RIPE NCC
RIPE NETWORK COORDINATION CENTRE

IPv6 Associated Protocols Security

Webinar

RIPE NCC Learning & Development

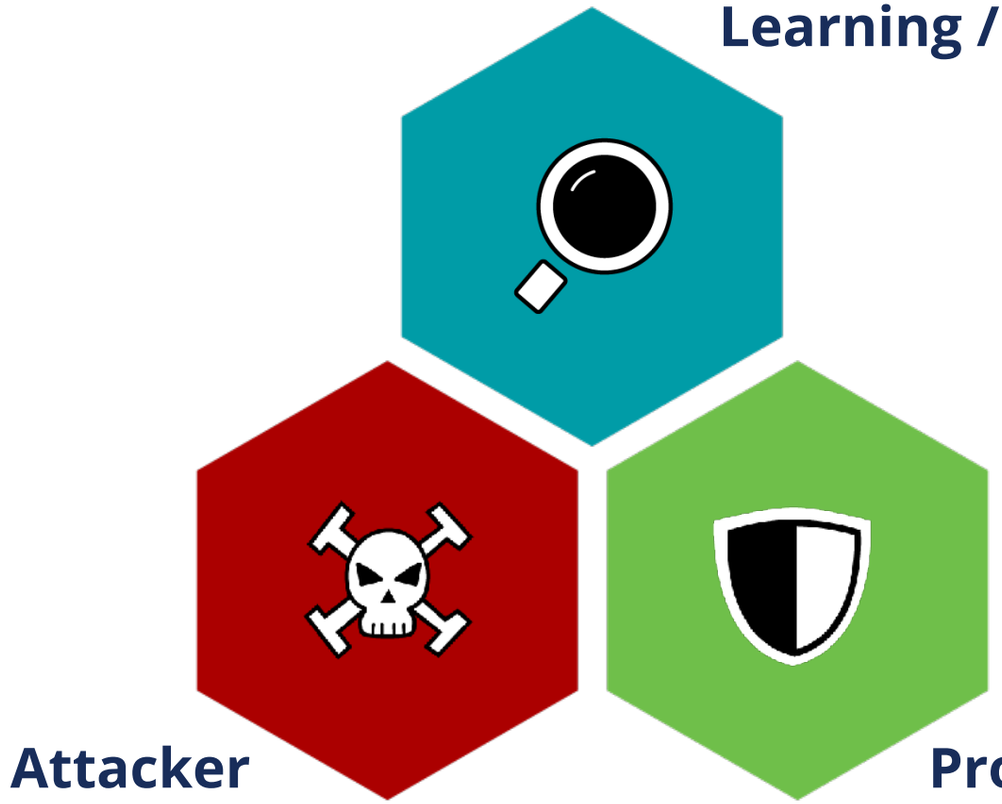
This webinar is being recorded

IPv6 Associated Protocols Security

ICMPv6

NDP

MLD


Learning / Understanding
Attacker
Protecting

Tell us about you!

Please answer the polls

2 min.

ICMPv6

Section 1

ICMPv6 [*RFC4443*] is an integral part of IPv6

Error Messages

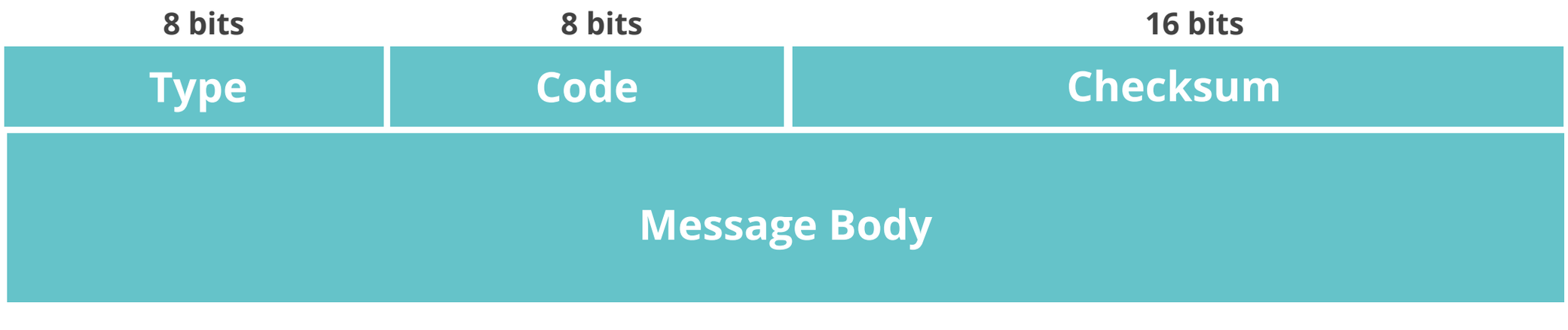
- **Destination Unreachable**
- **Packet Too Big**
- **Time Exceeded**
- **Parameter Problem**

Informational Messages

- **Echo Request**
- **Echo Reply**
- **NDP**
- **MLD**

ICMPv6 Format

- General Format



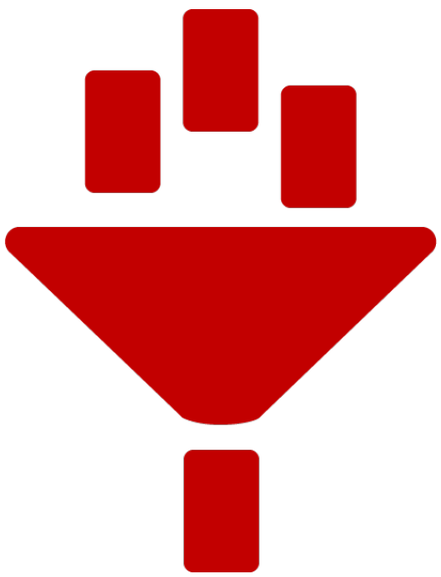
- Extended Format [*RFC4884*]

Used by:

- **Destination Unreachable**
- **Time Exceeded**

ICMPv6 Error Messages

Type	Code
Destination Ureachable (1)	No route to destination (0)
	Communication with destination administratively prohibited (1)
	Beyond scope of source address (2)
	Address Unreachable (3)
	Port Unreachable (4)
	Source address failed ingress/egress policy (5)
	Reject route to destination (6)
	Error in Source Routing Header (7)
Packet Too Big (2) Parameter = next hop MTU	Packet Too Big (0)
Time Exceeded (3)	Hop Limit Exceeded in Transit (0)
	Fragment Reassembly Time Exceeded (1)
Parameter Problem (4) Parameter = offset to error	Erroneous Header Field Encountered (0)
	Unrecognized Next Header Type (1)
	Unrecognized IPv6 Option (2)
	IPv6 First Fragment has incomplete IPv6 Header Chain (3)



FILTER ICMPv6 CAREFULLY!

Used in many IPv6 related protocols

ICMPv6 Security

Packet with MULTICAST destination address

No ICMPv6 Error message allowed as a response

avoids

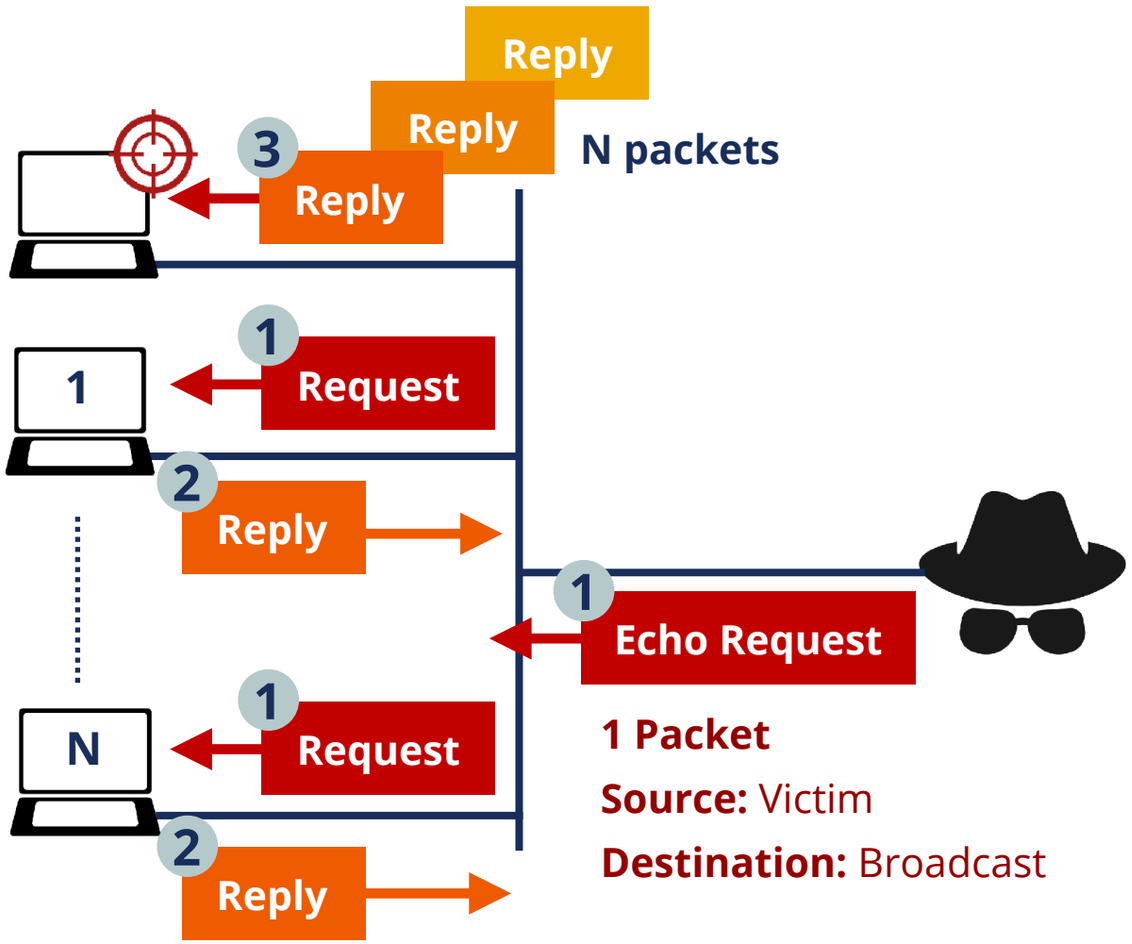
- **Hosts Discovery**
- **Amplification Attacks**

Echo Reply responding an Echo Request is Optional

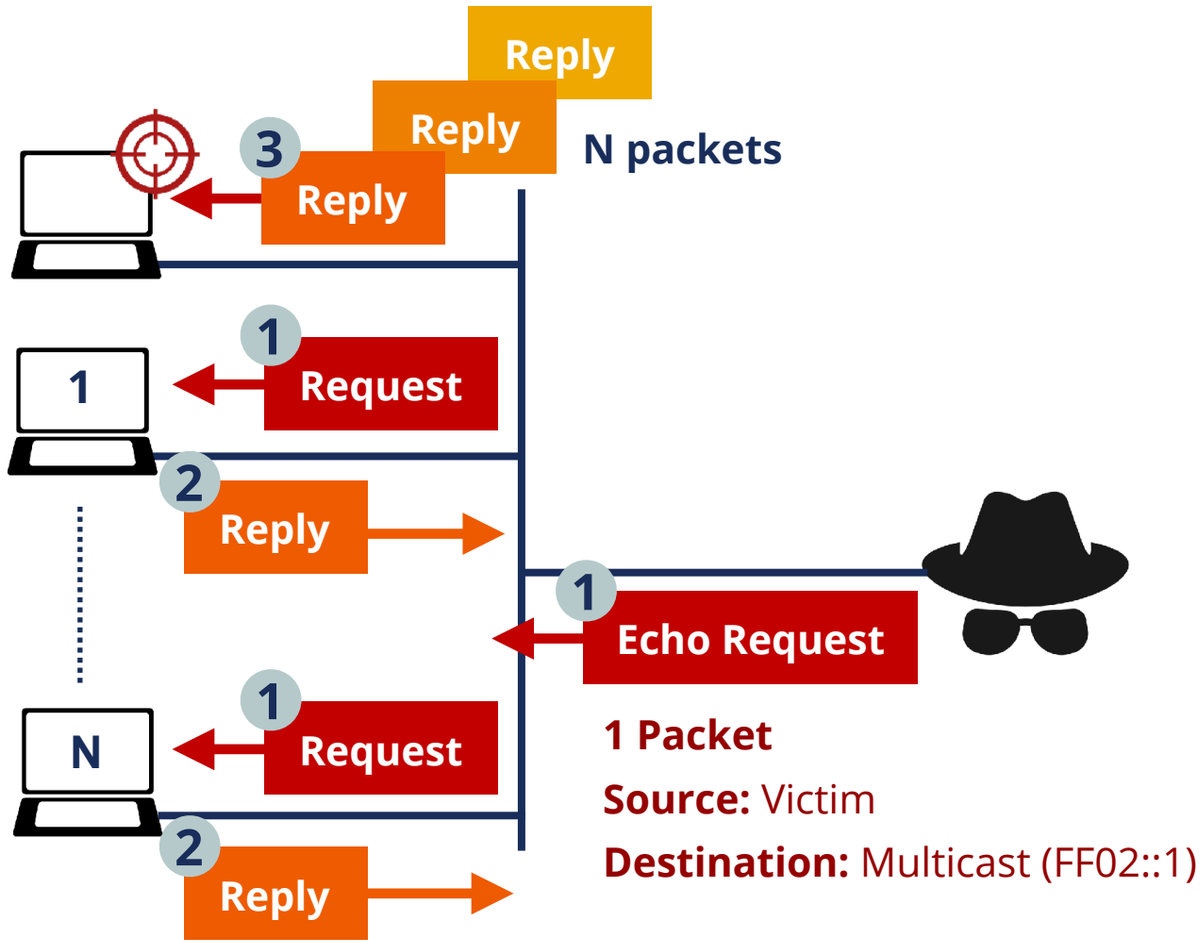
not recommended

- **Smurf Attacks**

Smurf Attack



IPv4



IPv6

Take the poll!

Which of the following are **ICMPv6 error** messages?

2 min.

Questions

NDP

Section 2

NDP [*RFC4861*] is used on a link

Messages

- **Neighbour Solicitation**
- **Neighbour Advertisement**
- **Router Solicitation**
- **Router Advertisement**
- **Redirect**

Used for:

Discovery: routers, prefixes, network parameters

Autoconfiguration

DAD

NUD

Address Resolution

Hop Limit = 255

if not then **discard**

NDP has vulnerabilities

[RFC3756]

[RFC6583]

Specification says to use IPsec

impractical, it’s not used

SEND [RFC3971]

(SEcure Neighbour Discovery)

Not widely available

Take the poll!

Which of the following are **ICMPv6 Neighbor Discovery Protocol** messages?

2 min.

