RIPE NCC
RIPE NETWORK COORDINATION CENTER

Interconnectivity in Central Asia

2022, 2024, 2026

Alex Semenyaka | November 2026 | IMD Almaty

Methodology

RIPE Atlas

What is RIPE Atlas?

- RIPE Atlas 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
- There are over **14,000 RIPE Atlas probes and anchors** in the RIPE Atlas network and that number is growing
- **RIPE Atlas performs active measurements on the data plane**

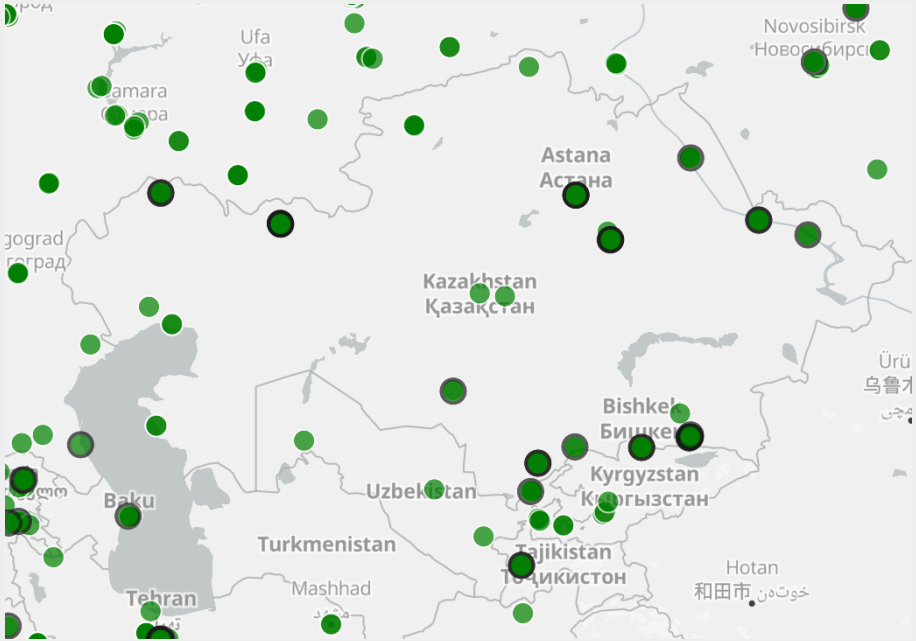


What Do We Do with RIPE Atlas?

Data collection

- We have 127 probes in 4 countries
  - Kazakhstan: **77**
    - 2022: 63, 2024: 53
  - Kyrgyzstan: **22**
    - 2022: 6, 2024: 8
  - Tajikistan: **16**
    - 2022: 9, 2024: 8
  - Uzbekistan: **12**
    - 2022: 13, 2024: 21

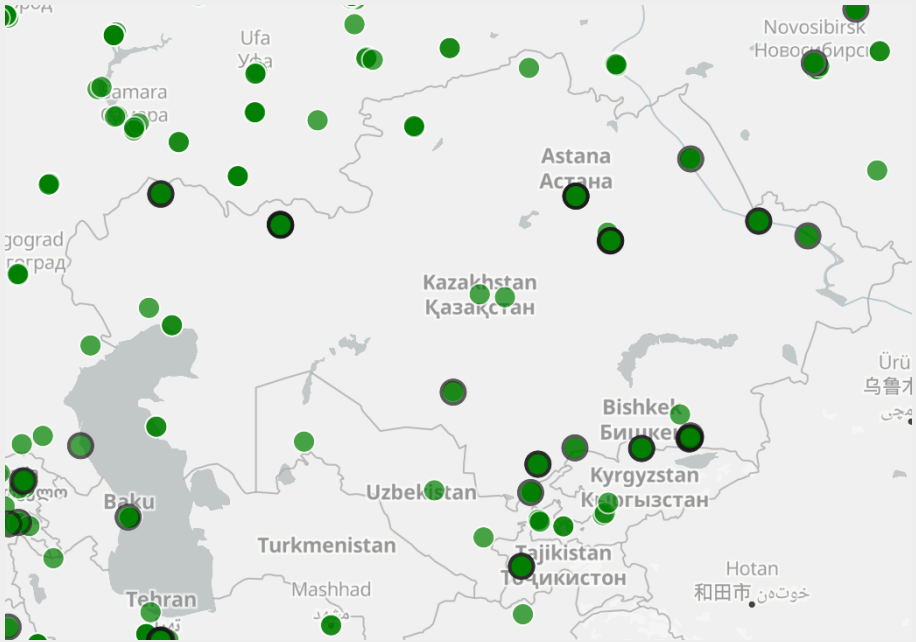
- We are using all of them to run measurements



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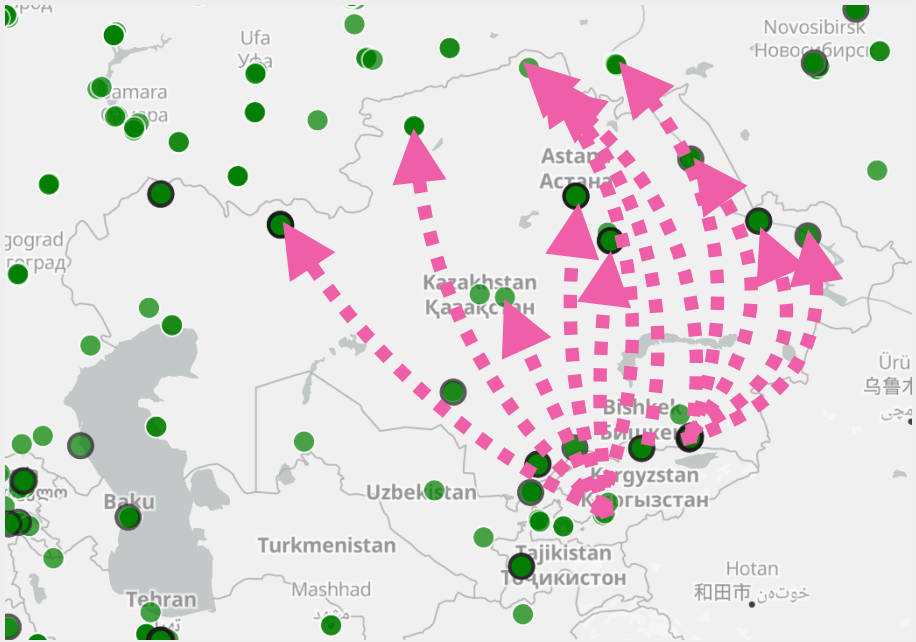
- Sources: all probes in a country



