RIPE NCC
RIPE NETWORK COORDINATION CENTRE

Analysis of DNS performance in the region 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.

What is RIPE Atlas?

- A technology
  - Can be embedded into the different products
  - Including your internal ones
- Allows measuring **some** parameters from **any** probe/archor to **any** point of the Internet
- See: https://atlas.ripe.net/

Equipment

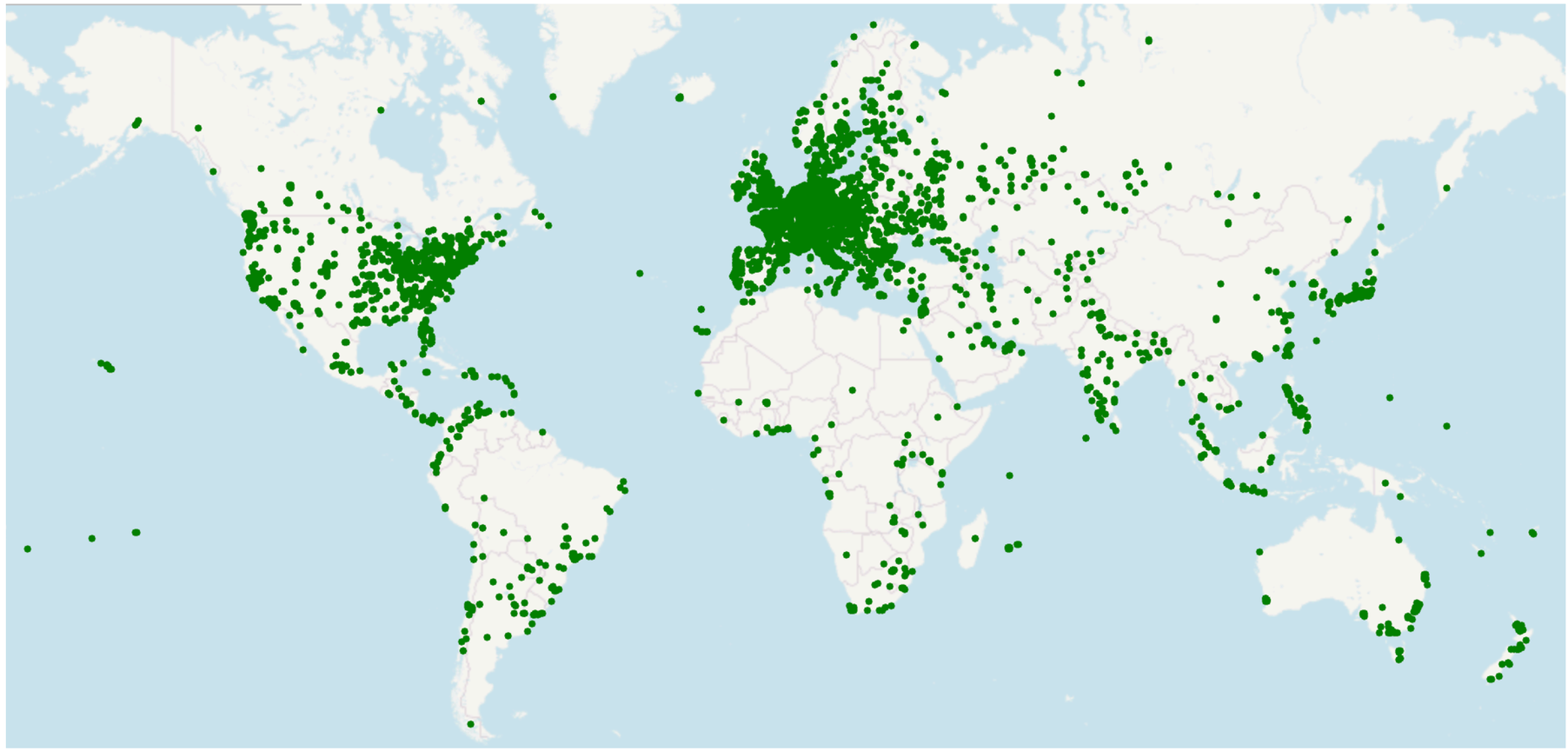
RIPE Atlas probe

RIPE Atlas Anchor

"Virtual" (software) versions also exist!

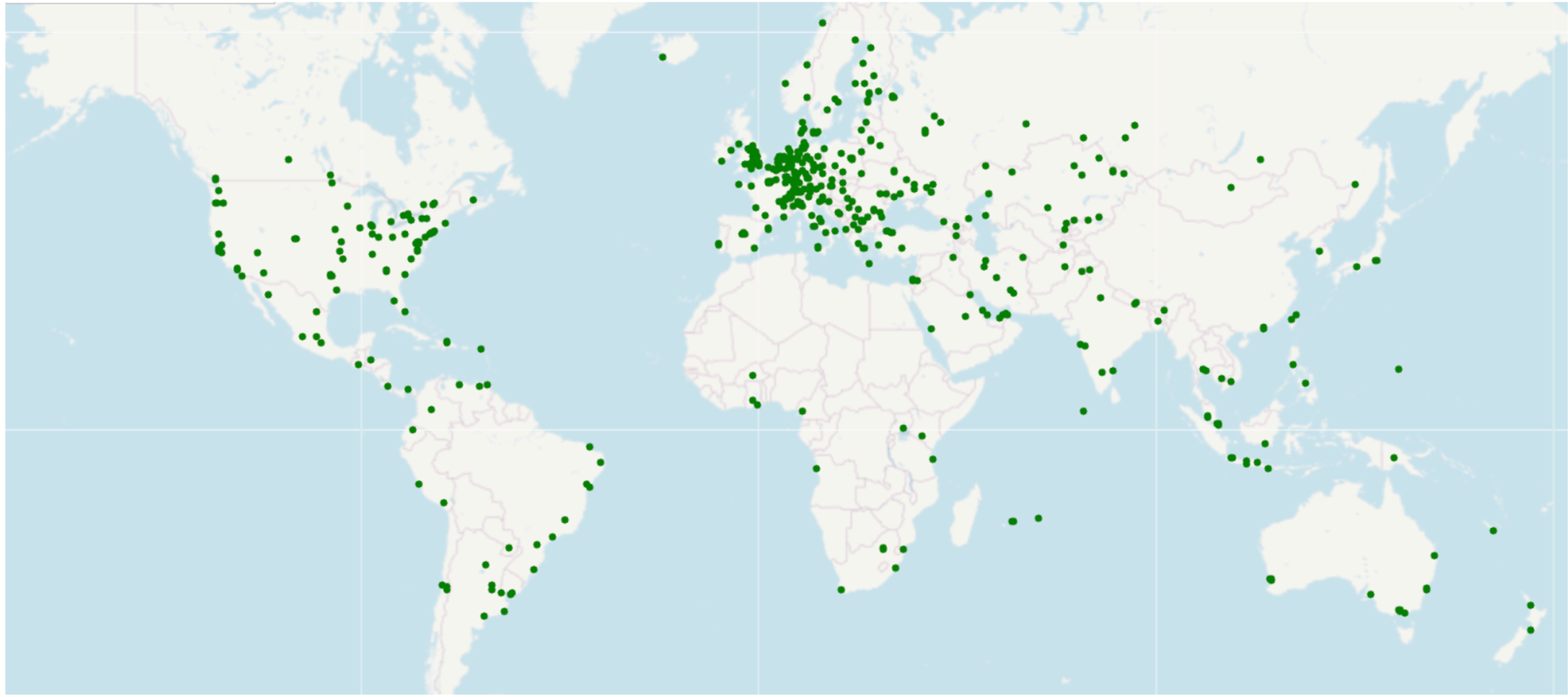
RIPE Atlas probes distribution

- 13000 probes all over the globe
  - 177 countries



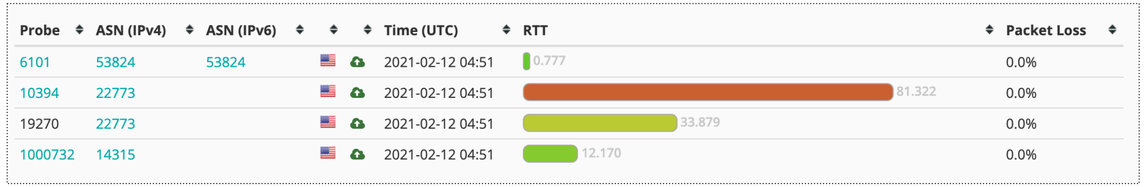
RIPE Atlas anchors distribution

- 1000+ anchors all over the globe
  - 102 countries

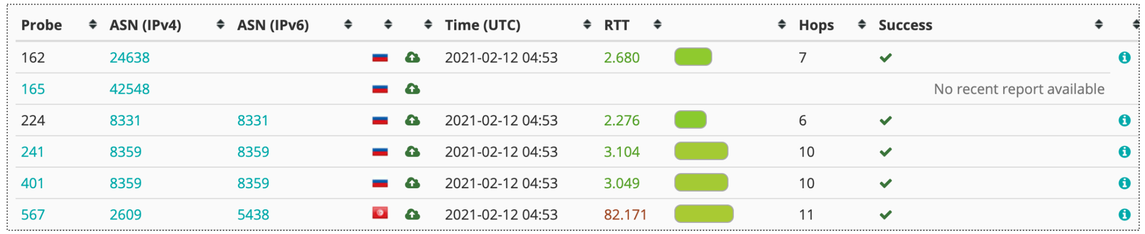


Types of measurements

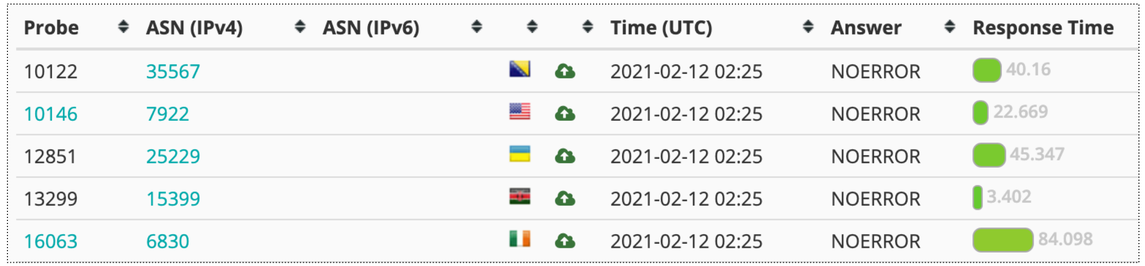
- What you can measure:
  - ICMP echo (ping)
  - Traceroute (TCP, UDP, ICMP)
  - DNS
  - HTTP
  - SSL/TLS
  - NTP
- Can somebody convert it to a botnet?
  - A lot of precautions and measures against such a scenario