NDP Threats

- **Neighbor Solicitation/Advertisement Spoofing**

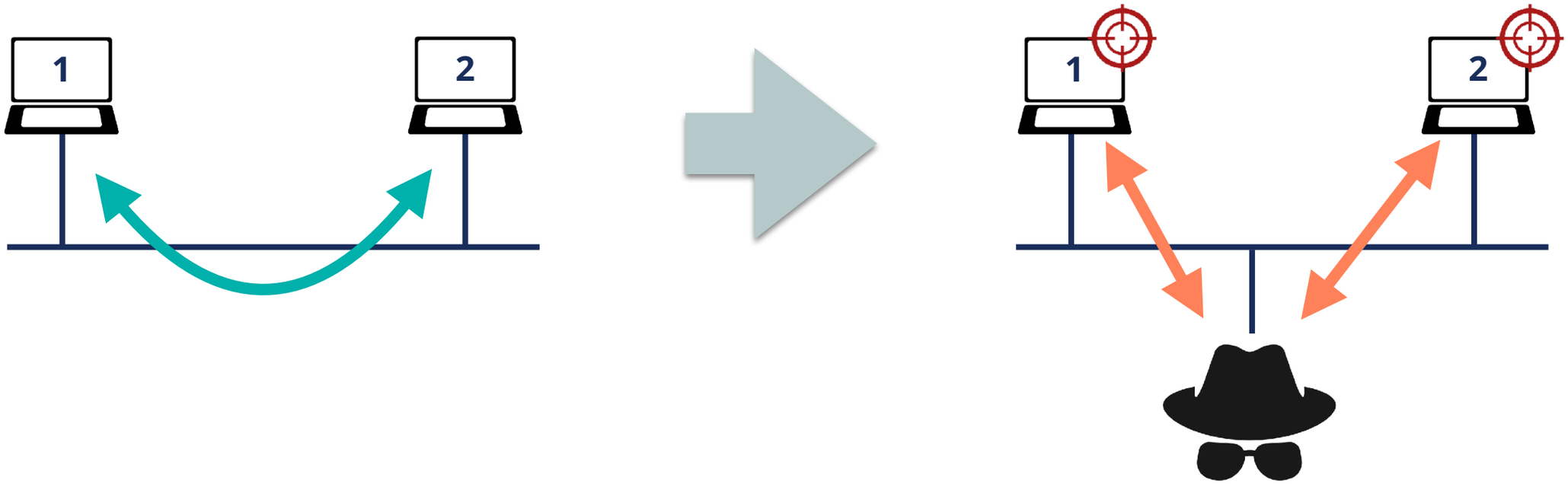
- Can be done sending:

  1. **NS** with “source link-layer” option changed
  2. **NA** with “target link-layer” option changed
     - Can send unsolicited **NA** or as an answer to **NS**

- Redirection/DoS attack
- Could be used for a “**Man-In-The-Middle**” attack

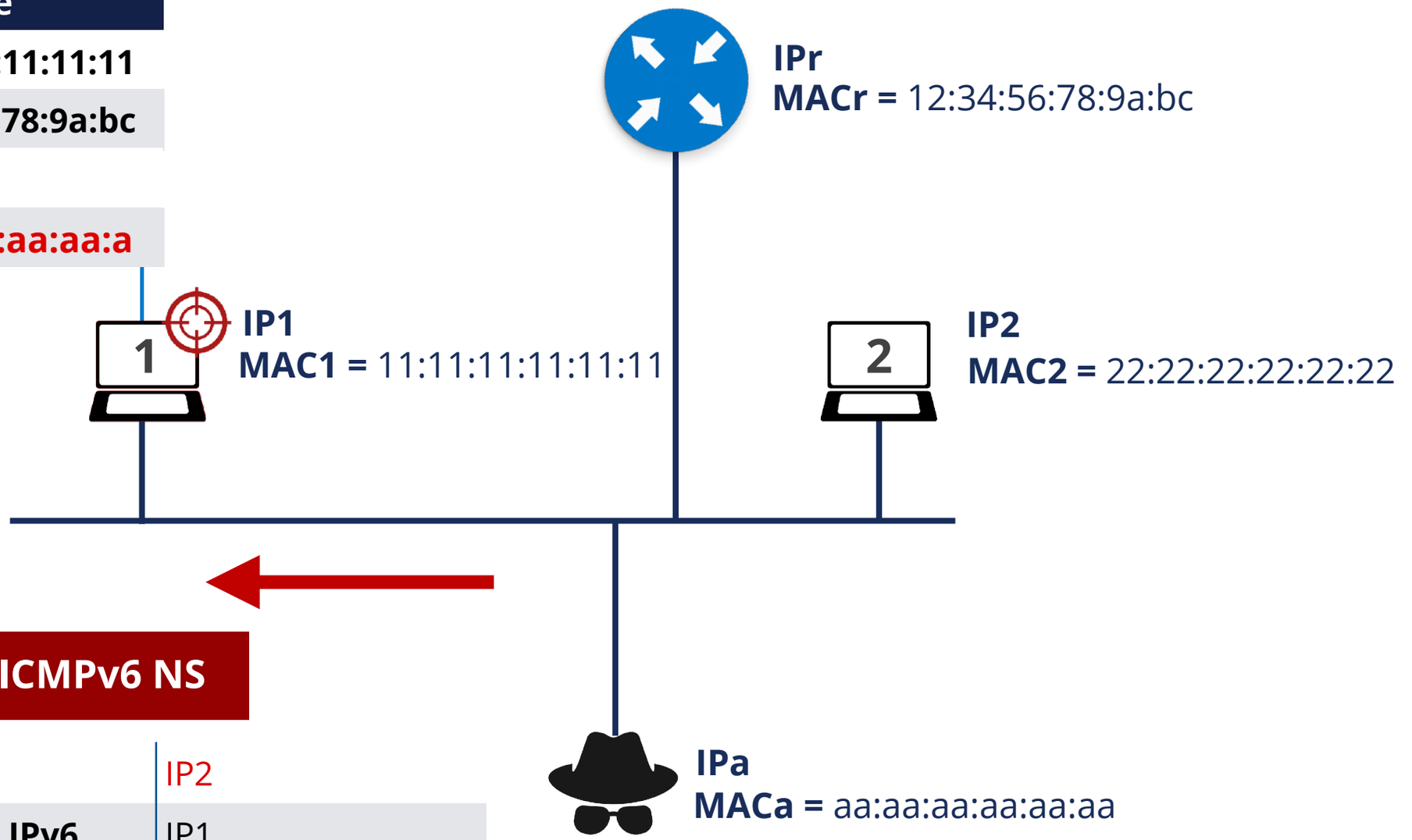
Man-In-The-Middle (MITM) Attack

- The attacker is able to be on the path of the packets



NS Spoofing (Redirection / DoS)

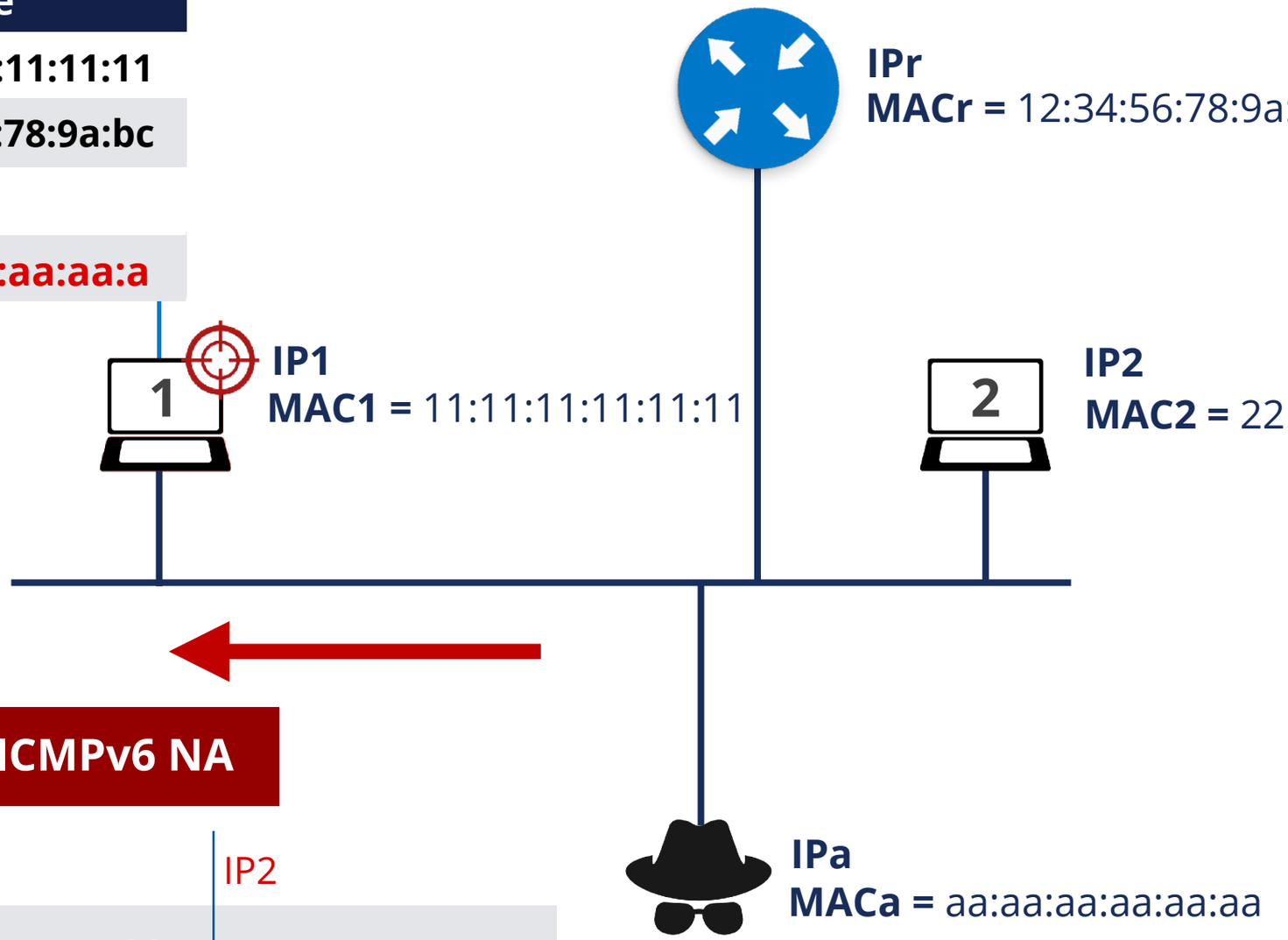
Neighbour Cache	
IP1	11:11:11:11:11:11
IPr	12:34:56:78:9a:bc
IP2	aa:aa:aa:aa:aa:a



IPv6	ICMPv6 NS
IPv6.Source IPv6	IP2
IPv6.Destination IPv6	IP1
NS.Target Addr	IP1
NS.Src Link-layer Addr	aa:aa:aa:aa:aa:aa

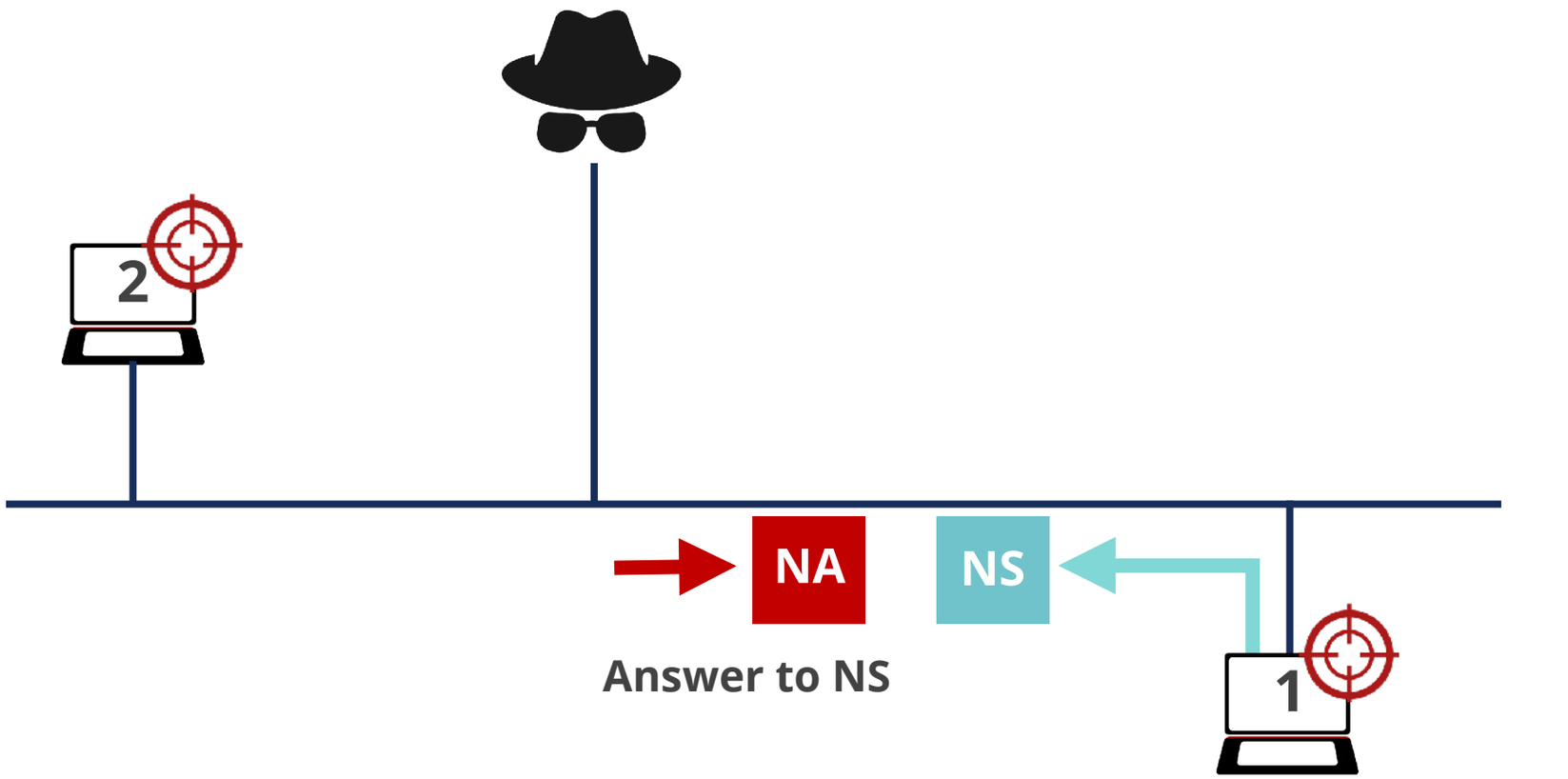
Unsolicited NA (Redirection / DoS)

Neighbour Cache	
IP1	11:11:11:11:11:11
IPr	12:34:56:78:9a:bc
IP2	aa:aa:aa:aa:aa:a

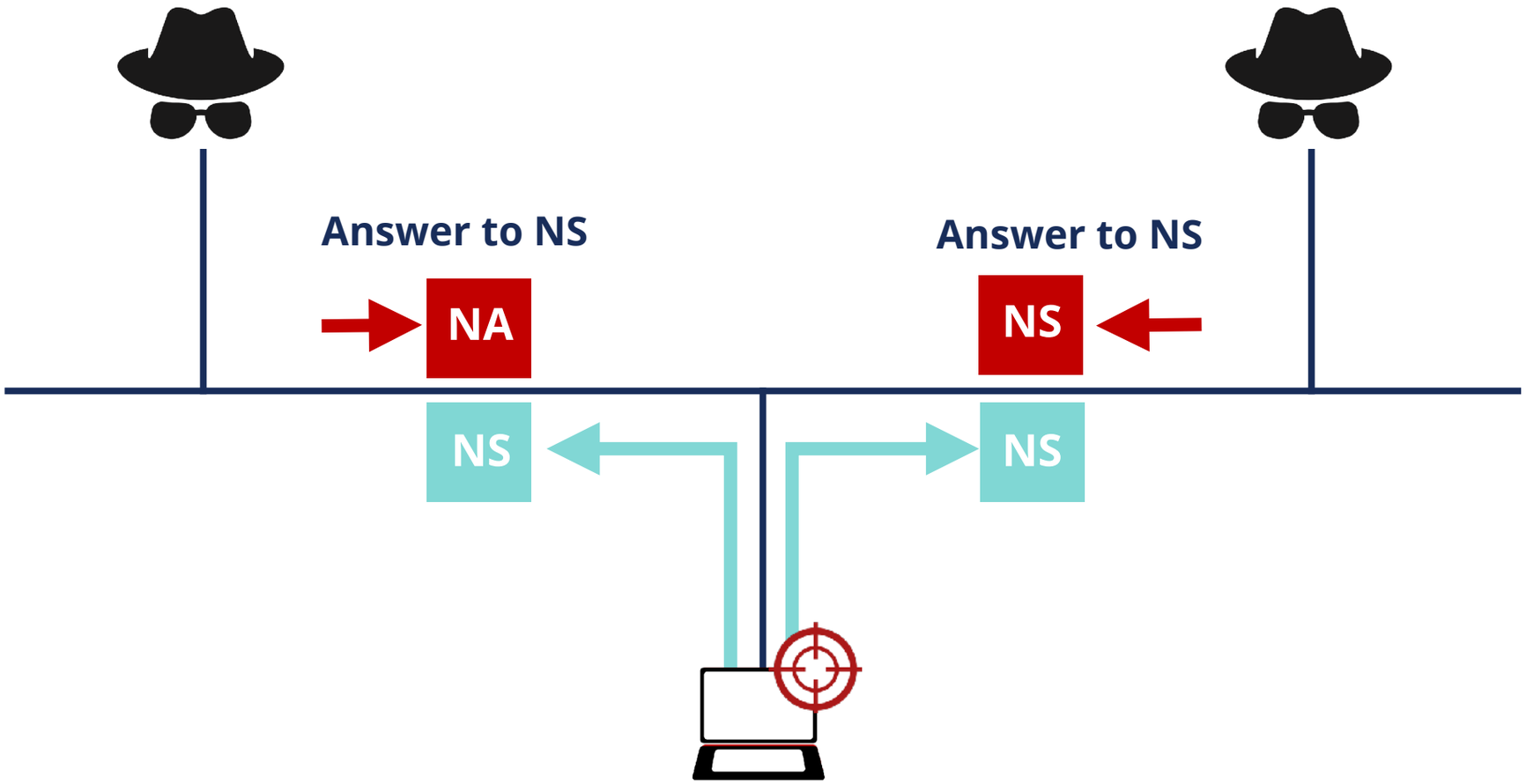


IPv6	ICMPv6 NA
NA.Target Addr	IP2
NA.Target Link-layer Addr	aa:aa:aa:aa:aa:aa

NUD Failure (DoS attack)



DAD (DoS Attack)



DAD for IP before configuring it

Take the poll!

