Measuring RPKI adoption and impact

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About Me

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Research Area: Internet Security and Policy, Internet Measurements

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Motivation: Internet for Society

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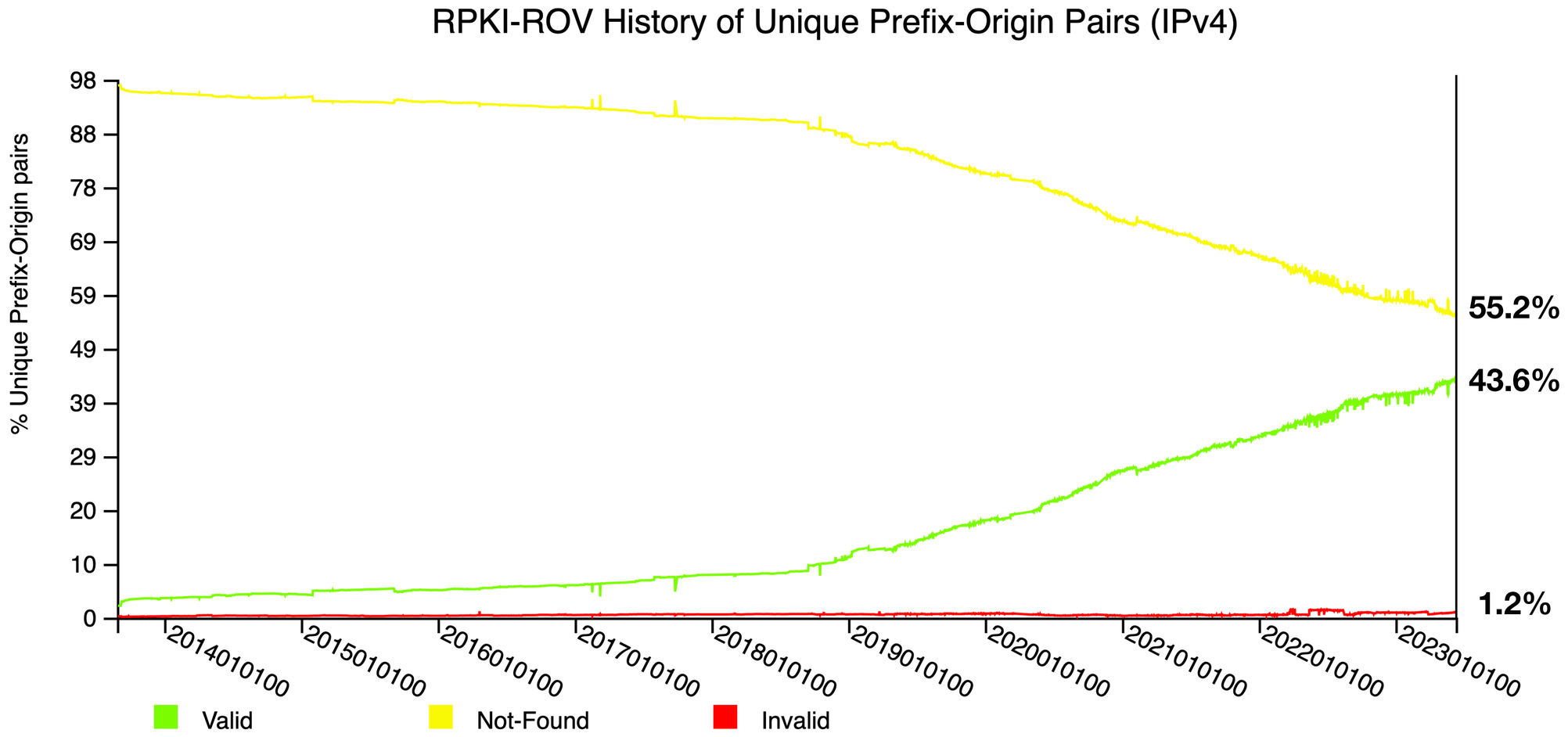
Research questions

- How is RPKI adoption evolving over time?
  - Coverage of routed prefixes by ROAs
  - Deployment of ROV
- What is the impact of RPKI adoption?
  - Spread of RPKI-invalid BGP updates
  - BGP hijacking

