ThousandEyes part of Cisco

Reviving BGP Zombies

Peering in the Routed Dead

Iliana Xygkou, Antonios Chariton, Fontas Dimitropoulos

NANOG 93 - Atlanta, U.S.A.

What are BGP Zombies?

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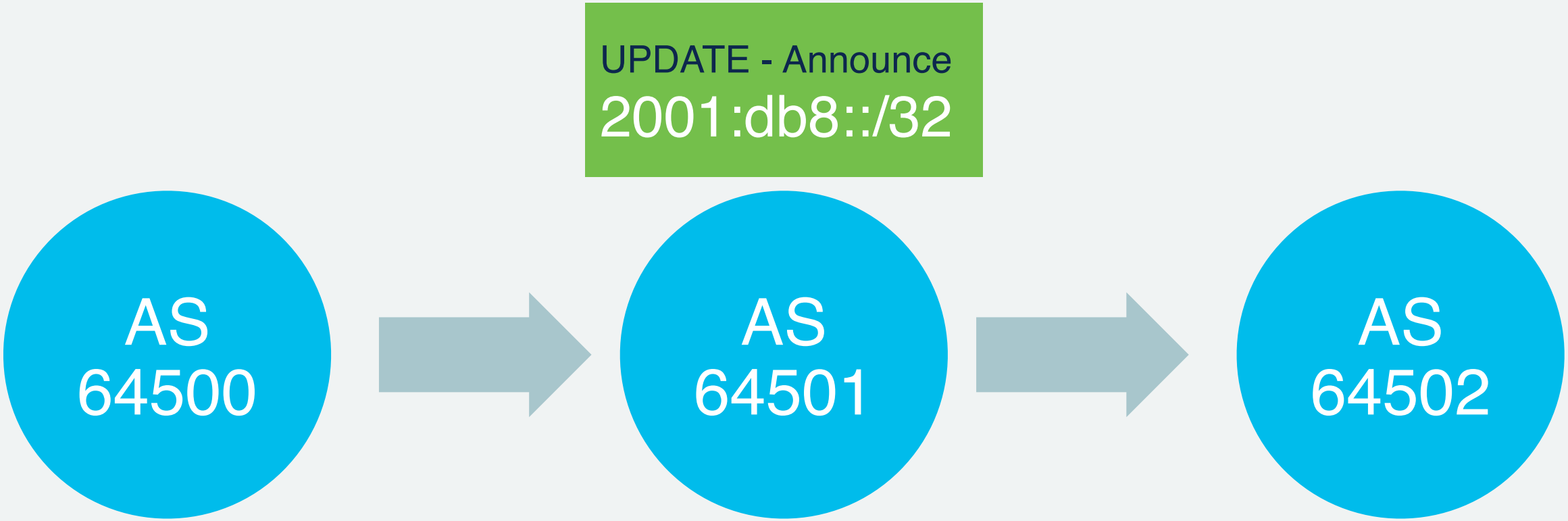
UPDATE - Announce
2001:db8::/32

What are BGP Zombies?



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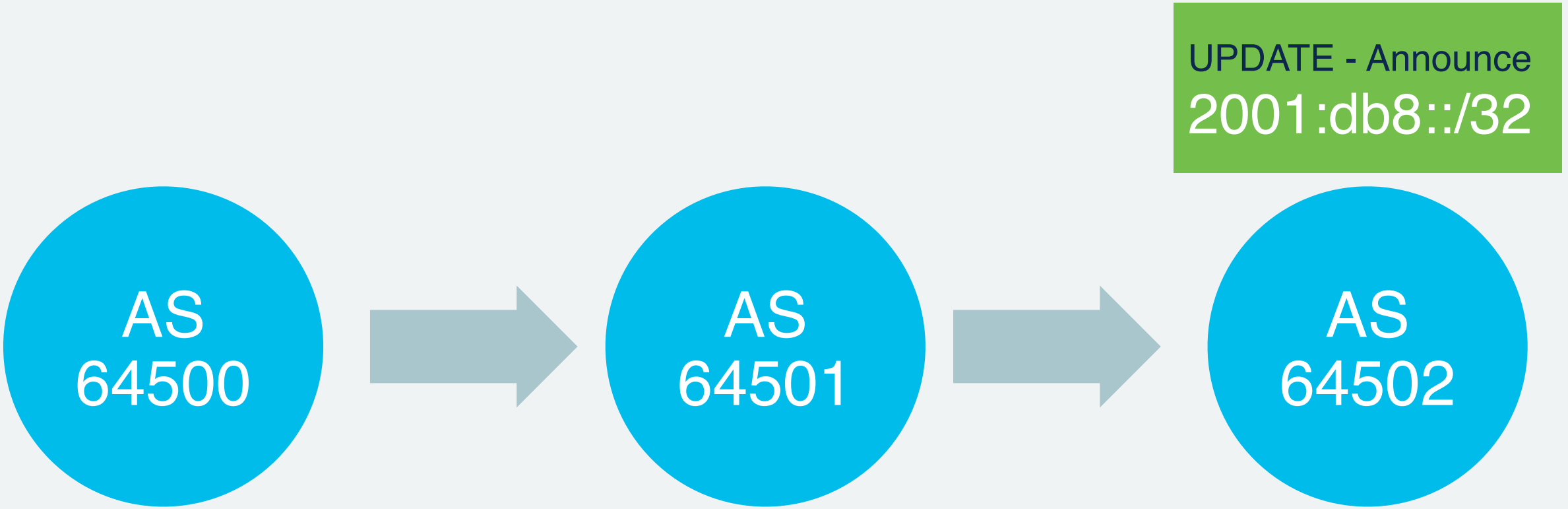

What are BGP Zombies?

UPDATE - Withdraw
2001:db8::/32

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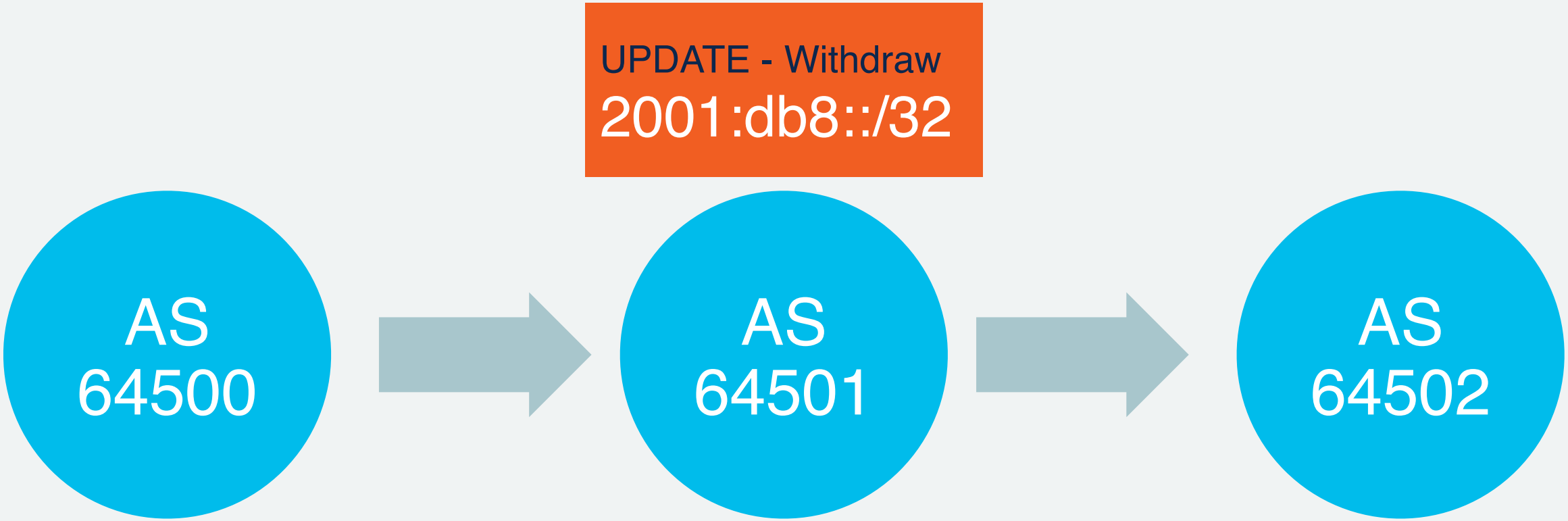