Who is the usual **”target”** in a host attacked by NDP Threats using NA/NS messages?

2 min.

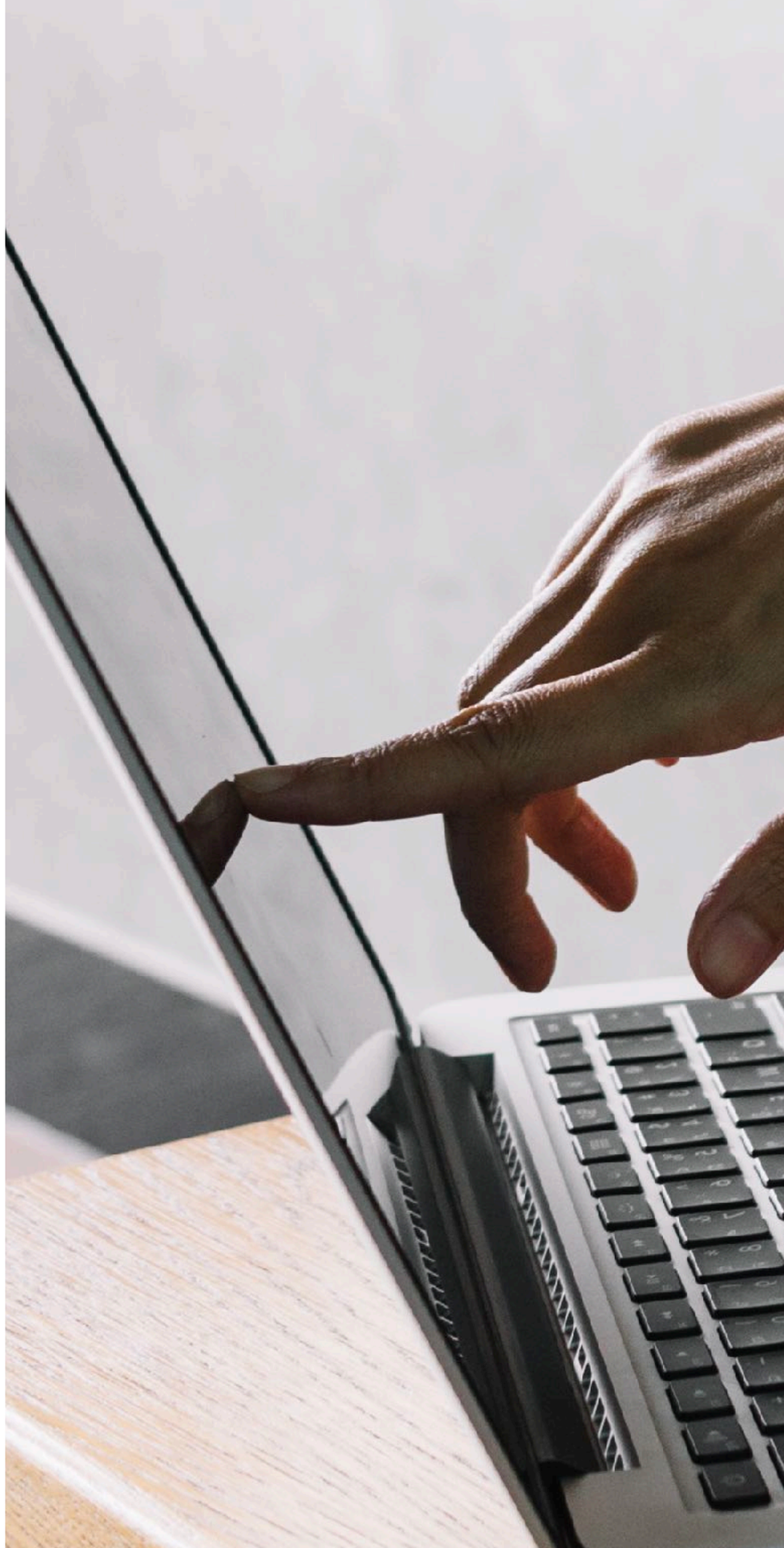
Questions

Demo 1

NDP

Demo time!

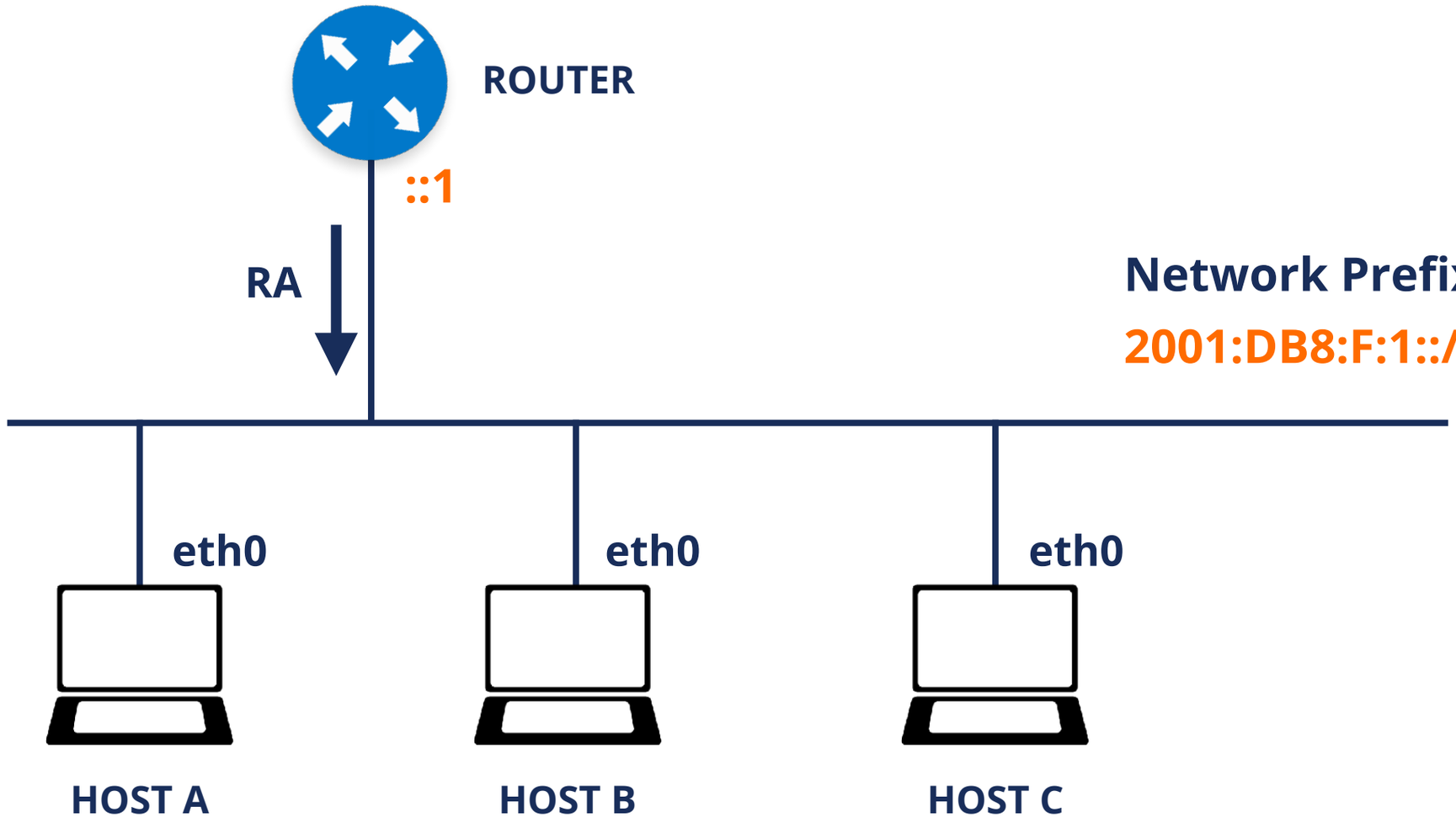
We will demo the activity on the screen.
Watch what we do.



Demo 1: NDP

- **Description**: Use NDP NA packets to poison neighbour cache
- **Goals**:
  - Understand how easy it is to modify the neighbour cache of other host in the same link
- **Time**: 10 minutes
- **Demo**:
  - Generate NA packets that change other host's neighbour cache (using Scapy)

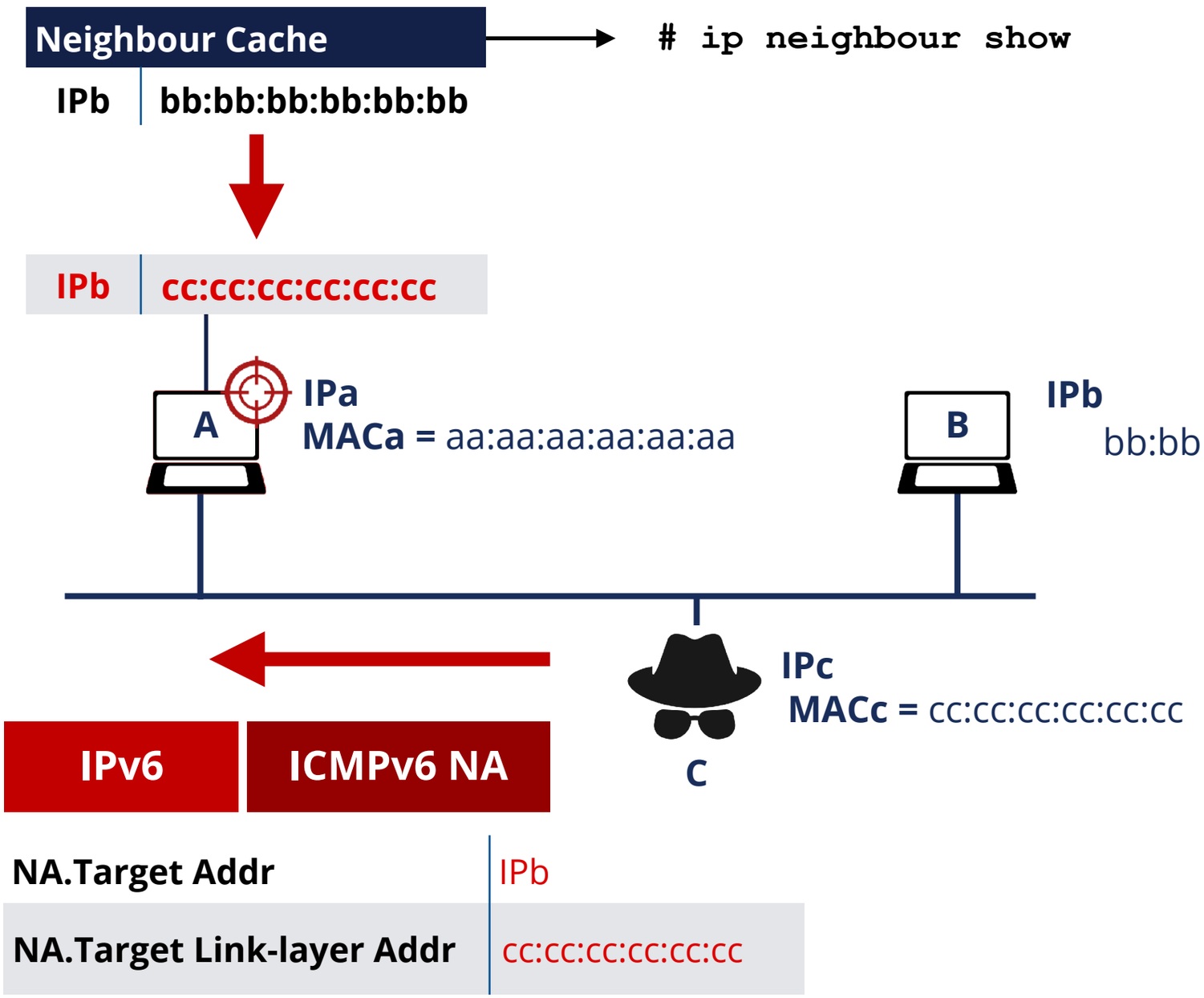
Demo 1: Lab Network



Network Prefix:

2001:DB8:F:1::/64

Demo 1: Neighbour Cache Attack with NA



- Is it possible to perform a **Man-in-the-middle** attack using **NA** or **NS** messages?

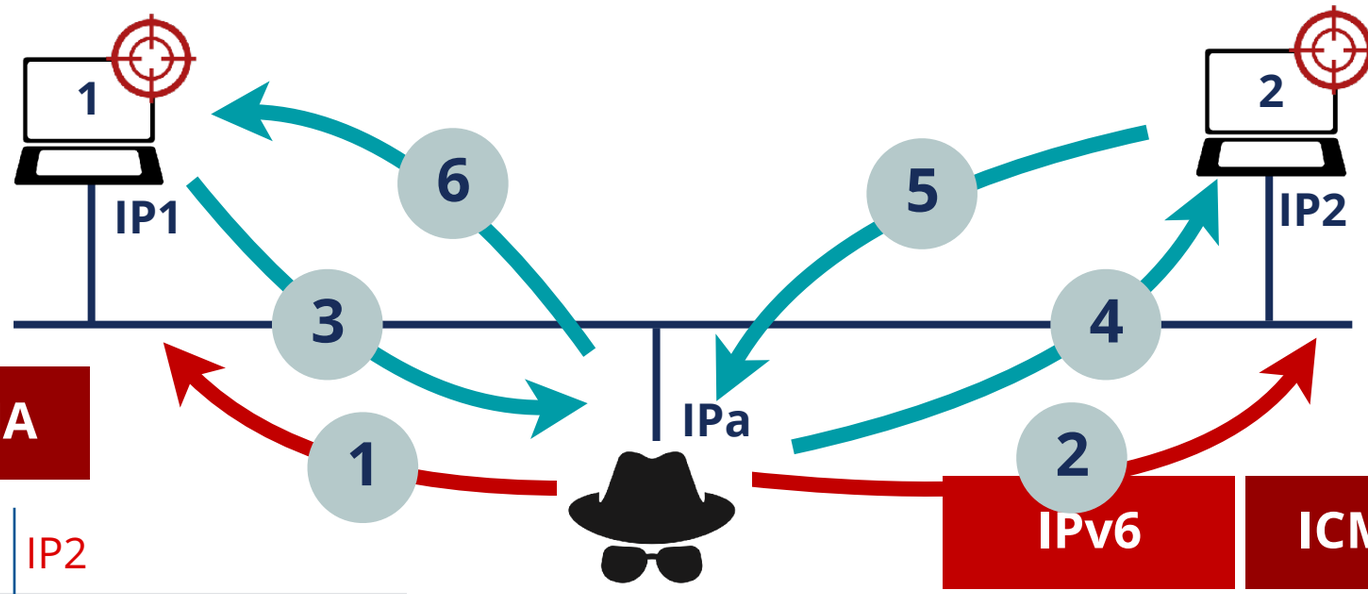
MITM Details

Neighbour Cache	
IP1	11:11:11:11:11:11
IP2	aa:aa:aa:aa:aa:aa

MAC1 = 11:11:11:11:11:11

MAC2 = 22:22:22:22:22:22

Neighbour Cache	
IP2	22:22:22:22:22:22
IP1	aa:aa:aa:aa:aa:aa



MACa =
aa:aa:aa:aa:aa:aa

IPv6	ICMPv6 NA
NA.Target Addr	IP2
NA.Target Link-layer Addr	aa:aa:aa:aa:aa:aa

IPv6	ICMPv6 NA
NA.Target Addr	IP1
NA.Target Link-layer Addr	aa:aa:aa:aa:aa:aa

3

Ethernet	IPv6
Src: MAC1	**Src:** IP1
Dst: MACa	**Dst:** IP2

4

Ethernet	IPv6
Src: MACa	**Src:** IP1
Dst: MAC2	**Dst:** IP2

5

Ethernet	IPv6
Src: MAC2	**Src:** IP2
Dst: MACa	**Dst:** IP1

6

Ethernet	IPv6
Src: MACa	**Src:** IP2
Dst: MAC1	**Dst:** IP1

Let’s take a **5 minutes** break!