Coverage of Routed Prefixes

BGP prefixes covered by ROA over time from NIST



NIST RPKI Monitor: RPKI-ROV Analysis **Protocol:** IPv4 **RIR:** All

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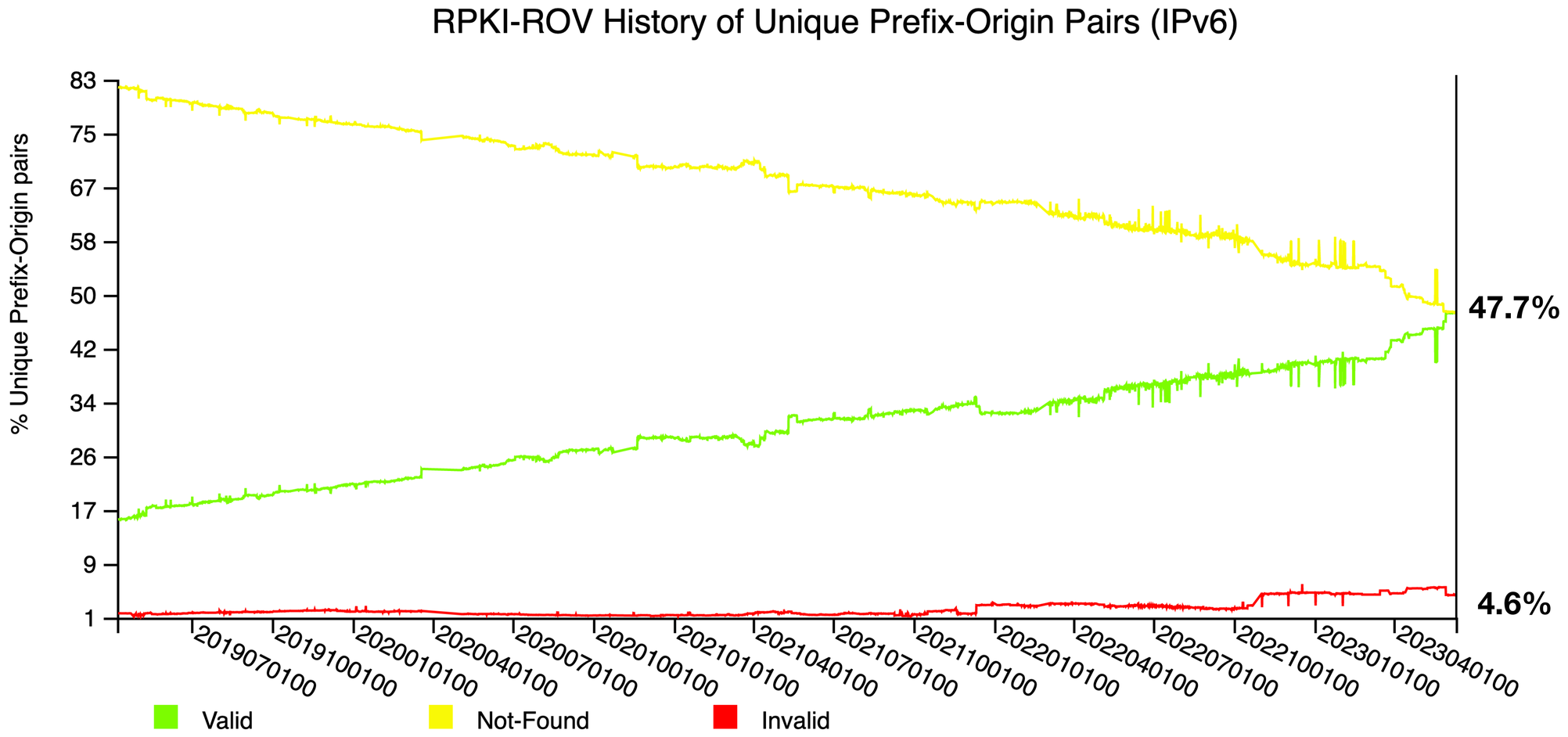
BGP prefixes covered by ROA over time from NIST



NIST RPKI Monitor: RPKI-ROV Analysis **Protocol:** IPv6 **RIR:** All

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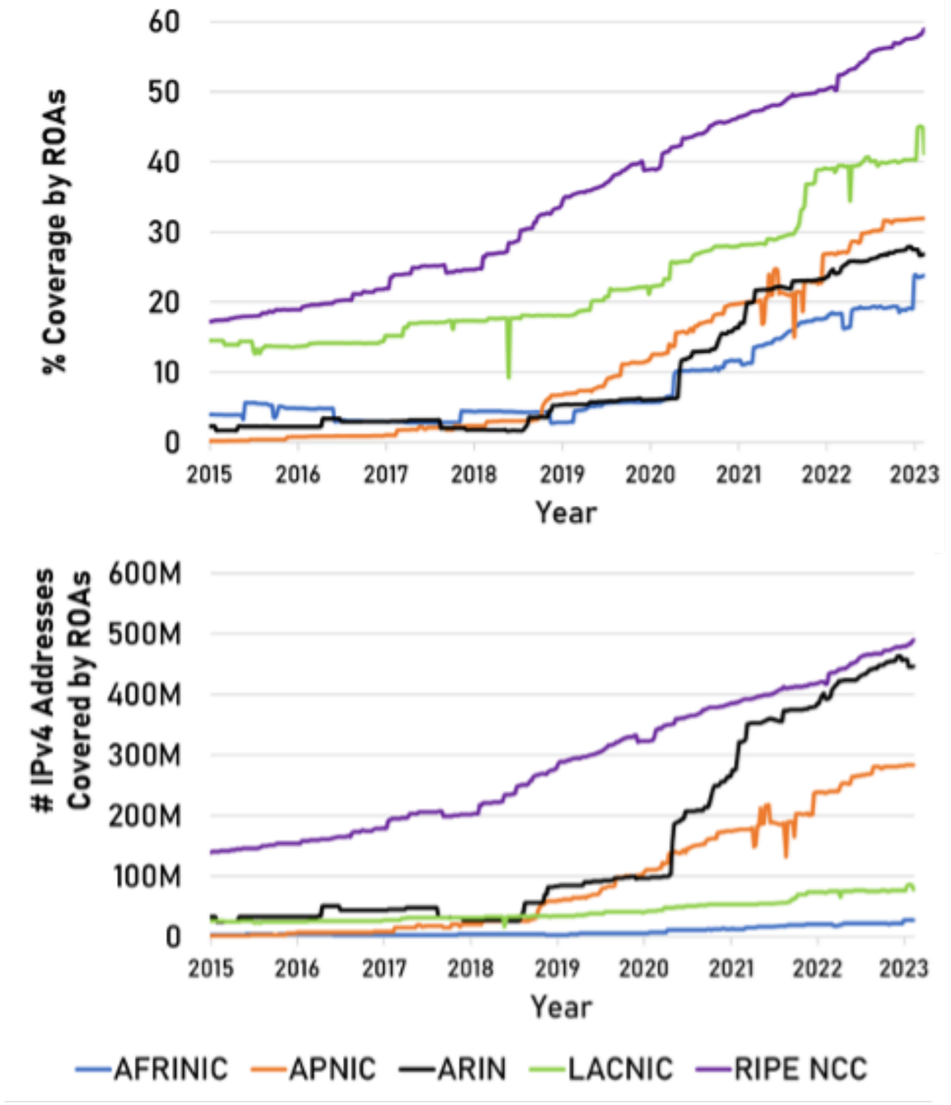
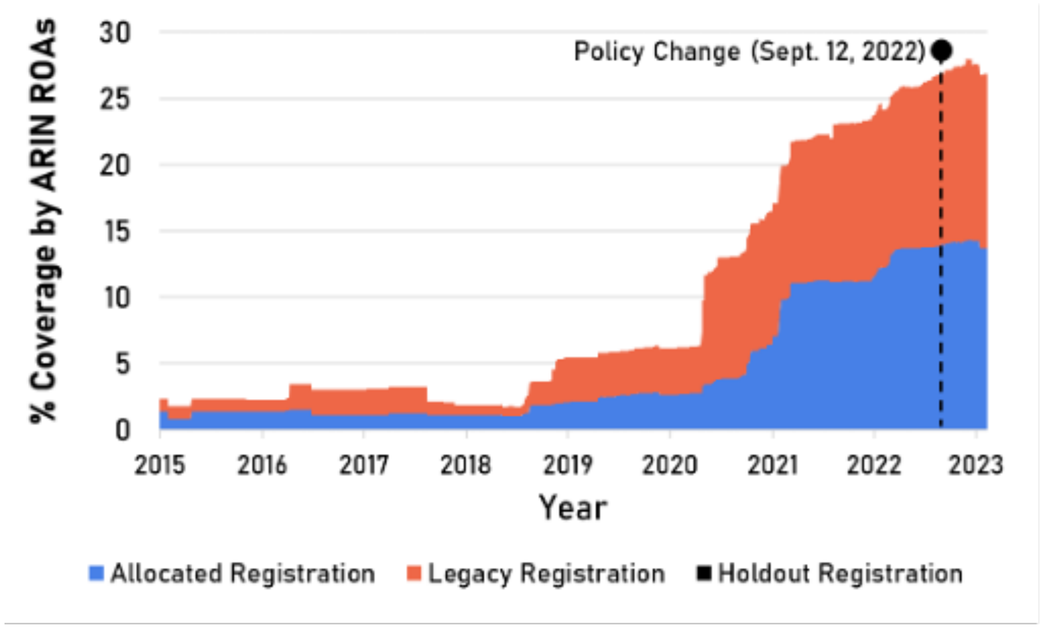
ARIN singularity