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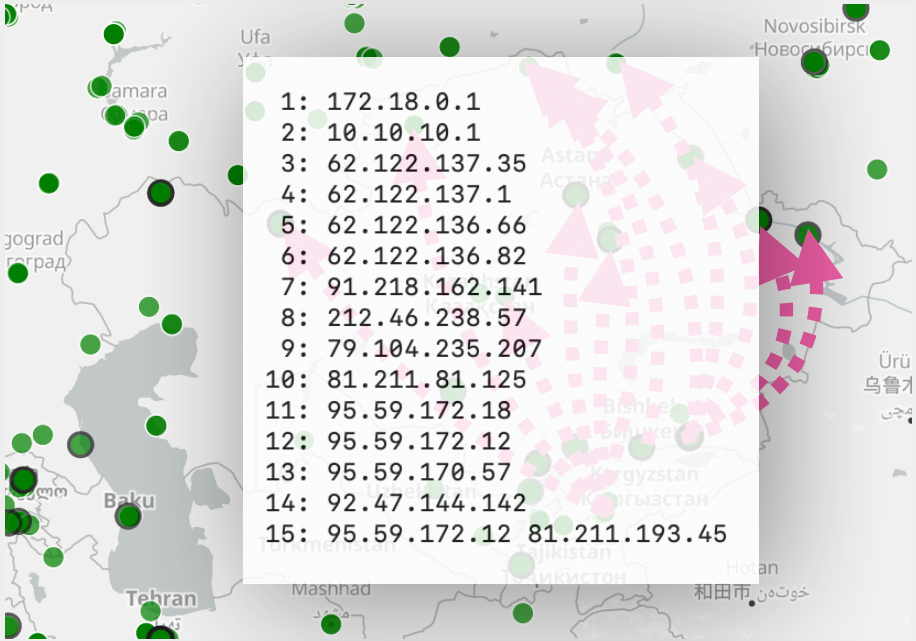
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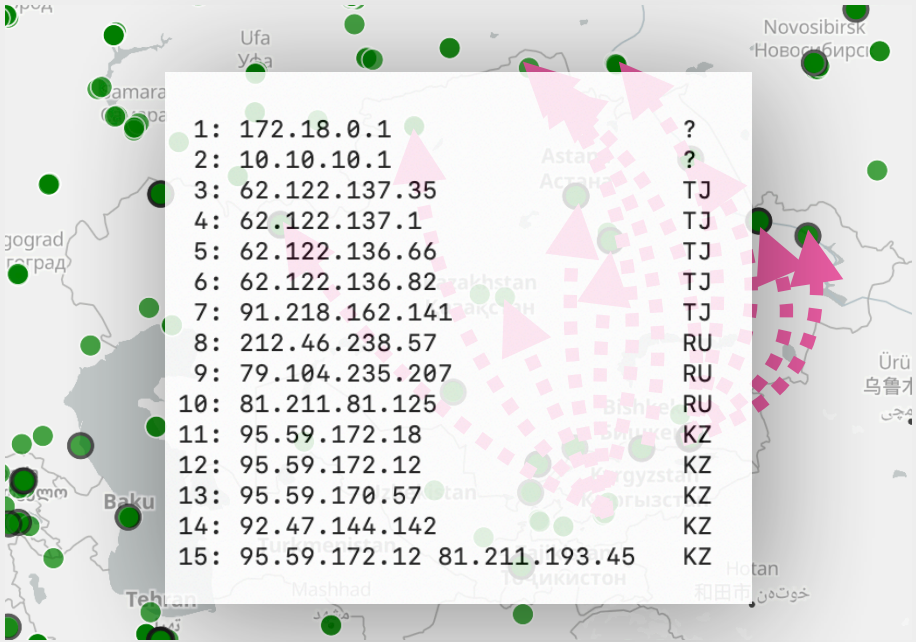
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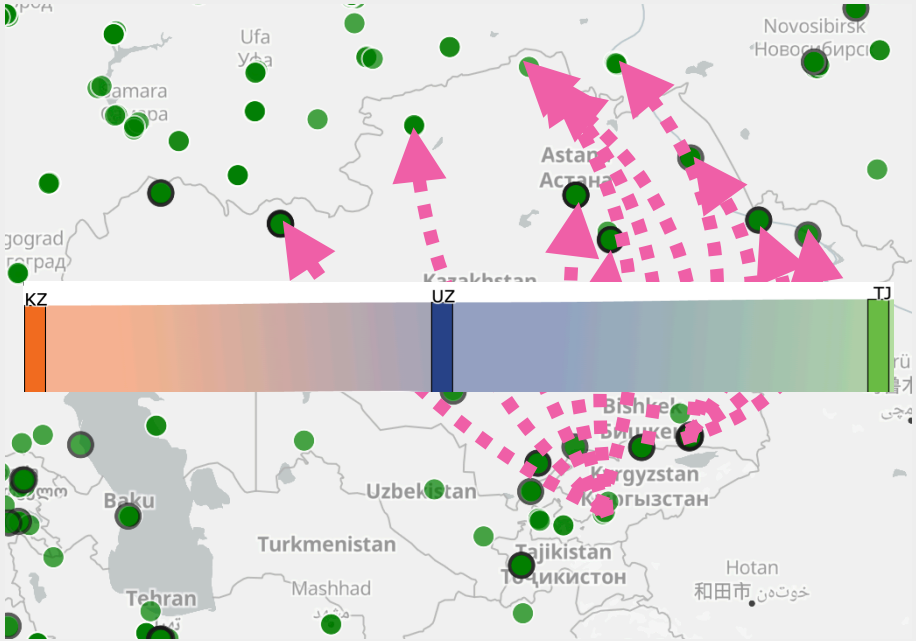
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- We run traceroutes and get a sequence of the hops
- By associating each hop with a country we get a chain of countries
  - Duplicates removed
  - Unknown hops become “??”



What Do We Do with RIPE Atlas?

