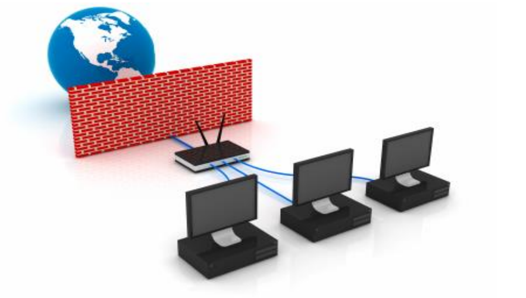
IPv6 Security & Management Capabilities of Commercial Security Products



Enno Rey & Christopher Werny

Heise IPv6 Kongress 2014

Disclaimer

- The presented results will simply demonstrate are pure findings.
- Performed tests were chosen based solely on the best of our knowledge / imagination.
- Devices were tested under exactly the same conditions.

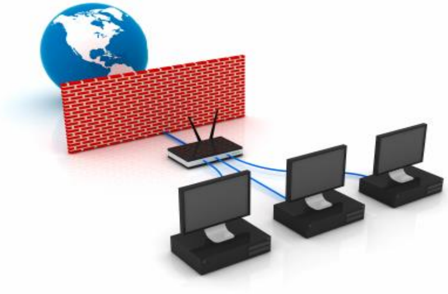
Agenda

- Part 1 – Testing Management / supporting technologies for their IPv6 support
  - Cisco
  - Checkpoint
  - Juniper
  - Fortinet
  - Tipping Point

Agenda

- Part 2 - Researching IPv6 Security Capabilities
  - Introduction to the RISC project.
  - Goal of the project.
  - List of the tested devices.
  - Used tools
  - (quotes from) RFC guidelines.
  - Description of the tests.
  - Results (per device)
  - Conclusions

IPv6 Management Capabilities of Commercial Security Products



Firewalls and IDPS (Part 1)

Cisco ASA 5505

Running Version 9.1(4)

Telnet / SSH
Management Access

- Management access over IPv4/IPv6 is supported

Guidelines and Limitations

This section includes the guidelines and limitations for this feature.

Context Mode Guidelines

Supported in single and multiple context mode.

Firewall Mode Guidelines

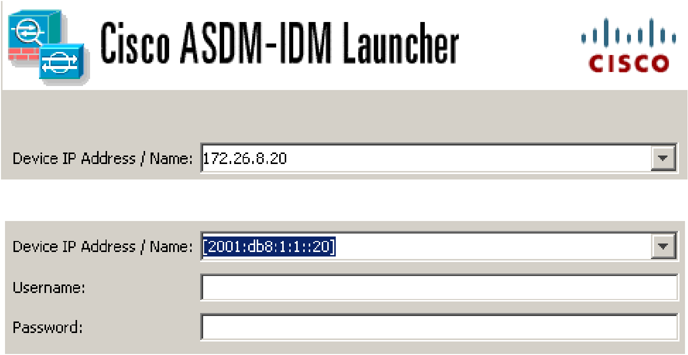
Supported in routed and transparent firewall mode.

IPv6 Guidelines

Supports IPv6.

ASDM 7.1(4)

- Connecting to the ASA via ASDM (GUI) is supported over IPv4 and IPv6



Syslog over IPv6

Prerequisites for Logging

Logging has the following prerequisites:

- The syslog server must run a server program called syslogd. Windows (exc its operating system. For Windows 95 and Windows 98, you must obtain a
- To view logs generated by the ASA or ASASM, you must specify a logging ou destination, the ASA and ASASM generate messages but does not save the different logging output destination separately. For example, to designate m command for each syslog server.

Guidelines and Limitations

This section includes the guidelines and limitations for this feature.

Context Mode Guidelines

Supported in single and multiple context modes.

Firewall Mode Guidelines

Supported in routed and transparent firewall modes.

IPv6 Guidelines

Does not support IPv6.

SNMP over IPv6

Prerequisites for SNMP

SNMP has the following prerequisite:

You must have Cisco Works for Windows or another SNMP MIB-II con

Guidelines and Limitations

This section includes the guidelines and limitations for this feature.

Context Mode Guidelines

Supported in single and multiple context mode.

Firewall Mode Guidelines

Supported in routed and transparent firewall mode.

Failover Guidelines

- Supported in SNMP Version 3.
- The SNMP client in each ASA or ASASM shares engine data with i flash:/snmp/*contextname*.

IPv6 Guidelines

Does not support IPv6.

VPNs

Configuring LAN-to-LAN IPsec VPNs

A LAN-to-LAN VPN connects networks in different geographic locations.

The ASA supports LAN-to-LAN VPN connections to Cisco or third-party peers when the two peers have IPv4 inside and outside networks (IPv4 addresses on the insid

For LAN-to-LAN connections using mixed IPv4 and IPv6 addressing, or all IPv6 addressing, the security appliance supports VPN tunnels if both peers are ASA 5500 s networks have matching addressing schemes (both IPv4 or both IPv6).

Specifically, the following topologies are supported when both peers are ASA 5500 series:

- The ASAs have IPv4 inside networks and the outside network is IPv6 (IPv4 addresses on the inside interfaces and IPv6 addresses on the outside interfaces).
- The ASAs have IPv6 inside networks and the outside network is IPv4 (IPv6 addresses on the inside interface and IPv4 addresses on the outside interfaces).
- The ASAs have IPv6 inside networks and the outside network is IPv6 (IPv6 addresses on the inside and outside interfaces).

Enabling IPv6 VPN Access

If you want to configure IPv6 access, you must use the command-line interface. Release 9.0(x) of the ASA adds support for IPv6 VPN connections to its outside interface using SSL and IKEv2/IPsec protoco

NetFlow

- Netflow data is supported for IPv4 and IPv6
- Netflow Exporter is only supported for IPv4

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High Availability

- Active/Standy Failover supported over IPv4 and IPv6
- Active/Active Failover supported over IPv4 and IPv6

Overall Result

- The ASA supports a number of management protocols / supporting technologies over IPv6
- But there is always room for improvement
- Overall good IPv6 support
  - Still, no feature parity with IPv4

Check Point SOFTWARE TECHNOLOGIES LTD.