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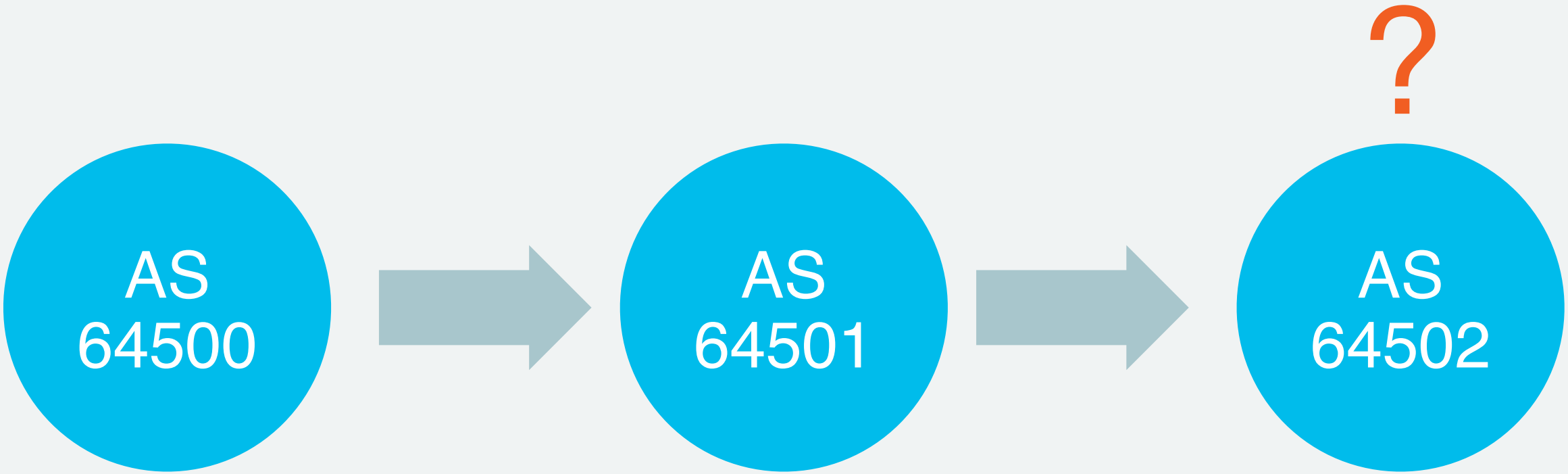

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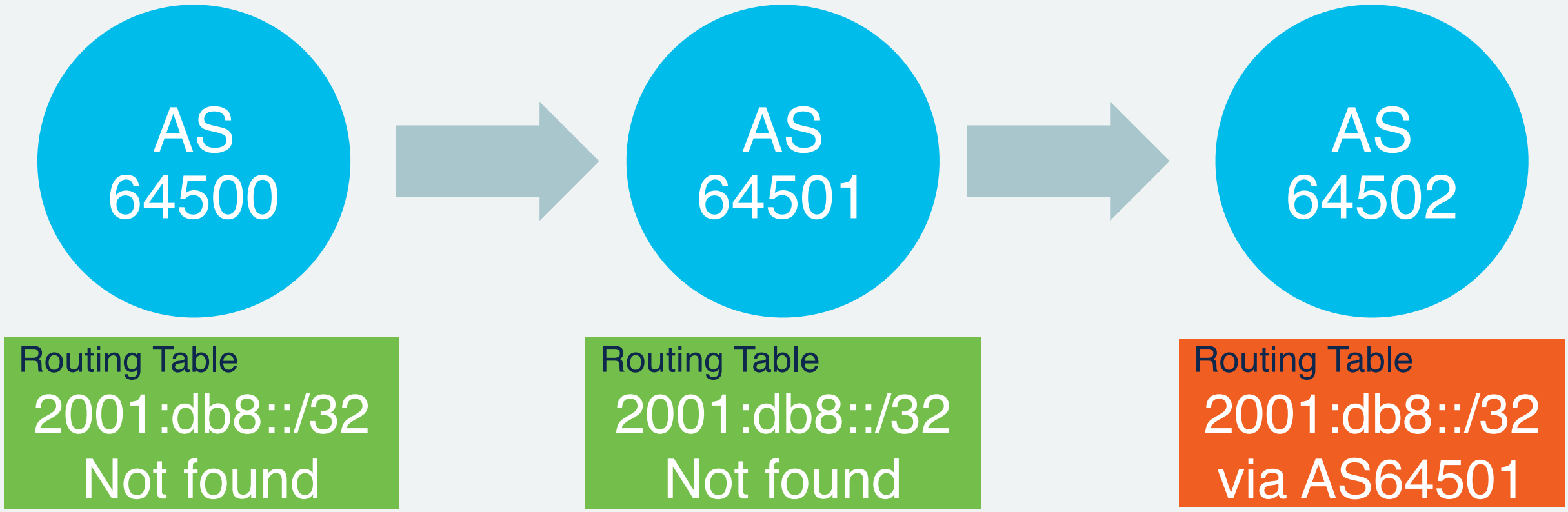

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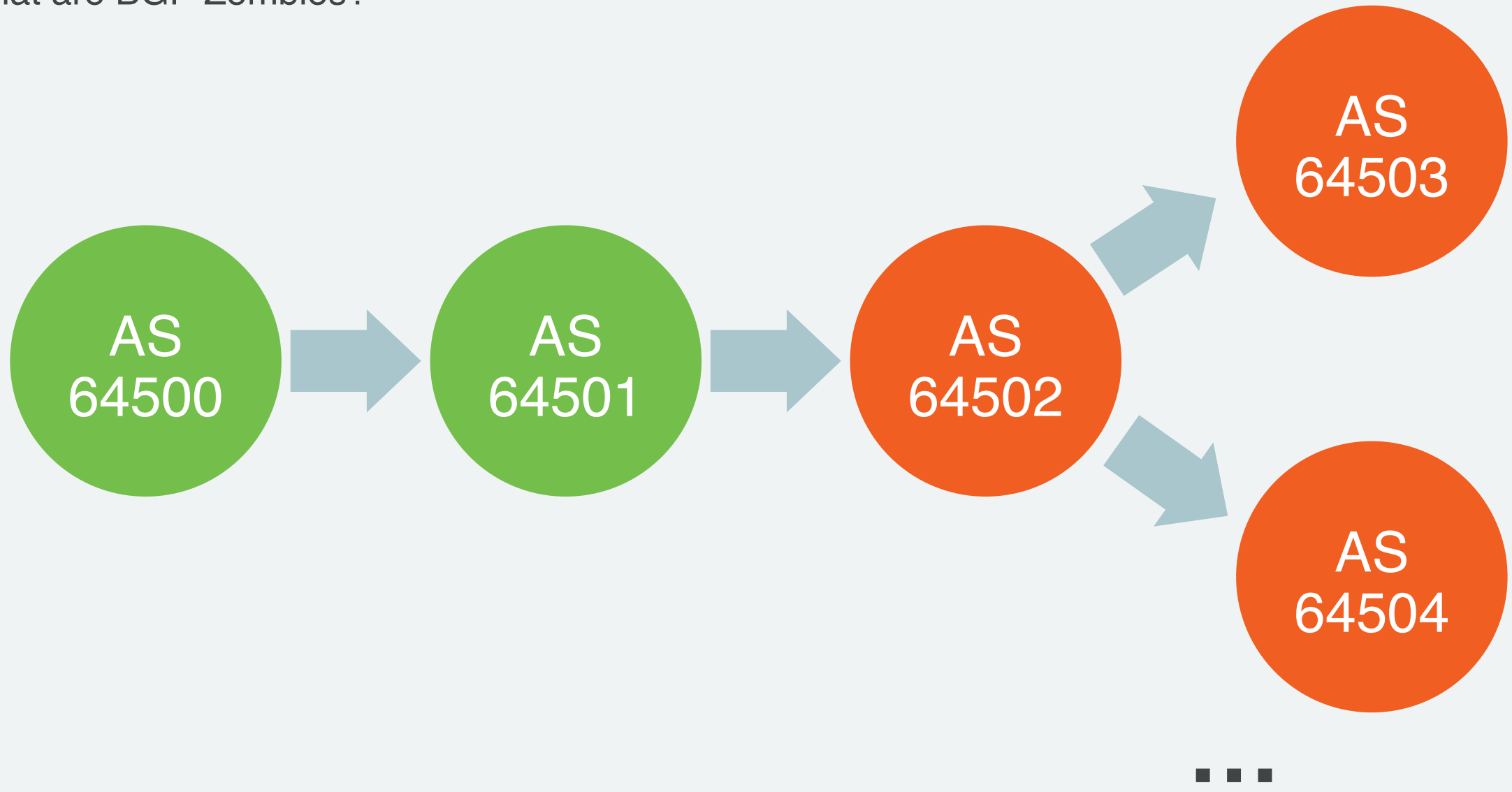


Why is this a problem?

Why is this a problem?

Effects of Zombies

Non-exhaustive

- Deaggregated prefixes for Traffic Engineering / DDoS Mitigation may remain in some locations
- Paths that are no longer there may appear and be used
  - Routing loops
  - Dropped traffic
- Sold or revoked IP space may cause small percentage of traffic being redirected
- False BGP Hijack Alerts / RPKI Invalids
- The number of prefixes on the Internet will keep going up

This is a problem both if your prefixes are stuck and if others' prefixes are stuck in yours or your upstreams' routers.

