# BGP Route Security Cycling to the Future!

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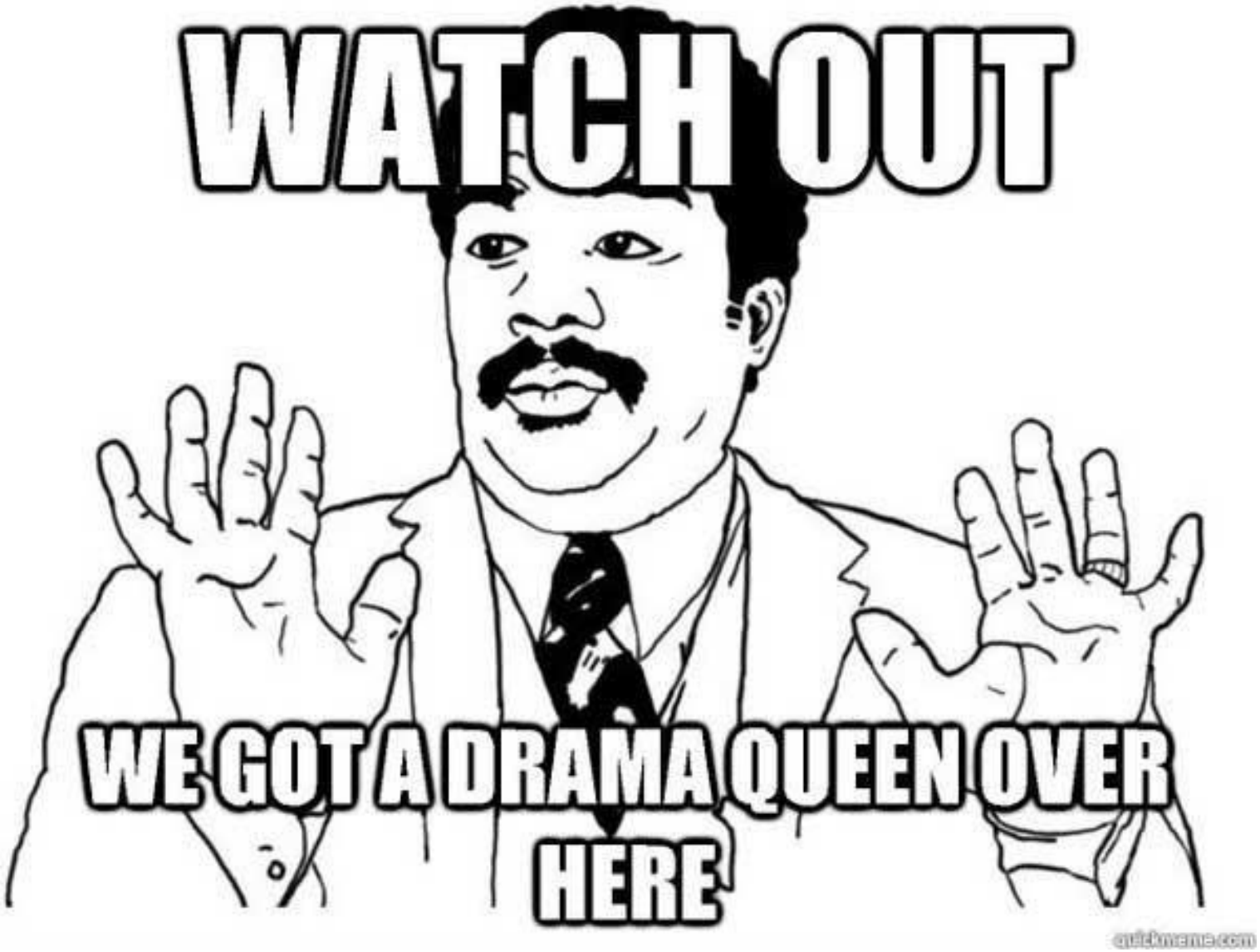
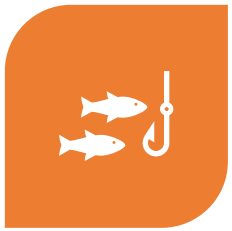

WATCH OUT
WE GOT A DRAMA QUEEN OVER HERE
quickmeme.com

# Malicious Hijacks/Leaks



FISHING SITES

HIJACK OF HTTPS CERTIFICATES

SPAM/BOTNET ACTIVITY

DOS ATTACKS

# BGP Hijack Factory Shutdown

- 25 June – first report on NANOG mailing list;
- 30 June – disconnect from HE;
- 07 July – disconnect from IXes;
- 15 July – disconnect from Cogent;
- 23 July – disconnect from GTT;

**Win!!!**

# BGP Hijack Factory Shutdown

- 25 June – first report on NANOG mailing list;
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- 23 July – disconnect from GTT;

**Win!!!** **But does it scale?**

We are always inventing new bicycles!