Checkpoint-Gaia

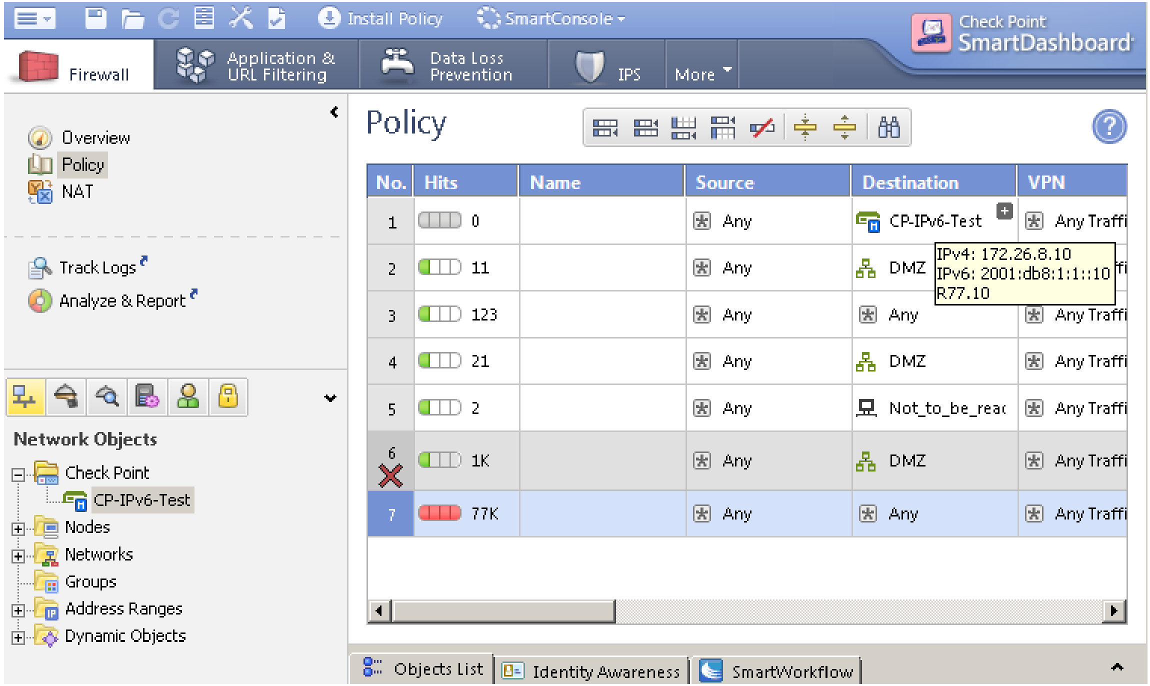
Ver.:R77.10 (build 131)

Telnet / SSH Management Access

- Management access over IPv4/IPv6 is supported

SmartDashboard

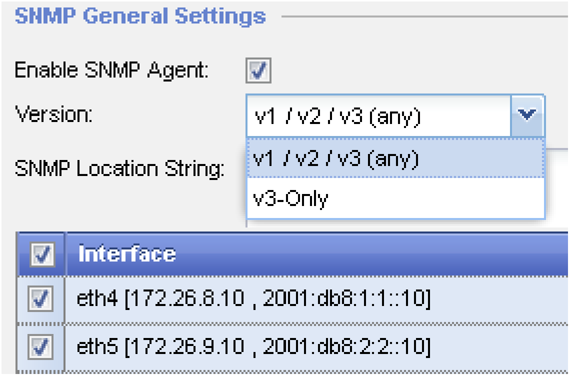
- Device management over SmartDashboard supports IPv4 and IPv6



SmartDashboard

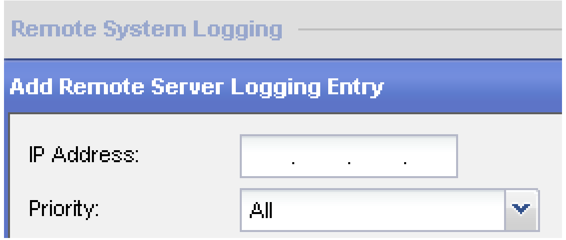
SNMP

- SNMPv1/2/3 is supported over IPv4 and IPv6



Syslog

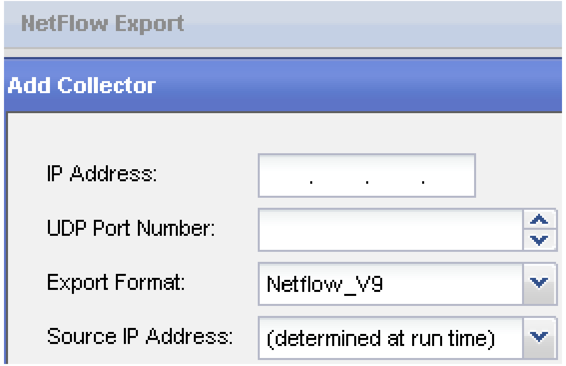
- Remote Syslog Server is only supported over IPv4



Netflow

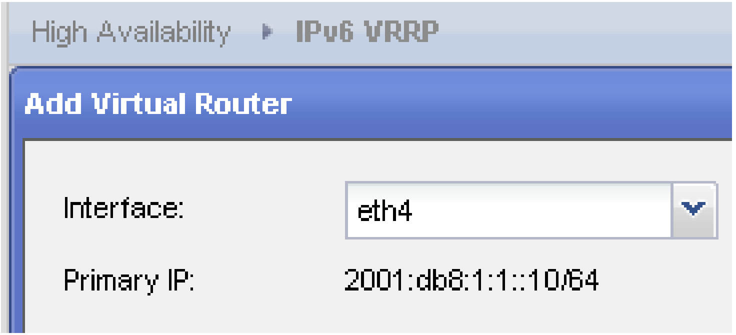
- Netflow data is supported for IPv4 and IPv6

- Netflow Exporter is only supported for IPv4



High Availability

- VRRP is supported over IPv4 and IPv6



Overall Result

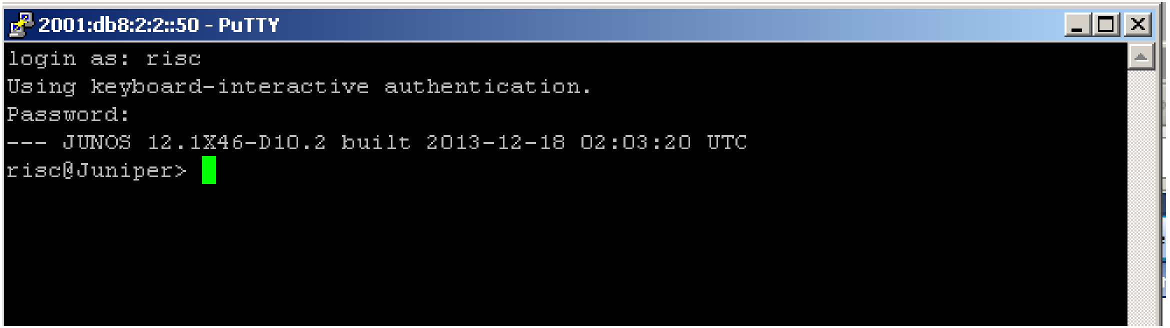
- The Checkpoint supports a number of management protocols / supporting technologies over IPv6
- But there is always room for improvement
- Overall good IPv6 support
  - Still, no feature parity with IPv4 yet

