



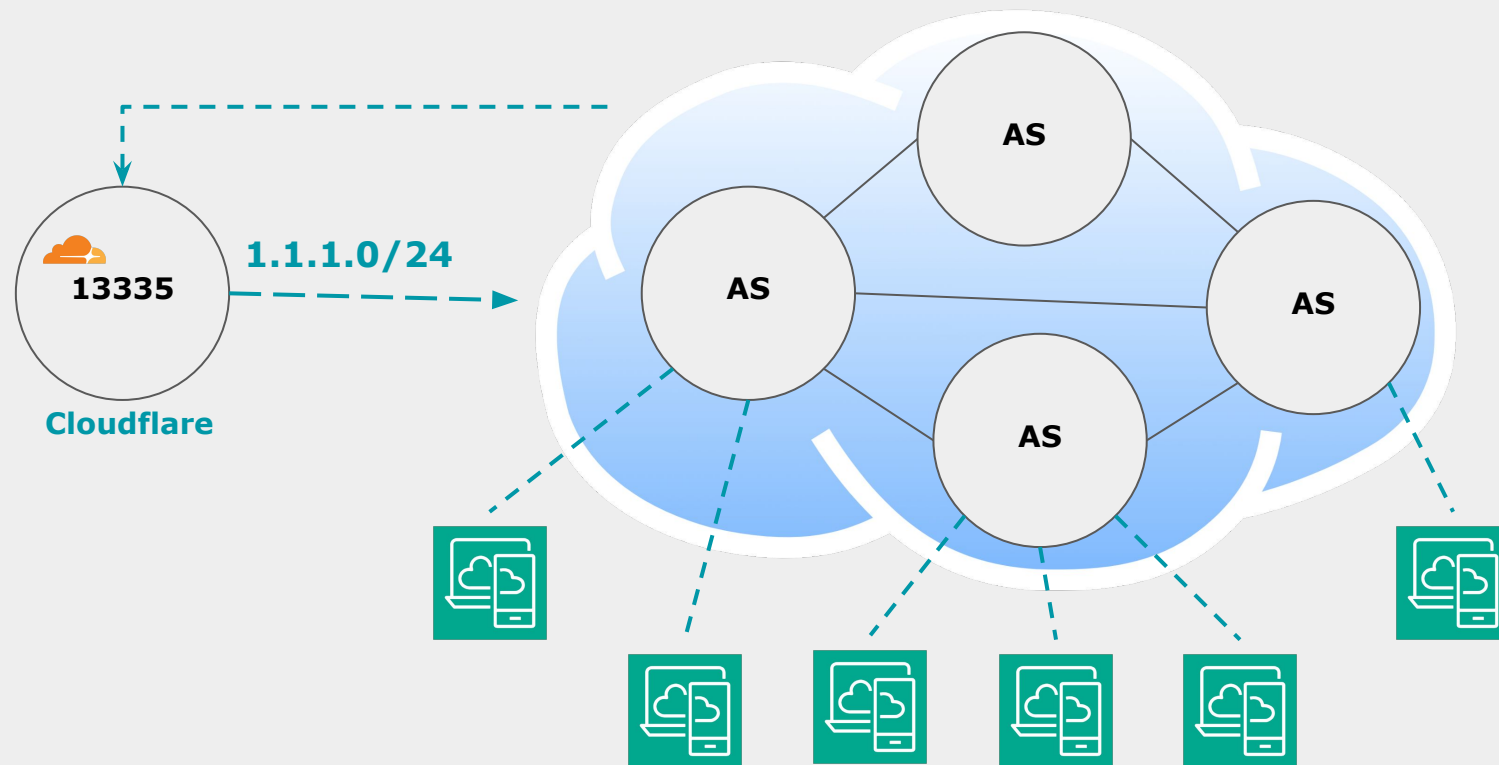
RIPE NCC
RIPE NETWORK COORDINATION CENTER

Global Routing Security: Where Are We Now

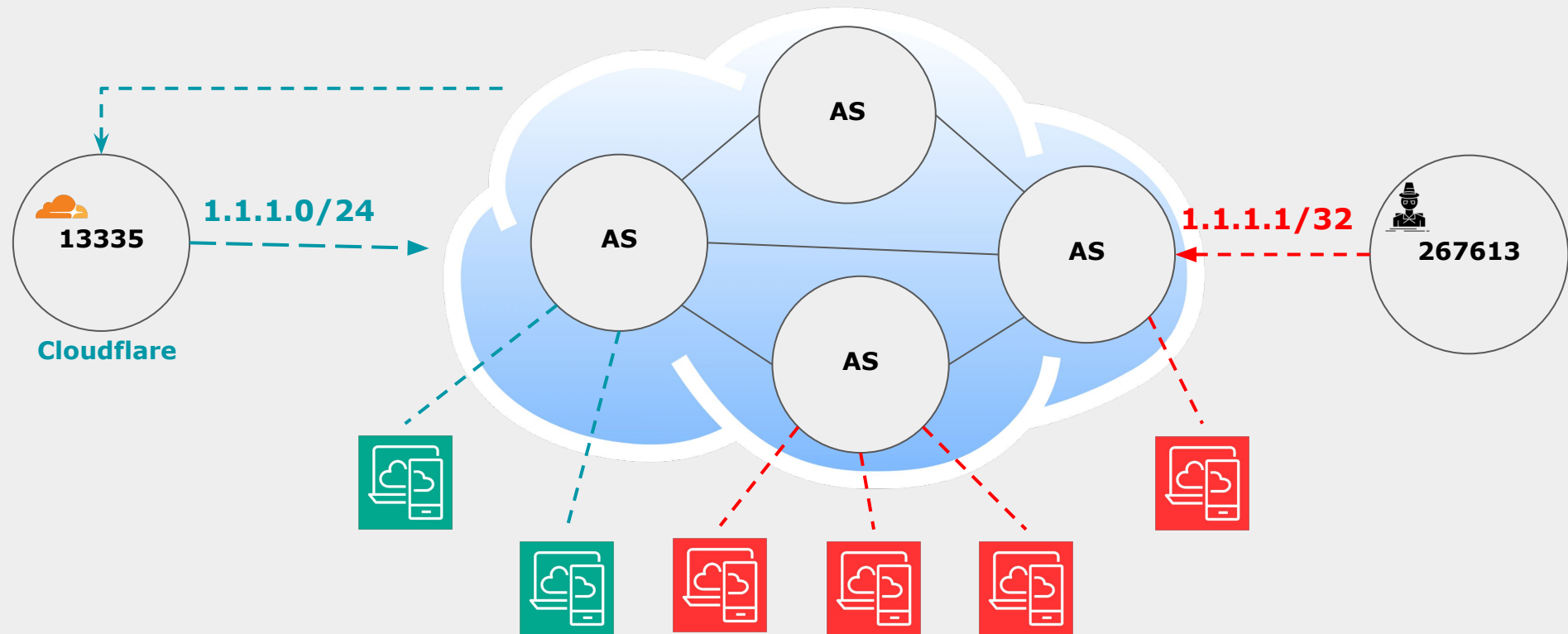


Routing Security

BGP hijack Cloudflare



BGP hijack Cloudflare





- **Why RPKI?**

- Prevents such incidents by cryptographically verifying the legitimacy of route announcements.
- Helps mitigate both accidental and malicious BGP misconfigurations.



