RIPE NCC

RIPE NETWORK COORDINATION CENTRE

Advanced IPv6

Training Course

November 2016

Schedule

09:00 - 09:30	**Coffee, Tea**
11:00 - 11:15	**Break**
13:00 - 14:00	**Lunch**
15:30 - 15:45	**Break**
17:30	**End**

Introductions

- Name
- Number in the list
- Experience with IPv6, Cisco, OSPF, BGP
- Goals

Overview Day 1

- IPv6 Packets
- IPv6 Routing Basics
- Exercise: Enable IPv6
- OSPFv3
- Exercise: Configuring OSPFv3
- BGP
- Exercise: Configuring BGP
- Content
- Mobile Providers

Overview Day 2

- Host Configuration
- Exercise: SLAAC
- DHCPv6
- Exercise: DHCPv6
- Security
- Exercise: 6rd
- IP Address Management
- Tips & Tricks

IPv6 Packets

1 - Section

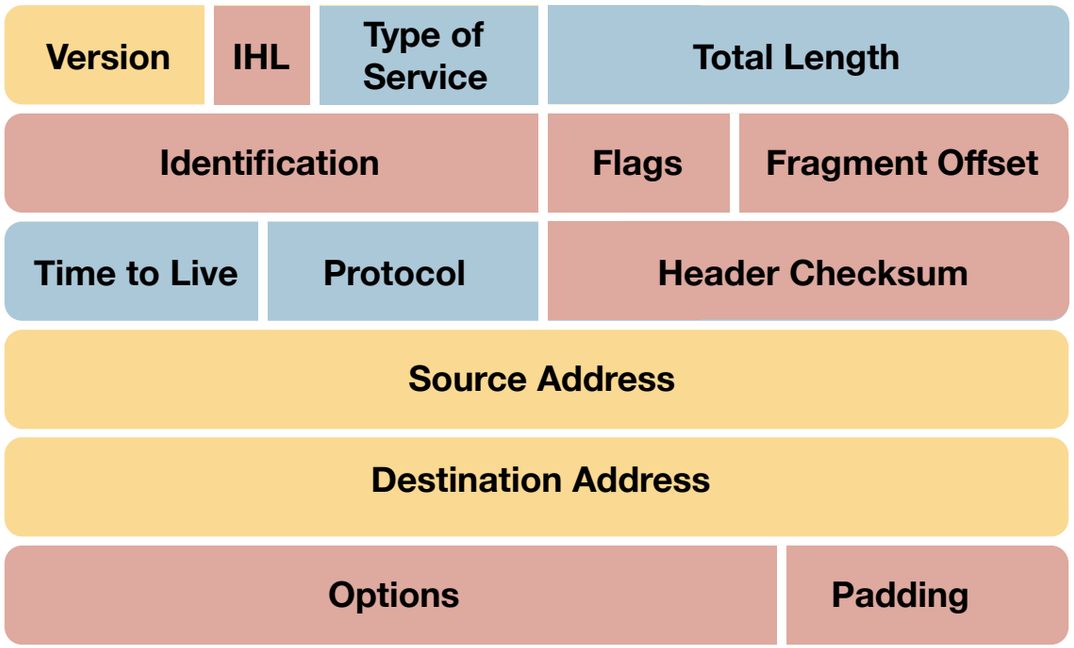
IPv6 Header Format

- **Fixed length**
  - Optional headers are daisy-chained

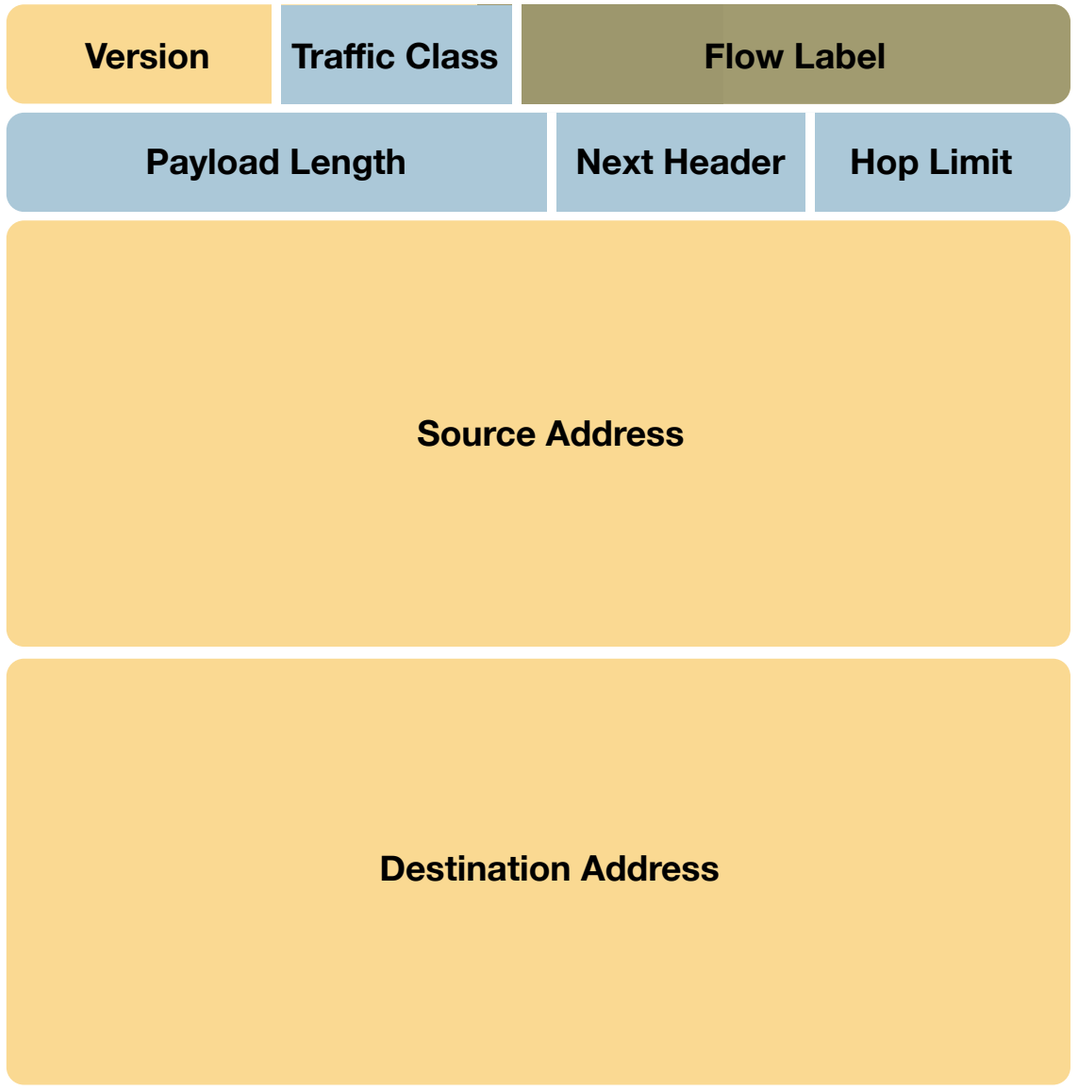
- **IPv6 header is twice as long (40 bytes) as IPv4 header without options (20 bytes)**

IPv6 Header

IPv4 Header



IPv6 Header

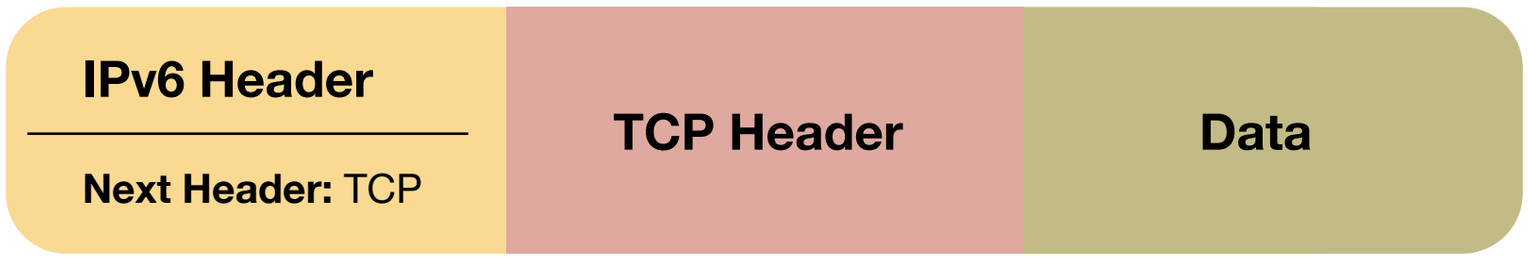


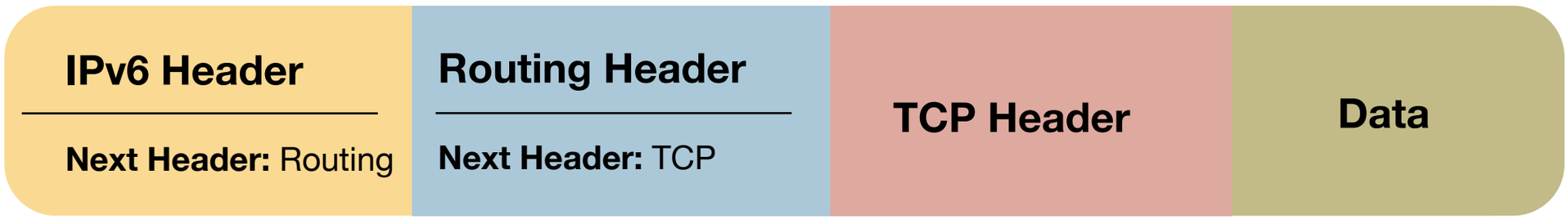
LEGEND

- Field's name kept from IPv4 to IPv6
- Field not kept in IPv6
- Name and position changed in IPv6
- New field in IPv6

IPv6 Header

- Optional fields go into extension headers
- Daisy-chained after the main header





Common Headers

- **Common values of Next Header Fields:**
  - 0 Hop-by-hop option (extension)
  - 6 TCP (payload)
  - 17 UDP (payload)
  - 43 Routing (extension)
  - 44 Fragmentation (extension)
  - 50 Encrypted Security Payload (extension)
  - 58 ICMPv6

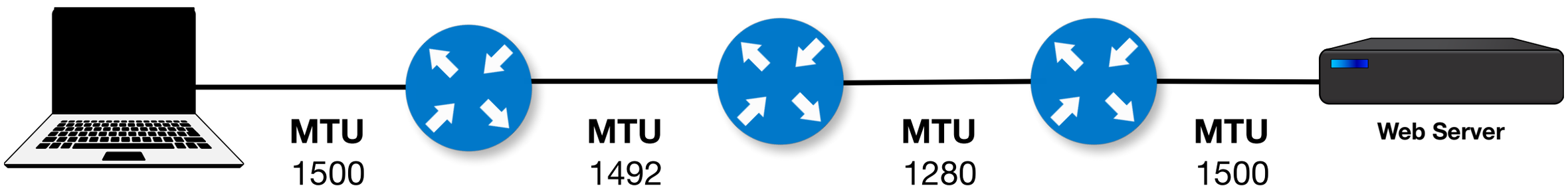
Fragmentation

- **Routers don’t fragment packets with IPv6**
  - More efficient handling of packets in the core
  - Fragmentation is being done by host

- **If a packet is too big for next hop:**
  - “Packet too big” error message
  - This is an ICMPv6 message
  - Filtering ICMPv6 causes problems

Path MTU Discovery

- **A sender who gets this “message-too-big” ICMPv6 error tries again with a smaller packet**
  - A hint of size is in the error message
  - This is called Path MTU Discovery



Ordering of Headers

- **Order is important:**
  - Only hop-by-hop header has to be processed by every node
  - Routing header needs to be processed by every router
  - Fragmentation has to be processed before others at the destination

Broadcast

- IPv6 has no broadcast
- There is an “all nodes” multicast group
  - ff02::1

- **Disadvantages of broadcast:**
  - It wakes up all nodes
  - Only a few devices are involved
  - Can create broadcast storms

Neighbor Discovery

- IPv6 has no ARP
- Replacement is called Neighbor Discovery
  - Uses ICMPv6
  - Uses Multicast
- Every ARP request wakes up every node
- Each ND request only wakes up a few nodes

