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S. Wang
Zhongguancun Laboratory
D. Li
Tsinghua University
L. Chen
R. Li
Zhongguancun Laboratory
L. He
Tsinghua University

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Source Address Validation Deployment Status
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Abstract

This document provides a summary of methods for measuring the deployment status of source address validation, with an overview of its deployment status. It reviews various methods for measuring outbound and/or inbound source address validation, including established tools like CAIDA Spoofer, as well as recently proposed remote measurement methods. By combining results from these different methods, the document offers a comprehensive overview of the status of source address validation deployment across the Internet.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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1. Introduction

IP spoofing, sending packets with source addresses that do not belong to the sending host, is one of the long-standing security threats in the Internet. Source address validation (SAV) is important for protecting networks from IP spoofing attacks. Several techniques have been proposed to validate the source address of traffic, including Access Control List (ACL), unicast Reverse Path Forwarding (uRPF), and Virtual routing and forwarding (VRF) table. SAV can be categorized into two types: outbound SAV (OSAV) and inbound SAV (ISAV). OSAV discards spoofed packets originating from within a network and destined for external destinations, while ISAV focuses on filtering spoofed packets arriving from external sources to the

network.

The MANRS initiative considers IP spoofing as one of the most common routing threats, and defines a recommended action to mitigate spoofing traffic [manrs], encouraging network operators to implement SAV for their own infrastructure and end users, and for any Single-Homed Stub Customer Networks. However, as a recommended action, not all MANRS members follow this action to implement SAV for their networks, and only 1.6% of all routed ASes participate in MANRS. As a result, there is a lack of comprehensive knowledge regarding the current status of SAV deployment across the Internet community.

This document aims to provide a comprehensive view about SAV deployment in the Internet. The topics discussed in this document are organized into three main sections.

* Section 3 summarizes methods for measuring the deployment of OSAV.

* Section 4 summarizes methods for measuring the deployment of ISAV.

* Section 5 describes and analyzes the SAV deployment based on the measurement results derived from these methods.

1.1. Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

2. Terminology

Spoofed Packet:
: A packet with forged source IP address. That is, the source IP address of the packet is not the legitimate IP address assigned to the sender.

Outbound Spoofing:
: The behavior where a network does not discard spoofed packets sent from the network to the outside.

Inbound Spoofing:
: The behavior where a network does not discard spoofed packets sent from the outside to the network.

Outbound Source Address Validation (OSAV):

The mechanism that discards spoofed packets sent from a network to the outside of it.

Inbound Source Address Validation (ISAV):
The mechanism that discards spoofed packets sent from the outside of a network to it.

Filtering Granularity:
The granularity of source address validation. If filtering granularity is /8, the network allows packets to be sent with any address that belong to the same /8 prefix as its own address. However, if filtering granularity is /8, the network allows to receive packets with any address as the source address that belongs to a different /8 prefix than its own address.

Filtering Depth:
The deployment depth of souce address validation. If filtering depth is 3, the source address validation is deployed 3 hops away from the sender for OSAV.

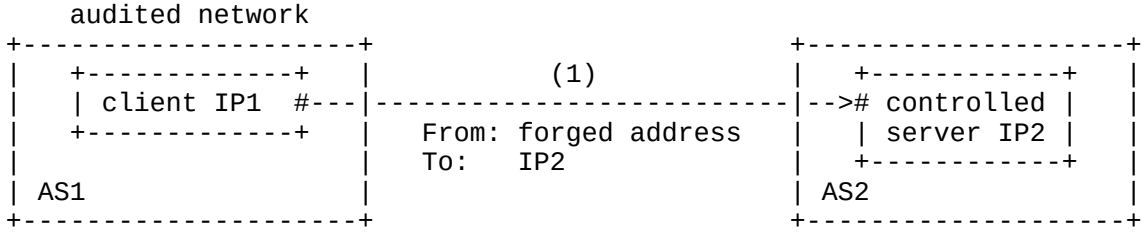
Authoritative DNS Nameserver (ADNS):
A DNS server that holds the definitive records for a domain and responds to DNS queries for that domain.

3. Outbound Source Address Validation Measurement Methods

To measure whether a network deploys OSAV, a common idea of different methods is to send spoofed packets from the network inside, and observe whether the spoofed packets reach the outside of the network. The SAV research community has proposed 3 methods for measuring OSAV deployment, i.e., client-based method, proxy-based method and DNAT-based method.

3.1. Client-based Method

As shown in Figure 1, by deploying a measurement client on a host in the audited network, the client can actively generate and send spoofed packets to the outside of the audited network. Hence, it is easy to learn whether spoofed packets have reached the outside of the network. Also, the client can set the time-to-live (TTL) of spoofed packets incrementally, and thus the forwarding path of the spoofed packets can be learned in a way like traceroute.



The client actively sends a set of spoofed packets to the controlled servers outside of the audited network.

Figure 1: An example of client-based OSAV measurement.

Benefiting from the controlbitly, a client can generate spoofed packets with arbitrary IP addresses as its source addresses. Hence, filtering granularity can be measured by observing which spoofed packets can reach outside of the audited network. Similarly, filtering depth can be measured by observing how far the spoofed packets reach.