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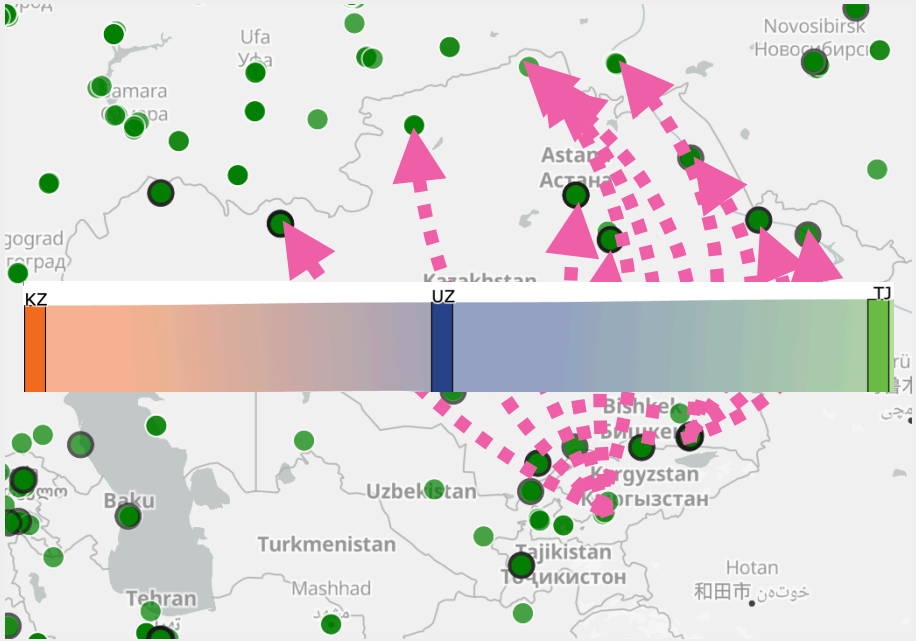
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- Results are aggregated by source and destination countries



What Do We Do with RIPE Atlas?

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- Results are aggregated by source and destination countries
- A pseudo-country: “**??**”



RTT Analysis

RTT Analysis

Traceroute is also like a ping on steroids

- When the traceroute reaches its destination, we have the round-trip time (RTT)

- We can collect this data and check if it meets rules of thumb

```
<20 ms        high quality
<50 ms        good quality
<100 ms       acceptable quality
100-200 ms    quality degradation is noticeable to all users
200+ ms       low quality
```

RTT Analysis

A bit of simple maths

The time we obtain from Internet measurements is known as round-trip time (RTT)

It consists of three components:

$$RTT = \sum d_{processing} + \sum d_{queue} + d_{propagation}$$

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The signal propagation delay is determined by the speed of light in optical fibre, which is ⅔ of the speed of light in a vacuum: 200 000 km/s

Combining all together: each 1 ms in RTT means 100 km of the optical fibre

Relative RTT Analysis

How many times better can it be?

The ratio

$$rRTT = 100 * RTT/distance$$

indicates how many times worse the actual route is compared to an ideal one (RTT is in ms, distance is in km)

Biases

Biases

Or why the picture is neither complete nor precise

- Not every network prefix or even AS has an RIPE Atlas probe
- We analyse the number of paths, not amount of the traffic: the real weight (in Mbps) of each route is unknown
- Traceroute works at the IP level: L1 and L2 geography is left out
  - Especially for multinational operators
  - And also there can be IP tunnels
- Geographic location of intermediate routers is always questionable
  - They may not be known at all ("stars" in traceroute output)
  - They may have private addresses
  - ECMP may still be displayed incorrectly (even with Paris traceroute)
- Routes tend to change over time
- The number of RIPE Atlas probes is changing over the time

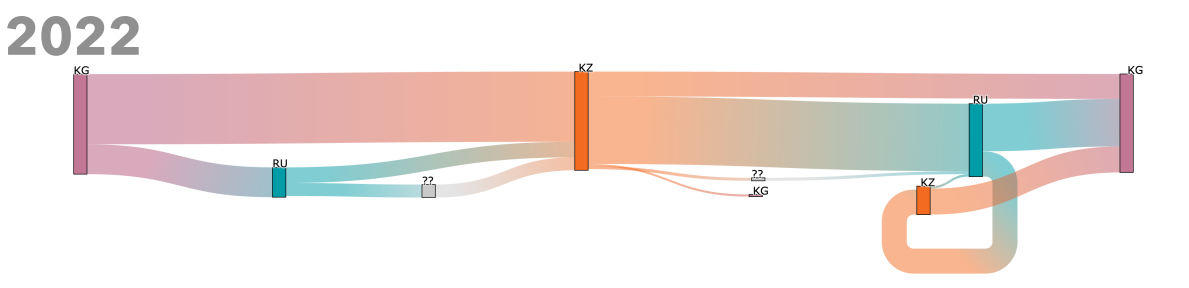
How to Work with these Biases

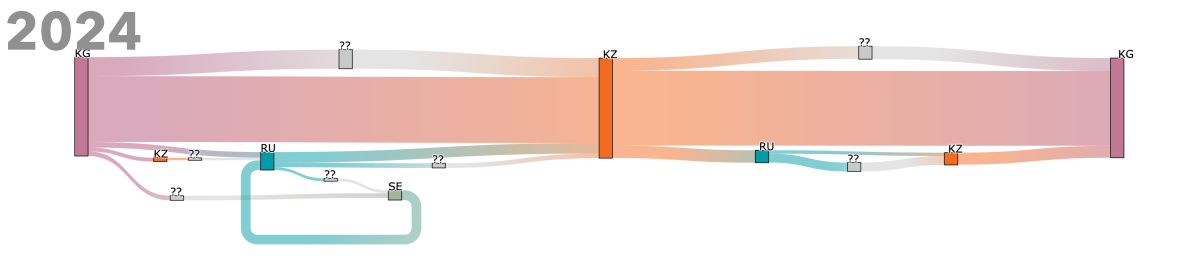
Or why this work is still useful

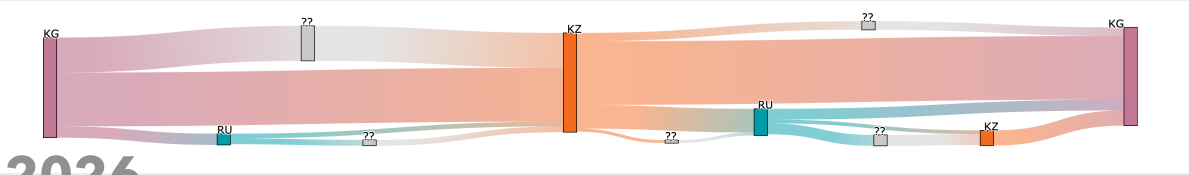
- Data refinement and filtering
- Statistical analysis
  - Exclude very rare cases
- If something is visible, it exists; if something isn't visible, that doesn't necessarily mean it doesn't exist
- **Treat charts as a qualitative result rather than a quantitative assessment**