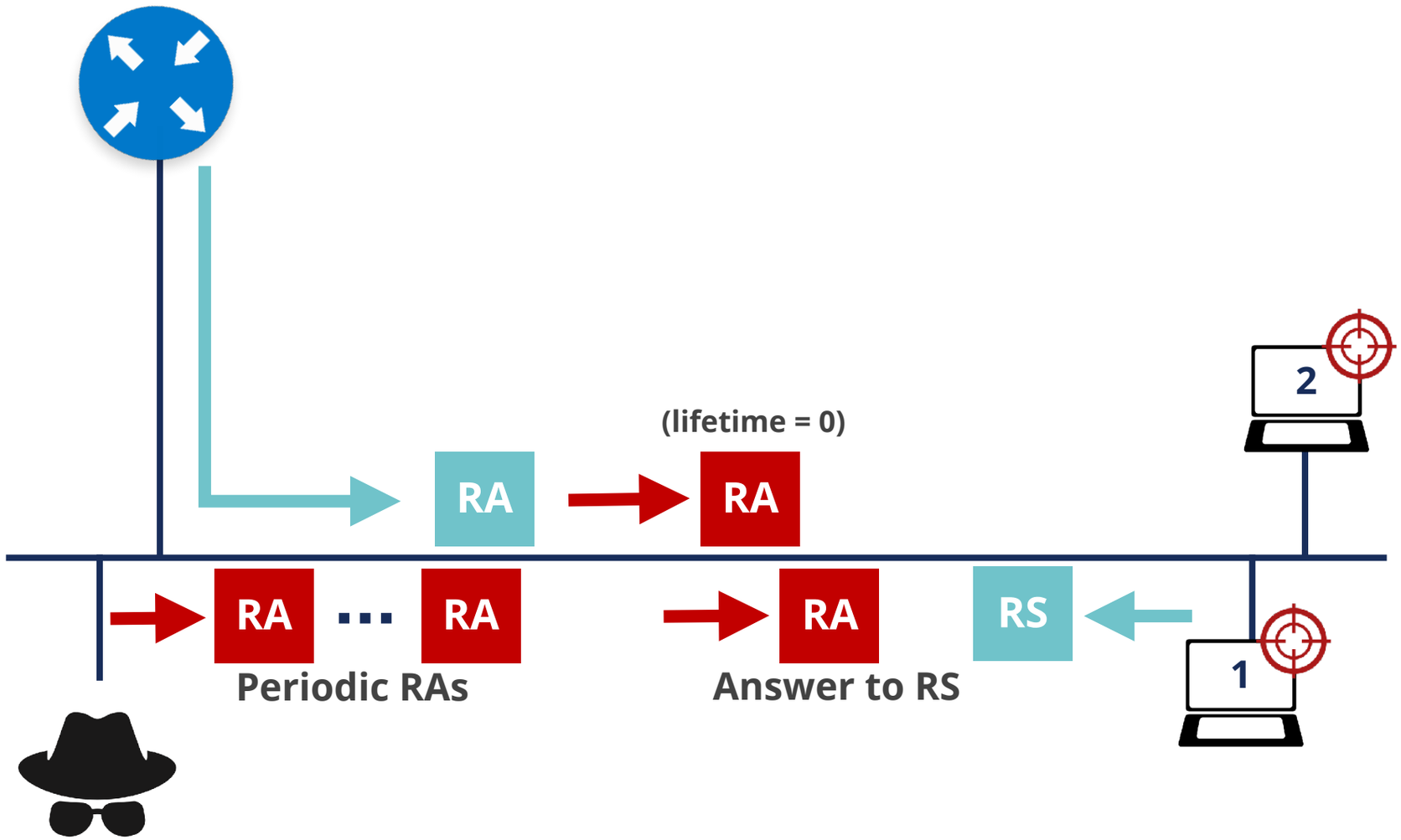

WELCOME
WE ARE
OPEN
PLEASE COME IN

Take the poll!

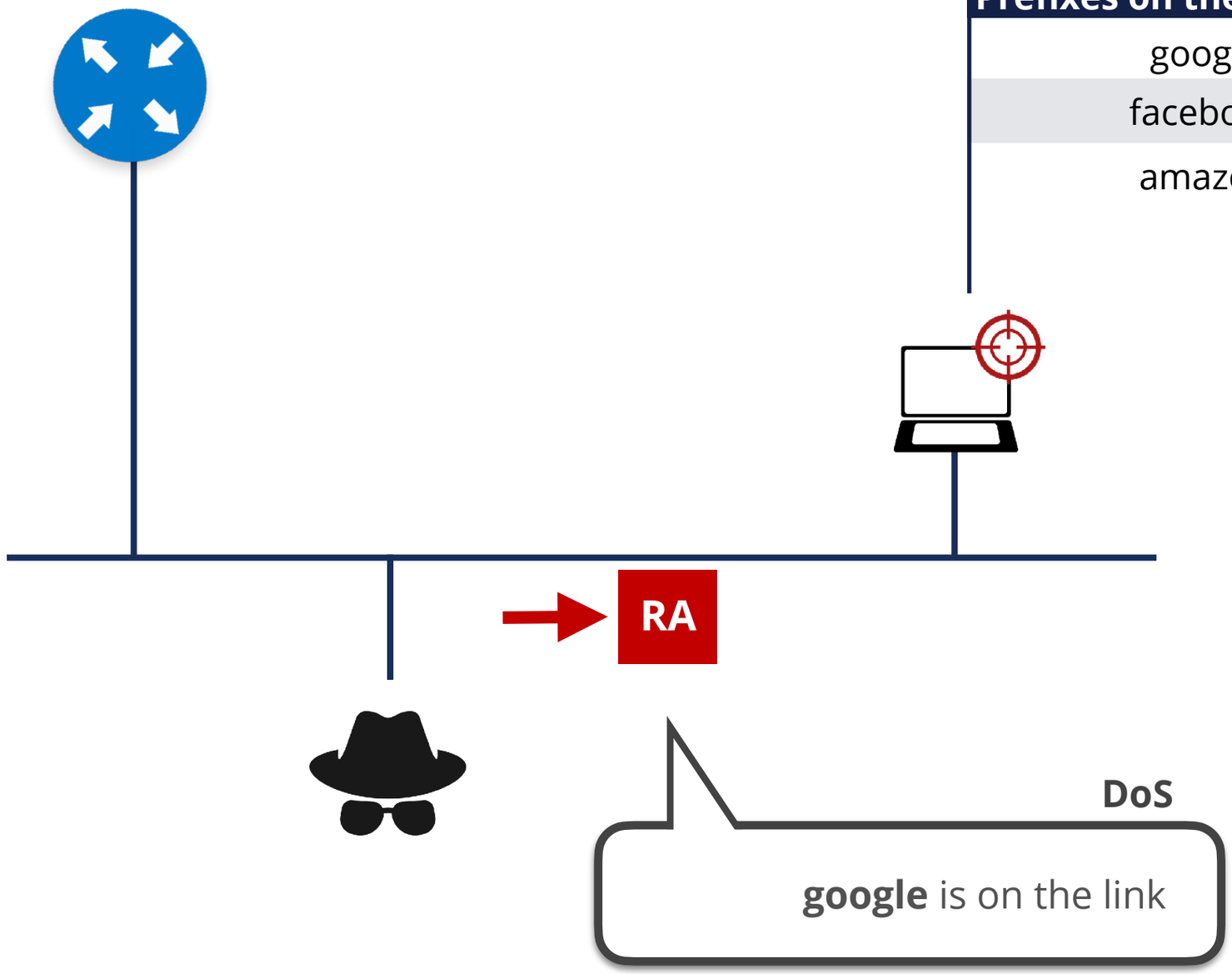
How can an **RA message** be used to attack hosts on the same network?

2 min.