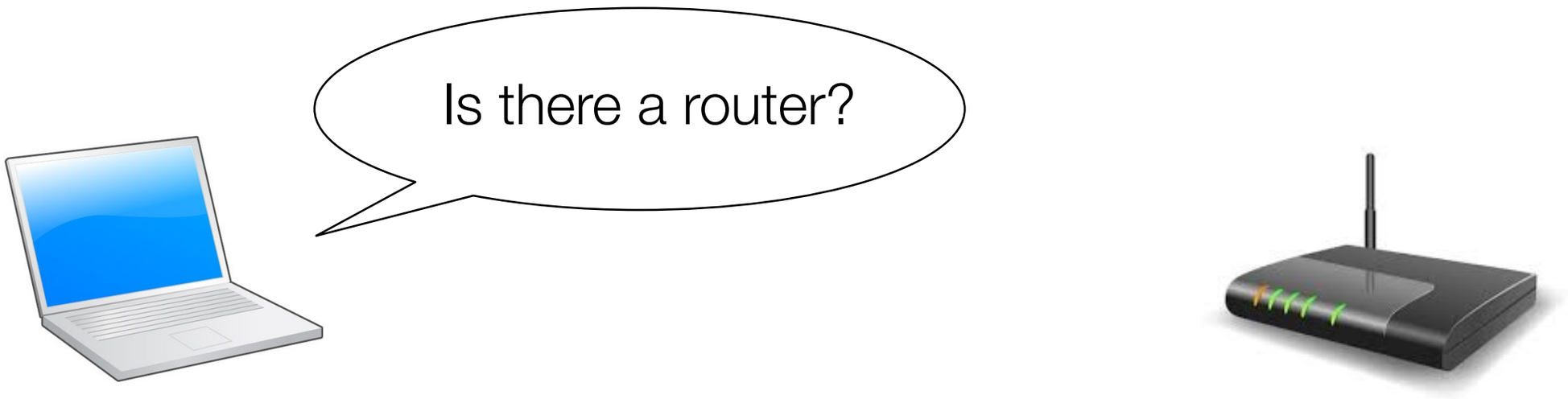
Neighbor Discovery

- **ND is used by nodes:**
  - For address resolution
  - To find neighboring routes
  - To track address changes
  - To check neighbor reachability
  - To do Duplicate Address Detection

- **ND uses 5 different ICMPv6 packet types**

Neighbor Discovery Protocol

- **Router Solicitation**
  - When an interface becomes active, the host will send out Router Solicitations that request routers to send out a Router Advertisement immediately



Neighbor Discovery Protocol

- **Router Advertisement**
  - Routers advertise their presence periodically or in response to a Router Solicitation message
  - Has a lot of important information for the host

Neighbor Discovery Protocol

- **Neighbor Solicitation**
  - Sent by a node to find the MAC-address of the neighbor, or to check if the neighbor is still reachable

Neighbor Discovery Protocol

- **Neighbor Advertisement**
  - A response to a neighbor solicitation message

Neighbor Discovery Protocol

- **Redirect**
  - A router points the host to a better first hop router for a destination

Questions

IPv6 Routing Basics

2 - Section

IPv6 Routing Basics

- **IPv6 routing is the same as IPv4 routing**
  - Longest matching prefix
  - Same structure and concepts
  - Some technical differences

Longest Matching Prefix

- Example routing table:

Route	Next-Hop
::/0	2001:db8:aaa:bbb::cdef:1
2001:db8::/32	2001:db8:bcd:aaa::1
2001:db8::/48	2001:db8:cde:bbb::1
2001:db8:1000::/36	2001:db8:ffff:eeee::1
2001:db8:1000::/48	2001:db8:def:bbb::1
2001:db8:2000::/48	2001:db8:def:bbb::2

Longest Matching Prefix

- Matches for a packet with destination:

2001:db8:2000:1a2b:02ab:9eff:fe01:f5b1

Route	Next-Hop
::/0	**2001:db8:aaa:bbb::cdef:1**
2001:db8::/32	**2001:db8:bcd:aaa::1**
2001:db8::/48	2001:db8:cde:bbb::1
2001:db8:1000::/36	2001:db8:ffff:eeee::1
2001:db8:1000::/48	2001:db8:def:bbb::1
2001:db8:2000::/48	**2001:db8:def:bbb::2**

Longest Matching prefix

- Matches for a packet with destination:

2001:db8:2001:1a2b:02ab:9eff:fe01:f8b2

Route	Next-Hop
::/0	**2001:db8:aaa:bbb::cdef:1**
2001:db8::/32	**2001:db8:bcd:aaa::1**
2001:db8::/48	2001:db8:cde:bbb::1
2001:db8:1000::/36	2001:db8:ffff:eeee::1
2001:db8:1000::/48	2001:db8:def:bbb::1
2001:db8:2000::/48	2001:db8:def:bbb::2

Longest Matching Prefix

- Matches for a packet with destination:

2001:db8:1001:1a2b:02ab:92ff:fe01:f8b2

Route	Next-Hop
::/0	**2001:db8:aaa:bbb::cdef:1**
2001:db8::/32	**2001:db8:bcd:aaa::1**
2001:db8::/48	2001:db8:cde:bbb::1
2001:db8:1000::/36	**2001:db8:ffff:eeee::1**
2001:db8:1000::/48	2001:db8:def:bbb::1
2001:db8:2000::/48	2001:db8:def:bbb::2

Summary

- **IPv6 routing uses the same structure as IPv4 routing**
  - Addresses are longer
  - Prefixes are longer

Questions

Add IPv6 to Loopback & Links

3 - Exercise

Discover the IPv4 Network

- Make sure you have connectivity
- Go to: workbench.ripe.net
- Your login is your number on the attendee list
- We will provide you with the password

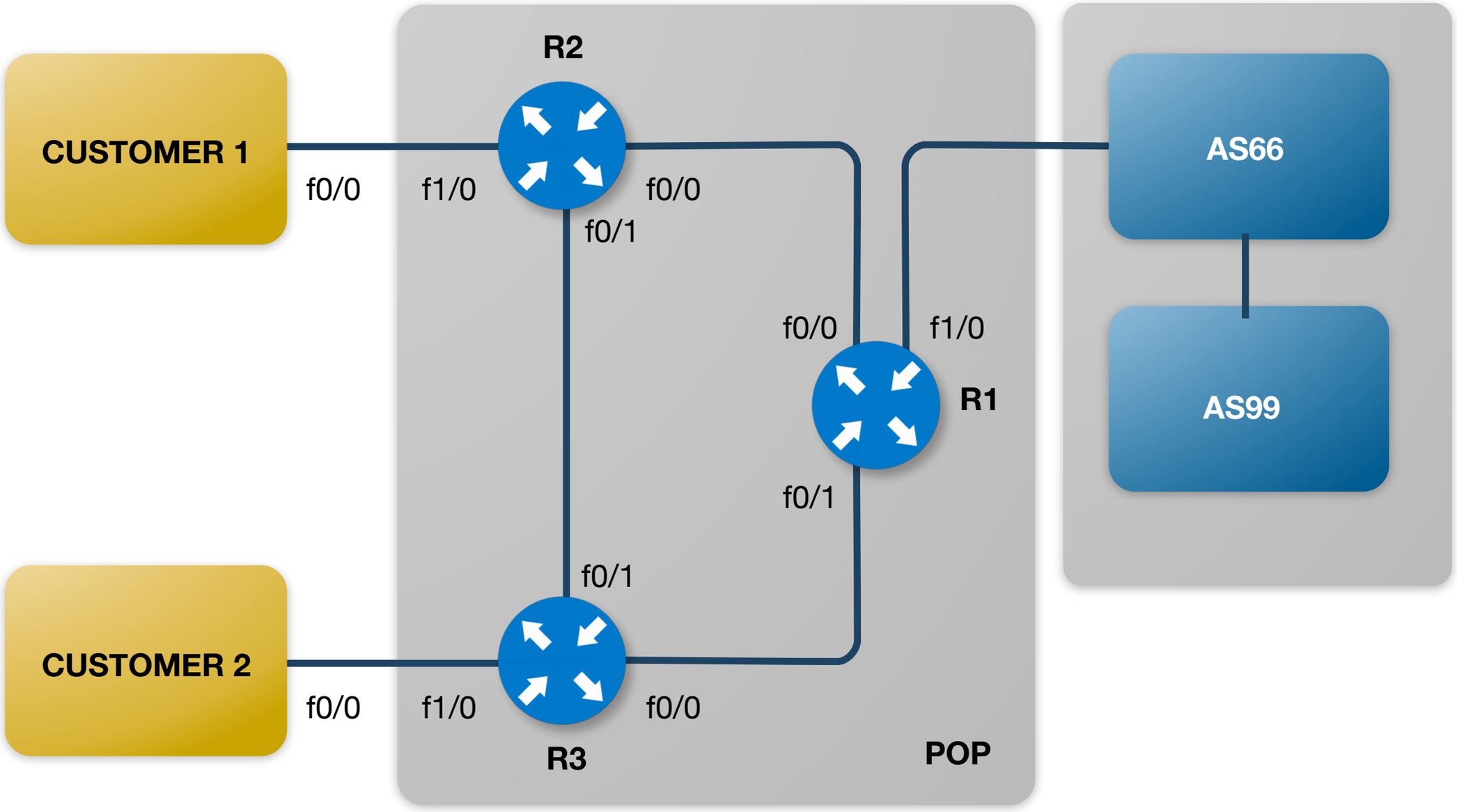
- Read instructions carefully
- First discover, then configure

Discover the IPv4 Network

- **Routing Protocol**
  - IGP (OSPF) is used for loopback addresses and point-to-point links
  - EGP (BGP) is used for the edge core routers

- **R1 announces a default route via OSPF**
- **Keeps routing tables in the area smaller**
  - All inter-area traffic must pass R1

Network Diagram



Adding IPv6 to the Network

- We will now add IPv6 to our existing network
- We will not change the network structure

- First step: Addressing Structure
- Find the addresses on the handout

Addressing with IPv6

Where X is your number on the attendee list!

- **Loopbacks:**
  - There is a /32 (IPv4): 172.X.255.Y(router number)
  - Use a /128 (IPv6) 2001:ffXX::Y(router number)/128

- **Point-to-point core:**
  - There is a /30 (IPv4) from 10.X.0.0/24
  - Use a /127 from 2001:ffXX::/60 for core links
  - Use a /64 from 2001:ffXX::/60 for the customer links

Interface IPv6 Settings Routers

- **Disable Router Advertisements**
  - On point-to-point interfaces
  - On LANs where unprepared devices are connected

- **Otherwise they will suddenly be globally reachable over IPv6 without being configured, prepared and/or protected**

Basic IPv6 Settings

- Before configuring IPv6 on your router interfaces, the basic IPv6 settings need to be set up on the router
- For R1, R2, R3 and the Customers

```
ipv6 unicast-routing
ipv6 cef
```

Interface IPv6 Settings Routers

- Use the information in the handouts
- Give the correct IPv6 addresses to the interfaces
- Start with the loopback interface
- Then configure the point-to-point links
- Fill in the appropriate interface name, IPv6 address and prefix length

```
interface xyz
 ipv6 address ...
 no ipv6 redirects
 ipv6 nd ra suppress all
```

Interface IPv6 Settings Customers

- Use the information in the handouts
- Give the correct IPv6 addresses to the interfaces
- We don’t configure loopback interfaces
- Then configure the point-to-point link
- Fill in the appropriate interface name, IPv6 address and prefix length (/64)
- We don’t disable router advertisements

```
interface xyz
 ipv6 address ...
 no ipv6 redirects
```

Interface IPv6 Settings Customers

- We will set a default route for the customers
- This is a manual configuration
- This is not needed if you use SLAAC

```
ipv6 route ::/0 2001:ffXX:0:ff01::b (customer 1)
ipv6 route ::/0 2001:ffXX:0:ff02::b (customer 2)
```

- XX is your number on the list

Checking Your Configuration

- **Check your own configuration**
  - Can you ping your own IPv6 loopback address?
  - Can you ping your own side of the point-to-point link?

