Gap Analysis, Problem Statement and Requirements for Source Address Validation in Intra-domain Networks

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Background

- Goals
  - Perform the gap analysis of existing intra-domain SAV mechanisms
  - Summarize the fundamental problems of existing intra-domain SAV mechanisms
  - Describe the requirements for new intra-domain SAV mechanisms
- Historical versions
  - **draft-li-savnet-intra-domain-problem-statement-00, IETF 114 SAVNET WG**
  - draft-li-savnet-intra-domain-problem-statement-01, Sep 25, 2022
  - draft-li-savnet-intra-domain-problem-statement-02, Oct 22, 2022
  - **draft-li-savnet-intra-domain-problem-statement-03, IETF 115 SAVNET WG**
  - draft-li-savnet-intra-domain-problem-statement-04, Nov 30, 2022
  - draft-li-savnet-intra-domain-problem-statement-05, Dec 15, 2022
  - draft-li-savnet-intra-domain-problem-statement-06, Feb 23, 2023
  - **draft-li-savnet-intra-domain-problem-statement-07, IETF 116 SAVNET WG**

Comments on Version-03

- Barry Greene: The impact of DOCSIS tools for SAV, TR-69 and FTTH tools for SAV, and DHCP Source Verify tools should be included in the Introduction section.
  - Response: They are all access network SAV tools. The updated draft introduces existing access network SAV tools and makes it clear that they are not the focus of SAVNET WG.
- Roland Dobbins: Should we focus on inter domain instead of intra domain?
  - Response: Both are in the scope of SAVNET WG. The updated draft describes the boundary between intra-domain and inter-domain SAV.
- Anthony: Why removed the part for misaligned incentive from intra-domain draft? Incentive problem is not technical, but a commercial one.
  - Response: First, incentive is actually a technical problem, i.e., the deployed AS can benefit from deployment. Second, incentive is mainly for inter-domain SAV. Third, we put incentive problem to an individual draft.

Comments on Version-03

- Jared Mauch: SAV may break more things than it can preventing, because the largest attack today doesn't come from spoofed packets.
  - Response: SAV is important for identifying and preventing various spoofing-based attacks. That is why communities (e.g., ISOC) and organizations (e.g., CAIDA) care much about the deployment of SAV. In recent years, the DDoS reports published by NetScout [1] and Cloudflare [2] have indicated that a significant proportion of DDoS attacks are based on source address spoofing.
- Jared Mauch: There are completely impossible things such as the entirety of 3.2 which must be striken in order to have a point to start with.
  - Response: It is worth of more discussion. The updated draft reframes the Requirement section to put requirements as which can be fully or partially fulfilled when designing new intra-domain SAV mechanisms.

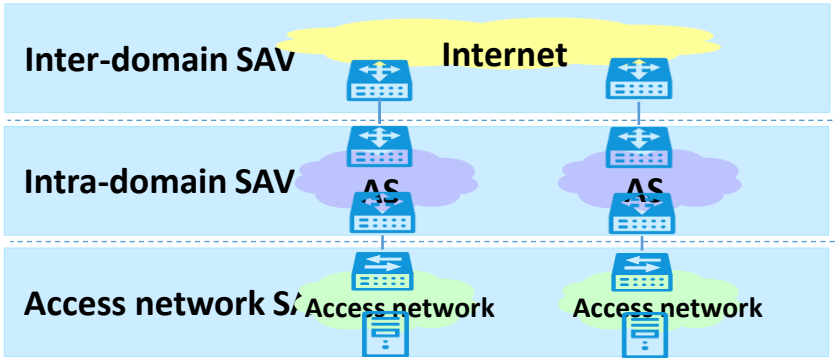
[1] DDoS THREAT INTELLIGENCE REPORT. https://www.netscout.com/threatreport/
[2] Cloudflare DDoS threat report for 2022 Q4. https://blog.cloudflare.com/ddos-threat-report-2022-q4/

