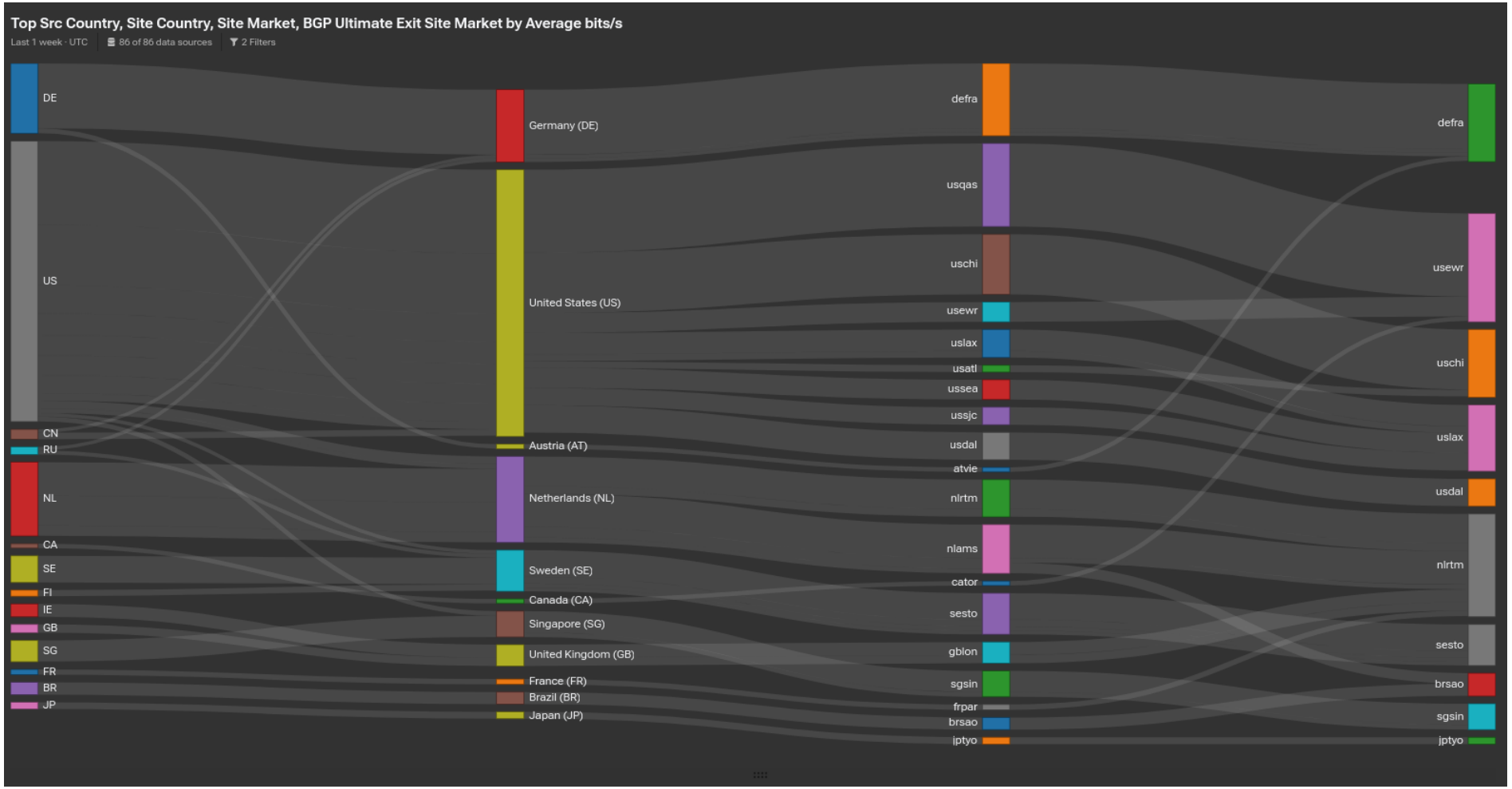
i3D.net enriched flow data: bird's eye prod overview

Source country GeoIP > ingest PoP country > ingest PoP > SIDN handover PoP

•Top30 combinations for readability, ~80% of total traffic on a weekly basis.



