Source Address Validation: Use Cases and Gap Analysis

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Background

- The traditional Internet architecture lacks the validation of a packet's source address
  - ✓ Source address spoofing leads to various malicious attacks

- **Source Address Validation (SAV)** is necessary in order to detect and reject spoofed IP packets in the network, and contributes to the security of IP networks (RFC6959)

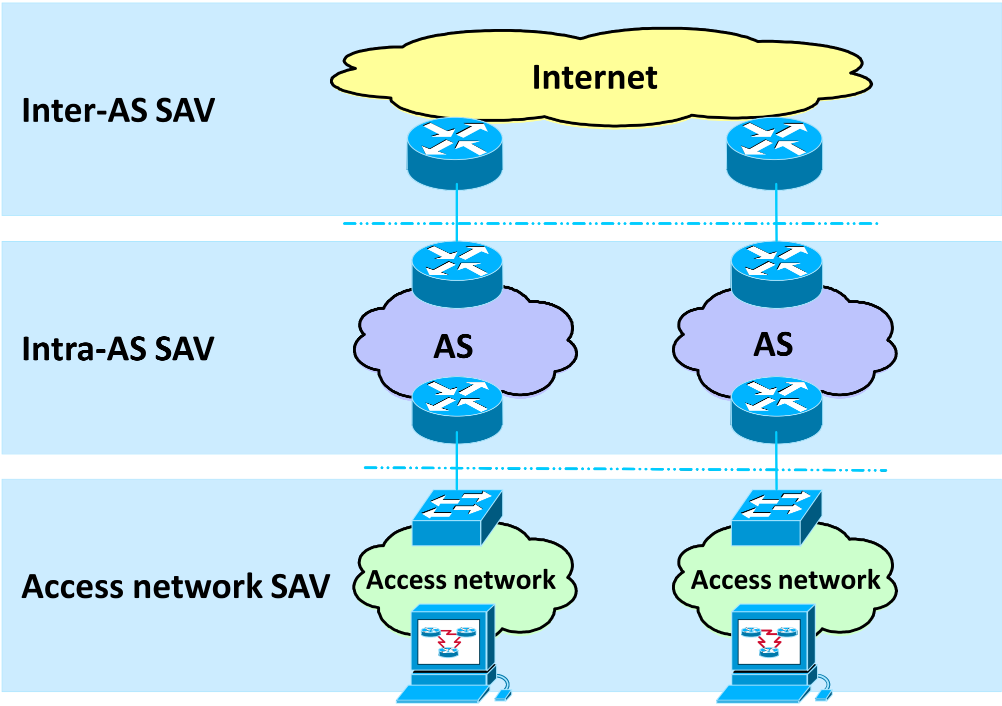
- Mutually Agreed Norms for Routing Security (**MANRS**) is calling on network operators to implement SAV to prevent source address spoofing

- However, it is difficult to solve the source address spoofing problem at a single "level" or through a single SAV mechanism (RFC5210)
  - ✓ It is unrealistic to require a SAV mechanism to be accepted by all network operators
  - ✓ The failure of a single SAV mechanism will completely disable SAV

Source address validation architecture (SAVA)

