RIPE NCC
RIPE NETWORK COORDINATION CENTER

RIPE Atlas in Action
The Connectivity of Moldova

Alex Semenyaka | June 2025 | RIPE NCC Days Chisinau

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.

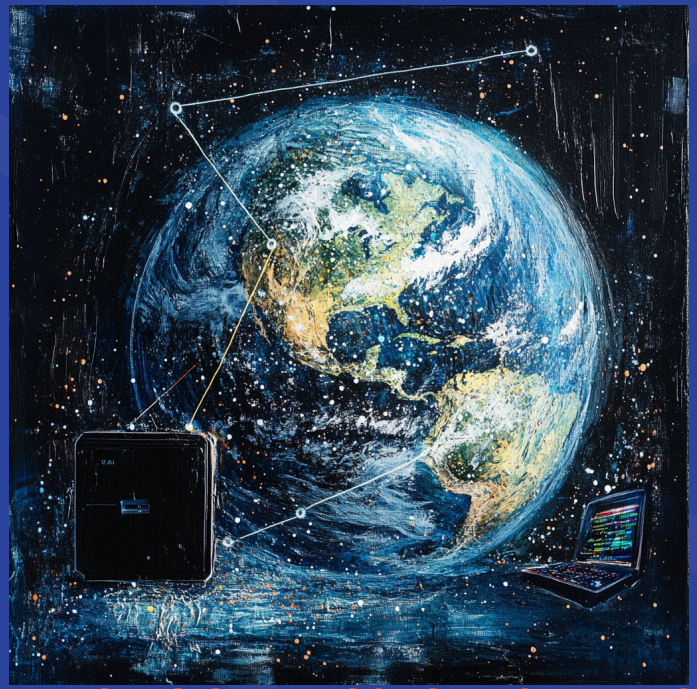
What is RIPE Atlas?

A technology…

- Can be embedded into the different products
- Including your internal ones

…measuring some parameters

- from any probe/archor
- to any point of the Internet



Check https://atlas.ripe.net/

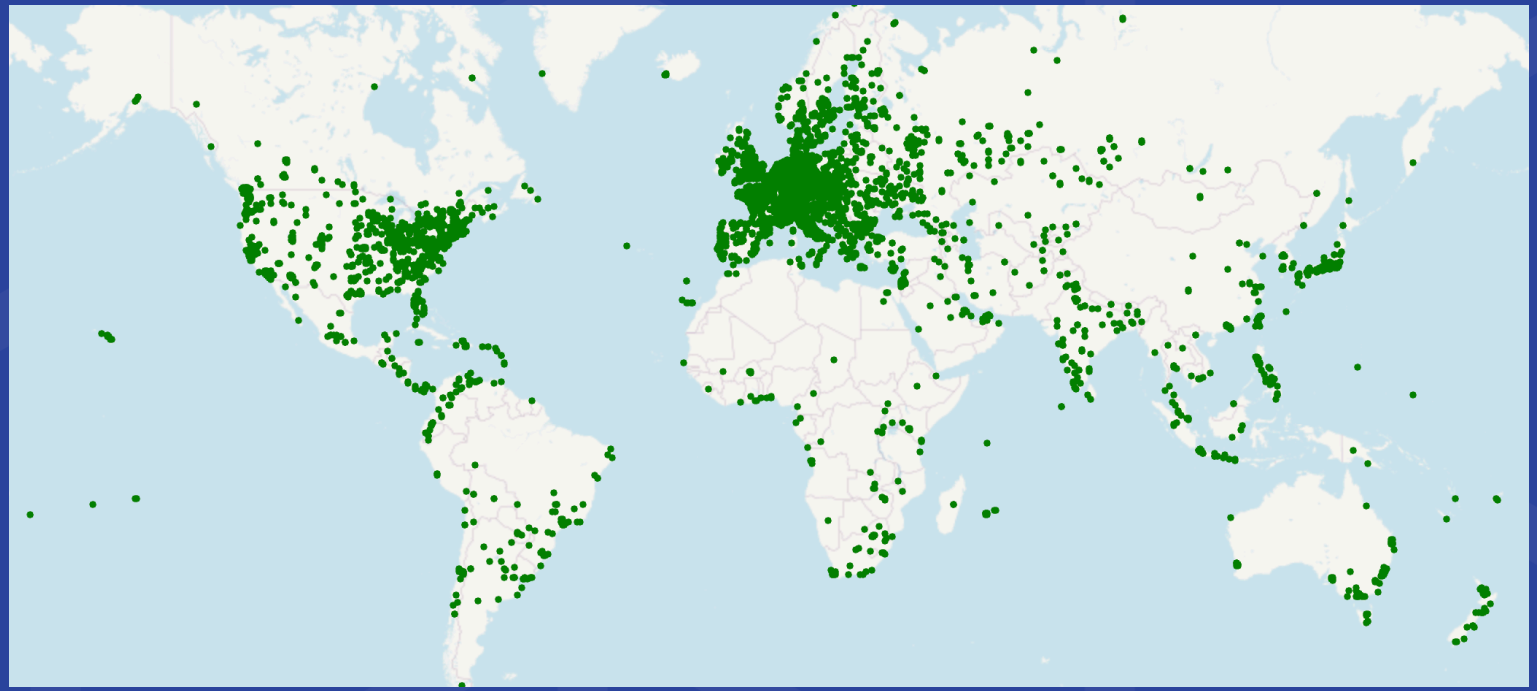
Equipment

RIPE Atlas Probe

RIPE Atlas Anchor

“Virtual” (software) versions also exist!