Main Updates Compared to Version-03

- Updates in Introduction section
  - Introduce access-network SAV mechanisms
  - Goals of intra-domain SAV mechanisms
- A new Existing Mechanism section
- Updates in Gap Analysis section
- Updates in Problem Statement section
- Updates in Requirements section

Introduce Access Network SAV Mechanisms

- SAVA architecture [RFC 5210] divides SAV into three checking levels
  - Access network SAV, intra-domain SAV, inter-domain SAV



- Access network SAV ensures that a host uses a legitimate source IP address
  - Such as Static ACL, Dynamic ACL (e.g., RADIUS and DIAMETER), SAVI [RFC7039], SAVI solution for DHCP [RFC7513], IP Source Guard (IPSG), Cable Source-Verify
  - Not the main focus of SAVNET WG
- Access network SAV is not enough
  - Given numerous access networks managed by different operators in the Internet, it is difficult to require all access networks to deploy SAV
  - When some access networks do not deploy SAV, intra-domain and inter-domain SAV at routers can help block spoofing traffic as close to the source as possible
  - The main focus of SAVNET WG; IP-prefix-level instead of IP-address-level

Boundary between Intra-domain and Inter-domain SAV Mechanisms

Intra-domain SAV mechanisms

- An AS X defends against source address spoofing without the collaboration of other Ases (without information from other ASes)
  - Goal 1: prevent the outgoing traffic originated from a subnet of AS X from spoofing the addresses of other subnets
  - Goal 2: prevent the incoming traffic to AS X from spoofing the addresses of AS X

Inter-domain SAV mechanisms

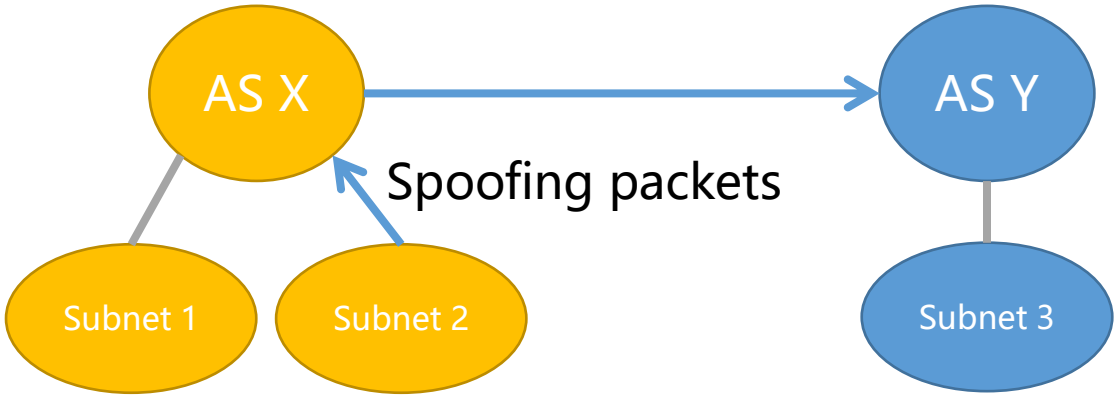
- Multiple ASes collaborate with each other for defending against source address spoofing (with information exchange between ASes)
  - An intermediate AS X helps defend against spoofing traffic originated from AS A which spoofs the addresses of AS B

Goals of Intra-domain SAV Mechanisms

- The intra-domain SAV for AS X has two goals:
  - Goal #1: outbound traffic validation
    - block the illegitimate packets originated from the local subnets of AS X which spoof the addresses of other subnets (either within the AS or other ASes)