Why is this a problem?

UPDATE - Withdraw

2001:db8::/32

Why is this a problem?

UPDATE - Announce

2001:db8::/32

Is this a big problem?

Is this a big problem?

BGP Zombies: an Analysis of Beacons Stuck Routes

Romain Fontugne, Esteban Bautista, Colin Petrie, Yutaro Nomura, Patrice Abry, Paulo Gonçalves, Kensuke Fukuda, Emile Aben

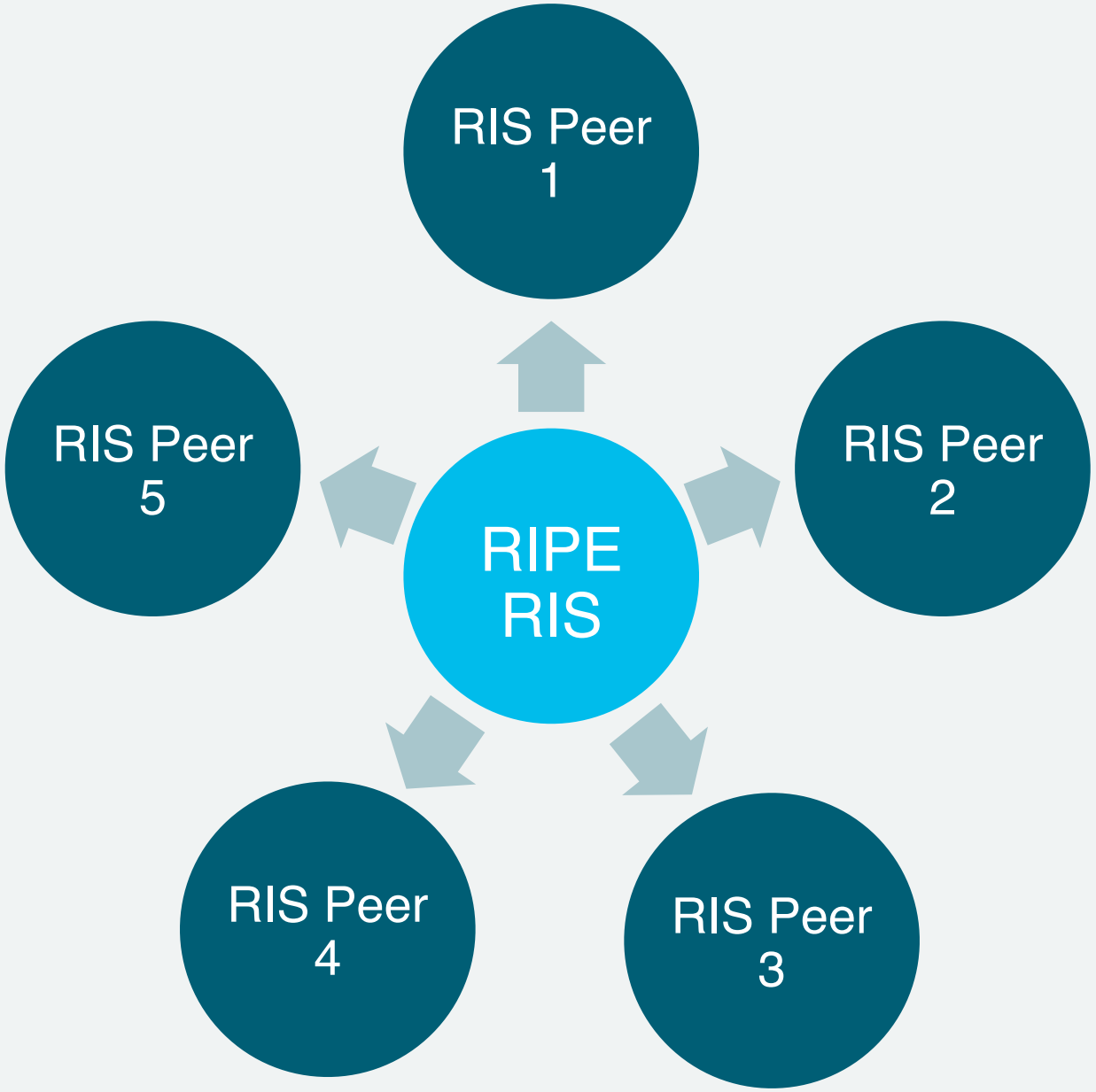
Is this a big problem?

RIPE RIS Beacons

- Announce its prefix every 4 hours (00:00, 04:00, …)
- Withdraw the prefix 2 hours later (02:00, 06:00, …)

UPDATE - Announce
2001:7fb:fe01::/48
84.205.65.0/24

UPDATE - Withdraw
2001:7fb:fe01::/48
84.205.65.0/24



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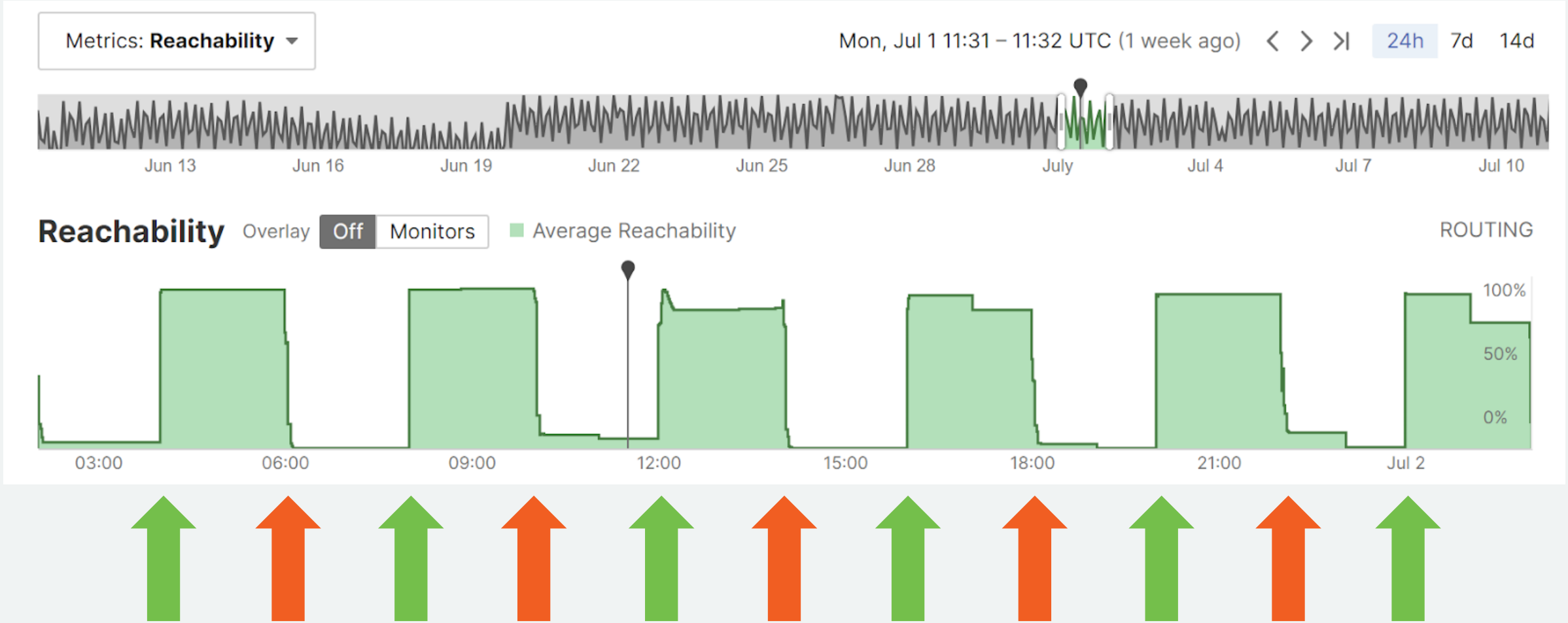
RIPE RIS Beacons