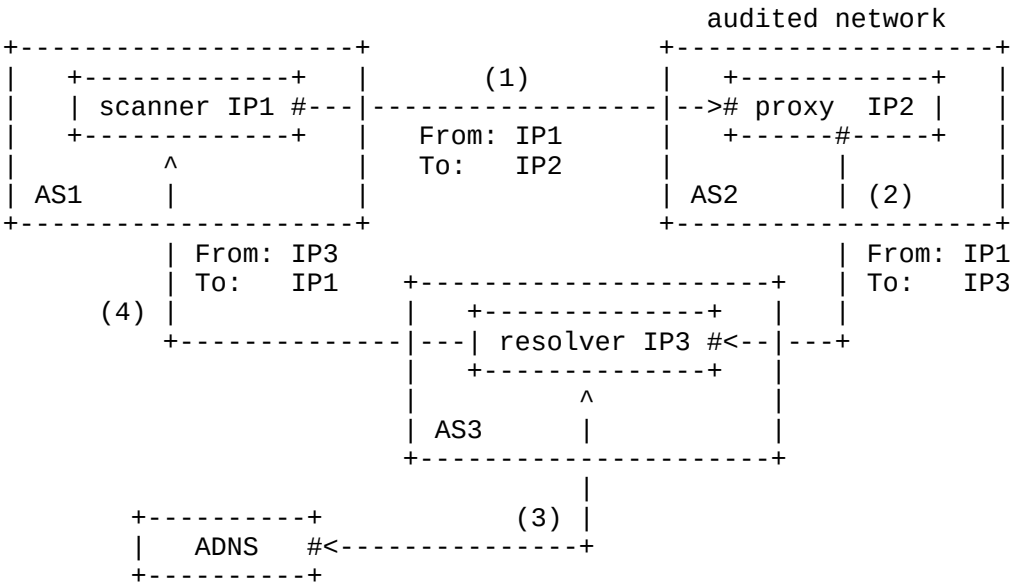
The most famous client tool is the CAIDA Spoofer project [spoofer], which re-launched in 2015. A CAIDA Spoofer client sends various spoofed packets to a set of servers maintained by the project, and based on the spoofed packets received by the servers, the project is able to infer the filtering granularity of SAV on paths traversed by these packets. The CAIDA Spoofer project employs tracefilter to measure where a SAV mechanism is deployed. Speicifically, a client sends spoofed packets with specially crafted TTLs, and when the packet's TTL expires, an ICMP TTL exceeded message will be sent to a controlled server. Based on the largest TTL among received ICMP messages, the project can infer the number of hops away from the client before spoofed packets are discarded.

The CAIDA Spoofer project relies on volunteers to spoof from many points in the network. If a volunteer installs the client within a Network Address Translation (NAT) network, CAIDA Spoofer will report the presence of a NAT device, and thus spoofed packets may be blocked by the NAT devices, rather than a SAV mechanism. Due to the wide deployment of NAT, though more than two thousands ASes were tested by the CAIDA Spoofer project in 2024, only about half of them were tested based on public IP addresses.

The KI3 SAV-T project [savt] also started supporting OSAV measurements in 2024 and has promoted these measurements via crowdsourced testing platforms.

3.2. Proxy-based Method

[dns-proxy] relies on misbehaving DNS proxies to perform remote measurement of IP spoofing. As illustrated in Figure 2, the measurement conducter controls a scanner, a DNS authoritative nameserver, and a domain name, but does not have control over the audited network. The scanner first sends a DNS query for the domain name to a DNS proxy in the audited network, i.e., the destination IP address of the DNS query is the DNS proxy. However, due to the misbehaviors of the DNS proxy, it will forward the query to a DNS resolver without changing the source IP address of the query. In this way, the DNS proxy creates a spoofed packet whose source IP address does not belong to the audited network. If the spoofed packet is not discared along the path, the DNS resolver will communicate with the controlled authoritative nameserver to resolve the domain name. Finally, the DNS resolver will directly respond to the scanner, since the source IP address of the DNS query received by the DNS resolver is the scanner. Hence, if the scanner receives a DNS response whose source address is different from the destination address of the DNS query, the network is considered to have no OSAV deployment.



The scanner sends a DNS query with IP1 as the source to the DNS proxy (IP2). The proxy forwards the query to the DNS resolver, with the source IP address remaining as IP1. The resolver resolves the domain name using the authoritative name servers and responds directly to the scanner.

Figure 2: An example of proxy-based OSAV measurement.

Note that the IP address of the DNS proxy is also encoded into the domain name before sending to the DNS proxy, so that a DNS response can be matched with the corresponding DNS query. In addition, there is no need to find misbehaving DNS proxies before sending DNS queries to them. Instead, we can send DNS queries directly to all the routable address space one by one. If the destination address of a DNS query is used by a misbehaving DNS proxy, the scanner will receive a DNS response with an unexpected source address.

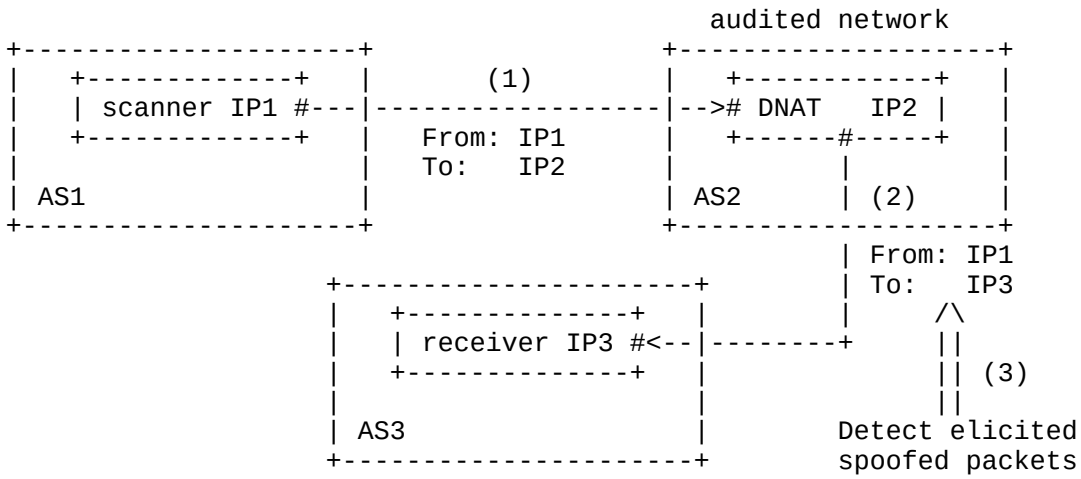
Proxy-based method can efficiently identify networks that do not deploy OSAV in a remote manner, but fails to identify networks that deploy OSAV. This is because, if OSAV is deployed in the audited network, the scanner will receive no DNS response, which is indistinguishable from the absence of a DNS proxy in the audited network.

3.3. DNAT-based Method

[DNAT] improves the proxy-based method by extending more than DNS protocol, identifying the deployment location of OSAV, and identifying the filtering granularity. Specifically, [DNAT] first figures out that the root cause of misbehaving DNS proxies is misconfigured destination NAT (DNAT) devices. As shown in Figure 3, when a packet matches DNAT rules, the DNAT device changes the packet’s destination to a preset address, while leaving the source address unchanged. Hence, to improve measurement coverage, DNAT-based method can also utilize other protocols, such as Network Time Protocol (NTP) and TCP protocol, to trigger the audited network into sending spoofed packets.