Questions

OSPFv3

4 - Section

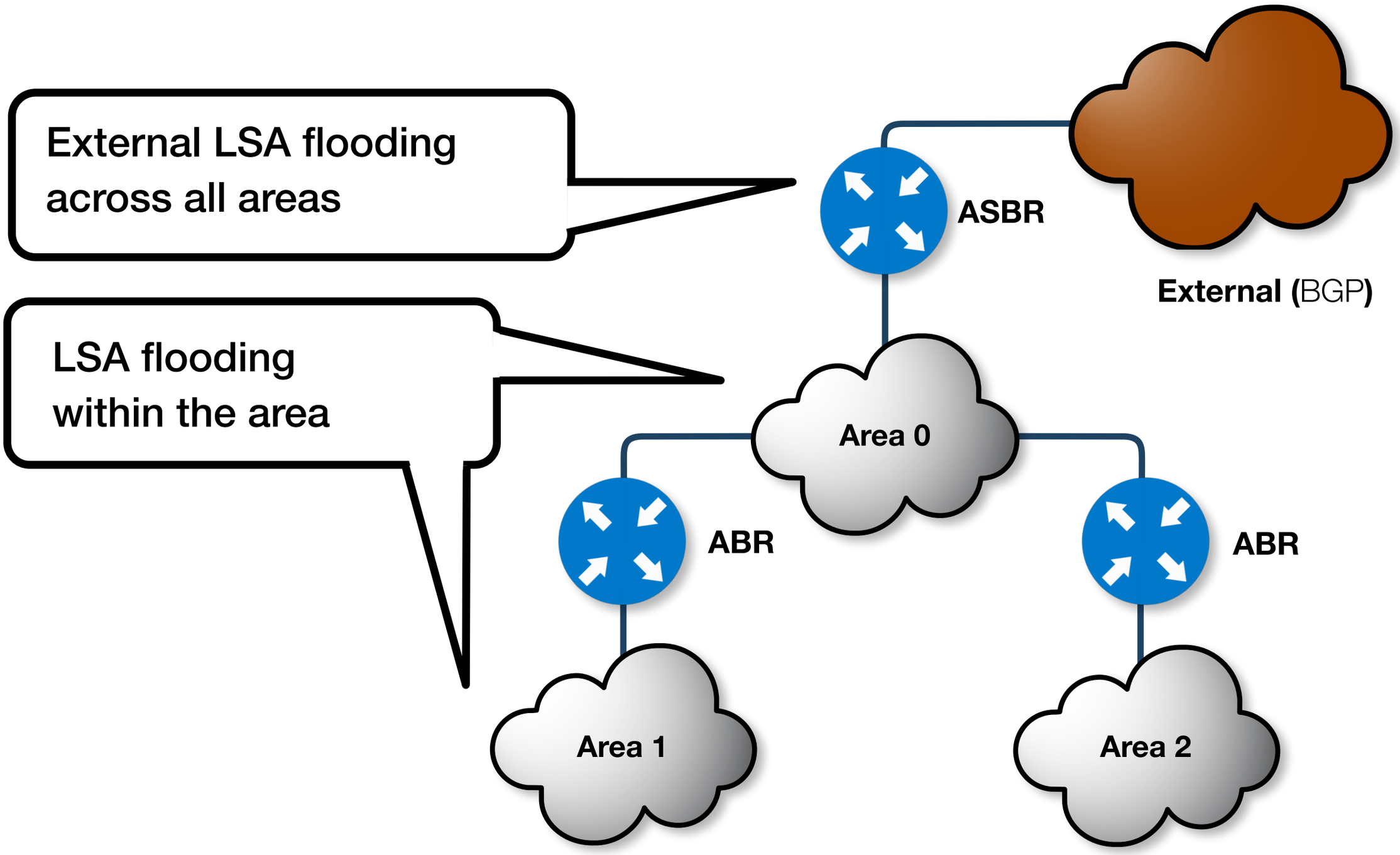
OSPF Characteristics

- OSPF = Open Shortest Path First
- Link State Protocol
- OSPFv3 is an implementation of OSPF for IPv6
- OSPFv2 (for IPv4) and OSPFv3 run independently on the router
- Most OSPFv3 functions are the same as OSPFv2

OSPF Refresher

- **Link state protocol**
  - Every router has full insight into network topology of the area
  - Routes are sent to other routers using Link State Advertisements (LSAs)
- **Role of Area Border Routers:**
  - Limit the flooding of LSAs to isolate topology changes within the area

OSPF Refresher



OSPF for IPv6

- **Multiple instances of OSPFv3 can be run on a link**
  - Unlike in OSPFv2

- **OSPFv3 still uses 32-bit numbers as a router ID**
  - If no IPv4 address is configured on any interface, the router ID command is required to set the 32-bit router ID (for IPv6-only networks)

OSPF for IPv6

- **Router ID is a unique identifier for the router**
  - Must be configured in the routing process
  - Is still a 32-bit number, written in 4 octets
  - It is used to sign routing updates

- **But to make your life easy, you can use an IPv4 loopback address**

OSPF for IPv6

- **OSPF for IPv4 (OSPFv2) can be configured:**
  - on each subnet or,
  - on each link
- **OSPF for IPv6 (OSPFv3) can be configured:**
  - on each link
- **Interface mode configuration will automatically activate the OSPF process on your running config**

OSPF for IPv6

- **LSA types and functions in OSPF are almost the same as for OSPFv2**
  - But there is no authentication in OSPFv3
- **OSPFv3 uses multicast addresses:**
  - ff02::5 for All OSPFv3 Routers
  - ff02::6 for All OSPFv3 Designated Routers
- **All OSPFv3 adjacencies are formed using link-local addresses**
  - From fe80::/10 IPv6's link-local address scope

Configuration of OSPF as IGP

- Example of OSPF for IPv4 per-subnet configuration

```
router ospf 1
 log-adjacency-changes
 passive-interface default
 network 172.16.1.1 0.0.0.0 area 1
 no passive-interface f0/0
 network 172.16.11.8 0.0.0.3 area 1
 no passive-interface f0/1
 network 172.16.11.0 0.0.0.3 area 1
```

Configuration of OSPF as IGP

- Example of OSPF for IPv4 per-link configuration

```
router ospf 1
 log-adjacency-changes
 passive-interface f1/1
 passive-interface f1/0
!
interface loopback 0
 ip ospf 1 area 1
!
interface f0/0
 ip ospf 1 area 1
!
interface f0/1
 ip ospf 1 area 1
!
```

Configuration of OSPF as IGP

- Example of OSPF for IPv6 per-link configuration

```
ipv6 router ospf 1
 log-adjacency-changes
 passive-interface f1/1
 passive-interface f1/0
!
interface loopback 0
 ipv6 ospf 1 area 1
!
interface f0/0
 ipv6 ospf 1 area 1
!
interface f0/1
 ipv6 ospf 1 area 1
!
```

Questions

Configuring OSPFv3

5 - Exercise

Overview of IGP Configuration

- You have to configure OSPFv3 as IGP for IPv6
- Dual Stack will be used to ensure both IPv4 and IPv6 operation
- OSPFv2 is already set up

Have a good look…

- At the IPv4 configuration….

```
show running-config | s router ospf
```

OSPFv3 Global Settings

- Tell the router to do OSPFv3 and the process-id
- Log adjacency changes
- Set a router ID
- Define passive interface

```
ipv6 router ospf 1
 log-adjacency-changes
 router-id 172.X.255.Y    (Y is router number)
 passive-interface FastEthernet1/0
 passive-interface FastEthernet1/1
 redistribute connected
```

- On router 1 also add:

```
ipv6 router ospf 1
 default-information originate always
```

OSPFv3 Interface Settings

- OSPFv3 interface settings

```
interface xyz
 ipv6 ospf network point-to-point
 ipv6 ospf 1 area 0
```

- Fill in the appropriate interface names and OSPF area

Checking Your Configuration

- **Check your own configuration**
  - Can you ping the loopback on R3 from C1?
  - Can you ping the loopback on R2 from C2?

Checking Your Configuration

- You should now have a running IPv6 core network!
- For every internal IPv4 route there should be a corresponding IPv6 route
- Try to ping and traceroute point-to-point connections and loopback addresses in your part of the network

Questions

BGP

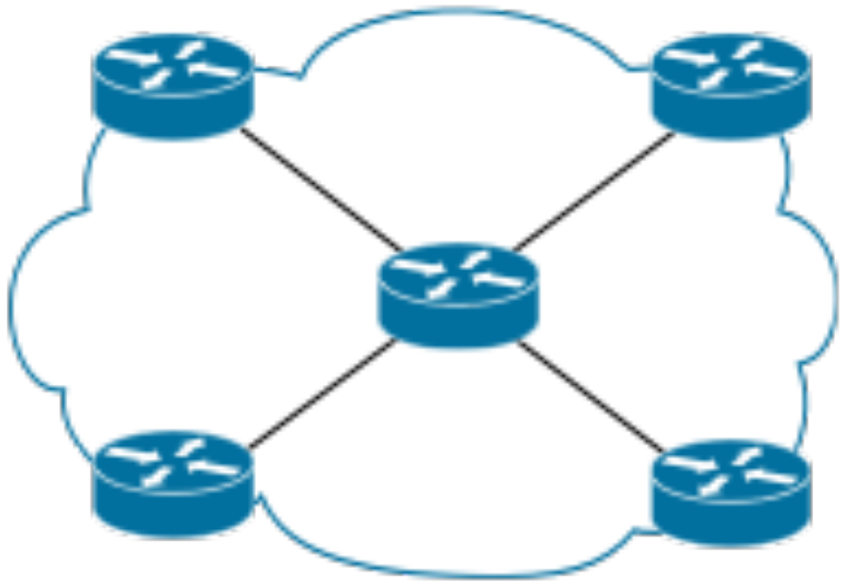
6 - Section

BGP Overview

- **Routing Protocol used to exchange routing information between networks**
  - Exterior Gateway Protocol
- **It is based on Path Vector Protocol**
  - Similar to Distance Vector
- **Each border router sends to its neigbors the full route to one destination, not just the distance**

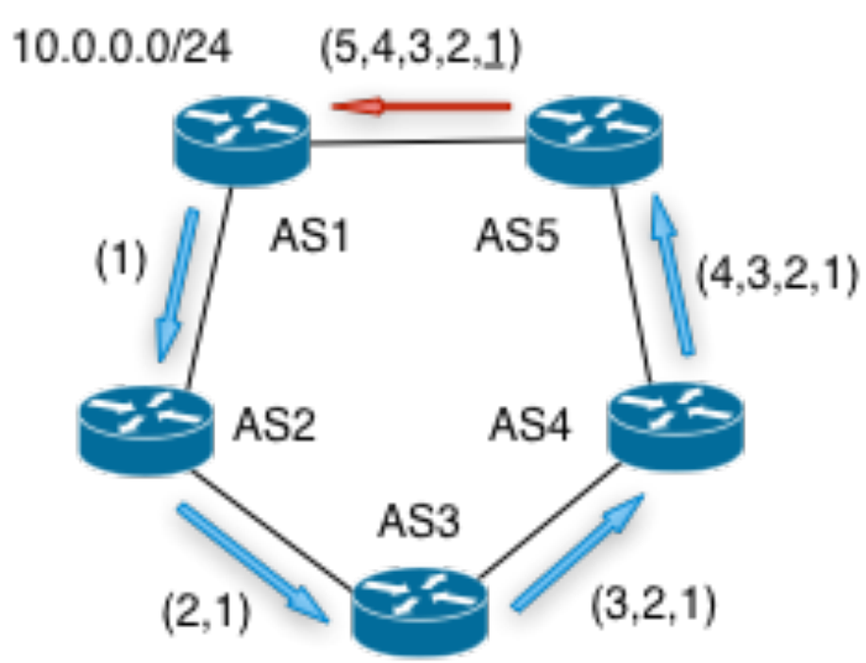
Autonomous System

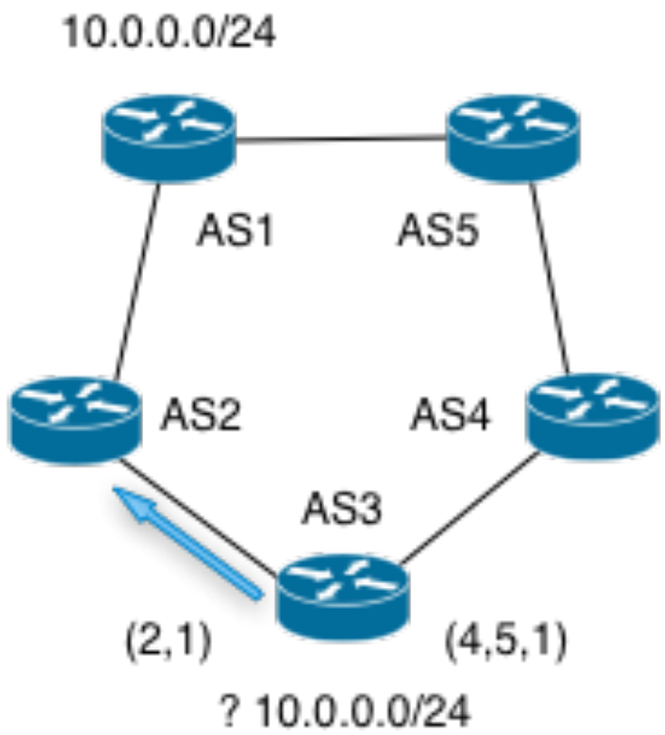
- Collection of networks with the same routing policy
- Usually under single ownership and administrative control
  - Single routing policy
- **Identified by 16 or 32 bit numbers**
  - 16bit: 0 - 65,535
  - 32bit: 65,536 - 4,294,967,295



AS Path

- **Sequence of ASes a route has traversed**
  - Loop detection
  - Path selection (AS-PATH length)

