Source Address Validation Using BGP UPDATEs, ASPA, and ROA (BAR-SAV)

https://datatracker.ietf.org/doc/html/draft-sriram-sidrops-bar-sav-00

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The Problem

Much interest in the community to improve Source Address Validation (SAV) to reduce unauthorized source address spoofing:

- 2000 – BCP 38: “Networks shall filter out invalid traffic on ingress”
- 2004 – RFC 3704: “Networks can filter traffic on router interfaces using …”

  ACLs – Manually maintained, *so unwieldy and gets stale fast*
  Strict RPF – Symmetrical routing only, *so cannot be used by most non-trivial networks*
  Feasible Path RPF – No route filtering (announce all routes to everyone), *so better but still no*
  Loose RPF – Lets everything but Martians though, *so very ineffective*

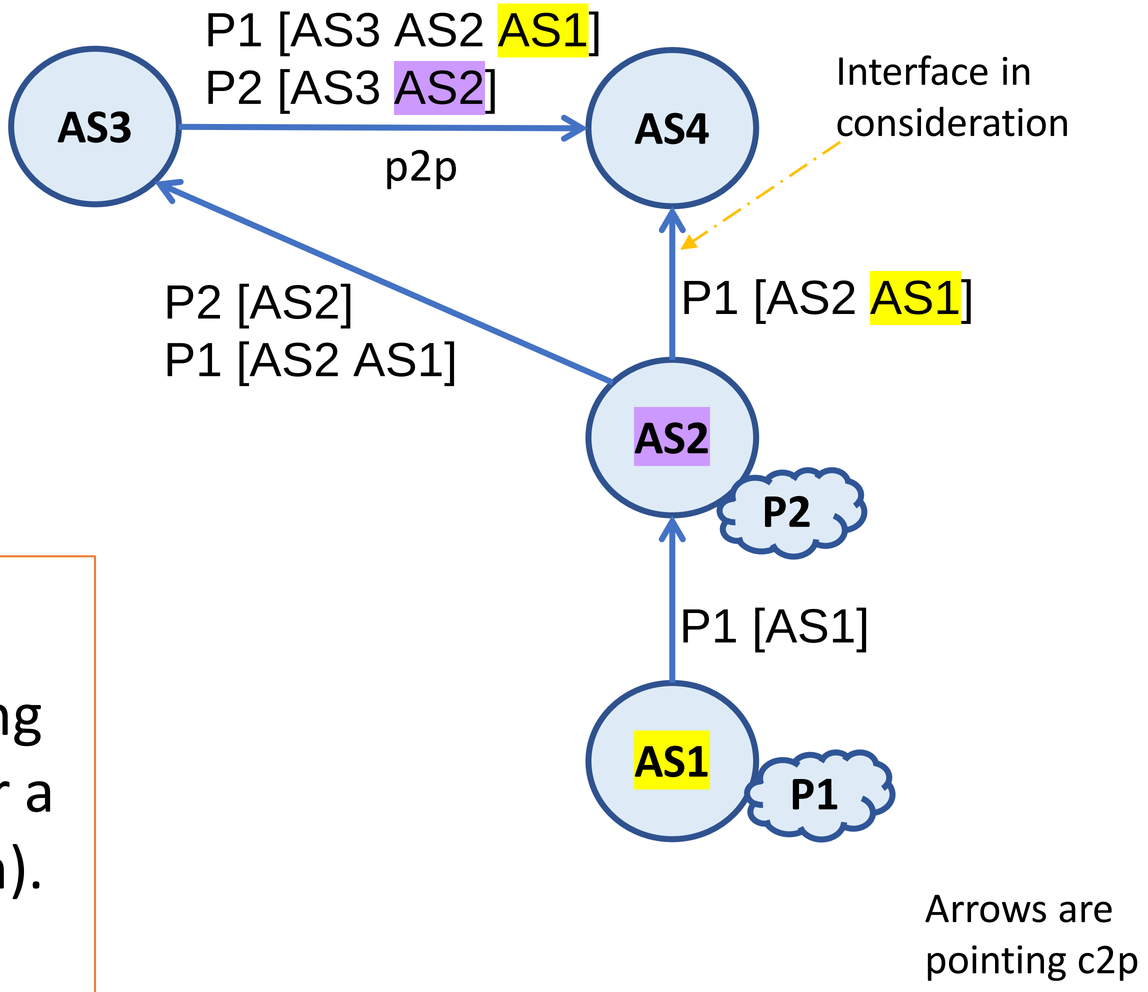
- 2020 – RFC 8704: “Better Feasible Path RPF using paths with common origin AS”

  EFP-uRPF Alg A – At least one path w/ the same origin AS is Feasible for the Interface
  Can still block legitimate traffic if AS announce no prefixes to the ISP
  … + ROA – Also use paths with the same origin AS learned from ROA (not just from BGP)
  EFP-uRPF Alg B – At least one path w/ the same origin AS is Feasible for any *Customer* Interface
  Can permit too much, since Customers can spoof each other’s addresses

- 2022 – Savnet at IETF-113 and IETF-114; EFP-uRPF improvements (like BAR-SAV)

The Problem: RFC 8704 still blocks too much

- P2 is *not* detected by RFC 8704 Alg. A or Alg. B



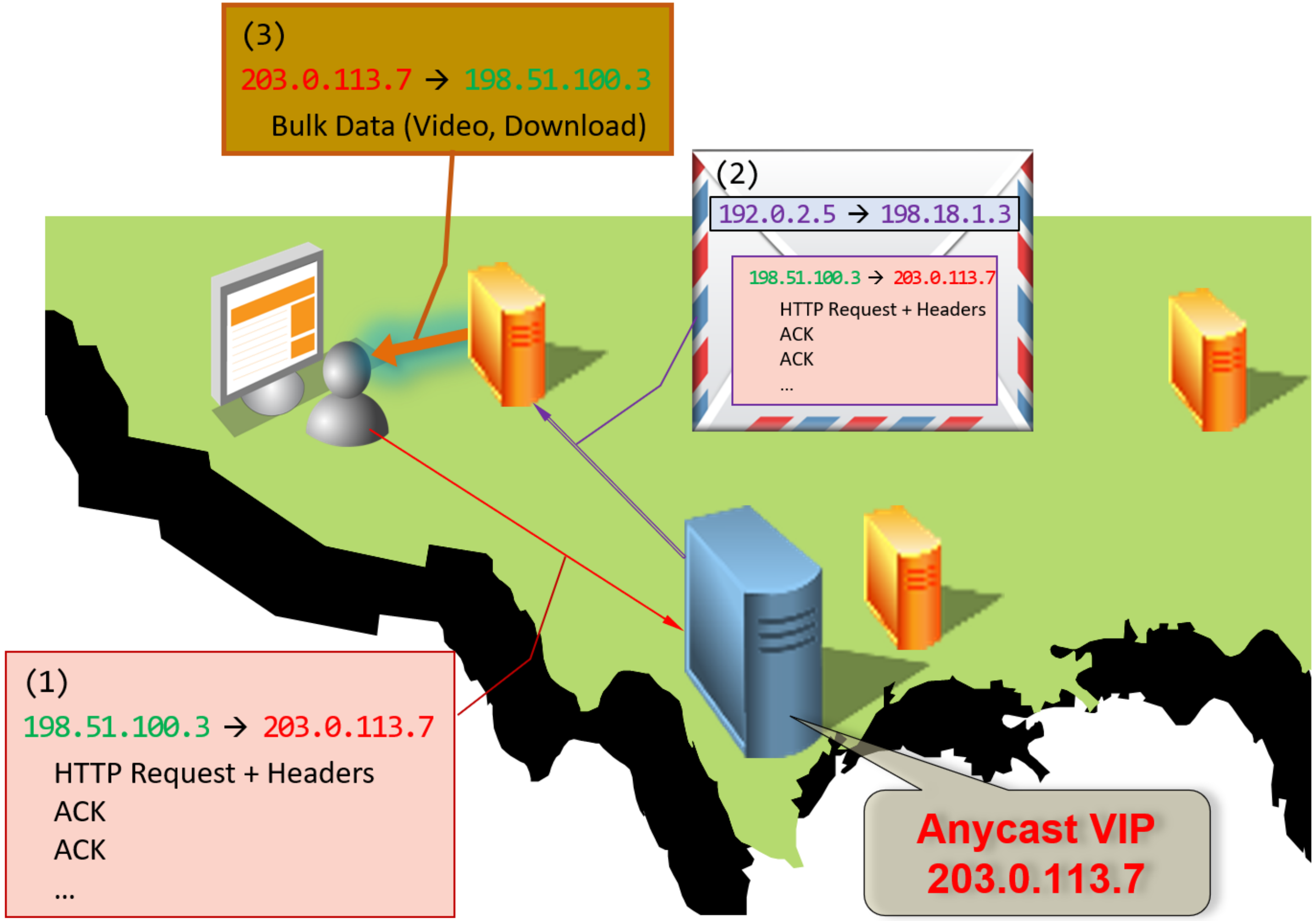
Why is this so hard?