DNAT-based method identifies the filtering depth in a similar way to tracefilter. As DNAT devices do not reset the TTL field when forwarding packets, the fowarding path taken by spoofed packets can be learned by gradually incrementing the initial TTL values in original packets. The last responsive hop is considered as the position where filtering happens.

To identify the filtering granularity, the scanner sends multiple original packets with various source IP addresses. By using addresses adjacent to IP2 as the source addresses, the DNAT device will send spoofed packets with these addresses. Hence, packets that use forged addresses within the filtering granularity as source address will reach the receiver IP3.



The scanner sends a packet sourced with IP1 to the DNAT device (IP2). The packet will elicit a spoofed packet sourced with IP1 and destined to IP3.

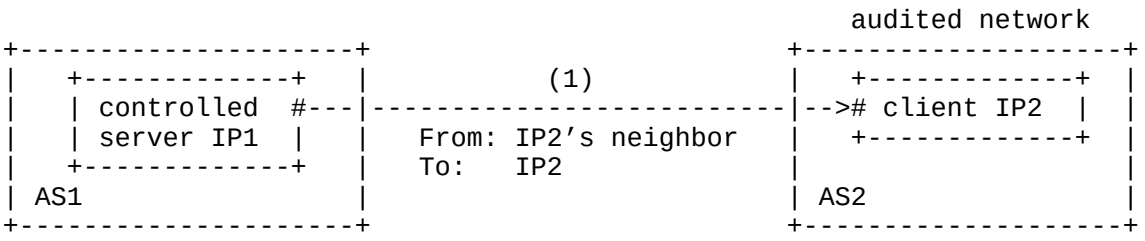
Figure 3: An example of DNAT-based OSAV measurement.

4. Inbound Source Address Validation Measurement Methods

The core idea of measuring whether a network deploys ISAV is to first send some spoofed packets to the target network and then observe whether the spoofed packets arrive inside of the target network. Since ISAV measurement does not require hosts in the audited network to generate spoofed packets, it is easier to measure ISAV deployment than OSAV. The SAV research community has proposed 5 methods for measuring OSAV deployment, i.e., client-based method, resolver-based method, ICMPv6-based method, IPID-based method and PMTUD-based method.

4.1. Client-based Method

As shown in Figure 4, by deploying a measurement client on a host in the audited network, client-based method can use a controlled server to send a spoofed packet to the client. The spoofed packets use an IP addresses adjacent to IP2 as its source IP addresses. If the client receives the spoofed packet, then the audited network has not deployed ISAV. Otherwise, the audited network has deployed ISAV.



The controlled server sends a spoofed packet to the client, and then client reports whether it has received the spoofed packets.

Figure 4: An example of client-based ISAV measurement.

Both the CAIDA Spoofer project [spoofer] and the KI3 SAV-T project also support ISAV measurements, which, like OSAV measurements, rely on volunteers. When volunteers install the client, both ISAV and OSAV measurements are performed on the audit network. However, if the client is installed within a NAT network, it becomes inaccessible from outside the network, even without spoofed addresses. As a result, client-based methods cannot measure ISAV deployments in this case.

4.2. Resolver-based Method

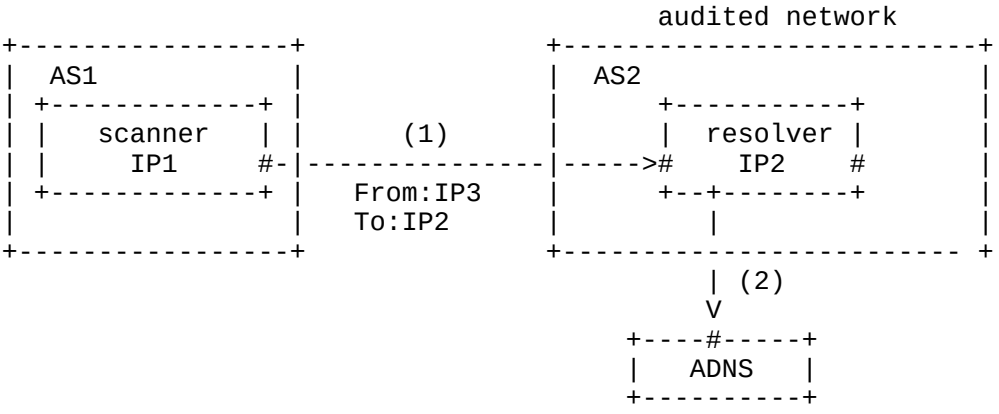


Figure 5: An example of resolver-based ISAV measurement.

Figure 5 shows an example of resolver-based ISAV measurement [dns-resolver]. The scanner in AS1 sends a DNS query with a forged IP address IP3, which belongs to the audited network (AS2), to a DNS resolver in AS2. If the audited network does not deploy ISAV, the DNS resolver will receive the spoofed DNS query. Next, the DNS resolver will send another DNS query to our controlled ADNS for

resolution. Therefore, if the controlled ADNS receives the DNS query from the DNS resolver in the audited network, the audited network AS2 does not filter the spoofed packets.

However, if the controlled ADNS does not receive the DNS query, we can not assume that the audited network filters the spoofed packets, since there may be no DNS resolver in the audited network. To futher identify networks that filter inbound spoofing traffic, we send a non-spoofed DNS query from the scanner to the same target IP address. If the controlled ADNS receives a DNS query triggered by the non-spoofed DNS query, a DNS resolver exists in the audited network. As a result, if the DNS resolver does not resolve the spoofed query, we can conclude that the audited network deploy ISAV.