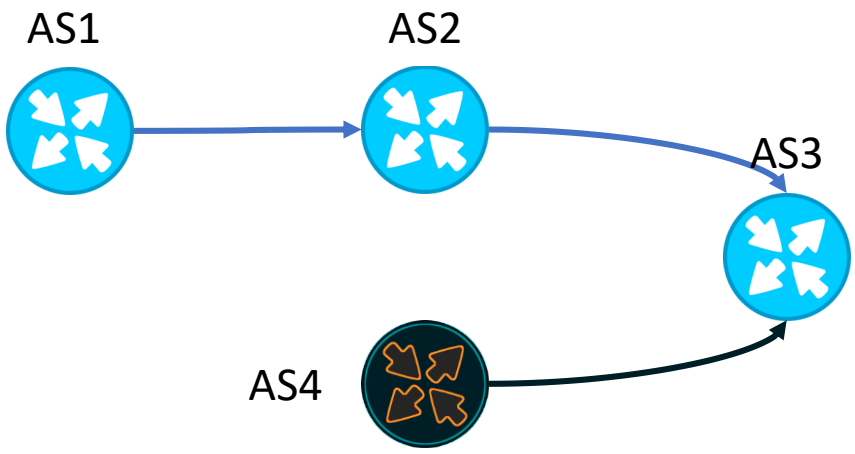
# IRR Filters

bgpq3 -S ripe as-qrator | head

no ip prefix-list NN
ip prefix-list NN permit 2.60.0.0/14
ip prefix-list NN permit 2.60.0.0/16
ip prefix-list NN permit 2.61.0.0/16
ip prefix-list NN permit 2.62.0.0/16
ip prefix-list NN permit 2.62.0.0/17
ip prefix-list NN permit 2.63.0.0/17
ip prefix-list NN permit 2.63.0.0/18
ip prefix-list NN permit 2.63.64.0/18
ip prefix-list NN permit 2.72.0.0/13

# IRR Filters

## User Wins!

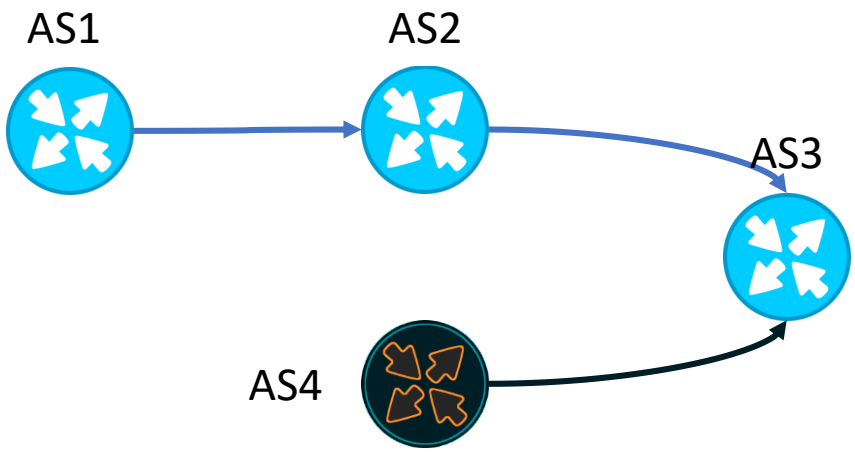



Route obect (AS1, x.x.x.x)

Route: x.x.x.x
AS_PATH: AS4

# IRR Filters: Bypassed

**Attacker Wins!**




Route Object (AS1, x.x.x.x)
**Route object (AS4, x.x.x.x)**

Route: x.x.x.x
AS_PATH: AS4

# Key Findings: IRR Filters

IRR Filters Can be Used to:

- Filter some mistake hijacks;
- Filter some mistake route leaks.

IRR Filters Can't be Used to:

- Filter malicious activity

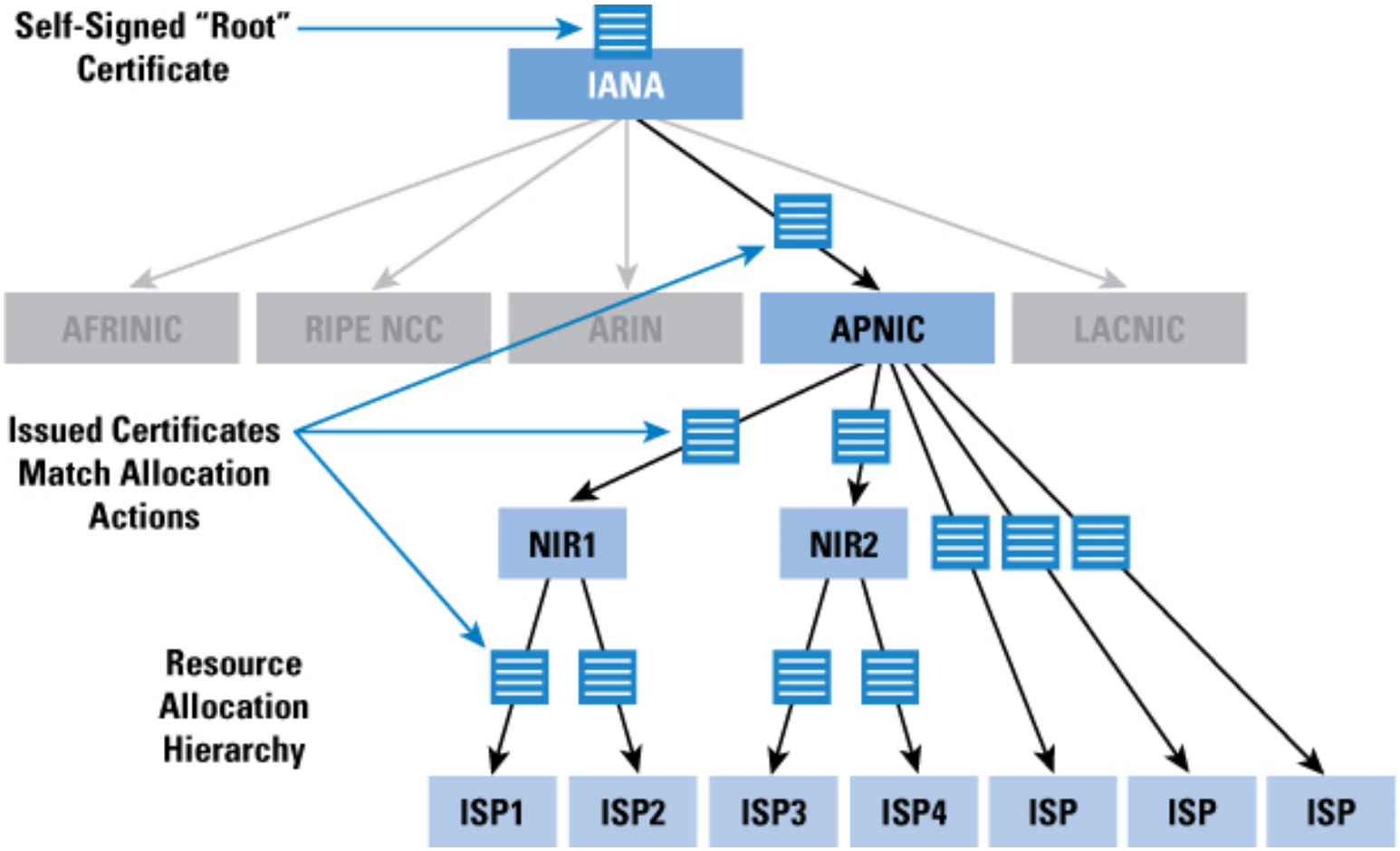
In reality:

- Many AS-SETs are poorly maintained;
- No filters at some huge Tier-2 networks;
- Even some Tier1 networks fail to configure filters;

Source: https://ripe76.ripe.net/presentations/37-ripe76.azimov.pdf


IRRrrrr!
© BNPS.CO.UK

# ROA Validation

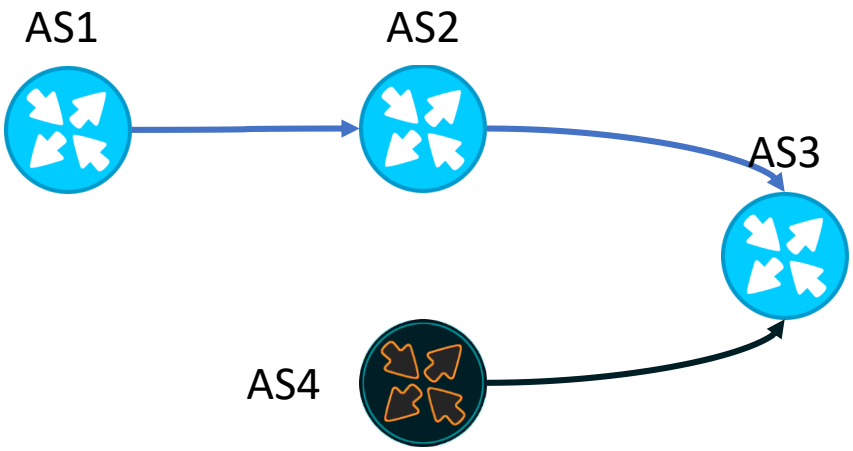


# ROA Validation (prefix, ASN)

1. Retrieve all cryptographically valid ROAs in a for selected *prefix*. This selection forms the set of **candidate ROAs**.
2. If the set of **candidate ROAs** is empty, then the procedure exits with an outcome of **unknown**.
3. If there is at least one candidate ROA where the AS number is *ASN* and prefix length less or equal to max_length option then the procedure exits with an outcome of **valid**.
4. Otherwise, the procedure exits with an outcome of **invalid**.

# ROA Validation

**User Wins!**

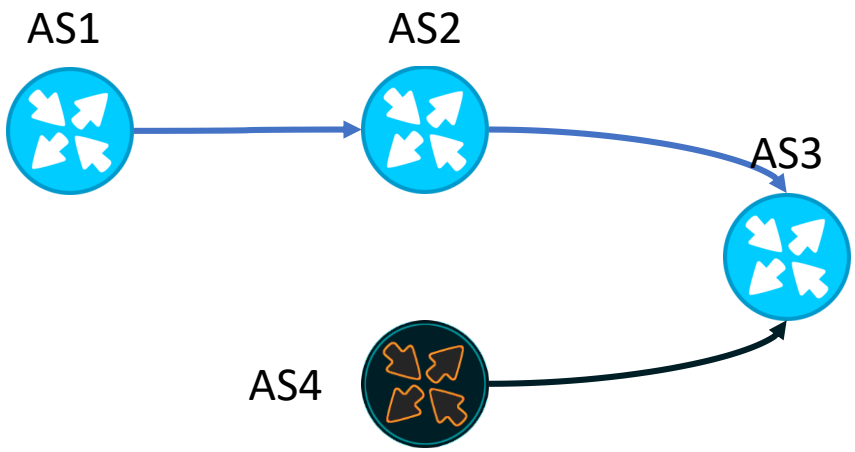



ROA {x.x.x.x, AS1}

Route: x.x.x.x
AS_PATH: AS4

# ROA Validation: Bypassed

**Attacker Wins!**




ROA {x.x.x.x, AS1}

Route: x.x.x.x
AS_PATH: AS4 **AS1**

# Key Findings: ROA Validation

ROA Validation Can be Used to:

- filter mistake hijacks;

ROA Validation Can't be Used to :

- filter route leaks;
- filter malicious hijacks.