Juniper-SRX100H2

Version 12.1X46-D10.2

Telnet / SSH

- Telnet/SSH access supported over IPv4 and IPv6



Web Frontend

- Supported over IPv6 and IPv4

SNMP

- Supported over IPv4 and IPv6

Syslog

- Supported over IPv6

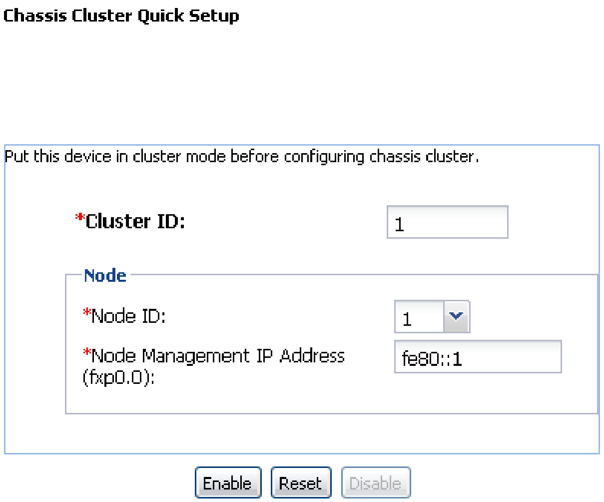
```
[edit]
risc@Juniper#

[edit]
risc@Juniper# set system syslog host 2001:db8:1:1::100 any warning

[edit]
risc@Juniper#
```

High Availability

- Cluster Mode supported over IPv6

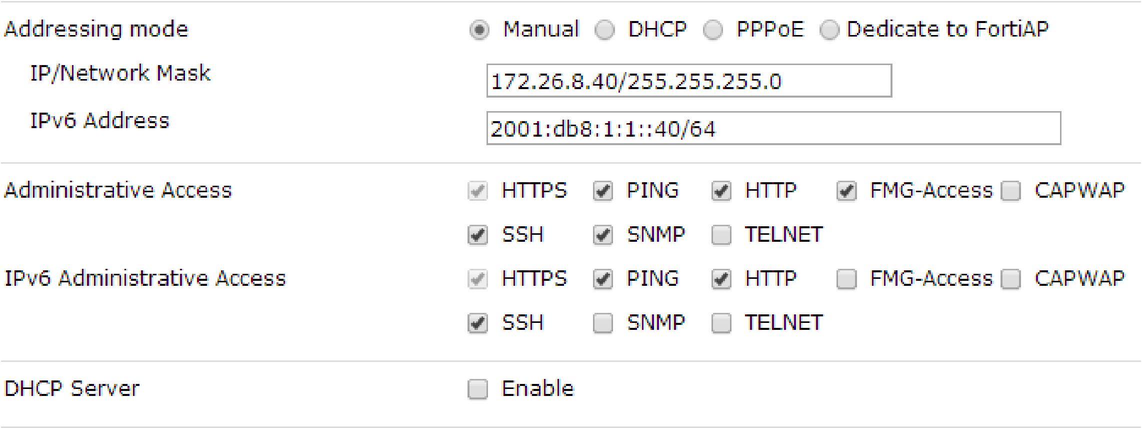


Overall Result

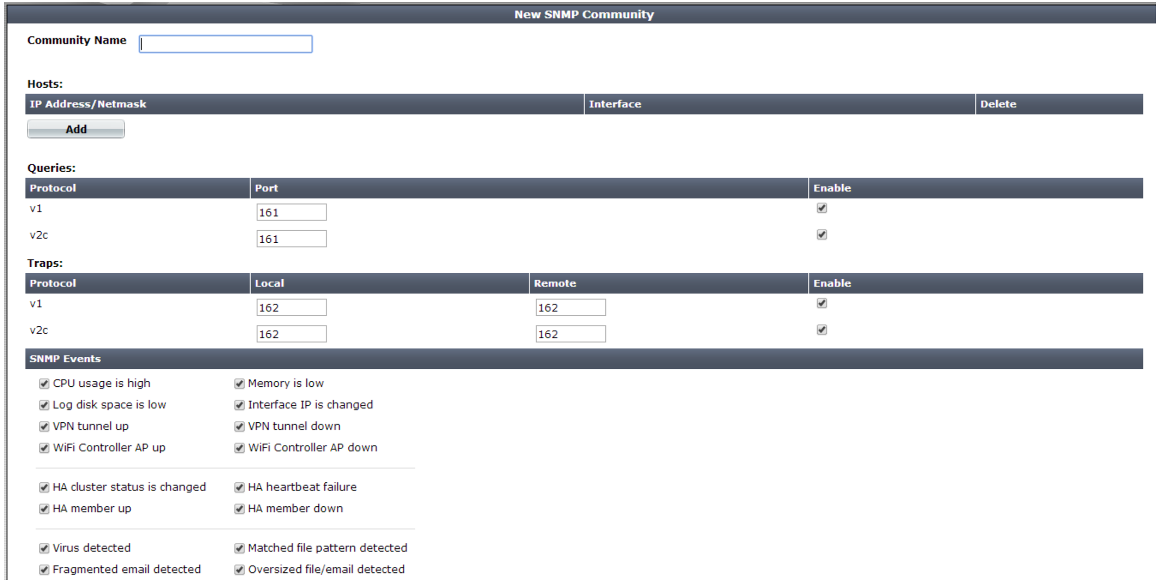
- Every tested management / supporting technology on the Juniper is supported over both protocols !
- Overall pretty good result!

FortiGate 200B

Ver.:v5.0,build0252 (GA Patch 5)


Addressing mode
Manual
DHCP
PPPoE
Dedicate to FortiAP
IP/Network Mask
172.26.8.40/255.255.255.0
IPv6 Address
2001:db8:1:1::40/64
Administrative Access
HTTPS
PING
HTTP
FMG-Access
CAPWAP
SSH
SNMP
TELNET
IPv6 Administrative Access
HTTPS
PING
HTTP
FMG-Access
CAPWAP
SSH
SNMP
TELNET
DHCP Server
Enable