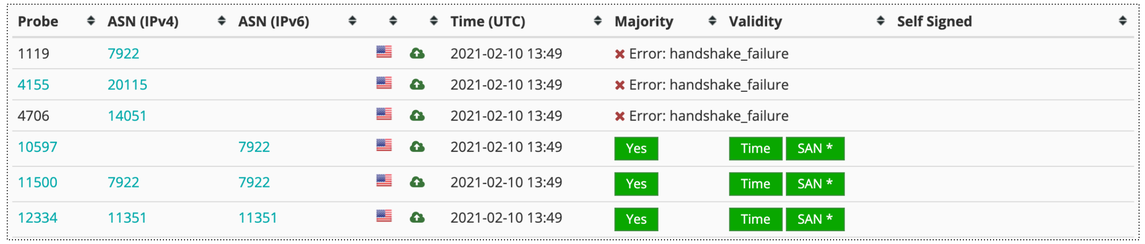
Probe	ASN (IPv4)	ASN (IPv6)	Time (UTC)	RTT	Packet Loss
6101	53824	53824	2021-02-12 04:51	0.777	0.0%
10394	22773		2021-02-12 04:51	81.322	0.0%
19270	22773		2021-02-12 04:51	33.879	0.0%
1000732	14315		2021-02-12 04:51	12.170	0.0%



Probe	ASN (IPv4)	ASN (IPv6)	Time (UTC)	RTT	Hops	Success
162	24638		2021-02-12 04:53	2.680	7	✔
165	42548					No recent report available
224	8331	8331	2021-02-12 04:53	2.276	6	✔
241	8359	8359	2021-02-12 04:53	3.104	10	✔
401	8359	8359	2021-02-12 04:53	3.049	10	✔
567	2609	5438	2021-02-12 04:53	82.171	11	✔



Probe	ASN (IPv4)	ASN (IPv6)	Time (UTC)	Answer	Response Time
10122	35567		2021-02-12 02:25	NOERROR	40.16
10146	7922		2021-02-12 02:25	NOERROR	22.669
12851	25229		2021-02-12 02:25	NOERROR	45.347
13299	15399		2021-02-12 02:25	NOERROR	3.402
16063	6830		2021-02-12 02:25	NOERROR	84.098



Probe	ASN (IPv4)	ASN (IPv6)	Time (UTC)	Majority	Validity	Self Signed
1119	7922		2021-02-10 13:49	✖ Error: handshake_failure		
4155	20115		2021-02-10 13:49	✖ Error: handshake_failure		
4706	14051		2021-02-10 13:49	✖ Error: handshake_failure		
10597		7922	2021-02-10 13:49	Yes	Time SAN *	
11500	7922	7922	2021-02-10 13:49	Yes	Time SAN *	
12334	11351	11351	2021-02-10 13:49	Yes	Time SAN *	

Methods to create measurements

- On the website
  - https://atlas.ripe.net
- Command-line interface
  - https://github.com/RIPE-NCC/ripe-atlas-tools
  - https://framagit.org/bortzmeyer/blaeu
- Python frameworks
  - https://github.com/RIPE-NCC/ripe-atlas-cousteau
  - https://github.com/RIPE-NCC/ripe-atlas-sagan
- REST API
  - https://beta-docs.atlas.ripe.net/apis/

Where results to be found?

- Most of the results are public
- RIPE Atlas API
  - https://beta-docs.atlas.ripe.net/apis/
- Direct access to the RIPE Atlas storage
  - https://data-store.ripe.net/datasets/atlas-daily-dumps/
  - Results for the last month
- RIPE Atlas data in Google BigQuery
  - https://github.com/RIPE-NCC/ripe-atlas-bigquery/blob/main/docs/gettingstarted.md

Built-in “Internet Maps”

- Internet Maps are RIPE NCC ready-to-be-used products for many stakeholders
- Root DNS Monitoring
  - DNS Root Instances: which one is using?
  - Comparative DNS Root RTT: which one is closer?
  - DNS Root Server Performance: how fast they are?
  - DNSMON: a comprehensive, objective and up-to-date overview of the quality of the high-level DNS servers
  - DomainMON: monitors your own domains
- RTT Measurements to Fixed Destinations

Time to create an own research!

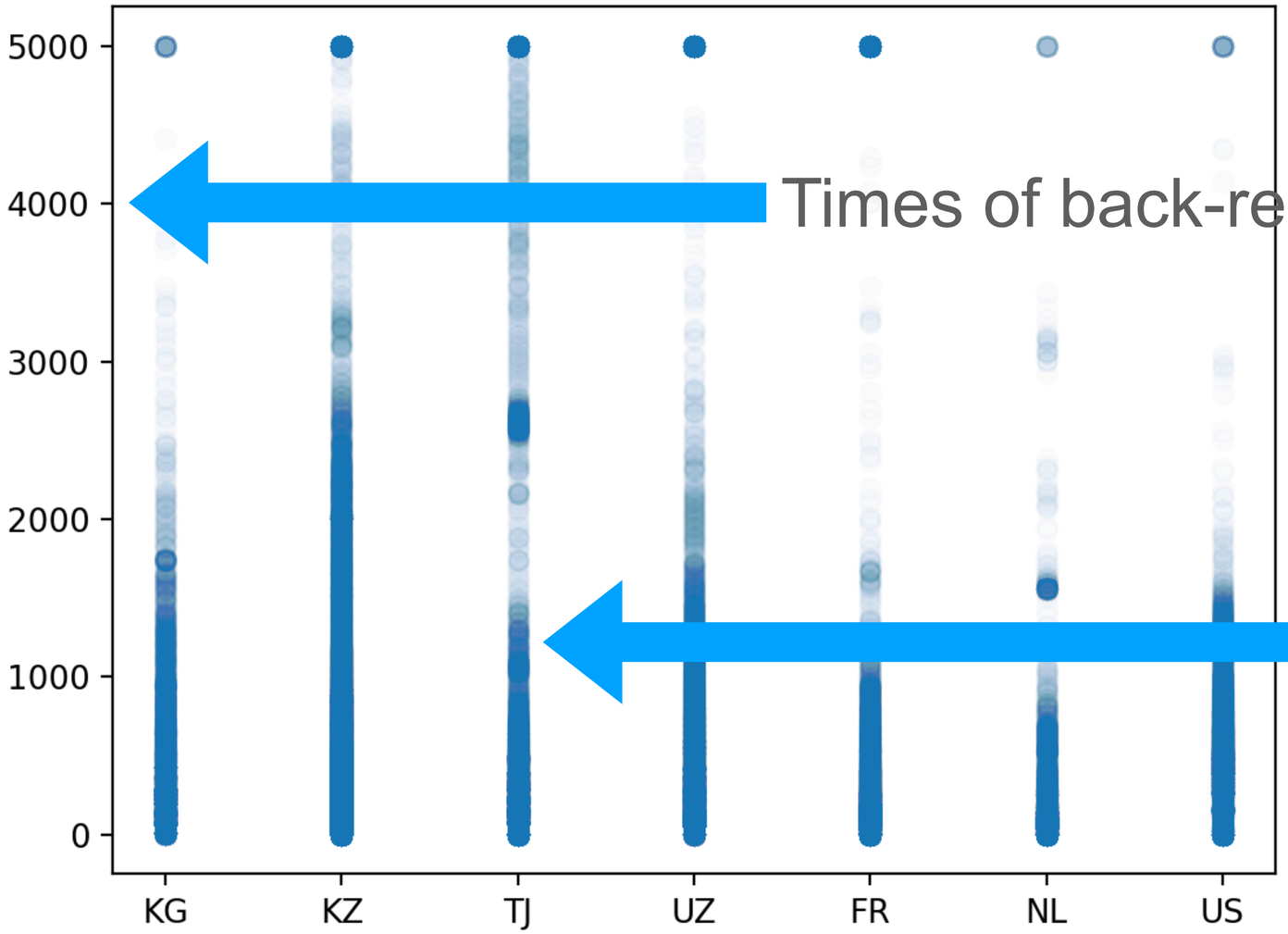
- We will study the performance of DNS servers in the region and compare it to how DNS servers in other countries perform
- To do this, we will measure the back-resolving time for a fixed and pre-prepared set of IP addresses across the RIPE region
  - Backresolving - turning IP addresses into domain names
- To minimize the impact of caching, we will create measurements at intervals longer than the TTL (time to live) of the corresponding DNS record
- The measurement results will be grouped by country and visualized for further discussion

You can do such a study on your own

This material was prepared using only public documentation and publicly available program interfaces (API) of the RIPE Atlas project.