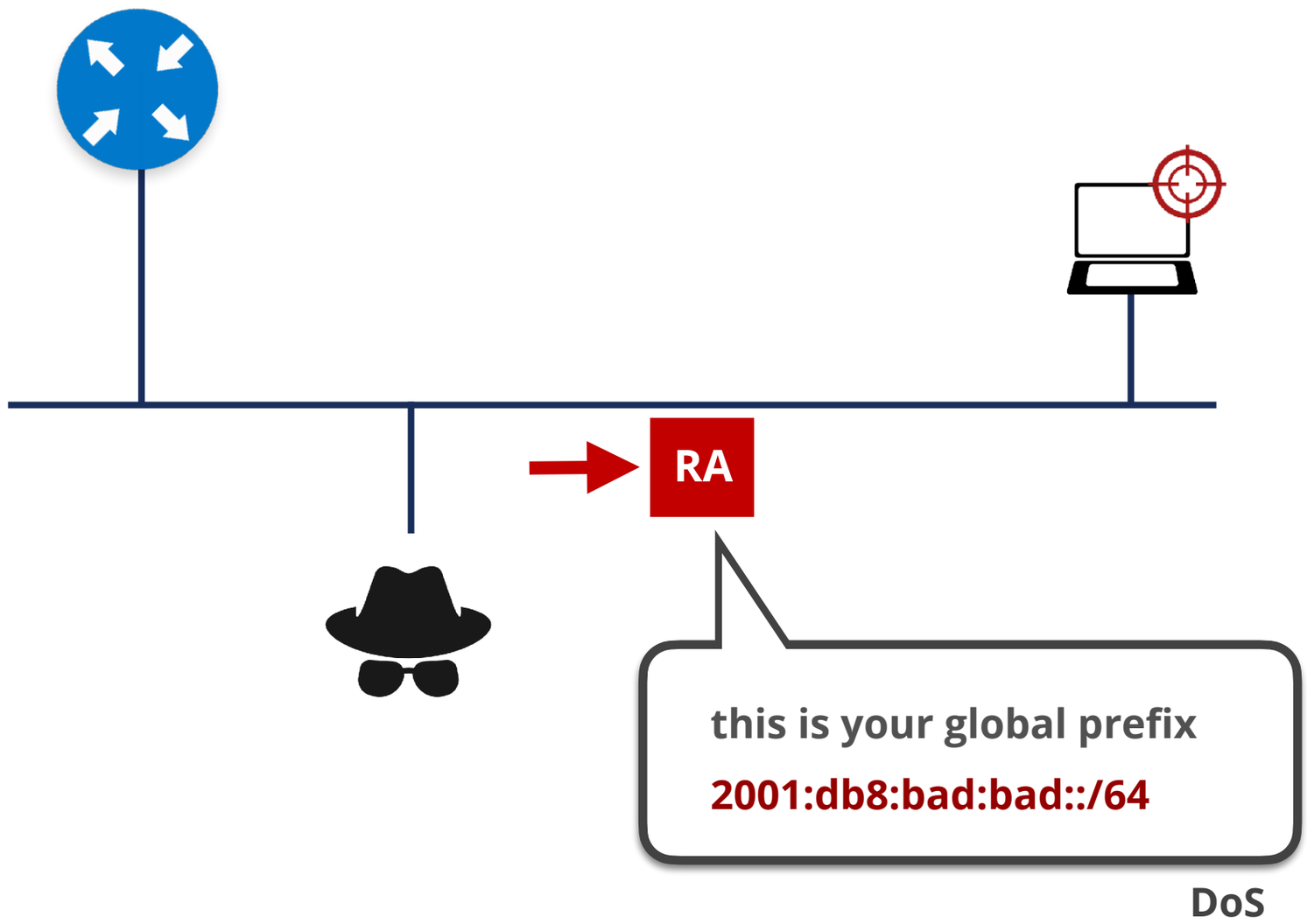
Malicious Last Hop Router



Bogus On-Link Prefix

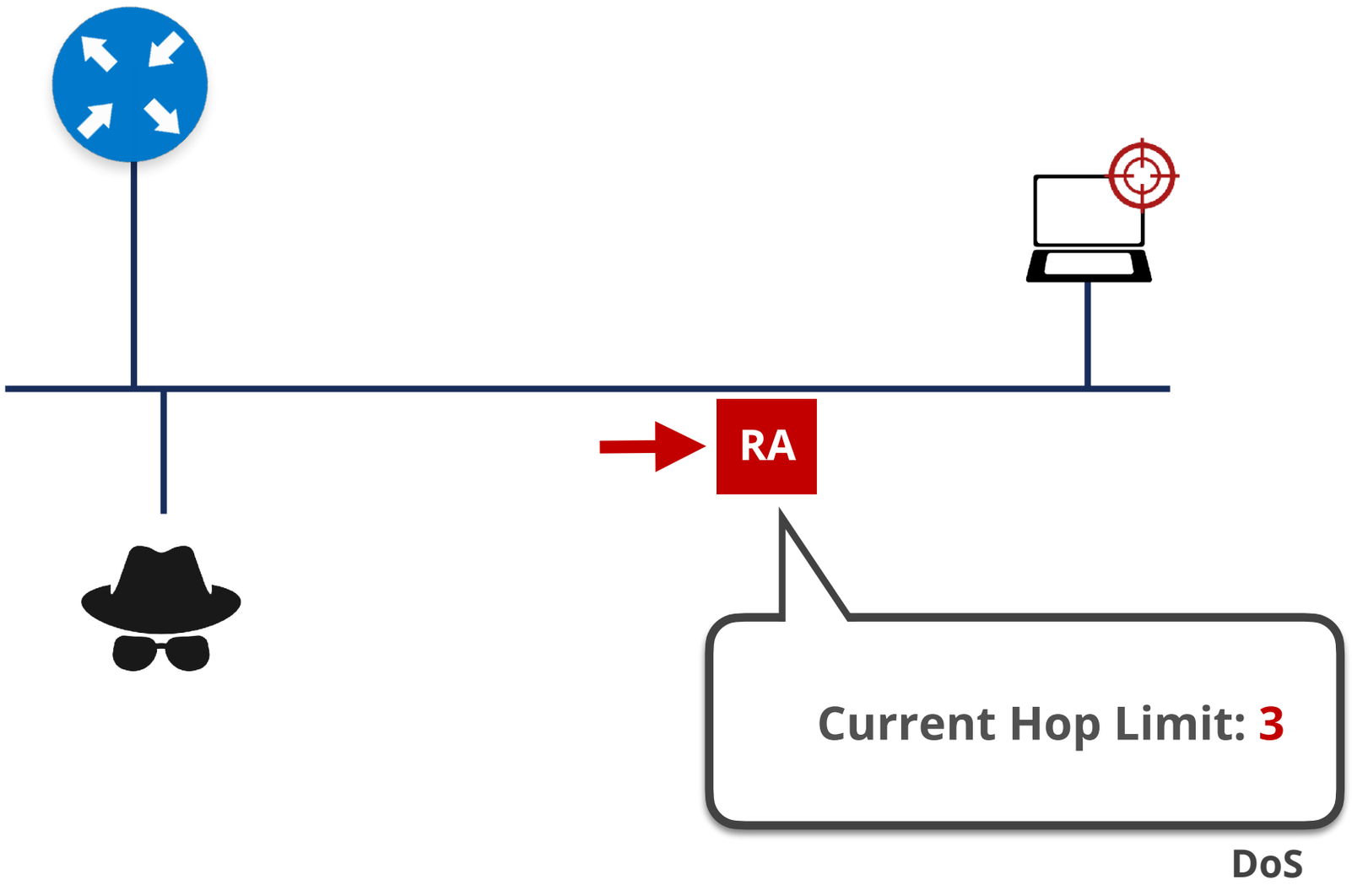


Bogus Address Configuration Prefix



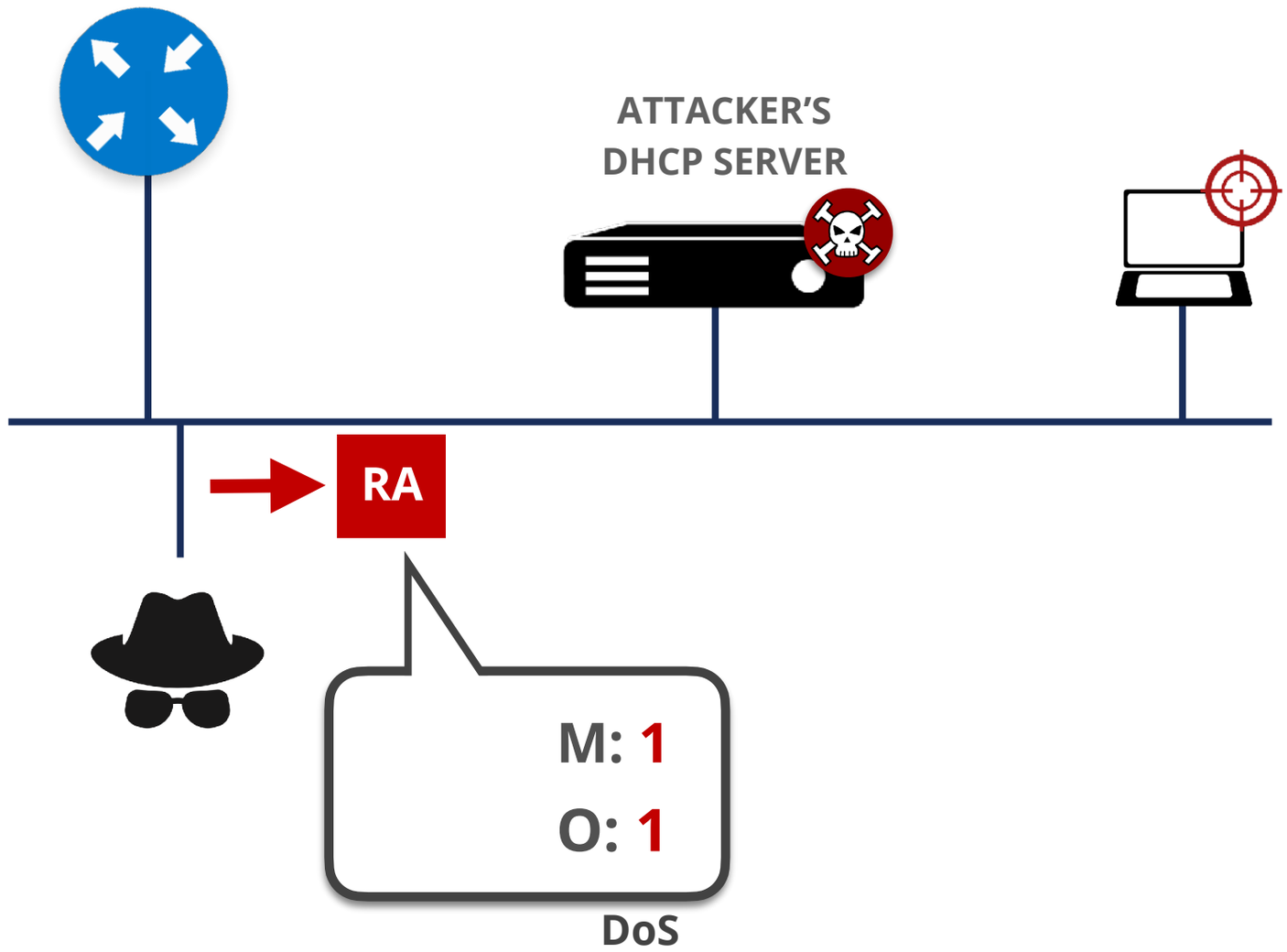
DoS

Parameter Spoofing: Hop Limit



DoS

Parameter Spoofing: DHCPv6



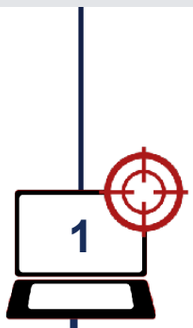
Spoofed Redirect Message

Neighbour Cache	
IP1	11:11:11:11:11:11
IPr	12:34:56:78:9a:bc

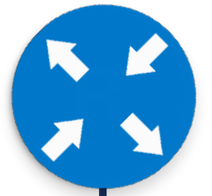
Routes on Host 1:

::/0 - fe80::a:b:c

2001:db8::face:b00c - fe80::a



IP1
MAC1 = 11:11:11:11:11:11



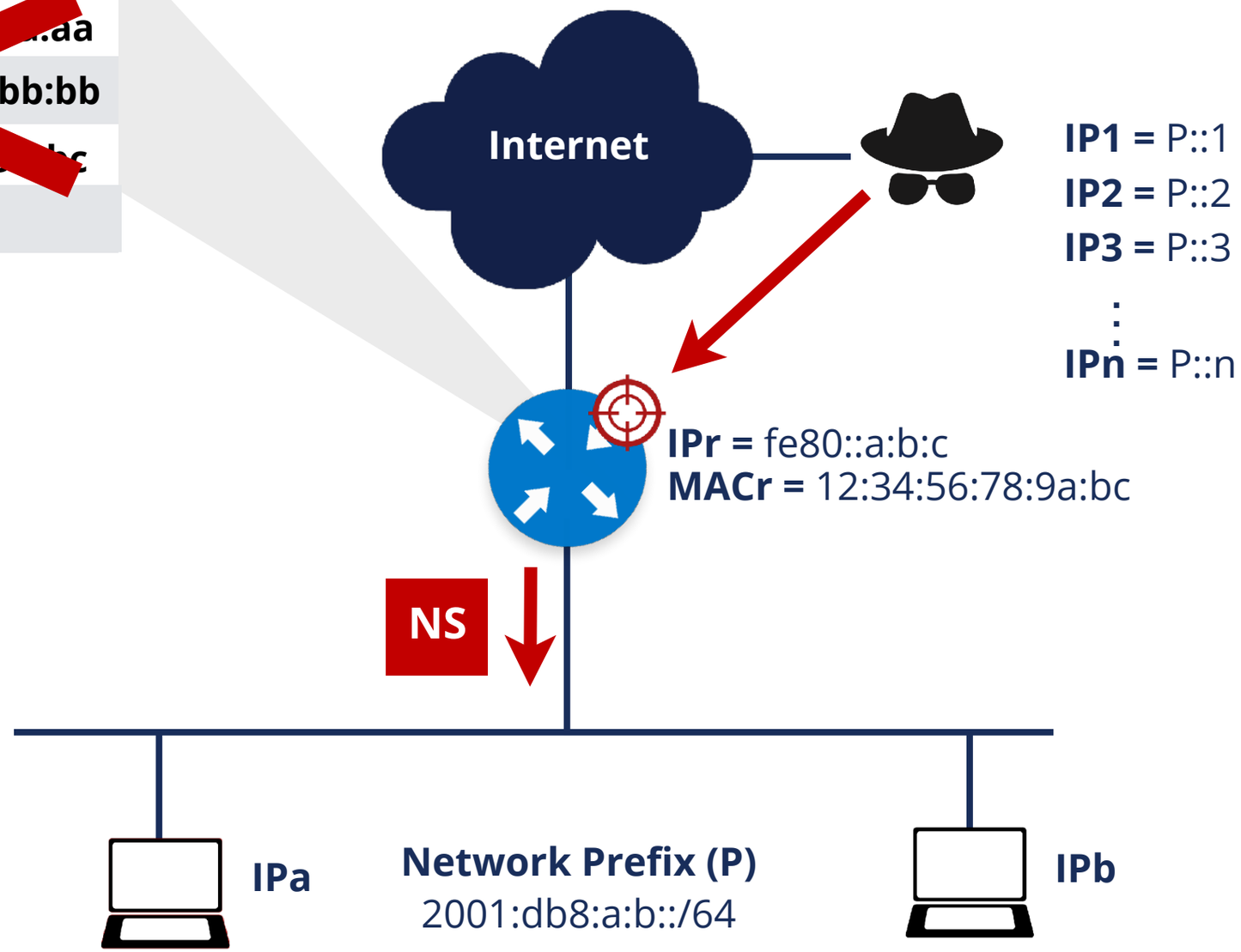
IPr = fe80::a:b:c
MACr = 12:34:56:78:9a:bc

IPa = fe80::a
MACa = aa:aa:aa:aa:aa:aa

IPv6	ICMPv6 Redirect
IPv6.Source IPv6	IPr = fe80::a:b:c
IPv6.Destination IPv6	IP1
Redirect.Target Addr	IPa = fe80::a
Redirect.Dst Addr.	2001:db8::face:b00c

Neighbour Discovery DoS Attack

Router Neighbour Cache	
~~IPa~~	~~aa:aa:aa:aa:aa:aa~~
IPb	bb:bb:bb:bb:bb:bb
~~IP~~	~~12:34:56:78:9a:bc~~
IP1	???
⋮	⋮
IPn	???



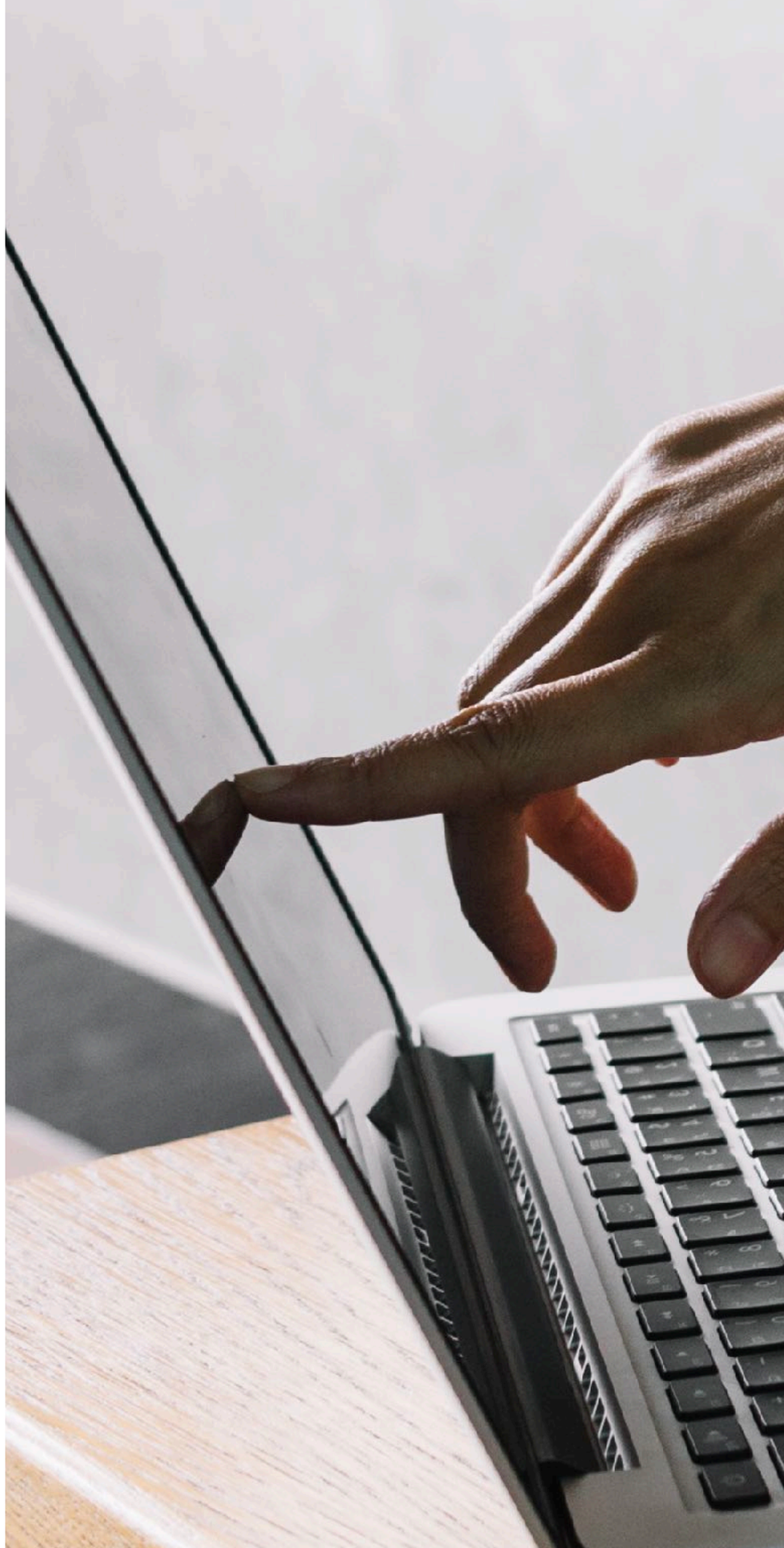
Questions

Demo 2

NDP

Demo time!

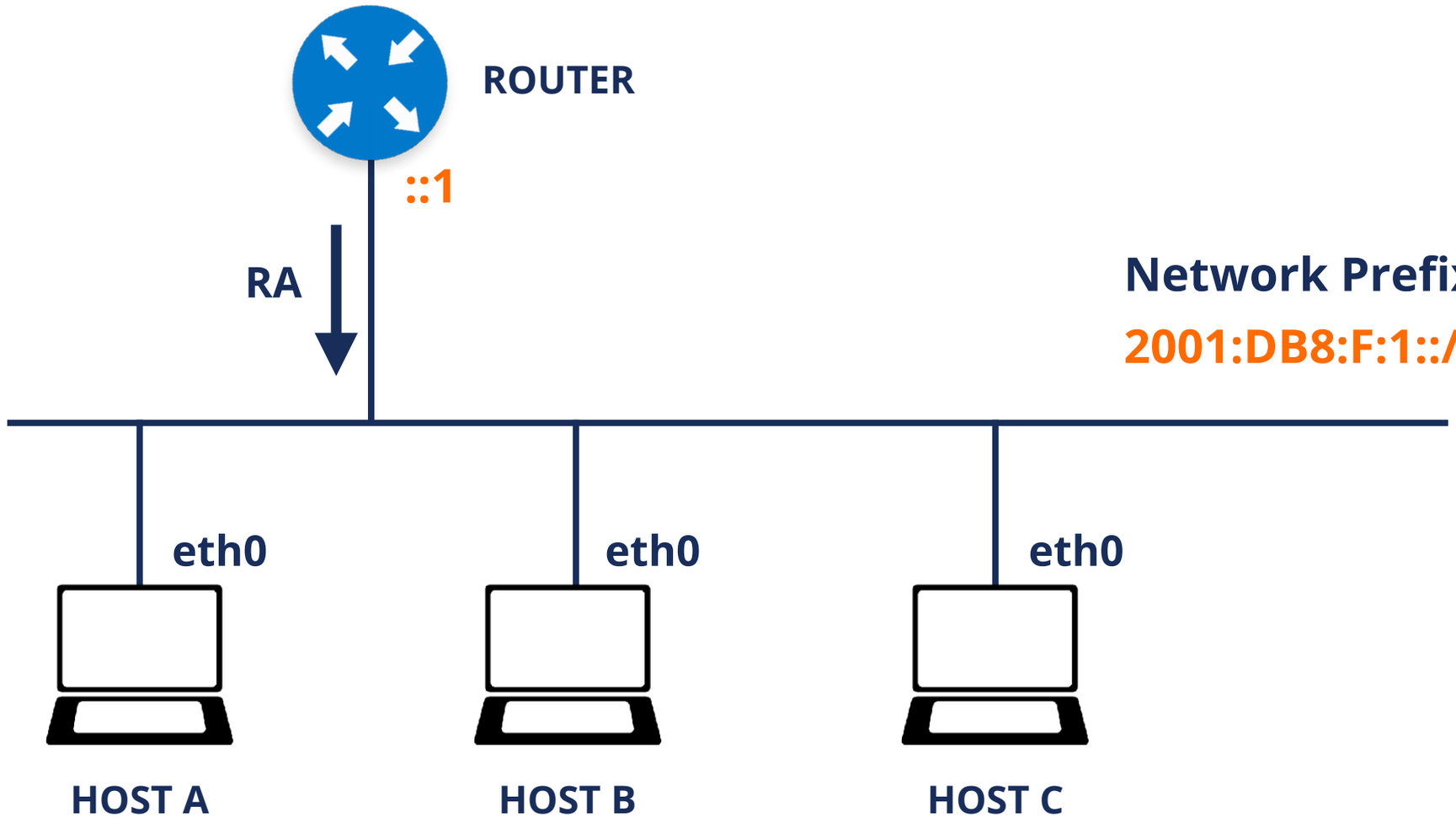
We will demo the activity on the screen.
Watch what we do.