Data Plane
RIPE Atlas Analysis

KG-KZ: Geographic Analysis



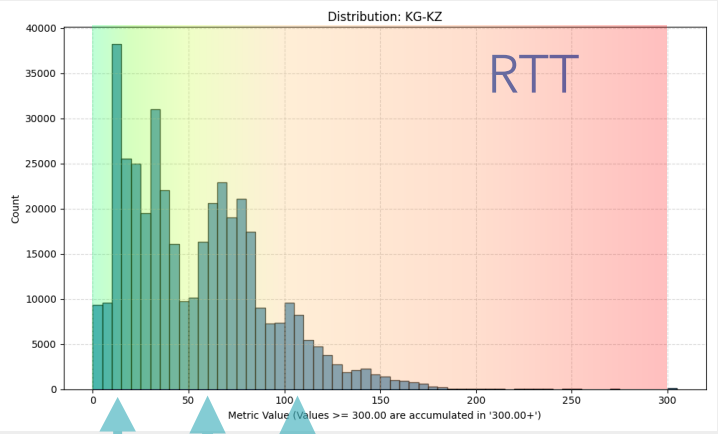


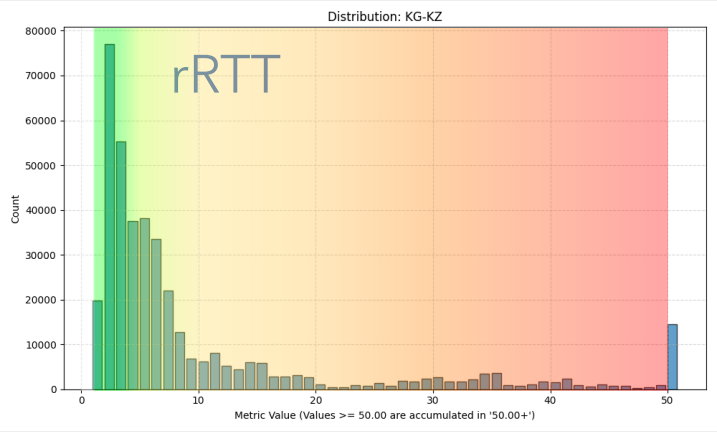


2026

- This is the region's best-performing pair across all three layers: cabling, routing, and latency
- **High share of direct paths**
  - KG→KZ ≈60%
  - KZ→KG ≈65%
- For indirect routes, the main transit hub is Russia
  - The share is decreasing, but not smoothly: since 2024, it has increased in the KZ→KG direction
- The number of European hops decreased
- There is a noticeable share of **traffic tromboning**: KZ-RU-KZ-KG

KG-KZ: RTT Analysis

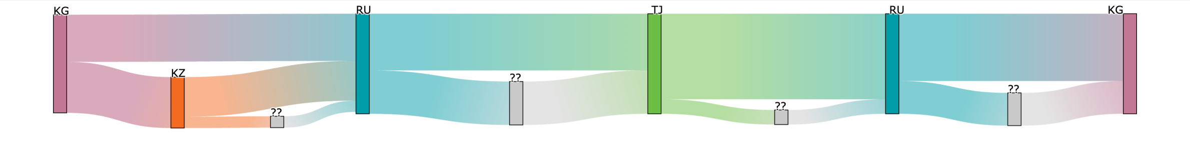




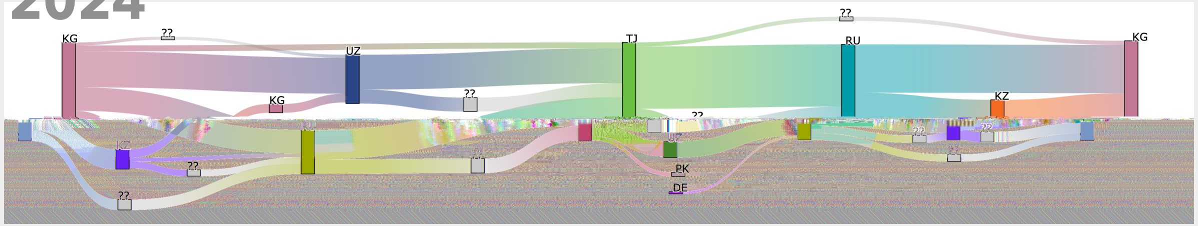
- The cause of a significant decline in quality is often not the infrastructure (lack of cables) but routing policies
  - Which are much easier to optimise than to build new cable routes

KG-TJ: Geographic Analysis

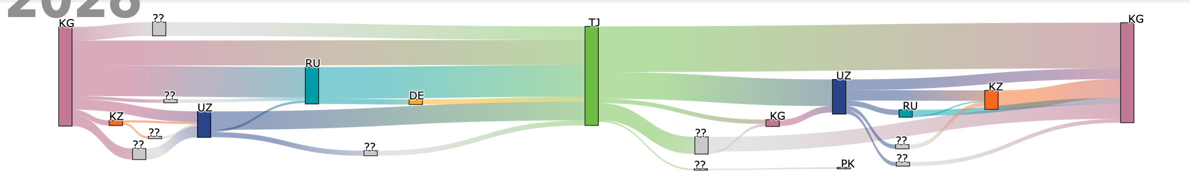
2022



2024

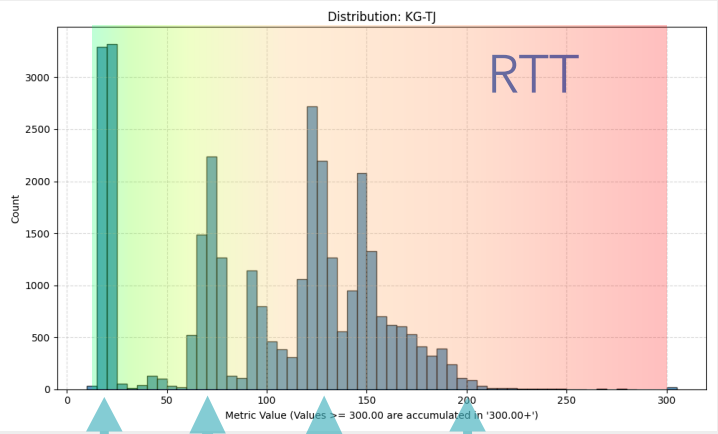


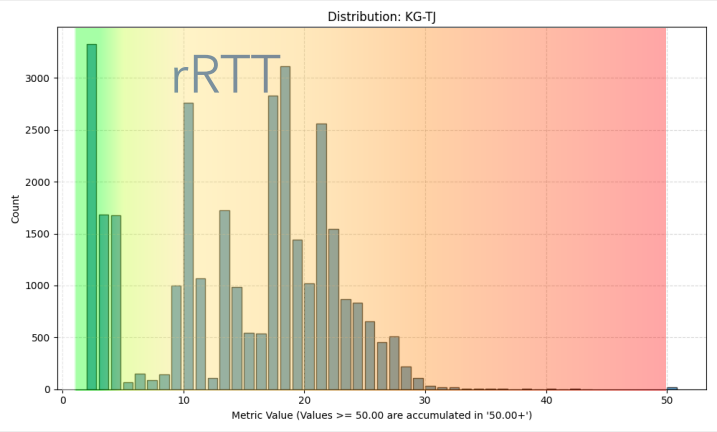
2026



- 2026 is the first year in which there are **direct routes** KG↔TJ
- **Kyrgyzstan has become a transit country** for Tajikistan
  - In 2022, both were end customers of Russian networks
- Uzbekistan's role as a transit country decreased slightly, while Kazakhstan's fell significantly
- **European routes are no longer that visible**
- Strong **localisation trend** is clear
  - So far: from externally mediated connectivity to regionally diversified connectivity, but not yet to consistently efficient direct one
- There is a small amount of traffic passing through **Pakistan**