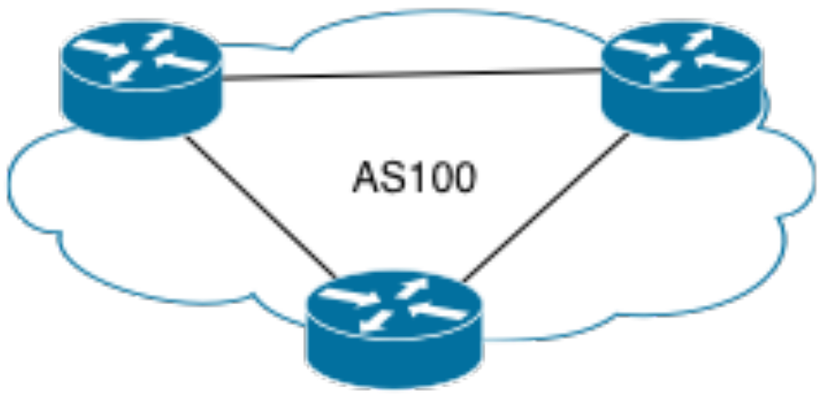




BGP Modes

- e**BGP**: Between BGP speakers in a different AS

- i**BGP**: Between BGP speakers within the same AS



BGP Messages

- **OPEN**
  - opens the tcp session
- **KEEPALIVE**
  - keeps the session running
- **NOTIFICATION**
  - error handling
- **UPDATE**
  - actual route updates (NLRI, AS-path, AS-path attributes)

NLRI

- **Network Layer Reachability Information**
  - Used to advertise feasible routes
  - Composed of:
    - Network Prefix
    - Mask Length

BGP Path Attributes

- **Well known**
  - They are known by all the routers and passed to BGP neighbors
  - Mandatory and are included in the UPDATE messages
- **Optional**
  - May not be supported by all BGP implementations
  - The transitive bit determines if an optional attribute is passed to BGP neighbors

Multiprotocol BGP (MP-BGP)

- Extension to the BGP protocol
- Carries routing information about other protocols:
  - Multicast
  - MPLS VPN
  - IPv6
- **Multi-Protocol NLRI exchange is negotiated at session set up (OPEN Message)**

MP-BGP

- **New features in OPEN Message:**
  - **BGP Capabilities Advertisement:**
  - Address Family Identifier (**AFI**)
  - Subsequent Address Family Identifier (**SAFI**)
  - Multiprotocol Reachable Network Layer Reachability Information

AFI / SAFI

- **Address Family Identifier (AFI)**
  - Identifies Address Type
    - AFI = 1 (IPv4)
    - AFI = 2 (IPv6)
- **Subsequent Address Family Identifier (SAFI)**
  - Sub category for AFI Field
    - Address Family Identifier (AFI)
      - Sub-AFI = 1 (NLRI is used for unicast)
      - Sub-AFI = 2 (NLRI is used for multicast RPF check)
      - Sub-AFI = 3 (NLRI is used for both unicast and multicast RPF check)
      - Sub-AFI = 4 (label)
      - Sub-AFI = 128 (VPN)

MP-BGP Capabilities Negotiation

- BGP routers establish peering sessions through the OPEN message
- OPEN message contains optional parameters
- BGP session is terminated if OPEN parameters are not recognised
- **A new optional parameter: CAPABILITIES containing its capabilities:**
  - Multiprotocol extension (AFI/SAFI)
  - Route Refresh
  - Outbound Route Filtering

Managing Multiple Protocols

- **Independent operation**
  - One RIB per protocol
  - Distinct policies per protocol (IP address specific route maps and prefix lists must be adjusted)
    - Make separate route maps for IPv4 and IPv6
    - Prefix lists are always separate
    - It is common to use a **_v4** and a **_v6** suffix to names

Questions

Configuring MP-BGP & Customers

7 - Exercise

eBGP

7.1 - Exercise

BGP Configuration R1

- Cisco defaults to address-family IPv4
- This must be disabled before configuring IPv6
- Your AS Number is 1 + your number on the participants list (e.g. 109)

```
router bgp 1XX
 no bgp default ipv4-unicast
```

Set the Route and Prefix list on R1

```
address-family ipv6
  network 2001:ffXX::/32
(exit)
ipv6 route 2001:ffXX::/32 Null0
ipv6 prefix-list filter_v6 seq 5 permit 2001:ffXX::/32
```

BGP Configuration R1

- Now we are going to set up BGP to our upstreams
- We use the same settings for IPv6 as we have for IPv4
- Only configure R1

```
router bgp 1XX
neighbor 2001:ff69::66 remote-as 66
neighbor 2001:ff69::99 remote-as 99
```

BGP Configuration R1

- And activate the external session in the correct address family

```
address-family ipv6
   redistribute static
   neighbor 2001:ff69::66 prefix-list filter_v6 out
   neighbor 2001:ff69::99 prefix-list filter_v6 out
   neighbor 2001:ff69::66 activate
   neighbor 2001:ff69::99 activate
```

Filtering

- **We filter the routes we announce**
  - Why?
  - Why in this way?
  - What are the differences in IPv4 and IPv6 ?

iBGP

7.2 - Exercise

BGP Configuration R1

- Now we are going to set up BGP on top of our IPv4 core
- We use the same settings for IPv6 as we have for IPv4

```
neighbor 2001:ffXX::2 remote-as 1XX
neighbor 2001:ffXX::2 update-source lo0
neighbor 2001:ffXX::3 remote-as 1XX
neighbor 2001:ffXX::3 update-source lo0
```

```
address-family ipv6
   redistribute static
   neighbor 2001:ffXX::2 activate
   neighbor 2001:ffXX::3 activate
   neighbor 2001:ffXX::2 next-hop-self
   neighbor 2001:ffXX::3 next-hop-self
```

BGP Configuration R2

- Now we are going to set up BGP on top of our IPv4 core
- We use the same settings for IPv6 as we have for IPv4

```
router bgp 1XX
  no bgp default ipv4-unicast
```

```
  neighbor 2001:ffXX::1 remote-as 1XX
  neighbor 2001:ffXX::1 update-source lo0
  neighbor 2001:ffXX::3 remote-as 1XX
  neighbor 2001:ffXX::3 update-source lo0
```

```
  address-family ipv6
    redistribute static
    neighbor 2001:ffXX::1 activate
    neighbor 2001:ffXX::3 activate
    neighbor 2001:ffXX::1 next-hop-self
    neighbor 2001:ffXX::3 next-hop-self
```

BGP Configuration R3

- Now we are going to set up BGP on top of our IPv4 core
- We use the same settings for IPv6 as we have for IPv4

```
router bgp 1XX
  no bgp default ipv4-unicast
```

```
 neighbor 2001:ffXX::1 remote-as 1XX
 neighbor 2001:ffXX::1 update-source lo0
 neighbor 2001:ffXX::2 remote-as 1XX
 neighbor 2001:ffXX::2 update-source lo0
```

```
 address-family ipv6
  redistribute static
   neighbor 2001:ffXX::1 activate
   neighbor 2001:ffXX::2 activate
    neighbor 2001:ffXX::1 next-hop-self
    neighbor 2001:ffXX::2 next-hop-self
```

BGP Customer1

7.3 - Exercise

BGP Configuration Customer 1

- We will remove the default route for the customers

```
no ipv6 route ::/0 2001:ffXX:0:ff01::b
```

BGP Configuration Router 2

- The AS number for customer is 2 + your number on the participants list (e.g. 209)
- Add BGP session for Customer 1

```
router bgp 1XX
  neighbor 2001:ffXX:0:ff01::a remote-as 2XX
```

```
  address-family ipv6
    neighbor 2001:ffXX:0:ff01::a activate
```

BGP Configuration Router 2

- Now add customer prefix to the prefix list
  - Customer 1 prefix: 2001:ffXX:ff01::/48

```
ipv6 prefix-list customer1_v6 seq 5 permit 2001:ffXX:ff01::/48
```

```
router bgp 1XX
 address-family ipv6
   neighbor 2001:ffXX:0:ff01::a prefix-list customer1_v6 in
```

BGP Configuration Customer 1

- The AS number for customer is 2 + your number on the participants list (e.g. 209)
- Configure BGP session with R2

```
router bgp 2XX
  no bgp default ipv4-unicast
```

```
  redistribute static
  neighbor 2001:ffXX:0:ff01::b remote-as 1XX
```

```
  address-family ipv6
    neighbor 2001:ffXX:0:ff01::b activate
```

BGP Configuration Customer 1

- Now add the prefix, prefix list and static route
  - Customer1 prefix: 2001:ffXX:ff01::/48

```
address-family ipv6
  network 2001:ffXX:ff01::/48
(exit)
ipv6 route 2001:ffXX:ff01::/48 Null0
ipv6 prefix-list my_v6 seq 5 permit 2001:ffXX:ff01::/48
```

```
router bgp 2XX
 address-family ipv6
   neighbor 2001:ffXX:0:ff01::b prefix-list my_v6 out
```

Challenge: BGP Customer 2

7.4 - Exercise

BGP Configuration Customer 2

- Configure BGP session between Customer 2 router and provider R3
- The AS number for customer is 3 + your number on the participants list (e.g. 309)
- **Add the prefix, prefix list and static route**
  - Customer2 prefix: 2001:ff**XX**:ff02::/48

Summary

- **We now added IPv6 to…**
  - Links/interfaces
  - IGP (OSPF)
  - EGP (BGP)
  - Customers
- **How difficult was it?**
- **Any surprises?**

Questions

Content

8 - Section

Definition

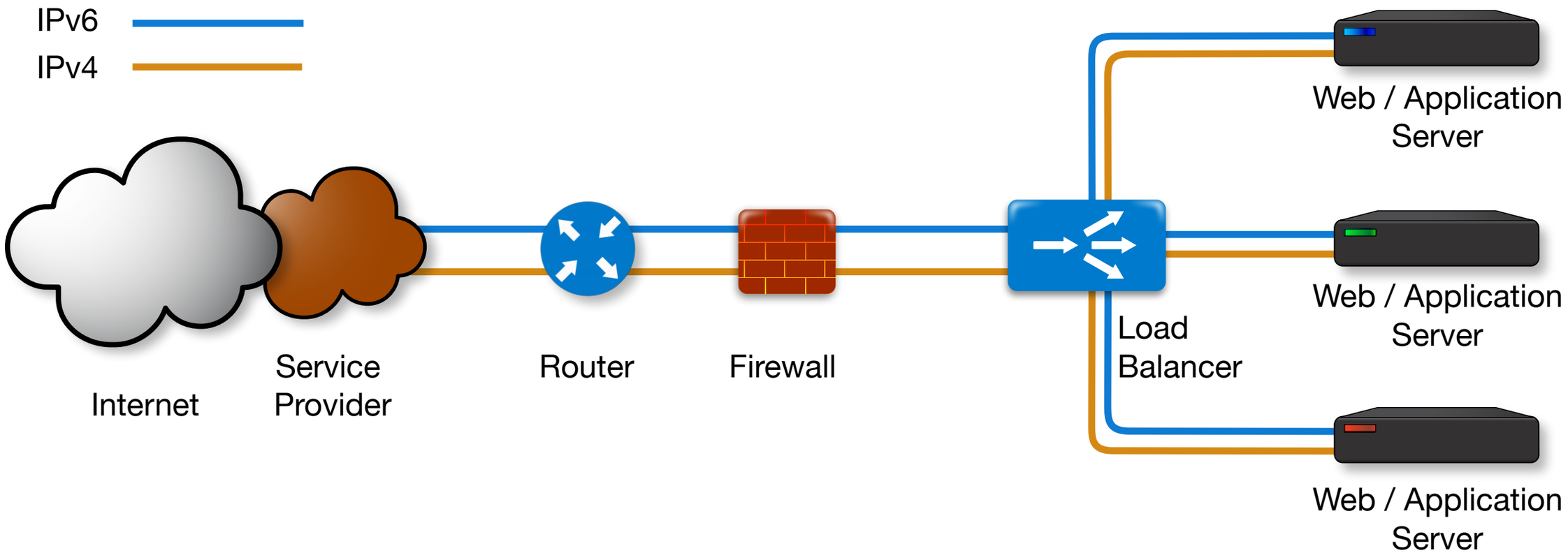
- This section is mostly about websites but it can also apply to:
  - SMTP
  - POP3
  - IMAP4
  - SSH
  - Remote Desktops
  - Cloud Services

Options

- **Multiple ways to make content dual stack**
  - Native dual stack
  - Dual stack load balancer
  - IPv6-to-IPv4 (reverse) proxy
  - NAT64