- We are trying to infer data-plane forwarding information from a BGP signal designed for a different purpose (reachability information).
- ROA and ASPA information, while also not designed for SAV purpose, can help a lot.

The Problem: CDN using DSR

Anycast/Edge Hybrid – Direct Server Return

1. Anycast POPs lookup "best" edge POP for each new connection (using the actual user IP)
2. Anycast POPs tunnel packets to edge POPs
3. Edge servers send data to users directly – Direct Server Return (DSR)



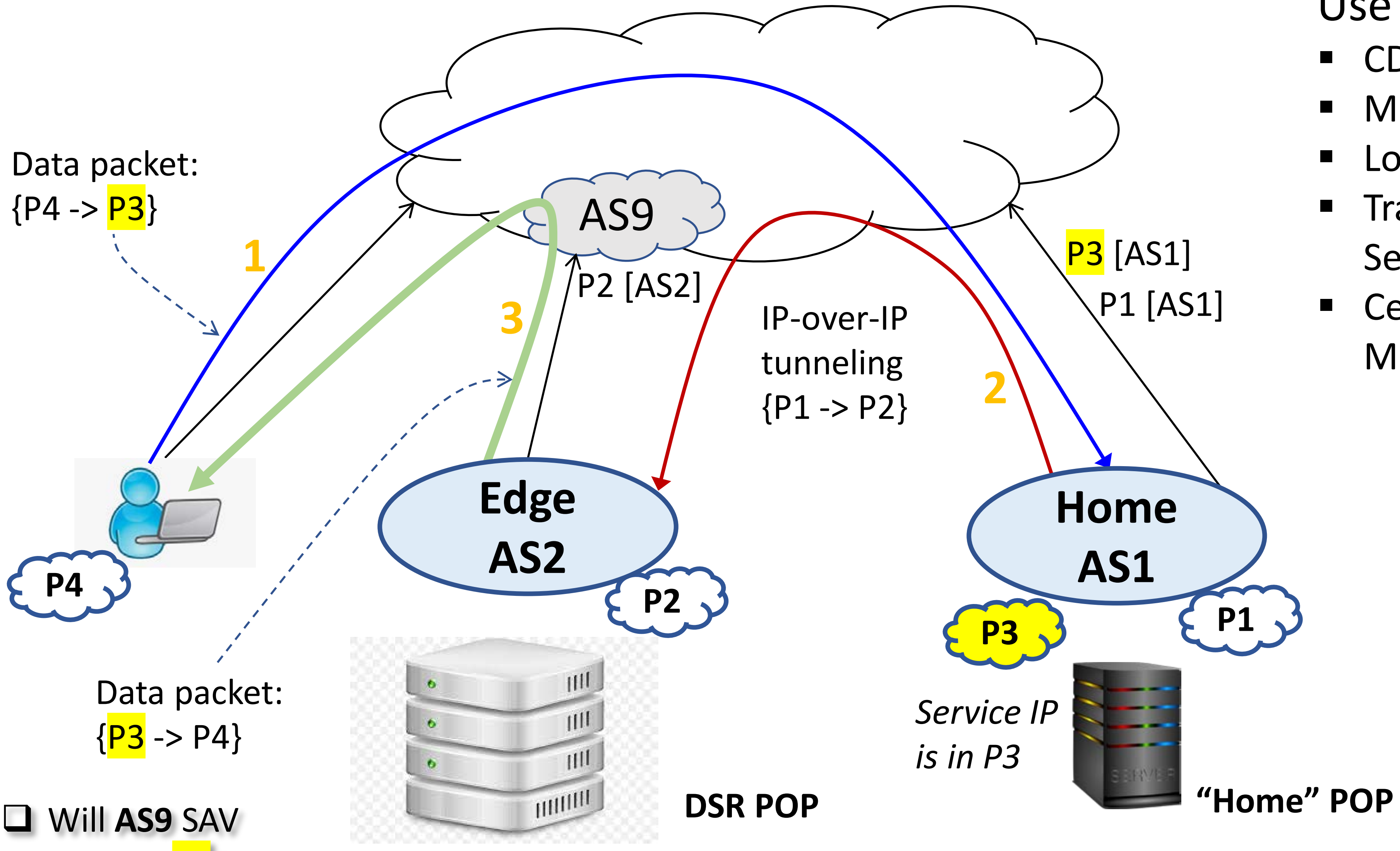
(3)
203.0.113.7 → 198.51.100.3
Bulk Data (Video, Download)

(2)
192.0.2.5 → 198.18.1.3
198.51.100.3 → 203.0.113.7
HTTP Request + Headers
ACK
ACK
...

(1)
198.51.100.3 → 203.0.113.7
HTTP Request + Headers
ACK
ACK
...

Anycast VIP
203.0.113.7

The Problem: Direct Server Return



❑ Will **AS9** SAV permits P3?