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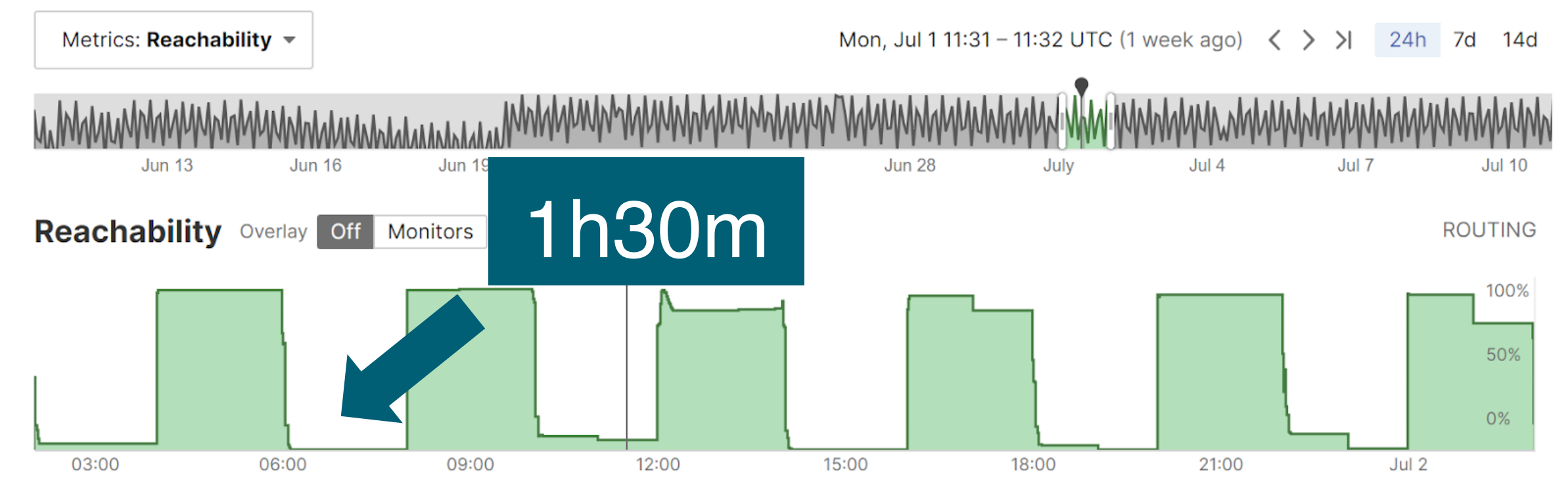

Is this a big problem?

Zombie Outbreaks

Fontugne et al, 2019

Start	End	IPv6 Outbreaks	IPv4 Outbreaks
2017-03-01	2017-04-28	591	1’732
2017-10-01	2018-12-28	1’202	384
2018-07-19	2018-08-31	686	520

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Is this a big problem?

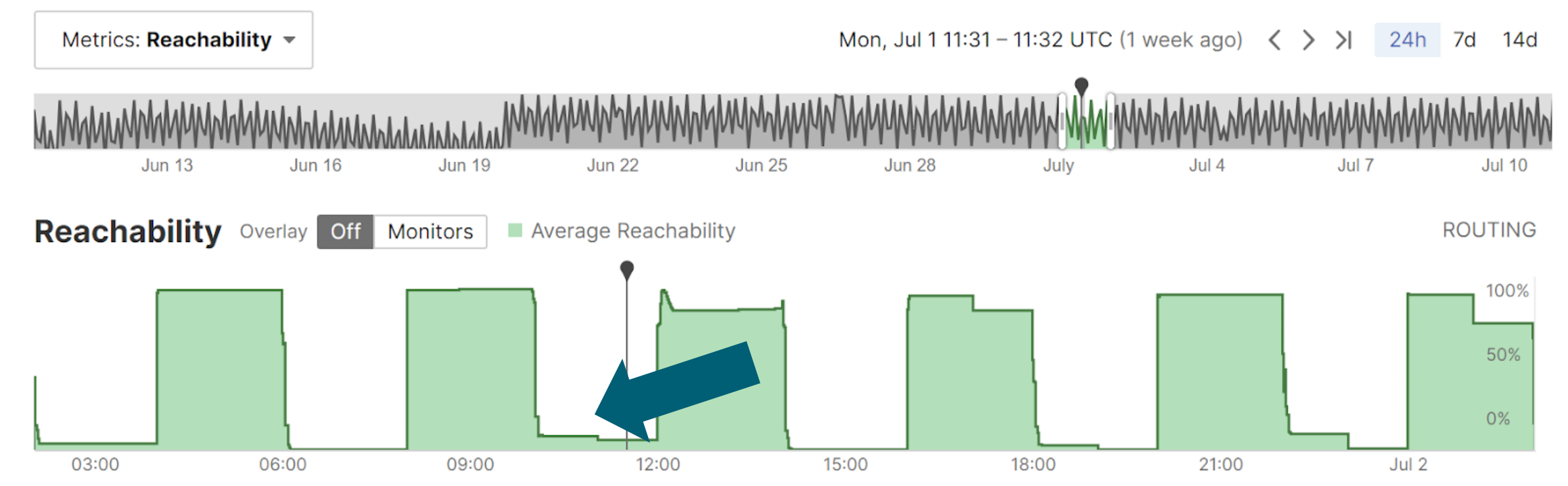
Zombie Outbreaks

Start	End	Study IPv6 Outbreaks	Study IPv4 Outbreaks	Our IPv6 Outbreaks	Our IPv4 Outbreaks
2017-03-01	2017-04-28	591	1’732	610	1’781
2017-10-01	2017-12-28	1’202	384	1’378	705
2018-07-19	2018-08-31	686	520	745	536

We are using RIB Dumps, UPDATEs, and STATE
The study used the LG and filtered the results with UPDATEs

Is this a big problem?

RIPE RIS Beacons



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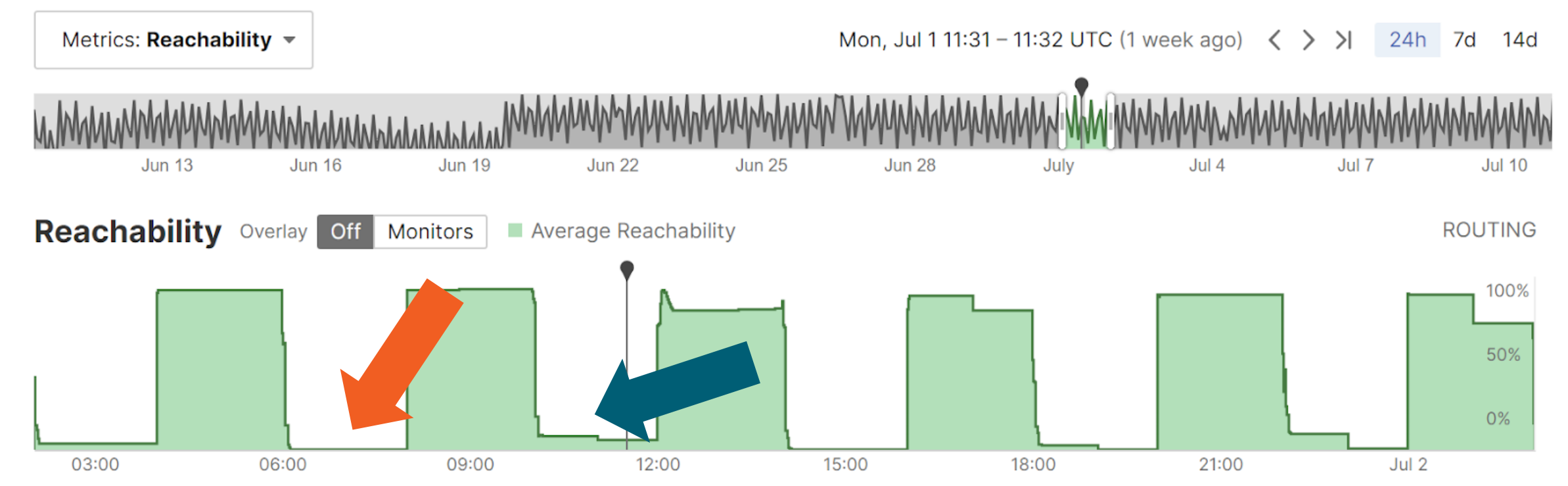

Is this a big problem?

Aggregator Address

10.XX.YY.ZZ

24-bit seconds since
beginning of month UTC

02/03/2025 15:00 EST (~Now)
10.[244’800] = 10.3.188.64

Is this a big problem?

Zombie Outbreaks

Start	End	Study IPv6 Outbreaks	Study IPv4 Outbreaks	Our IPv6 Outbreaks	Our IPv4 Outbreaks	IPv6 Outbreaks	IPv4 Outbreaks
2017-03-01	2017-04-28	591	1’732	610	1’781	610	1’319
2017-10-01	2017-12-28	1’202	384	1’378	705	1’370	478
2018-07-19	2018-08-31	686	520	745	536	514	226

Research Findings

- ~19% of RIPE RIS `<PeerAS,BeaconPfx>` pairs were not affected by BGP Zombies
- 50% of pairs have ~0.26% probability of falling for them
- On average, ~1.6% of IPv6 and ~0.5% of IPv4 probability for a pair to see Zombies
- Over 90-95% of the time, the Zombie path was NOT the best path

Can we improve our understanding?