DNS Measurements with RIPE Atlas

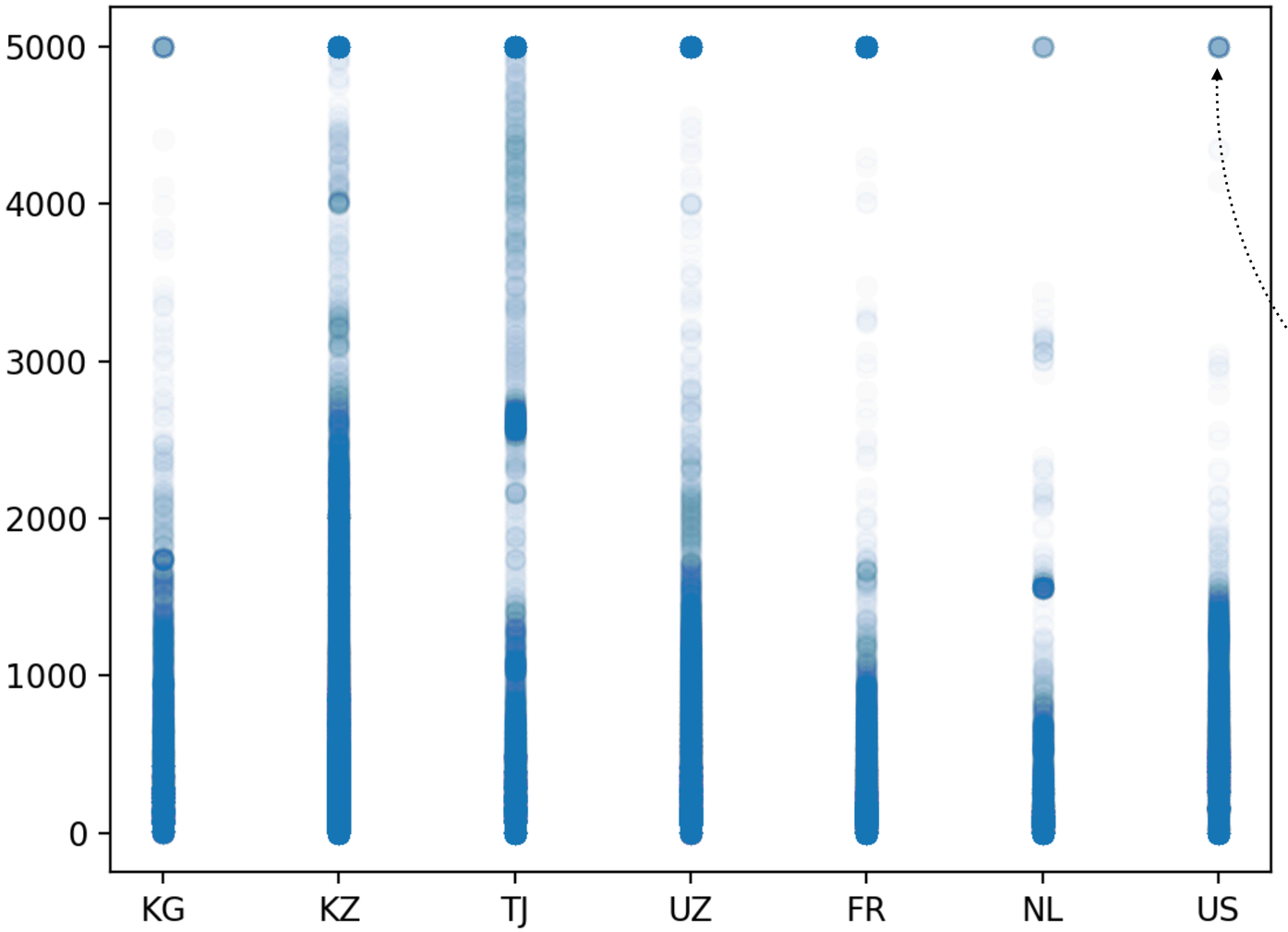
All results at a glance



Times of back-resolving in ms

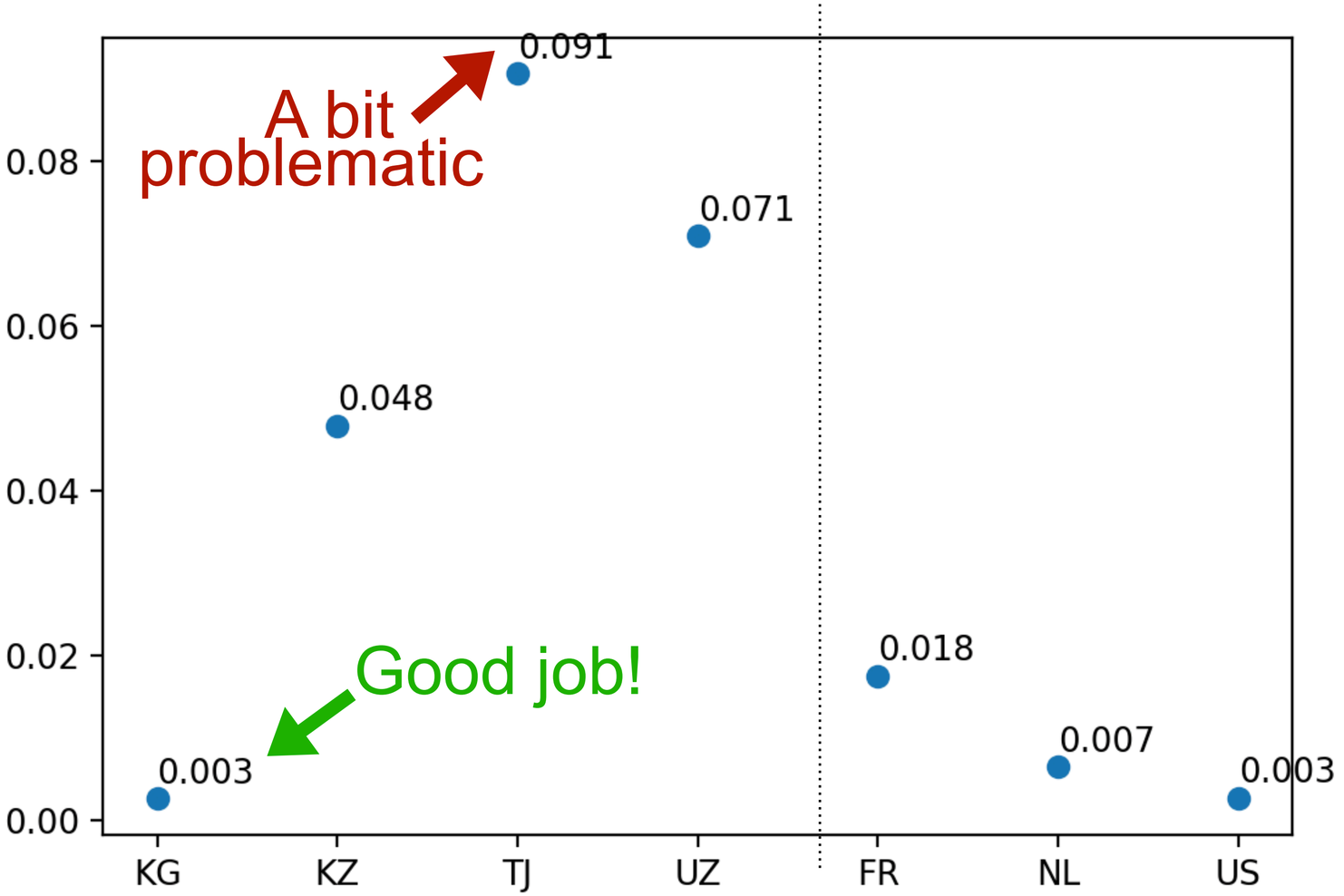
Intensity of the color corresponds to the density of this value in results

All results at a glance



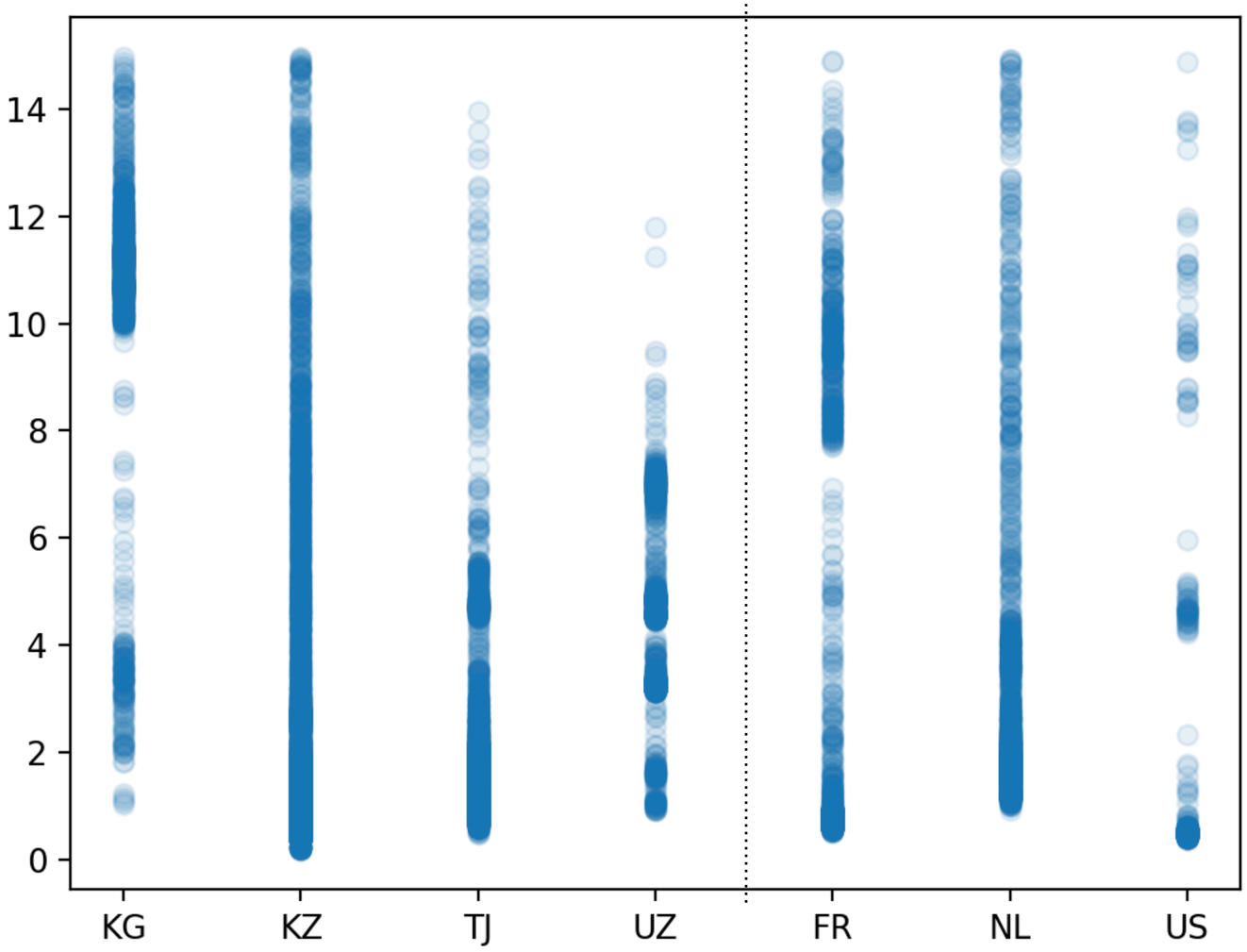
- We still have some caching effects
  - Because some probes share the same DNS-server
- We also have timeouts (points at 5000 ms)
- Some conclusions can be made already…
- …but let’s dive a bit deeper first