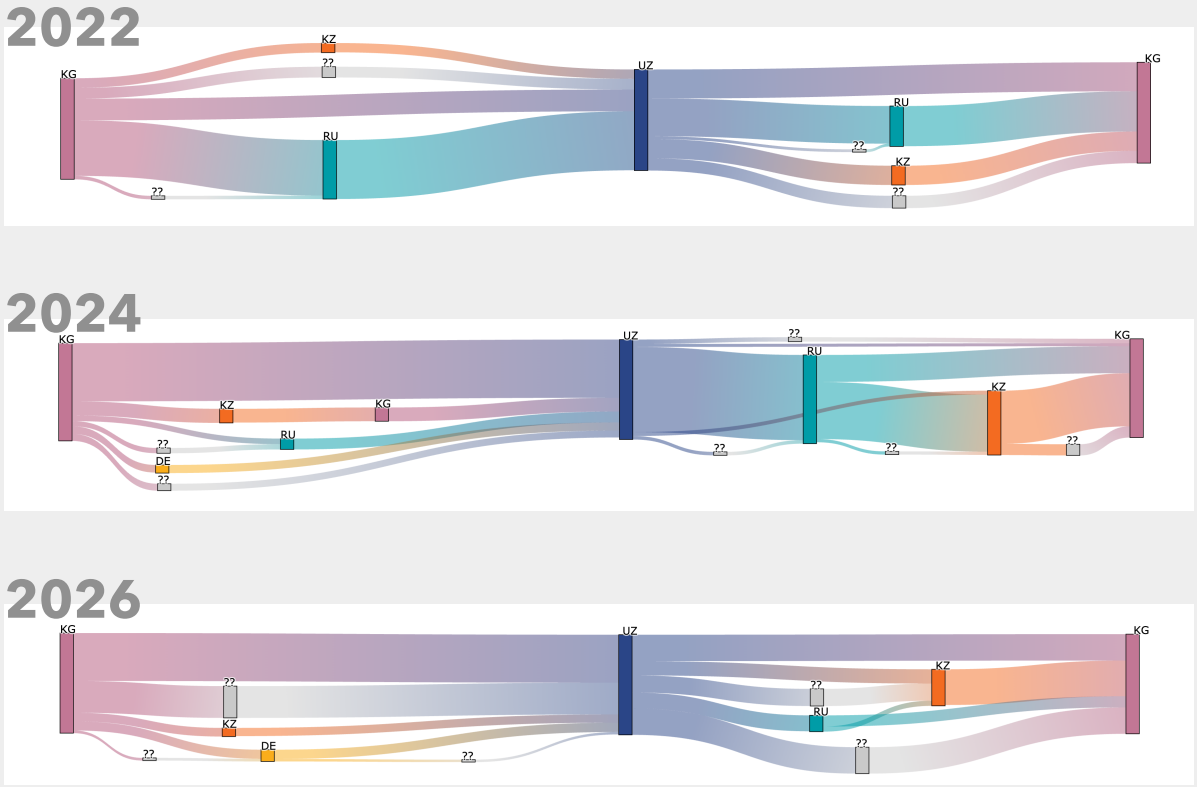
KG-TJ: RTT Analysis





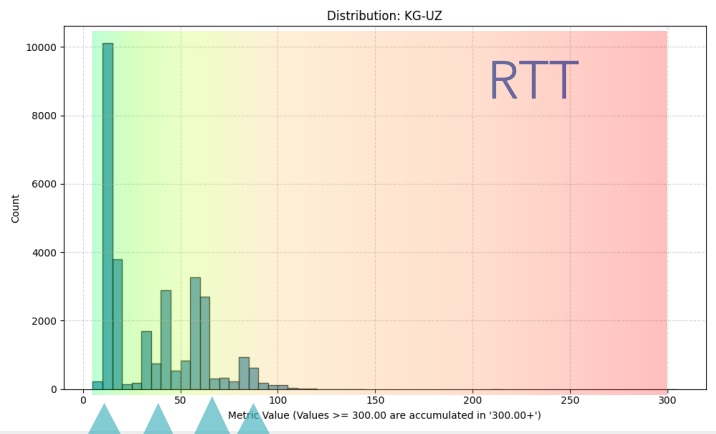
- The results of the route optimization are clearly evident, and it's also clear that there is enormous room for further optimization
- Even when the absolute RTT is quite acceptable, a significant proportion of routes are far from the physical optimum

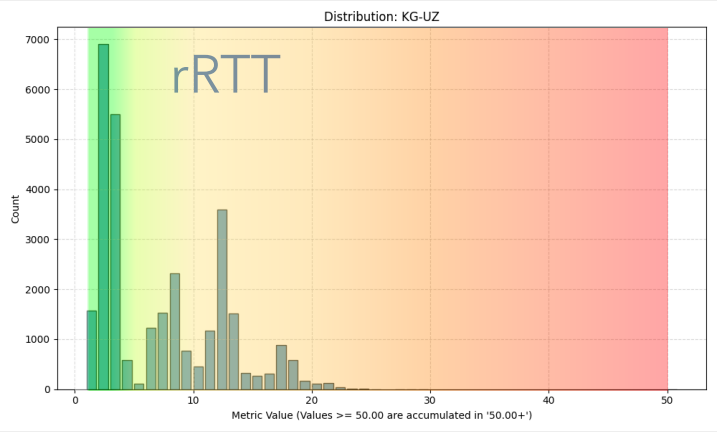
KG-UZ: Geographic Analysis



- **The process of traffic localisation with non-monotonic dynamics**
  - The increase in Russia's share in UZ→KG in 2024 was completely reversed in 2026
  - The situation in general has become less chaotic
- Germany's share, though small, is growing
  - Passing intra-regional traffic through Germany is no better than routing it through Russia
  - Main reason is the Uztelecom routing policy
- Tromboning KG-KZ-KG-UZ has disappeared
- Kazakhstan's role as a transit country has also grown
  - But that might not be a problem
  - In fact, even a **"direct" L3** connection **could physically run through Kazakhstan**