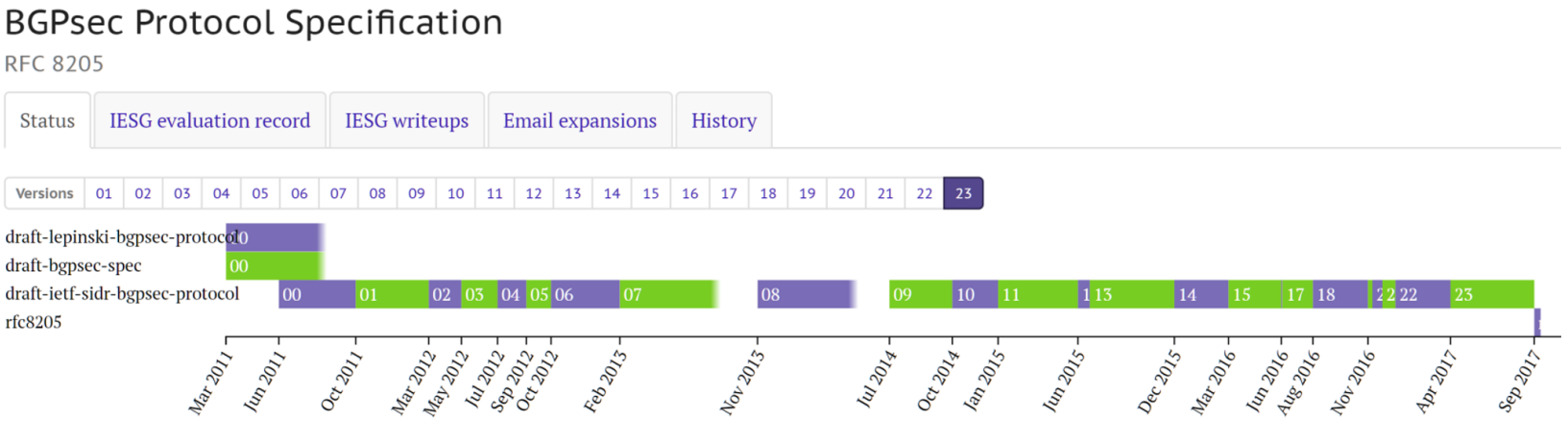
In reality:

- Only 10% of prefixes are signed, transit ISPs doesn't perform origin validations.
- There is progress at IXes!

Source: https://ripe76.ripe.net/presentations/37-ripe76.azimov.pdf

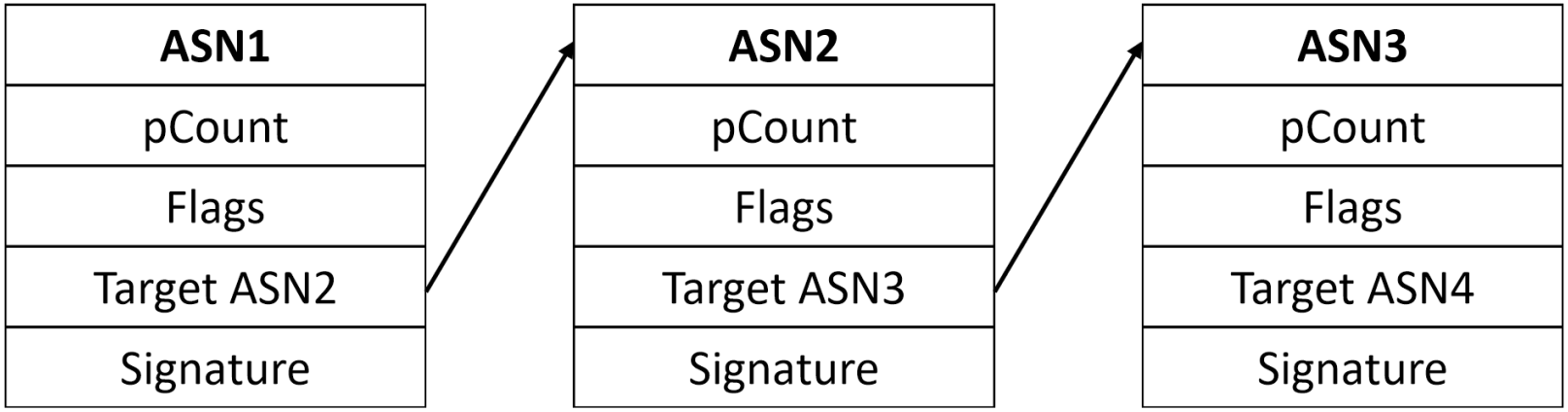

At least you have half of it!

# BGPSec



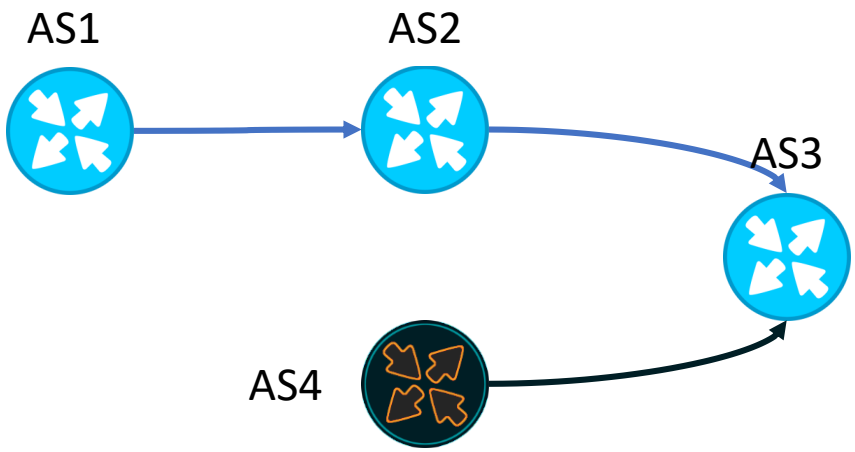

RFC 8205: BGPsec Protocol Specification
RFC 8206: BGPsec Considerations for Autonomous System (AS) Migration
RFC 8207: BGPsec Operational Considerations
RFC 8208: BGPsec Algorithms, Key Formats, and Signature Formats
RFC 8209: A Profile for BGPsec Router Certificates, Certificate Revocation Lists, and Certification Requests
RFC 8210: The Resource Public Key Infrastructure (RPKI) to Router
RFC 8211: Adverse Actions by a Certification Authority (CA) or Repository Manager in the Resource Public Key Infrastructure (RPKI)