Ratio of bad statuses in the responses



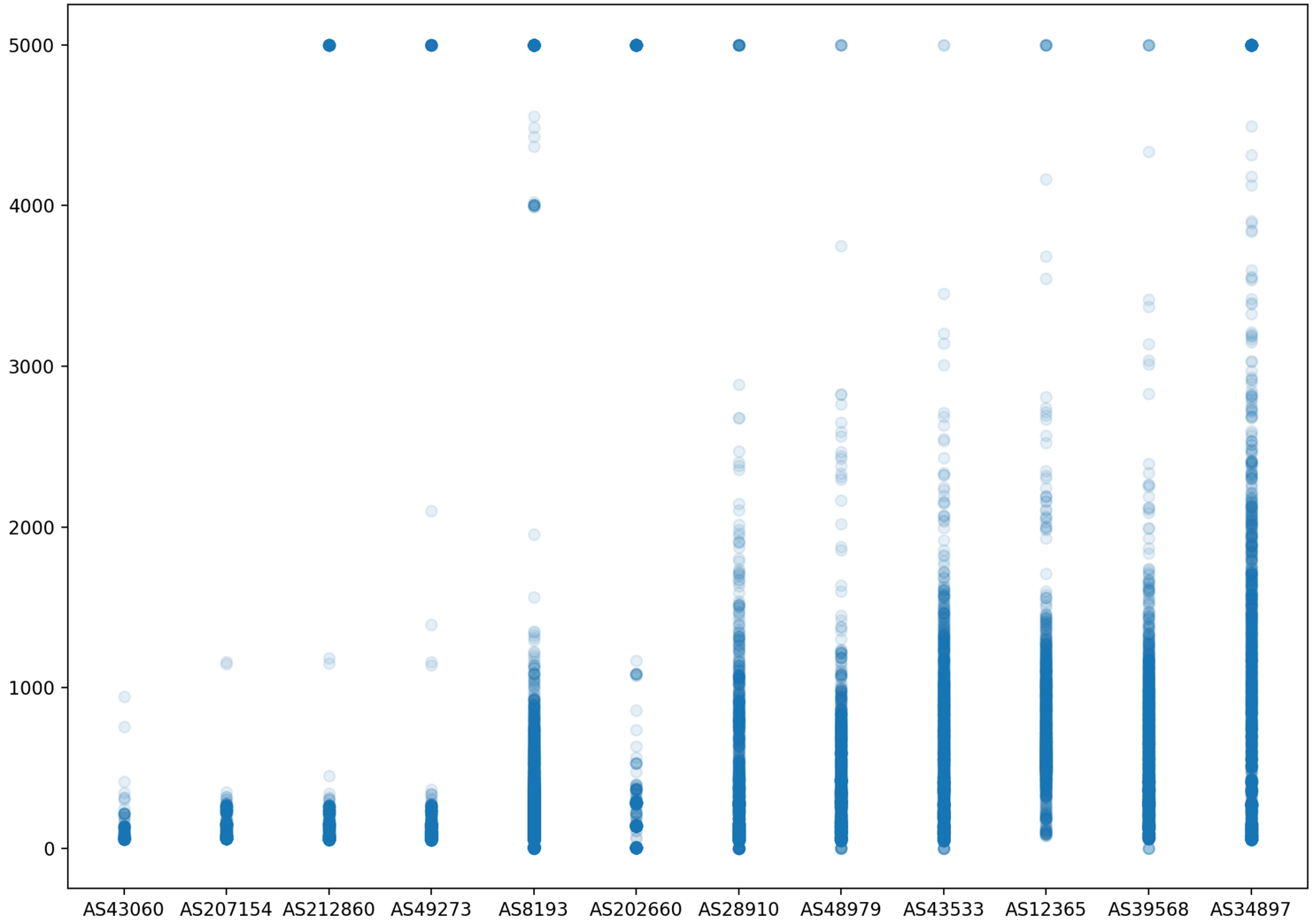
- Ratio of “bad statuses” for **valid** targets
- “Bad statuses” are:
  - NXDOMAIN
  - SERVFAIL
  - REFUSED
  - timeout
  - network errors
- Kyrgyzstan is a winner
- Other countries should try better (esp. Tajikistan)

Analysis of cached answers



- We use the bottom part of the cached answers, <15 ms
  - They are from caches: light speed is limited
- Uzbekistan shows the best DNS caching
- Still, all countries of the region take DNS caching some advantage
  - (Which is good)

Results in Uzbekistan per AS



- Non-uniform distribution across autonomous systems
  - But some results are good
- And here we can see the real example why DNS caches are important

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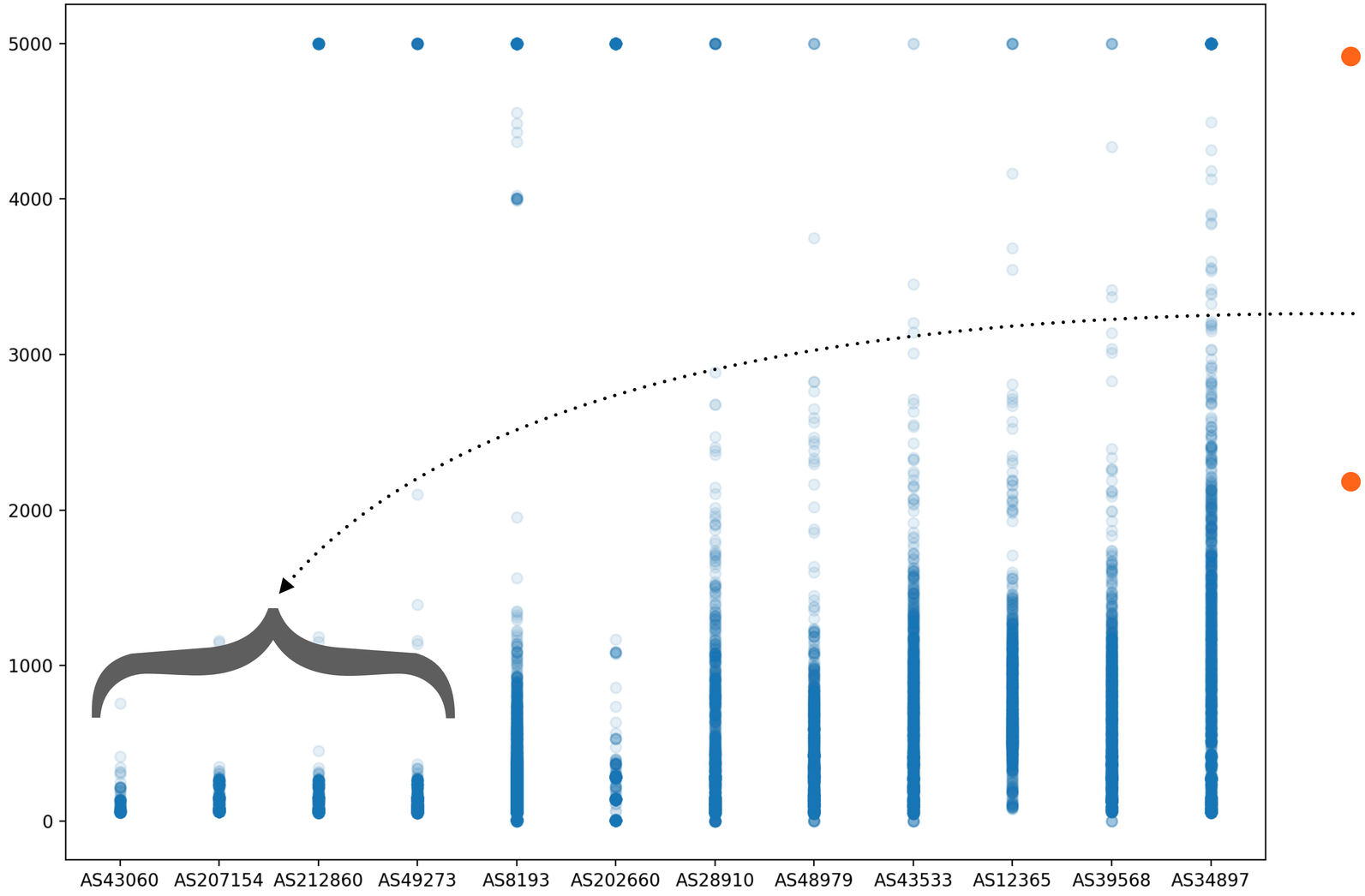