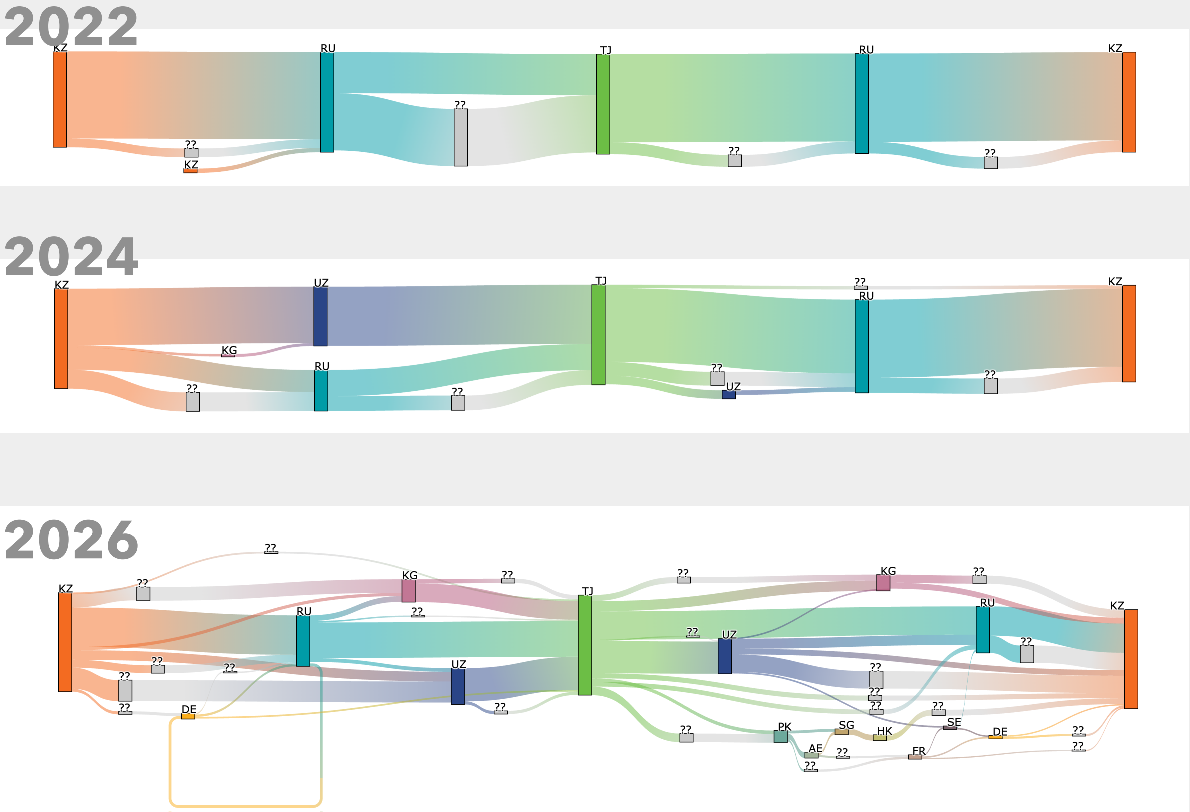
KG-UZ: RTT Analysis





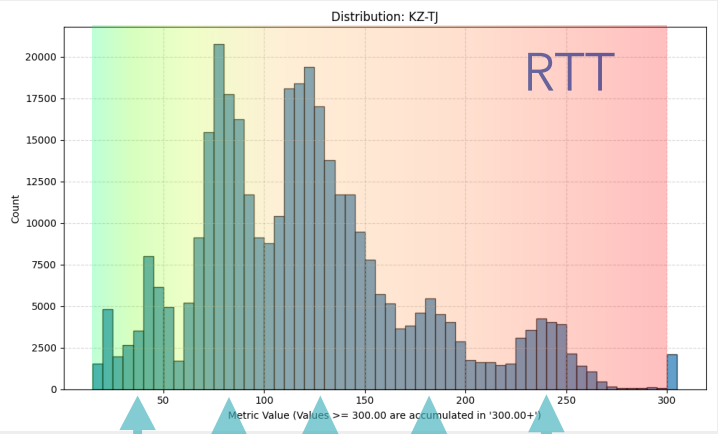
- The limitations of the ITU map is clearly evident: such low delays of the first peak are impossible without direct links
  - Which are not shown on their map
- UZ-KG: the only pair of countries without a red zone in RTT analysis

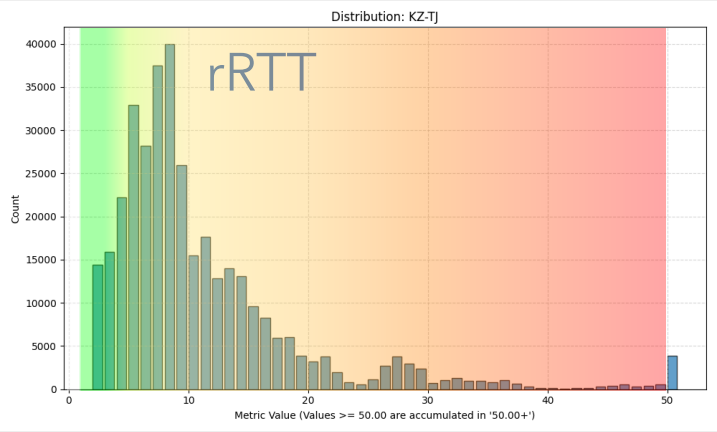
KZ-TJ: Geographic Analysis



- Over four years, **the very logic of connectivity changes**
  - It appears that Kyrgyzstan has decided to increase its regional influence
  - There is no common border. Any “intra-regional” route passes through Uzbekistan or Kyrgyzstan
- A **new class of routes** for the region: long-distance bypasses that avoid Russia
- **KG as a new transit country**
- As we've seen in other cases, while changes are underway, **the situation is somewhat chaotic**
  - Diversification occurred more quickly than optimization
  - Hence, a certain proportion of pathological paths like PK-AE-FR-SE-DE-KZ
- The **TJ→KZ** route has **improved** significantly, while the **KZ→TJ** route has **deteriorated** a bit

KZ-TJ: RTT Analysis

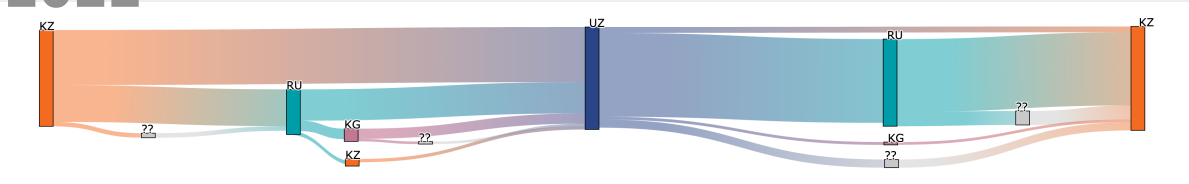




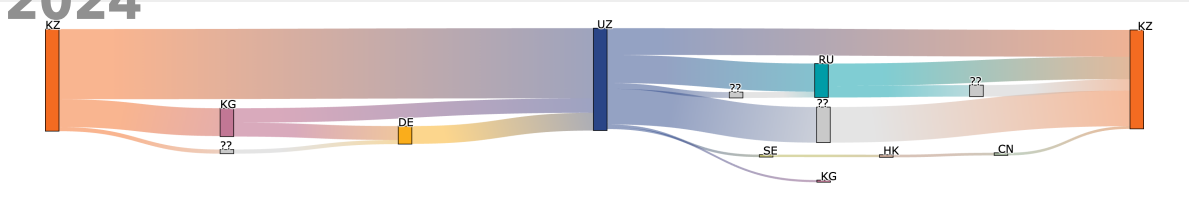
- In terms of delays, this is the second most severe situation amongst all pairs
  - After TJ-UZ
- With distances in question, rRTT becomes important
  - The peak around 8 indicates big room for the optimization