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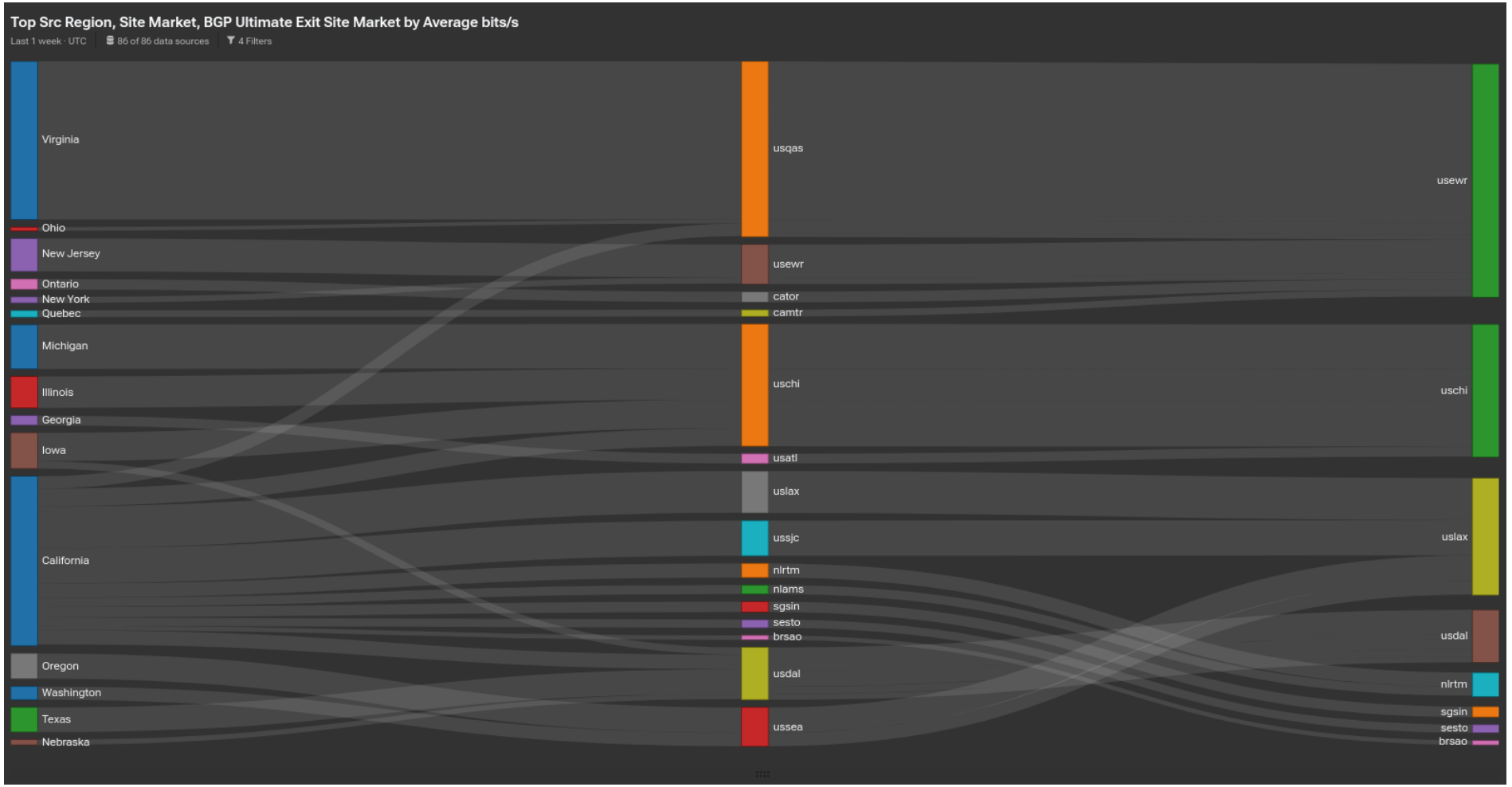
i3D.net enriched flow data: zoomed on US & CA

Source state/province GeoIP > ingest PoP > SIDN handover PoP

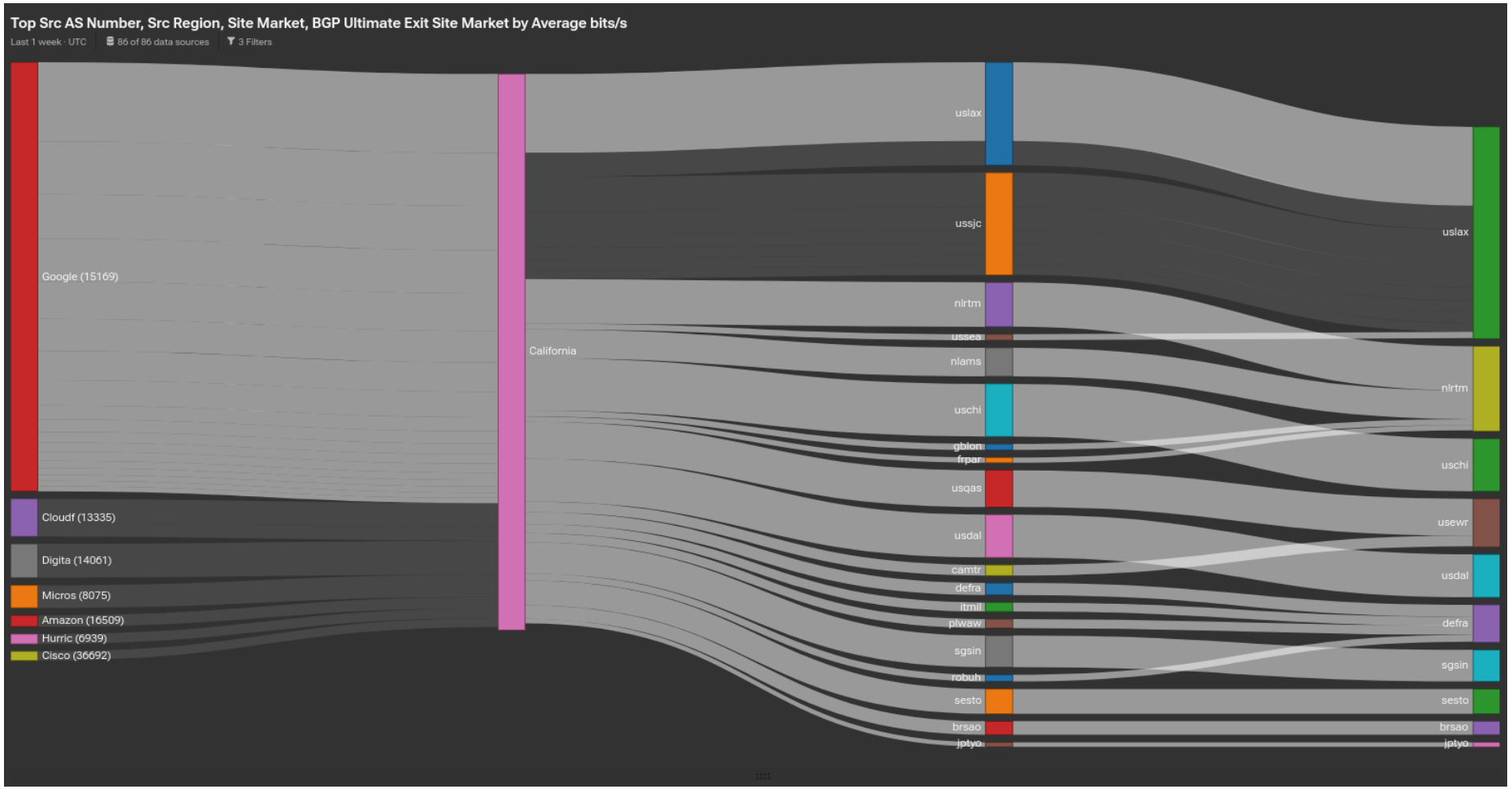
Top25 combinations for readability, note “California” traffic ingesting everywhere.



