

Basic IPv6 Protocol Security

Webinar

April 2025 RIPE NCC Learning & Development



This webinar is being recorded



Basic IPv6 Protocol Security

IPv6 Basic header and Extension Headers

IPSec

IPv6 Security Addressing Architecture





Tell us about you!

Please answer the polls







IPv6 Basic Header and Extension Headers

Section 1

Basic IPv6 Header: Threat #1



Version	Traffic Class		Flow Label	
Payload Length		Next Header	Hop Limit	
Source Address				
Destination Address				

Basic IPv6 Header: Threat #1





IP spoofing:

Using a fake IPv6 source address



Solution:

ingress filtering and RPF (reverse path forwarding)





Version	Traffic Class	Flow Label		
Payload Length		Next He	ader	Hop Limit
Source Address				
Destination Address				









Covert Channel:

Using Traffic Class and/or Flow Label



Solution:

Inspect packets (IDS / IPS)

Expected values:

- Traffic Class: 0 (unless QoS is used)
- Flow Label: 0

IPv6 Extension Headers





Extension Headers Properties



	Flexible (use is optional)
2	Only appear once (except Destination options)
3	Fixed (types and order)
4	Processed only at endpoints (except Hop-by-Hop and Routing)



- Flexibility means **complexity**
- Security devices / software must process the full chain of headers
- Firewalls must be able to filter based on
 Extension Headers



Questions



Routing Header



Includes one or more IPs that should be "visited" in the path

- Processed by the **visited routers**



Routing Header Threat



- Routing Header (Type 0):
 - RH0 can be used for traffic amplification over a remote path
- **RH0 Deprecated** [*RFC5095*]
 - RH1 deprecated. RH2 (MIPv6), RH3 (RPL) and RH4 (SRH) are valid



Take the poll!

What can **RHO** be used for?

Something bad?







Extension Headers Solutions





• Require security tools to inspect Header Chain properly



Fragment Header



- Used by IPv6 source node to send a packet **bigger than path MTU**
- **Destination host** processes fragment headers



M Flag:

- 1 = more fragments to come;
- 0 = last fragment

EH Threats: Fragmentation



Overlapping Fragments



Fragments that overlap because of wrong "fragment offset"

Take the poll!

Do you know how **Overlapping Fragments** works?



Overlapping Fragments





Overlapping fragments have wrong offset values

EH Threats: Fragmentation





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EH Solutions: Fragmentation





Take the poll!

For what other malicious attacks can **Extension Headers** be used for?



Bypassing RA Filtering/RA-Guard



Using **any** Extension Header

Basic IPv6 Header	Destination Options	ICMPv6: RA
Next Header = 60	Next Header = 58	

If it only looks at Next Header = 60, it does not detect the RA

Bypassing RA Filtering/RA-Guard



Using Fragment Extension Header

Basic IPv6 Header	Fragment	Destination Options
Next Header = 44	Next Header = 60	Next Header = 58

Basic IPv6 Header	Fragment	Destination Options	ICMPv6: RA
Next Header = 44	Next Header = 60	Next Header = 58	

Needs all fragments to detect the RA

Take the poll!

How would you change IPv6 to **avoid** the **bypass using fragment header**?



Extension Headers Solutions





• **Require** security tools to inspect Header Chain properly



Questions



 Is it possible to generate all those weird packets?

 How can I check if my devices/ software are ready to resist
 specific attacks? (Security assessment)?





Demo 1

IPv6 Packet Generation

Demo time!

We will demo the activity on the screen. Watch what we do.



Demo 1: IPv6 Packet Generation



- **Description**: Use **Scapy** to generate IPv6 packets
- Goals:
 - Know about the Scapy tool (<u>http://secdev.org/projects/scapy/</u>)
 - Learn about some of the capabilities of Scapy
- **Time**: 10 minutes
- Demo:
 - Generate IPv6 packets
 - Send and receive IPv6 packets

Demo 1 Lab Network








```
>>> a=IPv6()
```

```
>>> a
<IPv6 |>
>>> a.dst="2001:db8:a:b::123:321:101"
>>> a.src="2001:db8:1::A101"
>>> a.show()
###[ IPv6 ]###
  version= 6
 tc= 0
  fl= 0
  plen= None
  nh= No Next Header
  hlim= 64
  src= 2001:db8:1::a101
  dst= 2001:db8:a:b:0:123:321:101
```

Demo 1: IPv6 Packet Generation



```
>>> b=IPv6(src="2001:db8:5::5",dst="ff02::1")/ICMPv6ND_NA()
```

```
>>> b.show()
###[ IPv6 ]###
  version= 6
  tc=0
  f1 = 0
  plen= None
  nh= ICMPv6
  hlim= 255
  src= 2001:db8:5::5
  dst= ff02::1
###[ ICMPv6 Neighbor Discovery - Neighbor Advertisement ]###
     type= Neighbor Advertisement
     code= 0
     cksum= None
     R = 1
     S= 0
     0= 1
     res = 0x0
     tgt= ::
```

Demo 1: IPv6 Packet Generation



```
>>> c=IPv6(dst="2001:db8:F:1::1")/ICMPv6EchoRequest()
```

```
>>> ans,unans = sr(c)
Begin emission:
....Finished to send 1 packets.
*
Received 3 packets, got 1 answers, remaining 0 packets
>>> ans.summary()
IPv6 / ICMPv6 Echo Request (id: 0x0 seq: 0x0) ==> IPv6 / ICMPv6
Echo Reply (id: 0x0 seq: 0x0)
```

```
>>> ans[0][1].show()
```

Demo 1: IPv6 Packet Generation



- To exit from Scapy interpreter:
 - just type exit(),
 - or use Ctrl+D



Questions



Let's take a 5 minutes break!