Use Cases

- CDN Anycast/Edge Hybrid
- Mobile Roaming
- Low-Latency Gaming
- Traffic Scrubbing Center of a Security Provider
- Central Datacenter of a Multinational Corporation

BAR-SAV (BGP, ASPA, ROA - SAV)

- An improvement on EFP-uRPF Alg. A [RFC 8704]
  - ➢ Improved BGP AS_PATH processing (make use of all ASes, not just origin AS)
  - ➢ Makes complementary use of BGP UPDATEs, ASPAs, and ROAs

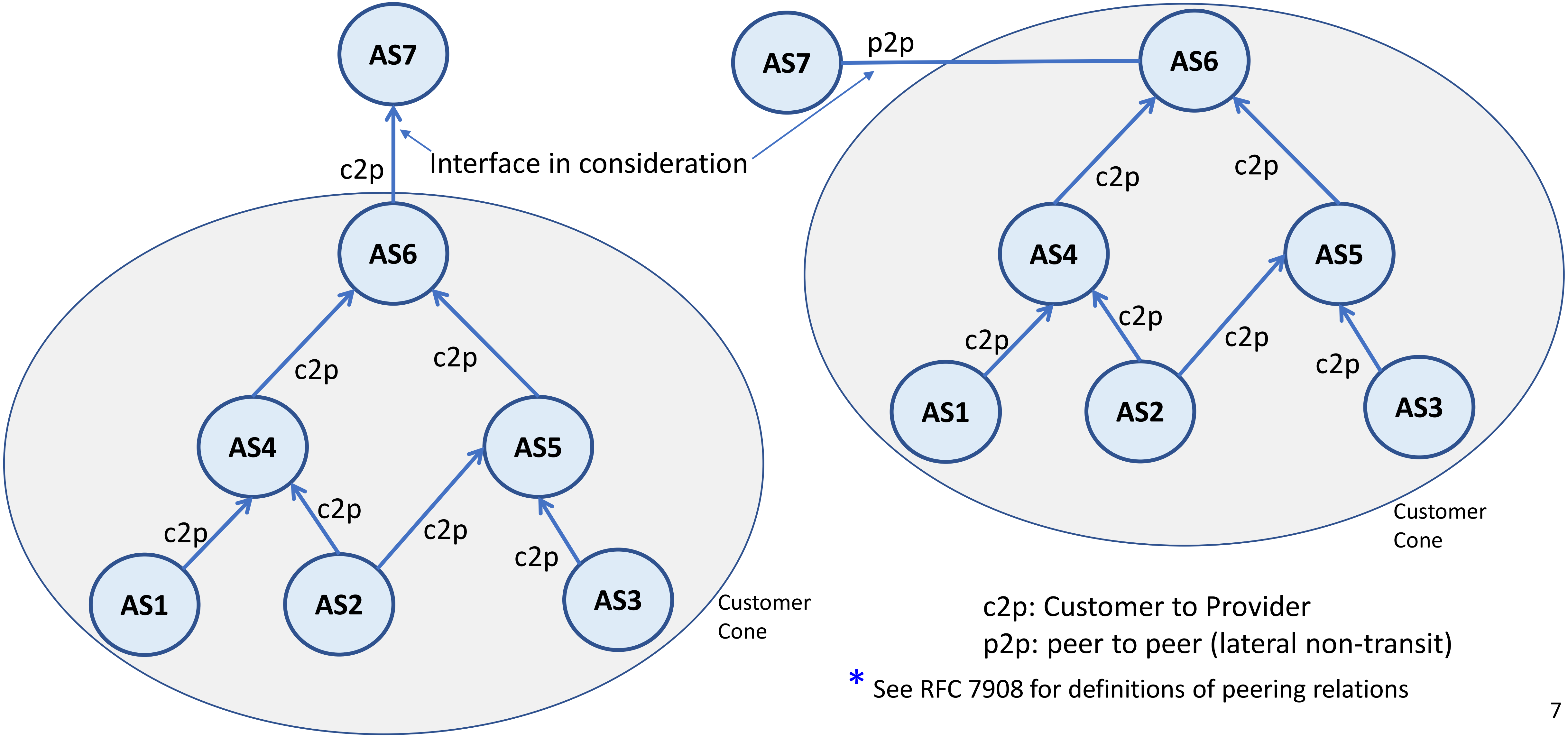
    New Draft: https://datatracker.ietf.org/doc/html/draft-sriram-sidrops-bar-sav-00

- BAR-SAV advances the technology for SAV filter design
  - ✓ Significantly improves the ability to detect hidden prefixes
  - ✓ Provides a solution to the CDN/Direct Server Return (DSR) problem

- No changes to any protocol on the wire
  - ➢ Offers immediate benefits to early adopters

Goal: Construct Permissible Ingress Prefix List for SAV (at AS7)

The methodology is the same for a Customer or Lateral (i.e., non-transit) Peer* Interface



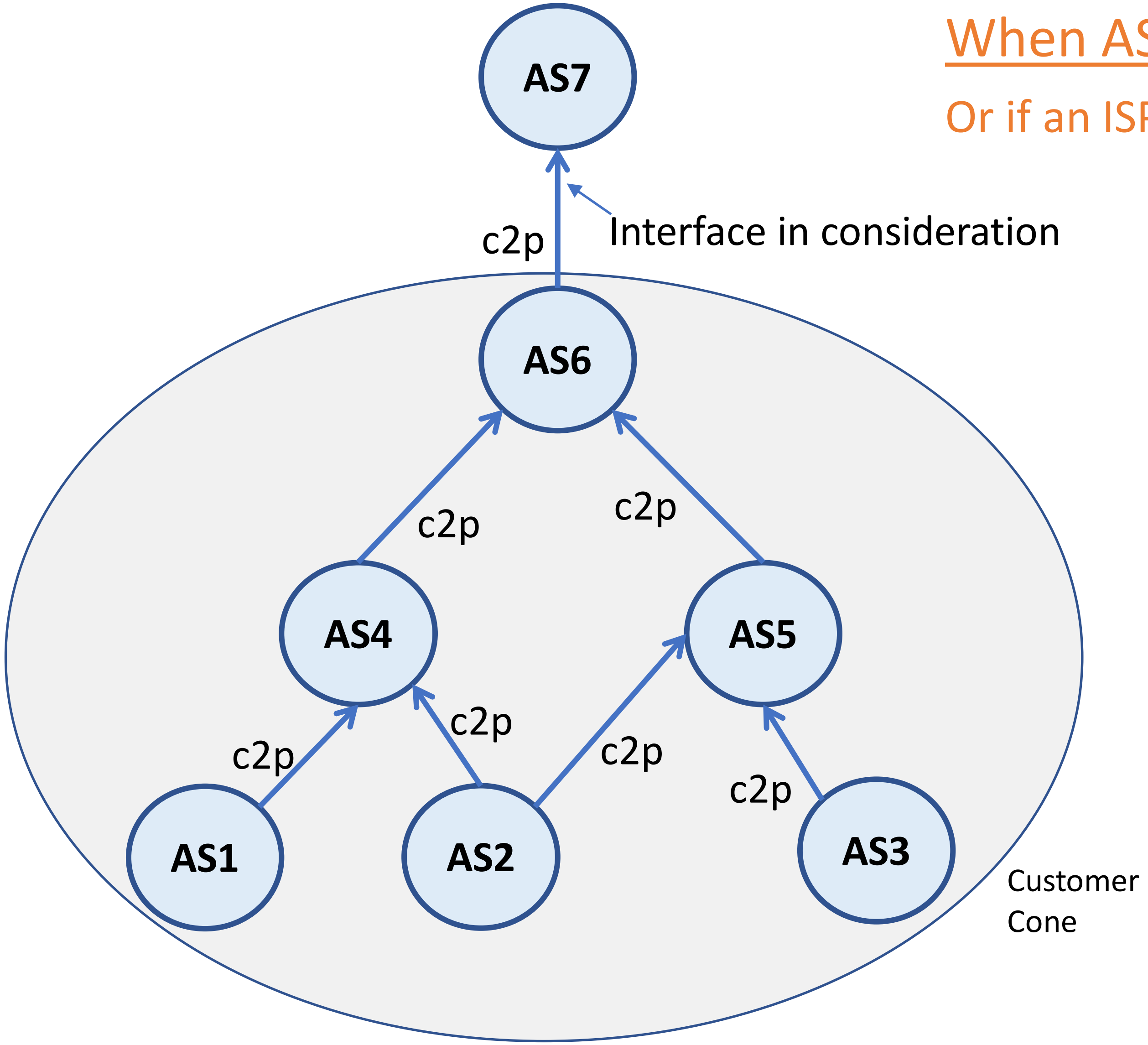
c2p: Customer to Provider

p2p: peer to peer (lateral non-transit)