i3D.net enriched flow data: zooming in on California

Source ASN > source state/province GeoIP > ingest PoP > SIDN handover PoP

Top25 combinations for readability, it seems Google is the reason. Bad GeoIP tags?



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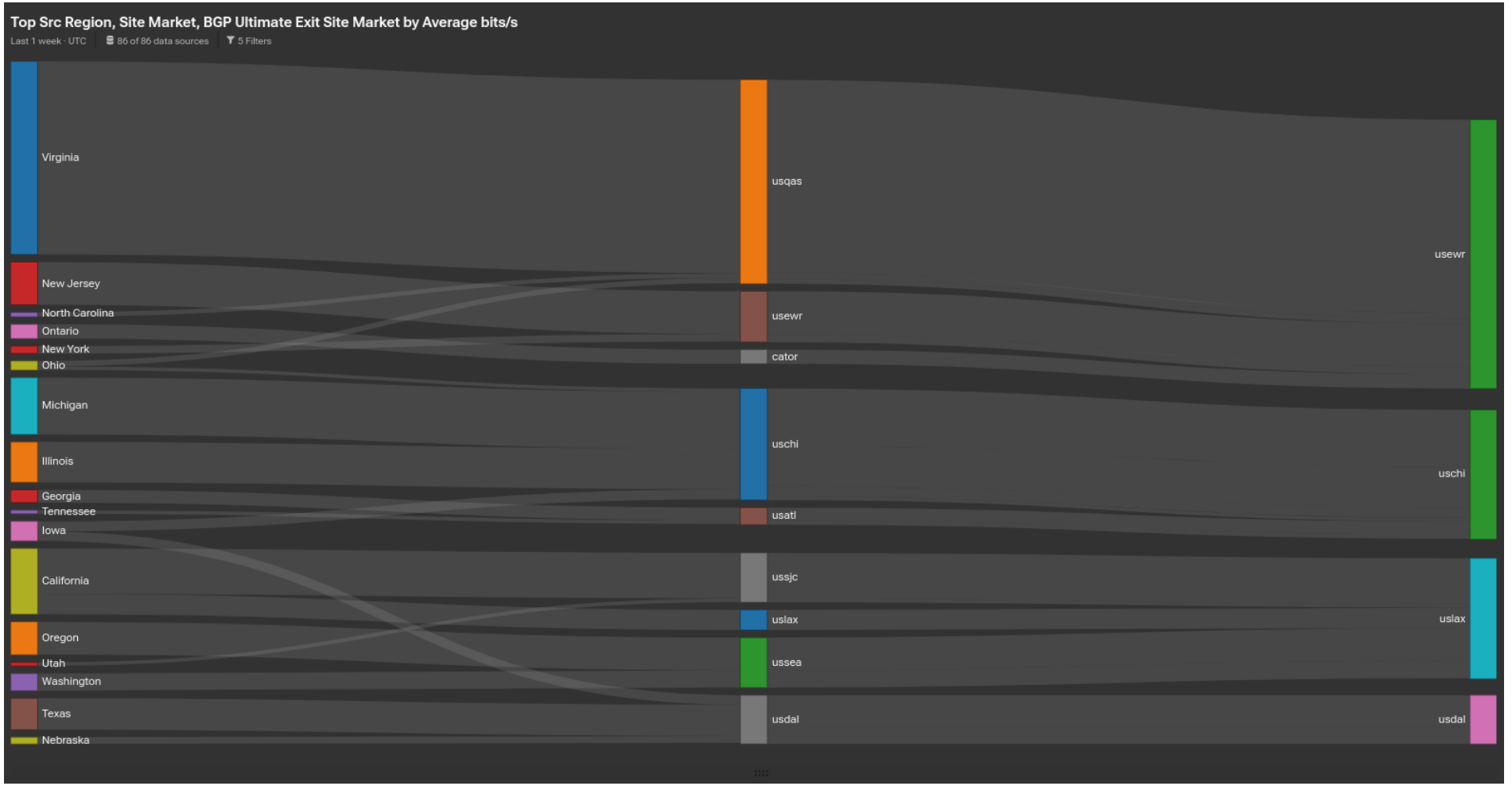
i3D.net enriched flows: zoomed on US & CA, no Google