RIPE Atlas Probes distribution

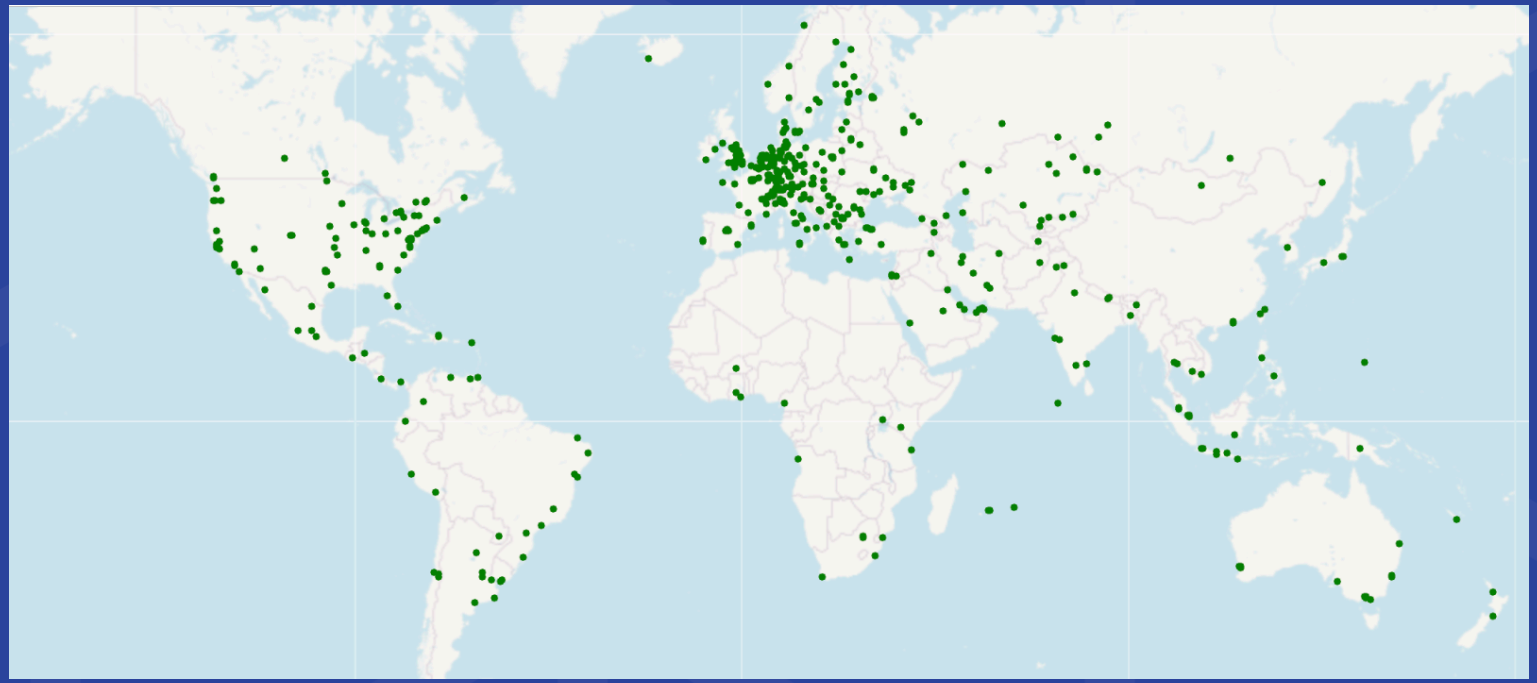


All over the globe

13000+ probes

177 countries

RIPE Atlas Anchors distribution

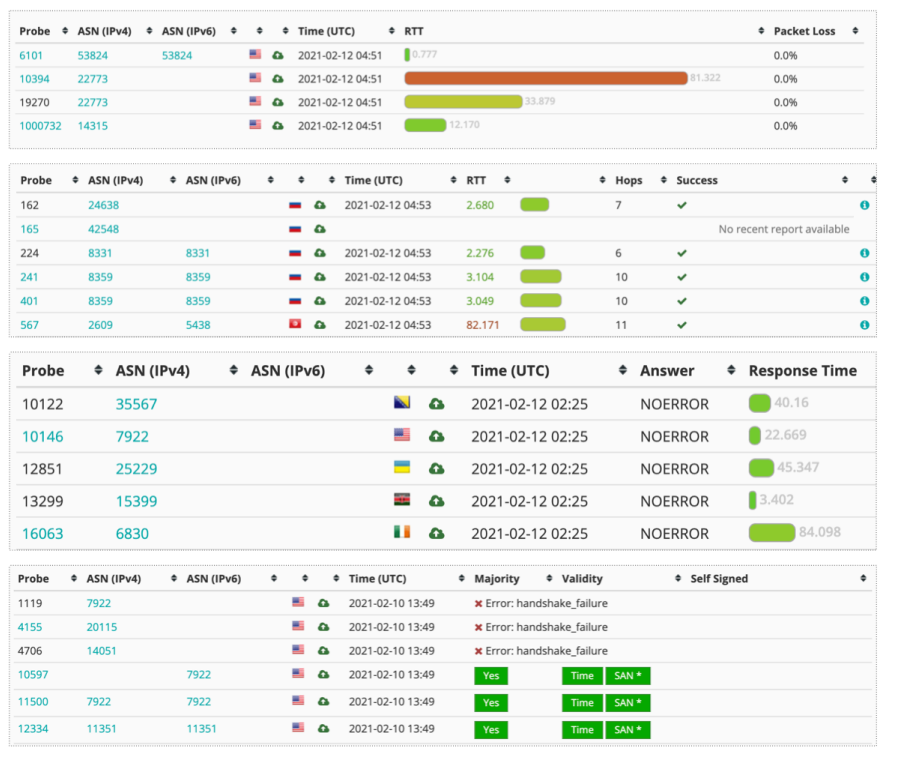


All over the globe

1000+ anchors

103 countries

Types of measurements



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 *	

What you can measure

- ICMP echo (ping)
- Traceroute (TCP, UDP, ICMP)
- DNS
- HTTP
- SSL/TLS
- NTP

+a lot of precautions and measures against converting it to a botnet

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

REST API

- https://beta-docs.atlas.ripe.net/apis/

Python frameworks

- https://github.com/RIPE-NCC/ripe-atlas-cousteau
- https://github.com/RIPE-NCC/ripe-atlas-sagan

Where results to be found?

Most of the results are public

RIPE Atlas Website - https://atlas.ripe.net

RIPE Atlas API - https://beta-docs.atlas.ripe.net/apis/

RIPE Atlas storage - https://data-store.ripe.net/datasets/atlas-daily-dumps/

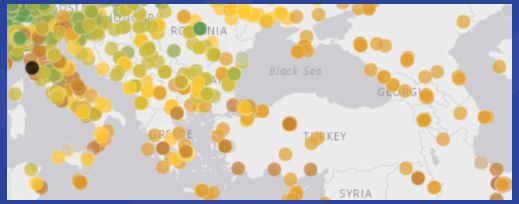
Google BigQuery - https://github.com/RIPE-NCC/ripe-atlas-bigquery/blob/main/docs/gettingstarted.md

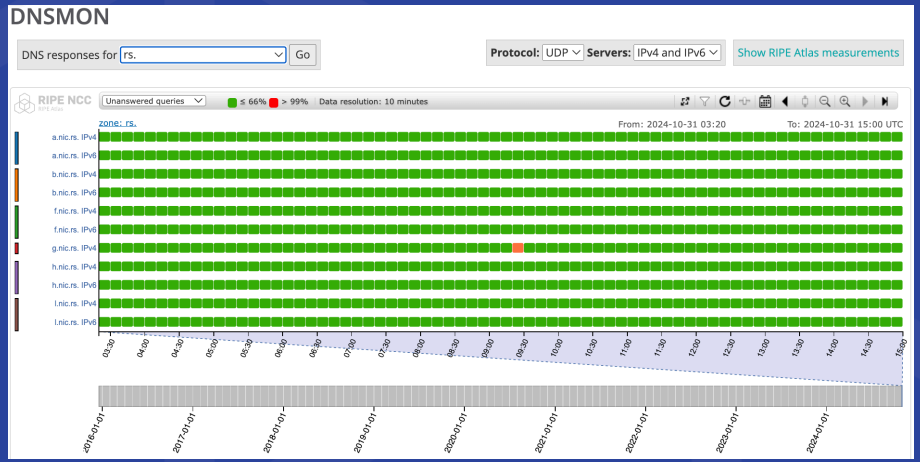
Built-in “Internet Maps”