* See RFC 7908 for definitions of peering relations

SAV Using Only ASPA and ROA (Procedure X)

Construction of Permissible Ingress Prefix List for SAV (at AS7)



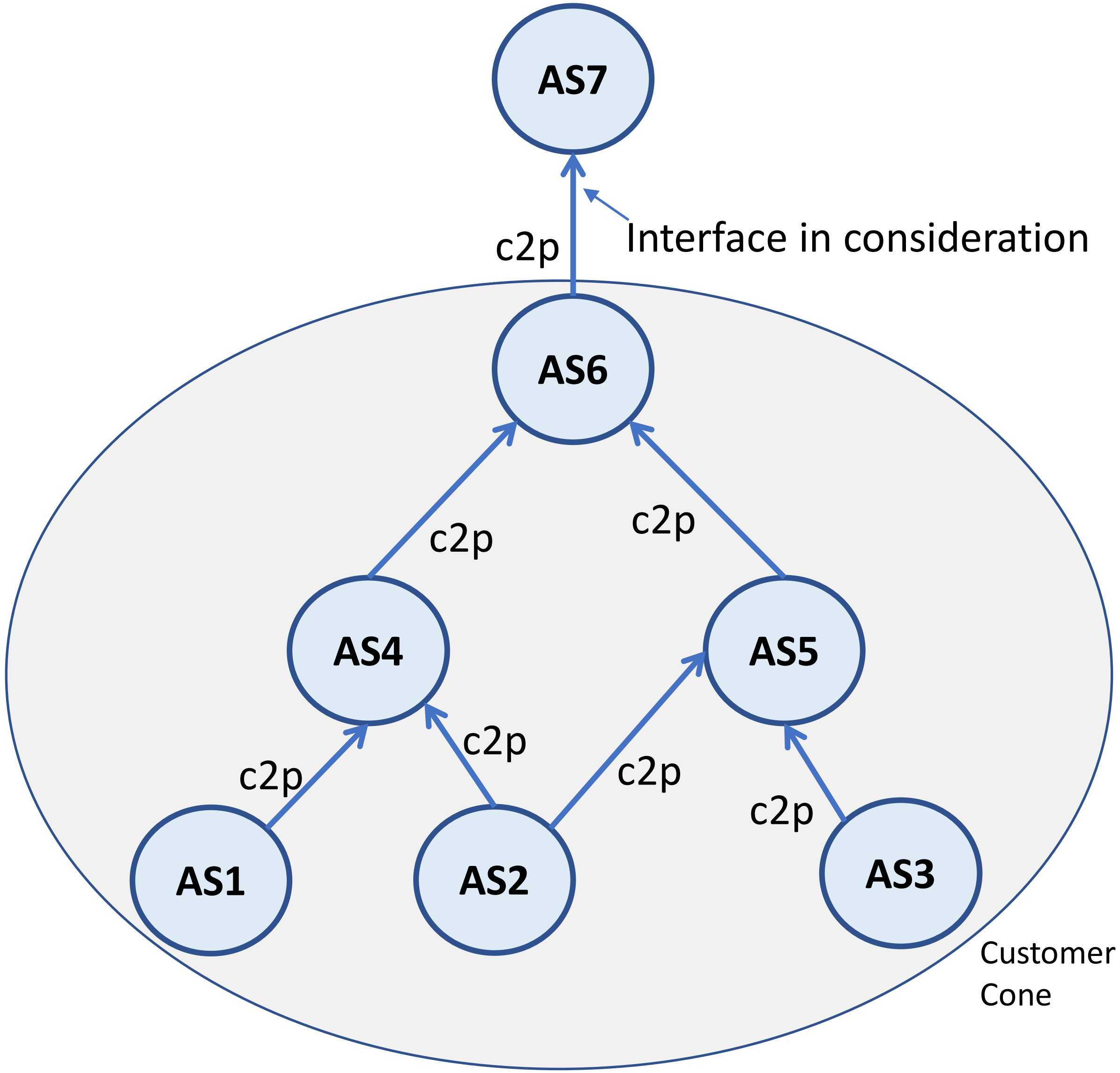
When ASPA and ROA adoption is ubiquitous (future)

Or if an ISP requires all its customers to register ROAs and ASPAs

A. Obtain the set of ASNs in the Customer's customer cone (CC) using ASPAs by transitively discovering customers of the customer or lateral peer in consideration.
B. Gather all prefixes in ROAs associated with the ASNs found in Step A. Keep only the unique prefixes.
C. The set computed in Step B is the permissible prefix list for SAV for the interface in consideration.

SAV Using BGP UPDATE, ASPA, and ROA (BAR-SAV)

Construction of Permissible Ingress Prefix List for SAV (at AS7)