Demo 2: NDP

- **Description**: Use NDP RA packets to configure fake network parameters
- **Goals**:
  - Understand how easy it is to modify the network parameters of other host in the same link
- **Time**: 10 minutes
- **Demo**:
  - Generate RA packets that configures fake address and gateway on other hosts (with Scapy)

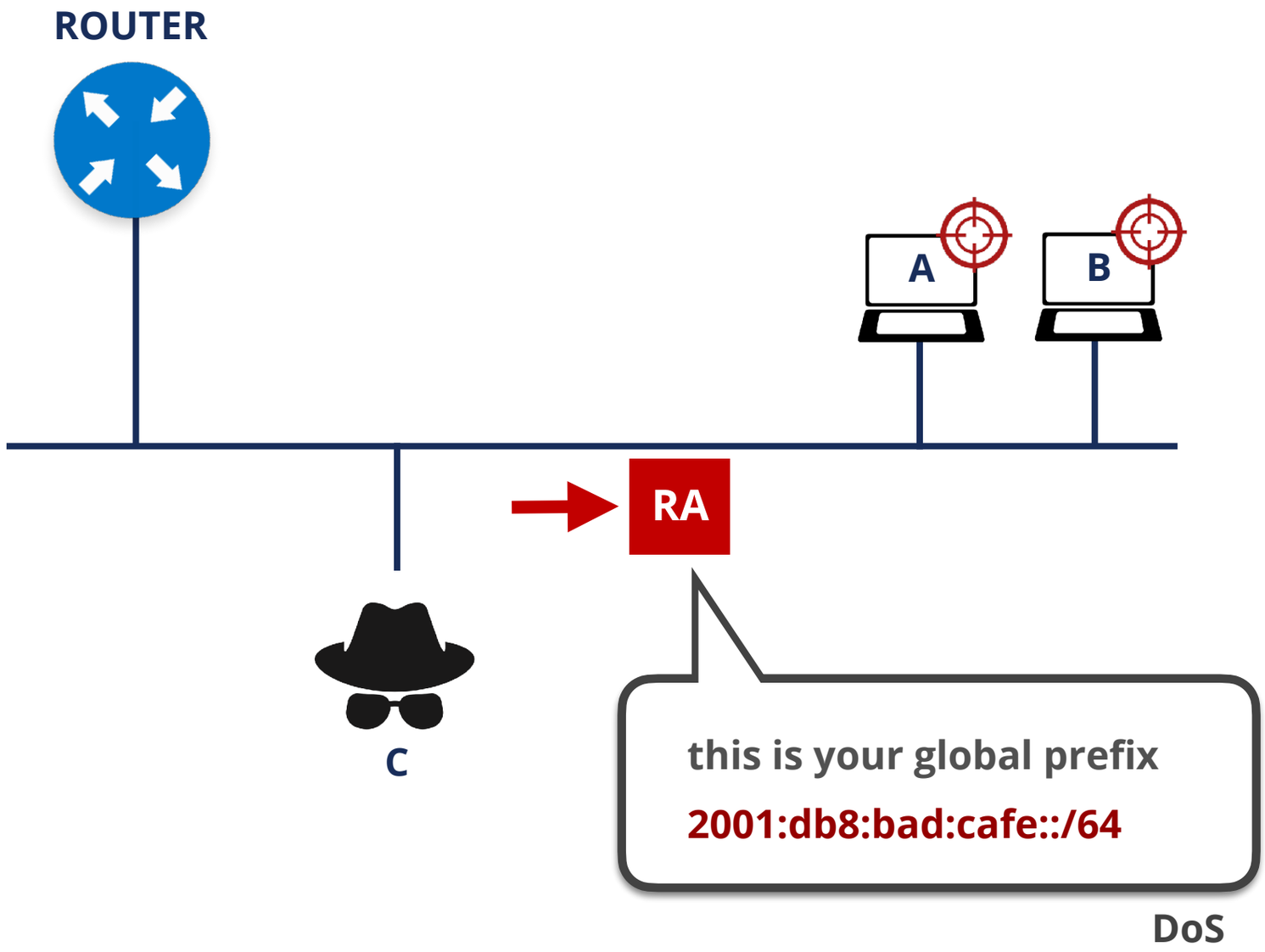
Demo 2: Lab Network



Network Prefix:

2001:DB8:F:1::/64

Demo 2: Rogue RA



Take the poll!

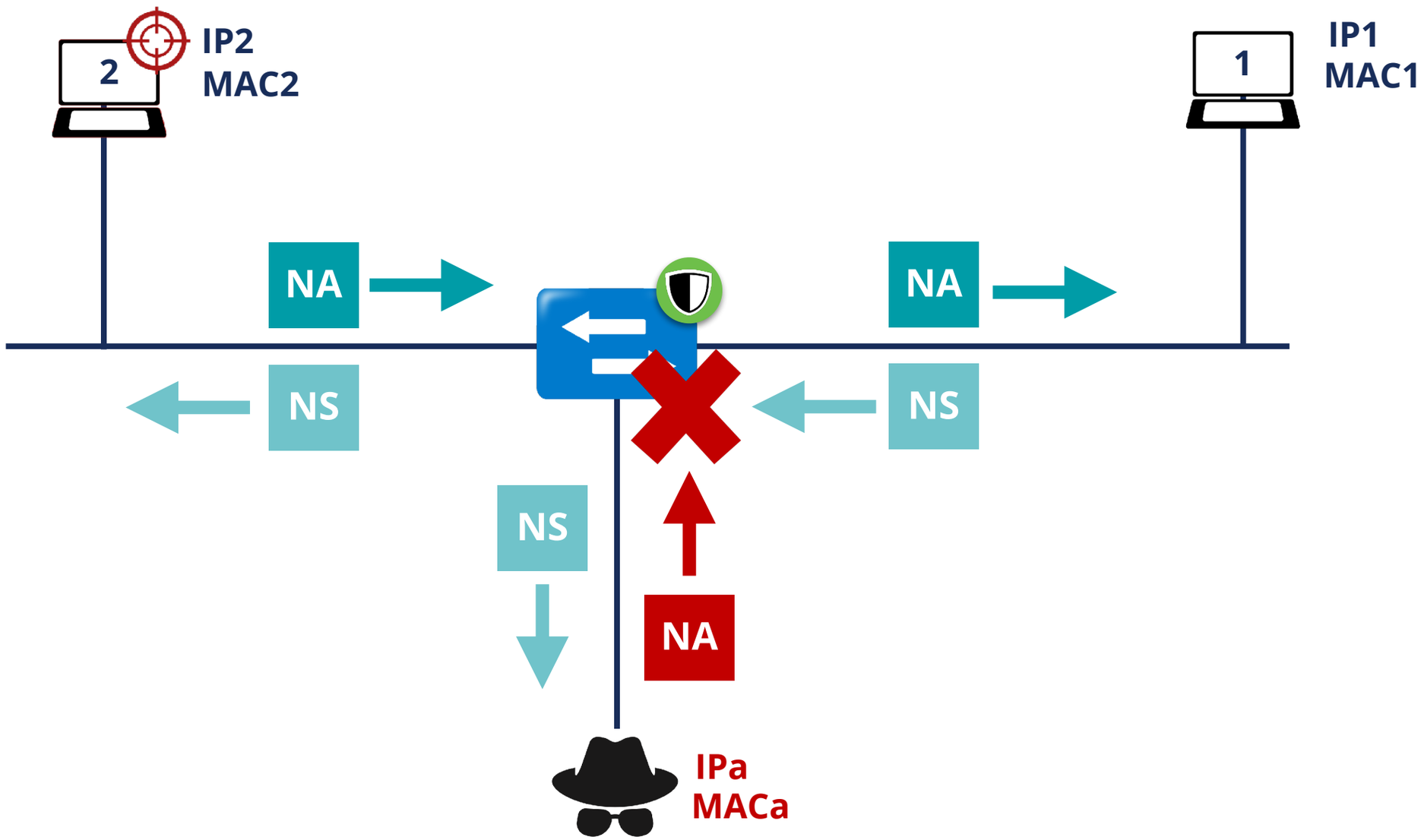
How could you protect your hosts from these **rogue RA** messages?

2 min.

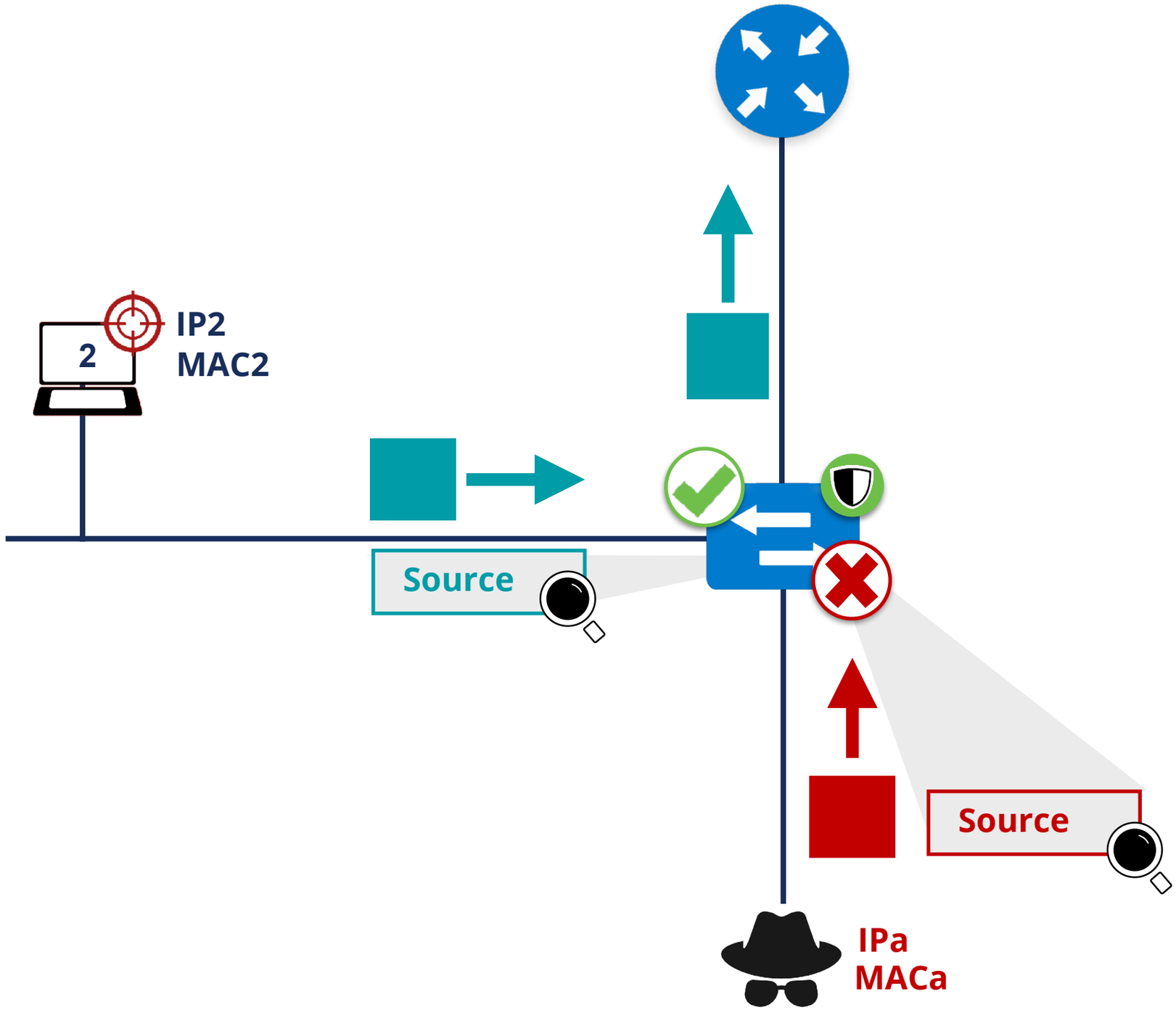
First Hop Security

- Security implemented **on switches**
- There is a number of techniques available:
  - RA-GUARD
  - IPv6 Snooping (*ND inspection* + *DHCPv6 Snooping*)
  - IPv6 Source / Prefix Guard
  - IPv6 Destination Guard (*or ND Resolution rate limiter*)
  - MLD Snooping
  - DHCPv6 Guard