Telnet / SSH



SNMP/Syslog/Netflow

Central Management

Central Management

Status — Not Managed

FortiManager IP/Domain Name: [ ] Send Request

☐ Use FortiManager for all FortiGuard communications

Administration Settings

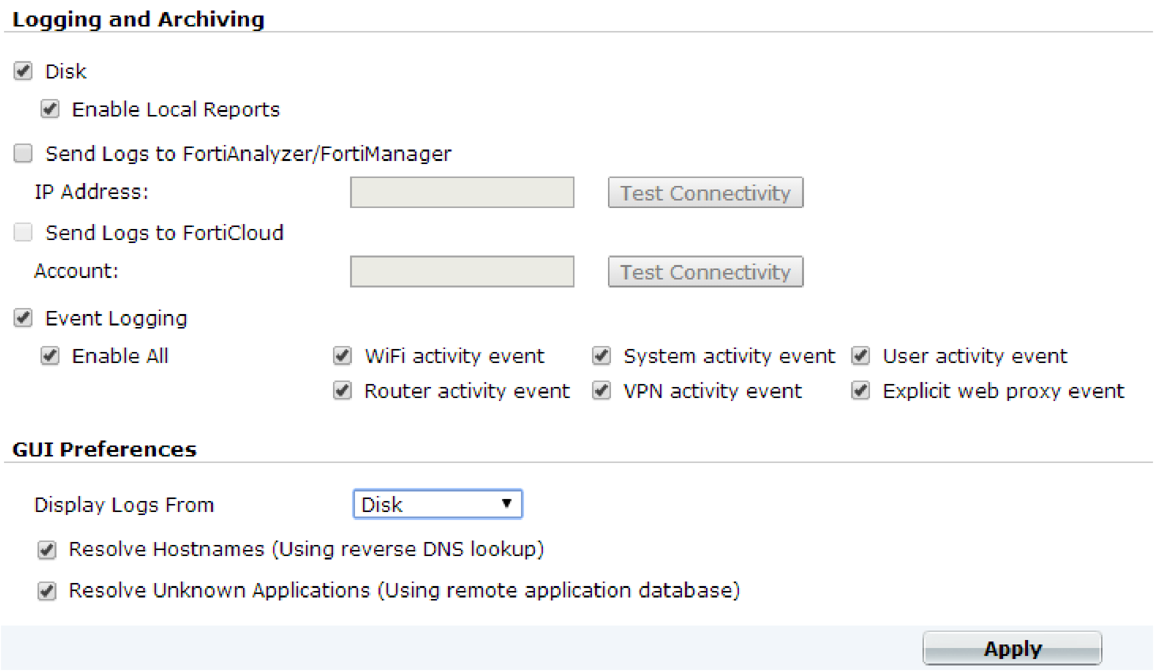
HTTP Port	80	☑ Redirect to HTTPS
HTTPS Port	443	
Telnet Port	23	
SSH Port	22	
Idle Timeout	5	(1-480 mins)

☐ **Enable Password Policy**

View Settings

Language	English ▾	
Lines Per Page	50	(20 - 1000)

Logging and Archiving

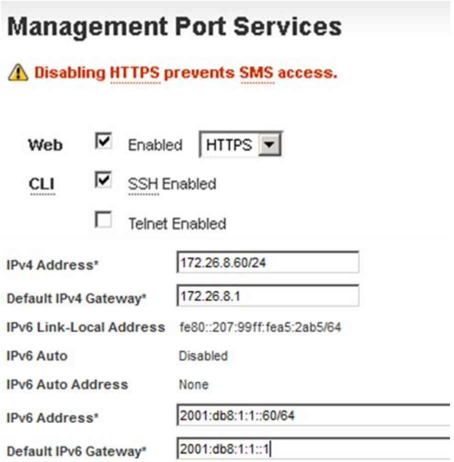


TippingPoint

Ver.:3.6.1.4036

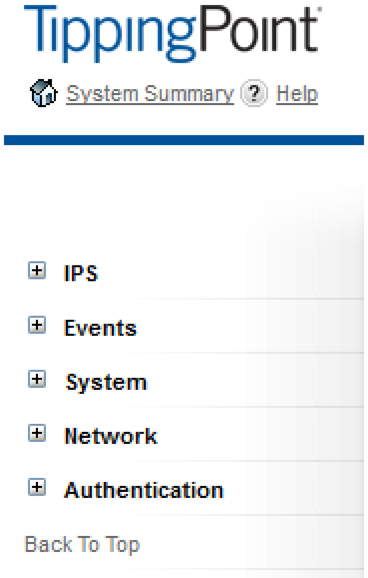
Telnet / SSH

- Management protocols are supported over IPv4 and IPv6



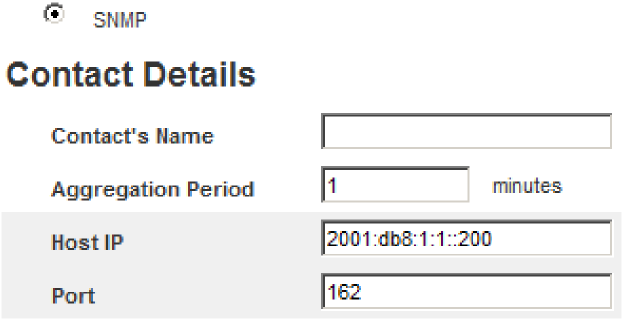
Web Frontend

- Web Frontend is supported over IPv4 and IPv6



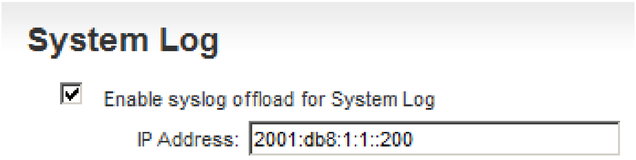
SNMP

- SNMP is supported over IPv4 and IPv6



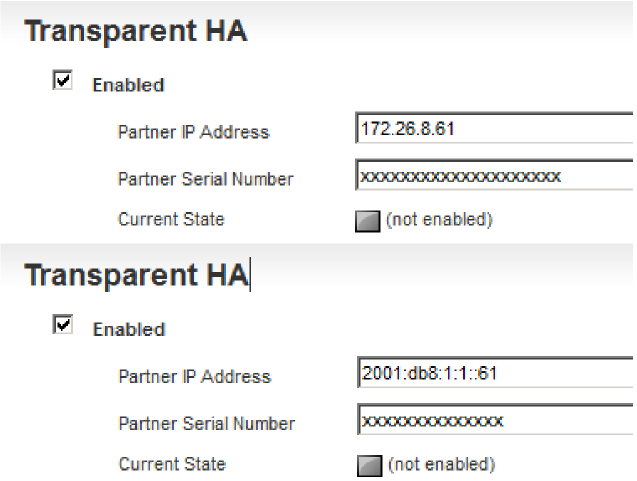
Syslog

- Syslog export is supported over IPv4 and IPv6



High Availability

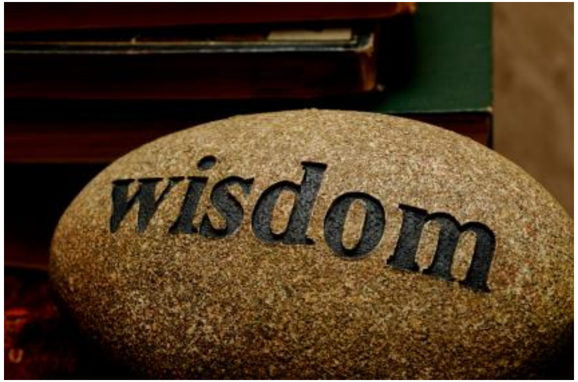
- Tipping Point HA mechanisms supported over IPv4 and IPv6



Overall Result

- Every tested management / supporting technology on the Tipping Point is supported over both protocols !
- Overall pretty good result!

Final Wisdom



- We are not there yet.
- But it is getting better, and overall good IPv6 support across all platforms.
- Hope to have parity to IPv4 next year
  - We'll see how that works out ;)

Researching IPv6 Security Capabilities

RISC (Part 2)

Agenda

- Part 2 - Researching IPv6 Security Capabilities
  - Introduction to the RISC project.
    - Goal of the project.
    - List of the tested devices.
    - Used tools
  - (quotes from) RFC guidelines.
  - Description of the tests.
  - Results (per device)
  - Conclusions

Goal of the Project

- To test some representative IPv6 security devices regarding:
  - Their IPv6 Security Capabilities.
  - The IPv6 security-related configuration capabilities that they offer.
  - Their RFC-compliance.