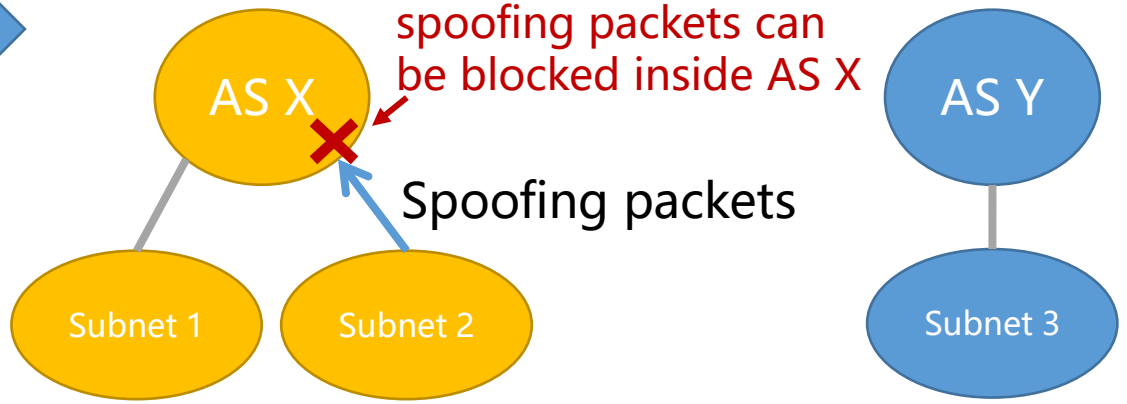
Case #1

Subnet 2 of AS X sends packets which spoof the addresses of subnet 1 or 3



Goal #1

If AS X deploys intra-domain SAV, the spoofing packets can be blocked inside AS X

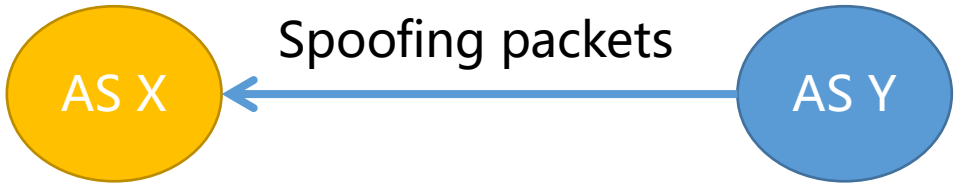


Function of Intra-domain SAV

- The intra-domain SAV for AS X has two goals:
  - Goal #1: outbound traffic validation
    - block the illegitimate packets originated from the local subnets of AS X which spoof the addresses of other subnets (either within the AS or other ASes)
  - Goal #2: inbound traffic validation
    - block the illegitimate packets coming from other ASes which spoof the source addresses of AS X

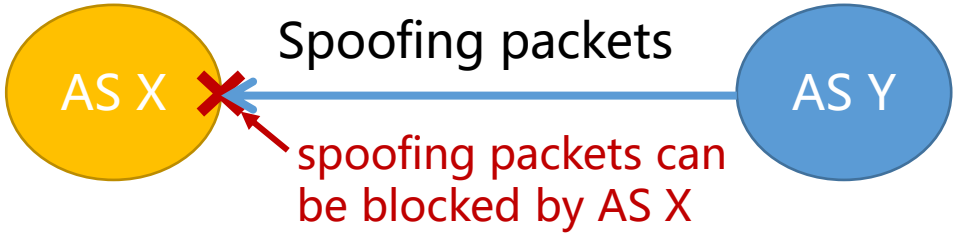
Case #2

AS X receives incoming packets which spoof AS X's addresses



Goal #2

If AS X deploys intra-domain SAV, the spoofing packets can be blocked by AS X



Main Updates Compared to Version-03

- Updates in Introduction section
- A new Existing Mechanism section
  - ◆Add more details about analyzing existing intra-domain SAV mechanisms
- Updates in Gap Analysis section
- Updates in Problem Statement section
- Updates in Requirements section

Existing Intra-domain SAV mechanisms

Ingress filtering [RFC2827, RFC3704] is the current practice of intra-domain SAV

- ACL-based SAV [RFC2827, RFC3704]
- Strict uRPF [RFC3704]
- Loose uRPF [RFC3704]
- Carrier Grade NAT

ACL-based SAV [RFC2827, RFC3704]

- Working principle
  - ACL rules can be configured for blocking or permitting packets with specific source addresses
- ACL-based SAV can work for both outbound traffic validation and inbound traffic validation
  - For outbound traffic validation
    - Applied at the downstream interfaces of edge routers connecting the subnets or at the downstream interfaces of aggregation routers
  - For inbound traffic validation
    - Applied at the upstream interfaces of routers connecting other ASes
- In any application scenario, ACL rules should be manually updated in time to be consistent with the latest filtering criteria