- ARIN required legal agreements to:
  - issue ROAs,
  - access ROAs (RPKI TAL),
  - publish ROAs in machine readable way.
- Legacy addresses treated differently.
- Requirements changed in Sept 2022.



Based on work by Noah Craft (MSc Student)

Legacy IP addresses



Organization	/8 legacy holdout count	Other Prefixes covered by ROAs
Apple	1	No
AT&T	1	Yes
Cogent	1	Yes
DISA	12	No
Ford	1	No

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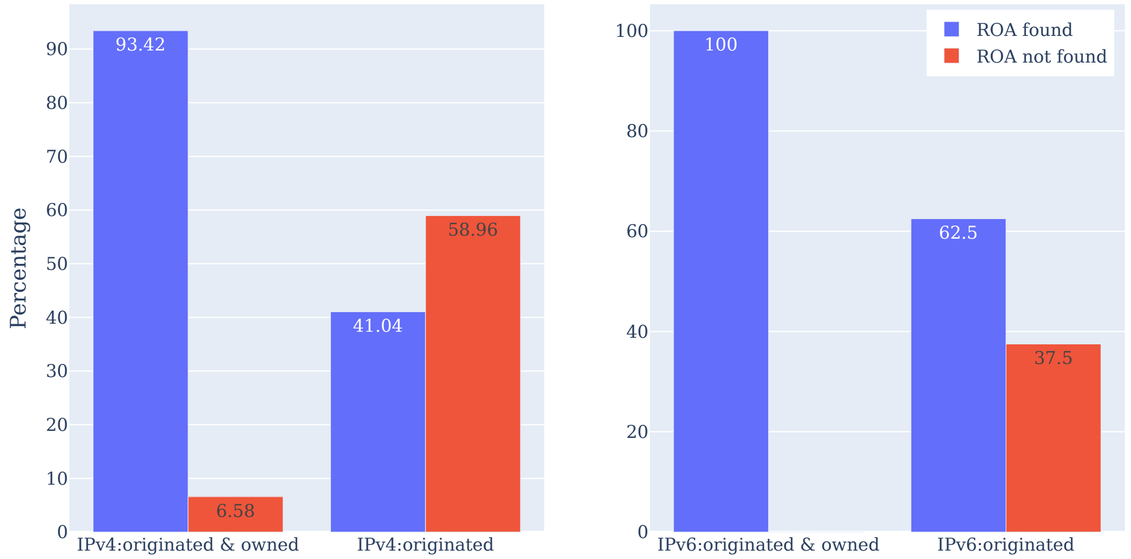
Based on work by Noah Craft (MSc Student)

ROA coverage by organization vs. by ASN

Case study of IIJ ROA Coverage

- Originated prefixes ~ 41%
- Originates & Owned ~ 93%



Based on work by Deepak Gouda (MSc Student)

ROA coverage by organization vs. by ASN

Org by prefix origination	% Prefixes	# Orgs	ROA Coverage (%)	
No AS	13.53	29765	47.23	← Should be easy but org. challenges
Originates only by own AS	10.12	23737	35.28	← Should be easy but org. challenges (?)
Originates by self & others	10.61	8906	33.65	← Afraid of mess
Originates self & others	12.38	10641	50.58	← Less afraid of mess
Originates self & others by self & others	53.36	5594	42.98	← Messy but large orgs