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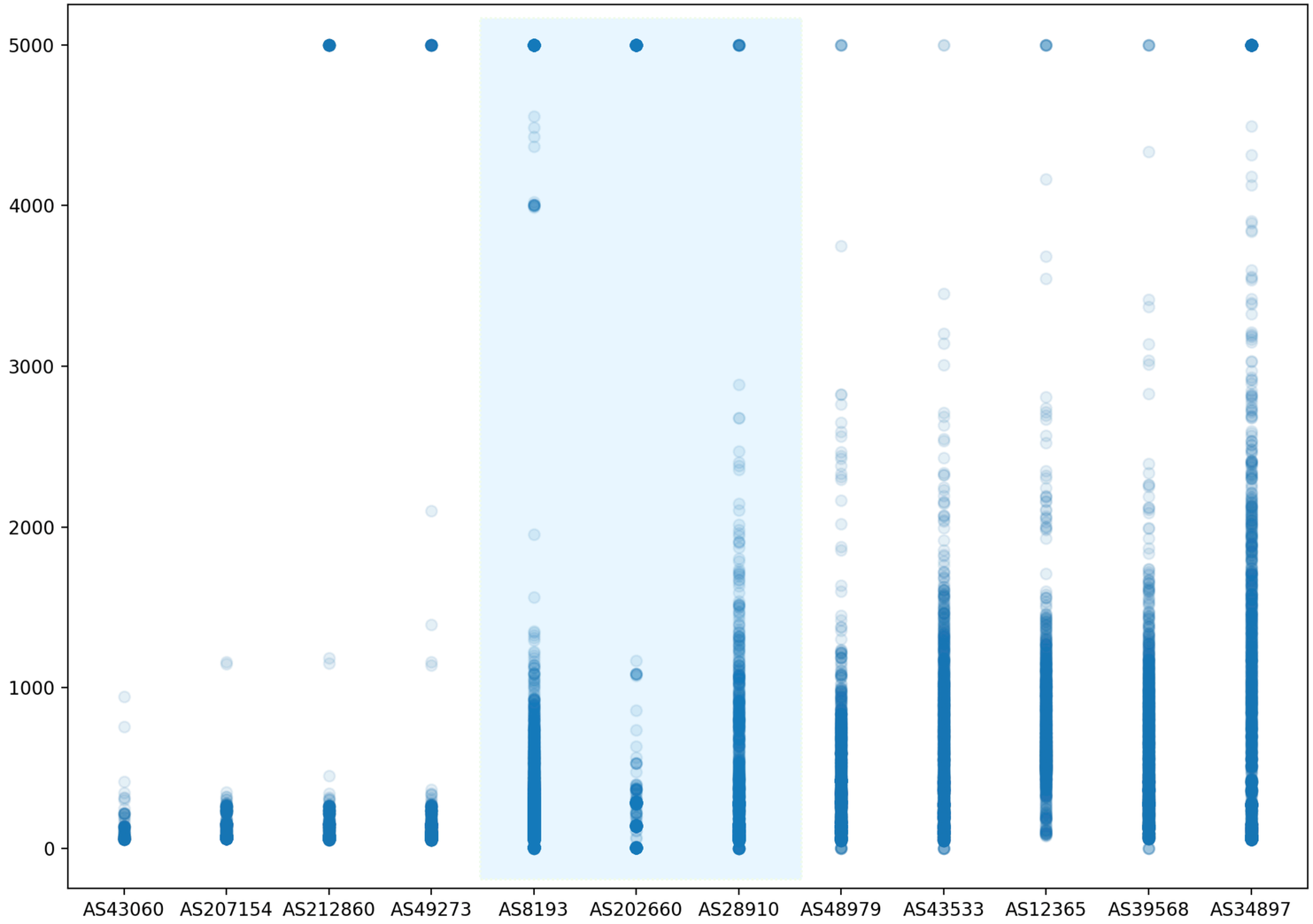
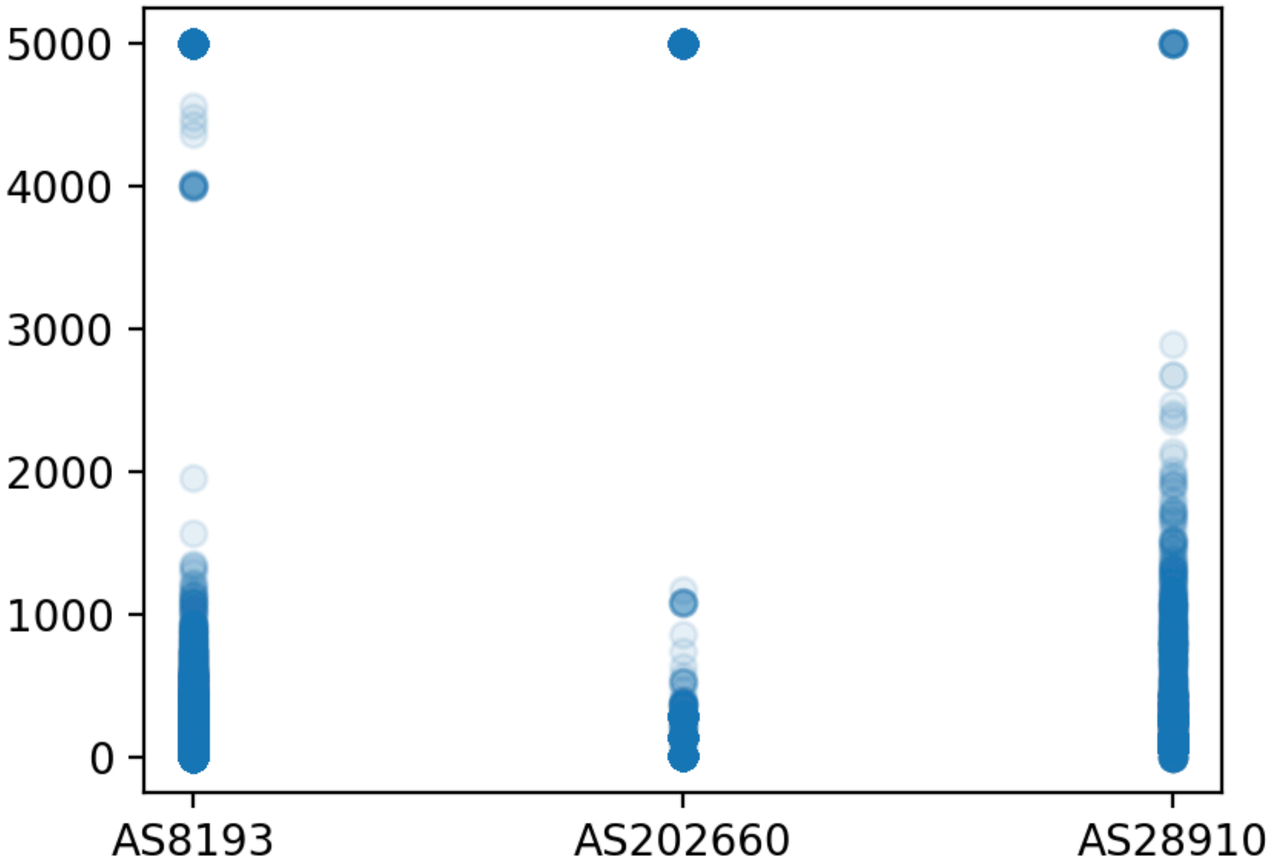
Caching effect for UzTelecom



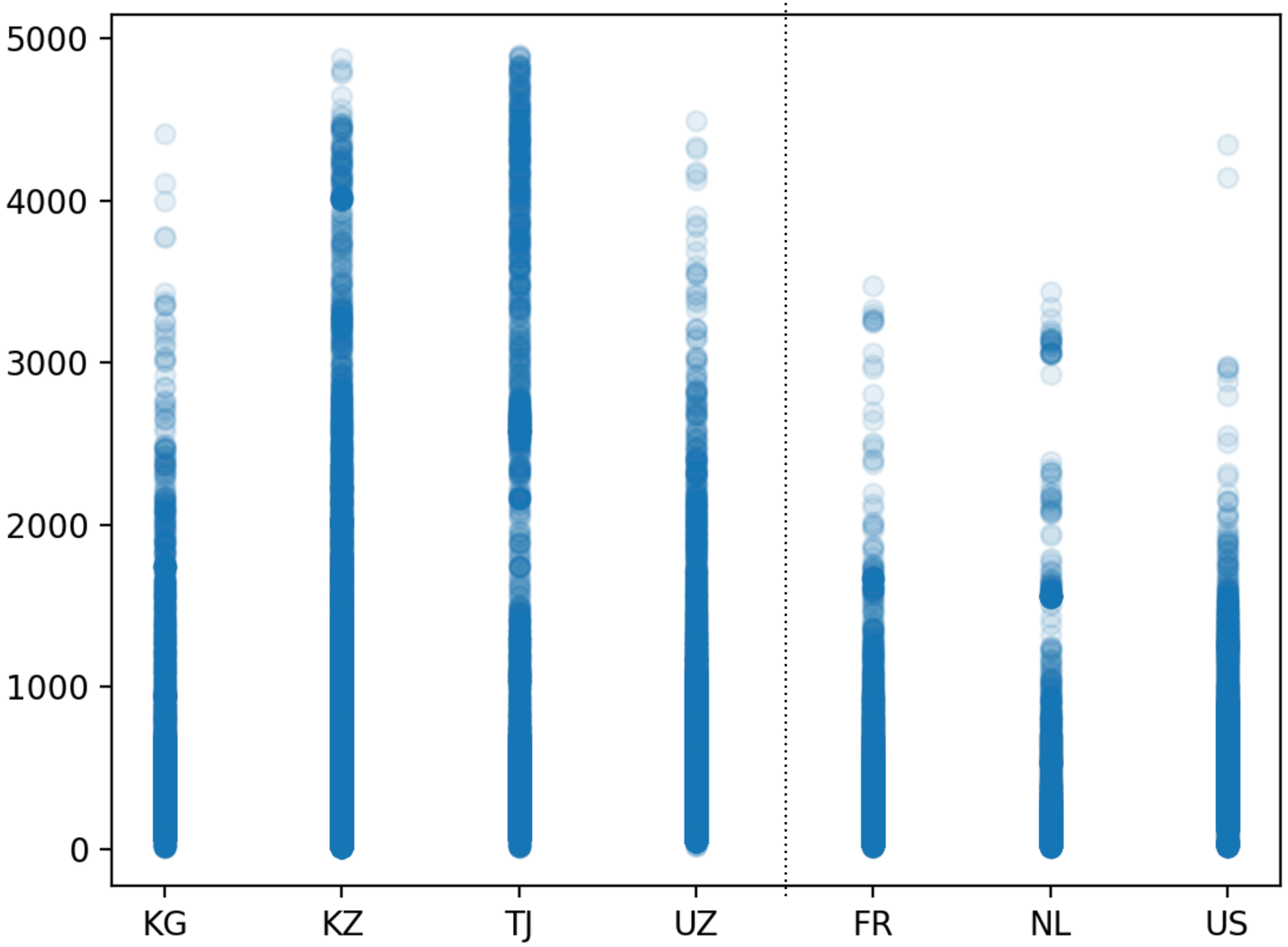
- Now let’s take a closer look on UzTelecom Autonomous Systems
  - AS8193
  - AS202660
  - AS28910