Tested Devices

- Firewalls:
  - Cisco ASA 5505 running firmware 9.1(4)
  - Checkpoint Gaia Release 77.10 running on commodity hardware
  - Juniper SRX 100H2 running JunOS 12.1X46-DH.2
  - Fortinet Fortigate 200B running v5.0,build0252 (GA Patch 5)
- IDS
  - Tipping Point, TOS Package 3.6.1.4036 and digital vaccine 3.2.0.8530.
    - Used as an IPS and inline.
- Layer-2 switch
  - Cisco Catalyst 4948E running Cisco IOS Release 15.2(1)E1.

Tool Used for Testing

- Chiron (an all-in-one IPv6 Pen-Testing Framework)
- running in a Linux Box
- Wireshark/tcpdump at both ends (attacker's and target's machine).
- Target's (victim's) OS did not matter during the tests.

RISC: Before We Start

Some Background Information Regarding the Processing of IPv6 Extension Headers
(or, what the RFCs say)

Terminology

- Node
  - a device that implements IPv6.
- Questions:
  - Is an IPv6 router a node?
  - Is an “IPv6 Ready” security device a node?

(Some of) the IPv6 Advantages

Source: RFC 2460

- Header Format Simplification: Some IPv4 header fields have been dropped or made optional, to reduce the common-case processing cost of packet handling and to limit the bandwidth cost of the IPv6 header.
- Improved Support for Extensions and Options: Changes in the way IP header options are encoded allows for more efficient forwarding, less stringent limits on the length of options, and greater flexibility for introducing new options in the future.
- In IPv6, optional internet-layer information is encoded in separate headers that may be placed between the IPv6 header and the upper- layer header in a packet. There are a small number of such extension headers, each identified by a distinct Next Header value. ...an IPv6 packet may carry zero, one, or more extension headers.

```
+---------------+------------------------
|  IPv6 header  | TCP header + data
|               |
| Next Header = |
|      TCP      |
+---------------+------------------------


+---------------+----------------+------------------------
|  IPv6 header  | Routing header | TCP header + data
|               |                |
| Next Header = |  Next Header = |
|    Routing    |      TCP       |
+---------------+----------------+------------------------


+---------------+----------------+-----------------+-----------------
|  IPv6 header  | Routing header | Fragment header | fragment of TCP
|               |                |                 |  header + data
| Next Header = |  Next Header = |  Next Header =  |
|    Routing    |    Fragment    |       TCP       |
+---------------+----------------+-----------------+-----------------
```

IPv6 Datagram Chain

Source: RFC 2460

Order and Number of Occurrences of Ext. Headers

Source: RFC 2460

- IPv6 nodes must accept and attempt to process extension headers in any order and occurring any number of times in the same packet, except for the Hop-by-Hop Options header which is restricted to appear immediately after an IPv6 header only. ...
- The Hop-by-Hop Options header, when present, MUST immediately follow the IPv6 header.

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Extension Headers Processing

Source: RFC 2460

- With one exception, extension headers are not examined or processed by any node along a packet's delivery path, until the packet reaches the node (or each of the set of nodes, in the case of multicast) identified in the Destination Address field of the IPv6 header.
- The contents and semantics of each extension header determine whether or not to proceed to the next header...
- ...extension headers must be processed strictly in the order they appear in the packet.

Unrecognised Extension Headers

Source: RFC 2460

- (if) the Next Header value in the current header is unrecognized by the node, it should discard the packet and send an ICMP Parameter Problem message to the source of the packet, with an ICMP Code value of 1 ("unrecognized Next Header type encountered")...

Recommended Order of Extension Headers

Source: RFC 2460

- When more than one extension header is used in the same packet, it is recommended that those headers appear in the following order:
  - IPv6 header
  - Hop-by-Hop Options header
  - Destination Options header
  - Routing header
  - Fragment header
  - Authentication header
  - Encapsulating Security Payload header
  - Destination Options header
  - upper-layer header

Number of Occurrences (again) and IPv6 Tunnelling

Source: RFC 2460

- Each extension header should occur at most once, except for the Destination Options header which should occur at most twice (once before a Routing header and once before the upper-layer header).
- If the upper-layer header is another IPv6 header (in the case of IPv6 being tunnelled over or encapsulated in IPv6), it may be followed by its own extension headers, which are separately subject to the same ordering recommendations.

IPv6 Extension Headers Processing

Source: RFC 2460

- IPv6 nodes must accept and attempt to process extension headers in any order and occurring any number of times in the same packet, except for the Hop-by-Hop Options header which is restricted to appear immediately after an IPv6 header only.
- Nonetheless, it is strongly advised that sources of IPv6 packets adhere to the above recommended order ...

Fragmenting an IPv6 Header Chain

Source: RFC 2460

- The Unfragmentable Part consists of the IPv6 header plus any extension headers that must be processed by nodes en route to the destination, that is, all headers up to and including the Routing header if present, else the Hop-by-Hop Options header if present, else no extension headers.
- The Fragmentable Part consists of the rest of the packet, that is, any extension headers that need be processed only by the final destination node(s), plus the upper-layer header and data.

Each Fragment is Composed Of

Source: RFC 2460

- The Unfragmentable Part of the original packet,...and the Next Header field of the last header of the Unfragmentable Part changed to 44.
- A Fragment header containing:
  - The Next Header value that identifies the first header of the Fragmentable Part of the original packet.

Reassembling a Fragmented IPv6 Datagram

Source: RFC 2460

- The Unfragmentable Part of the reassembled packet consists of all headers up to, but not including, the Fragment header of the first fragment packet (that is, the packet whose Fragment Offset is zero), with the following change(s):
- The Next Header field of the last header of the Unfragmentable Part is obtained from the Next Header field of the first fragment's Fragment header.

Delay in the reception of the fragments

Source: RFC 2460

- If insufficient fragments are received to complete reassembly of a packet within 60 seconds of the reception of the first-arriving fragment of that packet, reassembly of that packet must be abandoned and all the fragments that have been received for that packet must be discarded. If the first fragment (i.e., the one with a Fragment Offset of zero) has been received, an ICMP Time Exceeded -- Fragment Reassembly Time Exceeded message should be sent to the source of that fragment.

The following conditions are not considered errors:

Source: RFC 2460

- The number and content of the headers preceding the Fragment header of different fragments of the same original packet may differ. Whatever headers are present, preceding the Fragment header in each fragment packet, are processed when the packets arrive, prior to queueing the fragments for reassembly. Only those headers in the Offset zero fragment packet are retained in the reassembled packet.
- The Next Header values in the Fragment headers of different fragments of the same original packet may differ. Only the value from the Offset zero fragment packet is used for reassembly.