Source state/province GeoIP > ingest PoP > SIDN handover PoP

Top25, this looks almost perfect when filtering out Google's contaminated GeoIP data.



i3D.net enriched flows: global view, no Google

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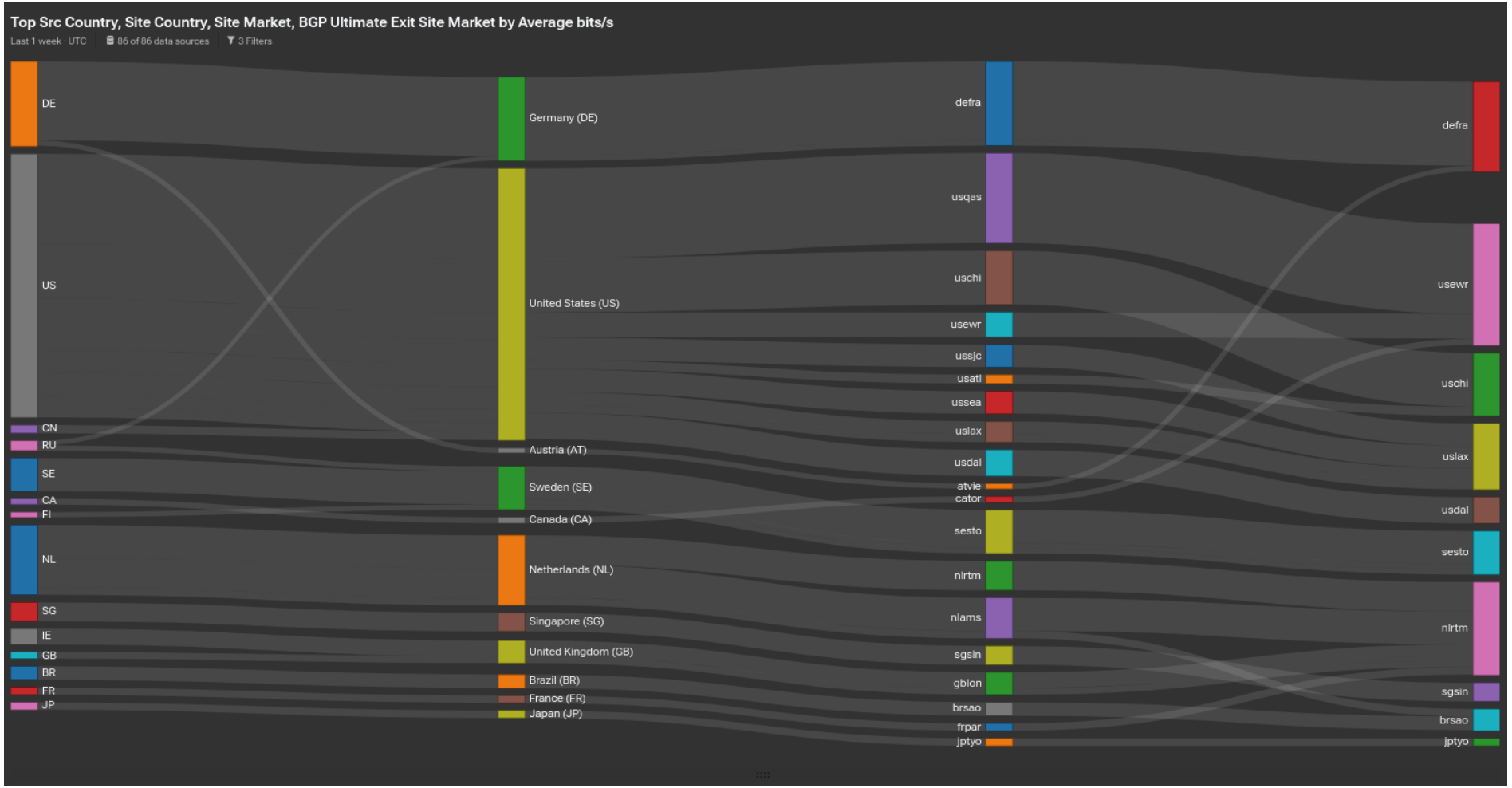
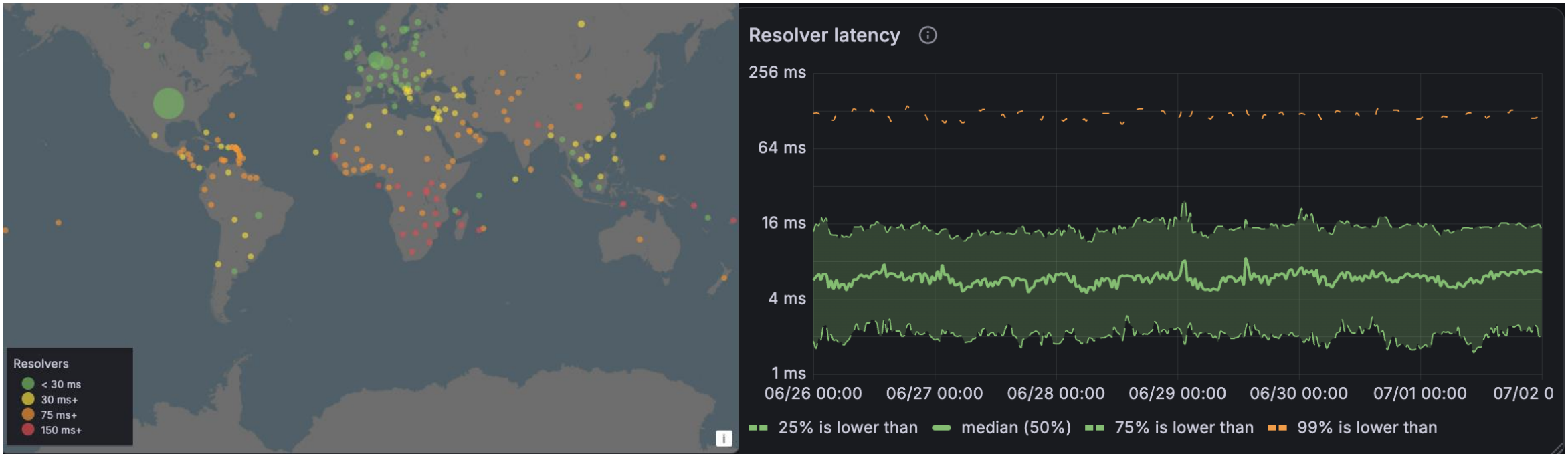