KZ-UZ: Geographic Analysis

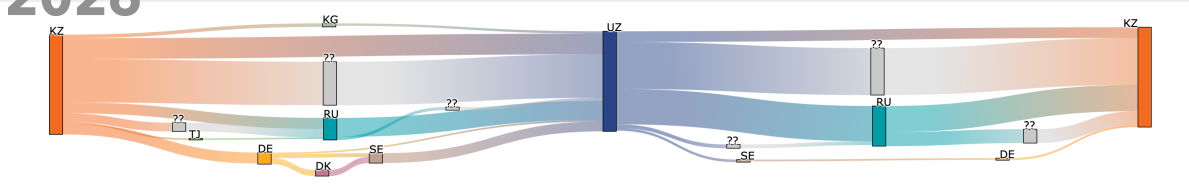
2022



2024

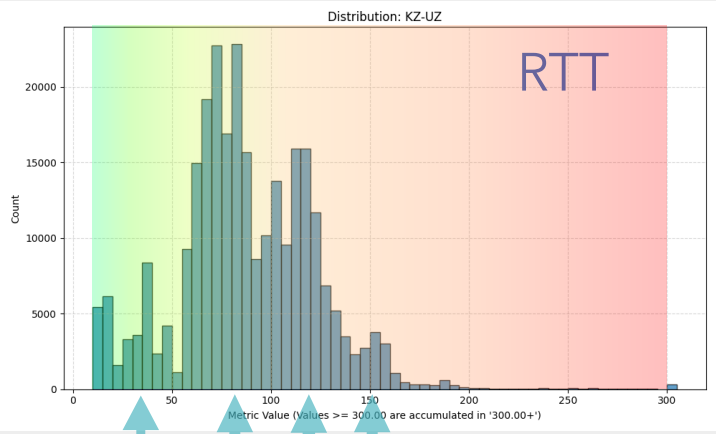


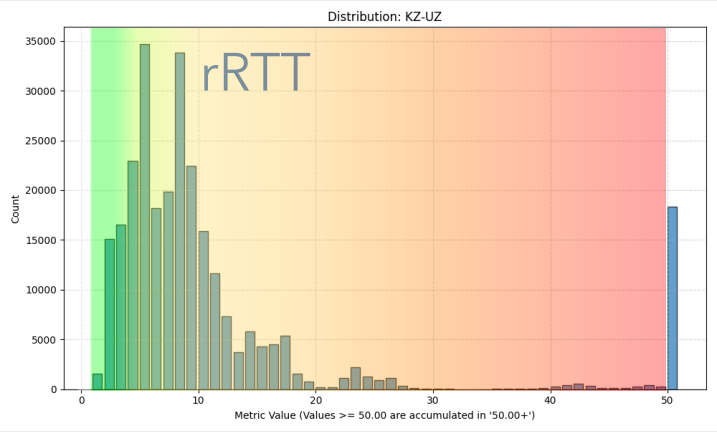
2026



- **Relationships of competitors**
  - On the RIS slide for KZ, UZ is not listed among the upstreams
  - On the RIS slide for UZ, KZ is not listed
- Following an improvement in 2024, there was a **slight decline in 2026**
  - Most likely, the majority of the KZ-??-UZ and UZ-??-KZ routes are direct
  - However, the share of international routes from KZ to UZ increased slightly (RU+DE) compared to 2024
  - The bridge across Kyrgyzstan has almost disappeared
- At the same time, the pathological routes through both Northern Europe and the Far East have disappeared

KZ-UZ: RTT Analysis

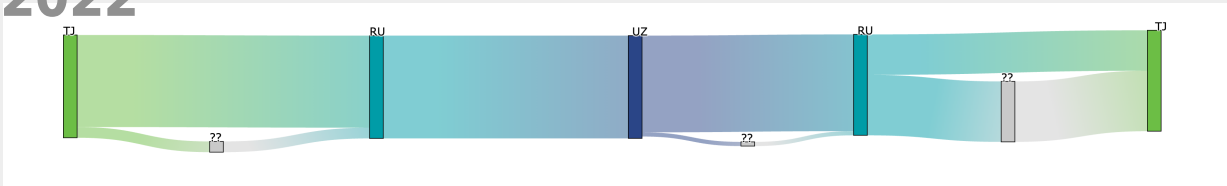




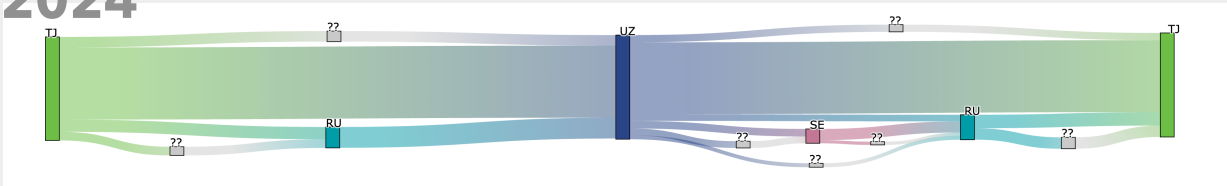
- There is no single measurement below 10 ms
  - By comparison, there are about 19,000 such measurements for the KG–KZ route
  - Shymkent–Tashkent: a one-hour drive
- Not that many below 50 ms (green zone)