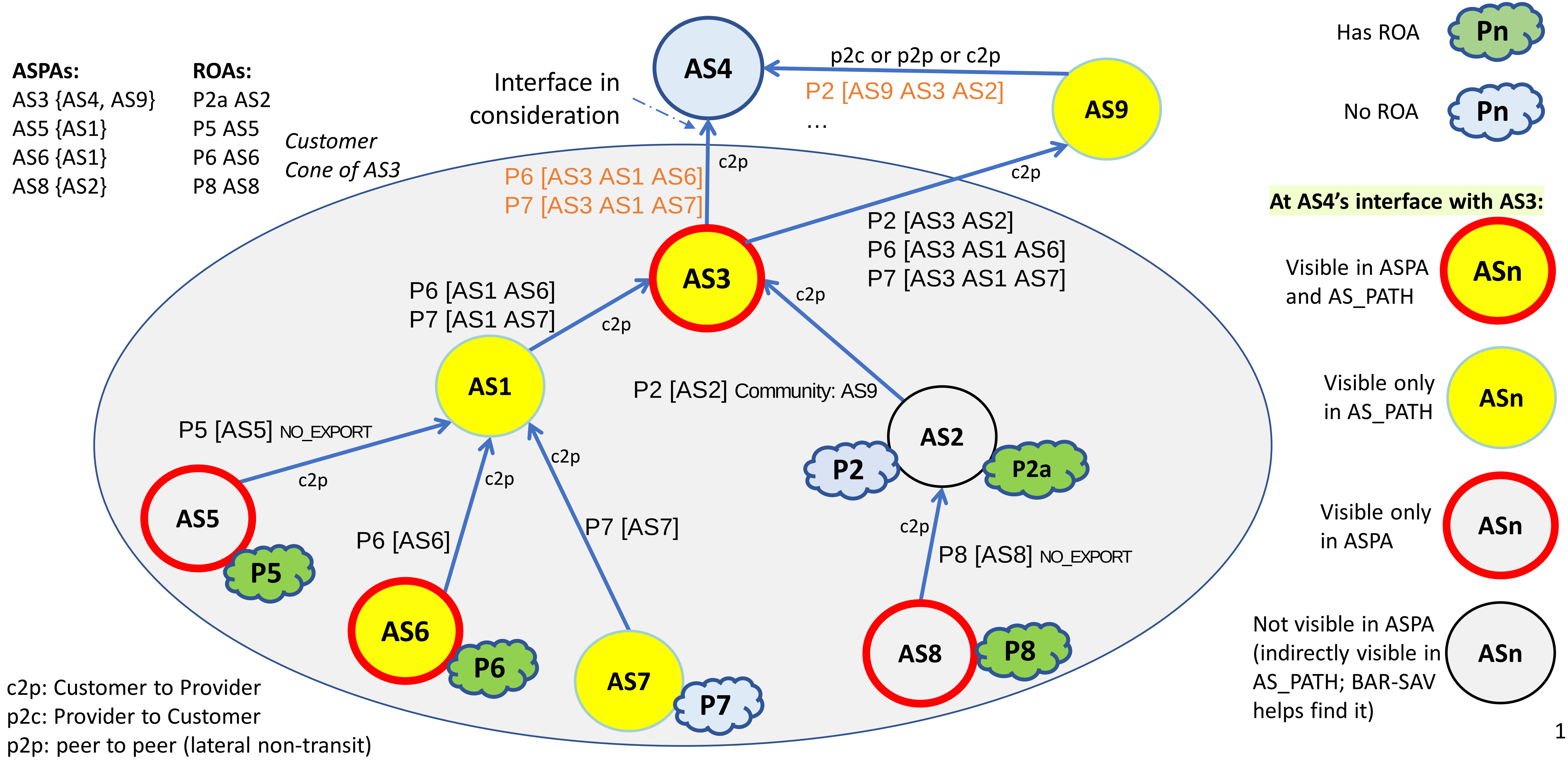


Applicable before ASPA and ROA adoption is ubiquitous (now)

A. Iteratively obtain the set of ASNs in the Customer’s customer cone (CC) using ASPAs and AS_PATHs
B. Gather all prefixes in ROAs associated with the ASNs found in Step A.
C. Gather all prefixes in BGP UPDATE messages with originating ASN among ASNs found in Step A.
D. Combine sets found in Steps B and C. Keep only the unique prefixes. This is the permissible prefix list for SAV for the interface in consideration.

The next 3 slides illustrate the details of how BAR-SAV works

How BAR-SAV Works
Finding **All** ASes and Prefixes in Customer’s (or Peer’s) Customer Cone
Using BGP Announcements (as seen at AS4), ASPA, and ROA



ASPAs:
AS3 {AS4, AS9}
AS5 {AS1}
AS6 {AS1}
AS8 {AS2}

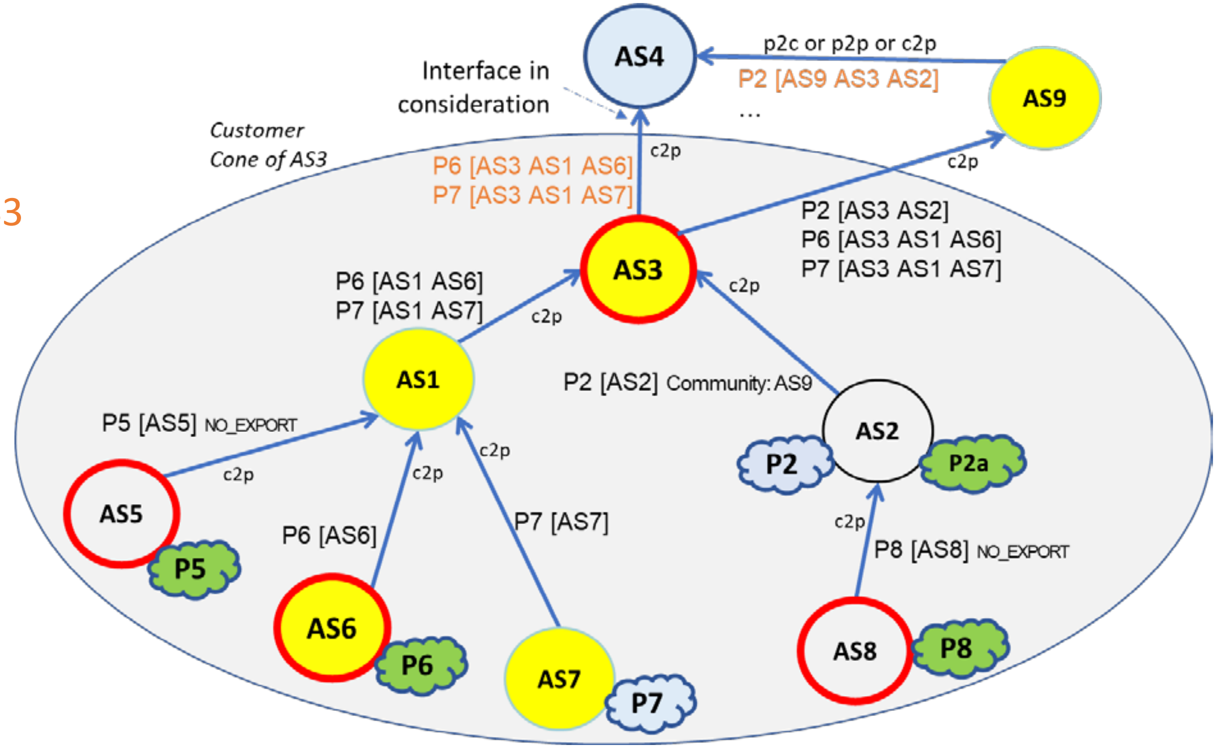
ROAs:
P2a AS2
P5 AS5
P6 AS6
P8 AS8

c2p: Customer to Provider
p2c: Provider to Customer
p2p: peer to peer (lateral non-transit)

Finding **All** ASes in the CC using BGP AS_PATH and ASPA

INPUTS

ASPAs:	ROAs:	BGP UPDATE AS_PATHs:
AS3 {AS4, AS9}	P2a AS2	Interface in Consideration: AS3
AS5 {AS1}	P5 AS5	P6 [AS3 AS1 AS6]
AS6 {AS1}	P6 AS6	P7 [AS3 AS1 AS7]
AS8 {AS2}	P8 AS8	Other Interfaces:
		P2 [AS9 AS3 AS2]



OUTPUT

Iteration	Customer Cone	New ASes from ASPA	New ASes from AS_PATH
1	AS3	None	P6 [AS3 AS1 AS6] → AS1 P7 [AS3 AS1 AS7] → AS1 P2 [AS9 AS3 AS2] → AS2
2	AS3, AS1, AS2	AS5 {AS1} → AS5 AS6 {AS1} → AS6 AS8 {AS2} → AS8	P6 [AS3 AS1 AS6] → AS6 P7 [AS3 AS1 AS7] → AS7
3	AS3, AS1, AS2, AS5, AS6, AS8, AS7	None	None