Caching effect, Uztelecom



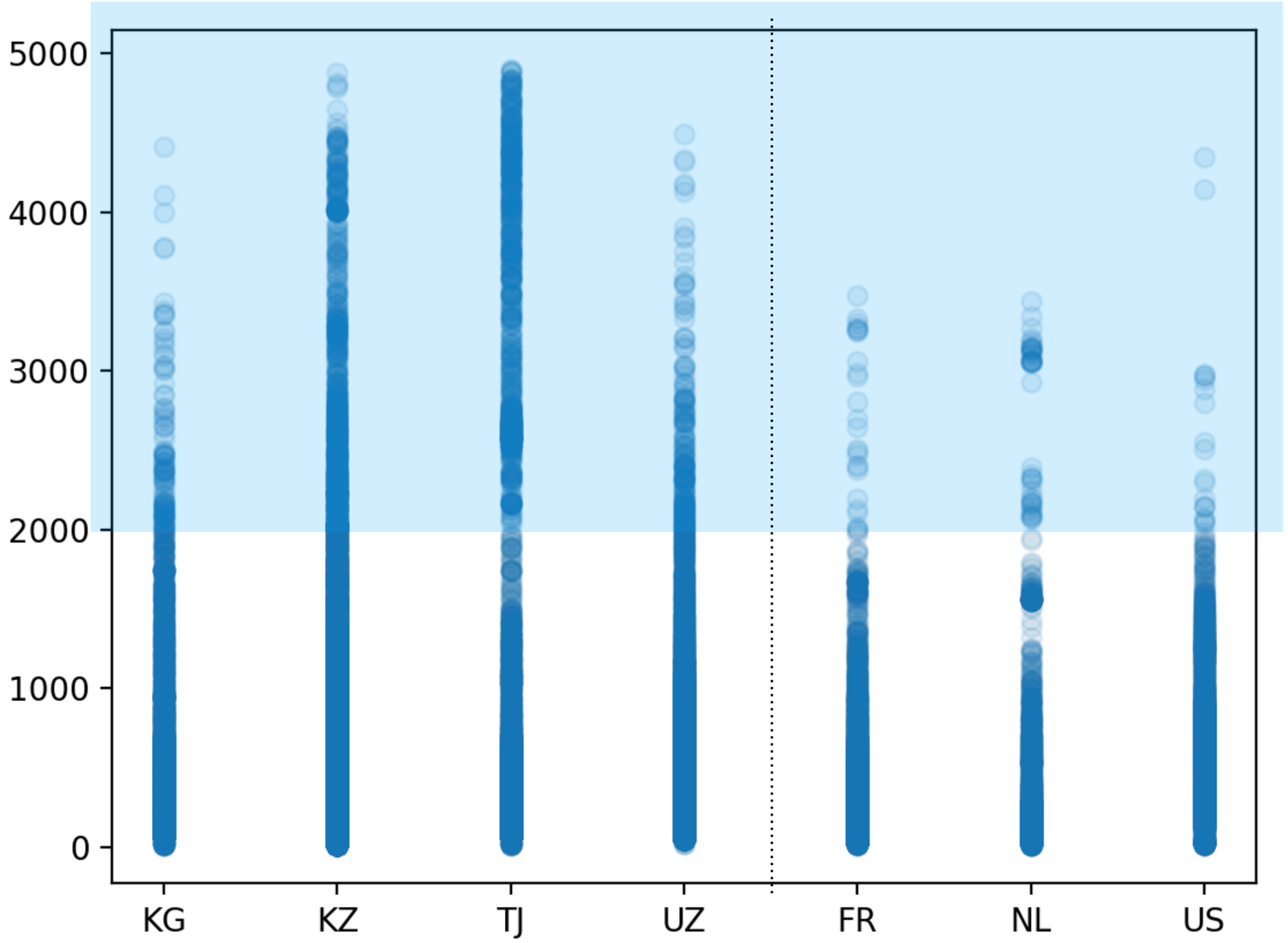
- Comparing the individual measurements, one can see that AS202660 shows time *either* the same as AS8193 *or* significantly less
  - Obviously, some part of the requests from AS202660 go through DNS servers in AS8193
- The significantly better average results of AS202660 compared to AS8193 can be seen on the plot
  - Even though the cache is not always queried
- AS28910 used to be a different operator, and it seems that the integration process is still underway

Results without caching and timeouts



- Let’s study the worst cases
- To do that, we switch to results above 2 secs

Results without caching and timeouts



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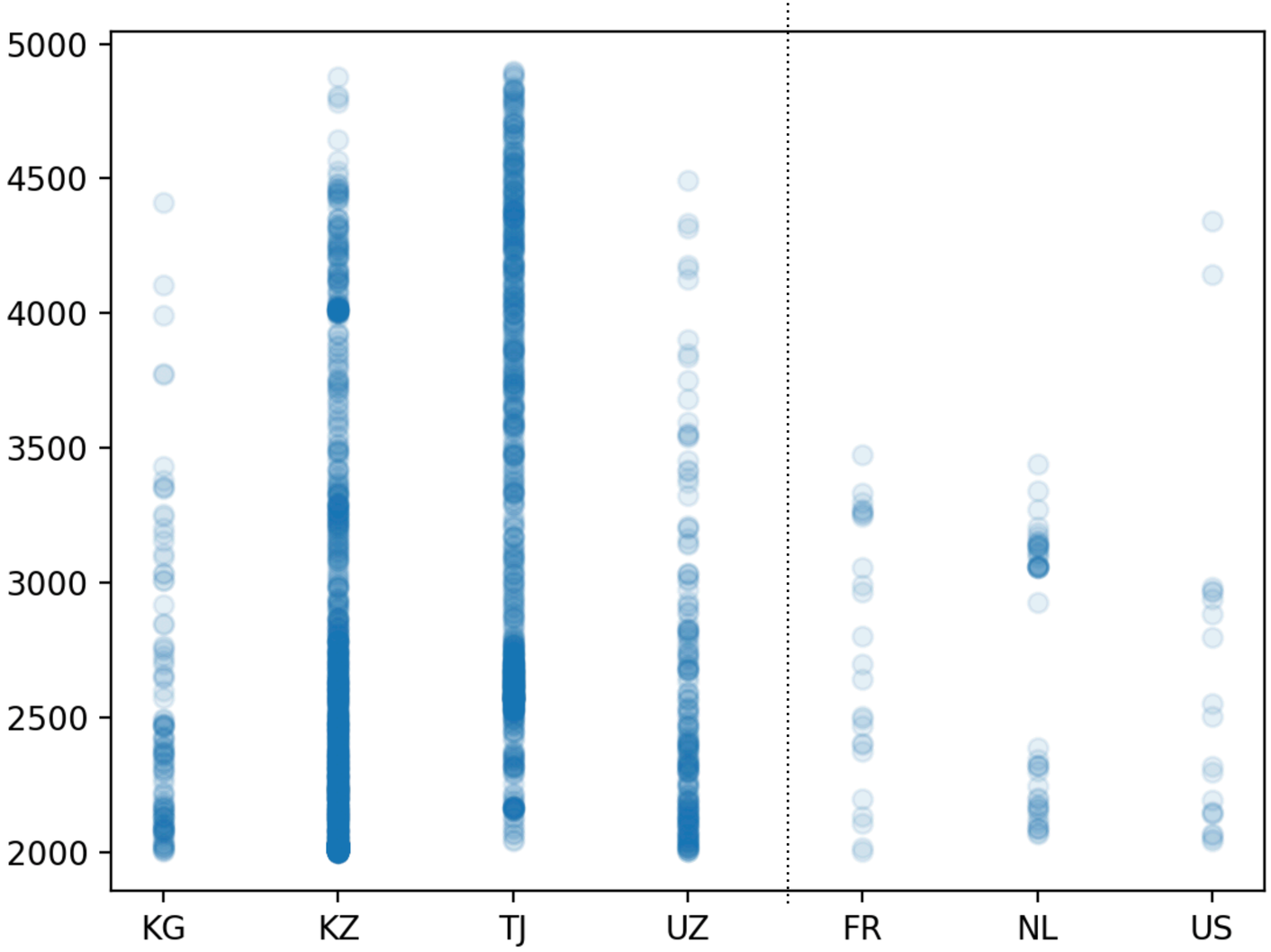
Upper part