TJ-UZ: Geographic Analysis

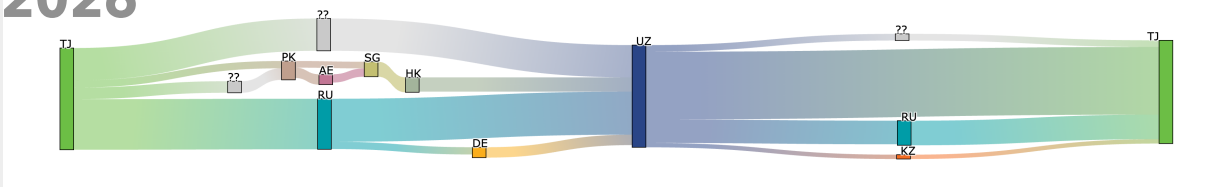
2022



2024

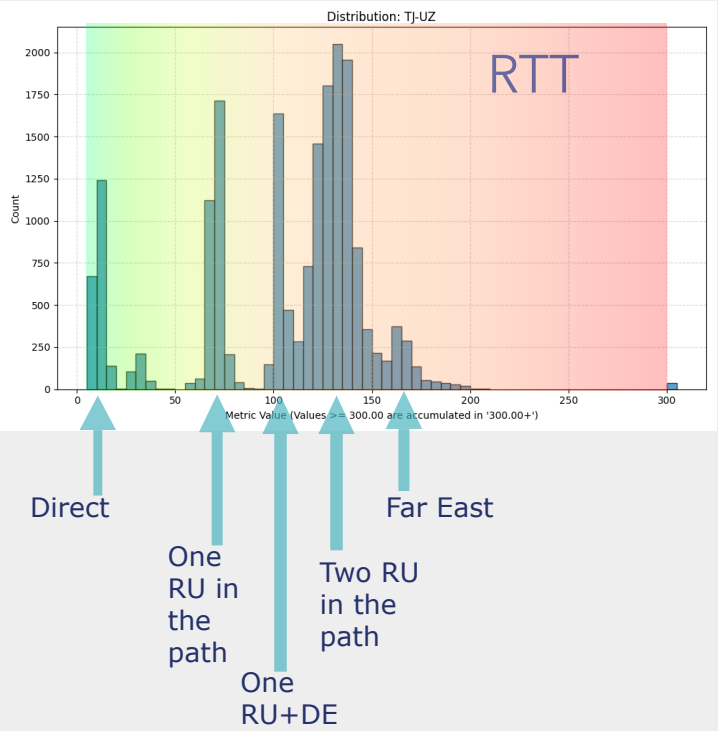


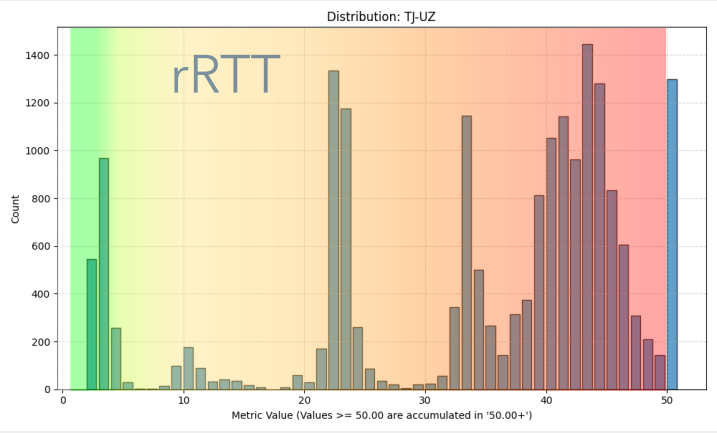
2026



- There are no TJ–UZ connections on the ITU map, although traceroutes show them
- Between 2022 and 2024, there was a turning point: neighbouring countries began to act like neighbours
  - By 2026, changes are moderate
  - The bulk of the TJ-??-UZ route consists of direct connections
  - The variety of routes has increased due to new upstreams of Tajikistan
- There is some deterioration
  - European transit has been mainly replaced by Far Eastern transit (which is even longer).
  - The proportion of long detours on the TJ→UZ route has increased significantly

TJ-UZ: RTT Analysis





- Dushanbe–Tashkent, 308 km: real direct route 6-15 ms, via Russia ≈70 ms with a detour one way, ≈130 ms both ways
  - In 2022, nothing traveled the direct route
  - In 2024, a direct link worked both ways
  - In 2026, 1/9 of measurements used it in both directions at once
- The most illustrative rRTT diagram

Two Localisation Models and Their Challenges

- **Establishing direct connections “between everyone”**
- **Selecting a common focal point**
  - A regional hub - or several
  - In Central Asia, Kazakhstan and Uzbekistan have clearly staked a claim to the role of this hub
  - It appears that Kyrgyzstan is also developing similar ambitions
- Routing policy is a one-way thing
- So the model for a way there and back might differ
- But for many services, the cumulative result is what matters
  - It turns out there are quite a few options
- Implementing logical decisions at the physical level isn't always straightforward

Some Segments Are Really Unexpected

- Examples:
  - KG→**KZ**→**NL**→**KZ**→**RU**→**KZ**→**RU**→UZ
  - **KZ**→**SE**→**KZ**→KG
  - TJ →**KG**→**UZ**→**KG**
  - **TJ**→**PK**→AE→FR→SE→NL→**KZ**→**RU**→**KZ**
  - **TJ**→**PK**→AE→OM→US→DK→SE→KZ
  - **UZ**→**RU**→**KZ**→**RU**→**AT**→**DE**→**RU**→**TJ**→**KZ**

- It appears that internal connectivity in Kazakhstan isn't very well coordinated
- To some extent, this also applies to Uzbekistan and Kyrgyzstan
- Due to the lack of native IPv6 support among providers, users are using a tunnel to Hurricane Electric
  - This creates a number of false paths

Observations and Conclusions

General Observations (1)

- **The region continues to develop**
- This development is accompanied by a **natural trend toward regionalisation and localisation of traffic routes**
  - More route diversity often appears before routes become shorter and cleaner
  - Improvements are followed by rerouting, partial regressions and new equilibria
  - Regionalisation is not a monotonic process
- **The number of countries with regional ambitions is growing**
  - But this complicates localisation at the tactical level
  - More cooperation between countries would help

General Observations (2)

- Between 2022 and 2024, the region experienced a significant leap forward; **the changes over the past two years have not been as substantial**
- **Lack of national routing policies coordination** also makes the situation worse
- **Customer–provider relationships keep traffic in the region; competitor relationships export it**
  - The biggest single gain is between the two hubs

Some Technical Notes

- Often **near-optimal and highly inefficient paths coexist** between the same country pairs
- Many regional links are often near the physical optimum. The problem is how **rarely they are used in both directions**
- **Traffic asymmetry** is everywhere
  - Therefore, even if the A→B direction performs optimally, the B→A direction may not
- **A handful of operators' policies shape the whole regional picture**
- **Localisation is reversible**
- Path diversity and operator diversity are not the same thing

My Next Steps

- **We need more Atlas probes in the region**
  - We have software probes, easy and convenient for operators
- The two-way routes to be studied in future
- Those “??” must be analysed deeper
- **I will return to this topic in 2 years**

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Questions? Comments? Applause?

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