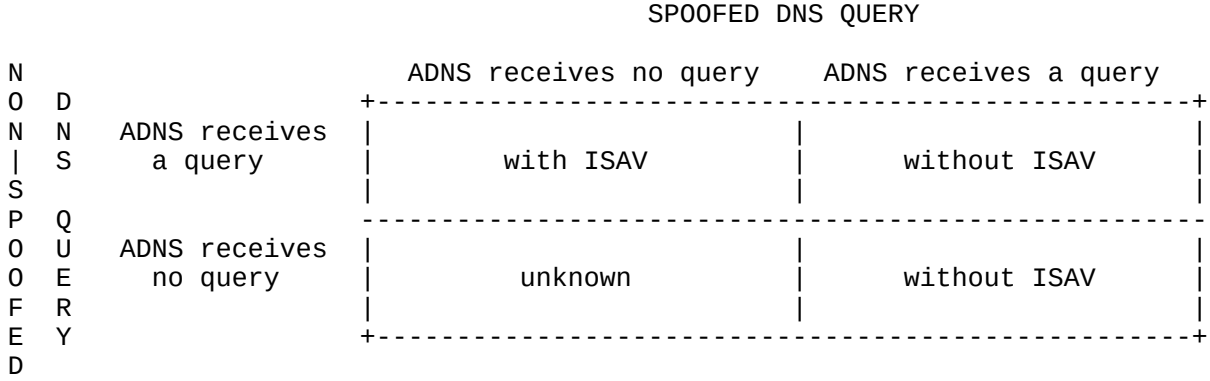


Figure 6: Classification of results based on DNS resolvers.

As illustrated in Figure 6, there are four cases when combining spoofed DNS query and non-spoofed DNS query.

* First, the ADNS receives DNS queries in both spoofing scan and non-spoofing scan, suggesting that the audited network does not deploy ISAV, and the DNS resolver is open.

* Second, the ADNS receives the DNS query only in spoofing scan, suggesting that the audited network does not deploy ISAV, and the DNS resolver is closed.

* Third, the ADNS receives the DNS query only in non-spoofing scan, suggesting that the audited network deploys ISAV.

* Fourth, the ADNS does not receive any DNS query. This suggests that no DNS resolver in the audited network can be utilized to measure ISAV deployment.

4.3. ICMPv6-based Method

As suggested by [RFC4443], in order to limit the bandwidth and forwarding costs incurred by originating ICMPv6 error messages, an IPv6 node MUST limit the rate of ICMPv6 error messages it originates. This provides an opportunity to infer whether the spoofed packets arrive inside of the audited network based on the state of ICMPv6 rate limiting. Since most of IPv6 addresses are inactive, an ICMP error message will be fed back from Customer Premises Equipment (CPE) devices when we send an ICMP echo request to a random IP address in the audited network. If the CPE device limits the rate of ICMPv6 error messages it originates, it can be utilized as a vantage point (VP).

Figure 7 illustrates the ICMPv6-based measurement method [ICMPv6]. We have a local scanner P1 in AS1, and AS2 is the audited network. Three rounds of testing with N and N+M ICMP echo requests packets are conducted in the measurement, and thus three values rcv1, rcv2, and rcv3 can be obtained respectively. Based on this, we can infer whether the audited network filters the spoofed packets by comparing rcv1, rcv2, and rcv3.

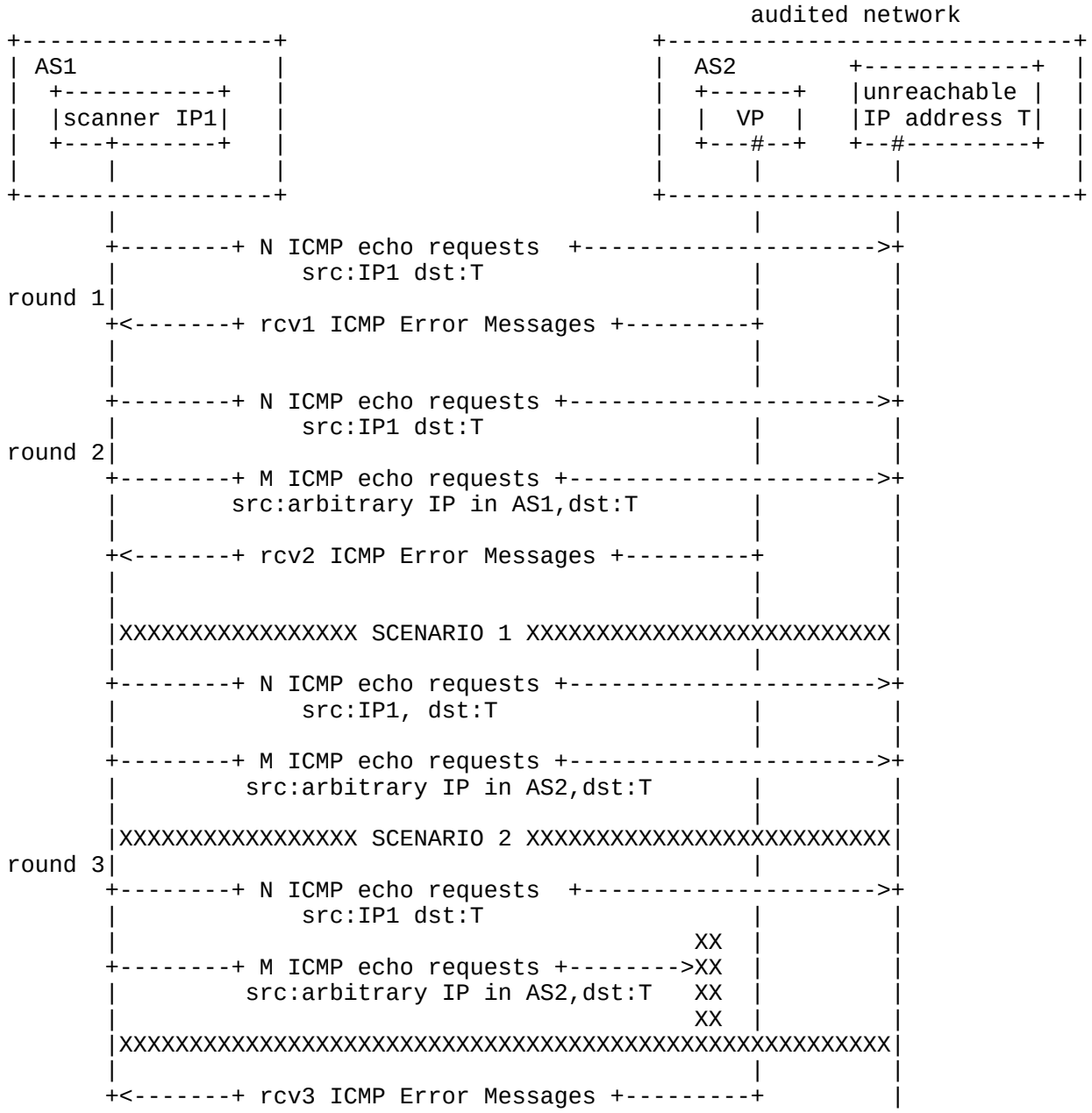


Figure 7: An example of ICMPv6-based ISAV measurement.