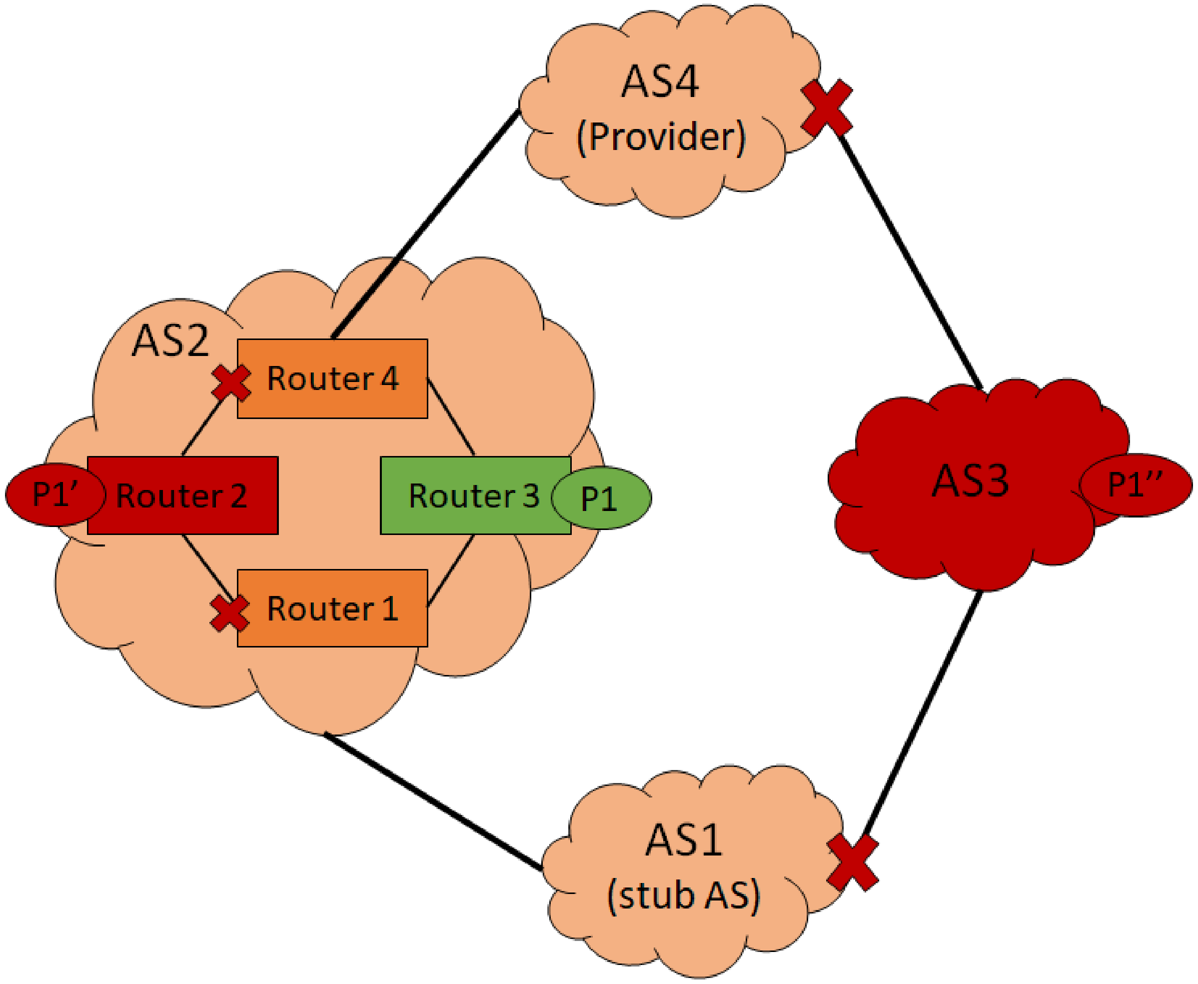
Source Address Validation Architecture (**SAVA**) [RFC5210] divides SAV into three checking levels and MANRS also follows this architecture:

- Access network SAV
  - ✓ Source Address Validation Improvement **(SAVI)** [RFC7039]
    - ➢ It is fully effective only when deployed by all access networks
- Intra-AS SAV
  - ACL based SAV [RFC2827]
  - Strict uRPF [RFC3704]
- Inter-AS SAV
  - EFP-uRPF [RFC8704]
  - Loose uRPF [RFC3704]



It is difficult to require all access networks to deploy SAVI simultaneously, so Intra-AS SAV and Inter-AS SAV are more encouraged by MANRS

Use cases: Intra-AS and Inter-AS SAV



P1 is the source address prefix of Router3
P1' is the spoofed P1 by Router2
P1'' is the spoofed P1 by routers in AS3

- Intra-AS SAV avoids source address spoofing from inner AS

  Router1 and Router4 should
  (1) drop the packet with P1' from Router2
  (2) accept the packet with P1 from Router 3

- Inter-AS SAV avoids source address spoofing from external ASes

  AS1 and AS4 should
  (1) drop the packet with P1'' from AS3
  (2) accept the packet with P1 from AS2