Ready-to-use products

RTT Measurements

- To some fixed destinations





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
  - quality of the tld DNS servers answers
- DomainMON
  - monitors your own domains

Connectivity research

Connectivity measurements using RIPE Atlas

We have geography

- Each probe have it's geographic coordinates

We have sources

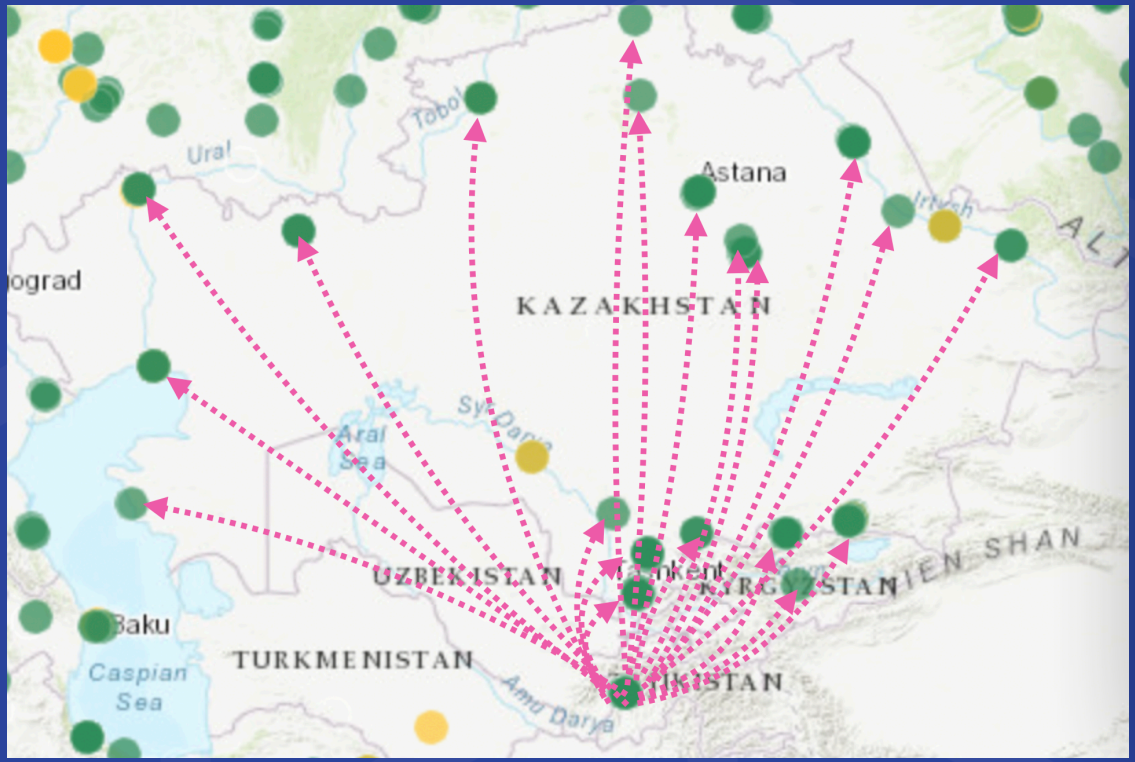
We have destinations

- Our Atlas probes and Anchors in both cases

We can gather mutual traceroutes

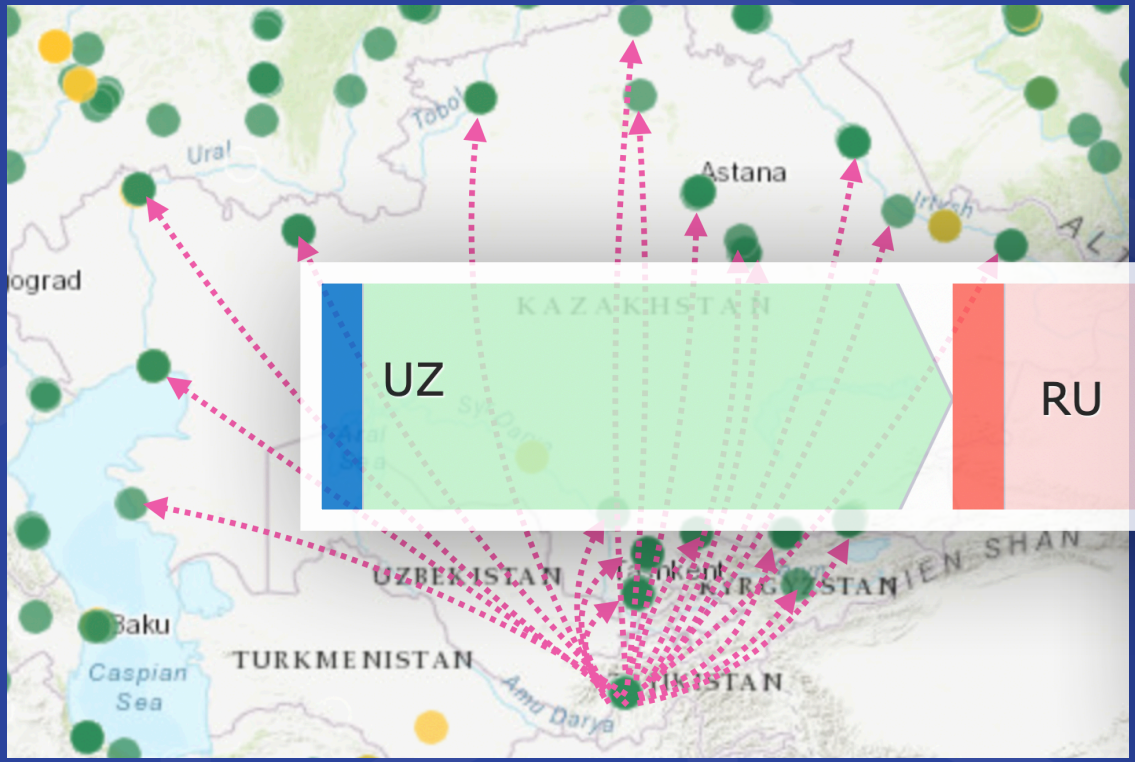
- And the geolocate all intermediate routers
- Then we can reveal the geopaths of packets

Central Asia case: methodology




```
 1: 172.18.0.1
 2: 10.10.10.1
 3: 62.122.137.35
 4: 62.122.137.1
 5: 62.122.136.66
 6: 62.122.136.82
 7: 91.218.162.141
 8: 212.46.238.57
 9: 79.104.235.207
10: 81.211.81.125
11: 95.59.172.18
12: 95.59.172.12
13: 95.59.170.57
14: 92.47.144.142
15: 95.59.172.12 81.211.193.45
```