Finding **All** Prefixes in the CC using BGP Routes and ROA

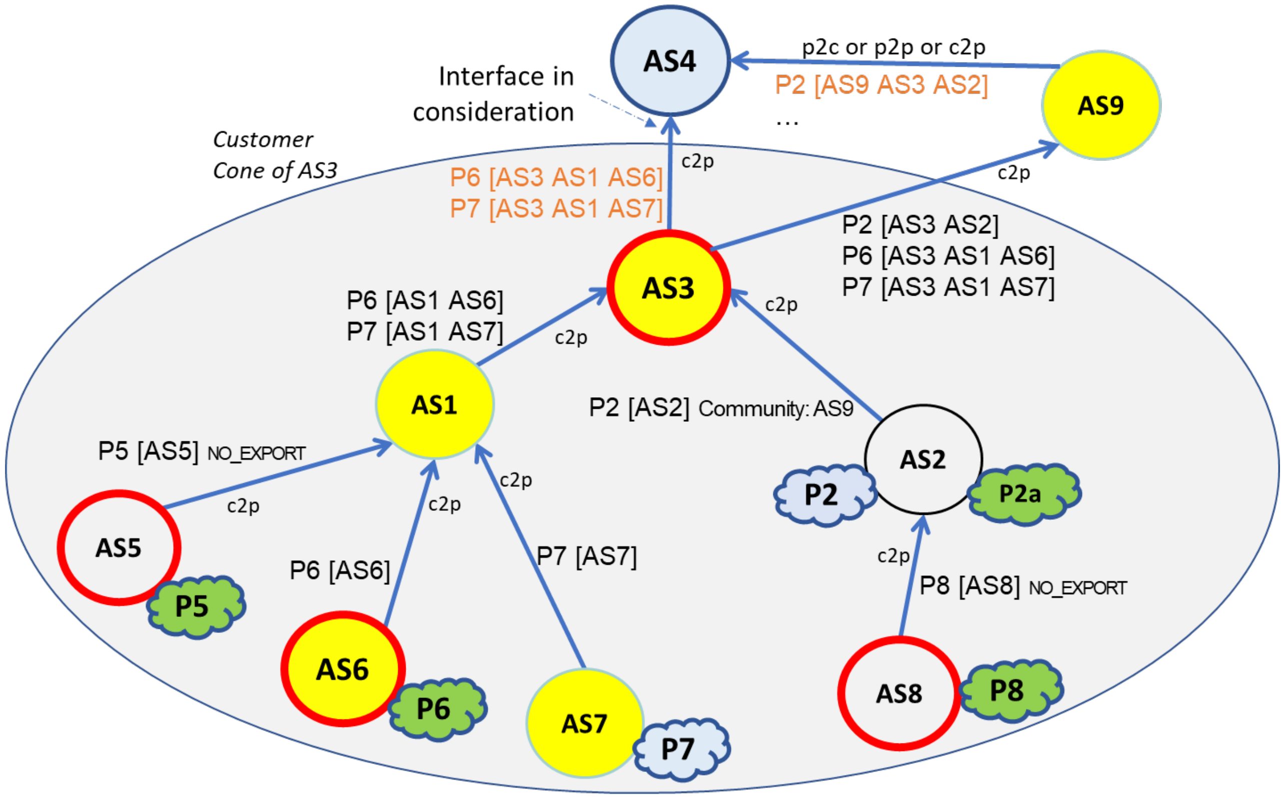
INPUTS

ASPAs:	ROAs:	BGP UPDATE AS_PATHs:
AS3 {AS4, AS9}	P2a AS2	Interface in Consideration: AS3
AS5 {AS1}	P5 AS5	P6 [AS3 AS1 AS6]
AS6 {AS1}	P6 AS6	P7 [AS3 AS1 AS7]
AS8 {AS2}	P8 AS8	Other Interfaces:
		P2 [AS9 AS3 AS2]

Customer Cone
AS1, AS2, AS3, AS5, AS6, AS7, AS8

OUTPUT

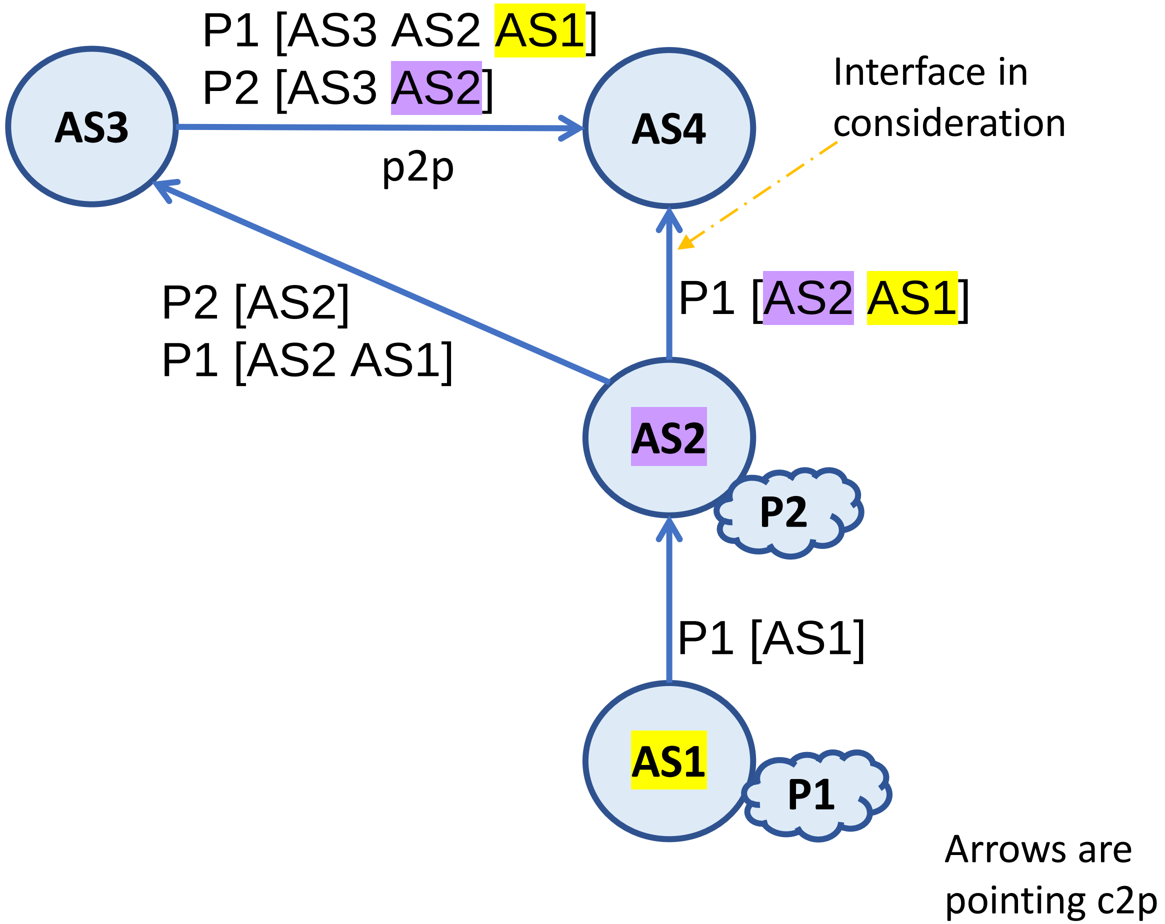
ASN	Prefixes from ROA	Prefixes from BGP
AS1		
AS2	(P2a AS2) → P2a	P2 [AS9 AS3 AS2] → P2
AS3		
AS5	(P5 AS5) → P5	
AS6	(P6 AS6) → P6	P6 [AS3 AS1 AS6] → P6
AS7		P7 [AS3 AS1 AS7] → P7
AS8	(P8 AS8) → P8	



SAV Prefixes
P2, P2a, P5, P6, P7, P8

Refined Version of Algorithm A of EFP-uRPF [RFC 8704] Incorporated into BAR-SAV

- P2 is *not* detected by RFC 8704 Alg. A or Alg. B
- P2 *is* detected by BAR-SAV