Native Dual Stack

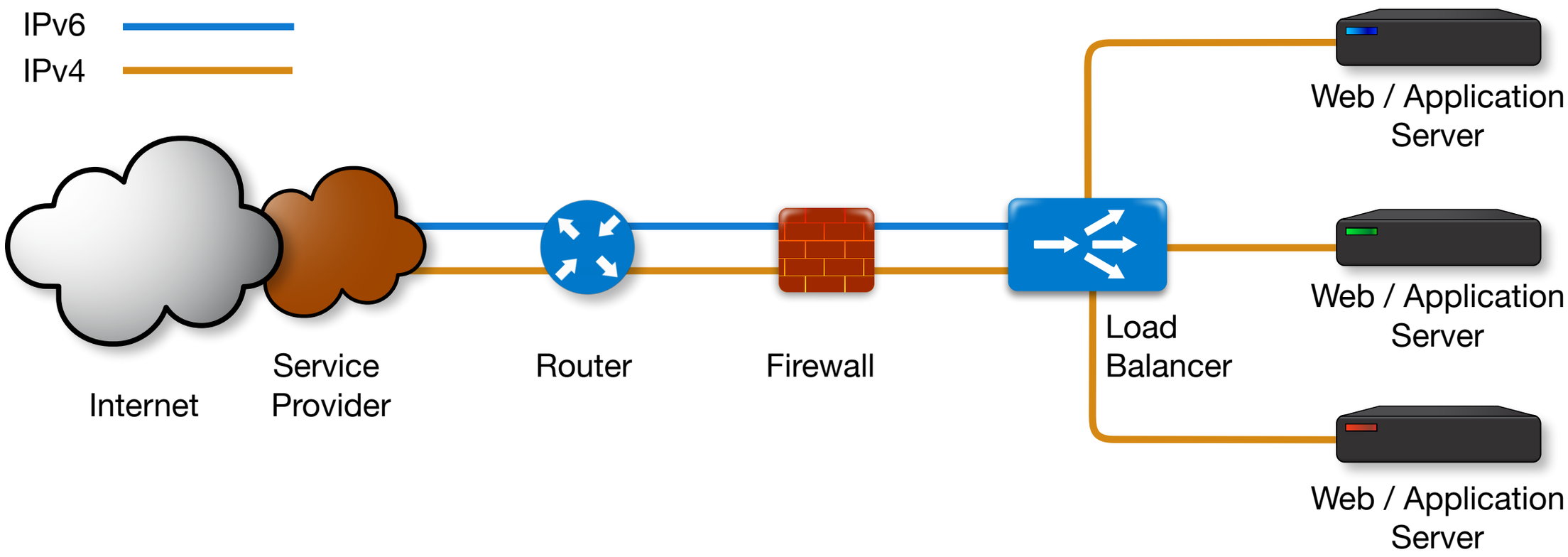
- If possible this is the preferred option



- Cleanest option: no mixing of IPv4 and IPv6
- Needs a fully dual stacked network
- All addresses fully visible where possible

Load Balancer with NAT or Proxy

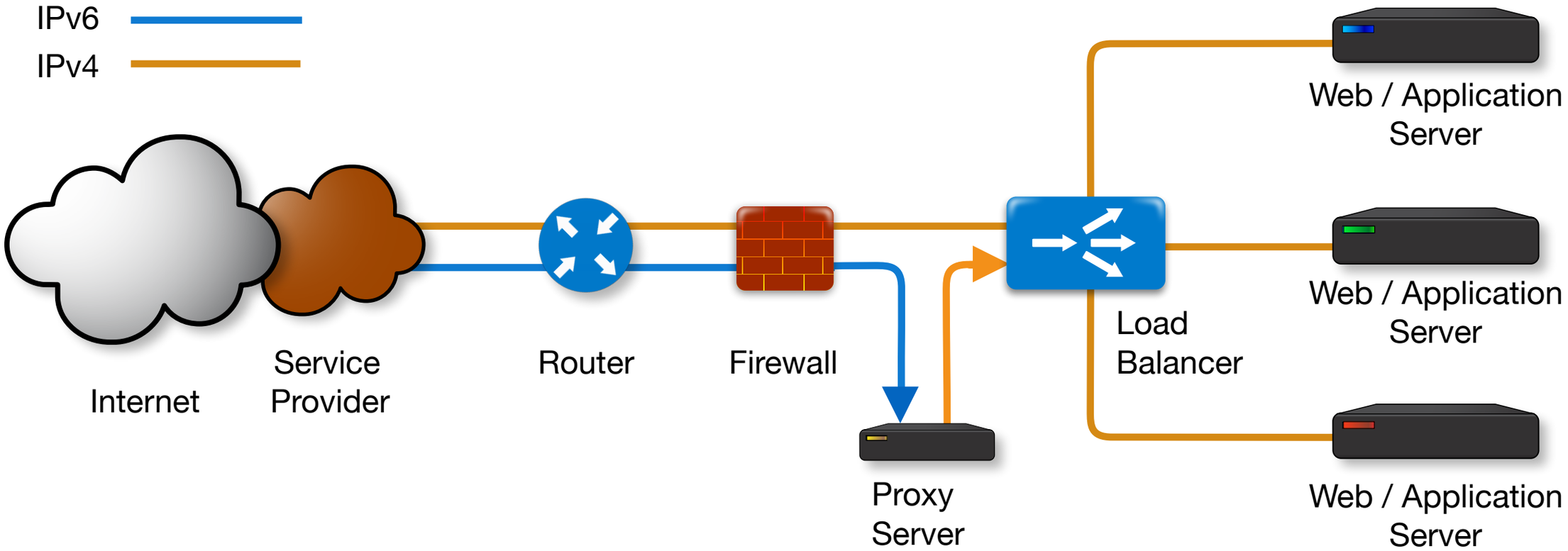
- If web servers can’t handle IPv6



- Needs a fully dual stacked network up to the load balancer
- Web servers might not see IPv6 addresses

IPv6-to-IPv4 Proxy

- If the load balancer or part of the network can't handle IPv6



- Web servers might not see IPv6 addresses

Proxy Protocol Level

- You can proxy on
  - Layer 4 (TCP)
  - Layer 7 (HTTP/HTTPS)

- Both have advantages and disadvantages

Proxy on Layer 4

- **Very easy to configure**
  - Doesn’t need to know about the protocol
  - Doesn’t need to be configured with host name
  - Don’t need SSL/TLS keys on the proxy server
- **Just map an IPv6 address+port to an IPv4 address+port**
- **Cannot provide information to the servers**

Proxy on Layer 4

- **This example shows haproxy**
  - Note the confusing notation in the config file
  - IPv6 address = 2001:db8:abc:123::cafe **port 25**

```
listen smtp1
  bind 2001:db8:abc:123::cafe:25
  mode tcp
  server smtp1 192.0.2.1:25
```

Proxy on Layer 7

- **Bit more work to configure**
  - Needs to know about the protocol or application
  - Might need to be configured with host name
  - Needs SSL/TLS keys on the proxy server
- **Can provide information to the servers**
  - Like X-Forwarded-For header

Proxy on Layer 7

- This example shows **haproxy**

```
listen website1
  bind 2001:db8:abc:123::cafe:80
  mode http
  option forwardfor
  server website1 192.0.2.1:80
```

- With **SSL**

```
listen website1-ssl
  bind 2001:db8:abc:123::cafe:443 ssl
    crt /etc/haproxy/website-ssl.pem
  mode http
  option forwardfor
  server website1 192.0.2.1:443 ssl
```

Happy Eyeballs

- Makes dual-stacked websites more responsive to users
- If there is both A and AAAA
  - First IPv6 is used with a 300 ms head start
  - If that fails, IPv4 is used
- Implemented by all browsers
- Instable connections can cause problems with cookies

IPv6 in the Root Servers and TLDs

- **11 of 13 root servers have IPv6 AAAA records**
  - E and G root servers don't have IPv6 yet
- **There are 1502 TLDs**
  - 1474 of them are IPv6 capable (98.1%)
- **Over 8 billion websites have AAAA records**

Source: http://bgp.he.net/ipv6-progress-report.cgi

Questions

Mobile Providers

9 - Section

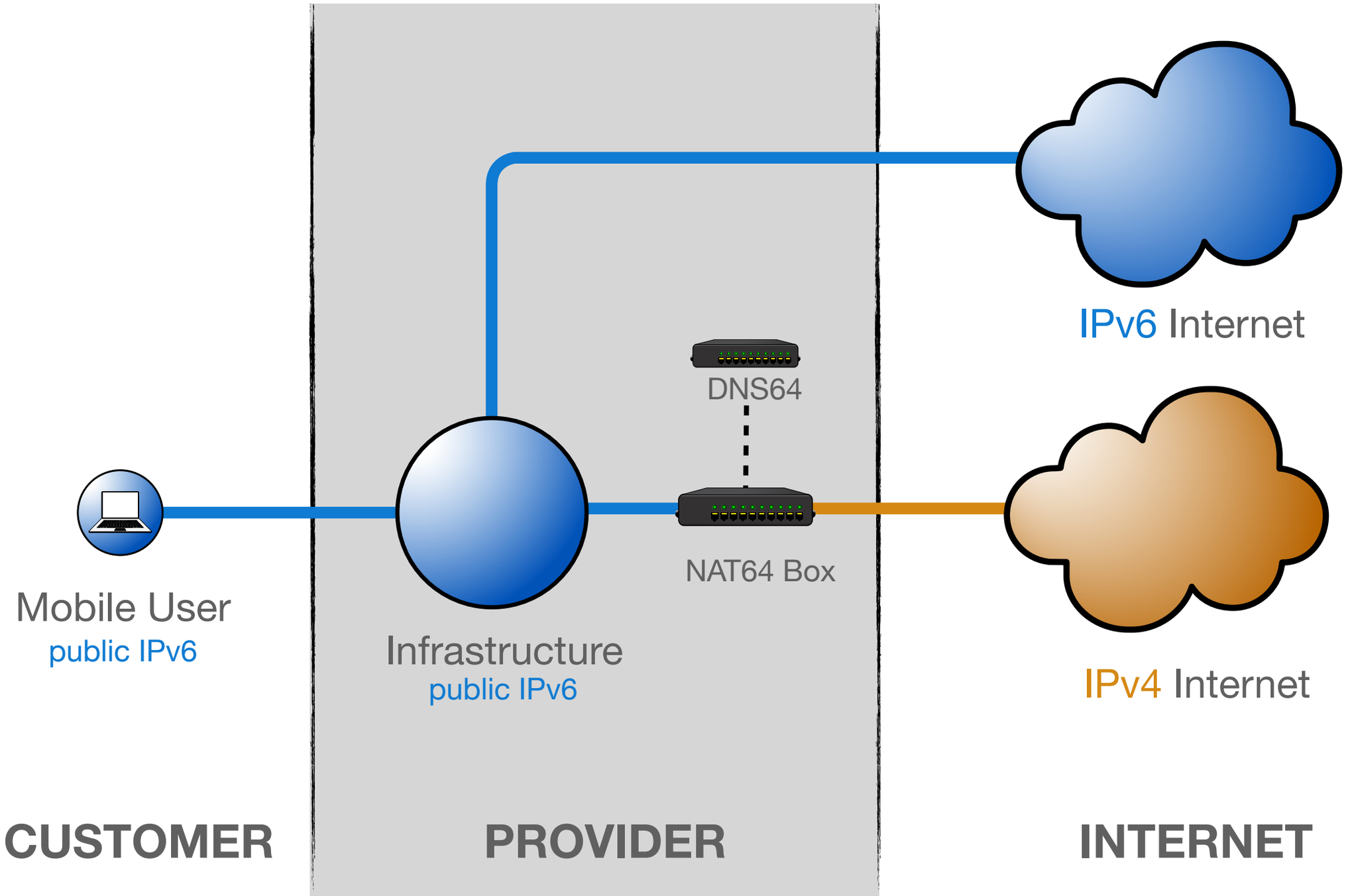
IPv6 in Mobile Networks

- IPv4 runout has a high and urgent impact on mobile internet providers
- Everyone has a smartphone
- Certain apps and protocols have problems with double NAT
- Do apps support IPv6?