Running in production: Tapdance data world for .nl

Log scale: median latency is around 5ms, 75% is lower than ~15ms

P99 is around 110ms, including 1% queries from the African continent



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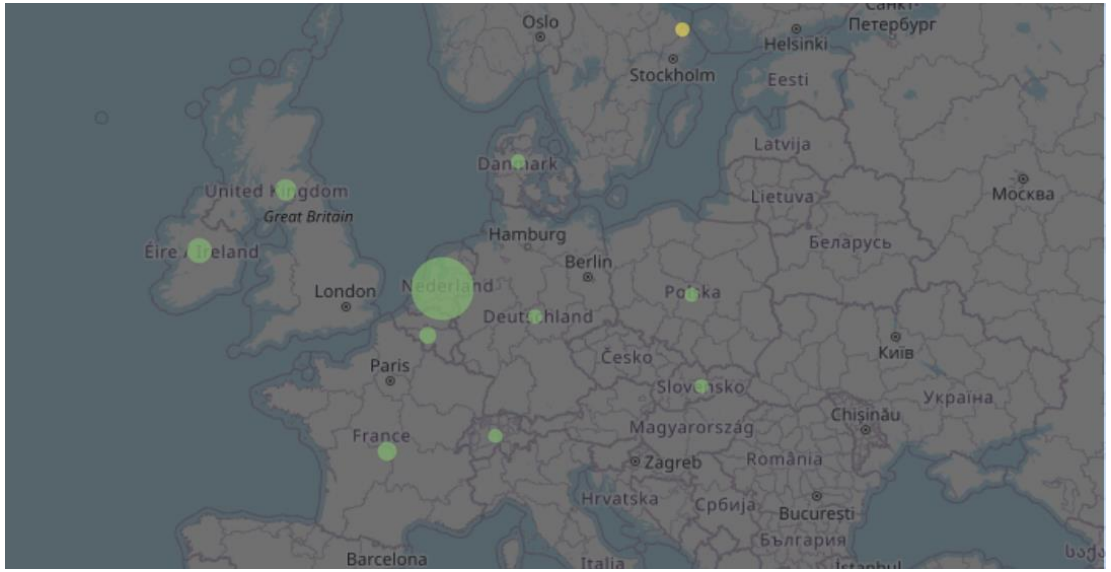
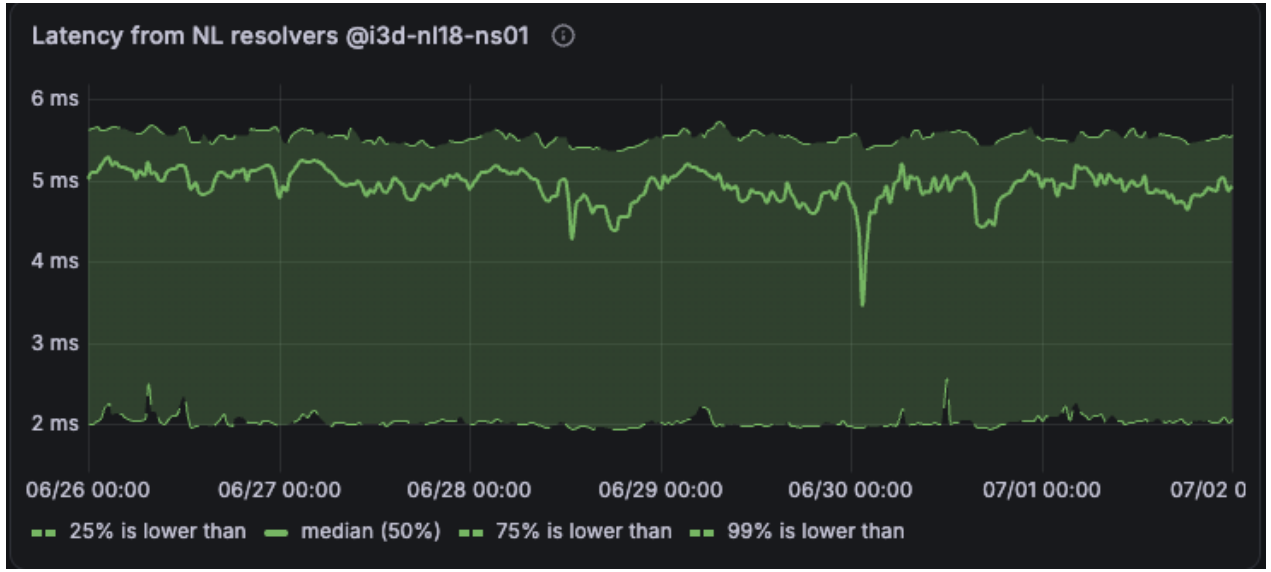
Running in production: Tapdance data Rotterdam