As illustrated in Figure 7, in the first round test, N ICMP echo requests are sent to a target with inactive IPv6 address in the audited network, and then VP will resposnd with rcv1 ICMP error messages to the scanner. In the second round test, besides the same N probe packets, extra M ICMP echo requests with forged source address that belongs to AS1 (noise packets) are sent to the target simultaneously. The number of ICMP error messages in the second round test are defined as rcv2. Similar to the second round test, in the third round test, M ICMP echo requests with forged source address that belongs to AS2 (spoofed packets) are sent to the target. The number of ICMP error messages in the third round test are defined as rcv3.

Comparing rcv1 and rcv3, if rcv1 > rcv3, it can be considered that the spoofed packets are not filtered in the third round test, suggesting that the audited network allows inbound spoofing. Comparing rcv2 and rcv3, if rcv2 < rcv3, it can be inferred that the target network has filtered the spoofed packet in the third round test, and thus is able to filter inbound spoofing traffic. The ability of filtering inbound spoofing traffic can be inferred according to the following rules.

* If rcv3 < a*rcv1, then the network allow inbound spoofing;

* Else if rcv2 < a*rcv3, then the network does not allow inbound spoofing;

* Else, the ability of filtering inbound spoofing traffic cannot be determined.

where a is a factor to avoid potential interference from fast-changing network environments, satisfying 0 < a < 1.

4.4. IPID-based Method

The core observation of using IPID to measure ISAV is that the globally incremental IPID value leaks information about traffic reaching the server[SMap]. Given a server in the audited network with a globally incremental IPID, the scanner samples the IPID value using its own IP address by sending packets to the server and receiving responses. Then, the scanner sends a set of packets to the server using a spoofed IP address that belongs to the audited network, i.e., an IP address adjacent to IP2. Afterward, the scanner sends another packet using its IP address to probe the IPID value again. If the spoofed packets reached the server, they would have incremented the server’s IPID counter. As a result, this increment can be inferred during the second IPID probe from the scanner’s IP address.