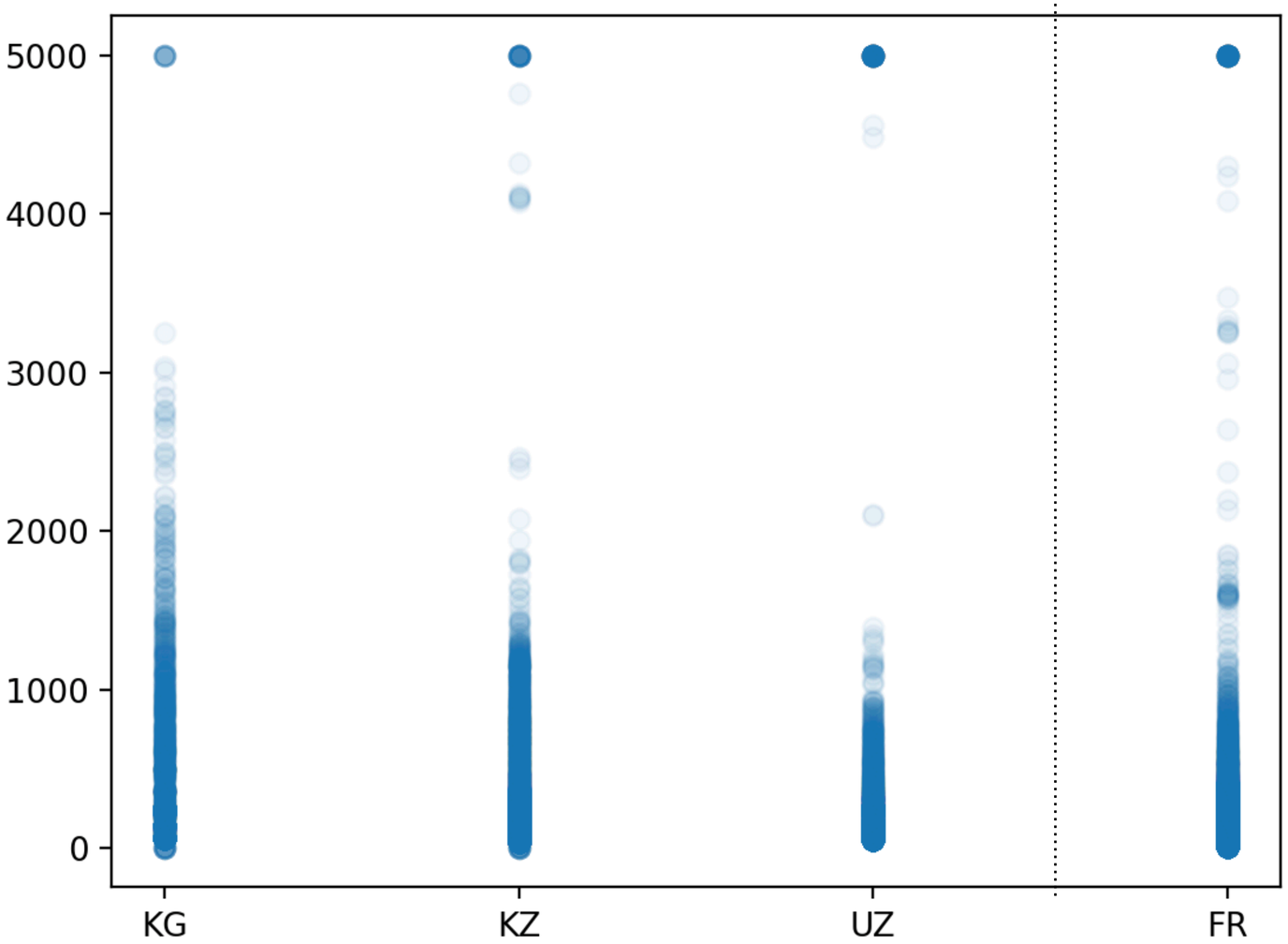


- "Tails" in the region are longer than for France, the Netherlands and the US
- There are a lot of good results as well
  - (Less than 2 seconds)
- Operators of Tajikistan and Kazakhstan should think about DNS servers optimizing
  - But Uzbekistan and Kyrgyzstan also have room for improvement

Public DNS servers

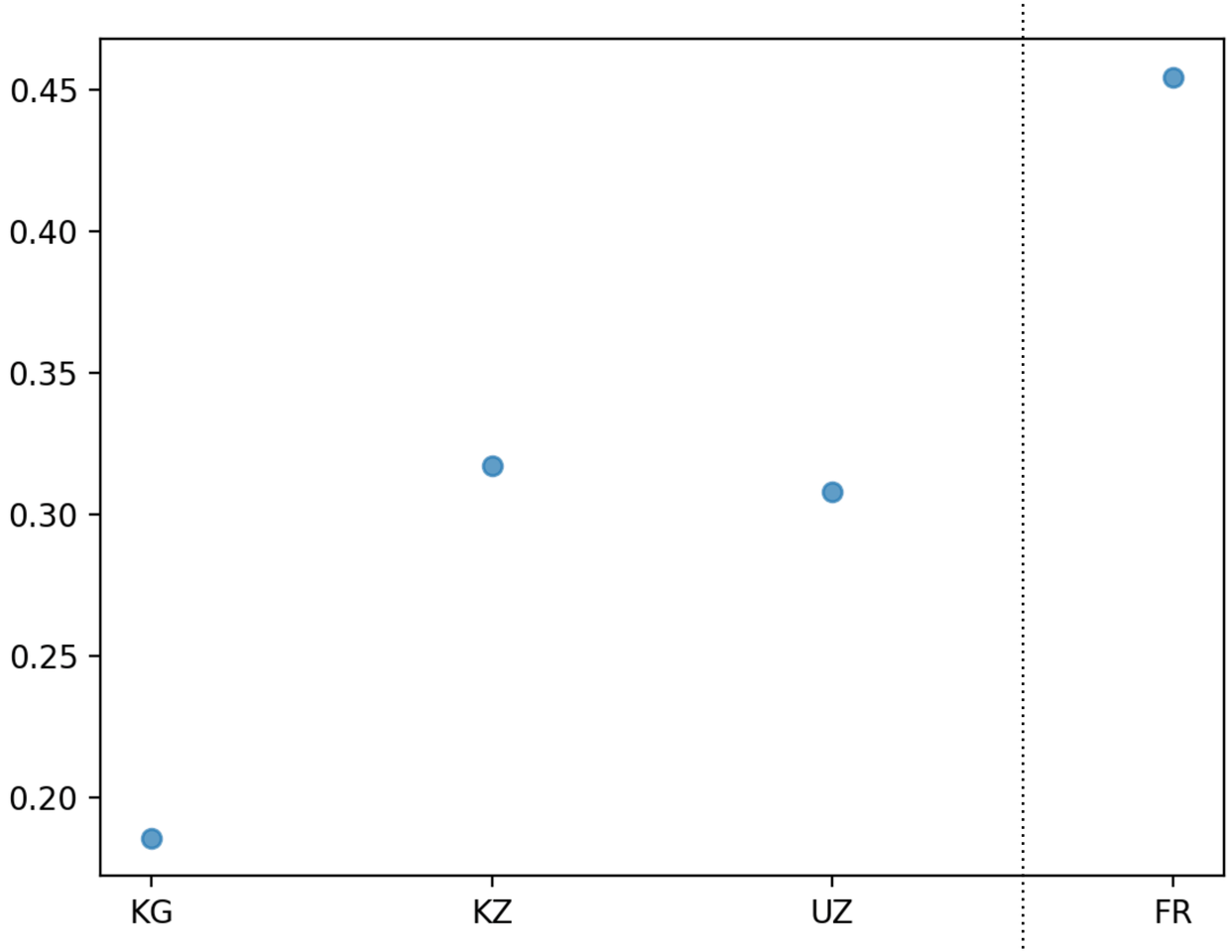
- With the emergence of publicly available DNS servers (pDNS), some operators refused to support their own DNS infrastructure, and began to give users the addresses of these public DNS servers.
- List of projects supporting public DNS servers:
  - Google (8.8.8.8, 8.8.4.4, …)
  - Quad9 (9.9.9.9…)
  - Cloudflare (1.1.1.1…)
  - Cisco/OpenDNS (208.67.222.222…)
  - AdGuard DNS (94.140.14.14…)
  - CleanBrowsing: (185.228.168.9…)
  - Yandex (77.88.8.8…)
- Let's see how they are used in Central Asia.

Public DNS servers usage



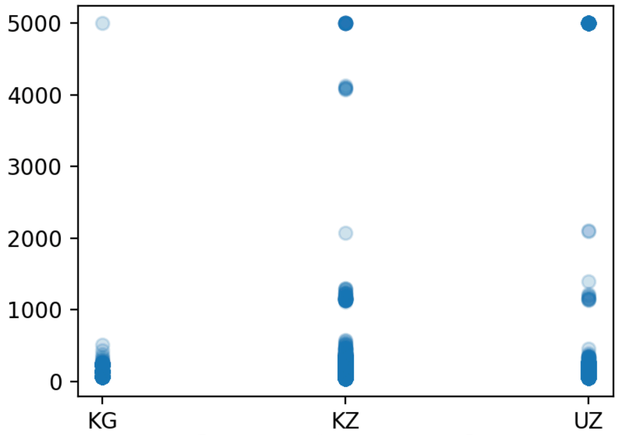
- Revealed the usage of the following public DNS Servers:
  - Google DNS
  - Quad9 (9.9.9.9 etc)
  - CloudFlare
- No usage of other public DNS services detected in Central Asia
  - Not even Yandex, which is unexpected
- Public DNS shows good timing results
  - But far from the best

Public DNS servers usage

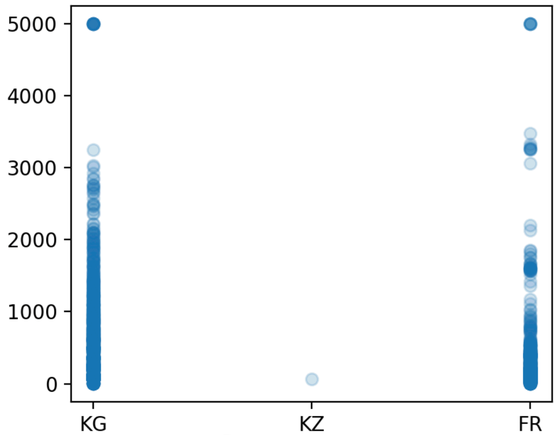


- The total share of requests from the entire dataset worked by pDNS servers is high: 28%
- This approach is used in three countries in the region: Kyrgyzstan, Kazakhstan and Uzbekistan
  - In Kyrgyzstan it is used the least (but it is still 18.5%)