Enhancing Routing Security

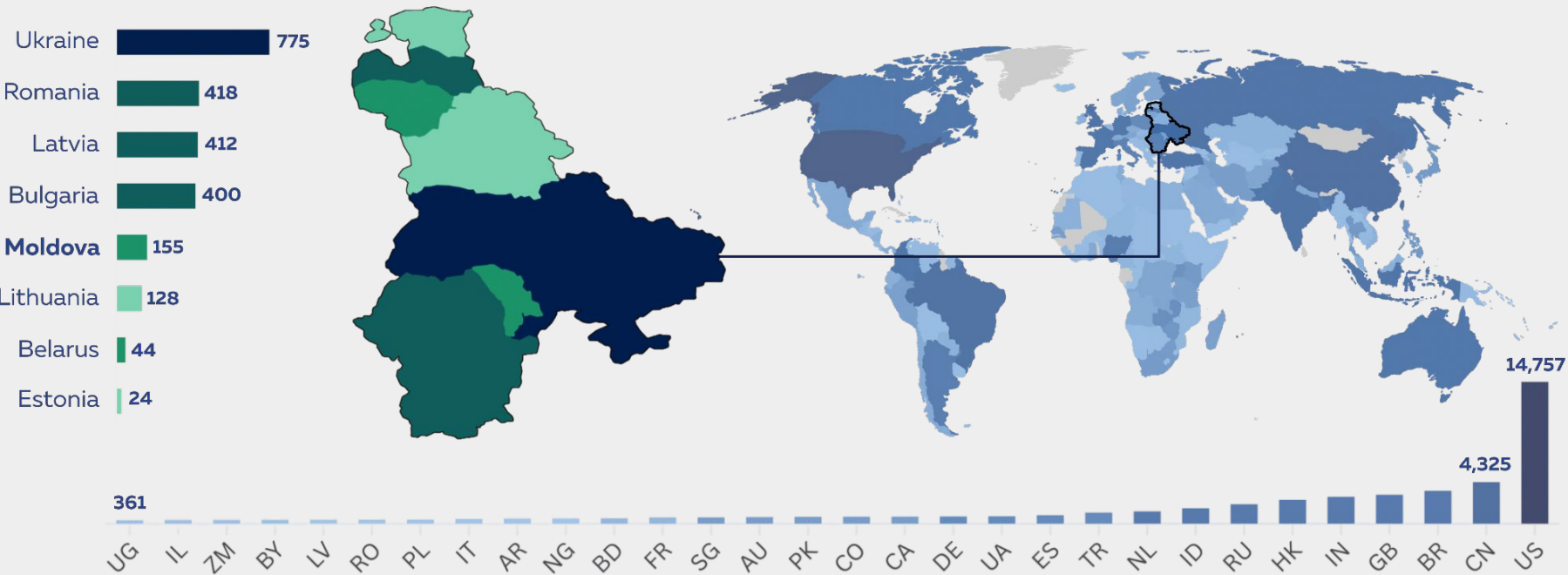


- Used to validate the origin of BGP announcements
 - Is the originating ASN authorised to originate this particular prefix?
- Has two parts:
 - **Route Origin Authorisation (ROA):** Defines which ASes are authorised to announce specific IP prefixes
 - **Route Origin Validation (ROV):** Validates routes based on ROAs, ensuring only legitimate routes are accepted.

BGP Incidents in the Region and Globally



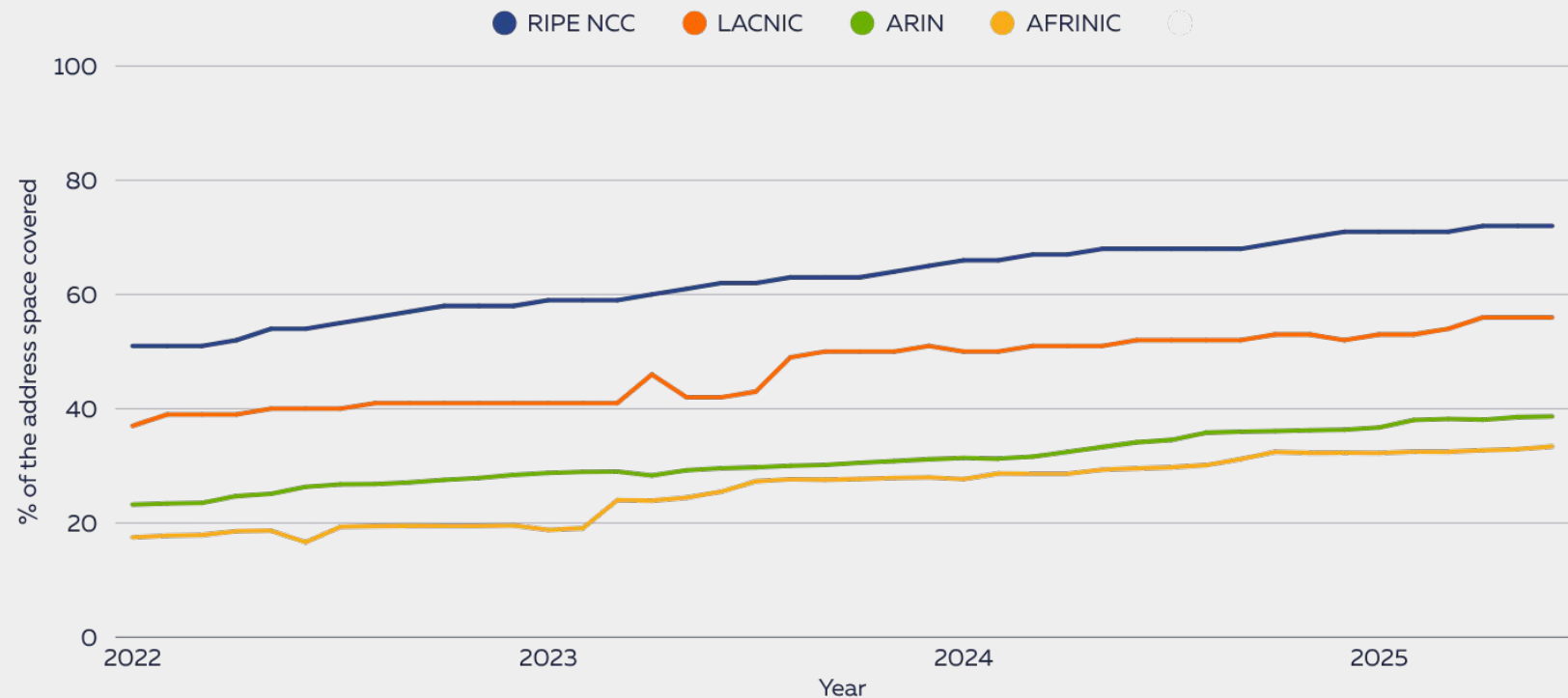
June 2024 - June 2025, source: Cloudflare