# AS_PATH Validation



# AS_PATH Validation

## User Wins!

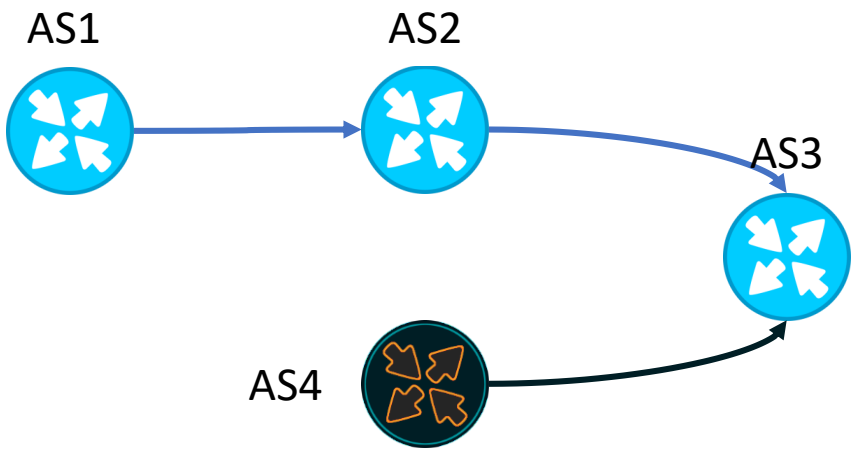



Route: x.x.x.x
AS_PATH: AS4

**ROA {x.x.x.x, AS1}**
(AS1, AS2) – signed
(AS2, AS3) – signed
(AS4, AS3) – signed

# AS_PATH Validation

## User Wins!

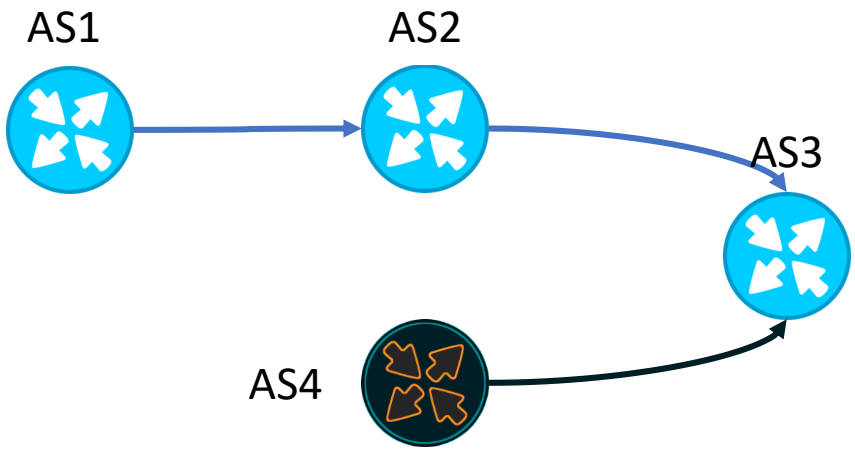



Route: x.x.x.x
AS_PATH: AS4 **AS1**

ROA {x.x.x.x, AS1}
(AS1, AS2) – signed
(AS2, AS3) – signed
(AS4, AS3) – signed
**(AS1, AS4) – illegal**

# AS_PATH Validation: Bypassed

**Attacker Wins!**




Route: x.x.x.x
AS_PATH: AS4 **AS1**

ROA {x.x.x.x, AS1}
(AS1, AS2) – signed
(AS2, AS3) – signed
**(AS4, AS3) – not signed**
**(AS1, AS4) – not signed**

# Key Findings: BGPSec

BGPSec can be used to:

- to detect malicious hijacks at high adoption rate!

In reality:

- Great computation cost;
- Vulnerable for downgrade attacks;
- Nobody is going to use BGPSec!


# BGPSec: Unclear who is the rider

Before RPKI

Before BGPSec

There was soBGP

# soBGP: Adjacencies

- ISP X publishes information about its connections;
- ISP Y publishes information about its connections;

If there are both pairs (X,Y) && (Y,X) –
the pair becomes trustable!

If there is only one pair (X,Y) || (Y, X)
the pair becomes… less trustable!

# soBGP: Security Preference

- The pair is trustable: **+A**
- The pair is less trustable: **-B**

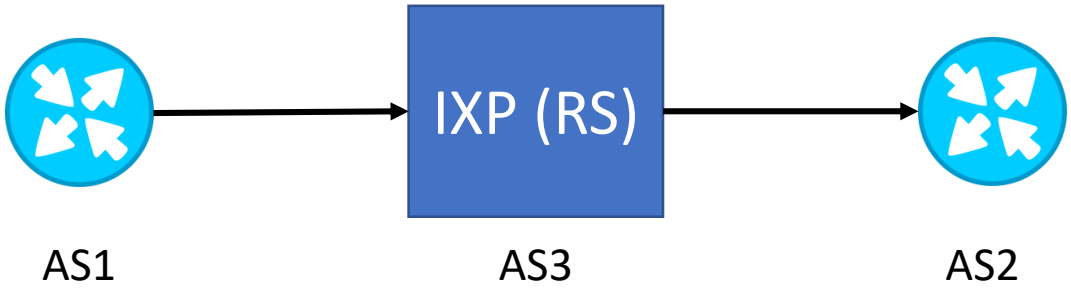
The route #1 has security preference: 2A – 3B

The route #2 has security preference: A – B

The route #3 has security preference: -2B

Which one is valid and which one is invalid?

# soBGP: IXes




AS3 isn't present in the AS_PATH

No adjacencies between AS1, AS2. Reject?!

# Key Findings: soBGP

soBGP Can be Used to:

- Filter bogon routes;
- Create security metrics for routes;

soBGP Can't be Used to:

- filter route leaks;

In reality:

- Problems with IXes;
- It's a rating function, not a solution.