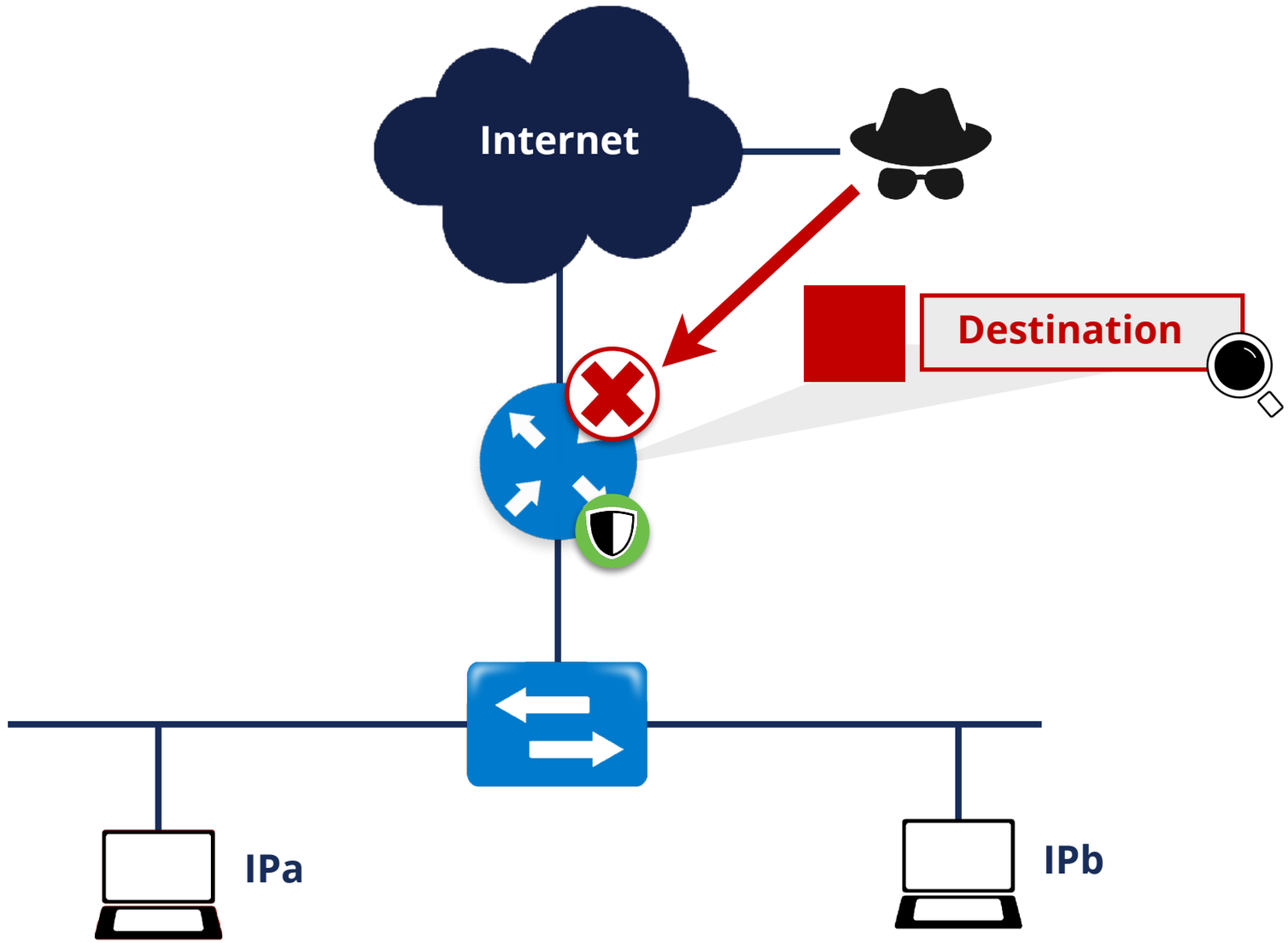
IPv6 Snooping



IPv6 Source / Prefix Guard



IPv6 Destination Guard



Rogue Router Advertisements

Rogue RA Solutions

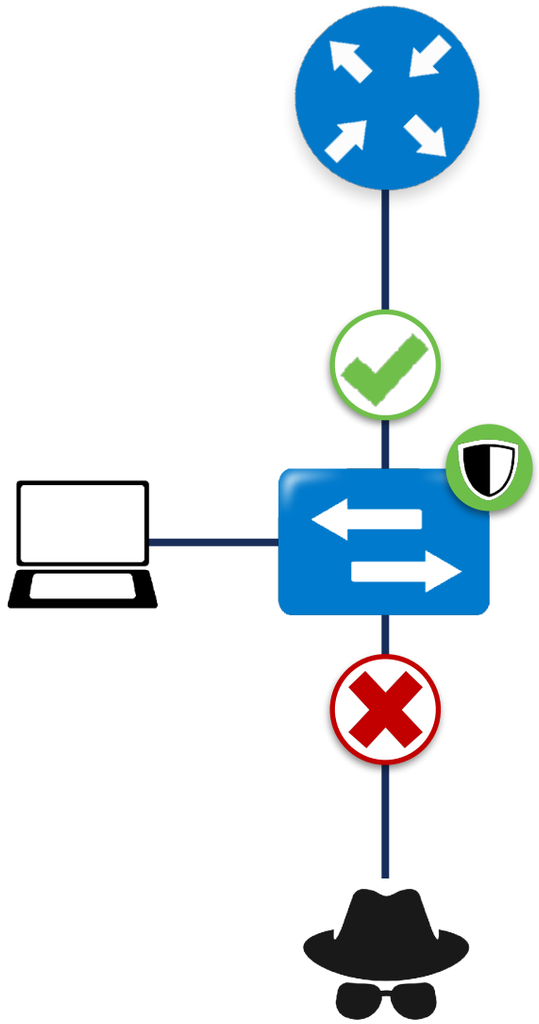
1. **Link Monitoring**
2. **SEND**
3. **MANUAL CONFIGURATION**
   + Disable Autoconfig
4. **Host Packet Filtering**
5. **Router Preference Option**
   [*RFC4191*]
6. **ACLs on Switches**
7. **RA Snooping on Switches (**RA GUARD**)**

Take the poll!

What protection do you use in your network against **Rogue RAs**?

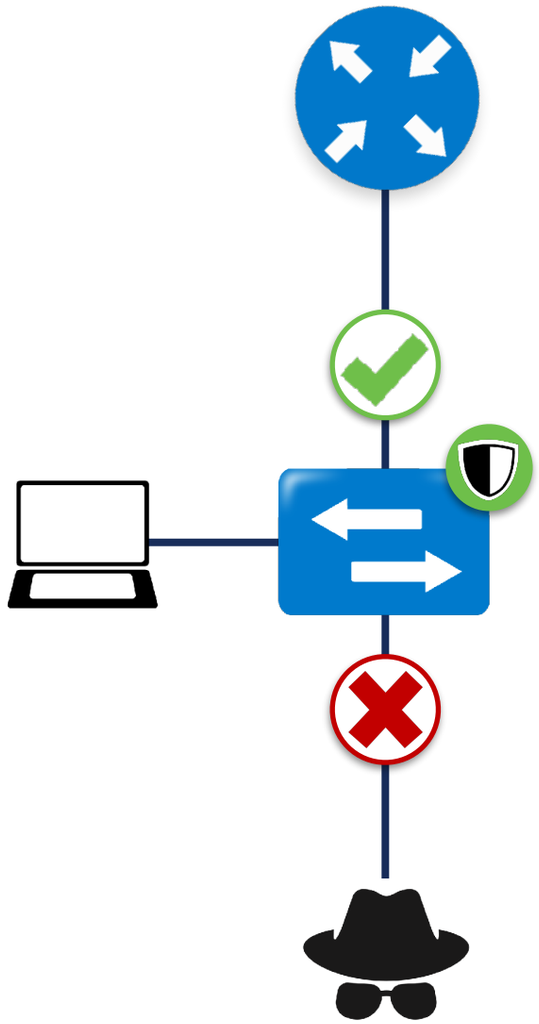
2 min.

RA-GUARD [*RFC6105*]



- Easiest available solution
- Only allows RAs on legitimate ports on L2 switches

Implementing RA-GUARD



Stateless RA Guard

Decision based on RA message or static configuration

Stateful RA Guard

Learns dynamically

Filtering

- Use Access Control Lists (ACLs) in switches

Switches need to understand

Ethernet	IPv6	ICMPv6
Ethertype 0x86DD for IPv6	Version 6	ICMPv6 Type and Code
Source/destination MAC address	Source/destination IPv6 address	
	Next Header	

Filtering Example

```
(config)#ipv6 access-list RA-GUARD
(config-ipv6-acl)#sequence 3 deny icmp any any router-advertisement
(config-ipv6-acl)#sequence 6 permit ipv6 any any
(config-ipv6-acl)#exit

(config)#interface FastEthernet0/5
(config-if)#ipv6 traffic-filter RA-GUARD in
```

Conclusions / Tips

- NDP is an important, powerful and vulnerable protocol
- **Recommended**: use available solutions to protect NDP
- Detection (IDS/IPS) can be easier and recommended

Questions

MLD

Section 3

Take the poll!

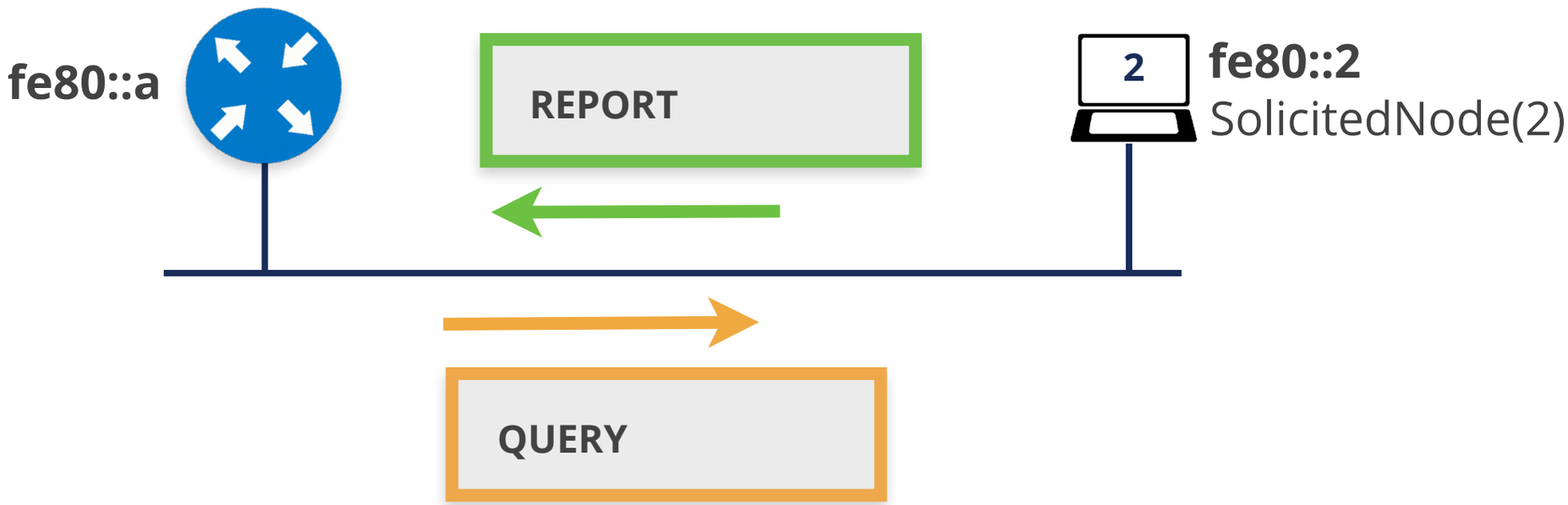
What is **MLD** (Multicast Listener Discovery) used for?

2 min.

- MLD (**Multicast Listener Discovery**) is:
  - Multicast related protocol, used in the **local link**
  - Two versions: MLDv1 and MLDv2
  - Uses **ICMPv6**
  - Required by NDP and “IPv6 Node Requirements”
  - IPv6 nodes use it when **joining a multicast group**

MLDv1

QUERY	REPORT	DONE
Router asks for listeners	Listeners report themselves	Listeners indicate that they're done
General		
Specific		


Src: fe80::2
Dst: SolicitedNode(2)
fe80::a
REPORT
2
fe80::2
SolicitedNode(2)
QUERY
Src: fe80::a
Dst: FF02::1

MLDv2

- Mandatory for all IPv6 nodes (**MUST**) [RFC8504]
- **Interoperable** with MLDv1
- Adds Source-Specific Multicast filters:
  - **Only accepted** sources
  - Or all sources accepted **except** specified ones

MLDv2

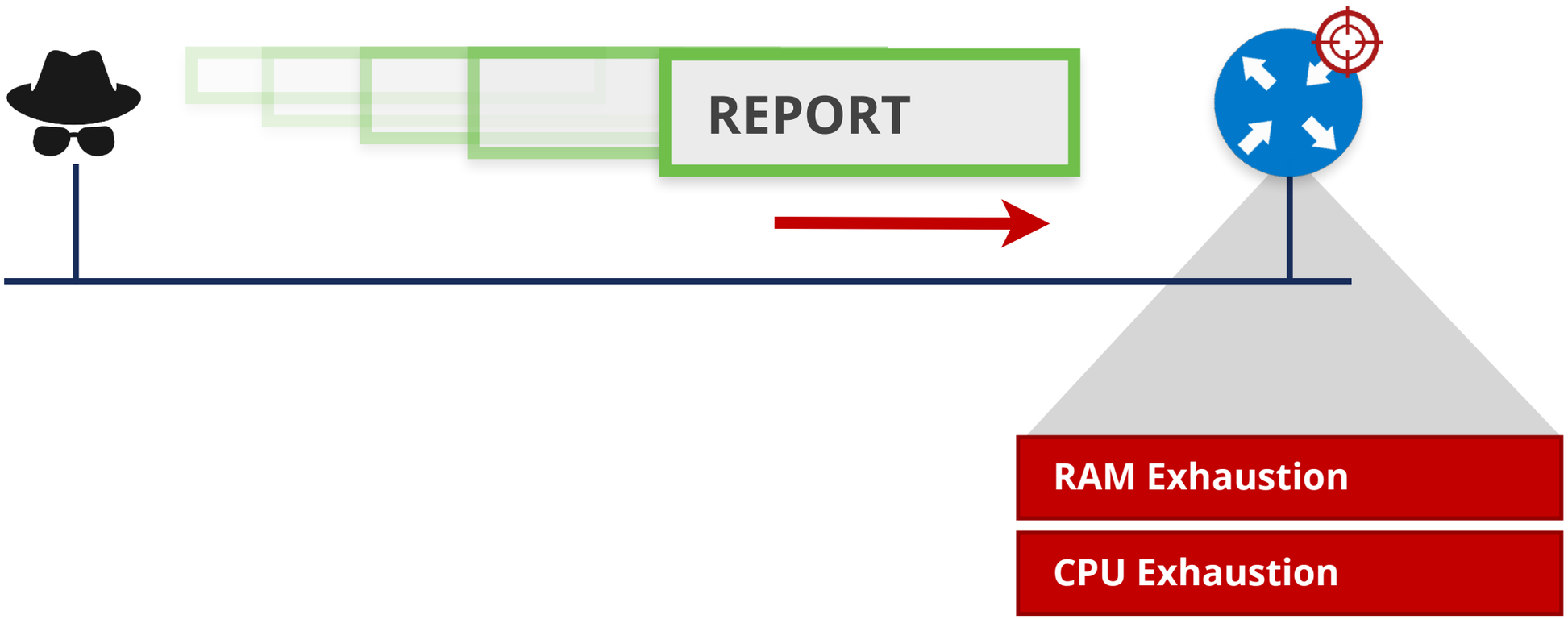
QUERY
Router asks for listeners
General
Specific Multicast Address
Specific Multicast Address and Source

REPORT-v2
Current state
State change (filter/sources)
Sent to FF02::16

MLD Details

- Nodes **MUST** process QUERY to any of its unicast or multicast addresses
- MLDv2 **needs all nodes** using MLDv2
- **All OSs join** (REPORT) to the Solicited Node addresses

MLD Flooding



MLD Flooding

- Rate limit MLD messages
- Limit MLD states
- Disable MLD (*if not needed*)

Take the poll!

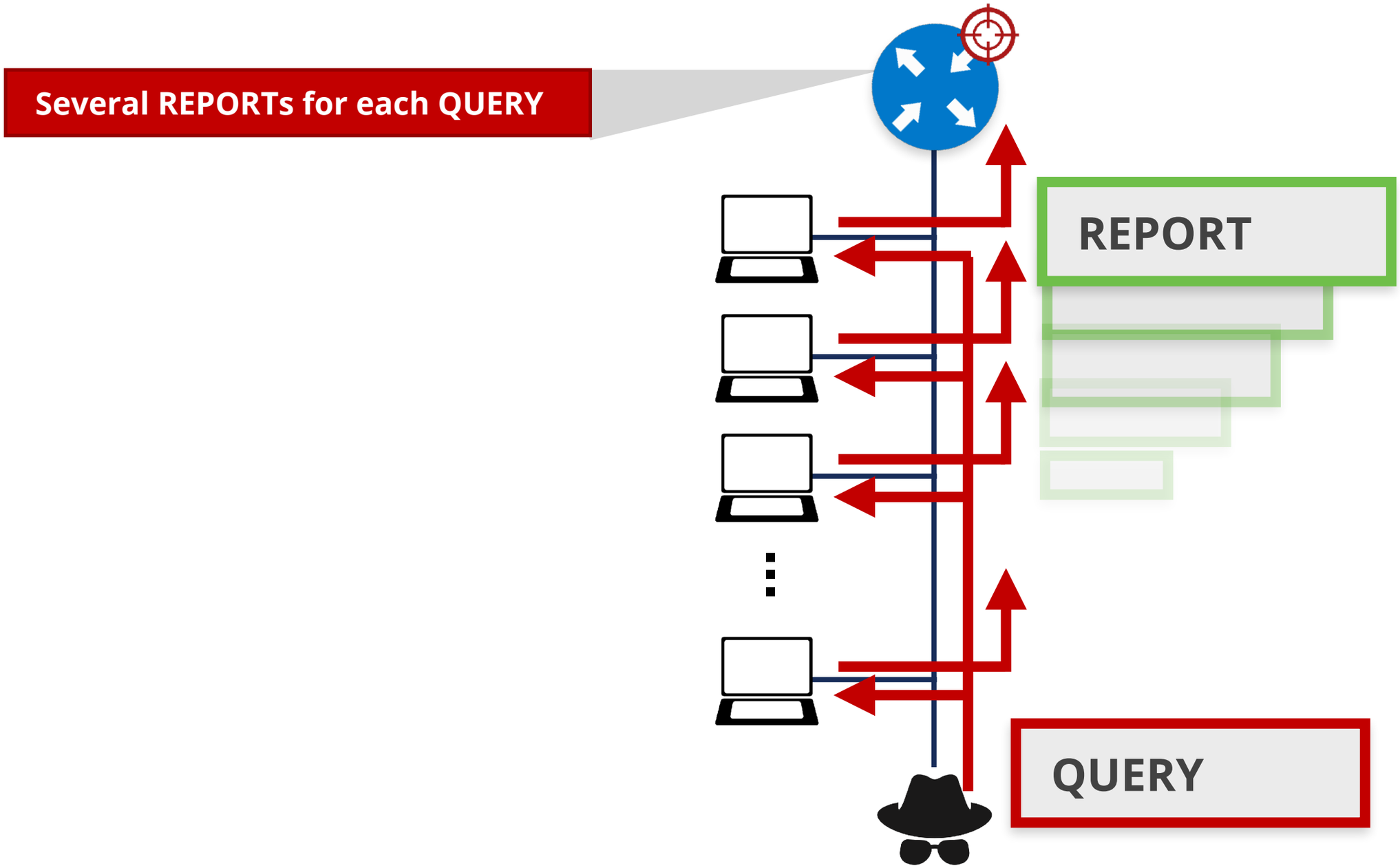
Assume you have **10** hosts in your network.