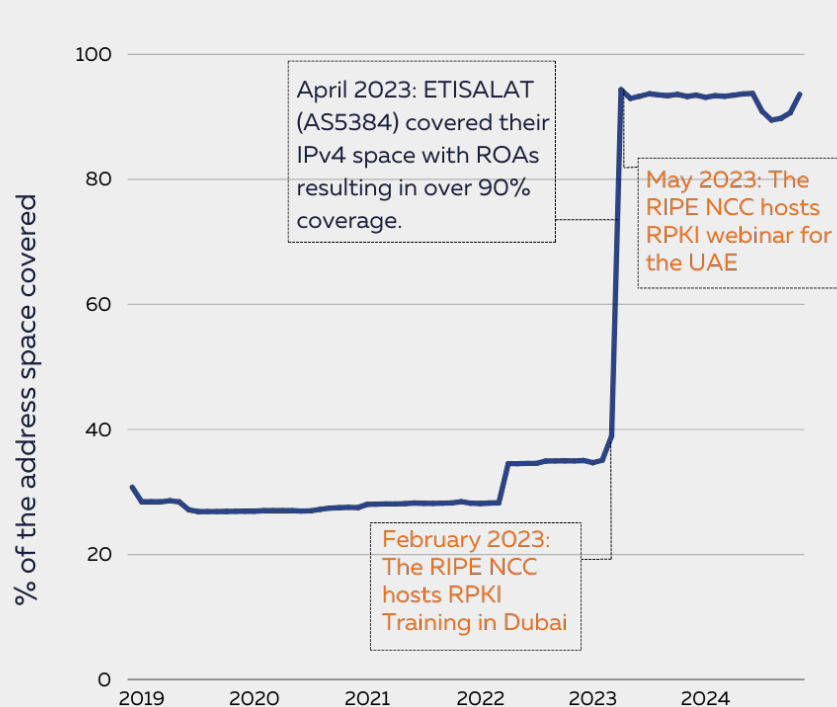
Route Origin Authorisation (ROA)

RIR IPv4 ROA Coverage (2022-2025)

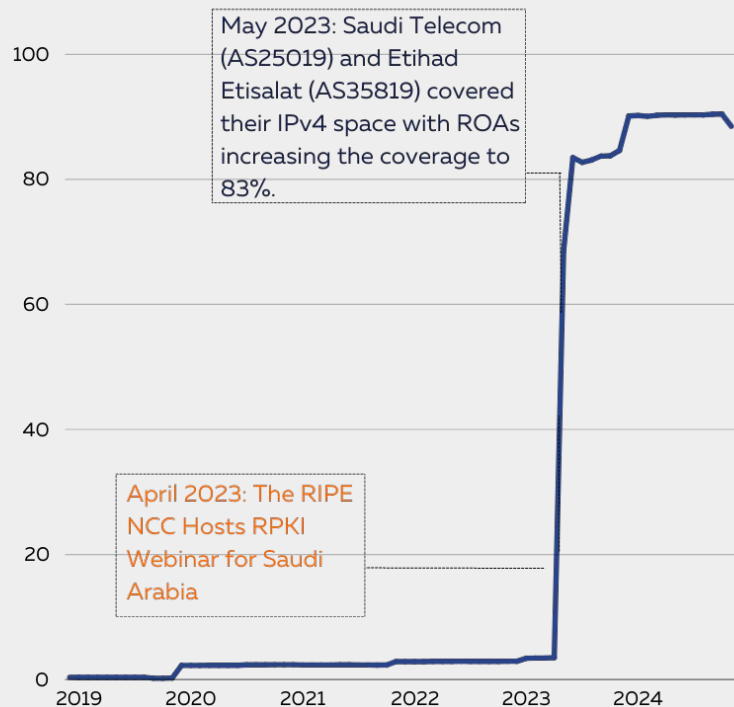


Source: RIPE NCC

ROA Coverage and the RIPE NCC Engagement

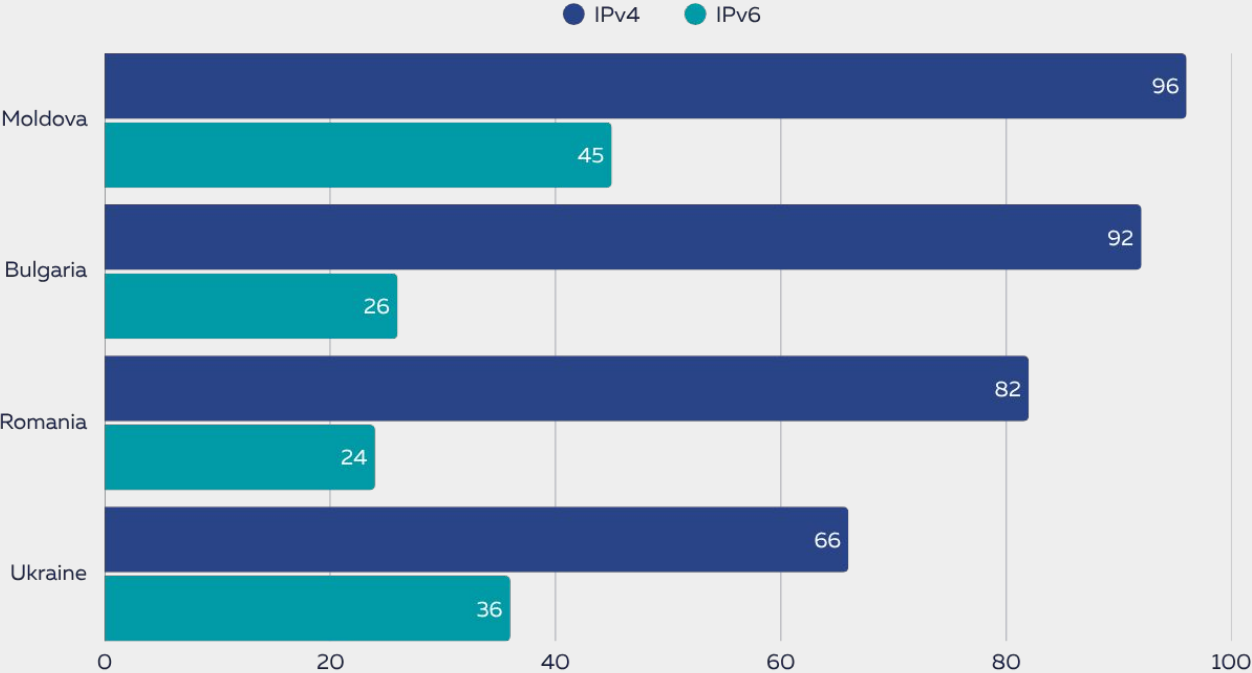


United Arab Emirates (UAE)