Upper-Layer Checksums

Source: RFC 2460

```
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
+                                                               +
|                                                               |
+                         Source Address                        +
|                                                               |
+                                                               +
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
+                                                               +
|                                                               |
+                      Destination Address                      +
|                                                               |
+                                                               +
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                   Upper-Layer Packet Length                   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                      zero                     |  Next Header  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

- The **Next Header** value in the pseudo-header identifies the upper-layer protocol (e.g., 6 for TCP, or 17 for UDP). It will differ from the Next Header value in the IPv6 header if there are extension headers between the IPv6 header and the upper-layer header.

IPv6 Specification "Grey" Areas

Source: RFC 4942

- The IPv6 Specification contains a number of areas where choices are available to packet originators that will result in packets that conform to the specification but are unlikely to be the result of a rational packet generation policy for legitimate traffic.
- The built-in flexibility of the IPv6 protocol may also lead to changes in the boundaries between legitimate and malicious traffic as identified by these rules.

Processing at Middleboxes?

Source: RFC 4942

- [RFC2460] does not appear to take account of the behavior of middleboxes and other non-final destinations that may be inspecting the packet, and thereby potentially limits the security protection of these boxes.
- In order to locate the transport header or other protocol data unit, the node has to parse the header chain.
- A middlebox cannot guarantee to be able to process header chains that may contain headers defined after the box was manufactured.

Extension Headers Clarification

Source: RFC 7045

- Any forwarding node along an IPv6 packet's path:
  - SHOULD forward IPv6 packets regardless of any Extension Headers that are present.
  - They MUST recognise and deal appropriately with all standard IPv6 Extension headers.
  - They SHOULD NOT discard packets containing unrecognised extension headers.

Implications of Oversized IPv6 Header Chains

Source: RFC 7112

- When a host fragments a IPv6 datagram, it MUST include the entire IPv6 header chain in the first fragment.
- A host that receives a First Fragment that does not satisfy the above-stated requirement SHOULD discard the packet and SHOULD send an ICMPv6 error message to the source address of the offending packet...
- An intermediate system (e.g., router or firewall) that receives an IPv6 First Fragment that does not satisfy the above-stated requirement MAY discard that packet, and it MAY send an ICMPv6 error message to the source address of the offending packet ...

Circumventing RA-Guard

Source: RFC 6980

- IPv6 fragmentation introduces a key challenge for these mitigation or monitoring techniques, since it is trivial for an attacker to conceal his attack by fragmenting his packets into multiple fragments. This may limit or even eliminate the effectiveness of the aforementioned mitigation or monitoring techniques.

Preventing the Circumvention of RA-Guard

Source: RFC 6980

- Nodes MUST silently ignore the following Neighbor Discovery and SEcure Neighbor Discovery messages if the packets carrying them include an IPv6 Fragmentation Header:
  - Neighbor Solicitation
  - Neighbor Advertisement
  - Router Solicitation
  - Router Advertisement
  - Redirect
  - Certification Path Solicitation

What IPv6 Capabilities were tested (in General)

- RFC Compliance.
  - Note: There are many case when non-conforming behaviour is better from a security perspective.
- Fragmentation.
- IPv6 Extension Headers (including deprecated ones).
- Other security features (RA Guard, IDS capabilities), when and where supported.

Testing Scenarios

- 1. Default configuration (and allowing only ICMPv6 Echo Request messages).
  - Test which IPv6 Extension Headers are allowed and which are not.
  - Use arbitrary and mix combinations of the above
- 2. Allowing all the available IPv6 Extension Headers.
  - Repeat the above tests.
- 3. By adding a “Default Allow” rule but also blocking specific TCP ports before this.
  - Such a configuration it shouldn't be used by any means, but still, the blocked TCP ports should be protected by unauthorised access.

Testing the Support of Extension Headers

- IPv6 Fragment Header
  - Simple Fragmentation
  - Atomic Fragments
- Destination Options Header / Hop-by-Hop Extension Header
  - Unknown Options?
- IPv6 Routing Header
  - Type 0
  - Types 2-3
  - Unknown (non-existing) type
- IPv6/IP4 (as an Extension Header) – Tunnelling (more on this, later).
- Mobility Header.
- Fake (non-existing) header (to test RFC 7045).

Checking the Order and the Number of Occurrences

- 1. Repeat one IPv6 Extension Header Multiple Time
- 2. Mix Various IPv6 Extension Headers in a non-Recommended Order
- 3. Combine tests 1 and 2.
- 4. Increase the IPv6 Header Chain size (by combining methods of tests 1-3) and fragment it so as layer 4 header to appear at fragment 2, 3, 4, etc.
- If one or more of the above pass through the device, check whether they can be used for circumventing firewalls/IDS/RA Guard.

Tunnelling IPv4/IPv6 in IPv6

- IPv6/IPv4 traffic tunnelled inside IPv6.
  - Can they filter such a traffic?
  - What if combined with additional IPv6 Extension Headers per IPv6 main Header or mixing / fragmented them (combined with tests 1-4 of previous slide)?

Other Attacks

- Flooding Attacks (combined with any of the above).
  - Can the devices handle them?
- Delay fragment attacks
  - What if fragments stored until all of them received?
  - What if they forwarded before all of them are received? How does filtering take place?

Cisco ASA 5505

running firmware 9.1(4)

Default Configuration: Fragmentation

CISCO ASA

- Check whether simple fragmentation is allowed: YES
- Varying the time interval between consecutive fragments:
  - 2 fragments with 5 sec in between, dropped.
  - 2 fragments with 5 sec in between, not dropped.
  - 3 fragments with 2 sec in between, pass through.
  - 3 fragments with 3 sec in between, do not.
- If all the fragments are stored before the last one is received: YES

Default Configuration: IPv6 Extension Headers Support

CISCO ASA

- Hop-by-Hop Options Header: YES
- IPv4 Header: NO
- IPv6 Header: NO
- Type 0/2/3/10 Routing Header: NO
- Fragment Extension Header (Atomic Fragment): YES
- Destination Options Header: YES
- Mobility Header: NO
- Fake Header: NO

Default Configuration: Additional Tests

CISCO ASA

- Sending the layer-4 protocol header at the 2nd, 3rd, 4th, etc. Fragment by fragmenting an “Options” Header. They don't pass through.
- Repeating the supported extension headers, two, three, or more times.
  - Hop-by-Hop is allowed only once and only if it is at the beginning (as it should).
  - Destination Options is allowed up to twice, as it should.
  - Fragment Ext. Header is allowed only once.
- Mixing the order of the supported extension headers: All of them are allowed only in the correct order.

Default Allow All Rule (and blocking a specific TCP port)

CISCO ASA

- All the known Extension Headers are allowed.
- Fake Header is also allowed.
- Type 0 Routing Header is still not allowed (kernel blocked?)
- When the packet is NOT fragmented, using a FAKE header we can reach a TCP port that is not allowed!

Cisco ASA: Conclusions

- Good IPv6 supported functionality (many known IPv6 Extension Headers, fragmentation, etc.).
  - It allows out-off-the-box only “risky” IPv6 Extension headers.
- Operational issues may arise when fragments are slightly delayed.
- Not a 100% RFC compliant (especially when compliance circumvents security).
- Security-oriented:
  - Type-0 Routing header is blocked, even if everything else is allowed.
  - Layer-4 header in a fragment other than the 1st is not accepted.
  - Extension Headers are accepted only in the correct order and in the correct number of occurrences.
- Can be circumvented only if a Default Allow Rule is used.

Checkpoint-Gaia

Release 77.10(running on commodity hardware)

Default Configuration: Fragmentation

Checkpoint

- Check whether simple fragmentation is allowed: YES
- Varying the time interval between consecutive fragments:
  - Two fragments accepted only when the inter-arrival time is about 0.5 sec – definitely do not pass through for 0.8 sec or more.
  - Five fragments do not pass through when the inter-arrival time is about 0.1 sec
- If all the fragments are stored before the last one is received.
  - Not possible to figure out whether fragments are stored before the last one is received due to the very small inter-arrival time. Probably yes.

Default Configuration: IPv6 Extension Headers Support

Checkpoint

- Hop-by-Hop Options Header: NO
- IPv4 Header: NO