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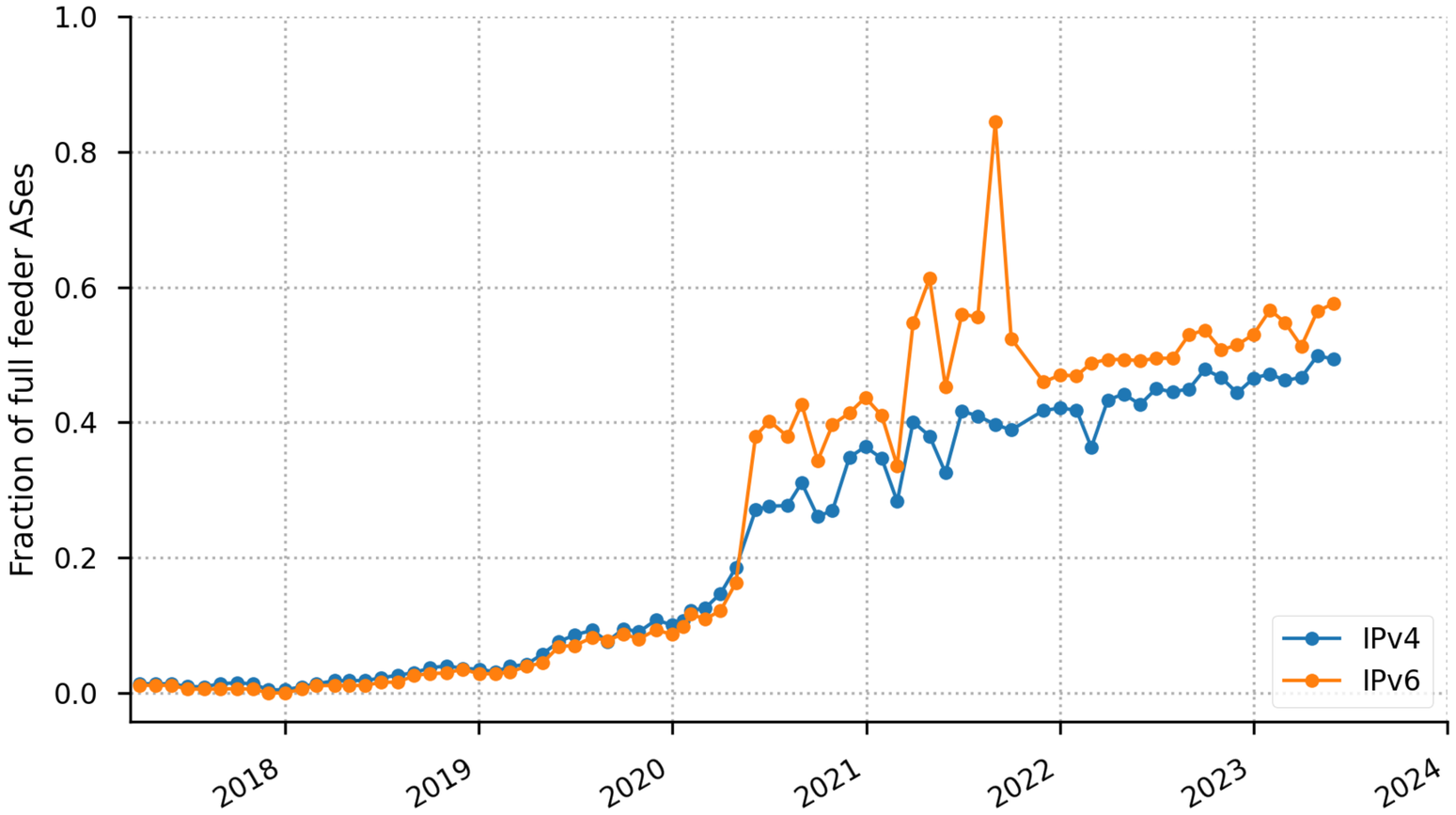
Based on work by Deepak Gouda (MSc Student)

ROV Deployment

ROV deployment in ASes peering with BGP collectors

- BGP collectors peers in 2023:
  - IPv4: 315-320 ASNs
  - IPv6: 280-290 ASNs
- ROV ASNs 06/2023
  - IPv4: 155
  - IPv6: 163
- Unique ROV ASNs: 303



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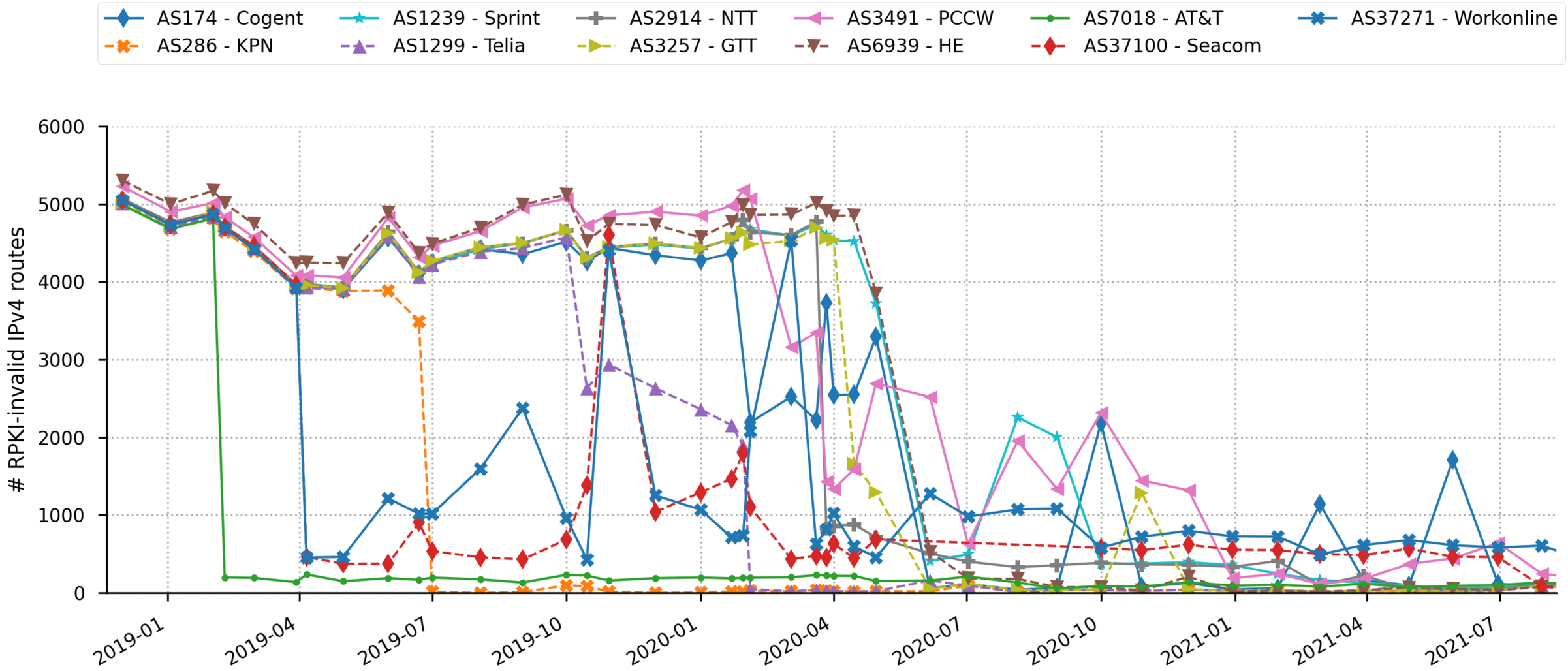
RPKI-invalid prefix count over time 2019-2021