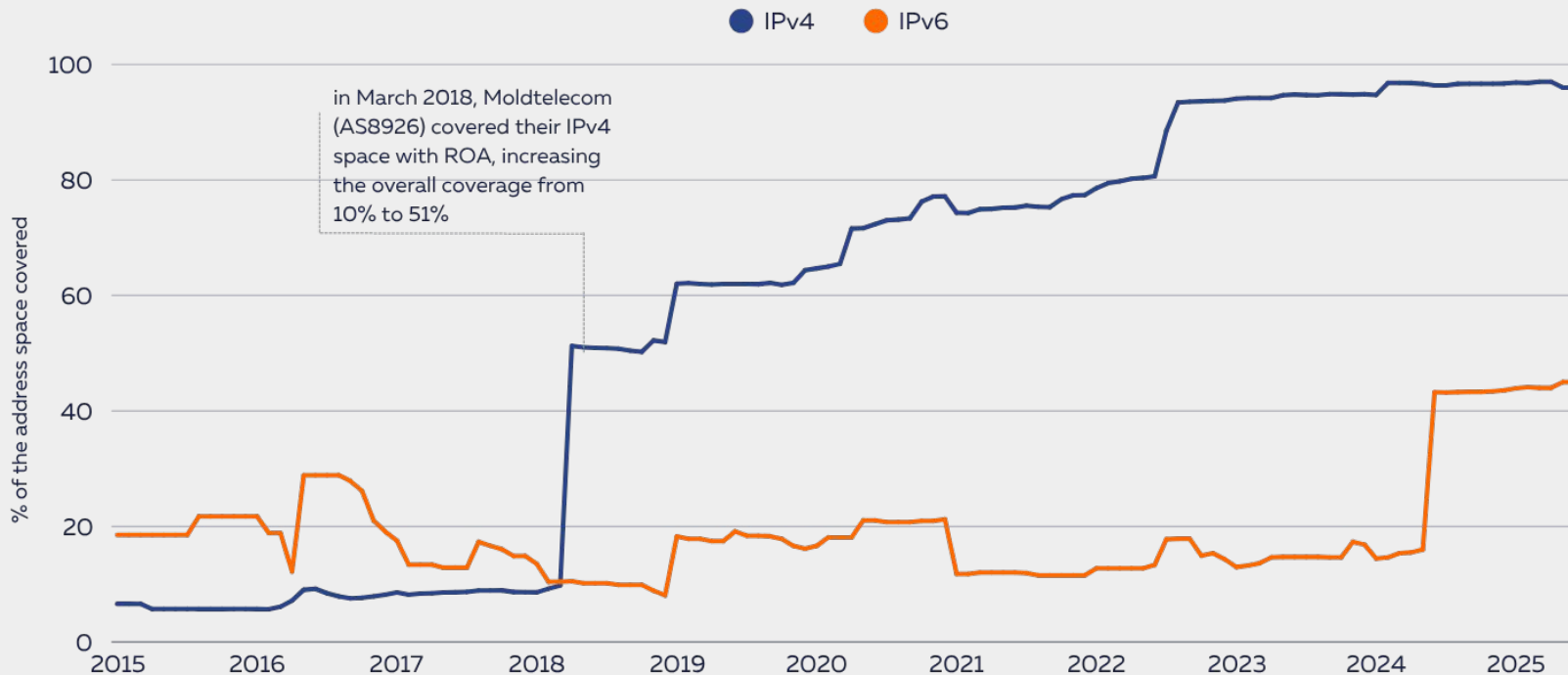
Saudi Arabia

ROA Coverage (% , IPv4 and IPv6)



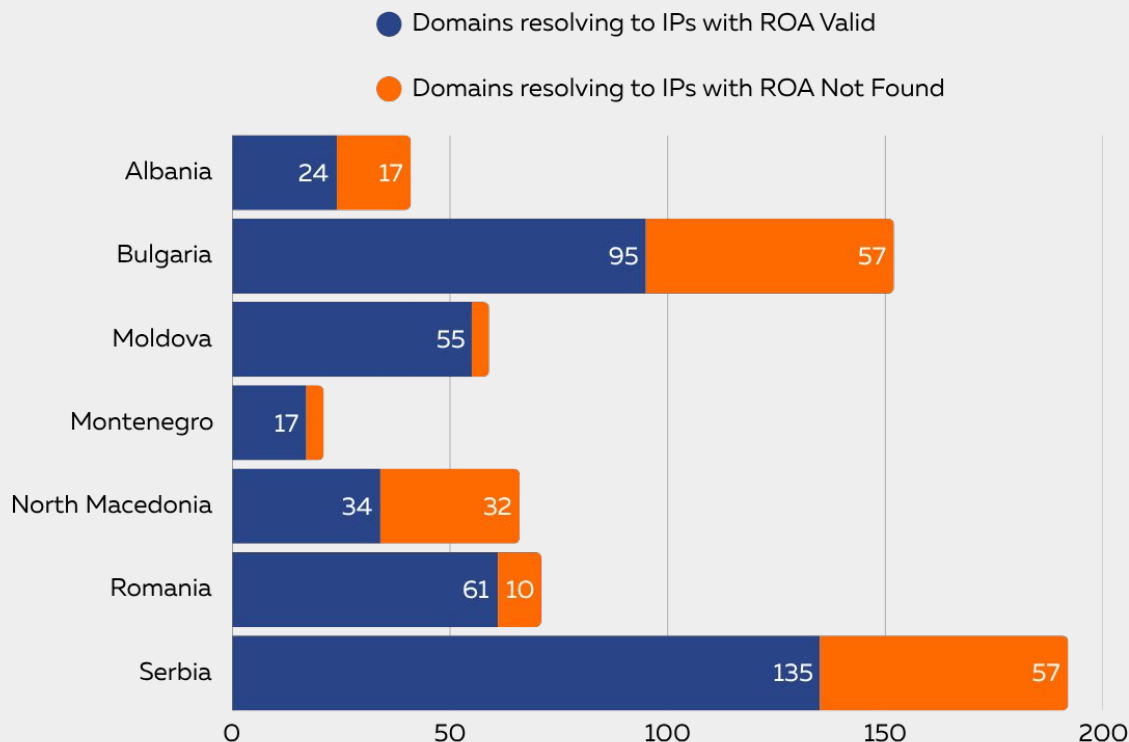
Source: RIPE NCC
Snapshot from June 2025

ROA Coverage in Moldova (%, IPv4, IPv6)



Source: RIPEstat, RIPE NCC

ROA Coverage: Government Domains in Moldova



We analysed whether IP addresses resolved to the government domains in Moldova and some countries from the SEE region are covered by ROAs. We chose a sample of countries that experienced cyber attacks on government websites in the past few years.