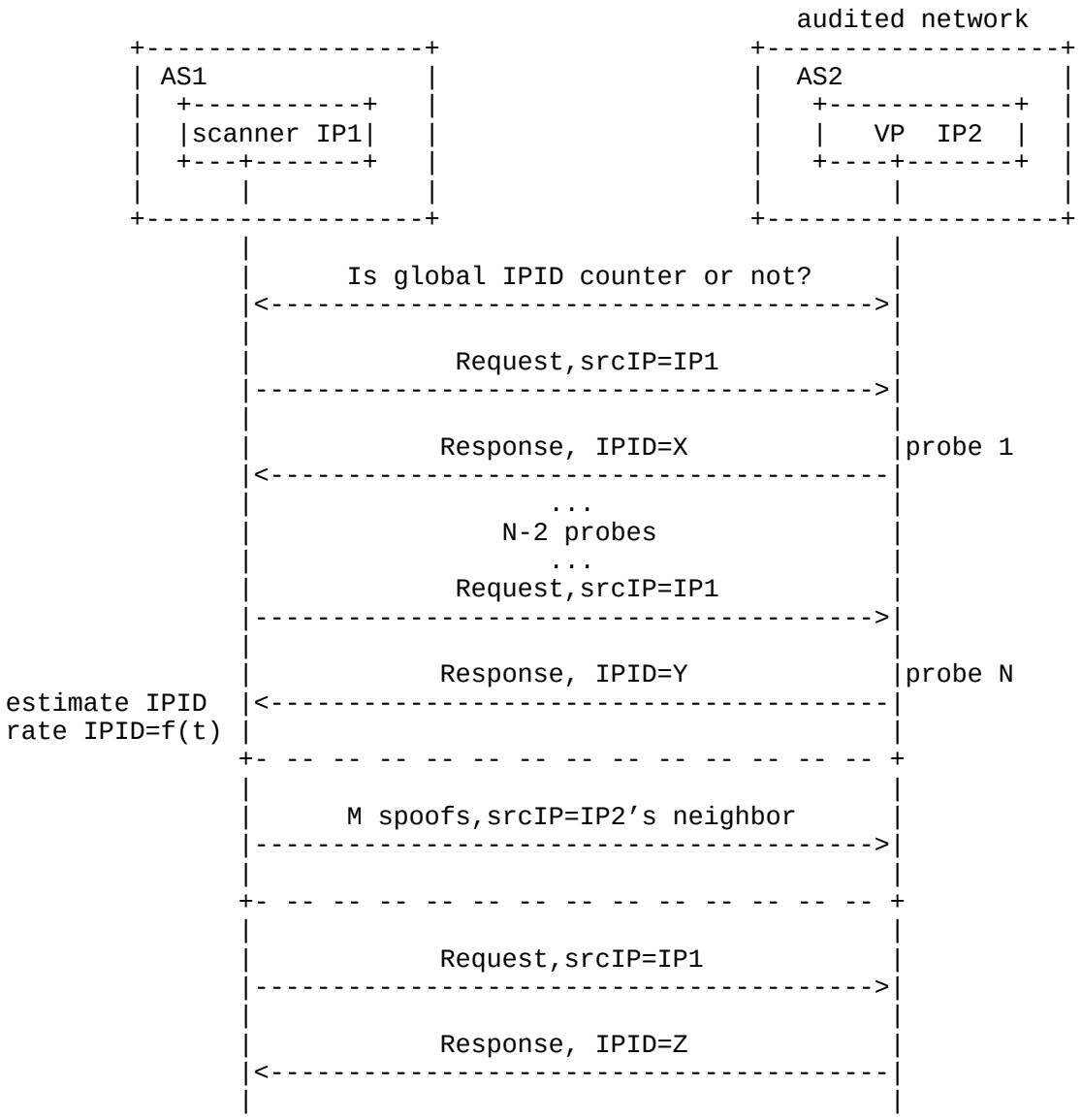


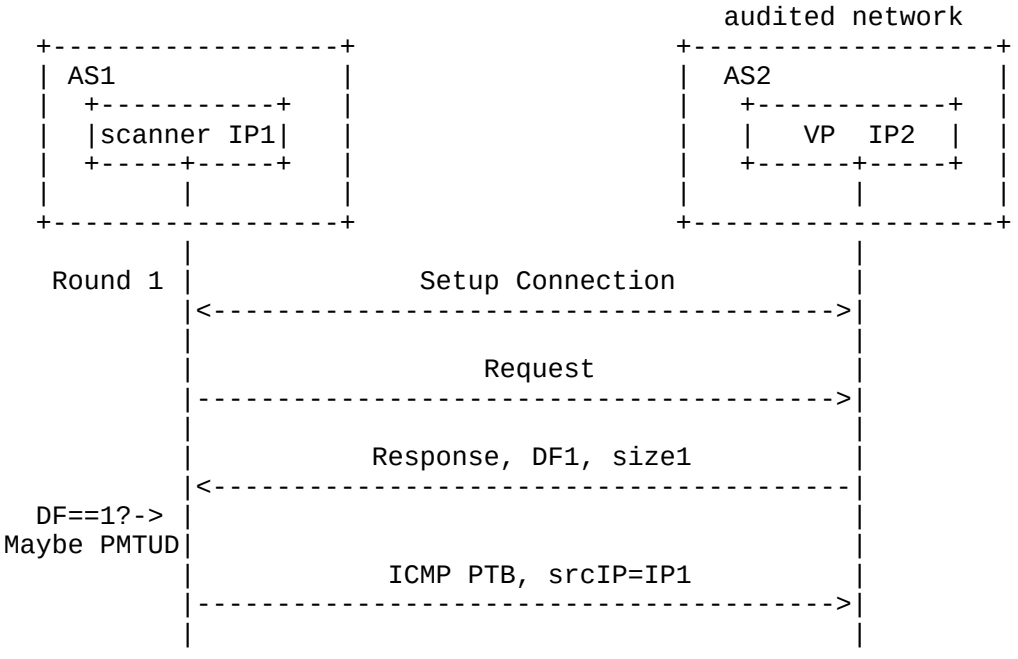
Figure 8: An example of IPID-based ISAV measurement.

Figure 8 illustrates the measurement process of ISAV based on global IPID. First, the scanner measures the current IPID value and the rate of IPID increments. Ordinary Least Squares (OLS) linear regression can be used to estimate the relationship between the IPID and the timestamp t: IPID = a*t + b + ε , ε N (0, σ^2). Next, N probes are sent to the VP. With these N probes, the parameters a, b,

and σ can be estimated using the OLS method. Then, a group of M = 6 * σ packets with a spoofed source IP address are sent to the audited network. Finally, the IPID value Z from the VP is sampled by using IP1 as source address, while the IPID value W at that moment can be estimated using the linear regression model. If the M spoofed packets are filtered, according to the 3-sigma rule, there is a 99.73% probability that the following condition holds: W - 3 * σ Z W + 3 * σ . If the spoofed packets are not filtered, meaning the audited network has not deployed ISAV, the IPID counter will increase by M. In this case, Z > W + 3 * σ , or equivalently, Z > W + M/2.

4.5. PMTUD-based Method

The core idea of the Path MTU Discovery (PMTUD) method is to send ICMP Packet Too Big (PTB) messages with a spoofed source IP address that belongs to the audited network [SMap]. The real IP address of the scanner is embedded in the first 8 bytes of the ICMP payload. If the network does not deploy ISAV, the server will receive the PMTUD message and reduce the MTU for the IP address specified in the first 8 bytes of the ICMP payload. First, probe the MTU of the service in the audited network. Then, send an ICMP PTB message from a spoofed IP address. If the packet reaches the service, it will reduce the MTU for the scanner's IP address. This reduction will be identified in the next packet received from the service, indicating that the audited network does not deploy ISAV.



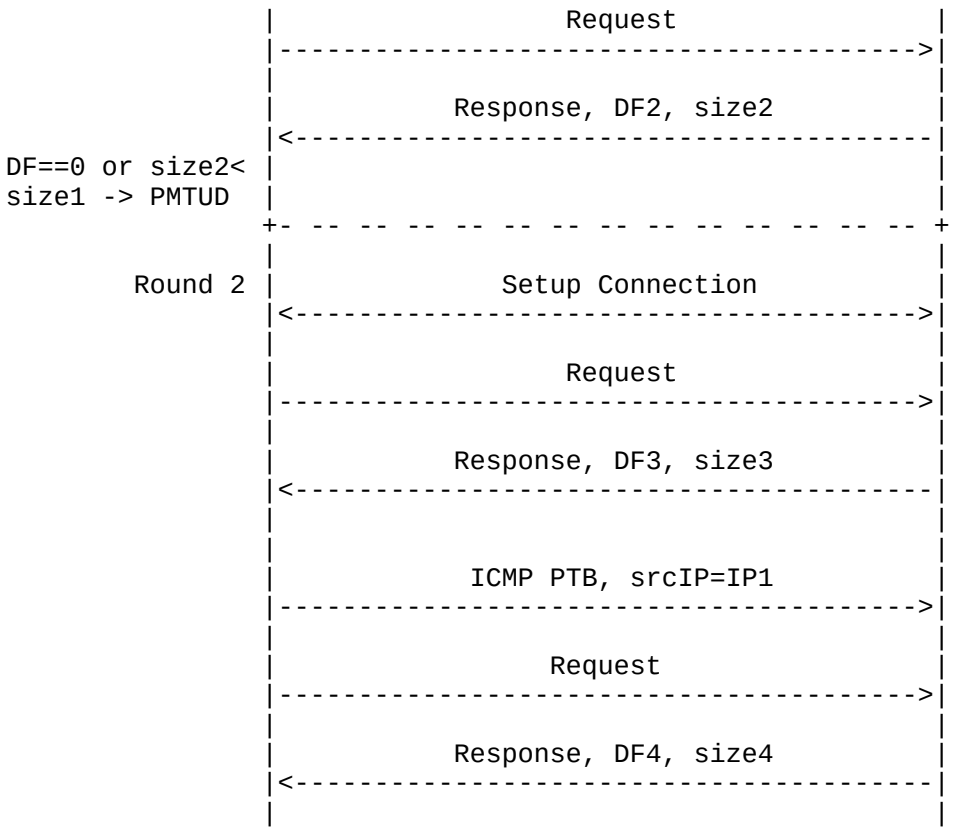


Figure 9: An example of PMTUD-based ISAV measurement.