Multiple Solutions

- **Dual Stack users:**
  - Public IPv4 and public IPv6
  - Private IPv4 and public IPv6
- **IPv6 only users:**
  - NAT64
  - IPv6 only

NAT64/DNS64


IPv6 Internet
DNS64
NAT64 Box
IPv4 Internet
Mobile User
public IPv6
Infrastructure
public IPv6
CUSTOMER
PROVIDER
INTERNET

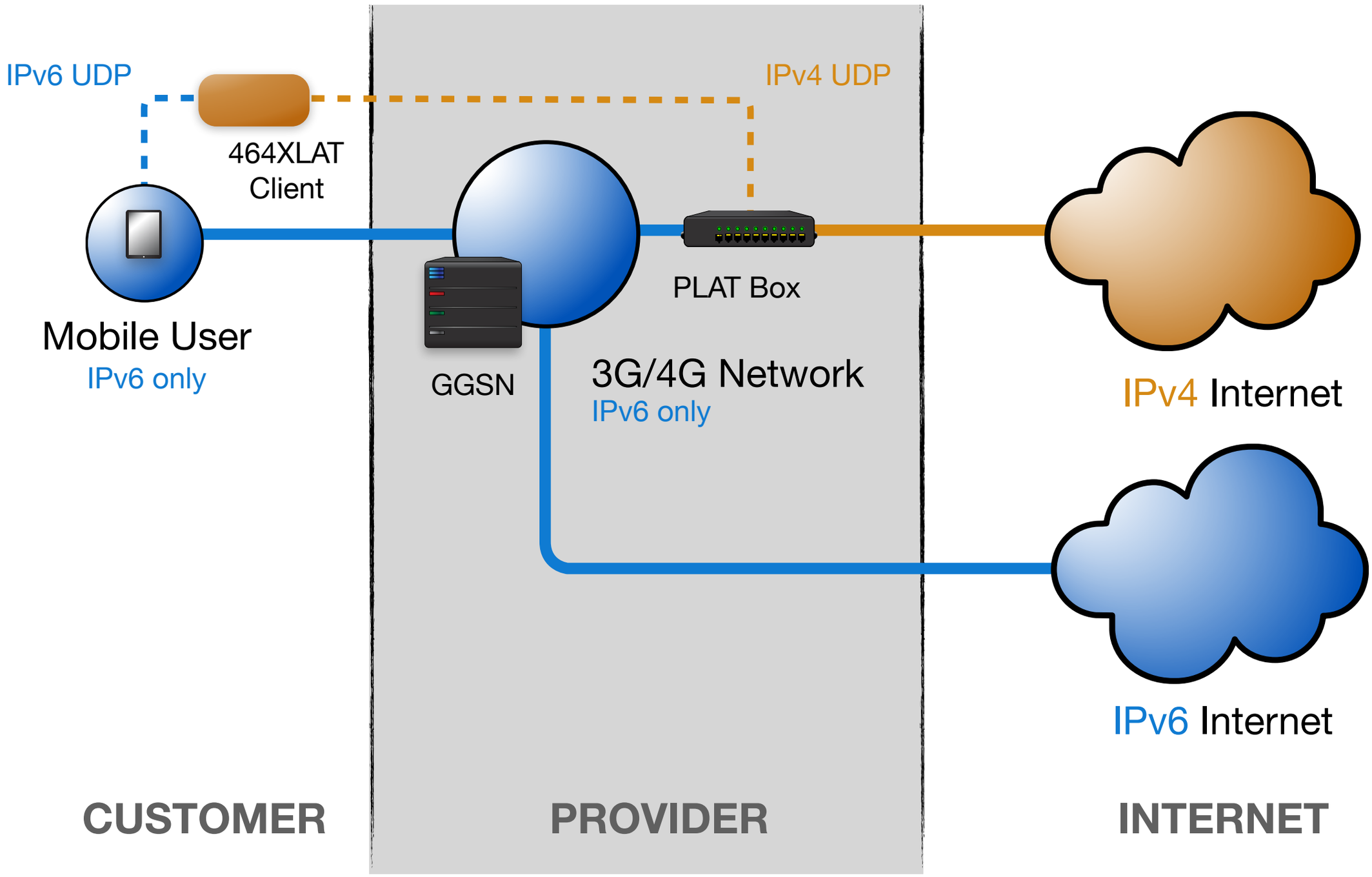
464XLAT

- Extension to NAT64 to access IPv4-only applications (like Skype or Whatsapp)

- Handset pretends there is an IPv4 address (CLAT) **and sends IPv4 packets in UDP over IPv6**

  - Support from: Android 4.4 and Samsung Galaxy Note, Galaxy Light and Google Nexus

464XLAT


IPv6 UDP
IPv4 UDP
464XLAT
Client
PLAT Box
Mobile User
IPv6 only
GGSN
3G/4G Network
IPv6 only
IPv4 Internet
IPv6 Internet
CUSTOMER
PROVIDER
INTERNET

Apple Approach

- Apple recently announced they will not support 464XLAT on the iPhone
- Instead they urge app developers to make apps work over IPv6
- That way, operators can use just NAT64 without 464XLAT

3G

- **Works with Packet Data Protocol (PDP) Contexts**
  - Initiated by the phone to establish a connection
  - IPv4, IPv6 and IPv4v6

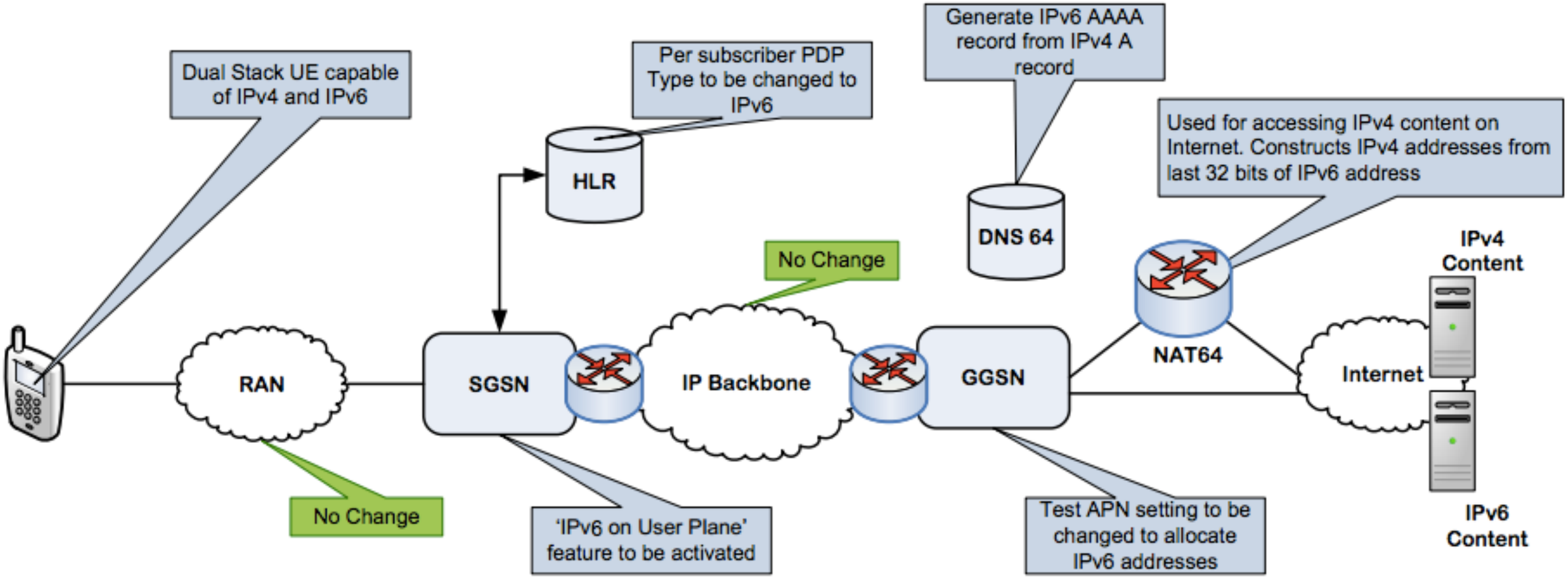
- **No requirement for always-on connection**
- **Only works with SLAAC**

4G

- **Works with Evolved Packet System (EPS) Bearer**
  - Initiated by the phone to establish a connection
  - IPv4, IPv6 and IPv4v6

- **Always-on Packet Data Network (PDN) Connection**
- **Due to the need for supporting VoIP**

What Needs To Be Done



Source: Cameron Byrne T-Mobile USA

What Needs To Be Done

- **Handset:**
  - IPv6 capable
- **Home Location Register (HLR)**
  - Subscriber management needs to understand new PDP types (IPv6, IPv4v6)
- **Serving GPRS Support Node (SGSN)**
  - ‘IPv6 on user plane’ needs to be enabled
  - Fallback strategy

What Needs To Be Done

- **Gateway GPRS Support Node (GGSN)**
  - New PDP types (IPv6, IPv6v4)
  - IPv6 routing
  - DHCPv6
  - Neighbor Discovery Protocol
  - DNS Configuration
  - Fallback strategy
  - Billing

What Needs To Be Done

- And the usual….
  - Firewalls, servers, etc.

Challenges

- Only 1 IPv4 address and 1 IPv6 subnet on a handset
- Fallback from IPv4v6 to IPv4-only or IPv6-only is difficult in some cases

Questions

Overview Day 2

- Host Configuration
- Exercise: SLAAC
- DHCPv6
- Exercise: DHCPv6
- Security
- Exercise: 6rd
- IP Address Management
- Tips & Tricks

Host Configuration

Section 10

Operating Systems

- We will look at Windows, Linux, OSX
- All of them support IPv6 natively

- Good news: it works automatically
- Bad news: it works automatically

Managing clients

- Users might not notice that their computer is using IPv6

- For management purposes, you want control over addresses
  - Disable SLAAC, Privacy extensions, other

Obtaining addresses

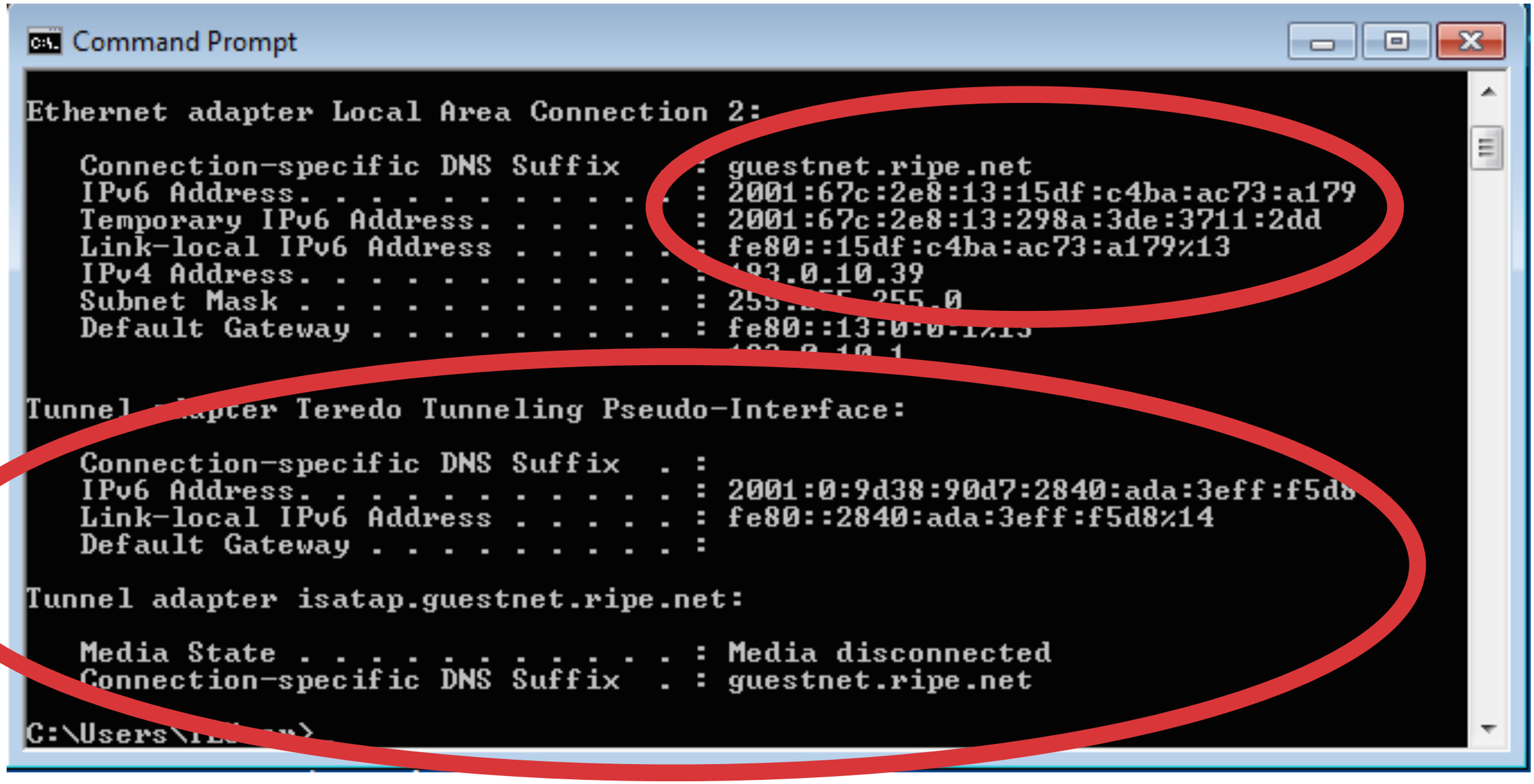
- Disabling SLAAC does not mean disabling Router Advertisements

- RAs are an important part of address distribution
- They point clients at a DHCPv6 server

Windows 7

- By default, many services/protocols are enabled:
  - Privacy extensions
  - Teredo
  - 6to4
  - ISATAP
  - You might want to disable some/all of them

Windows 7: Before



De-configuring Windows 7

- First, disable all the transition methods

- On the command prompt, as administrator:

```
netsh interface ipv6 6to4 set state state=disabled

netsh interface ipv6 isatap set state state=disabled

netsh interface ipv6 set teredo disable
```