Central Asia case: methodology

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 7: 91.218.162.141
 8: 212.46.23[illegible]7
 9: 79.104.235.207
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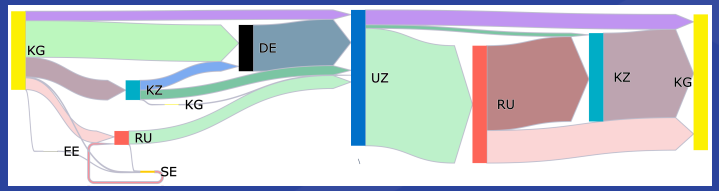
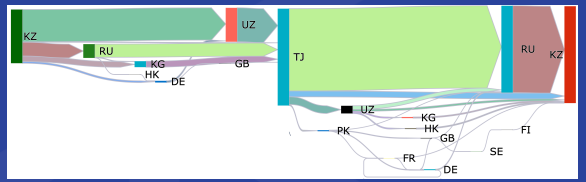
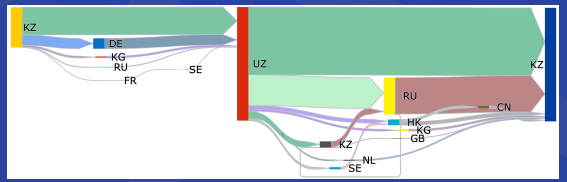
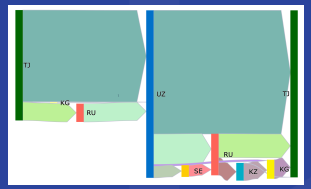
15: 95.59.172.12 81.211.193.45
```

Central Asia case: results









Basic trends

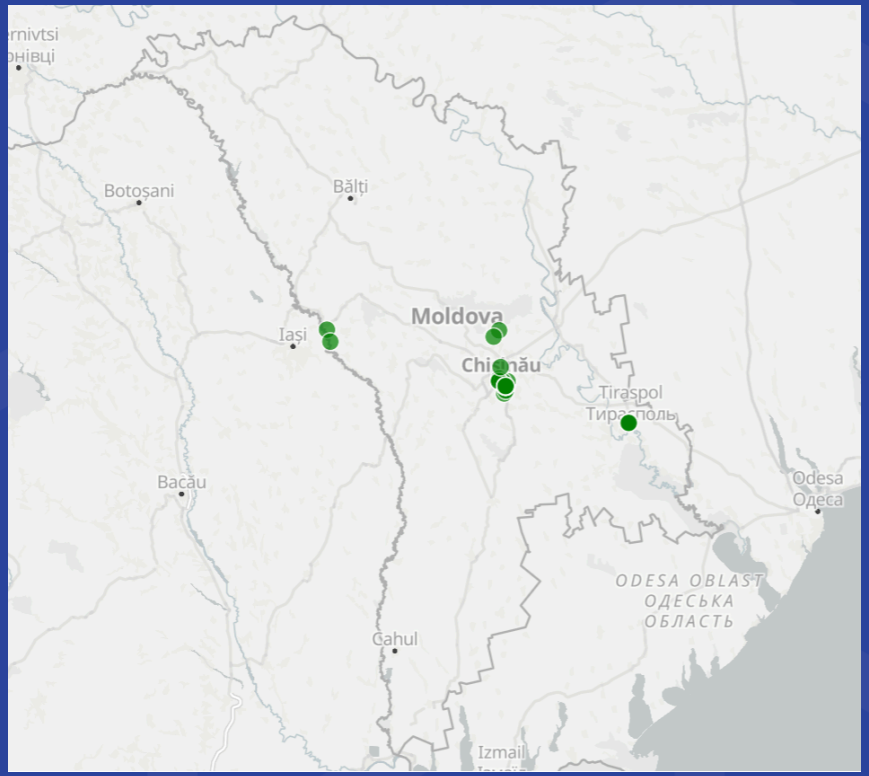
- Traffic is becoming regionalised
- Connectivity continues to diversify
- New players are emerging

Some oddities found

- KZ-RU-HK-DE-GB-TJ
- TJ-PT-GB-SE-FI-KZ
- UZ-SE-RU-KZ-KG-TJ
- UZ-SE-HK-CN-KZ

Case of Moldova

RIPE Atlas probes in Moldova

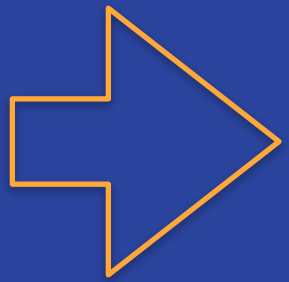


- Probes exist beyond Chisinau — which is good
    - However, geographic diversity is still limited
- Total number of probes remains low
- Clear room for growth and outreach

RIPE Atlas probes: neighbours

Probes and opportunities

- Romania: 96 probes
- Ukraine: 195 probes



- 14550 combinations “src-dst”
- Digging up data on hundreds of thousands of intermediate nodes

Repeating the methodology for Central Asia would be TOO labour-intensive

Science behind ping

Some math...

$$RTT = d_1 + d_2 + d_3$$

$$d_1 = \sum_i (propagation\ delay)_i$$ — Channels

$$d_2 = \sum_i (equipment\ delay)_i$$ — Hardware

$$d_3 = \sum_i (queue\ delay)_i$$ — Load

$$min(d_3) = 0 \quad (!)$$

- **In 2025:**

$$d_2 \approx 0$$

$$RTT = min(\{RTT_i\}) = d_1 + d_2$$

$$d_1 = \sum_i \frac{distance_i}{c_{fibre\ i}}$$ — $distance_i$: Length of the fiber sector; $c_{fibre\ i}$: Velocity of speed in this fibre

The speed of light in different fibers differs insignificantly (±10% max), so:

$$d_1 \approx \frac{total\ distance}{c_{fibre}}$$