Figure 9 illustrates the measurement process of ISAV based on PMTUD. First, establish a TCP connection with the server in the audited network. Then, send Request1 and receive Response1. If the DF (Don't Fragment) bit is not set, the server does not support PMTUD. Otherwise, send an ICMP PTB message with a smaller MTU. Next, issue another request and receive Response2. If DF1 == 1 and (DF2 == 0 or size2 size1), the server supports PMTUD. Now, proceed to test whether ISAV is deployed. Use the neighbor's IP address of the server as the source IP address to spoof an ICMP PTB with the smallest MTU. After that, issue another request. If the following condition is observed, the server is not protected by ISAV: size4 size3 or (DF3 == 1 and DF4 == 0).

5. Deployment Status

5.1. Global Picture

In January 2026, we used the above methods to measure SAV deployment in the Internet. ASes are classified into three deployment states based on measurement observations: Deployed, indicating that SAV was consistently observed across all available measurements; Not Deployed, indicating that SAV was not observed in any of our measurements; and Partially Deployed, indicating inconsistent observations across measurements, where SAV was detected in some cases but not in others. The same classification is also applied at the IP prefix level.

As shown in Figure 10 and Figure 11, 66.6% of IPv4 and 80.5% of IPv6 ASes lacked any ISAV deployment. Partial deployment was observed in 29.6% of IPv4 and 15.1% of IPv6 ASes, which may indicate that ISAV is selectively deployed, for example at access-facing interfaces.

Category	IPv4 ASNs	IPv6 ASNs
Deployed	1,465 (3.9%)	352 (4.4%)
Not Deployed	25,319 (66.6%)	6,490 (80.5%)
Partially Deployed	11,255 (29.6%)	1,217 (15.1%)

Figure 10: ISAV deployment status across IPv4 ASes and IPv6 ASes.

Category	IPv4 Prefixes	IPv6 Prefixes
Deployed	189,321 (24.4%)	48,864 (12.6%)
Not Deployed	539,649 (69.7%)	277,610 (71.7%)
Partially Deployed	45,626 (5.9%)	60,944 (15.7%)

Figure 11: ISAV deployment status across IPv4 /24 and IPv6 /48 prefixes.

Figure 12 and Figure 13 illustrate notable differences in OSAV deployment between IPv4 and IPv6 networks. Only 11.0% of IPv4 ASes and 11.2% of IPv4 /24 prefixes exhibit consistent OSAV deployment. However, IPv6 networks show substantially higher observable OSAV deployment ratios. This discrepancy may be influenced by measurement coverage limitations. Specifically, OSAV deployment in IPv6 networks is currently observable only via the client-based method, while other measurement methods used for IPv4 OSAV are not applicable to IPv6.

Category	IPv4 ASNs	IPv6 ASNs
Deployed	290 (11.0%)	387 (80.5%)
Not Deployed	2,272 (85.8%)	62 (12.9%)
Partially Deployed	86 (3.2%)	32 (6.7%)

Figure 12: OSAV deployment status across IPv4 and IPv6 ASes.

Category	IPv4 Prefixes	IPv6 Prefixes
Deployed	795 (11.2%)	2,904 (96.0%)
Not deployed	6,211 (87.7%)	112 (3.7%)
Partially Deployed	73 (1.0%)	10 (0.3%)

Figure 13: OSAV deployment status across IPv4 /24 and IPv6 /48 prefixes.

Figure 14 presents the filtering granularity observed for OSAV deployment in IPv4 networks. Prefix lengths between /16 and /24 account for 67.71% of the observed deployment, corresponding to common IPv4 allocation units for ASes. This distribution is consistent with OSAV being predominantly deployed at AS border routers, where filtering is typically performed using aggregated address blocks, rather than at access-facing routers that would require finer-grained prefix filtering.

Granularity	Percentage
/8	0.00 %
/9	0.00 %
/10	0.62 %
/11	0.00 %
/12	2.48 %
/13	0.62 %
/14	0.62 %
/15	4.35 %
/16	17.39 %
/17	5.59 %
/18	3.73 %
/19	5.59 %
/20	5.59 %
/21	3.11 %
/22	9.32 %
/23	5.59 %
/24	11.80 %
/25	4.35 %
/26	4.35 %
/27	2.48 %
/28	4.35 %
/29	4.97 %
/30	2.48 %
/31	0.62 %

Figure 14: OSAV filtering granularity in IPv4 networks.

Figure 15 shows the observed filtering granularity for ISAV deployment. Notably, 44.48% of networks implement spoofing filters at /29/30 granularity, which is consistent with the recommendations in IETF BCP 38. This pattern suggests that ISAV is predominantly deployed at access-facing interfaces, where fine-grained prefix filtering is operationally feasible.

Granularity	Percentage
/8	0.50 %
/9	2.26 %
/10	5.31 %
/11	4.86 %
/12	4.57 %
/13	3.58 %
/14	3.64 %
/15	7.41 %
/16	2.59 %
/17	2.67 %
/18	2.09 %
/19	1.57 %
/20	1.16 %
/21	2.28 %
/22	1.45 %
/23	2.73 %
/24	1.47 %
/25	1.02 %
/26	1.27 %
/27	1.31 %
/28	1.78 %
/29	24.53 %
/30	19.95 %

Figure 15: ISAV filtering granularity in IPv4 networks.

Figure 16 characterizes the depth of OSAV filtering. We observe that 96.28% of OSAV deployment occurs within 2 IP hops from the traffic source, with no observable deployment beyond 10 hops. This result suggests that OSAV is typically enforced close to network edges.

Hop	Percentage
1	87.55 %
2	8.73 %
3	1.21 %
4	0.61 %
5	0.61 %
6	0.52 %
7	0.52 %
8	0.17 %
9	0.09 %
10	0.00 %

Figure 16: OSAV filtering depth in IPv4 networks.