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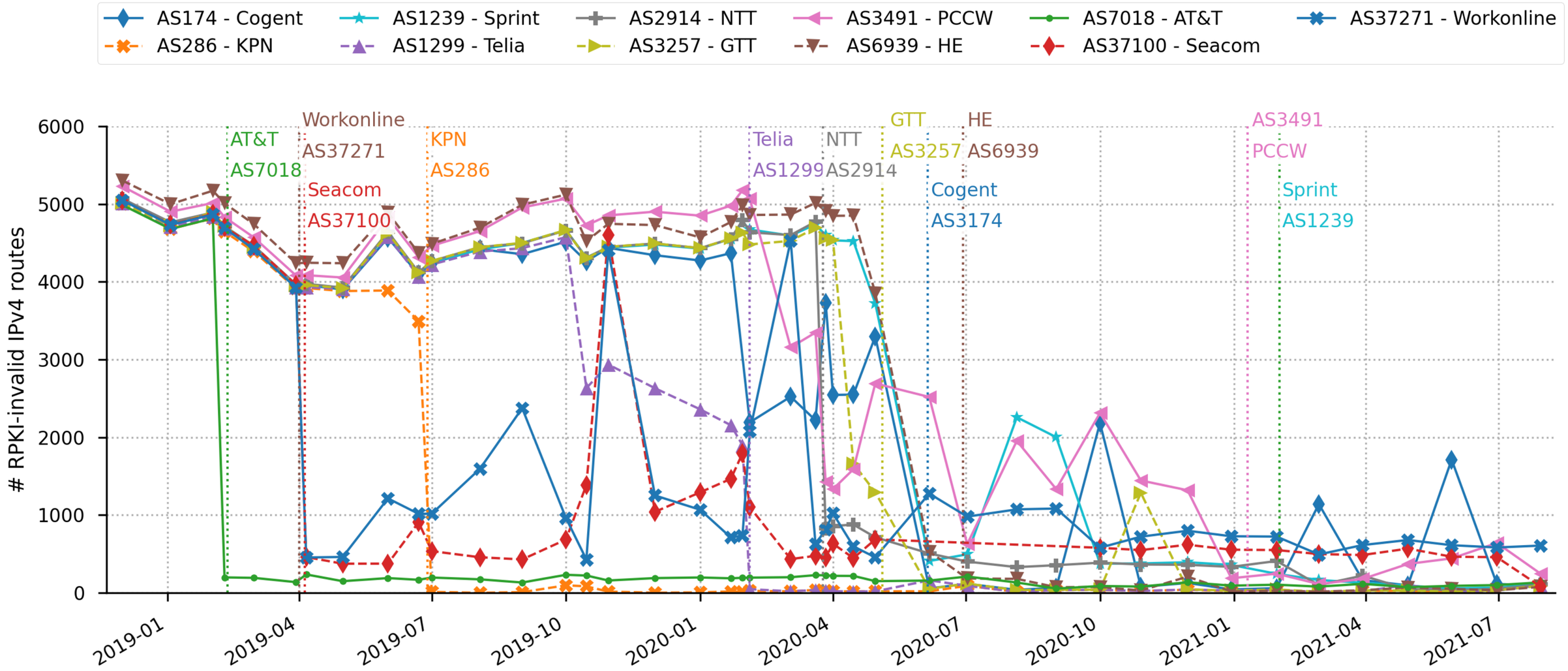