$$RTT \approx \frac{total\ distance}{c_{fibre}}$$

Science behind ping

Some physics…

- The speed of light in fiber is 60-70% of the speed of light in vacuum, i.e.

$$c_{fibre} \approx 200 \frac{km}{ms}$$

- Therefore, in the case of perfectly straight fiber the ratio

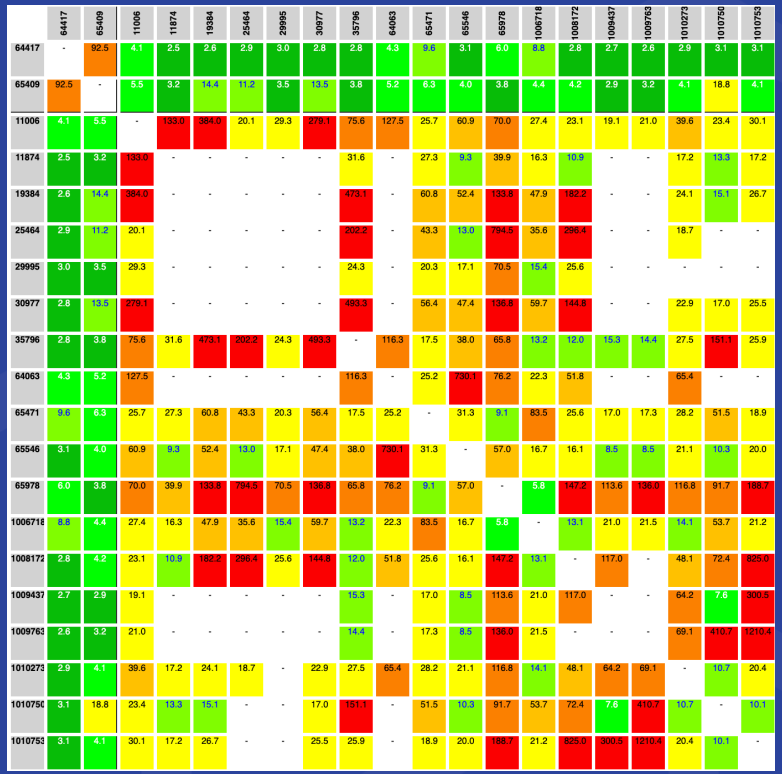
$$S = 100 \frac{RTT, ms}{distance, km}$$

is equal to 1

Simplified approach

- Let’s measure RTT!
  - Moldova ↔ Moldova
  - Ukraine ↔ Moldova
  - Romania ↔ Moldova
- Filter out bizarre probes and probes in disputable locations
- Find a minimal RTT between each two points
- Analyze the RTT and S-factor matrix
- Try to find oddities and analyse them

Internal connectivity: S-factor

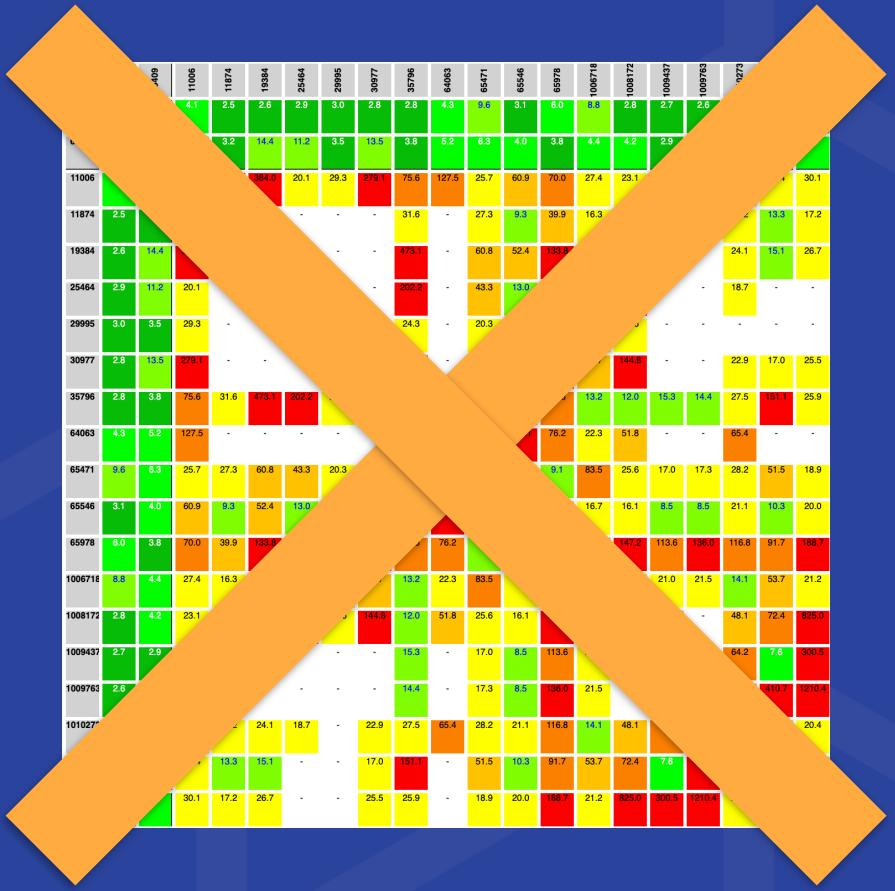


	64417	65409	11006	11874	19384	25464	29995	30977	35796	64063	65471	65546	65978	1006718	1008172	1009437	1009763	1010273	1010750	1010753
64417	-	92.5	4.1	2.5	2.6	2.9	3.0	2.8	2.8	4.3	9.6	3.1	6.0	8.8	2.8	2.7	2.6	2.9	3.1	3.1
65409	92.5	-	5.5	3.2	14.4	11.2	3.5	13.5	3.8	5.2	6.3	4.0	3.8	4.4	4.2	2.9	3.2	4.1	18.8	4.1
11006	4.1	5.5	-	133.0	384.0	20.1	29.3	279.1	75.6	127.5	25.7	60.9	70.0	27.4	23.1	19.1	21.0	39.6	23.4	30.1
11874	2.5	3.2	133.0	-	-	-	-	-	31.6	-	27.3	9.3	39.9	16.3	10.9	-	-	17.2	13.3	17.2
19384	2.6	14.4	384.0	-	-	-	-	-	473.1	-	60.8	52.4	133.8	47.9	182.2	-	-	24.1	15.1	26.7
25464	2.9	11.2	20.1	-	-	-	-	-	202.2	-	43.3	13.0	794.5	35.6	296.4	-	-	18.7	-	-
29995	3.0	3.5	29.3	-	-	-	-	-	24.3	-	20.3	17.1	70.5	15.4	25.6	-	-	-	-	-
30977	2.8	13.5	279.1	-	-	-	-	-	493.3	-	56.4	47.4	136.8	59.7	144.8	-	-	22.9	17.0	25.5
35796	2.8	3.8	75.6	31.6	473.1	202.2	24.3	493.3	-	116.3	17.5	38.0	65.8	13.2	12.0	15.3	14.4	27.5	151.1	25.9
64063	4.3	5.2	127.5	-	-	-	-	-	116.3	-	25.2	730.1	76.2	22.3	51.8	-	-	65.4	-	-
65471	9.6	6.3	25.7	27.3	60.8	43.3	20.3	56.4	17.5	25.2	-	31.3	9.1	83.5	25.6	17.0	17.3	28.2	51.5	18.9