The methodology involves extracting BGP routing data from RIS and then validating against RIPE NCC's RPKI Validator, categorising each prefix as Valid (properly authorised), Invalid (violating a ROA), or Not-Found (lacking RPKI protection).

IP addresses that resolved to these domains and fell under RPKI Invalid or Not-Found prefixes – and were not concurrently covered by a more specific Valid ROA – were classified as belonging to RPKI Invalid or Not-Found prefixes

Help us make the domain lists comprehensive!



Route Origin Validation (ROV)

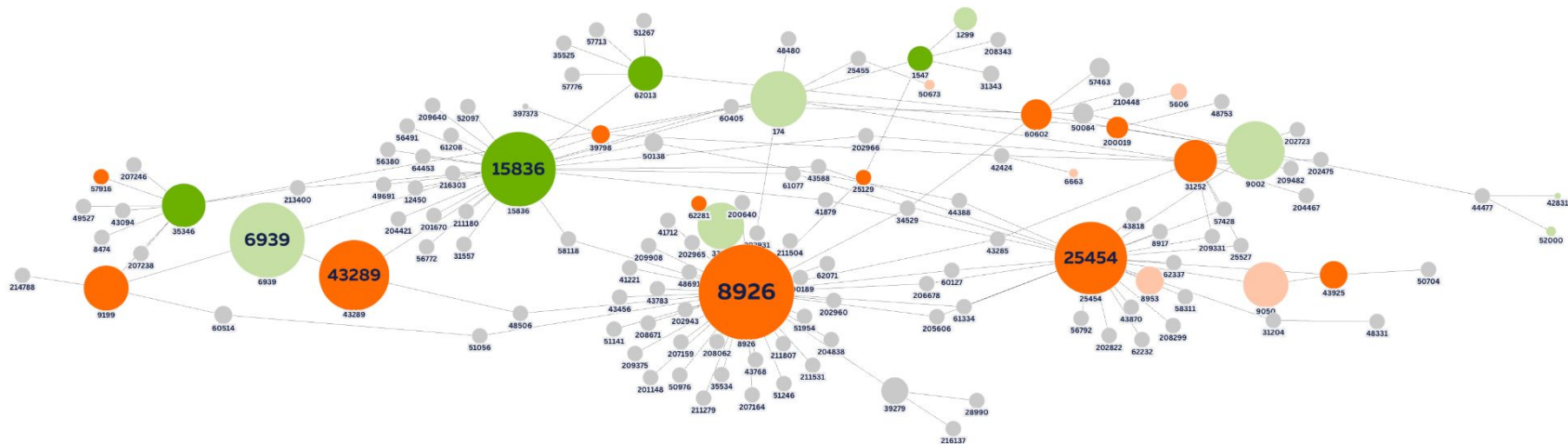


- We used RoVISTA to analyse deployment of ROV across the SEE region
 - RoVISTA calculates the scores based on the number of RPKI-invalid prefixes that an AS can reach. We used a more inclusive approach where we classify an AS as having implemented ROV if its score is greater than 0, indicating any level of ROV deployment.
- **Collateral benefit**
 - We assessed ROV impact from the perspective of network centrality, utilising the AS Hegemony methodology, which measures the centrality of autonomous systems within a country.
 - The methodology measures the common transit networks to a local AS and how much this AS relies on these transit networks based on BGP data. AS hegemony values range between 0 and 1 and indicate the fraction of paths crossing a node.

Moldova Interconnectivity Map (AS Hegemony, ROV)



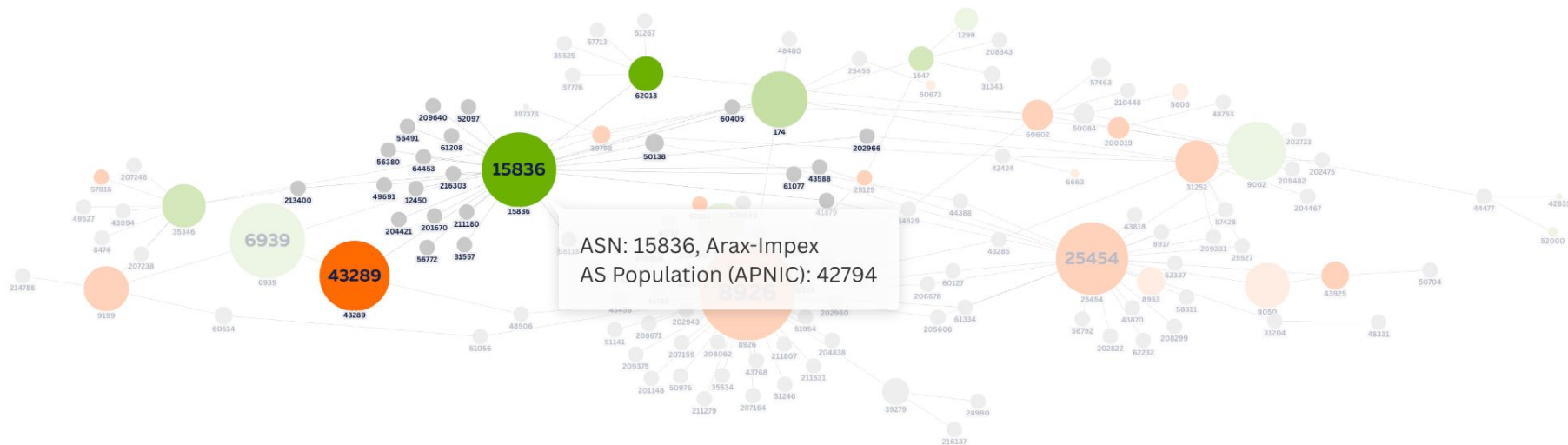
● Local ASN with ROV ● Local ASN no ROV ● Foreign ASN with ROV ● Foreign ASN no ROV ● No Data



Moldova Interconnectivity Map (AS Hegemony, ROV)