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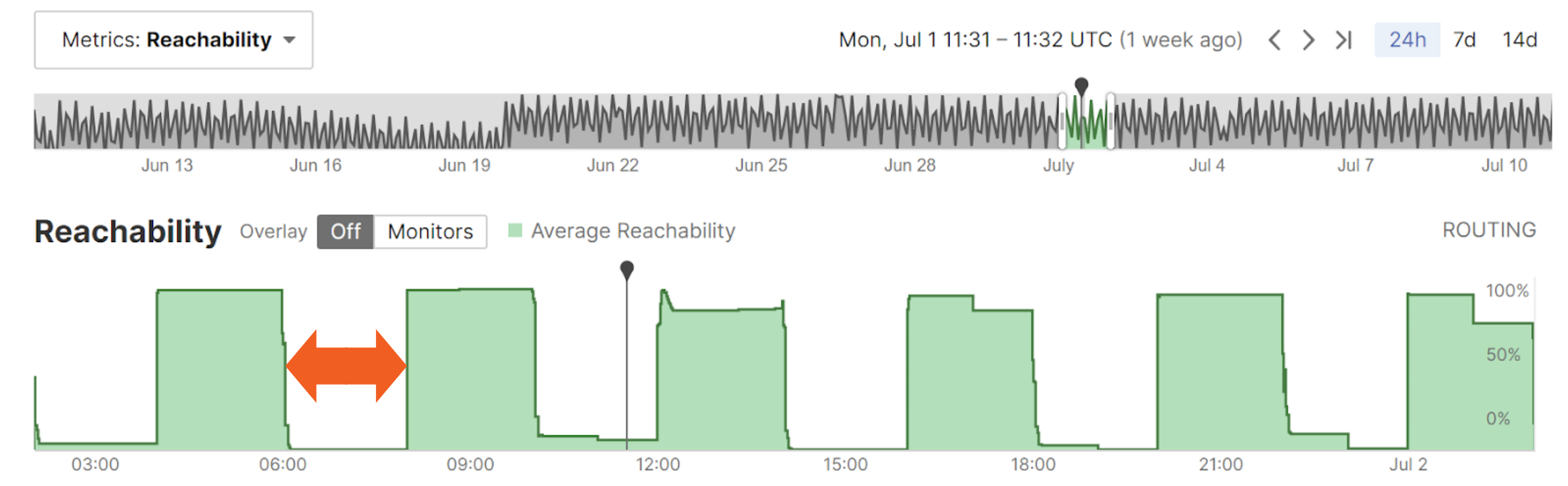
RIPE RIS Beacons



BGP Clock

Can we improve our understanding?

2a0d:3dc1:HHMM::/48

Every 15’

Can we improve our understanding?

2a0d:3dc1:(HH)(MM+dd%15)::/48

Every 15’

Can we improve our understanding?

RPKI ROA
2a0d:3dc1::/32-48 AS210312

BGP Clock

- Prefixes recycled every 24h / 15d, not every 4 hours
- Allows us to see beyond the 1h30m – 2h mark into the unknown
- Many more prefixes – 4 / Hour → More data to study
- Originated from AS210312 to over 1’700 direct adjacencies

- Or “Route Cycler” as per Ben Cartwright-Cox :)

Can we improve our understanding?

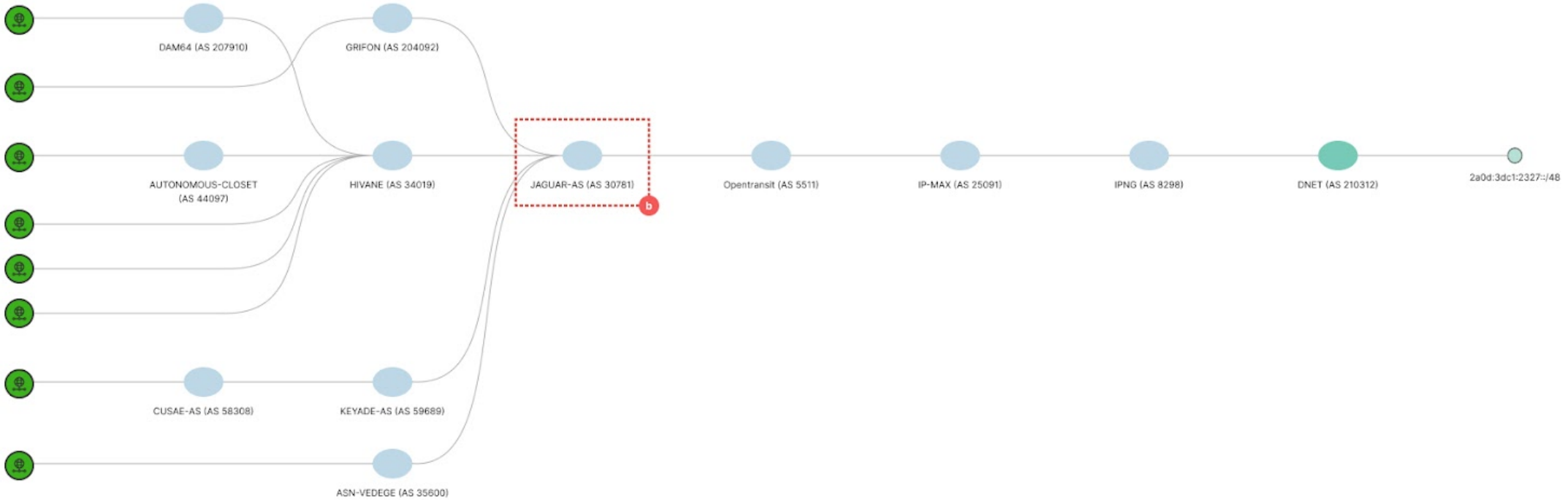
2a0d:3dc1:2327::/48

Findings

- Stuck in 8 RIPE RIS Peers (6 Unique ASNs)
- Common Subpath: 30781 5511 25091 8298 210312
- Stuck in Free Pro SAS in France (> 200 ASNs in Cone)
  - Probably all 200+ ASes in the Cone were “infected”, but only 6 had RIS Peers

Can we improve our understanding?

Visualization



Can we improve our understanding?

2a0d:3dc1:2233::/48

Findings

- Stuck in 24 RIPE RIS Peers (21 Unique ASNs)
- Common Subpath: 33891 25091 8298 210312
- Stuck in Core Backbone GmbH in Germany (> 2’000 ASNs in Cone)
  - Probably all ASes in the Cone were “infected”, but only 21 had RIS Peers

Can we improve our understanding?