65546	3.1	4.0	60.9	9.3	52.4	13.0	17.1	47.4	38.0	730.1	31.3	-	57.0	16.7	16.1	8.5	8.5	21.1	10.3	20.0
65978	6.0	3.8	70.0	39.9	133.8	794.5	70.5	136.8	65.8	76.2	9.1	57.0	-	5.8	147.2	113.6	136.0	116.8	91.7	188.7
1006718	8.8	4.4	27.4	16.3	47.9	35.6	15.4	59.7	13.2	22.3	83.5	16.7	5.8	-	13.1	21.0	21.5	14.1	53.7	21.2
1008172	2.8	4.2	23.1	10.9	182.2	296.4	25.6	144.8	12.0	51.8	25.6	16.1	147.2	13.1	-	117.0	-	48.1	72.4	825.0
1009437	2.7	2.9	19.1	-	-	-	-	-	15.3	-	17.0	8.5	113.6	21.0	117.0	-	-	64.2	7.6	300.5
1009763	2.6	3.2	21.0	-	-	-	-	-	14.4	-	17.3	8.5	136.0	21.5	-	-	-	69.1	410.7	1210.4
1010273	2.9	4.1	39.6	17.2	24.1	18.7	-	22.9	27.5	65.4	28.2	21.1	116.8	14.1	48.1	64.2	69.1	-	10.7	20.4
1010750	3.1	18.8	23.4	13.3	15.1	-	-	17.0	151.1	-	51.5	10.3	91.7	53.7	72.4	7.6	410.7	10.7	-	10.1
1010753	3.1	4.1	30.1	17.2	26.7	-	-	25.5	25.9	-	18.9	20.0	188.7	21.2	825.0	300.5	1210.4	20.4	10.1	-

S-factor does not work

- Distances too small, error too large
- Best results: two distant probes on the Romanian border

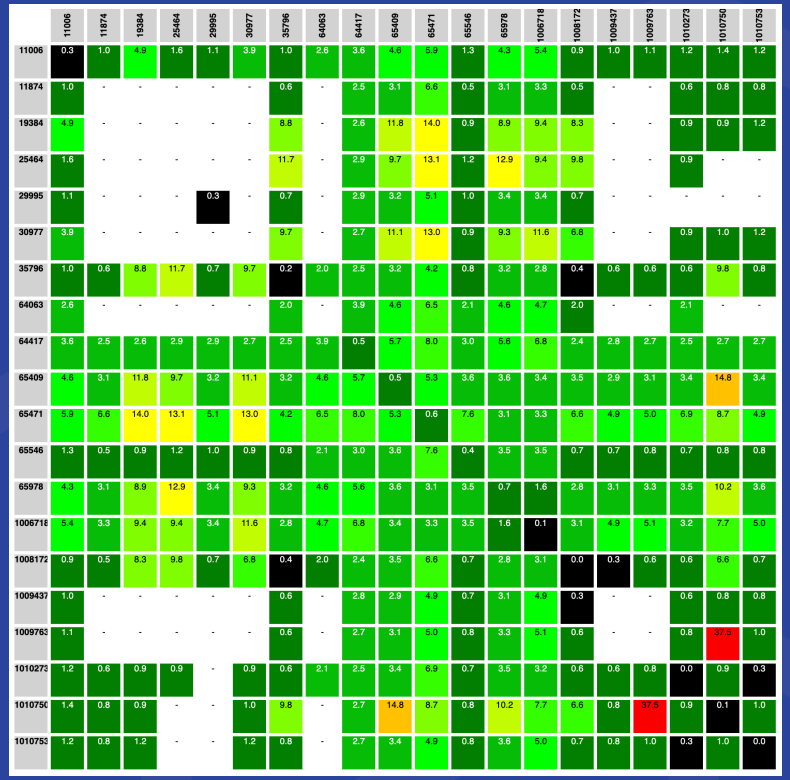
Internal connectivity: S-factor



S-factor does not work

- Distances too small, error too large
- Best results: two distant probes on the Romanian border

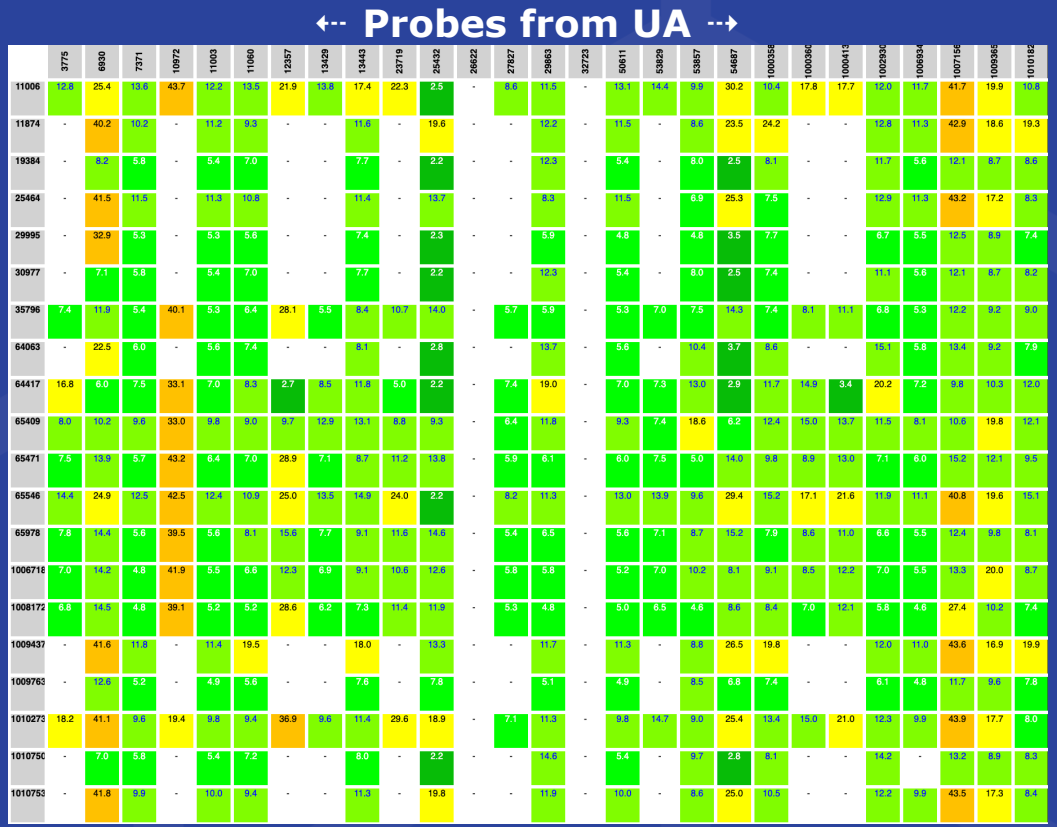
Internal connectivity: RTT



Evaluation: not bad

- Most of RTT inside the country are below 10 ms
- Only one value greater than 25 ms was detected
  - Between probes #1009763 and #1010750
  - AS Sequence from traceroute:
    AS31252 (Starnet)
    InterLAN
    AS6939 (HE)
    AS28917 (Fiord), Frankfurt
    AS8926 (Moldtelecom)
    AS200019 (AlexHost)
- Oversight in routing policies

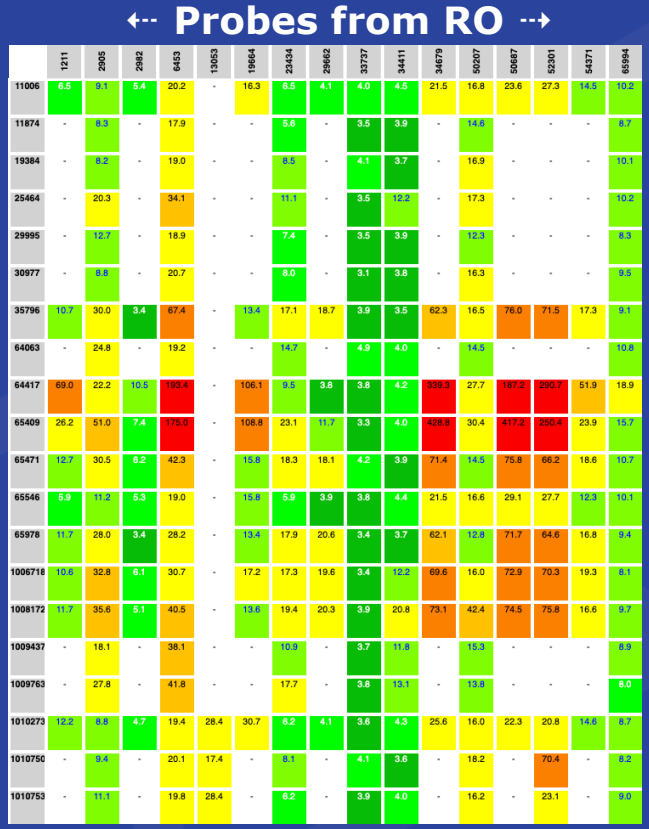
Connectivity between Moldova and Ukraine (S-factor)



Evaluation: mediocre

- S-factor values are mostly not pathological, but far from ideal