Strict uRPF [RFC3704]

- Working principle
  - The packet is permitted only when i) the local FIB contains a prefix encompassing the packet's source address, and ii) the corresponding outgoing interface for the prefix in the FIB matches the packet's incoming interface
- Strict uRPF usually works for outbound traffic validation
  - Applied at downstream interfaces of edge routers connecting local subnets
- Strict uRPF can generate and update SAV rules automatically, but has serious improper block problems in the scenario of asymmetric routing

Loose uRPF [RFC3704]

- Working principle
  - The packet is permitted if the local FIB contains a prefix encompassing the packet's source address
- Loose uRPF usually works for inbound traffic validation
  - Applied at upstream interfaces of routers connecting other ASes
- Loose uRPF can generate and update SAV rules automatically, but most spoofing packets will be improperly permitted

Carrier Grade NAT

- Working principle
  - If the source address of a packet is in the INSIDE access list, the NAT rule can translate the source address to an address in the pool OUTSIDE
- Carrier Grade NAT has some operations on source addresses of packets, but is not an anti-spoofing tool, as described in the MANRS Implementation Guide
  - The NAT rule cannot judge whether the source address is spoofed or not
  - The packet with a spoofed source address will be forwarded directly if the spoofed source address is not included in the INSIDE access list

Main Updates Compared to Version-03

- Updates in Introduction section
- A new Existing Mechanism section
- Updates in Gap Analysis section
  - Outbound traffic validation
  - Inbound traffic validation
- Updates in Problem Statement section
- Updates in Requirements section