# so-make-bgp-security-by-yourself

# BGP Quadrant

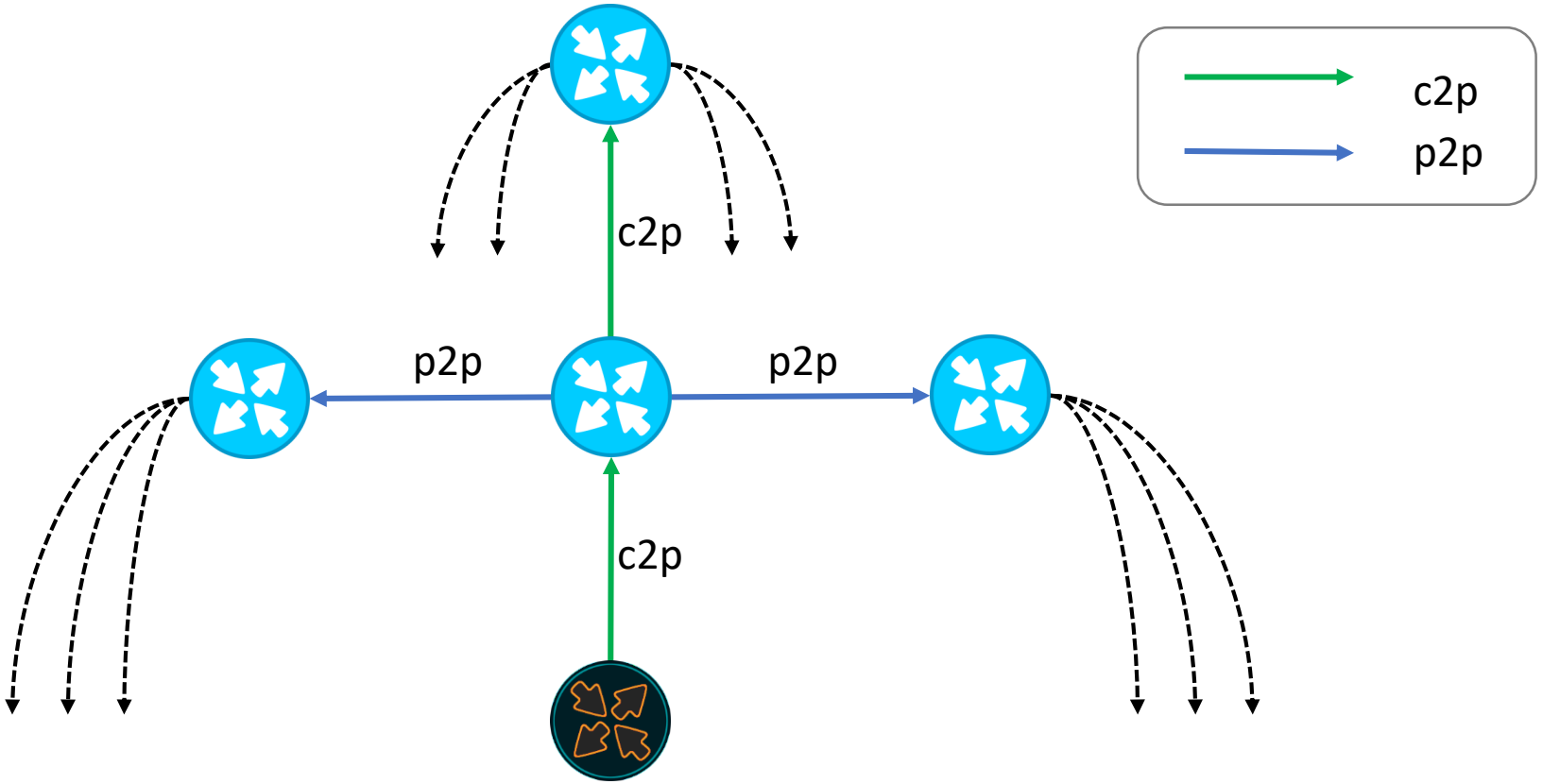
| | BGP Hijacks | BGP Route Leaks |
|---|---|---|
| Mistake | IRR Filters;<br>ROA; | IRR Filters;<br>Route Leak Detection Draft<br>Route Leak Mitigation Draft |
| Malicious | ! | ! |