  - Most in the range of 8-15
- Single-colour ‘columns’ prevail over ‘rows’
  - Most probably: routing policies are managed by a foreign partner

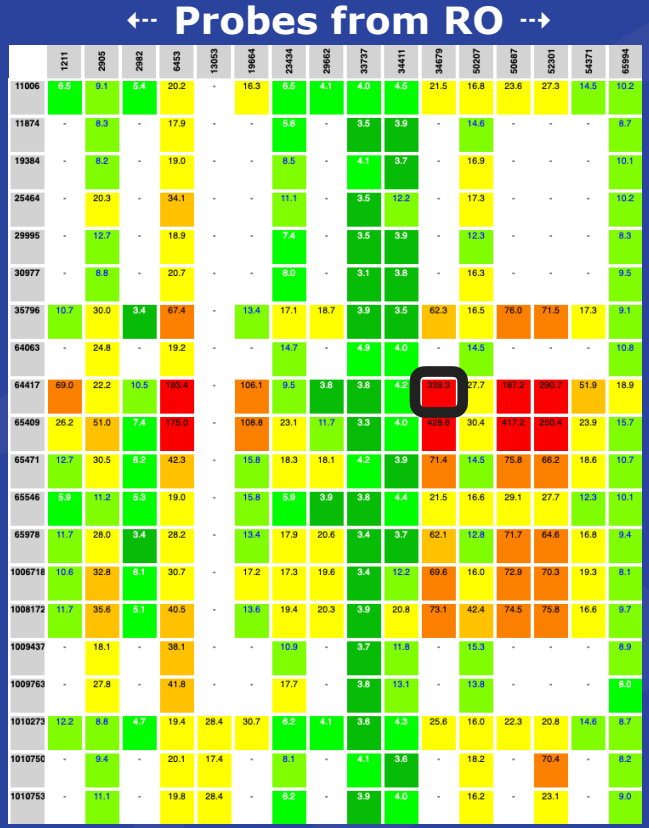
Connectivity between Moldova and Romania (S-factor)



Evaluation: bad

- Many really bad values of S-factor
- Single-colour ‘columns’ also prevail over ‘rows’

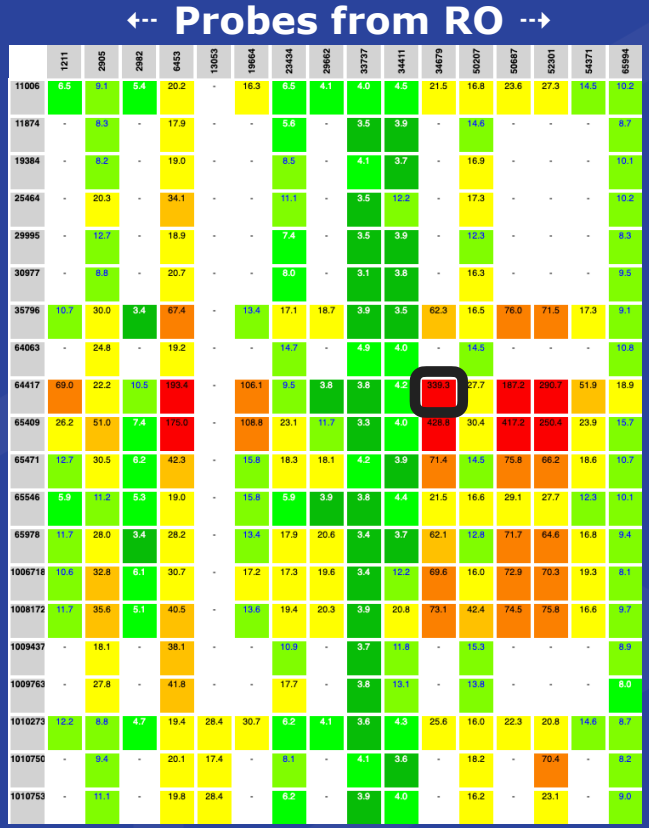
Connectivity between Moldova and Romania (S-factor)



Evaluation: bad

- Many really bad values of S-factor
  - LET'S ANALYSE ONE OF THEM

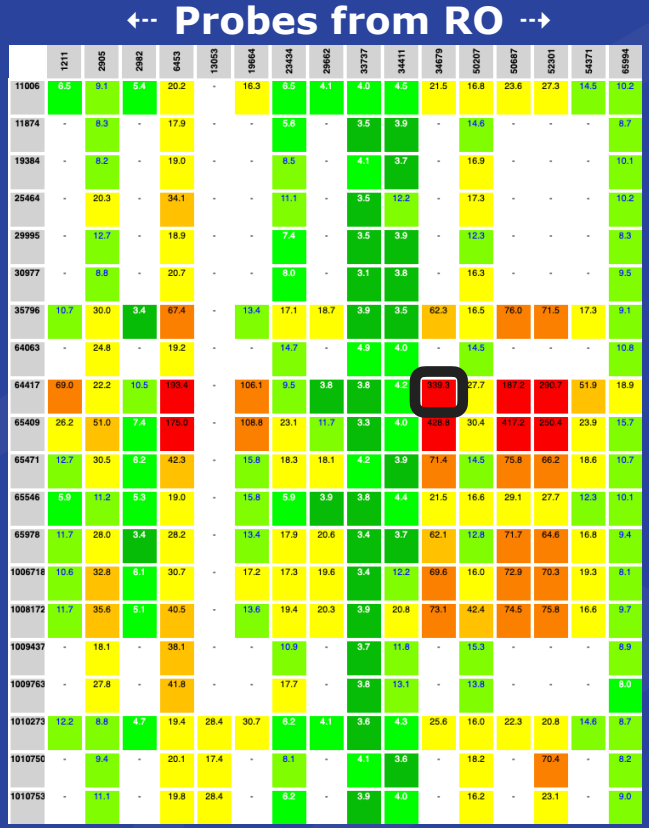
Connectivity between Moldova and Romania (S-factor)



Evaluation: bad

- Many really bad values of S-factor
  - LET'S ANALYSE ONE OF THEM
  - Between probes #64417 and #34679

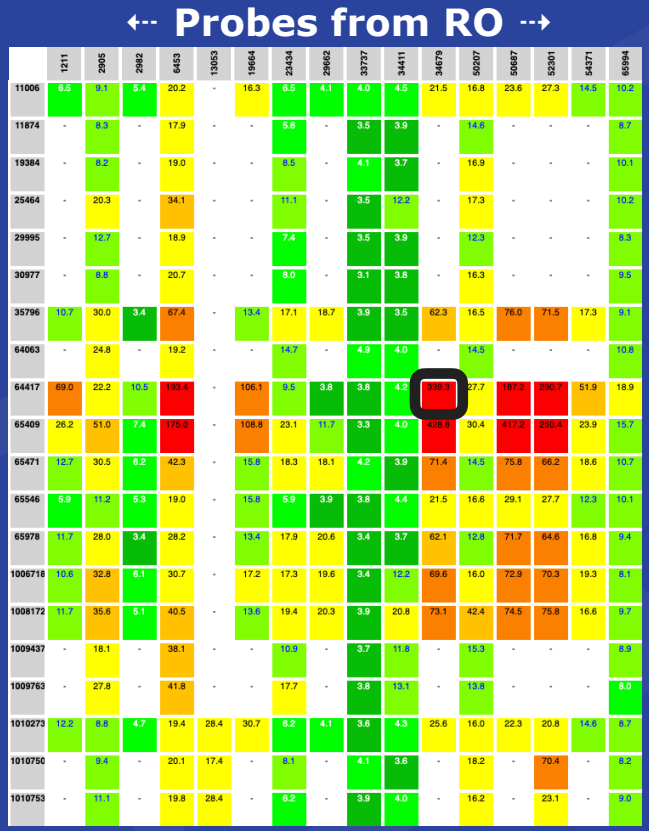
Connectivity between Moldova and Romania (S-factor)



Evaluation: bad

- Many really bad values of S-factor
  - LET'S ANALYSE ONE OF THEM
  - Between probes #64417 and #34679
  - Distance between them: 16 km

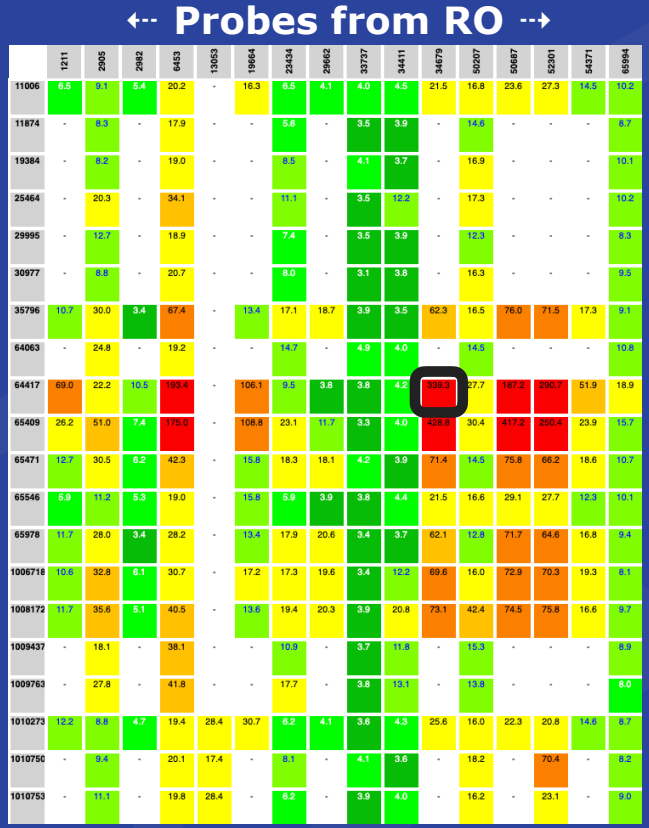
Connectivity between Moldova and Romania (S-factor)



Evaluation: bad

- Many really bad values of S-factor
  - LET'S ANALYSE ONE OF THEM
  - Between probes #64417 and #34679
  - Distance between them: 16 km
  - Located near the Romanian border, from the different sides

Connectivity between Moldova and Romania (S-factor)



Evaluation: bad

- Many really bad values of S-factor
  - LET'S ANALYSE ONE OF THEM
  - Between probes #64417 and #34679
  - Distance between them: 16 km
  - Located near the Romanian border, from the different sides
  - NOW, let's perform the traceroute measurement

Long way from #34679 to #64417

1	10.1.0.1	3.11	ms	3.489	ms	3.49	ms
2	10.0.34.125	1.342	ms	1.248	ms	1.266	ms
3	10.65.137.33	1.57	ms	1.926	ms	1.621	ms