2a0d:3dc1:1737::/48

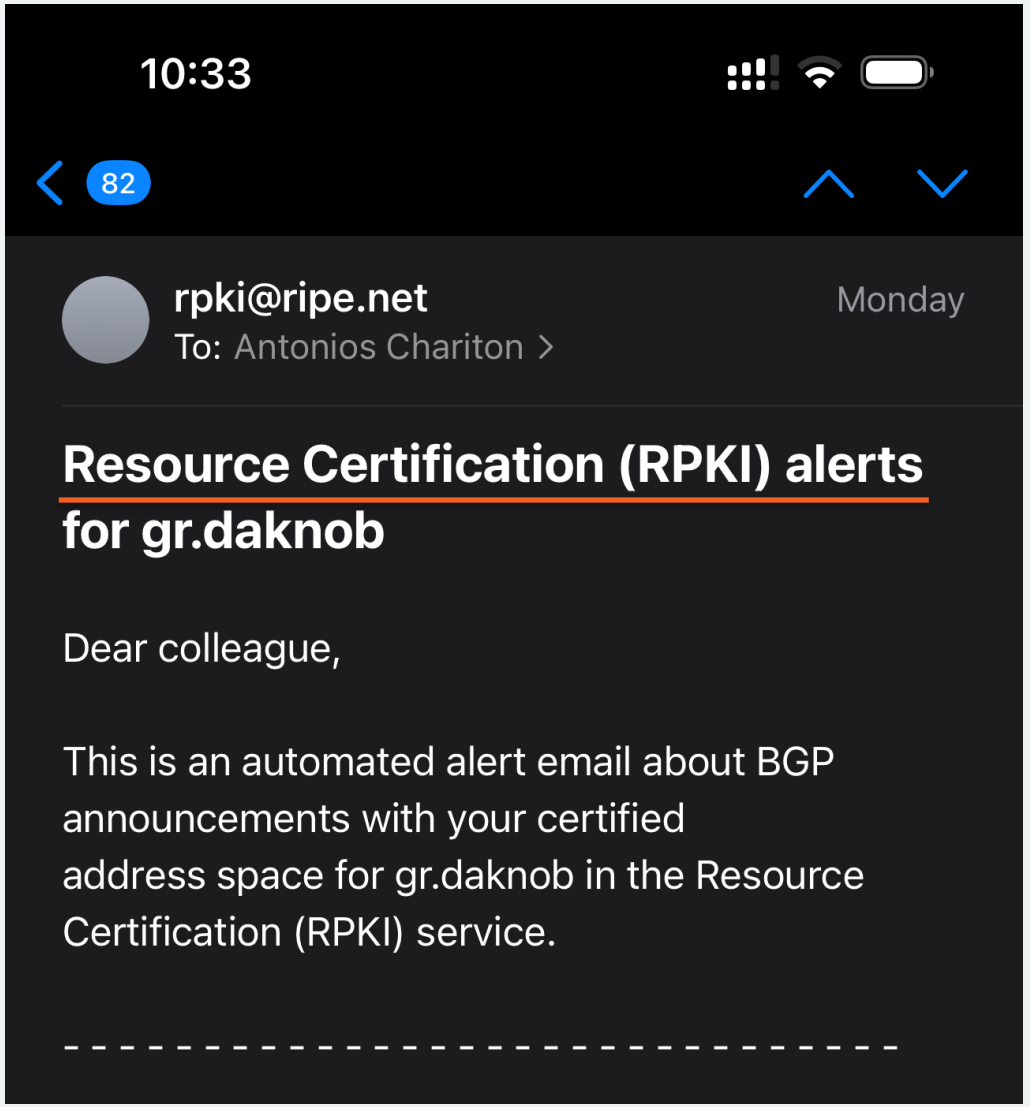
Findings

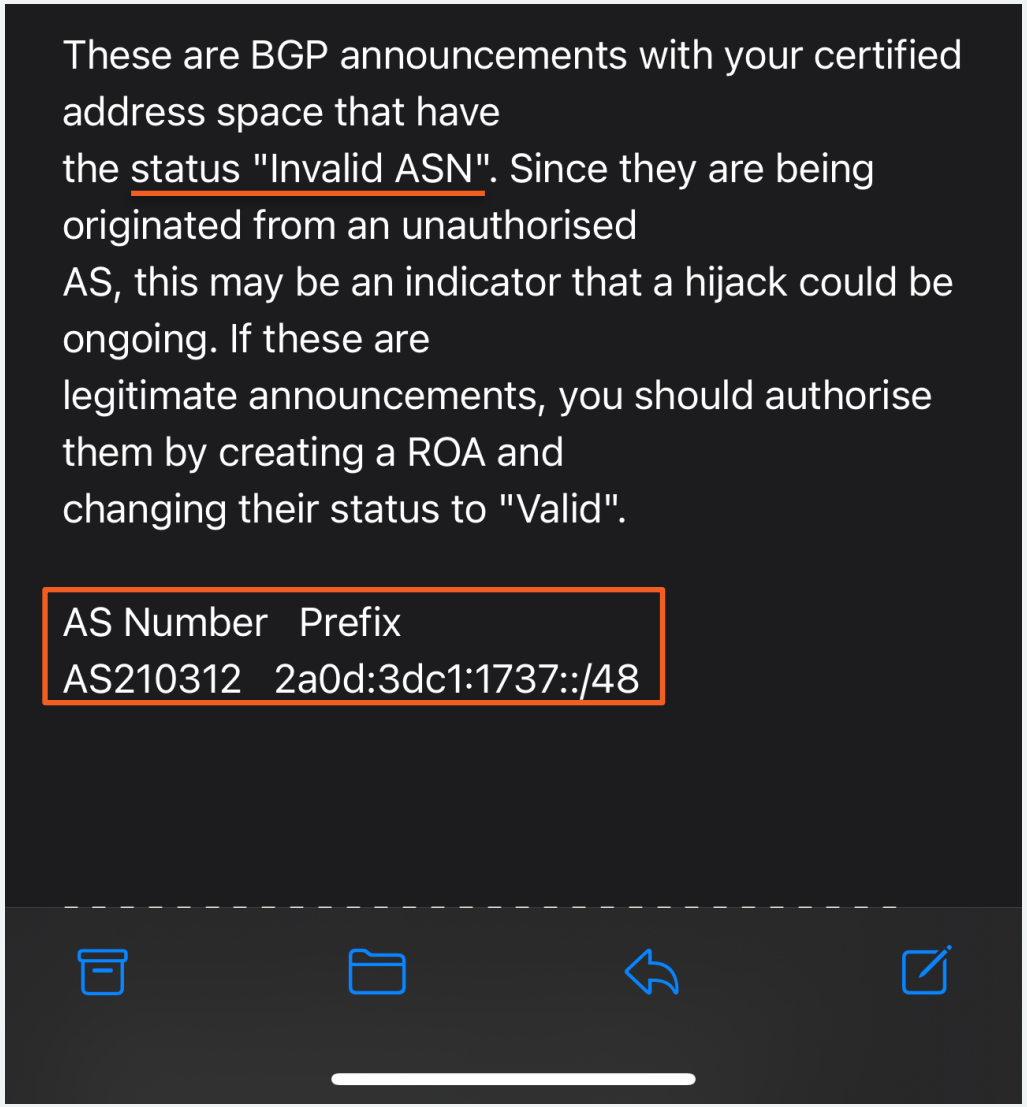
- Stuck in 7 RIPE RIS Peers
- Common Subpath:
  24961 210312
- Stuck in WIIT AG / myLoc in Germany (> 200 ASNs in Cone)
  - Probably all 200+ ASes in the Cone were “infected”, but only 7 had RIS Peers

Can we improve our understanding?

RPKI ROA
2a0d:3dc1::/32-48 AS210312

Can we improve our understanding?





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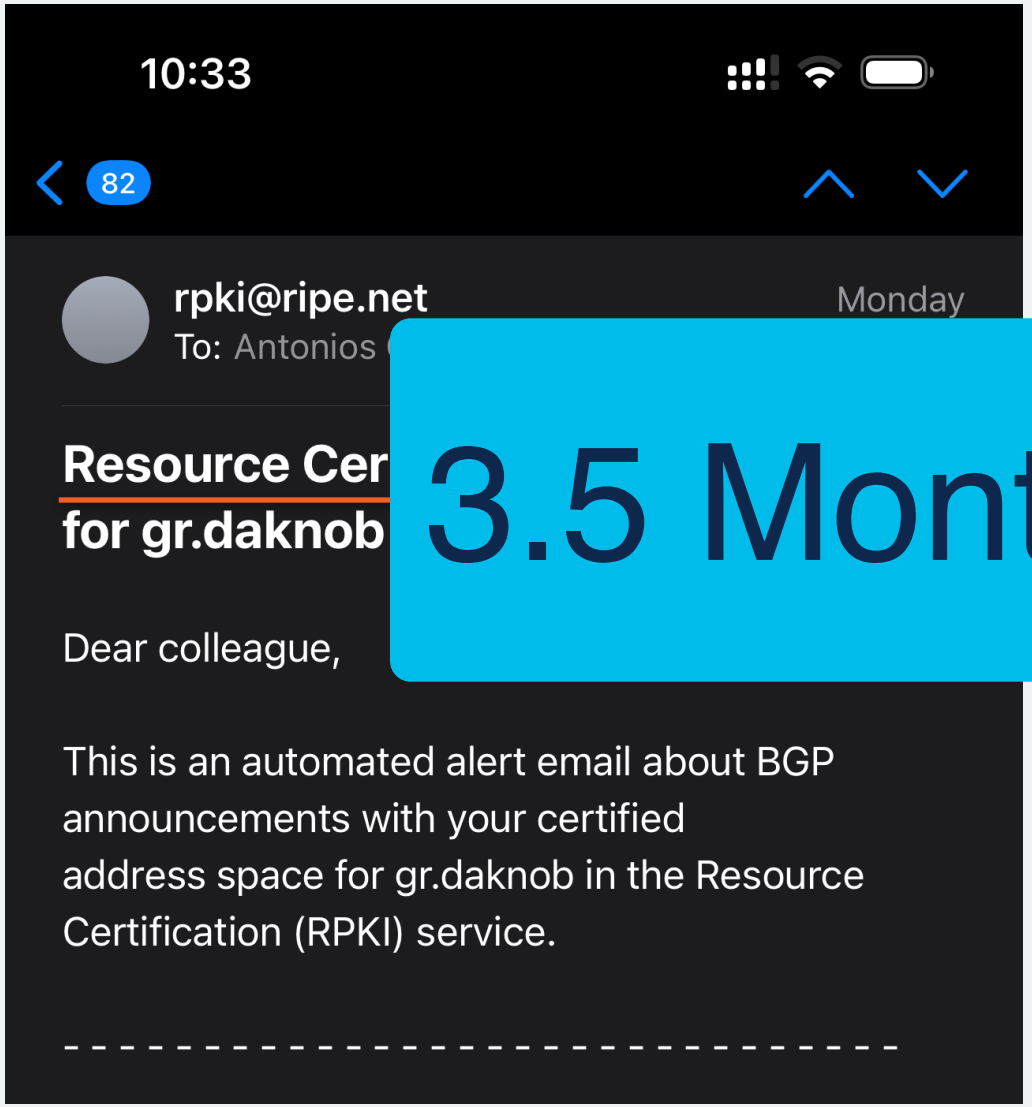