Each one has **3** IPv6 Multicast addresses to “REPORT” using MLD.

If you send **1 QUERY** message, **how many REPORTs** are sent?

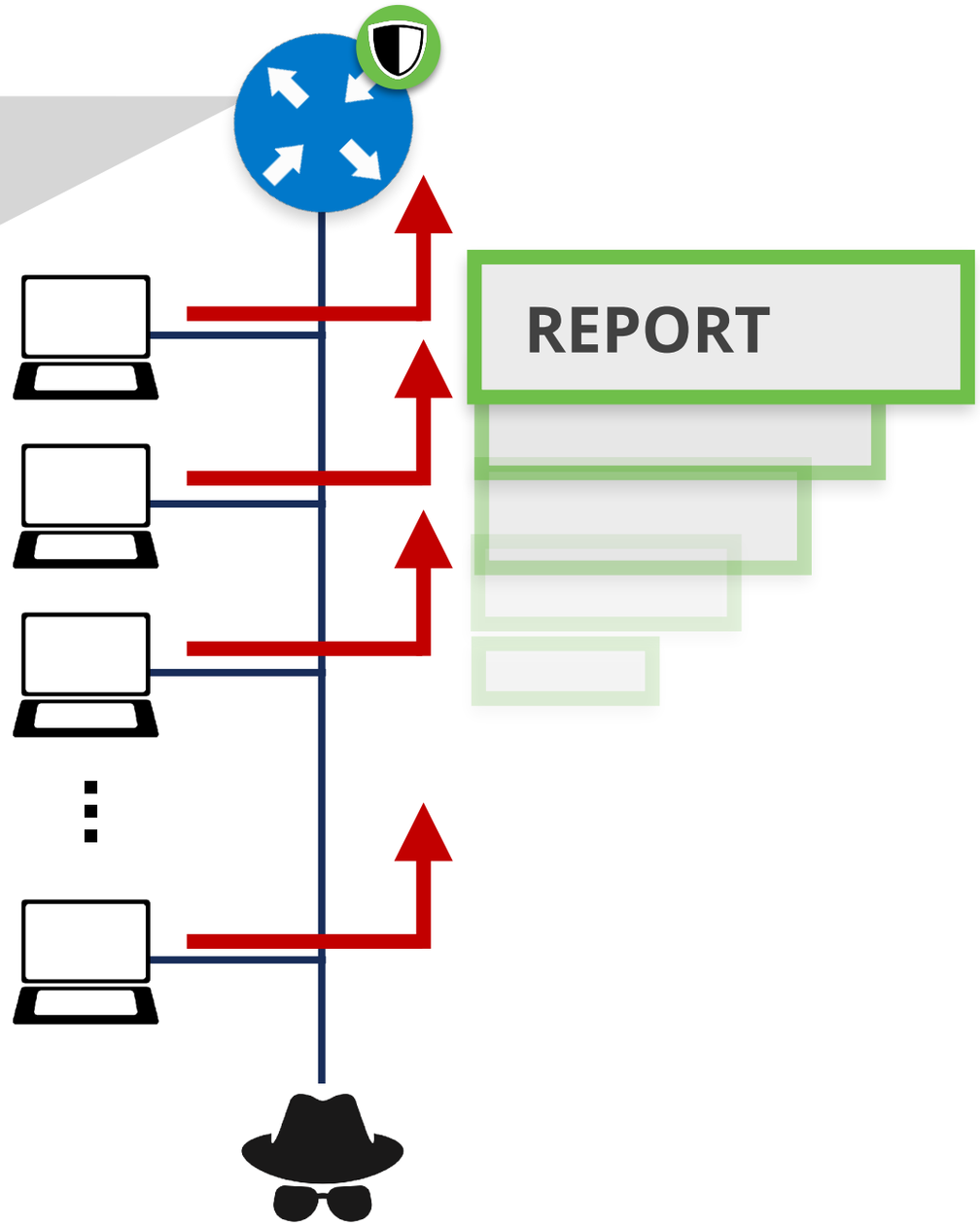
2 min.

MLD Traffic amplification

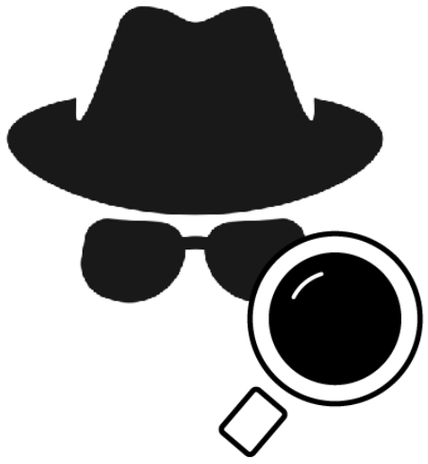


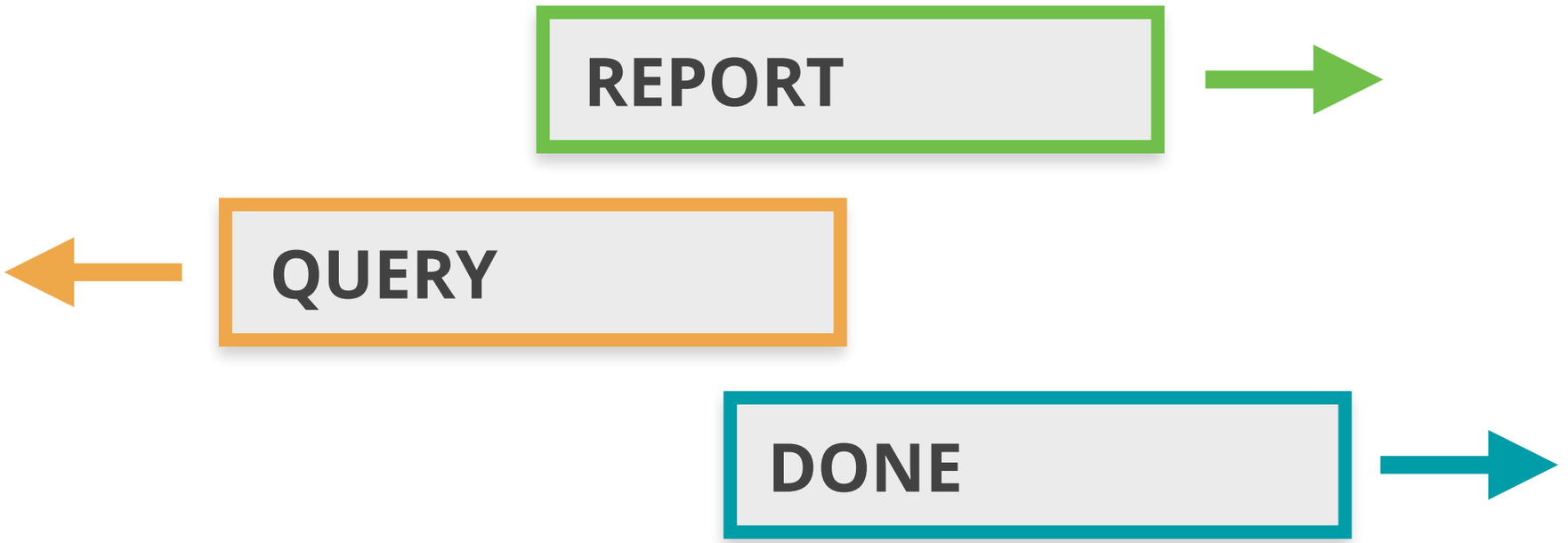
MLD Traffic amplification

- Rate limit MLD messages
- Disable MLD (*if not needed*)



Passive MLD Scanning





Active MLD Scanning

QUERY

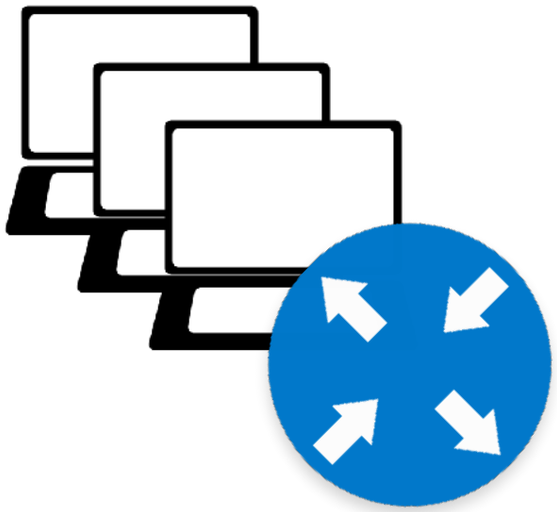
All Nodes (FF02::1)

Routers (FF02::2, FF02::16)

REPORT

REPORT

REPORT



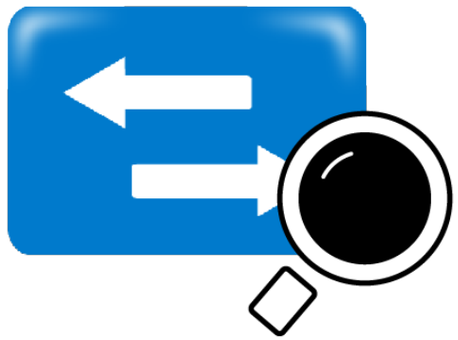
Built-in MLD Security

MLD Message
Source: Link local address **only**
Hop Limit = 1
Router Alert option in Hop-by-Hop EH

Discard non-compliant messages

MLD Snooping

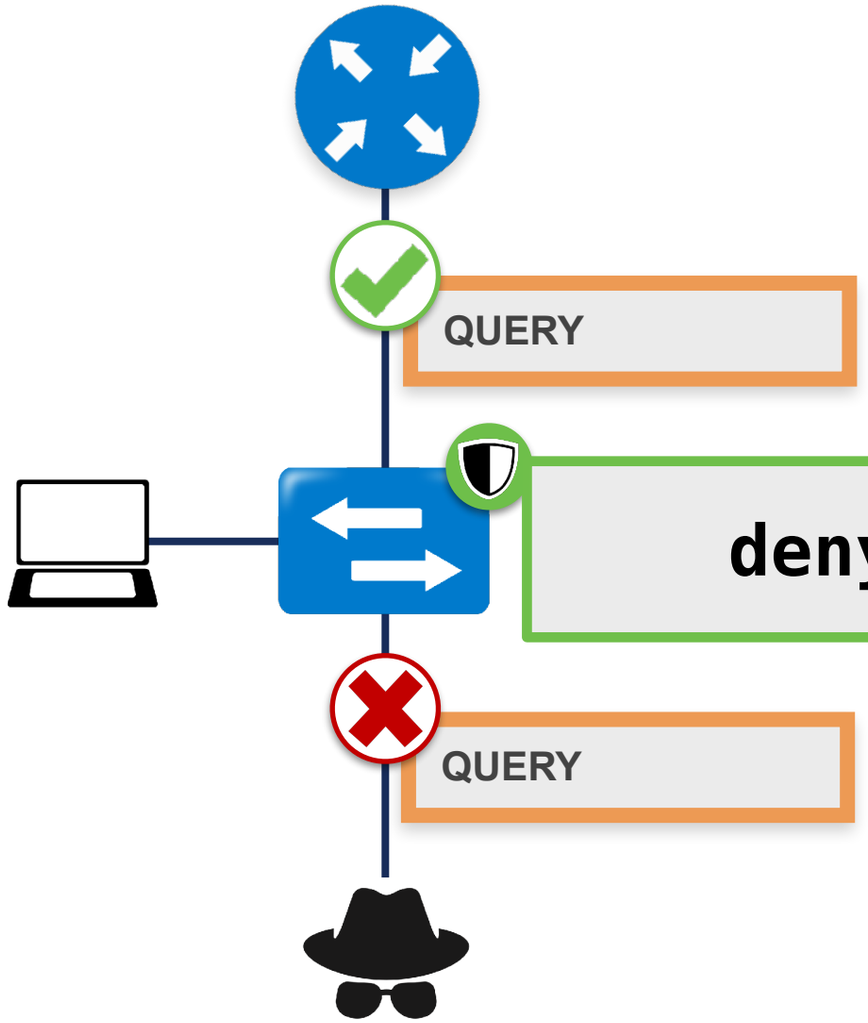
RFC4541



QUERY

Only allow multicast traffic **on ports with listeners**

MLD Protection on Switches



Only allow **QUERIES** on router's port

```
deny icmp any any mld-query
```

Questions

ICMPv6 is fundamental for IPv6

- Filter carefully
- Multicast considerations

NDP is mandatory

- NS/NA/RA Redirect Threats
- First Hop Security
- Rogue RA/Solutions

MLD is mandatory

- Flooding/Amplification/Scanning
- Solutions

Take the poll!

Think of what you learned in this webinar.

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

2 min.

What's Next in IPv6

Webinars

Attend another webinar live wherever you are.

- Introduction to IPv6 (2 hrs)
- IPv6 Host Configuration (2 hrs)
- IPv6 Addressing Plan (1 hr)
- Basic IPv6 Protocol Security (2 hrs)
- IPv6 Associated Protocols (2 hrs)
- IPv6 Security Myths, Filtering and Tips (2 hrs)

For more info click the link below

learning.ripe.net

Face-to-face

Meet us at a location near you for a training session delivered in person.

- Basic IPv6 (8.5 hrs)
- Advanced IPv6 (17 hrs)
- IPv6 Security (8.5 hrs)

E-learning

Learn at your own pace at our online Academy.

- IPv6 Fundamentals (15 hrs)
- IPv6 Security (24 hrs)

For more info click the link below

academy.ripe.net

Examinations

Learnt everything you needed? Get certified!

- IPv6 Fundamentals - Analyst
- IPv6 Security - Expert

For more info click the link below

getcertified.ripe.net

We want your feedback!

What did you think about this webinar?

Take our survey at:

https://www.ripe.net/feedback/ipv6s2

RIPE NCC
Academy

Learn something new today!

academy.ripe.net

RIPE NCC Certified Professionals

https://getcertified.ripe.net/


Ënn
Соңы
An Críoch
پایان
Y Diwedd
Vége
Endir
Finvezh
Ende
Koniec
Son
დასასრული
վերջ
Кінець
Finis
Lõpp
Amaia
הסוף
Tmiem
Kpaj
Sfârşit
Loppu
Liðugt
Slutt
Fund
Kraj
النهاية
Конец
Konec
Τέλος
Fin
Fine
Fí
Край
Einde
Pabaiga
Slut
Fim
Beigas

Copyright Statement

[...]

The RIPE NCC Materials may be used for **private purposes, for public non-commercial purpose, for research, for educational or demonstration purposes**, or if the materials in question specifically state that use of the material is permissible, and provided the RIPE NCC Materials are not modified and are properly identified as RIPE NCC documents. Unless authorised by the RIPE NCC in writing, any use of the RIPE NCC Materials for advertising or marketing purposes is strictly forbidden and may be prosecuted. The RIPE NCC should be notified of any such activities or suspicions thereof.

[...]

Find the full copyright statement here:
https://www.ripe.net/about-us/legal/copyright-statement