Existing intra- and inter-AS SAV mechanisms

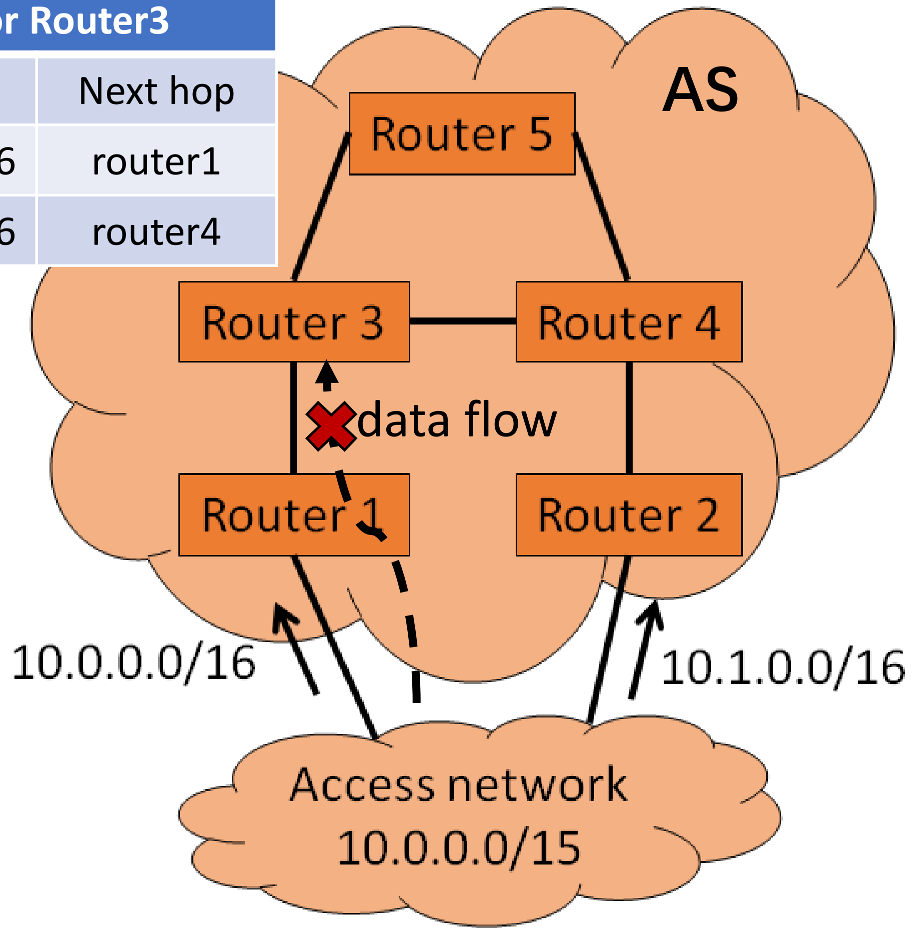
RFC8704 summarizes the recommendations concerning SAV mechanisms:

- Intra-AS SAV
  - ✓ **ACL based SAV** [RFC2827] configures matching rules to specify which source prefixes are acceptable
    - ➢ Require manual configuration to update
    - ➢ Lacks incentive
  - ✓ **Strict uRPF** [RFC3704] takes the source address as a destination address to lookup the FIB and requires the forwarding interface of the FIB matches the incoming interface of the packet
- Inter-AS SAV
  - ✓ **EFP-uRPF** [RFC8704] automatically sets a RPF(Reverse Path Filter) list on each **customer interface**
  - ✓ **Loose uRPF** [RFC3704] is implemented at **provider and peer interfaces**, which only requires the source address appears in the FIB

However, existing intra- and inter-AS uRPF mechanisms have inherent false positive or false negative problems

Gap analysis: Intra-AS SAV mechanisms

FIB for Router3	
Prefix	Next hop
10.0.0.0/16	router1
10.1.0.0/16	router4



Access network advertises 10.0.0.0/16 to Router 1 while advertises 10.1.0.0/16 to Router 2