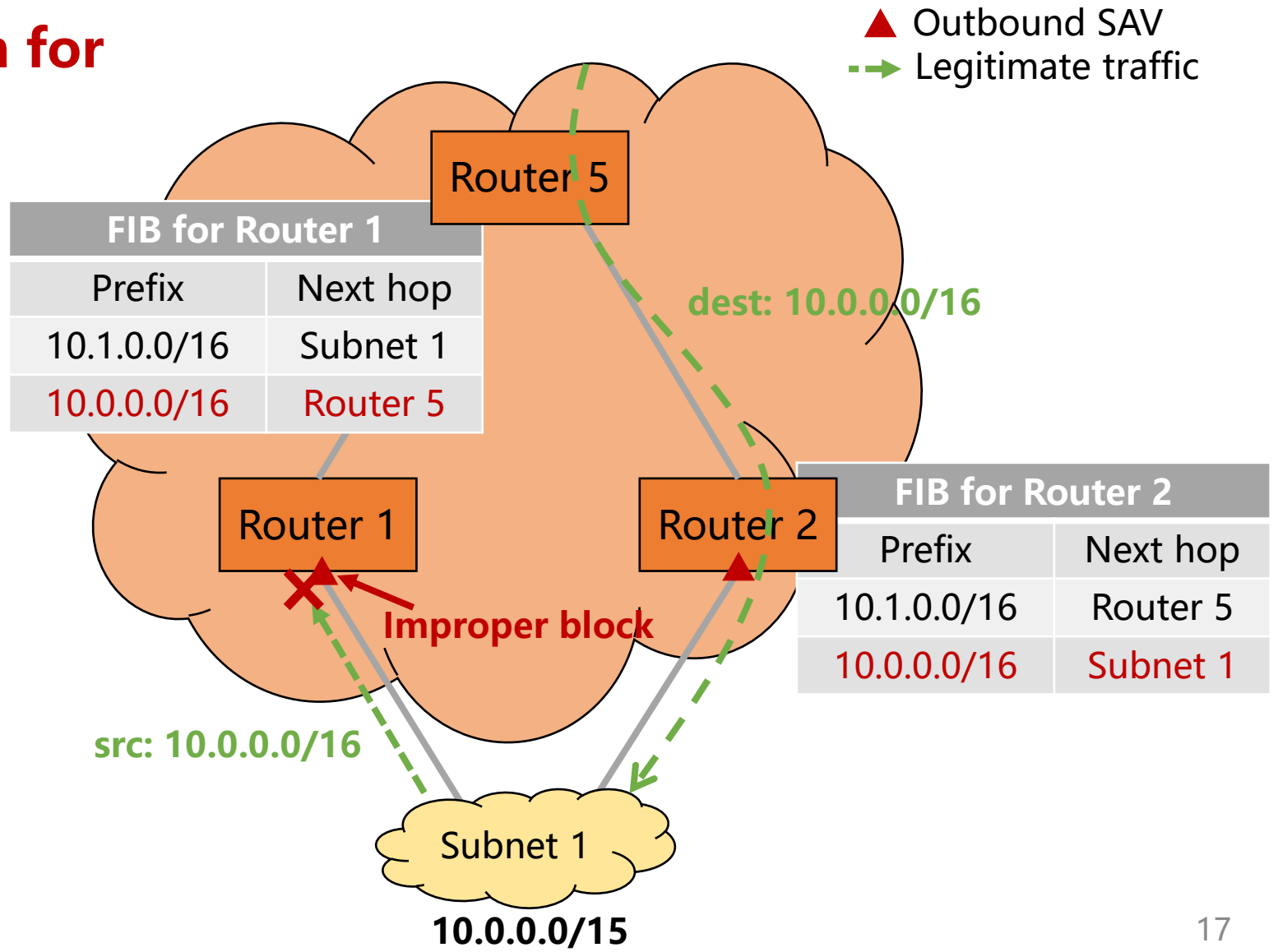
Outbound Traffic Validation

Outbound traffic validation for multi-homed subnet

- Router 1 only advertises 10.1.0.0/16 in IGP
- Router 2 only advertises 10.0.0.0/16 in IGP

Behavior

- If applying ACL-based SAV
  - Manual update given prefix or topology update in Subnet 1
- If applyiing strict uRPF
  - Improper block