5.2. Deployment in Countries/Regions

The global distribution of SAV deployment is summarized in Figure 17 and Figure 18. We analyze the top 20 countries/regions with the most tested prefixes and observe distinct deployment patterns. Canada, China, and the United States exhibit relatively higher OSAV deployment ratios, while India, Bangladesh, and Ecuador show limited observable OSAV deployment. Brazil also exhibits relatively low OSAV deployment ratios with 2,210 prefixes tested. ISAV deployment remains limited in most regions; however, South Korea and Egypt stand out as notable exceptions with substantially higher ISAV deployment ratios.

Note that these ratios should not be interpreted as rankings, as measurement coverage vary significantly across countries.

Country	ISAV Tested Prefixes	ISAV Deployment Ratio
KR	45,709	73.9%
EG	9,923	71.4%
TW	11,757	68.6%
VN	9,101	55.5%
PL	12,921	53.3%
FR	14,123	43.8%
DE	17,631	27.3%
US	180,683	24.7%
CA	9,507	23.8%
BR	26,366	22.7%
GB	10,883	18.7%
RU	45,055	15.7%
AU	11,022	14.3%
JP	23,134	12.5%
IT	15,400	10.5%
IN	16,891	7.1%
CN	96,451	5.9%
ID	13,797	5.4%
MX	11,193	4.7%
DZ	11,093	0.9%

Figure 17: ISAV deployment among countries/regions.

Country	OSAV Tested Prefixes	OSAV Deployment Ratio
CA	114	50.0%
CN	130	43.1%
US	339	41.6%
CZ	61	26.2%
ES	43	23.3%
PL	59	20.3%
TR	213	19.7%
MX	36	19.4%
IT	119	9.2%
RU	74	5.4%
PK	98	5.1%
ZA	65	4.6%
BR	2,210	3.7%
ID	382	3.4%
NG	36	2.8%
AR	216	1.9%
PA	77	1.3%
IN	1,276	1.2%
BD	584	0.0%
EC	71	0.0%

Figure 18: OSAV deployment among countries/regions.

5.3. Comparison between ISAV and OSAV

Figure 19 and Figure 20 compare ISAV and OSAV deployment across ISP ASes, selecting the top 20 ASs with the most tested prefixes.

For ISAV, several large providers, including Chunghwa Telecom (AS3462), SK Broadband (AS9318), Korea Telecom (AS4766), Telecom Egypt (AS8452), Charter Communications (AS10796, AS20115), and Comcast Cable Communications (AS7922), exhibit high deployment ratios.

For OSAV, a smaller number of ASes, such as DigitalOcean (AS14061) and China Telecom (AS4134), demonstrate high OSAV deployment ratios across their tested /24 prefixes. Note that some ASes have relatively small numbers of tested prefixes, which may amplify extreme deployment ratios.

ASN	ISAV Tested Prefixes	ISAV Deployment Ratio
3462	8,462	93.3%
9318	7,537	91.8%
4766	26,312	90.3%
8452	6,523	84.3%
10796	6,809	60.3%
7922	9,071	59.7%
20115	10,434	56.8%
209	8,514	9.9%
7018	6,559	9.3%
12389	9,557	8.7%
4812	6,052	7.4%
16509	8,371	6.1%
3269	7,196	5.9%
4134	23,992	5.9%
4713	6,972	5.4%
4837	23,663	4.0%
8151	7,988	1.7%
36947	11,064	0.9%
749	9,636	0.0%
45090	7,000	0.0%

Figure 19: ISAV deployment ratio of ASes.

ASN	OSAV Tested Prefixes	OSAV Deployment Ratio
14061	37	100.0%
4134	42	83.3%
17995	67	77.6%
9121	31	51.6%
15924	88	20.5%
52965	31	3.2%
52468	75	1.3%
150008	101	0.0%
23956	54	0.0%
395582	51	0.0%
58495	45	0.0%
52419	43	0.0%
34984	42	0.0%
52444	38	0.0%
18002	36	0.0%
45804	35	0.0%
18229	34	0.0%
58678	32	0.0%
52426	32	0.0%
37403	29	0.0%

Figure 20: OSAV deployment ratio of ASes.

5.4. Impact of MANRS on SAV Deployment

To examine the relationship between MANRS participation and the deployment of SAV, we analyze measurement results for both OSAV and ISAV deployments.

For OSAV, MANRS-participating ASes exhibit a substantially higher proportion of Deployed networks compared to non-MANRS ASes (37.5% versus 10.1%). In contrast, the Not Deployed state is significantly more prevalent among non-MANRS ASes (86.3%) than among MANRS ASes (51.9%). A chi-squared test suggests that MANRS participation and OSAV deployment status are not independent.

A similar trend is observed for ISAV. MANRS ASes show higher proportions of Deployed and Partially Deployed networks, while non-MANRS ASes are more likely to be classified as Not Deployed. The chi-squared test for ISAV also indicates a statistically significant association between MANRS participation and ISAV deployment status.

Overall, these results indicate a strong statistical association between MANRS participation and the observed deployment of SAV mechanisms in both OSAV and ISAV scenarios. While this analysis does not establish causality, the measurements consistently show that ASes participating in MANRS are more likely to deploy SAV than those that do not.

	Consistent Presence	Partial Absence	Consistent Absence
MANRS	117 (37.5%)	33 (10.6%)	162 (51.9%)
Non-MANRS	314 (10.1%)	113 (3.6%)	2,694 (86.3%)

Figure 21: The impact of MANRS on OSAV deployment.

	Consistent Presence	Partial Absence	Consistent Absence
MANRS	124 (18.6%)	339 (50.7%)	205 (30.7%)
Non-MANRS	2,902 (12.1%)	9,561 (39.8%)	11,565 (48.1%)

Figure 22: The impact of MANRS on ISAV deployment.

6. IANA Considerations

This document has no IANA requirements.

7. References

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Authors' Addresses

Shuai Wang
Zhongguancun Laboratory
Beijing
China
Email: wangshuai@zgclab.edu.cn

Dan Li
Tsinghua University
Beijing
China
Email: tolidan@tsinghua.edu.cn

Li Chen
Zhongguancun Laboratory
Beijing
China
Email: lichen@zgclab.edu.cn

Ruifeng Li
Zhongguancun Laboratory
Beijing
China
Email: lirf@zgclab.edu.cn

Lin He
Tsinghua University
Beijing
China
Email: he-lin@tsinghua.edu.cn