Strict uRPF [RFC3704] exhibits false positives in the case of routing asymmetry

When Router3 forwards packets to 10.1.0.0/16

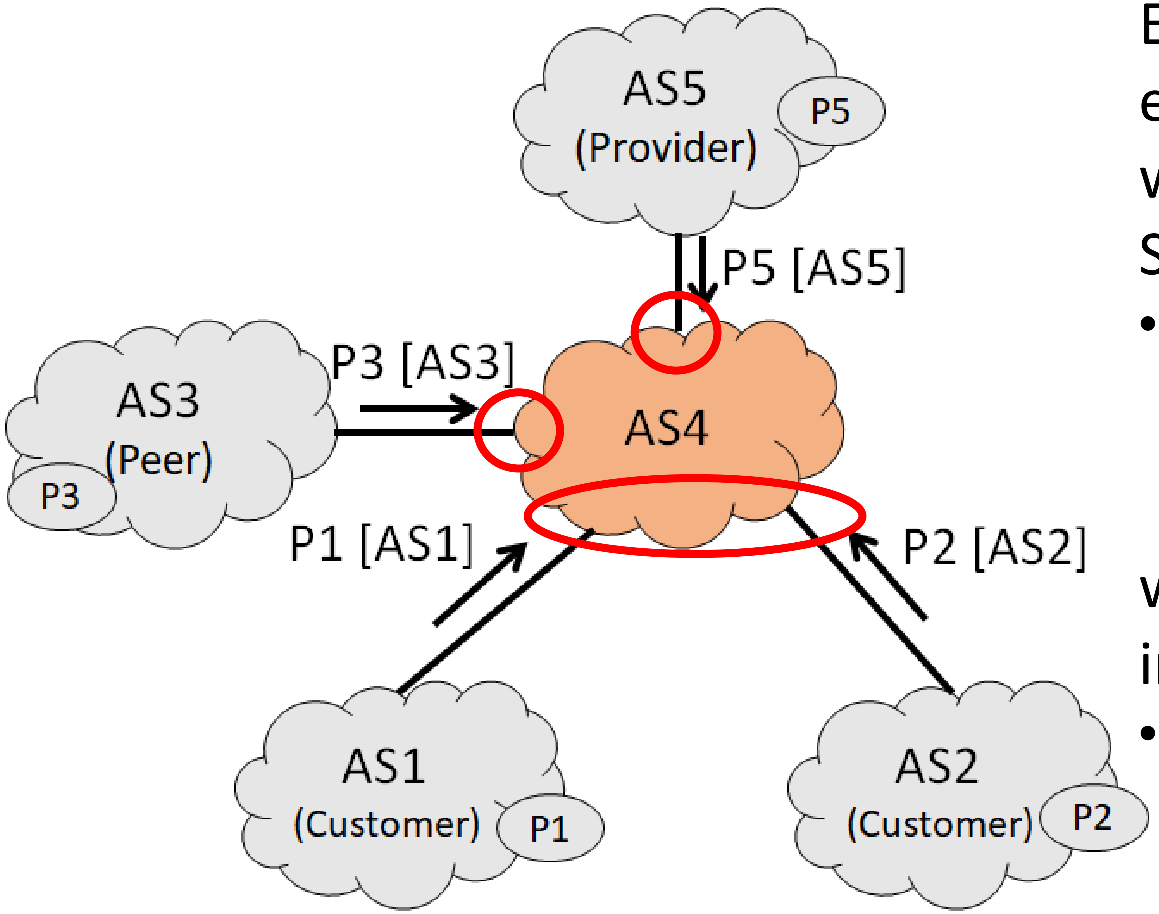
- Forwarding Path: Router3 → Router4 → Router2 → Access network
- Reverse Path: Access network → Router1 → Router3

When Router3 runs strict uRPF, the SAV rule is:

- Packets with source addresses of 10.1.0.0/16 must arrive from Router4
  - ✓ The reverse data flow will be dropped

Existing intra-AS SAV mechanism has false positive problems

Gap analysis: Inter-AS SAV mechanisms



EFP-uRPF [RFC8704] and loose uRPF [RFC3704] exhibit false negatives

when AS4 runs EFP-uRPF at customer interfaces, the SAV rule is:

- Packets with source addresses belonging to AS4's customer cone can arrive from every customer
  - ✓ ASes in AS4's customer cone (AS1 and AS2) can forge each other

when AS4 runs loose uRPF at provider and peer interfaces, the SAV rule is:

- Packets with any source addresses existing in FIB can arrive from every provider or peer
  - ✓ ASes outside AS4's customer cone (AS3 and AS5) can forge any source address in FIB

Existing inter-AS SAV mechanisms have false negative problems

Gap analysis: intra- and inter-AS SAV mechanisms

- An ideal SAV mechanism should guarantee accuracy
  - ✓ False positives cause legitimate traffic to be discarded
  - ✓ False negatives give attackers the freedom to forge source addresses

- All existing intra- and inter-AS SAV mechanisms cannot guarantee accuracy
  - ✓ Intra-AS SAV mechanisms have false positive problems
  - ✓ Inter-AS SAV mechanisms have false negative problems

- The root cause of their inaccuracy is that:
  - ✓ They all achieve SAV based on local FIB/RIB information which may not match the real data-plane forwarding paths from other sources

Design considerations

- In order to achieve high accuracy → Avoid false positives & Reduce false negatives as much as possible
  - ✓ SAV should follow the real data-plane forwarding path

- A path probing method
  - ✓ The source router sends probing packets carrying source information. Then each intermediate router can generate SAV rules based on <source information, incoming interface>
  - ✓ A combination of allowlist and blocklist can improve the accuracy when forwarding information is incomplete

- Requirements
  - ✓ High scalability
    - ➢ The design should not induce much overhead (e.g. bandwidth cost of path probing)
  - ✓ High deployability
    - ➢ The design should generate SAV table automatically and support incremental deployment
  - ✓ High security
    - ➢ The design should guarantee the integrity of each probing packet (e.g. man in the middle attack)

Next step

- Where to promote this work?
  - ✓ Intarea
    - ➢ SAVA (source address validation architecture) and SAVI (source address validation improvement) are adopted by intarea
  - ✓ RTG
    - ➢ Intra-AS SAV and inter-AS SAV are related to routing
  - ✓ Opsec
    - ➢ EFP-uRPF [RFC8704] is adopted by opsec
  - ✓ Others?

- Solicit comments and refine the draft

- Seek collaborators

THANKS!

Questions/Comments?