4	10.220.211.144		ms	11.77	ms	11.776	ms
5	10.221.100.112	11.872	ms	11.464	ms	11.994	ms
6	10.221.96.54	52.545	ms	42.458	ms	42.273	ms
7	149.11.160.1	42.875	ms	42.453	ms	42.61	ms
8	154.54.61.161	42.502	ms	42.505	ms	42.463	ms
9	130.117.51.42	46.165	ms	46.387	ms	46.082	ms
10	154.54.38.210	64.558	ms	64.072	ms	67.583	ms
11	154.54.59.62	64.683	ms	64.636	ms	64.613	ms
12	154.54.59.106	64.259	ms	64.541	ms	64.557	ms
13	154.54.59.178	65.528	ms	66.091	ms	65.566	ms
14	154.54.38.246	65.973	ms	65.669	ms	65.867	ms
15	154.54.61.177	64.149	ms	64.713	ms	65.176	ms
16	154.54.58.249	64.285	ms	64.656	ms	64.127	ms
17	154.54.72.134	65.796	ms	65.695	ms	65.449	ms
18	149.14.58.99	64.942	ms	64.951	ms	65.223	ms
19	37.233.0.21	72.259	ms	65.307	ms	65.306	ms
20	37.233.0.20	64.252	ms	68.922	ms	64.438	ms
21	89.28.33.1	67.1	ms	67.174	ms	67.845	ms
22	89.28.33.213	68.245	ms	68.27	ms	68.261	ms

Long way from #34679 to #64417

Moldovan-Romanian border
London 🤝🤝🤝 !!!

Amsterdam
Hamburg
Prague
Bratislava
Budapest
Bucharest
Ukranian border
Odesa 🤝🤝🤝 !!!

Chisinau
Other side of Moldovan-Romanian border

Why?!

Typical story, that’s why

Large operators

- They perform traffic engineering to ensure the effective utilisation of their channels.
- They do not care of the traffic localisation
    - And often they do opposite

Summary

Long story short

- There is huge room for optimising the external connectivity of Moldovan operators
- This process can be monitored using RIPE Atlas:
  - RIPE Atlas is a powerful tool
  - It provides insights even in the simplest usage scenarios
- You could carry out the described research yourself…
  - …or even conduct it on a regular basis

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Questions?
Comments?

asemenyaka@ripe.net

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THANK YOU!