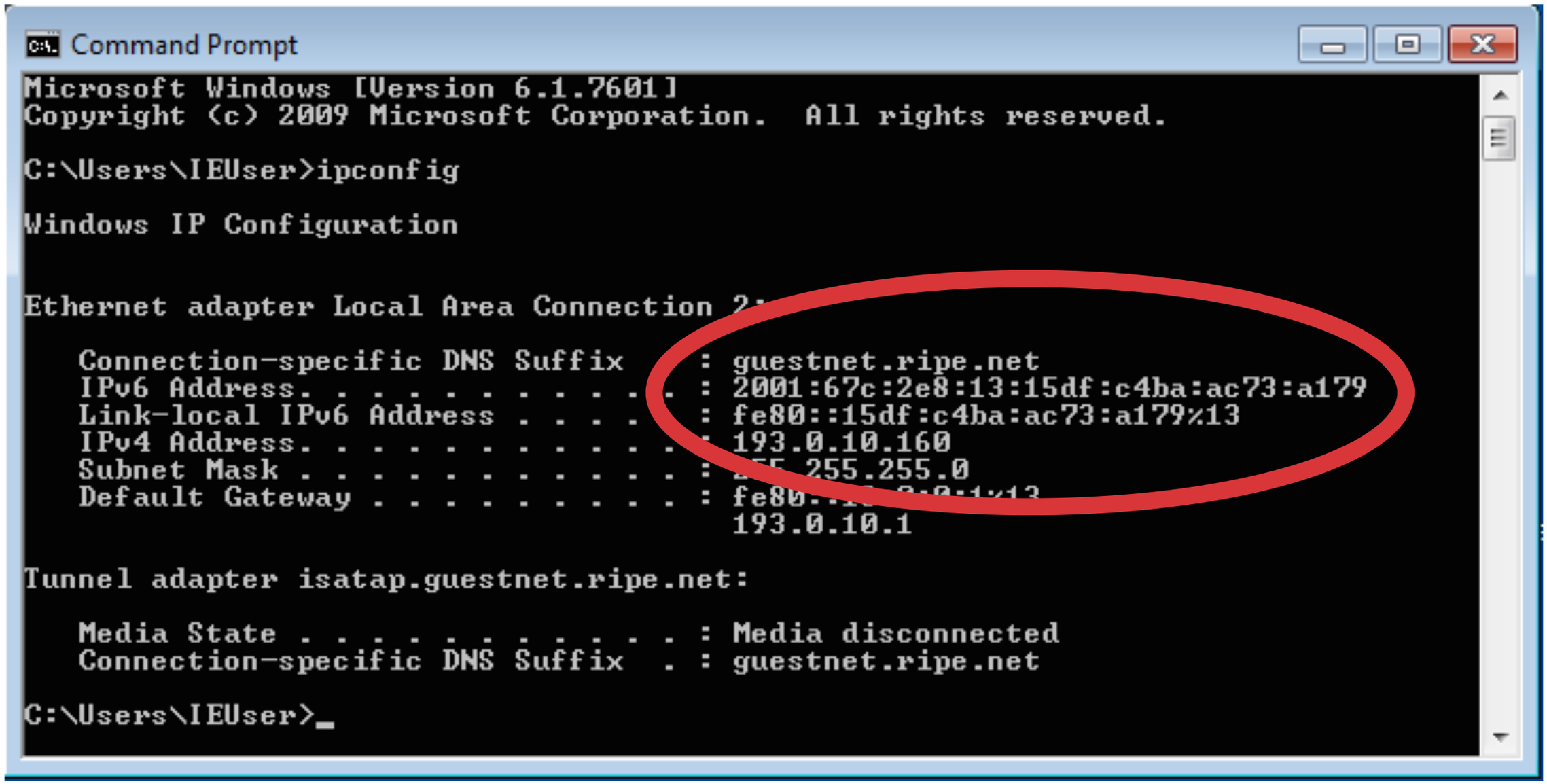
Windows 7 Privacy Extensions

- Disable privacy extensions

```
netsh interface ipv6 set privacy state=disable

netsh interface ipv6 set global randomizeidentifier=disabled
```

Windows 7:After



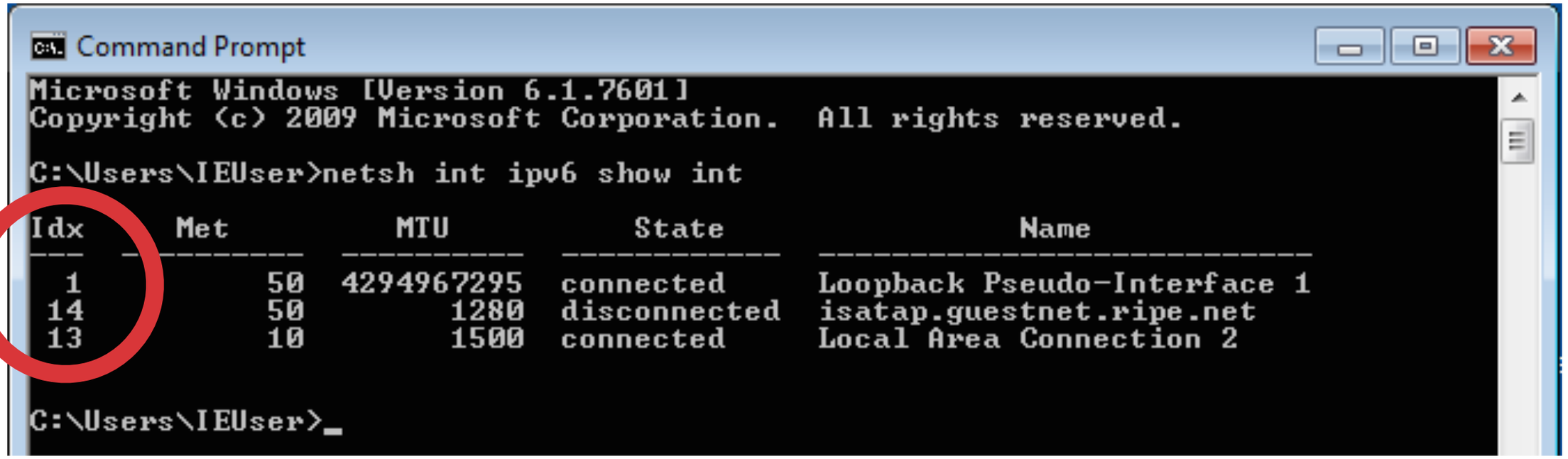
Windows 10

- By default, many services/protocols are disabled:
  - Privacy extensions
  - Teredo
  - 6to4
  - ISATAP

DHCPv6 client on Windows

- First, get the interface ID:

```
netsh interface ipv6 show interfaces
```



DHCPv6 client on Windows

- With the interface ID instead of the red XX, run the command:

```
netsh interface ipv6 set interface ipv6 XX advertise=enabled managed=enabled
```

- (This has to be run as an Administrator)

Check configuration

- To check the configuration:

```
netsh interface ipv6 show interface XX
```

- (This has to be run as an Administrator)

Activating DHCPv6

- Without DHCPv6:

```
Neighbor Discovery                          : enabled
Neighbor Unreachability Detection           : enabled
Router Discovery                            : enabled
Managed Address Configuration               : disabled
Other Stateful Configuration                : disabled
Weak Host Sends                             : disabled
Weak Host Receives                          : disabled
```

- With DHCPv6:

```
Neighbor Discovery                          : enabled
Neighbor Unreachability Detection           : enabled
Router Discovery                            : enabled
Managed Address Configuration               : enabled
Other Stateful Configuration                : disabled
Weak Host Sends                             : disabled
Weak Host Receives                          : disabled
```

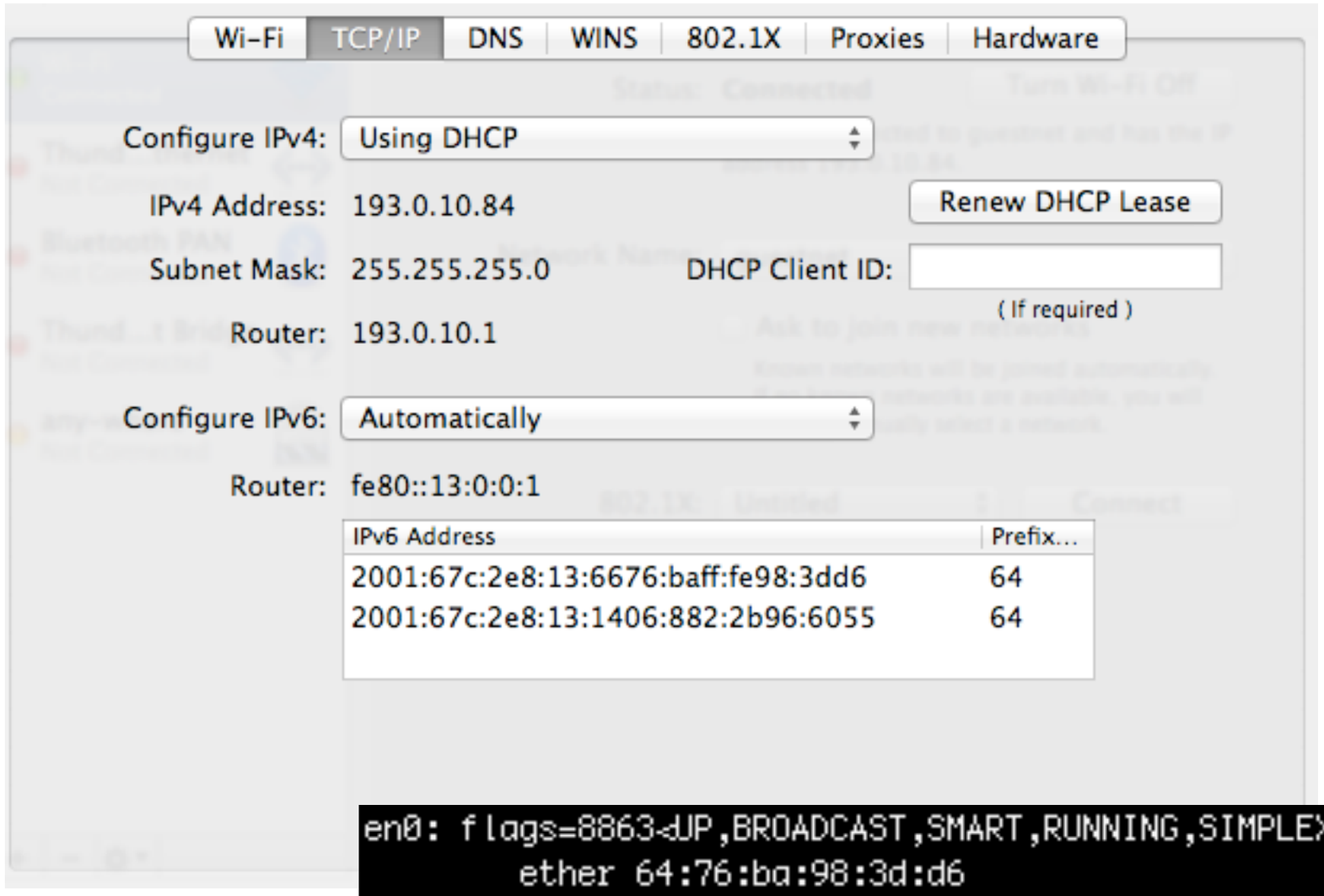
Windows and DHCPv6

- You can either:
- Configure a router to supply the “M” flag
  - But with no prefix announced
- Or disable router discovery (as shown)
  - And let other clients pick up addresses from SLAAC

OSX

- It will automatically configure IPv6
- It will look in the RA messages to check M flag
- If present, it will check with DHCPv6

OSX Configuration




```
en0: flags=8863<UP,BROADCAST,SMART,RUNNING,SIMPLEX,MULTICAST> mtu 1500
        ether 64:76:ba:98:3d:d6
        inet6 fe80::6676:baff:fe98:3dd6%en0 prefixlen 64 scopeid 0x4
        inet6 2001:67c:2e8:13:6676:baff:fe98:3dd6 prefixlen 64 autoconf
        inet6 2001:67c:2e8:13:1406:882:2b96:6055 prefixlen 64 autoconf temporary
        inet 193.0.10.84 netmask 0xffffff00 broadcast 193.0.10.255
        nd6 options=1<PERFORMNUD>
        media: autoselect
        status: active
```

Linux

- As client, same behaviour as OSX
  - Everything works out of the box
  - IPv6 is enabled automatically
- As server, static configuration is required

Linux Static configuration

- For CentOS/Red Hat:
- /etc/sysconfig/network

- Add:

```
NETWORKING_IPV6=yes
```

Linux Static configuration

- In /etc/sysconfig/network-scripts/ifcfg-ethX
- Add:

```
IPV6INIT=yes
IPV6ADDR=2001:0db8:aaaa:bbbb:0000:0000:0000:0002/64
IPV6_DEFAULTGW=2001:db8:aaaa:bbbb:0000:0000:0000:0001
IPV6_AUTOCONF=no
```