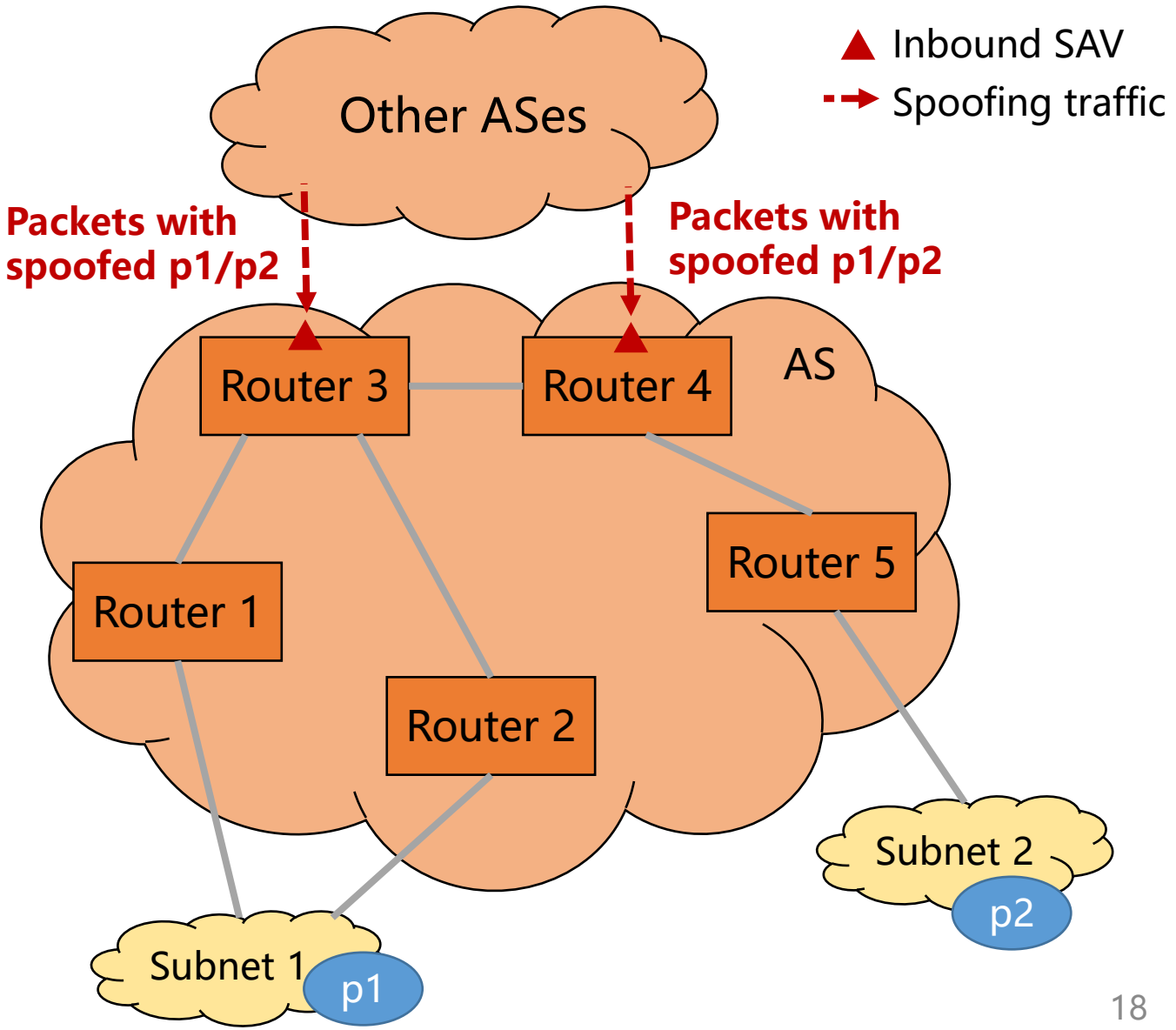
Inbound Traffic Validation

Inbound traffic validation

- Block inbound packets with internal source addresses at upstream interfaces

Behavior

- If applying ACL-based SAV
  - Manual update when internal prefixes or network topology change dynamically
- If applying loose uRPF
  - Large amount of improper permit



Main Updates Compared to Version-03

- Updates in Introduction section
- A new Existing Mechanism section
- Updates in Gap Analysis section
- Updates in Problem Statement section
  - ◆Remove the problem of “limited protection”
  - ◆Summarize the problem for each intra-domain SAV mechanism
- Updates in Requirements section

Problem Statement

- ACL-based SAV
  - Problem: high operational overhead
  - Reason: requiring manual update when network topology, IP prefix or routing rule changes
- Strict uRPF
  - Problem: improper block under asymmetric routing
  - Reason: conducting SAV based on local FIB which may not match the real data-plane forwarding path from the source
- Loose uRPF
  - Problem: large amount of improper permit
  - Reason: allowing packets with source addresses that exist in the FIB table at all router interfaces

Main Updates Compared to Version-03

- Updates in Introduction section
- A new Existing Mechanism section
- Updates in Gap Analysis section
- Updates in Problem Statement section
- Updates in Requirements section
  - ◆Add the requirement of “working in Incremental/Partial Deployment”
  - ◆Revise the description of other requirements

Requirements for New Intra-domain SAV Mechanisms

The requirements can be fully or partially fulfilled when designing new intra-domain SAV mechanisms

- Requirement #1: The mechanism MUST support automatic update
  - Automatically adapt to network dynamics instead of relying on manual update
- Requirement #2: The mechanism MUST improve the validation accuracy
  - Avoid improper block under asymmetric routing
    - Must include the real forwarding path in the data plane
  - Reduce improper permit as much as possible
    - By including the real forwarding path in the data plane, minimize the set of permittable paths
- Requirement #3: The mechanism SHOULD work in incremental/partial deployment
  - Provide effective protection when partially deployed in the intra-domain network

Acknowledgements

Many thanks to the valuable comments from:

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