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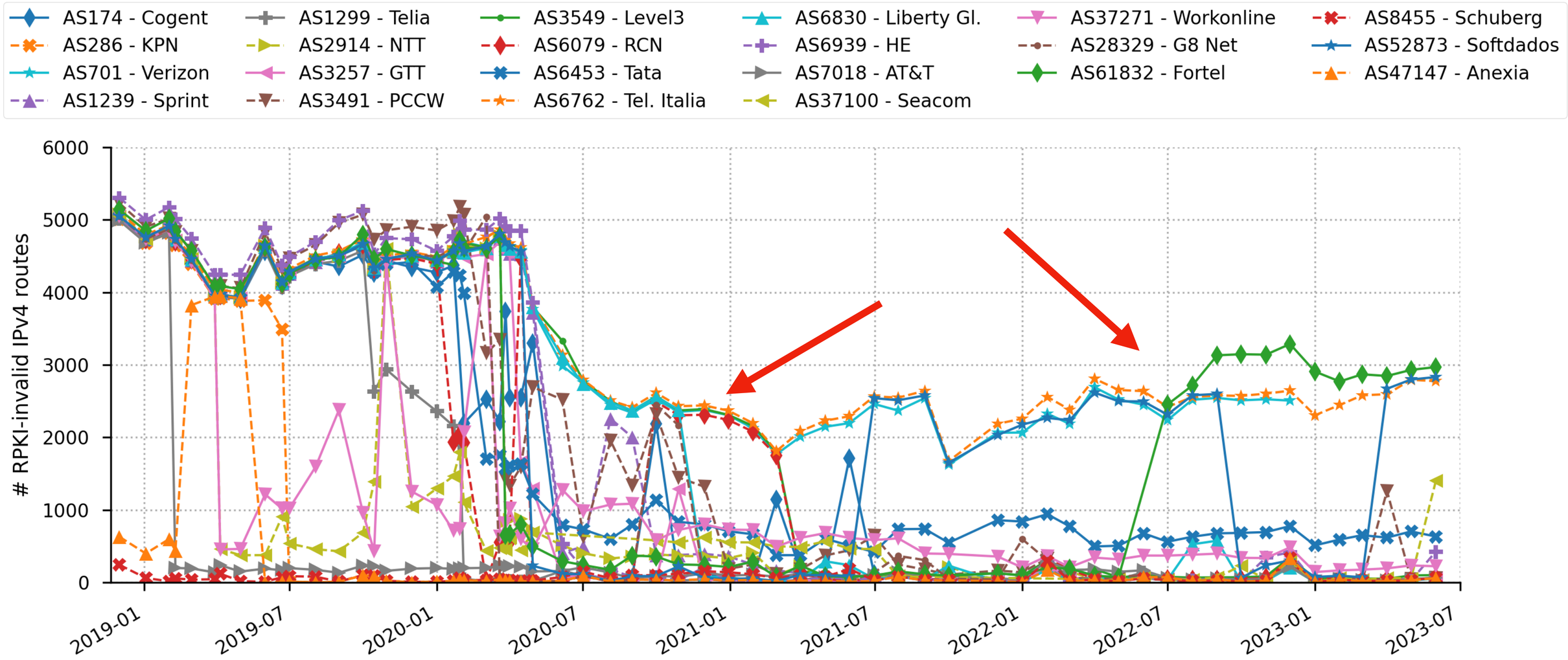
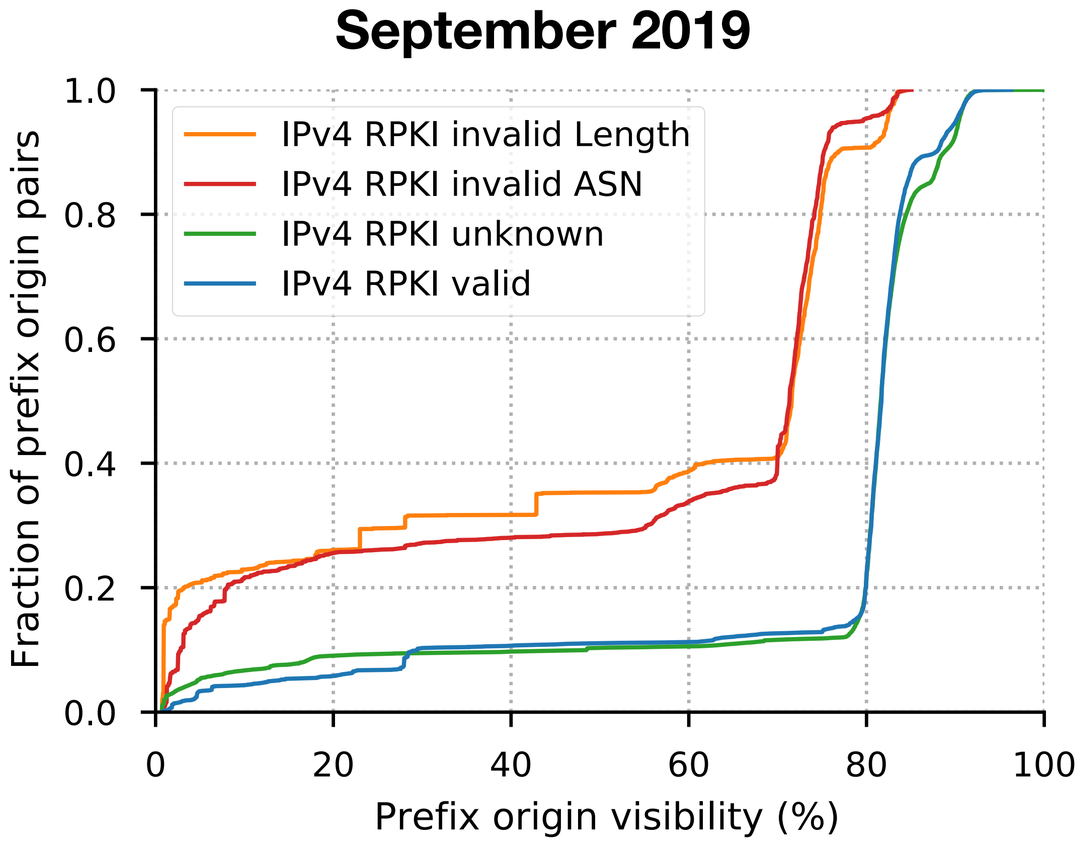
RPKI-invalid prefix count over time 2019-2023