# Are We Doomed for This?

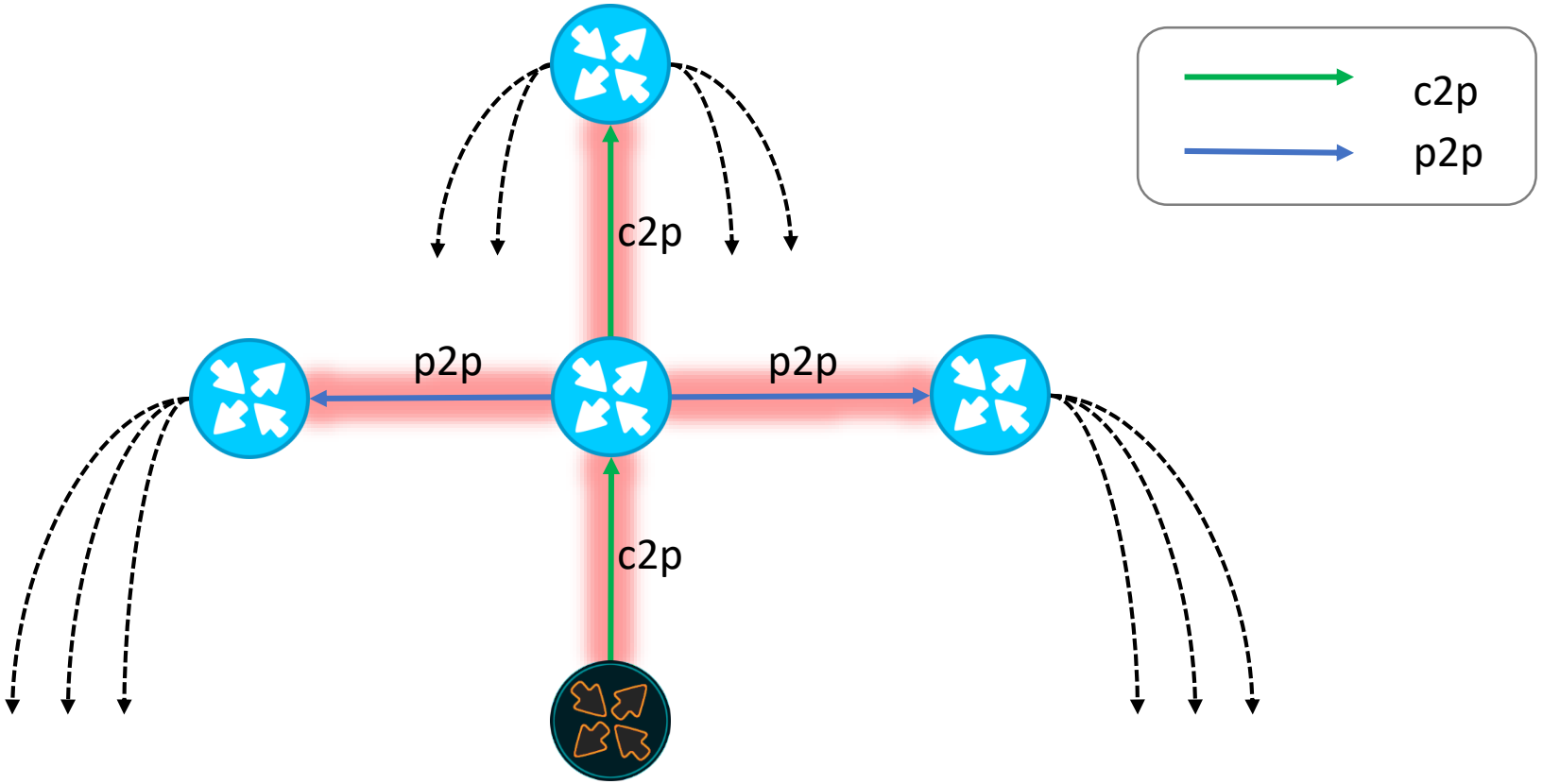
# Re-inventing Goals

- Stop propagation of (malicious) hijacks;
- Stop propagation of (malicious) route leaks;
- Incremental deployment;
- Lightweight – no significant changes in BGP!
- Automatiseret!

# Anomaly Propagation



# Anomaly Propagation




If we can stop propagation at the level of c2p and p2p – we are done!

# A Beautiful Note

If valid route is received from customer or peer it MUST have only customer-to-provider pairs in its AS_PATH.

Then if we have a validated database of customer-to-provider pairs we will be able to verify routes received from customers and providers!

# Autonomous System Provider Authorization

ASPA := {

customer_asn – signer

provider_asn – authorized to send routes to upper providers or peers

AFI – IPv4 or IPv6

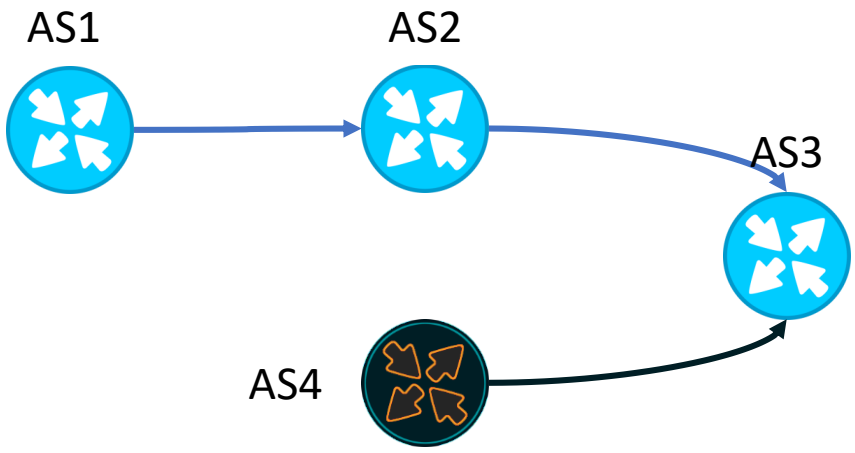
}

# Pair Verification (AS1, AS2)

1. Retrieve all cryptographically valid ASPAs in a selected AFI with a customer value of AS1. This selection forms the set of **candidate ASPAs**.
2. If the set of **candidate ASPAs** is empty, then the procedure exits with an outcome of **unknown**.
3. If there is at least one candidate ASPA where the provider field is AS2, then the procedure exits with an outcome of **valid**.
4. Otherwise, the procedure exits with an outcome of **invalid**.

# AS_PATH Verification

1. If the closest AS in the AS_PATH is not the receiver's neighbor ASN then procedure halts with the outcome "invalid";
2. If in one of AS_SEQ segments there is a pair (AS(I-1), AS(I)) is "invalid" then the procedure also halts with the outcome "invalid";