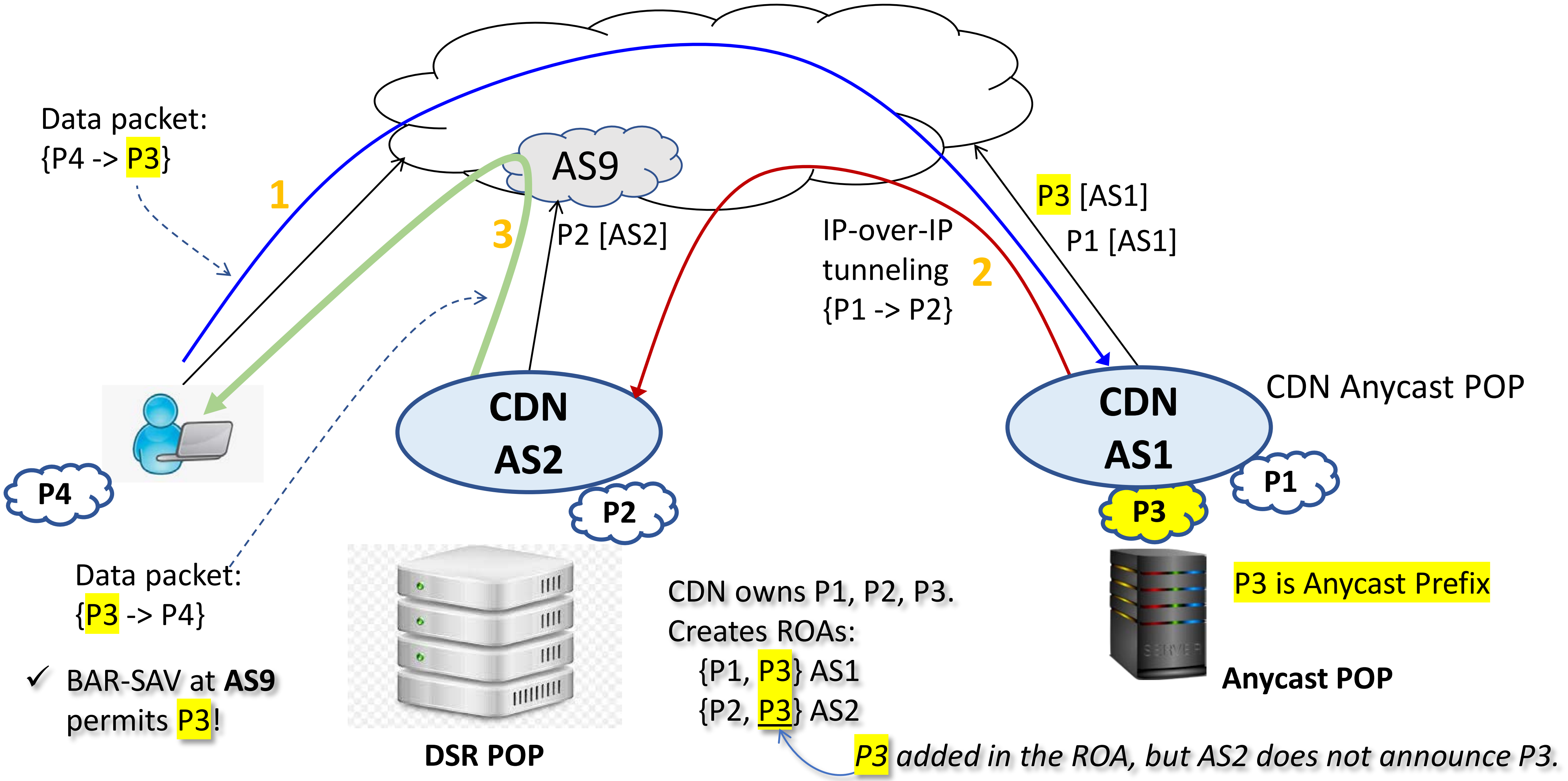


EFP-uRPF = Enhanced Feasible Path uRPF

- Much better detection of “Hidden” prefixes in multihoming scenarios by BAR-SAV

Content Delivery Network (CDN) Application

Example of how the BAR-SAV method solves the CDN DSR blocking problem



Data packet:
{P4 -> P3}

1

3

AS9

P2 [AS2]

IP-over-IP
tunneling
{P1 -> P2}

2

P3 [AS1]

P1 [AS1]

CDN Anycast POP

CDN
AS2

CDN
AS1

P4

P2

P1

P3

Data packet:
{P3 -> P4}

✓ BAR-SAV at **AS9** permits P3!

DSR POP

CDN owns P1, P2, P3.
Creates ROAs:
{P1, P3} AS1
{P2, P3} AS2

P3 is Anycast Prefix

Anycast POP

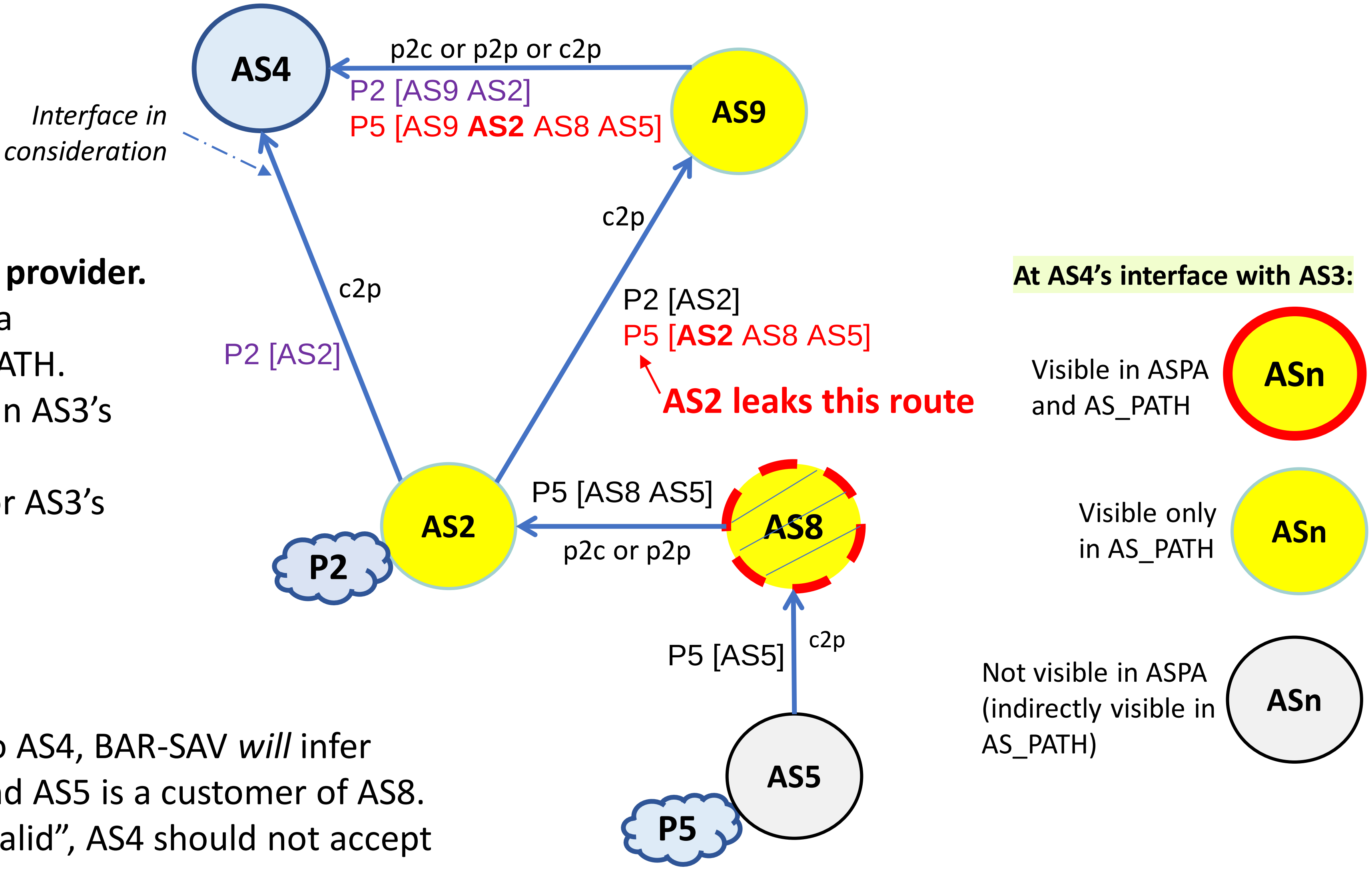
P3 added in the ROA, but AS2 does not announce P3.