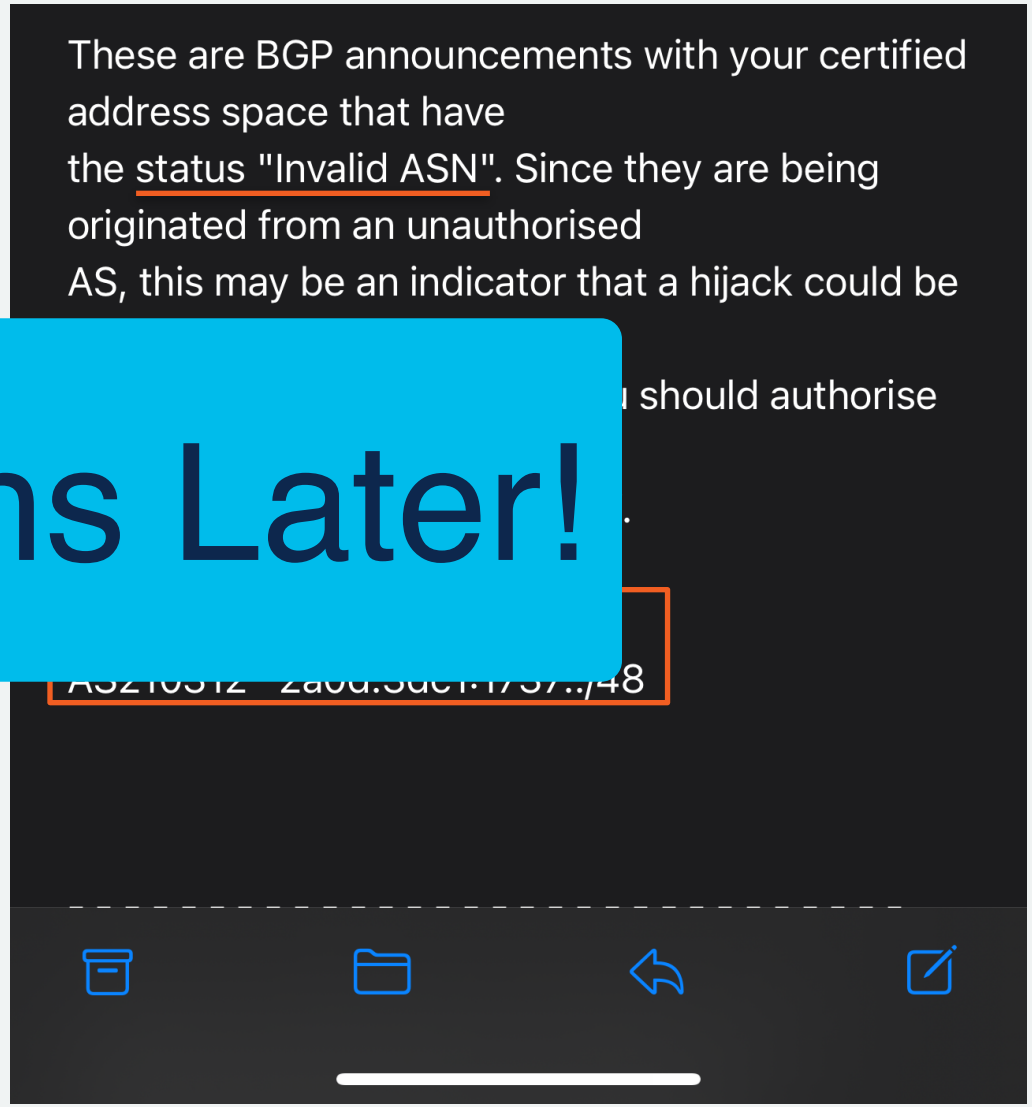

3.5 Months Later!

Can we improve our understanding?

Routes still stuck…

Over 7 months later, we can see:

- 1 in RIPE RIS
  - Disappeared after 3.5 months
  - Reappeared ~2 months later
- ~~3~~ 1 in bgp.tools
  - 2 life of at least 3-4 months!
- 4 1 in bgp.he.net
  - Half life of 3 months!
- RPKI Invalid for > 6-7 months ¯_(ツ)_/¯

What did we learn?

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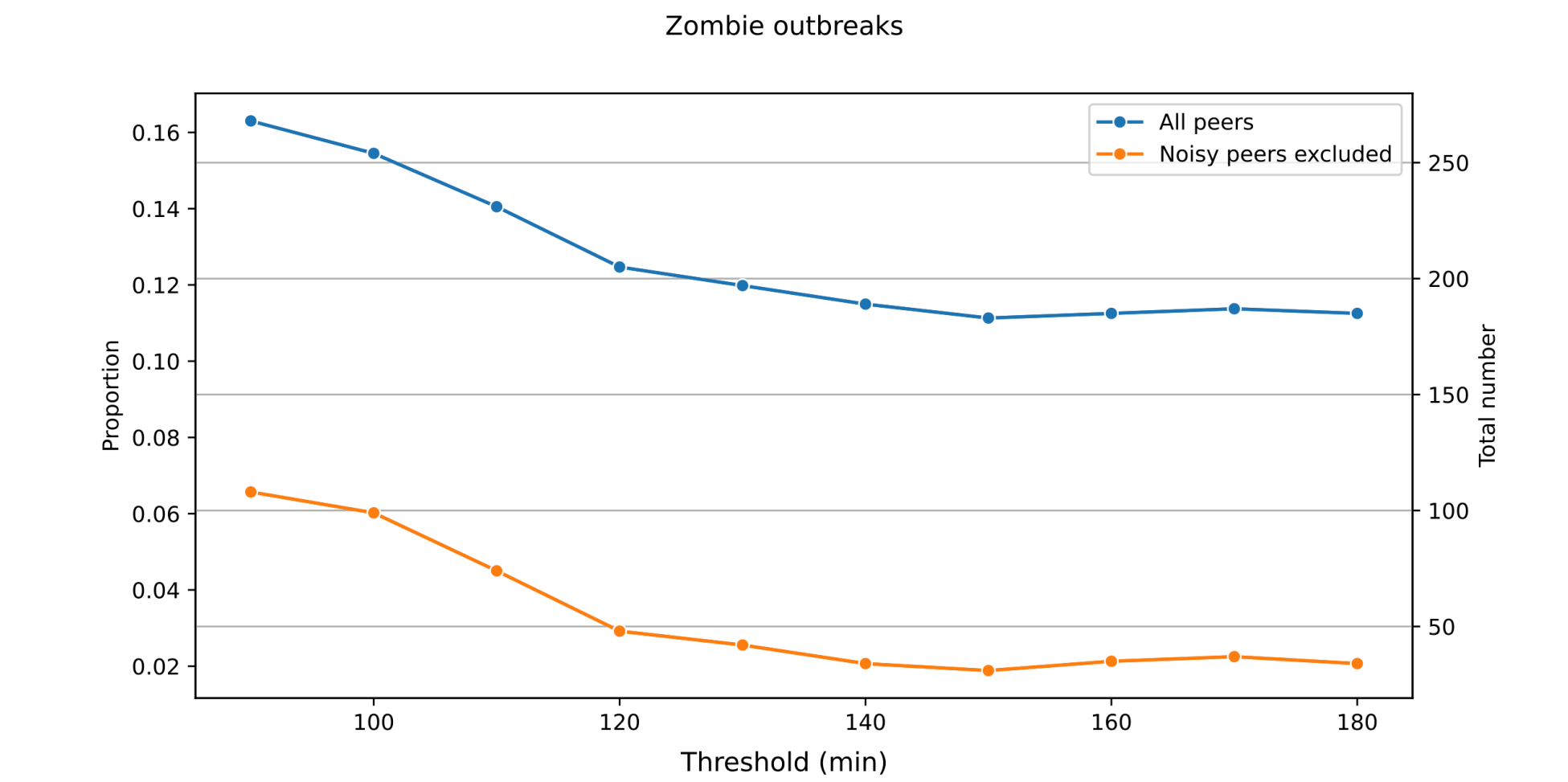
Thresholds Matter