IPSec

Section 2

IPsec - Security Protocols

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Authentication Header (AH)

Provides Integrity

MAY be implemented

. . .

•••

Encapsulating Security Payload (ESP)

Provides Confidentiality and Integrity **MUST** be implemented





SPD Security Policy Database indicates what to do with packets

SA Security Association: info needed for IPsec with 1 host, 1 direction



Internet Key Exchange allows automatic creation of SAs











Hash Function

- Input: Variable length bit string, for example a text
- **Output**: Fixed length bit string, represented by a series of characters



IPsec: ESP





Take the poll!

How is the **ICV** (**Integrity Check Value**) used in **IPsec** to provide integrity?







Questions





IPv6 Addressing Architecture

Section 3



340,282,366,920,938,463,463,374,607,431,768,211,456



IPv6 Address Scope





Take the poll!

What is the **scope** of the following IPv6 address?

fe80::0123:aff:ad34



IPv6 Network Scanning





IID Generation Options



64 bits

li	nterface ID (IID)		
H	Modified EUI-64 (uses MAC address)	"stable" IID	
н	Stable, semantically opaque [RFC7217]		
H	Temporary Address Extensions [RFC8981]	"temporary" IID for SLAAC	
\square	DHCPv6		
	Manually		
	Others (CGA, HBA)		



SLAAC IIDs Currently



• Consider IID bits "**opaque**", no value or meaning [RFC7136]

How to generate IIDs [RFC7217]

Different for each interface in the same network prefix

Not related to any fixed interface identifier

Always the same when same interface connected to same network

 Widely used and standardised for "stable" addresses [RFC8064]

Take the poll!

How can the **EUI-64** make it easier to guess an **IID**?





Take the poll!

Why is a **Dual-Stack network** easier to scan?





Locally Scanning IPv6 Networks





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Special / Reserved IPv6 Addresses

Name	IPv6 Address	Comments		
Unspecified	::/128	When no address available		
Loopback	::1/128	For local communications		
IPv4-mapped	::ffff:0:0/96	For dual-stack sockets. Add IPv4 address 32 bits		
Documentation	2001:db8::/32 & 3ff::/20	RFC 3849 & RFC 9637		
IPv4/IPv6 Translators	64:ff9b::/96	RFC 6052		
Discard-Only Address Block	100::/64	RFC 6666		
Teredo	2001::/32	IPv6 in IPv4 Encapsulation Transition Mechanism		
6to4	2002::/16	IPv6 in IPv4 Encapsulation Transition Mechanism		
ORCHID	2001:10::/28	Deprecated RFC 5156		
Benchmarking	2001:2::/48	RFC 5180		
Link-local	fe80::/10	RFC 4291		
Unique-local	fc00::/7	RFC 4193		
6Bone	3ffe::/16, 5f00::/8	Deprecated RFC 3701		
IPv4-compatible	::/96	Deprecated RFC 5156		
http://www.iana.org/assignments/iana-ipv6-special-registry/				

Security Tips

- Use hard to guess IIDs
 - RFC 7217 better than EUI-64
 - RFC 8064 establishes RFC 7217 as the default
- Use IPS/IDS to detect scanning
- Filter packets where appropriate
- Be careful with routing protocols
- Use "default" /64 size IPv6 subnet prefix

• Is it easy to **scan** an IPv6 network?

Demo 2

IPv6 Network Scanning

Demo time!

We will demo the activity on the screen. Watch what we do.

Demo 2: IPv6 Network Scanning

- **Description**: Use available toolsets to scan a subnet
- Goals:
 - Know about two toolsets:
 - THC-IPV6 (https://github.com/vanhauser-thc/thc-ipv6)
 - The IPv6 Toolkit (https://www.si6networks.com/tools/ipv6toolkit/)
 - Learn which tool they have to scan a link
- **Time**: 5-10 minutes
- Demo:
 - Use The IPv6 Toolkit to scan a subnet
 - Use THC-IPV6 to scan a subnet

Demo 2 Lab network

Demo 2: IPv6 Network Scanning

[root@host-c ~]# alive6 eth0 Alive: 2001:db8:f:1:5054:ff:fec1:4275 [ICMP echo-reply] Alive: 2001:db8:f:1:5054:ff:fe9d:32ea [ICMP echo-reply] Alive: 2001:db8:f:1::1 [ICMP echo-reply]

Scanned 1 address and found 3 systems alive [root@host-c ~]#

Demo 2: IPv6 Network Scanning

[root@host-c ~]# scan6 -L -i eth0 [6797.089211] device eth0 entered promiscuous mode fe80::5054:ff:fec1:4275 fe80::5054:ff:fe9d:32ea fe80::5054:ff:fe99:5165 2001:db8:f:1:5054:ff:fec1:4275 2001:db8:f:1::1 2001:db8:f:1:5054:ff:fe9d:32ea [6801.104679] device eth0 left promiscuous mode
Take the poll!

Why do you think alive6 only finds **global** addresses and **scan6** also finds the **link-local** addresses?



What Have We Seen?



Basics of IPv6 brings some security considerations

Same as in IPv4: IP spoofing, covert channel, or even IPsec

New in IPv6: Extension headers, new addressing scheme, new scanning techniques

There are tools that allow security assessment of IPv6 networks



Take the poll!

Think of what you learned in this webinar.

What things can you apply or use in **your own network**?



What's Next in IPv6

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