Help from ASPA Data to Clean-Up Anomalies in AS_PATH Data

ASPAs:
AS8 {AS10}

AS8 has an ASAP, but AS2 is not its provider.

- ➢ BAR-SAV refuses to infer AS8 as a customer of AS2 from BGP AS_PATH.
- ➢ Therefore, AS8 and AS5 are not in AS3's Customer Cone
- ➢ Therefore, P5 is not in SAV list for AS3's interface.



Note:

- Since the leaked route made it to AS4, BAR-SAV *will* infer that AS2 is a customer of AS9, and AS5 is a customer of AS8.
- Since ASPA deems the route "Invalid", AS4 should not accept the leaked route for forwarding to P5.

Backup slides

https://datatracker.ietf.org/doc/html/draft-sriram-sidrops-bar-sav-00

The Problem: Some Stats

Percentage of networks doing SAV (by Akamai's estimates):

- 2015 – 15%
- 2022 – 15%

Why?

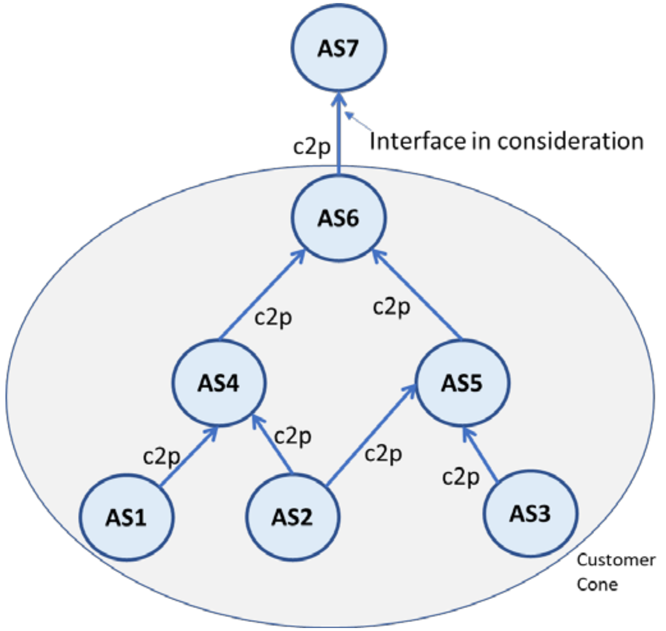
- Could be economics, but even most smaller networks do not filter
- Likely SAV today is either ineffective or just breaks too many things
  - Is EFP-uRPF (RFC 8704) just too recent, and it will gain use in ~5 years? Or Alg. A is seen as too risky (blocks too much), and Alg. B is too loose?

Requirements for a Solution

- Improved fidelity – reduced improper block and improper permit
- Incrementally deployable – offers immediate benefits to early adopters
- Economical – benefits outweigh the costs (especially for early adopters)
- Network effect – late movers are feeling greater pressure to adopt
- Friendly to smaller networks – SAV is done best at the edge

A Note on Customer Cone Computation

- One should *not* compute a customer cone by separately processing ASPA data and AS_PATH data and then merging the two sets of ASes at the end. Doing so is likely to miss ASes from the customer cone.



- Instead, both ASPAs and AS_PATHs should be used to iteratively expand the discovered customer cone. When new ASes are discovered, both ASPA and AS_PATH data should be used to discover customers of those ASes. This process is repeated for newly discovered customer ASes until there are no new ASes to be found.

Detailed Procedure X

Creating the Permissible Prefix List for SAV for a Customer or Lateral Peer using only ASPA and ROA

1. Let the Customer or Lateral Peer ASN be denoted as AS-k.
2. Let i = 1. Initialize: AS-set S(1) = {AS-k}.
3. Increment i to i+1.
4. Create AS-set S(i) of all ASNs whose ASPA data declares at least one ASN in AS-set S(i-1) as a Provider.
5. If AS-set S(i) is null, then set i_max = i - 1 and go to Step 6.
   Else, go to Step 3.
6. Form the union of the sets, S(i), i = 1, 2, ..., i_max, and name this union as AS-set A.
7. Select all ROAs in which the authorized origin ASN is equal to any ASN in AS-set A. Form the union of the sets of prefixes listed in the selected ROAs. Name this union set of prefixes as P-set.
8. Apply P-set as the list of permissible prefixes for SAV.

Note: Algorithm X is for future use when the deployment of ASPA and ROA is ubiquitous.

Detailed Description of the BAR-SAV Procedure

1. Let the Customer or Lateral Peer ASN be denoted as AS-k.
2. Let i = 1. Initialize: AS-set Z(1) = {AS-k}.
3. Increment i to i+1.
4. Create AS-set A(i) of all ASNs whose ASPA data declares at least one ASN in AS-set Z(i-1) as a Provider.
5. Create AS-set B(i) of all "non-ASPA" customer ASNs each of which is a customer of at least one ASN in AS-set Z(i-1) according to unique AS_PATHs in Adj-RIBs-In [RFC4271] of all interfaces at the BGP speaker computing the SAV filter. "Non-ASPA" ASN are ASNs that declare no provider in ASPA data.
6. Form the union of AS-sets A(i) and B(i) and call it AS-set C.
   From AS-set C, remove any ASNs that are present in Z(j), for j=1 to j=(i-1). Call the resulting set Z(i).
7. If AS-set Z(i) is null, then set i_max = i - 1 and go to Step 8. Else, go to Step 3.
8. Form the union of the AS-sets, Z(i), i = 1, 2, ..., i_max, and name this union as AS-set D.
9. Select all ROAs in which the authorized origin ASN is in AS-set D. Form the union of the sets of prefixes listed in the selected ROAs. Name this union set of prefixes as Prefix-set P1.
10. Using the routes in Adj-RIBs-In of all interfaces, create a list of all prefixes originated by any ASN in AS-set D. Name this set of prefixes as Prefix-set P2.
11. Form the union of Prefix-sets P1 and P2. Apply this union set as the list of permissible prefixes for SAV.