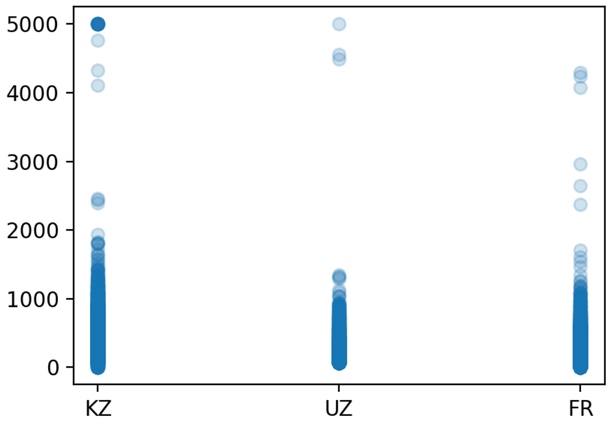
pDNS usage by services



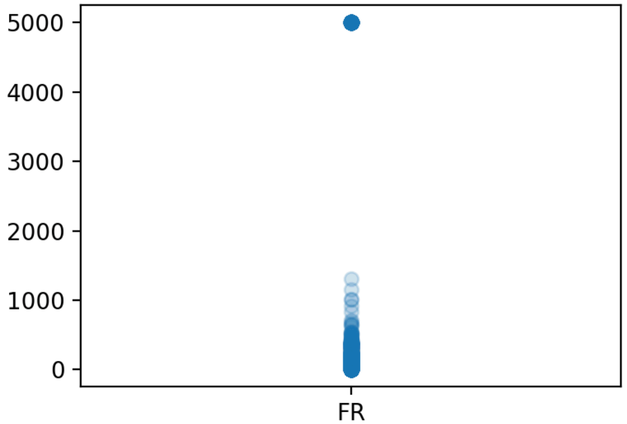
Google DNS



Quad9



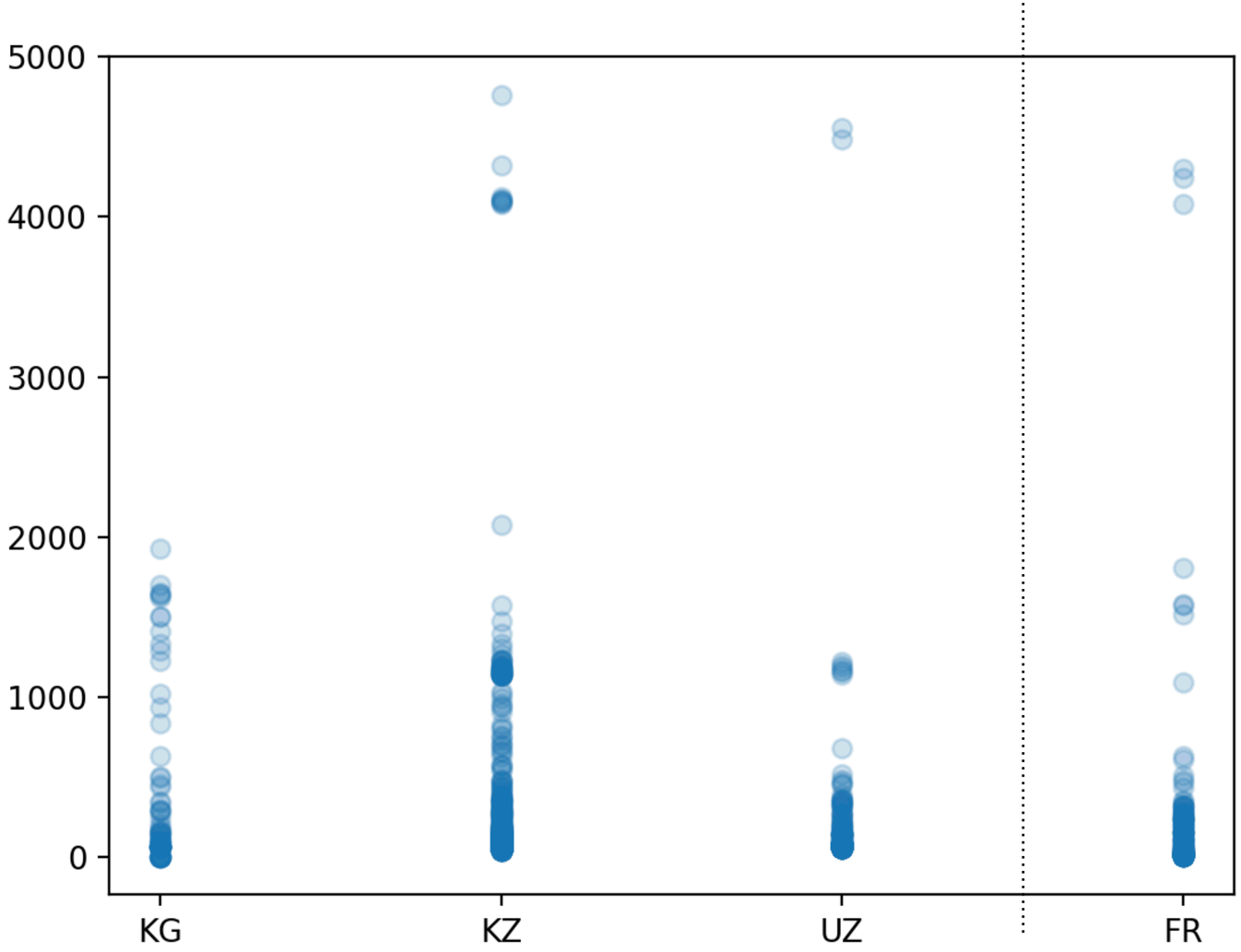
Cloudflare



Cisco

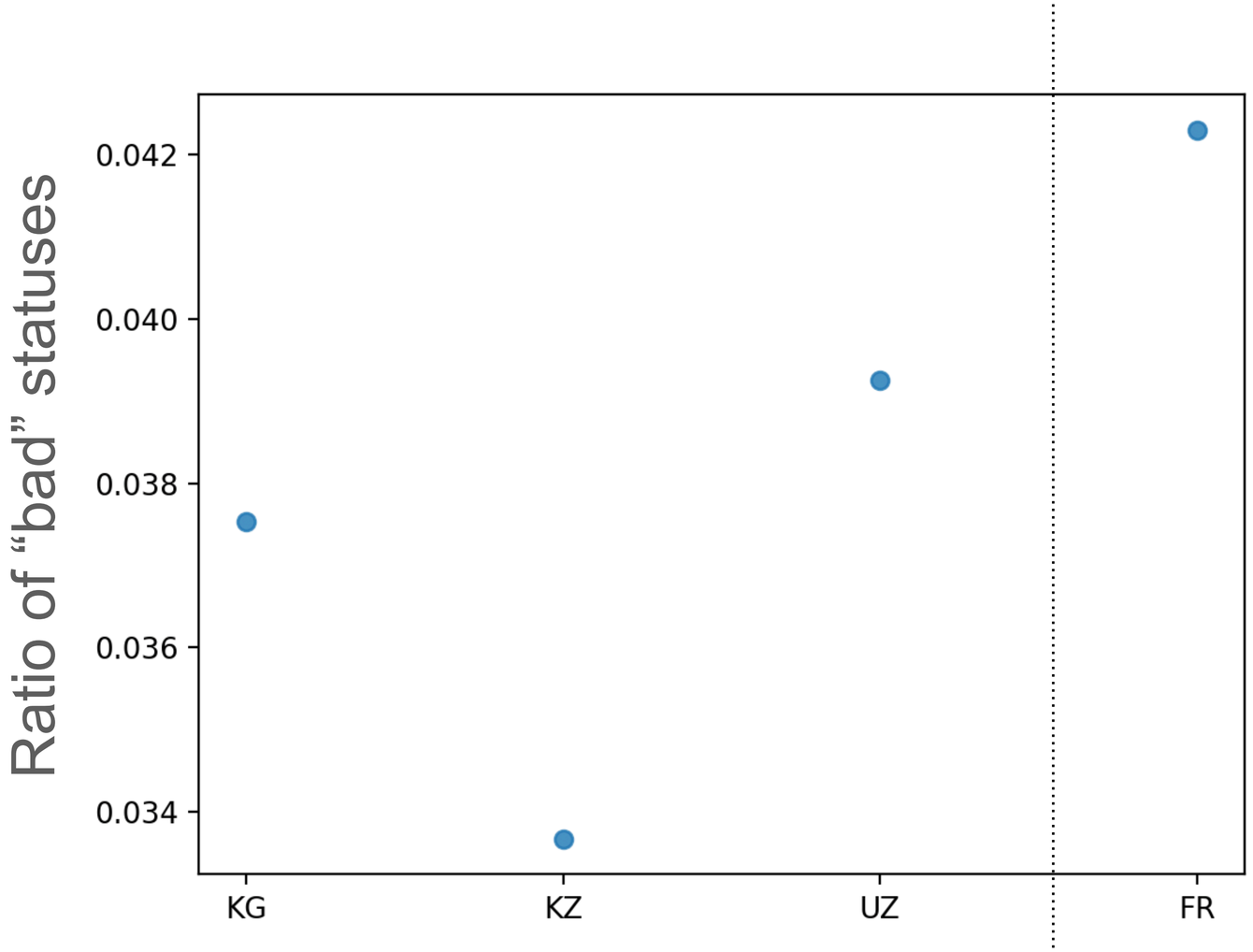
- Google shows the best results
  - KZ: there are some islands of values that are looking suspicious.
  - (Connectivity issues?)
- Quad9: service definitely is not optimized for Central Asia
- Using pDNS does not get rid of a noticeable fraction of timeouts

pDNS returning “bad” statuses



- pDNS return "bad" statuses too
  - I.e. users get SERVFAIL or network error for valid requests
- Timing results for such queries don't look good either

pDNS returning “bad” statuses



- 3-4% is a lot
  - Most of them are not real statuses but network issues
- Cisco/OpenDNS in France are the worst!
  - I.e. it does not look like a regional problem

Conclusions

- DNS query processing time is important for all network applications
- Currently, not all operators in Central Asia provide adequate performance
  - On average, the situation is best in Kyrgyzstan, with Uzbekistan in second place.
- Using public DNS servers can help
  - But not all of them work equally well!
  - At the moment, Google DNS is a winner
- However, well-configured in-house DNS servers do a better job
- Caching and deployment of authoritative servers in the region can greatly improve the situation
- RIPE NCC can contribute to improvement: AuthDNS

AuthDNS

- With the AuthDNS service RIPE NCC hosts:
  - ripe.net and related zones
  - reverse DNS zones corresponding to all address space allocated to us he other four RIRs
  - Secondary DNS service to a number of small and developing ccTLDs
  - Secondary DNS for extra large LIRs
- **You can apply to host our AuthDNS service to improve your DNS infrastructure**
- Future reading:
  - https://www.ripe.net/analyse/dns/authdns/
  - https://labs.ripe.net/author/anandb/expanding-our-authoritative-dns-cluster/

Questions

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