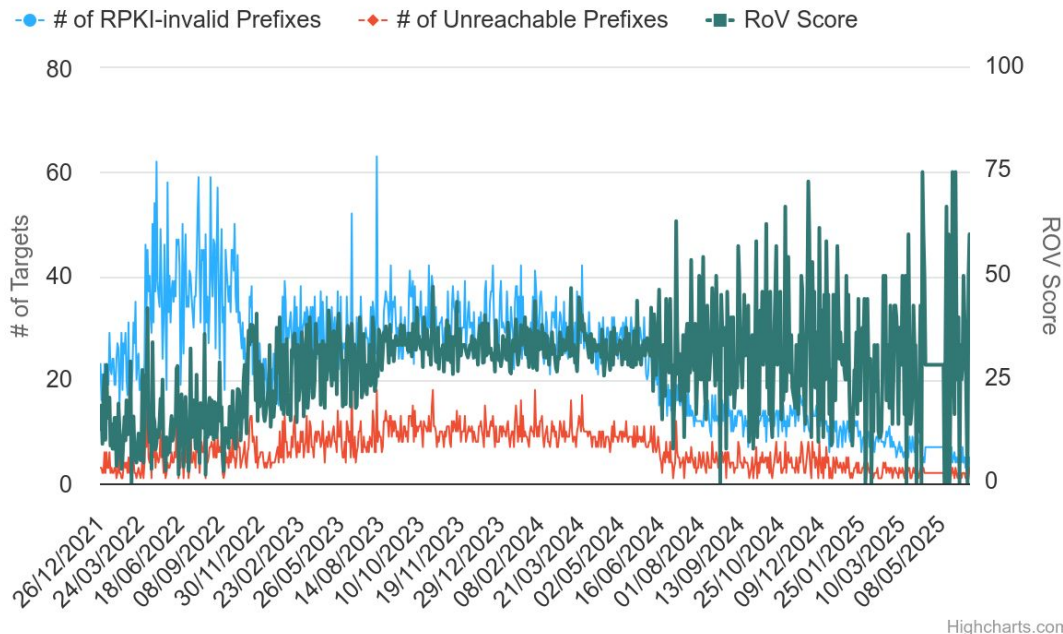
● Local ASN with ROV ● Local ASN no ROV ● Foreign ASN with ROV ● Foreign ASN no ROV ● No Data



Why ROV Is Hard in Practice



ROV Score



Path-Dependent Enforcement:

Invalid routes are blocked only if their AS-path includes at least one RPKI-validating network—but can still propagate through non-validating networks.

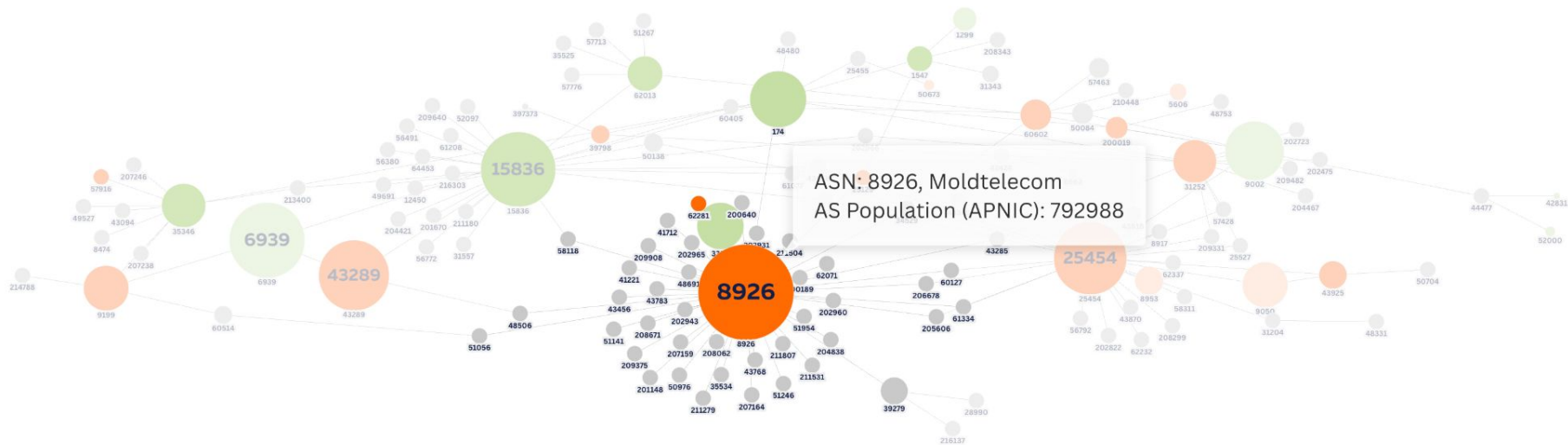
Requires Complete Border

Deployment: An AS only provides full hijack protection when all its border routers filter invalid routes; any unprotected edge allows route leaks to continue.

Moldova Interconnectivity Map (AS Hegemony, ROV)



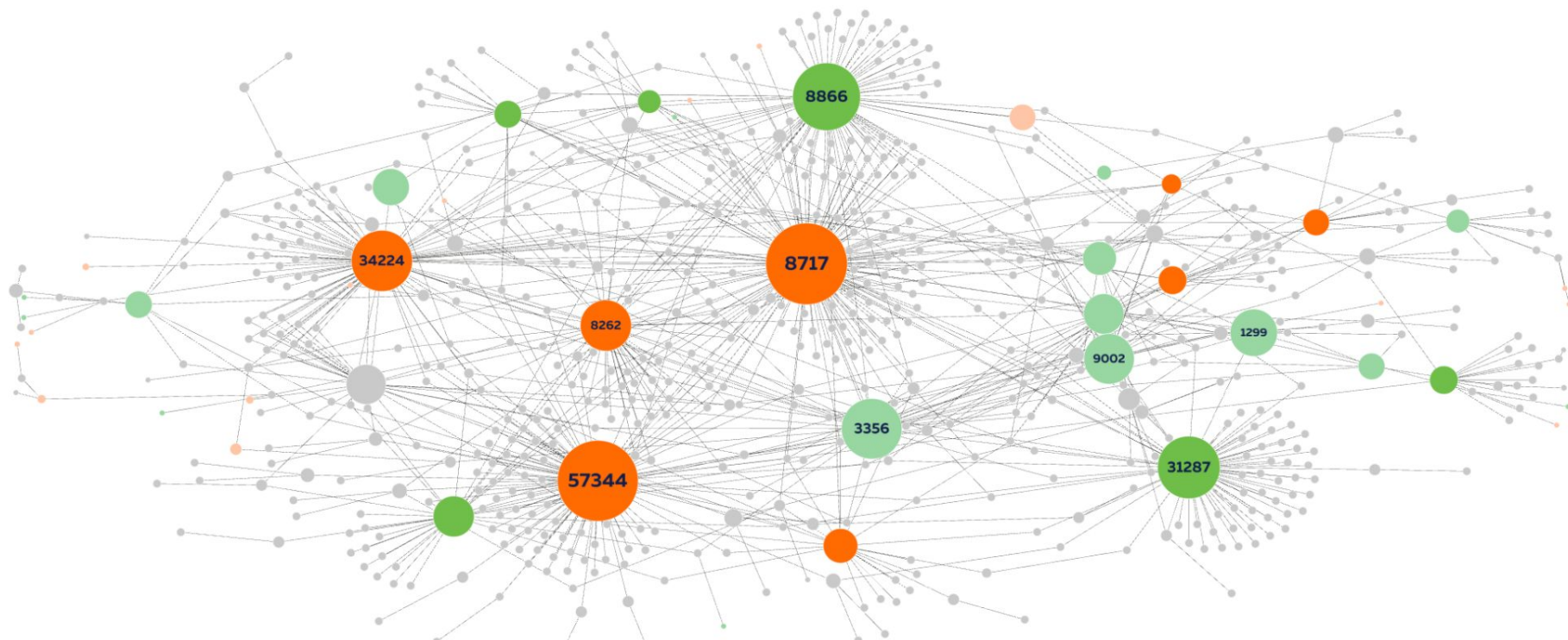
● Local ASN with ROV ● Local ASN no ROV ● Foreign ASN with ROV ● Foreign ASN no ROV ● No Data