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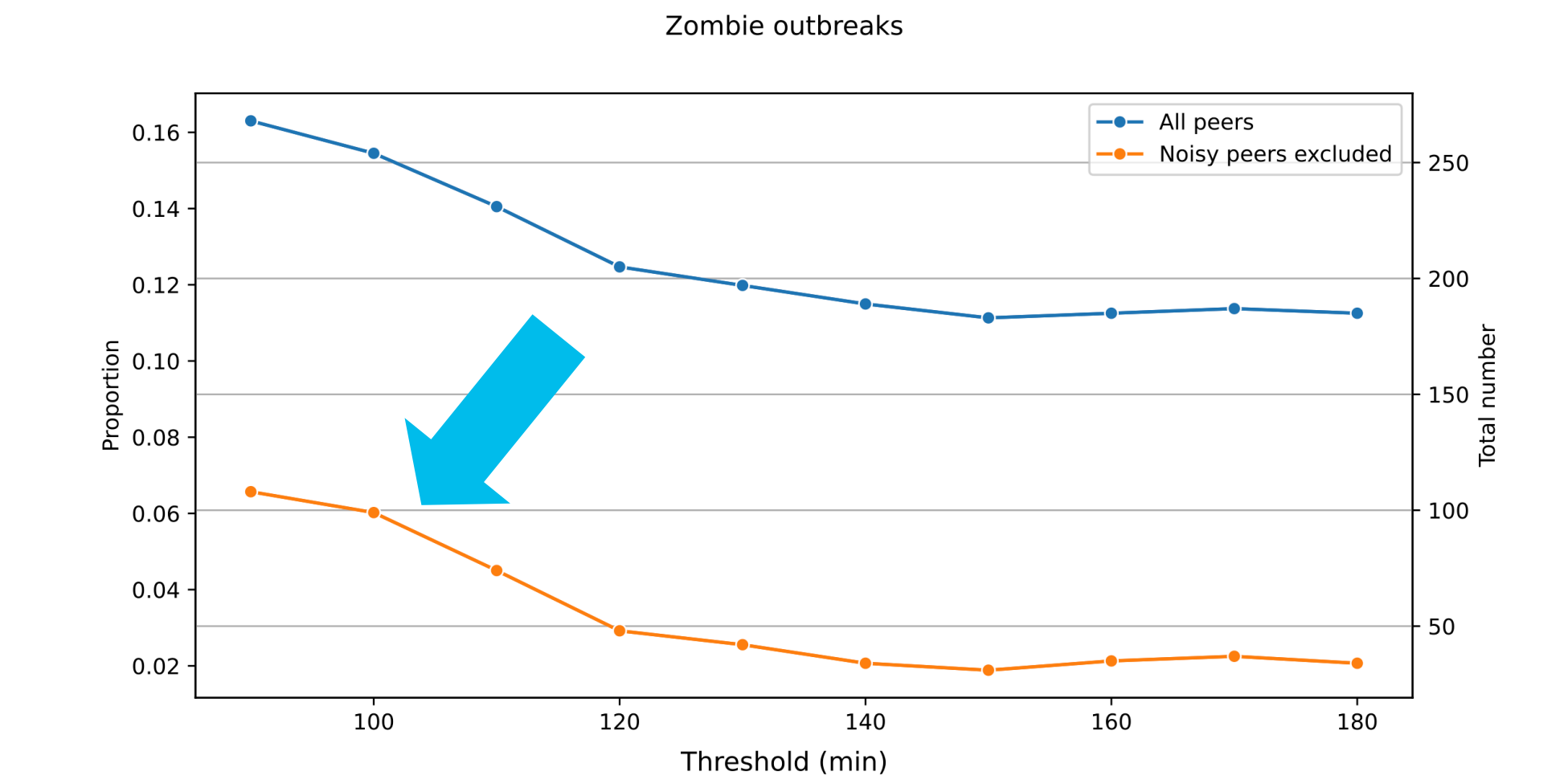
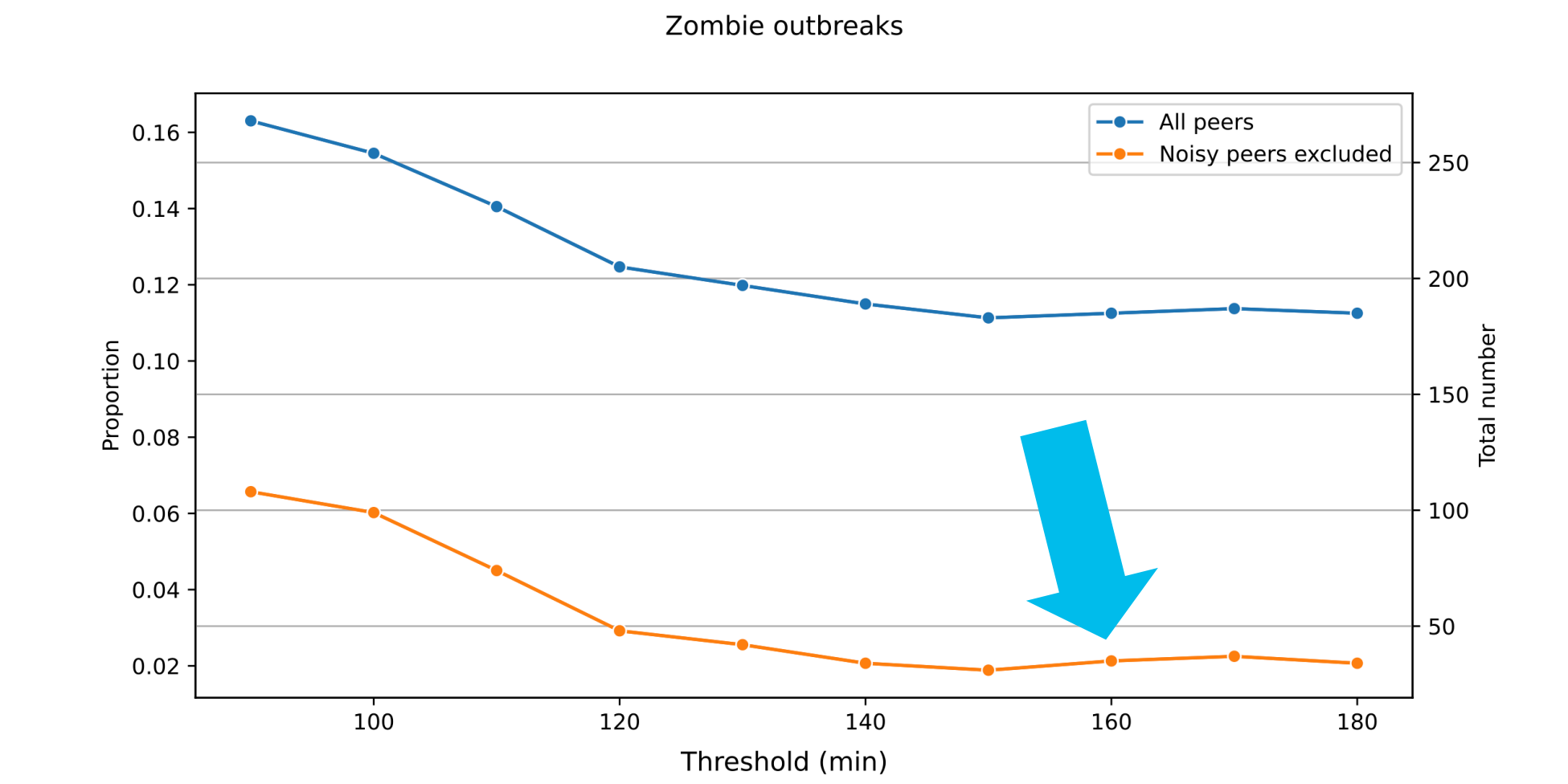


Noisy Peers

Peer IP	ASN	1h30m Threshold	3h Threshold
176.119.234.201	211509 Rudakov Ihor	9.91%	9.06%
2001:678:3f4:5::1	211509 Rudakov Ihor	9.91%	9.06%
2a0c:9a40:1031::504	211380 Simulhost Limited	7%	6.88%

What did we learn?

Thresholds Matter



Stuck routes up over time?

What happened

- We observed zombies increasing at ~160’
- Prefixes that withdrew 10’ earlier, are coming back
- There’s a new Announcement!
- Common subpath:
  4637 1299 25091 8298 210312
- Telstra Global, with > 5’000 ASNs in Cone
- Session reset? Filter update?
- Reinfections can happen!

Can we do something?

Can we do something?

Yes!

RFC9687

- Adds a SendHoldTimer in addition to the HoldTimer
- Tears down sessions if messages can’t be sent (not just received)
- Addresses XX% of stuck route causes
- **Ask for support from your vendor!**
- Has to be added, included in stable releases, operators have to upgrade, ???, profit!

Can we do something?

Yes! A lot!

Stuck Route Observatory

- Interest from Tier 1s and many RIPE members
- BGP clock to become a **long-term** service!
- Open Research Data - Improve understanding
- IPv4 space is needed (n x/16 total, less is fine too)
  - Reach out if you have unused space
  - No long-term commitment, returnable in < 24 h
  - No traffic, purely BGP-based
  - Non-continuous / fragmented is fine
  - Only takes a route object and a ROA (< 5’ work)

Thank you!

Questions? Comments?

Learn more