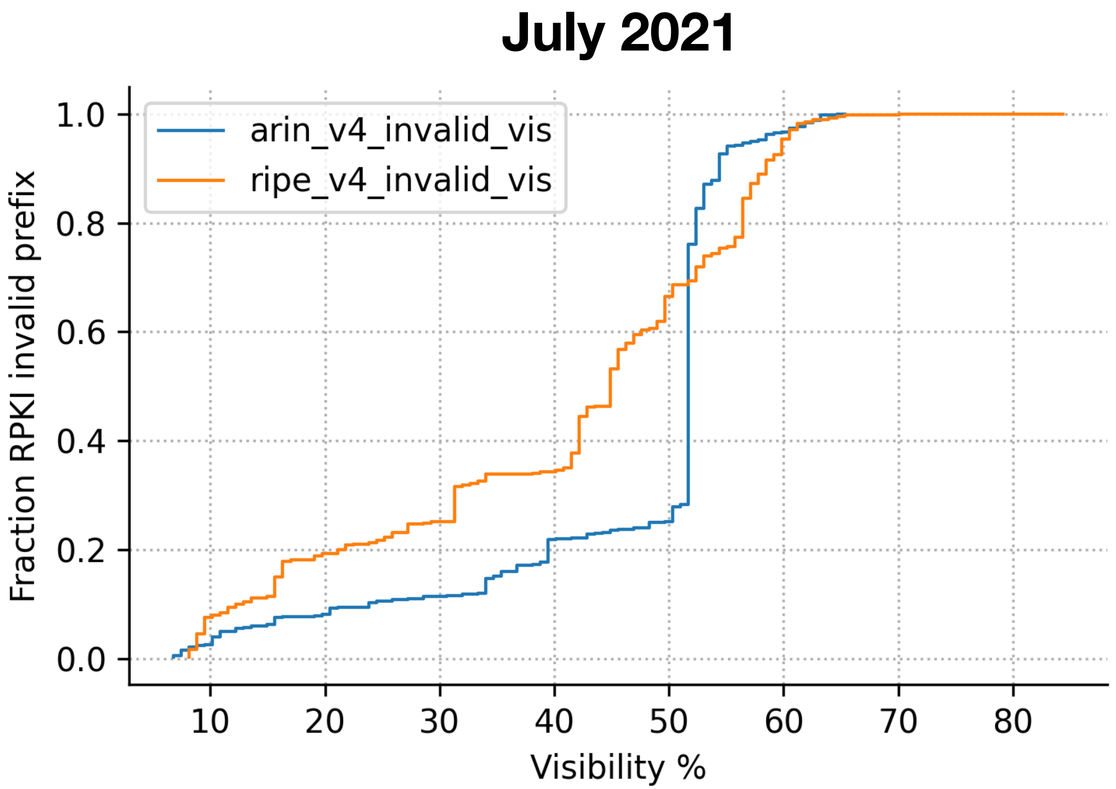
ROV Impact - RPKI Invalid visibility

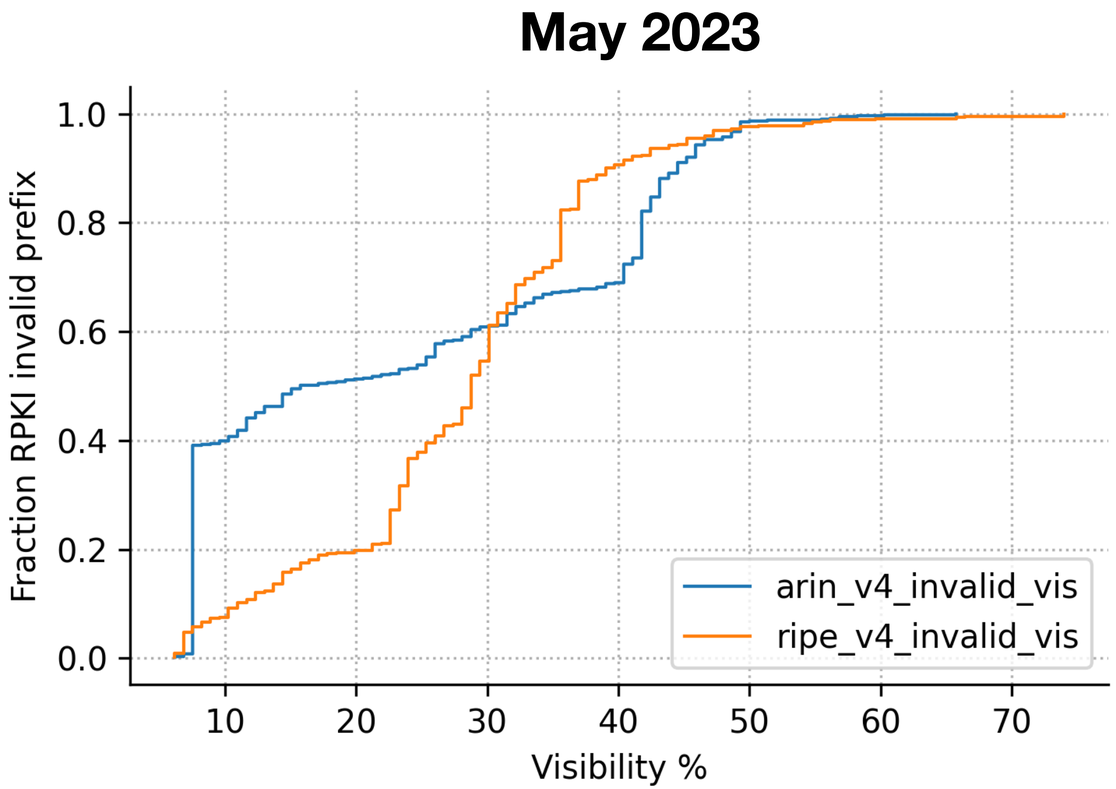
ROV impact in prefix visibility

- ROAs impact prefix visibility.
- Most prefixes are either high visibility or low visibility
- Natural experiment option: each RIR defines its own RPKI-related policies.



ROV impact in RPKI invalid prefix visibility ARIN & RIPE





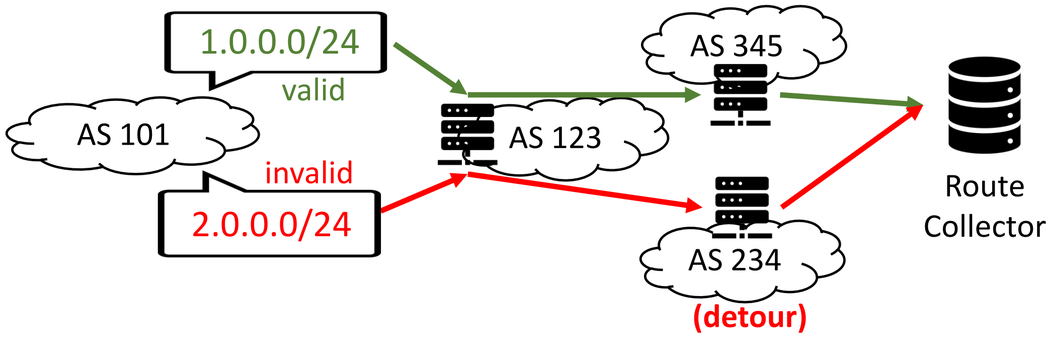
- Arin still has more high-visibility RPKI-invalid prefixes

ARIN RPA

Validator	Auto download ARIN repo	Date of ARIN Update
FORT Validator	No, requires agreement	N/A
Routinator	Yes	11/10/22
RPKI Prover	Yes	11/22/22
Octo RPKI	Yes	4/5/23
RPSTIR2	Yes	3/4/21

ROV Impact - RPKI Invalid detour

Detour of RPKI invalid BGP announcements



- 160 detour ASNs
- Limitations: ROV depends on AS relationships (Hegemony score may help)

Transit ASN	Company	# AS	# Invalid Pfx
AS 6762	Telecom Italia	301	1,125
AS 6461	Zayo	59	147
AS 7473	Singapore Telecom	54	135
AS 6453	TATA America	38	78
AS 1273	Vodafone	13	18