Route: x.x.x.x
AS_PATH: AS4

**ROA {x.x.x.x, AS1}**
ASPA {AS1, AS2}
ASPA {AS2, AS3}
ASPA {AS3, 0}

# AS_PATH Verification

1. If the closest AS in the AS_PATH is not the receiver's neighbor ASN then procedure halts with the outcome "invalid";
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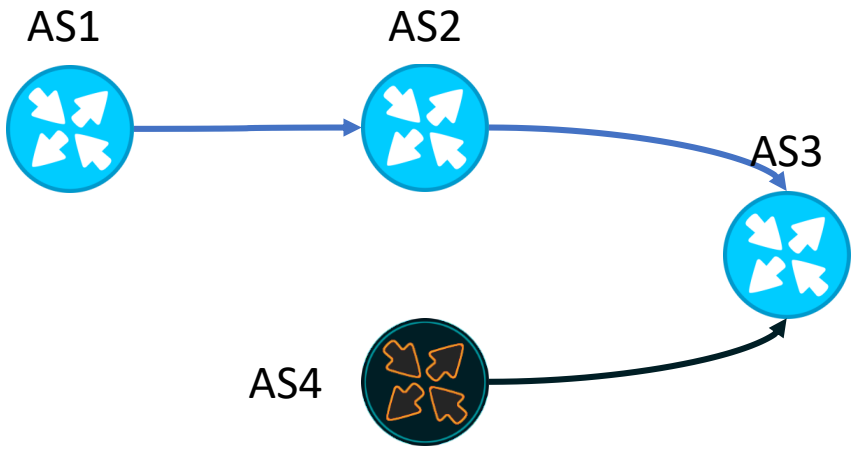


ROA {x.x.x.x, AS1}
**ASPA {AS1, AS2}**
ASPA {AS2, AS3}
ASPA {AS3, 0}

Route: x.x.x.x
AS_PATH: AS4 **AS1**

# AS_PATH Verification

1. If the closest AS in the AS_PATH is not the receiver's neighbor ASN then procedure halts with the outcome "invalid";
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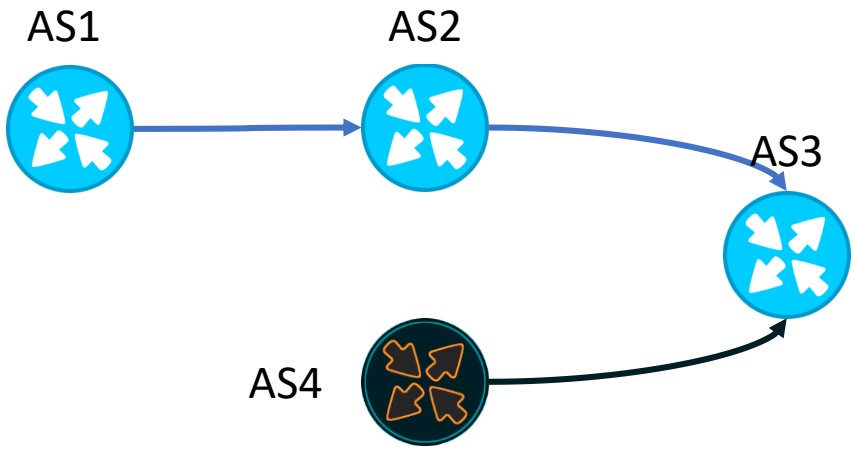
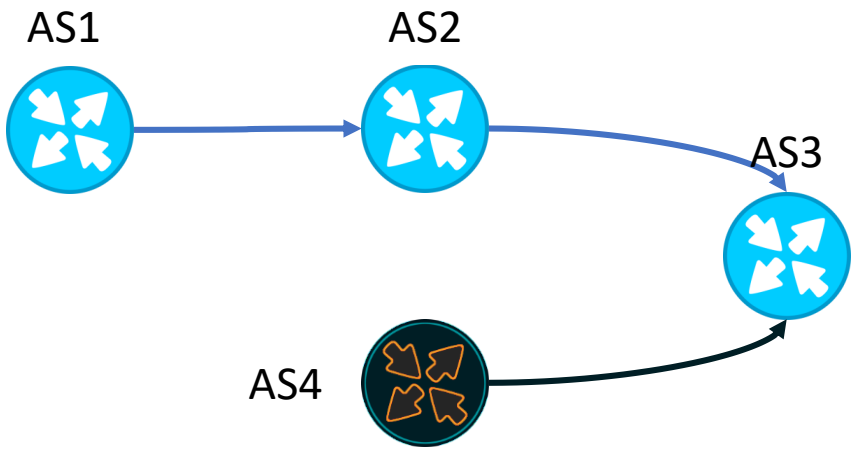



ROA {x.x.x.x, AS1}
ASPA {AS1, AS2}
**ASPA {AS2, AS3}**
ASPA {AS3, 0}

Route: x.x.x.x
AS_PATH: AS4 **AS2 AS1**

# AS_PATH Verification

1. If the closest AS in the AS_PATH is not the receiver's neighbor ASN then procedure halts with the outcome "invalid";
2. If in one of AS_SEQ segments there is a pair (AS(I-1), AS(I)) is "invalid" then the procedure also halts with the outcome "invalid";




ROA {x.x.x.x, AS1}
ASPA {AS1, AS2}
ASPA {AS2, AS3}
ASPA {AS3, 0}

Route: x.x.x.x
AS_PATH: **AS2 AS1**

# User always wins!

# Summary

- ASPA – it’s simple, it scales;
- Works for both route leaks and hijack detection;
- Low computational cost;
- Doesn’t change the protocol itself;
- Works on existing RPKI infrastructure;
- Brings benefit at state of partial adoption.

# BGP Quadrant: Possible Future

| | BGP Hijacks | BGP Route Leaks |
|---|---|---|
| Mistake | ROA | ASPA |
| Malicious | ROA + ASPA | ROA + ASPA |

# Inernet Drafts are Published

AS_PATH verification procedure:

draft-azimov-sidrops-aspa-verification

ASPA profile:

draft-azimov-sidrops-aspa-profile

# The Orchestra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- Job Snijders job@ntt.net
- Keyur Patel keyur@arrcus.com
- Russ Housley housley@vigilsec.com

# BGP Security: Joint Effort

Want to get rid off BGP hijacks/leaks?

- Sign ROAs!
- Support ASPA at IETF mailing list;
- Support ASPA as RIR members!
- Make BGP great again!


Let’s make ASPA ASAP!