Bulgaria Interconnectivity Map (AS Hegemony, ROV)



● Local ASN with ROV ● Local ASN no ROV ● Foreign ASN with ROV ● Foreign ASN no ROV ● No Data

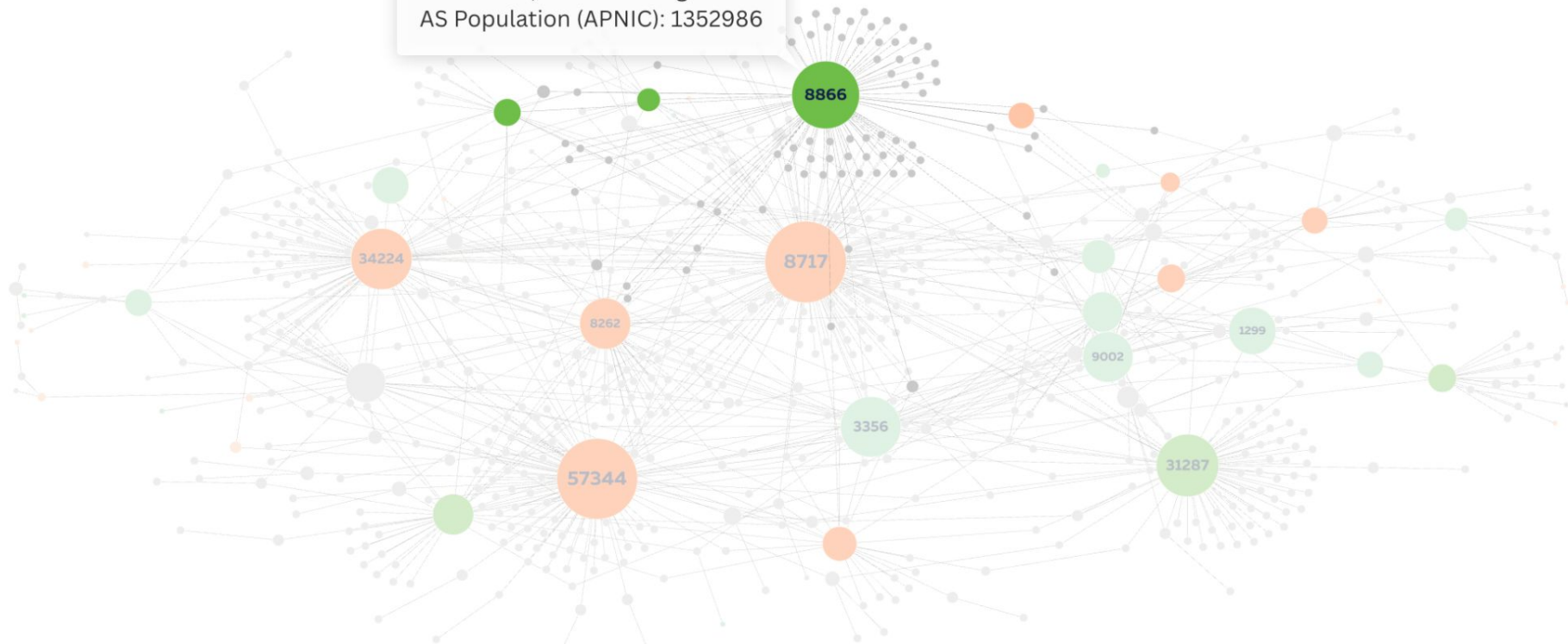


Bulgaria Interconnectivity Map (AS Hegemony, ROV)



● Local ASN with ROV ● Local ASN no ROV ● Foreign ASN with ROV ● Foreign ASN no ROV ● No Data

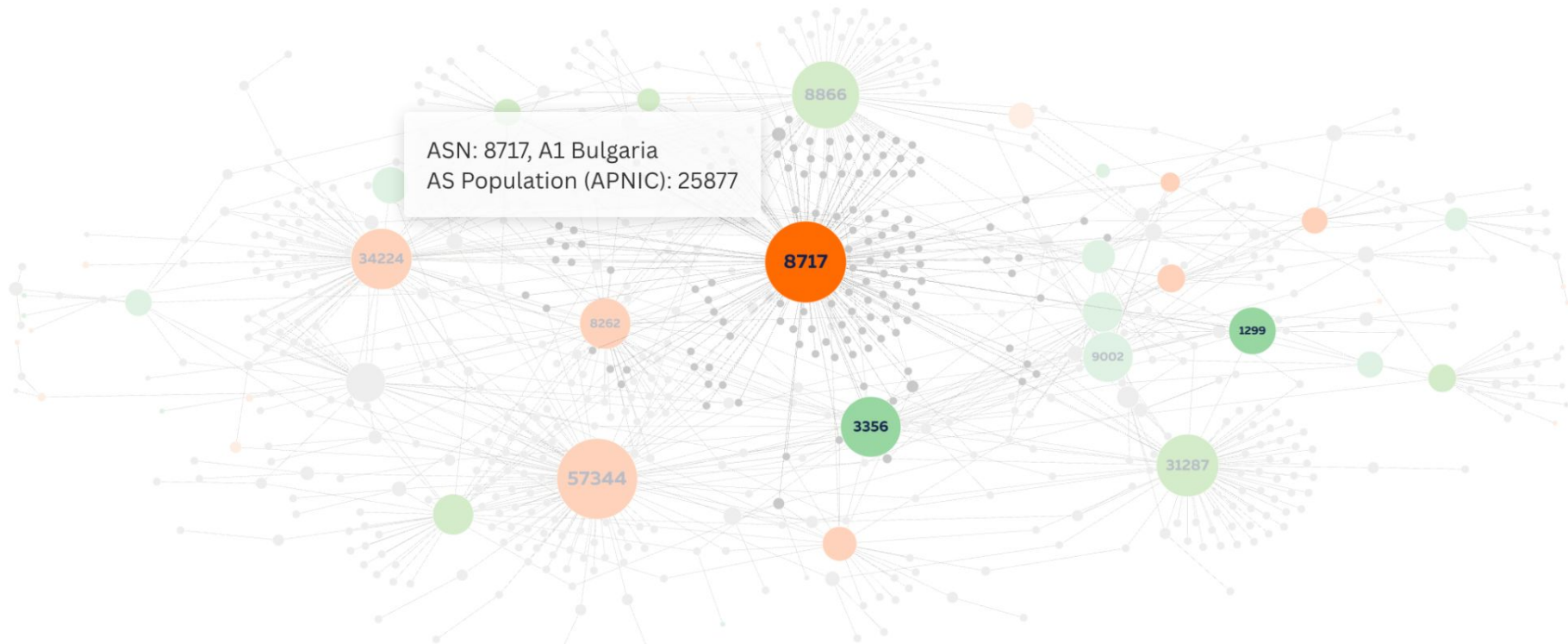
ASN: 8866, Vivacom Bulgaria
AS Population (APNIC): 1352986