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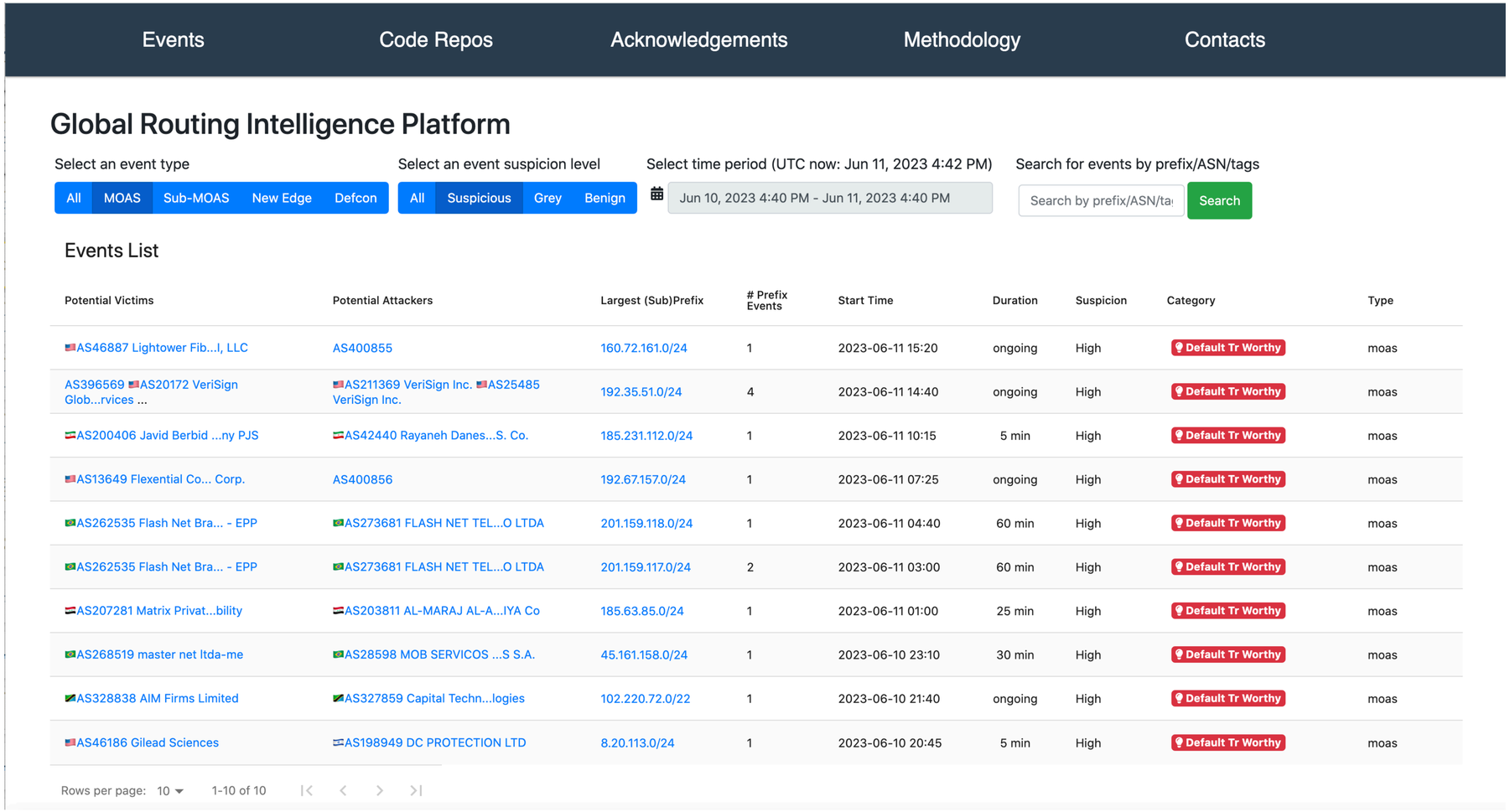
Based on work by Ben Du (PhD candidate UCSD)

BGP Hijacks

Global Routing Internet Platform (GRIP)

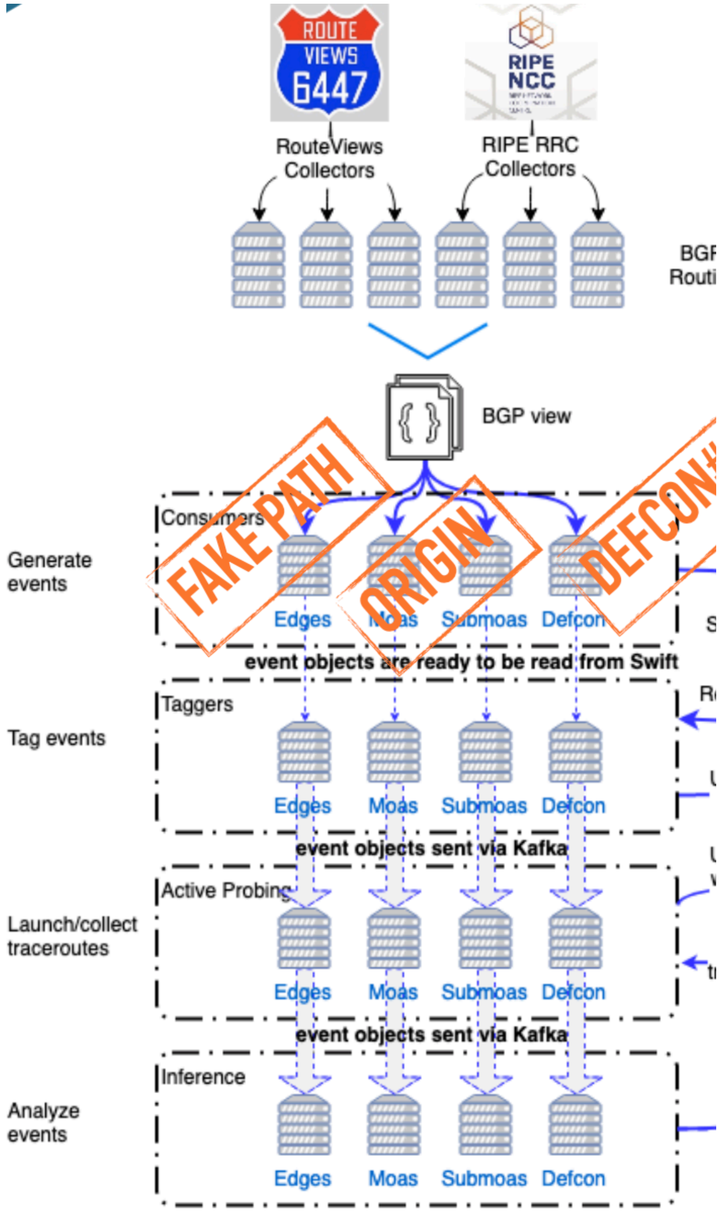
- All types of hijacks:
  - Origin
  - Fake path
  - Not preferred path (Defcon #16)
- In use by MANRS Observatory



Collaboration with Alberto Dainotti et al.

GRIP Infrastructure

- Gathers all potential events
- Tags based on routing behavior and additional data (RPKI, IRR, AS type, etc)
- Inference engine to weed out false positive cases
- Allows to gather feedback



Thanks