Linear scale: 75% queries under 6ms

Queries mainly from Netherlands and Western Europe





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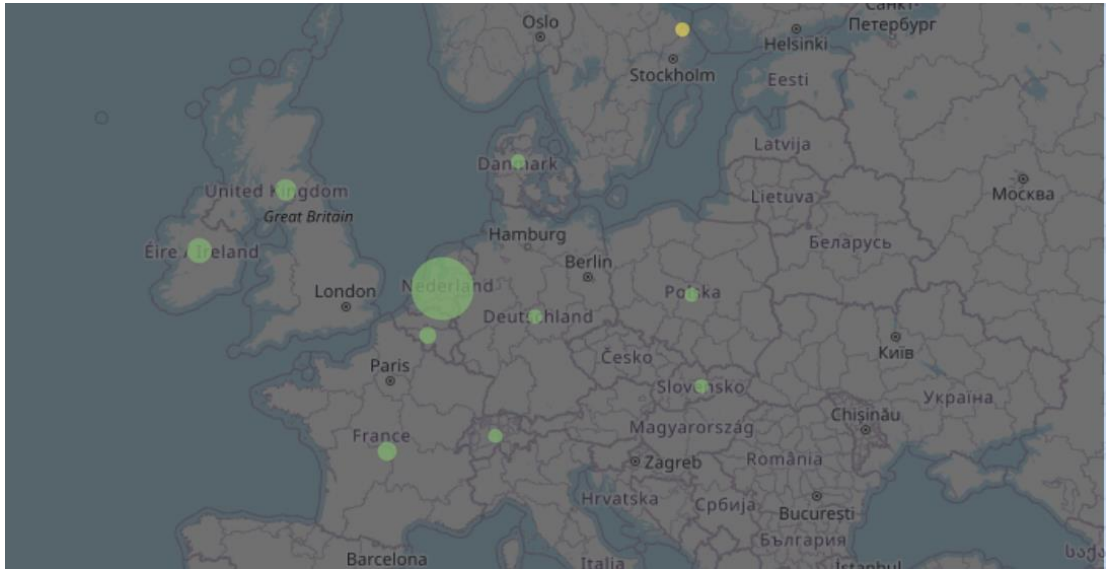
Running in production: Tapdance data Rotterdam