Bulgaria Interconnectivity Map (AS Hegemony, ROV)



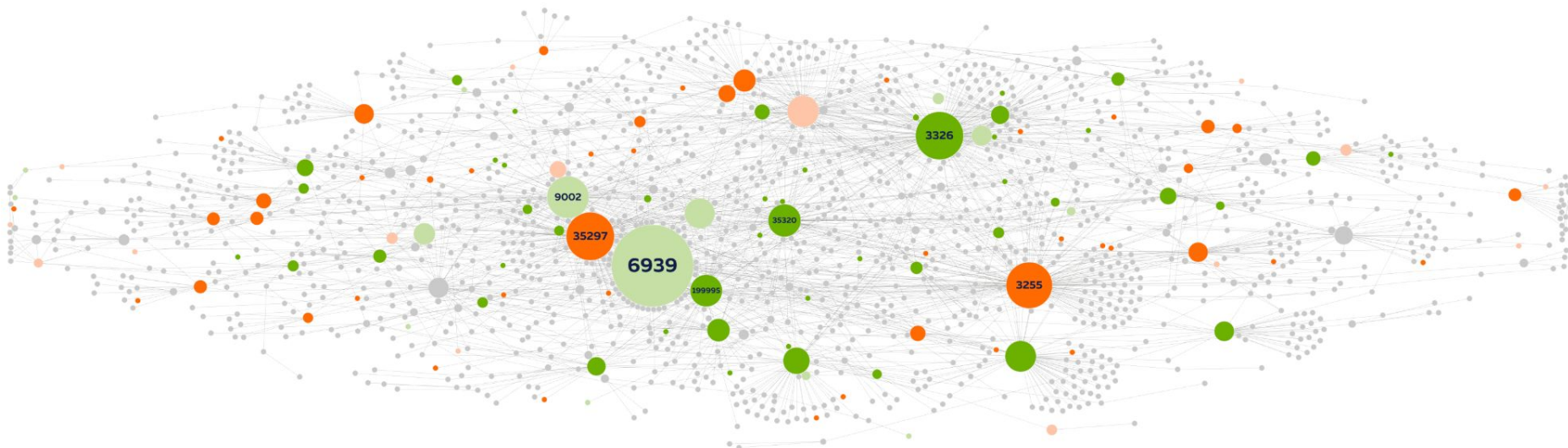
● Local ASN with ROV ● Local ASN no ROV ● Foreign ASN with ROV ● Foreign ASN no ROV ● No Data



Ukraine Interconnectivity Map (AS Hegemony, ROV)



● Local ASN with ROV ● Local ASN no ROV ● Foreign ASN with ROV ● Foreign ASN no ROV ● No Data

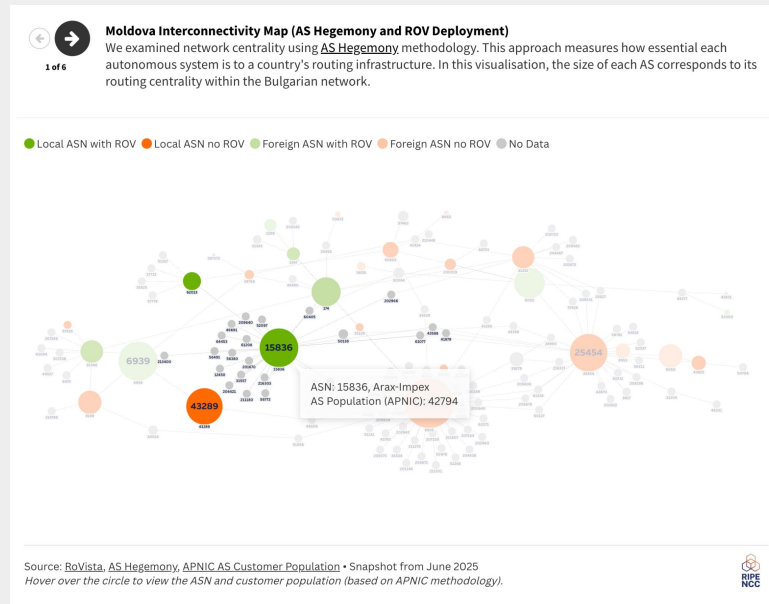


Find your AS!



Check out the interactive graph

Sources: AS Hegemony, RoVista, APNIC
Network graphs made by Flourish



Conclusion – RPKI Adoption



- Growing recognition of RPKI importance at government level:
 - White House roadmap advocating RPKI as mature solution for BGP vulnerabilities
 - US government aims to have 60% of advertised IP space under ARIN RSA, explicitly paving the way to ROAs for federal networks
- Regulatory bodies taking action:
 - FCC (in US), proposing annual BGP security risk management plans for ISPs
 - Forum Standaardisatie (in NL), “apply or explain” by the end of 2024 for all governmental entities, both ROAs and ROV
- Implications for South East Europe:
 - Opportunity for operators and policymakers to enhance routing security
 - Potential to establish guidelines and timelines for RPKI adoption



BGP Security E-learning Course

- ✓ Free online course
- ✓ Interactive, you can study at your own pace
- ✓ Practical lab environment and activities



academy.ripe.net/bgp-security/

My network - AS100

Router 1

[open logs reconnect pop out](#)

```
AS100 - R1 router
R1# []
```

Router 2

[open logs reconnect pop out](#)

```
AS100 - R2 router
R2# []
```

Hints

- Feel free to **resize terminal windows** by dragging (does not work in Safari)
- To scroll inside the tmux, use **Ctrl-B** and **PageUp/PageDown** (**Fn + Up/down** on Mac)
- To open new tmux window, use **Ctrl-B c**
- See [tmux cheatsheet](#)

Scratchpad

Here you can put some text you need to copy and paste.



- [1] RoVista <https://rovista.netsecurelab.org>
- [2] AS Hegemony,
https://labs.ripe.net/author/romain_fontugne/as-hegemony-measuring-as-interdependence/
- [3] Cloudflare,
<https://developers.cloudflare.com/api/resources/radar/subresources/bgp/subresources/hijacks/subresources/events/methods/list/>
- [4] RIS, ripe.net/ris



Questions & Comments



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