- IPv6 Header: NO
- Type 0 Routing Header: NO 'Parameter problem, erroneous header field encountered'
- Type 2/3/10 Routing Header: NO
- Fragment Extension Header (Atomic Fragment): NO
- Destination Options Header: NO
- Mobility Header: NO
- Fake Header: NO

Default Allow All Rule (and blocking a specific TCP port)

Checkpoint

- ALL the known IPv6 Extension Headers are still dropped.
- However, unknown (non-existing) Extension Headers are allowed to pass through!?
- This is still true no matter how many Fake Headers are added (10 or more) or, if you fragmented them!
- If we send the layer-4 header at a fragment other than the 1st (by adding the Fake Header), the firewall is bypassed (we can reach the otherwise blocked TCP port).

Allowing IPv6 Extension Headers

Checkpoint

- We finally found a way to configure the allowance of IPv6 Extension Headers at Checkpoint.
- Not that easy!

Allowing IPv6 EH (w/o allow rule)

- Destination Options, Hop-by-Hop, Routing Header, Mobility Header are only allowed!
- Not IPv4, IPv6 or Fragment Extension Headers. Atomic Fragments are not allowed. IPv4 or IPv6 Tunnelling is not allowed either.
- When we use a Dest-Opt Header (or any other allowed header) and move layer 4 at a fragment other than the 1st, it does NOT pass through.
- If we mix several headers multiple times (for example 3 Hop-by-Hop, then 2 Destination Options, then 2 Hop-by-Hop), the packet passes through.
- Type 0 Routing Header is nevertheless blocked. Types 1 to 10 (non-existing) pass through.
- If you use Type 2 Routing Header, then the packet pass through even to an IPv6 Address that is otherwise explicitly blocked.

Checkpoint: Conclusions

- In it's default configuration, it actually eliminates any IPv6 Extension Headers functionality (except from fragmentation). The most paranoid default IPv6 configuration.
- Not that easy to configure it to allow some IPv6 Extension Headers. When you do, the correct order or the correct number of occurrences are not filtered (traffic passes through).
- Very low level of RFC compliance (by default).
- Very strict (less than 1 sec) accepted inter-arrival delay between fragments. Again, the most “paranoid”.
- Type-0 Routing header is nevertheless blocked.
- Can be circumvented only if a Default Allow Rule is used.

Juniper-SRX100H2

running JunOS 12.1X46-D10.2

Default Configuration: Fragmentation

Juniper

- Check whether simple fragmentation is allowed: YES
- Varying the time interval between consecutive fragments:
  - 5 fragments, 3 sec delay, one passed, rest dropped
  - 3 fragments, 1 sec delay, just the two passed
  - 2 fragments if 1.3 sec accepted, if 1.5 sec rejected
- If all the fragments are stored before the last one is received: NO

Default Configuration: IPv6 Extension Headers Support

Juniper

- Hop-by-Hop Options Header: YES
- IPv4 Header: NO
- IPv6 Header: NO
- Type 0 Routing Header: NO 'Parameter problem, erroneous header field encountered'
- Type 2/3/10 Routing Header: YES
- Fragment Extension Header (Atomic Fragment): YES
- Destination Options Header: YES
- Mobility Header: NO
- Fake Header: NO

Default Configuration: Additional Tests

Juniper

- Sending the layer-4 protocol header at the 2nd, 3rd, 4th, etc. Fragment by fragmenting an “Options” Header. Blocked.
- For the supported Headers, repeat them two, three, and more times - Mix the order of the supported headers.
  - It strictly respects the number of occurrences.
  - It respects the order of the hop-by-hop header but not the other ones (e.g. Routing header is accepted at the end)

Default Allow All Rule (and blocking a specific TCP port)

Juniper

- Using a Fake Header, we can reach a TCP port that is not allowed, only when the IPv6 datagram is fragmented.

Juniper: Conclusions

- Good IPv6 supported functionality (many known IPv6 Extension Headers, fragmentation, etc.).
- Not a 100% RFC compliant.
- Supports out-of-the box the RFC 2460 Extension Headers.
- Type-0 Routing header is dropped by default.
- Delayed fragments are not stored, and also accepted only for a few seconds
- It strictly respects the number of occurrences of the Extension Headers, but not the recommended order (except from the Hop-by-Hop).
- It allows layer-4 protocol header in a fragment other than the 1st (it cannot be circumvented though).
- Can be circumvented only if a Default Allow Rule is used.

Fortinet Fortigate 200B

running v5.0, build0252 (GA Patch 5)

Default Configuration: Fragmentation

Fortigate Fortinet

- Check whether simple fragmentation is allowed: YES
- Varying the time interval between consecutive fragments:
  - When delay >60 secs, packets are dropped. Sends back ICMPv6 Time exceeded fragment reassembly time exceeded message.
  - Tested for 2 fragments, 50 secs in between: Passed through.
  - Tested for 3 fragments, 22 secs: Passed through
- If all the fragments are stored before the last one is received: YES

Default Configuration: IPv6 Extension Headers Support

Fortigate Fortinet

- Hop-by-Hop Options Header: YES
- IPv4 Header: NO
- IPv6 Header: NO
- Type 0 Routing Header: NO
- Type 2/3/10 Routing Header: YES
- Fragment Extension Header (Atomic Fragment): YES
- Destination Options Header: YES
- Mobility Header: NO
- Fake Header: NO

Default Configuration: Additional Tests

Fortigate Fortinet

- Sending the layer-4 protocol header at the 2nd, 3rd, 4th, etc. Fragment by fragmenting an “Options” Header. They pass through. You can send the layer-4 header in the 32nd fragment.
- Can this be used to circumvent firewall (for instance, use TCP SYN scan against a closed port). NO
- For the supported Headers, repeat them two, three, and more times - Mix the order of the supported headers.
  - 0, 2x60, 2x44, 60 worked.
  - 2x60, 8 fragments, also worked.

Default Allow All Rule (and blocking a specific TCP port)

Fortigate Fortinet

- Using a Fake Header, we can reach a TCP port that is not allowed, either when the IPv6 datagram is fragmented or not.

Flooding Attacks

Fortigate Fortinet

- Possible, in theory, since:
  - Fragments are stored and not forwarded until all of them are received.
  - Fragments are retained (if not all of them have been received) until 60 seconds.
- We could NOT DoS it, but using a single machine, we increased the CPU load at about 20%-24%.
- We finally DoSed the attacker's machine!

Fortigate Fortinet: Conclusions

- Very good IPv6 supported functionality (many known IPv6 Extension Headers, fragmentation, etc.). Supports out-of-the box the RFC 2460 Extension Headers.
- Still not a 100% RFC compliant.
- Type-0 Routing header is dropped by default.
- Delayed Fragments are stored and accepted up to 60 seconds.
  - Could be possibly DoSed.
- It allows Extension Headers no matter what the order or their number of occurrences are even in the default configuration.
- It allows layer-4 protocol header in a fragment other than the 1st (it cannot be circumvented though).
- Can be circumvented only if a Default Allow Rule is used.

RISC: IDS/IPS Testing

Tipping Point

TOS Package 3.6.1.4036 and digital vaccine 3.2.0.8530

Default Configuration

Tipping Point

TippingPoint

- It doesn't store the fragments locally.
- It immediately forwards them as long as the layer-4 headers is in the 1st fragment.
- It drops a packet when layer-4 header is in the 2nd fragment without issuing an alert.
- What about if it is in parallel and not inline?

Default Configuration: More Findings

Tipping Point

TippingPoint®

- When 10 or more Extension headers are used, it issues an alert.
- But it does not issue an alert if 9 Hop-by-Hop Ext Headers are used.
- Type 0 Routing Header is detected.
- Tunnelling is NOT detected.

How we can bypass Tipping Point

How we can bypass

Tipping Point

- 2 fragments
  - 1st Fragment:
  - IPv6 main Header + Fragment Ext Header (offset =0, M=1, next header =60) + Dest Opt Header (8 bytes long, no data on it but padding, next header = 6)
  - 2nd Fragment:
  - IPv6 main header + Fragment Ext Header (offset=1, M=0, next header = 6) + TCP header.
- Such a packet is accepted by Windows 7, Kali, Fedora 20 AND OpenBSD, FreeBSD does NOT.

Responsibly Disclosured

Tipping Point

- Tipping point was informed in 19th of February. A pcap file and some info were provided.
- The description of the attack (crafted IPv6 fragments) was also sent in 22nd of February.
- Tipping Point reaction: PENDING

But, What's the Problem With These Fragments?

- 1st Fragment:
  - IPv6 main Header + Fragment Ext Header (offset =0, M=1, next header =60) + Dest Opt Header (8 bytes long, no data on it but padding, next header = 6)
- 2nd Fragment:
  - IPv6 main header + Fragment Ext Header (offset=1, M=0, next header = 6) + TCP header.

Each Fragment is Composed Of

Source: RFC 2460

- The Unfragmentable Part of the original packet,...and the Next Header field of the last header of the Unfragmentable Part changed to 44.
- A Fragment header containing:
  - The Next Header value that identifies the first header of the Fragmentable Part of the original packet.

But, What's the Problem With These Fragments?

- 1st Fragment:
  - IPv6 main Header + Fragment Ext Header (offset =0, M=1, next header =60) + Dest Opt Header (8 bytes long, no data on it but padding, next header = 6)
- 2nd Fragment:
  - IPv6 main header + Fragment Ext Header (offset=1, M=0, next header = 6) + TCP header.

Confirming the Issue with a Layer-7 Attack

- XSS Attack:

```
GET /index.php?asd=\"><script>alert(1)</script>
```

- XSS is blocked even in “aggressive” mode.
- It also works even all HTTP traffic is blocked at the Tipping Point.

Cisco Catalyst 4948E

running Cisco IOS Release 15.2(1)E1.

RA-Guard Protection

- Known Issue:
  - RA messages circumvent RA-Guard protection if the RA message is in the 2nd fragment, or later.
- What our tests showed:
  - RA in 2nd fragment, just a DestOpt in the 1st – blocked
  - RA in 2nd fragment (or later), DestOpt with data – passed

Confirmed

Other Ways to Circumvent RA-Guard Protection?

- At least two other ways were found (no fragmentation at this time):
  - Tunnel the traffic (IPv6 in IPv6).
  - Use a Fake (unknown) header:
- However, the target does not easily accept such a packet, unless:
  - IPv6 (for some reason) has been implemented, or
  - (more possible) there is a new Extension Header, which is known to the target and not to the Switch (usually OS are updated more frequently and more easily than switches firmware).
- Hence, still an issue but probably not of a high risk.

Conclusions

- Cisco ASA appears to have the most “secure” out-of-the-box configuration, while preserving a very good IPv6 functionality.
- It is the only one that passes through traffic only when Extension Headers appear in the correct order and in the correct number of occurrences (typically not RFC-2460 compliant behaviour but definitely, more secure).
- Type-0 Routing Header is blocked no matter what other traffic is allowed (protecting you for potential misconfiguration).
- The very small accepted inter-arrival delay, although it may eliminates any security issues, it may create operational ones (at least in extreme cases).

Conclusions

- Checkpoint actually eliminates IPv6 functionality. ⚠
- Very low level of RFC compliance.⚠
- Difficult to configure the usage of IPv6 Extenion Headers.⚠
- Almost “paranoid” accepted inter-arrival time between fragments (less than 1 sec). It may cause operational issues more easily than the others. ⚠

Conclusions

- Juniper also appears to have a security-oriented default configuration, quite similar to Cisco one but slightly less strict
- It can also encounter operational issues due to the small accepted inter-arrival delay between fragments.

Conclusions

- Fortigate Fortinet appears to have ✅ very good IPv6 functionality, but, potential issues can be that:
  - Delayed Fragments are stored and accepted up to 60 seconds. Could be possibly DoSed?⚠
  - It allows Extension Headers no matter what the order or their number of occurrences are even in the default configuration. ⚠
  - It allows layer-4 protocol in a fragment other than the 1st (it cannot be circumvented though). ⚠

Conclusions
Tipping Point

- Yet another IPS that appears to have problems regarding examining not expected IPv6 traffic.
- It can be circumvented quite easily.
- Other ways of circumventing it may still exist.

Conclusions

- Cisco Catalyst 4948E RA-Guard Evasion:
  - Known issues ⚠
  - Other issues also exist, but more difficult to exploit. ⚠

Future Work

- These were just a first bunch of tests / experiments.
- More thorough ones are required to further examine any other potential issues.
- The results of RISC project show that securing IPv6 is not as easy as are used from IPv4.
- Thorough knowledge of the protocol is required even from sys and network admins.
- Not to mention about vendors!!

There's never enough time…

THANK YOU…

...for yours!

Questions & Discussion