Linear scale: 75% queries under 6ms

Note: this is data from a single node

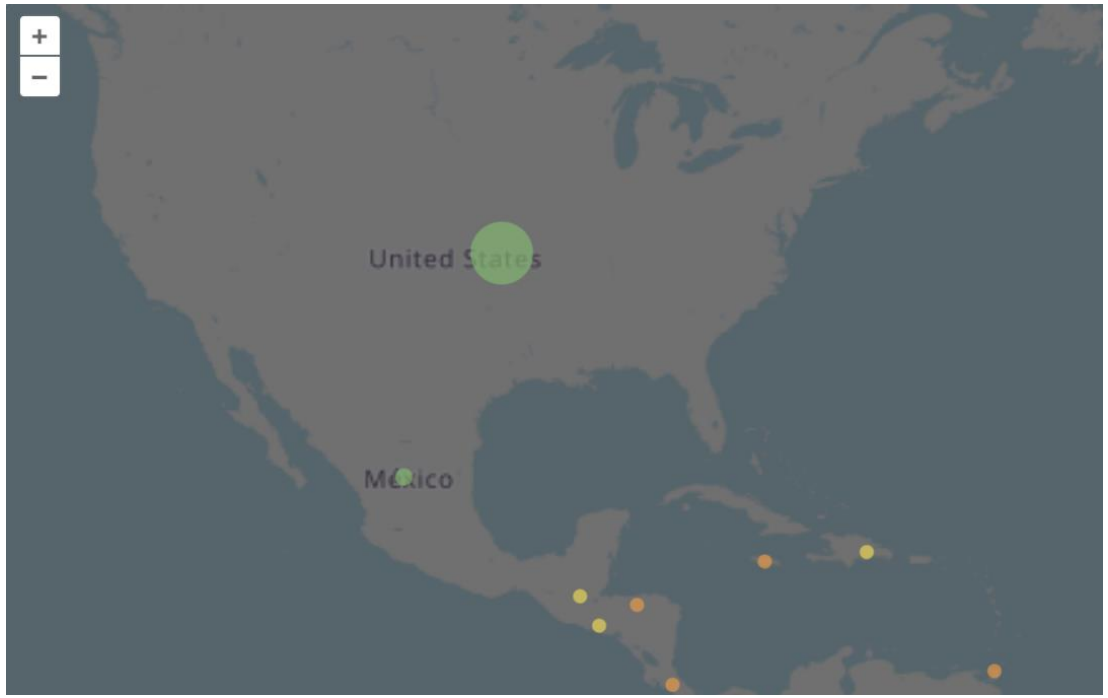


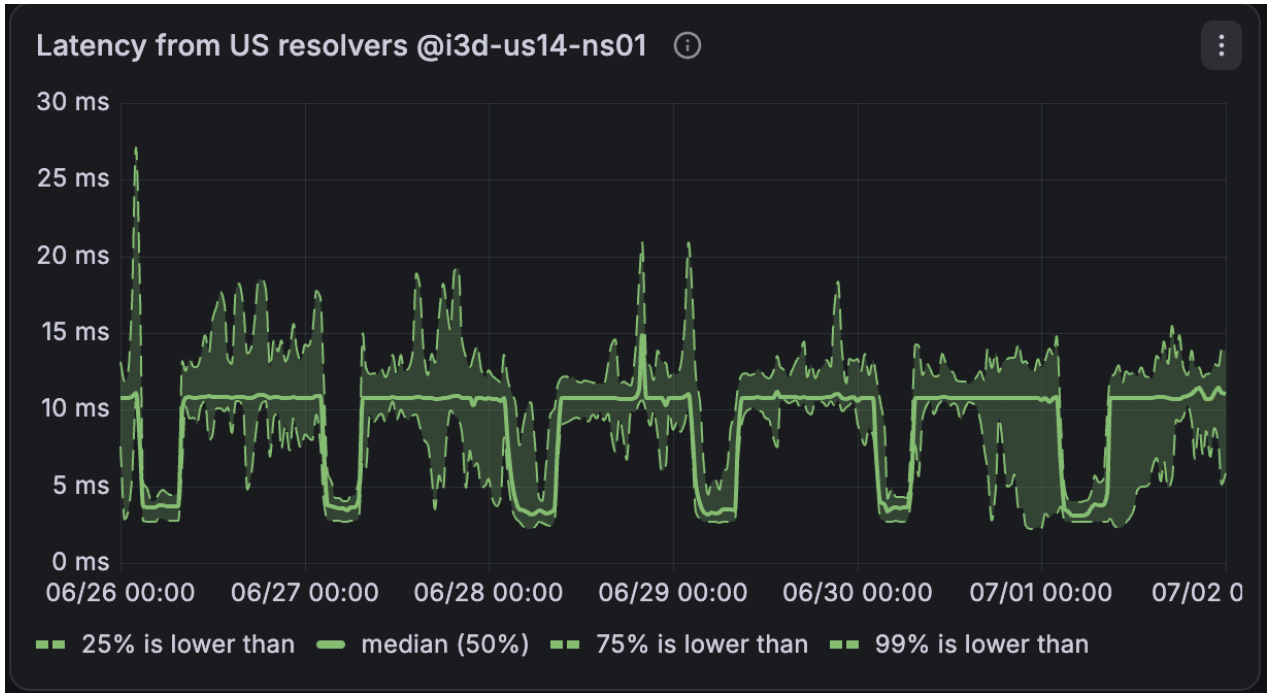


Running in production: Tapdance data Chicago

Linear scale: 50% queries under 5/10ms

Repeating pattern





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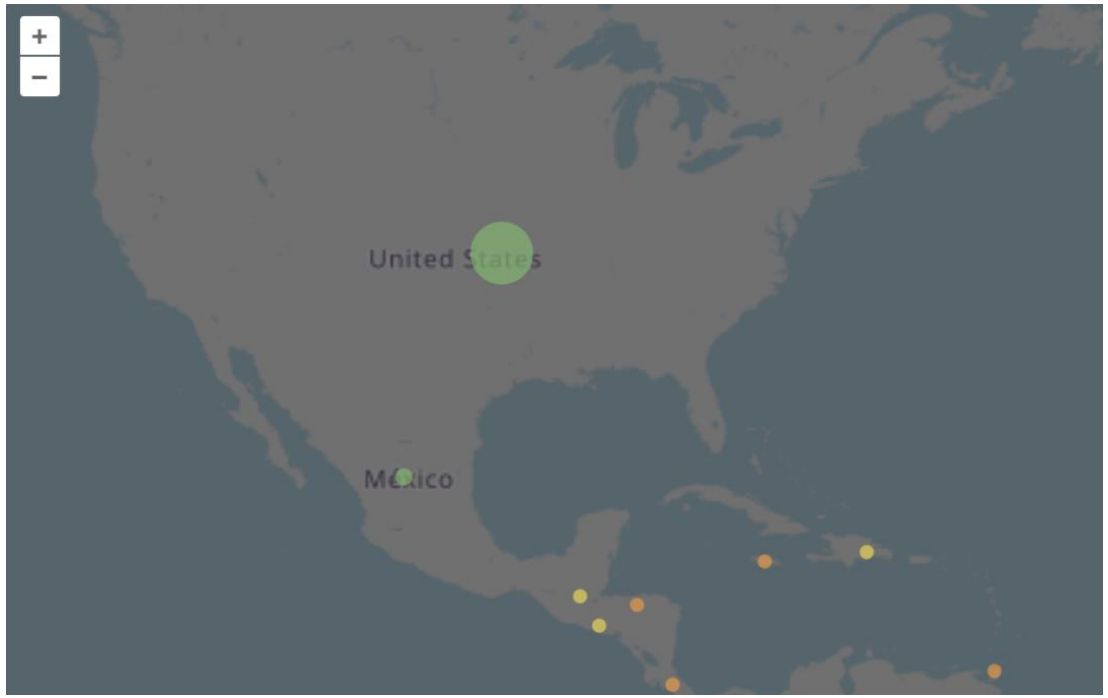
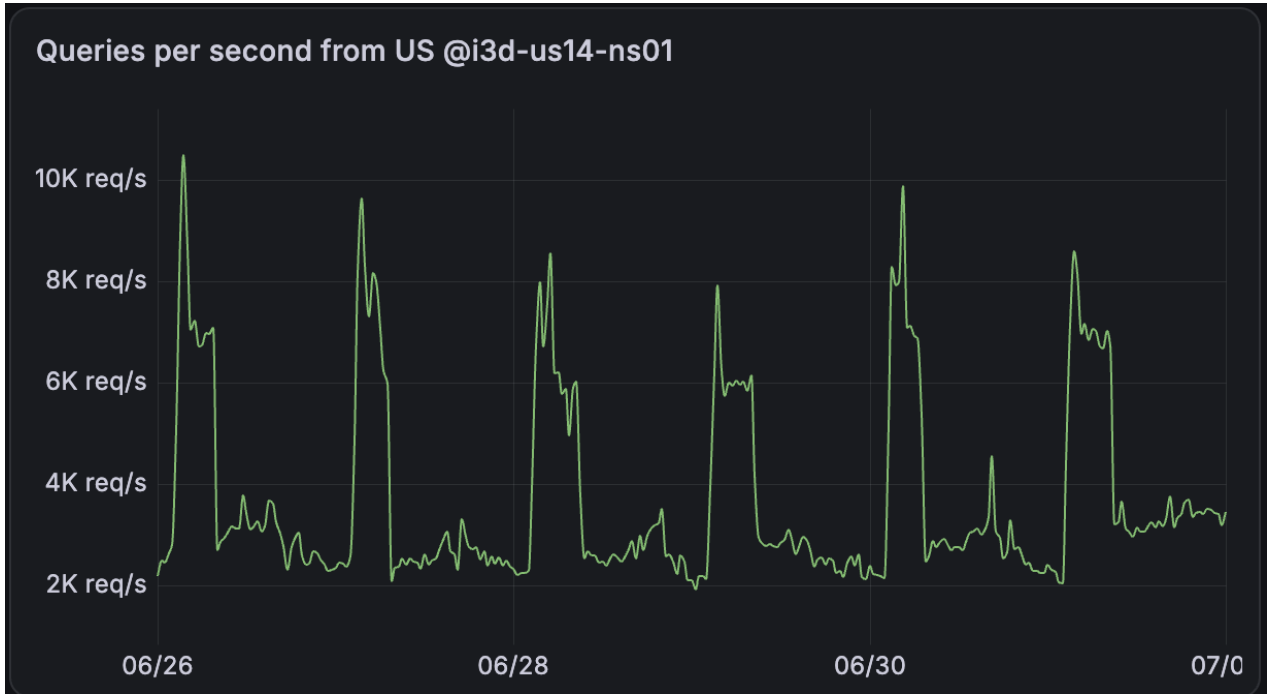
Running in production: Tapdance data Chicago

Linear scale: 50% queries under 5/10ms

Repeating pattern related to qps spikes





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Summary and conclusions

- Data driven migration considered successful
- Vendor agnostic automation efforts paid off
- Keep monitoring continously to optimize and detect anomalies



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Are there any questions?





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Thank you for your attention!