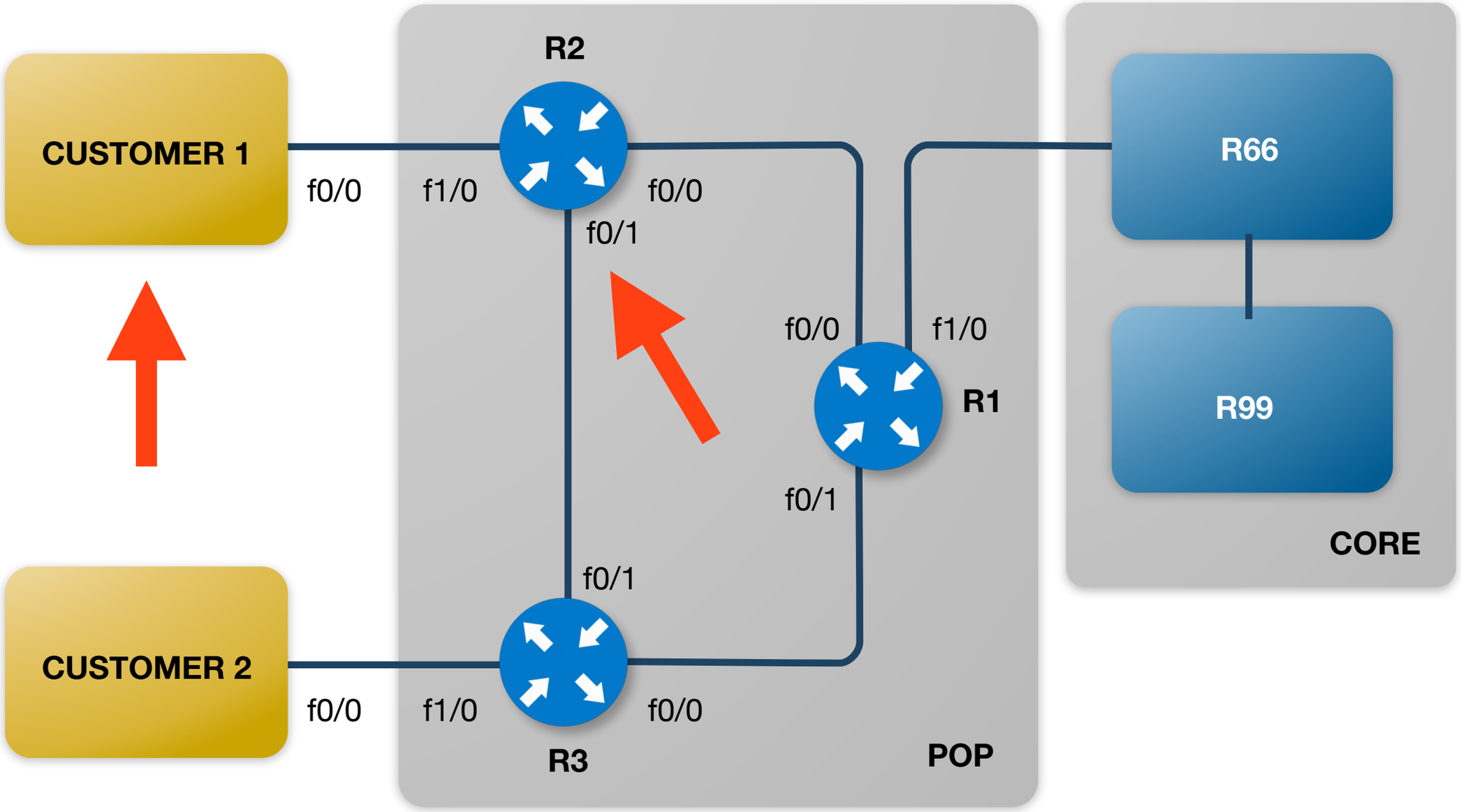
- Where X is the number of the interface, then:

```
service network restart
```

SLAAC

10 - Exercise

SLAAC


R2
CUSTOMER 1
f0/0
f1/0
f0/0
f0/1
f0/0
f1/0
R66
R1
R99
f0/1
CORE
f0/1
CUSTOMER 2
f0/0
f1/0
f0/0
R3
POP

On C1

- Now we will enable SLAAC

```
interface f0/0
 ipv6 address autoconfig default
 no shutdown
```

- Leave configuration mode
- Enable debug ND

```
debug ipv6 nd
```

On R2

- Now we will remove the suppression

```
interface f1/0
  ipv6 address 2001:ffXX:0:ff01::b/64
  no ipv6 nd ra suppress all
  no shutdown
```

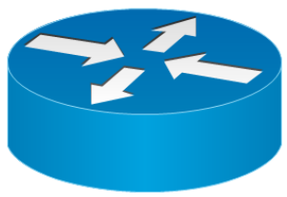
- Leave configuration mode
- To stop debug messages on C1

```
undebug all
```

Debugging SLAAC

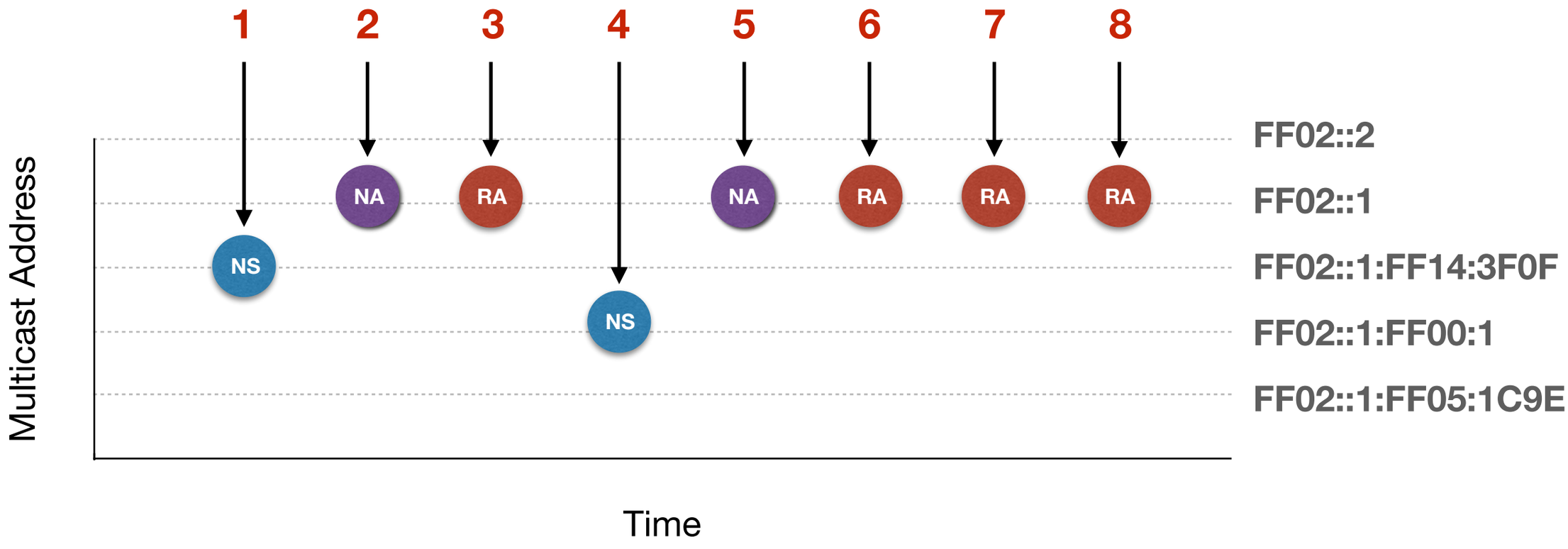
- Can you find the new IPv6 address?
- Look at the routing…
- Do you see any interesting debug messages?

SLAAC: Router Messages



Link-local: fe80::a390:45ff:fe14:3f0f

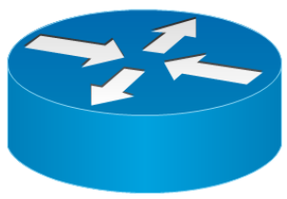
Global unicast: 2001:db8:a:b::1



Link-local: fe80::ba8d:12ff:fe05:1c9e

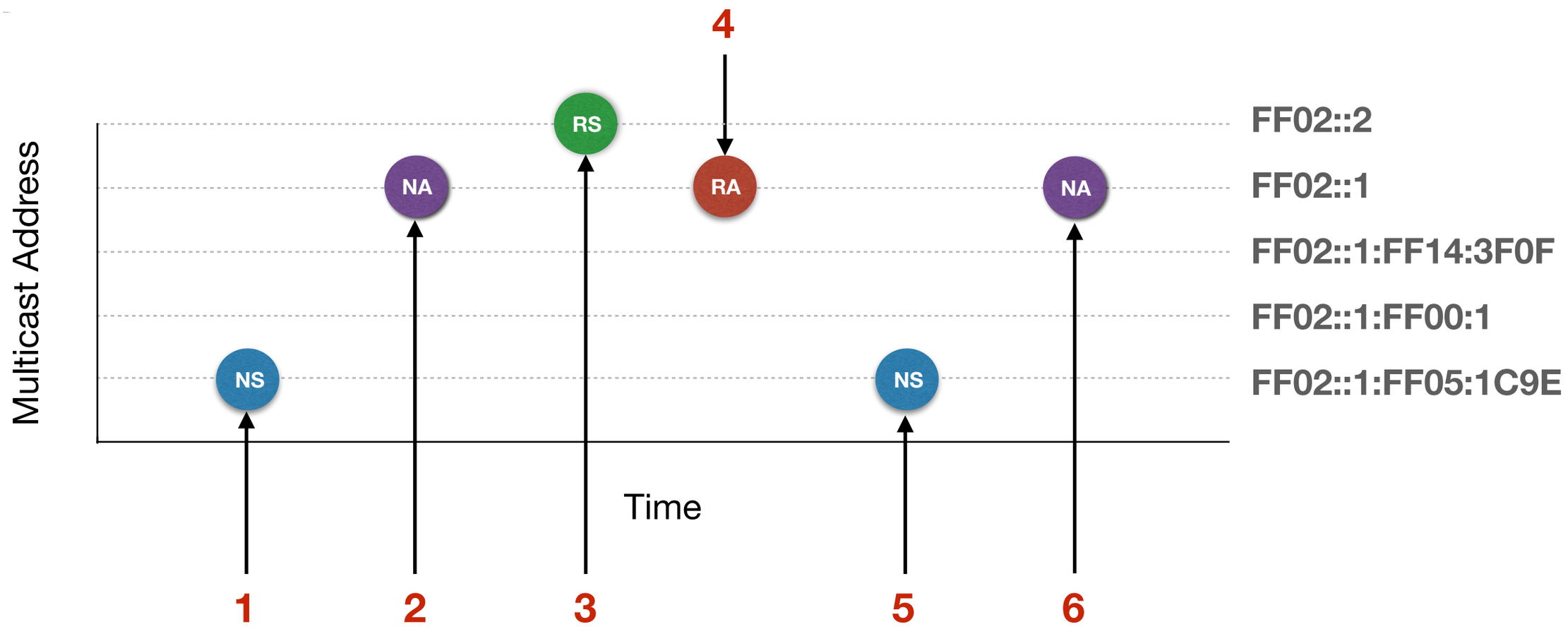
Global unicast: 2001:db8:a:b:ba8d:12ff:fe05:1c9e

SLAAC: Client Messages



Link-local: fe80::a390:45ff:fe14:3f0f

Global unicast: 2001:db8:a:b::1



Link-local: fe80::ba8d:12ff:fe05:1c9e

Global unicast: 2001:db8:a:b:ba8d:12ff:fe05:1c9e

Questions

DHCPv6

11 - Section

About DHCPv6

- New protocol
- Requires IPv6 transport
- Offer similar functionality to DHCPv4 but for IPv6
- Allows more control than SLAAC
  - Routers and servers can have static or dynamic assignments
- **Is supported by Cisco IOS, Microsoft, Juniper, Linux, BSD, Solaris, etc.**

Information provided by DHCPv6

- **No routing information is distributed**
  - no default route (routers in IPv6 have different roles in the network)
- **Only host configuration protocol**
- **Other configuration parameters**
  - includes DNS, NTP etc

DHCPv6 Fundamentals

- Client driven via DHCPv6 request message

- Solely layer 3 protocol unlike DHCPv4:
  - port 546 for clients
  - port 547 for server

- **DHCPv6 options are similar to those in DHCPv4**

DHCPv6 Operation

- Client first detects the presence of routers on link
- Client examines router advertisements to check if DHCP can be used (managed flag)
- If no router is found or if DHCP can be used, **the client:**
  - sends DHCP solicit message to “all-DHCP-agents” multicast address (ff02::1:2)
  - uses link-local address as source address

DUID

- **DHCP Unique IDentifier**
- **A globally unique identifier used to identify the single machine/device**
  - One DUID per DHCPv6 client
- **DHCPv6 does not use only MAC address as identifier**
- **Variable length between 96 - 160 bits**
  - Example Client DUID: 00030001001A2F875602

DHCPv6 Modes

- **Stateful**
  - Also requesting an address
  - **M** flag
- **Stateless**
  - Only other configuration parameters
  - **O** flag
- **Prefix Delegation**

Stateful DHCPv6

- Similar to DHCPv4 today
- A router can act as a DHCP server
- **Configuration parameters include:**
  - DHCP pool name
  - Prefix information
  - List of DNS servers
  - Addresses for clients

Stateful DHCPv6 Server

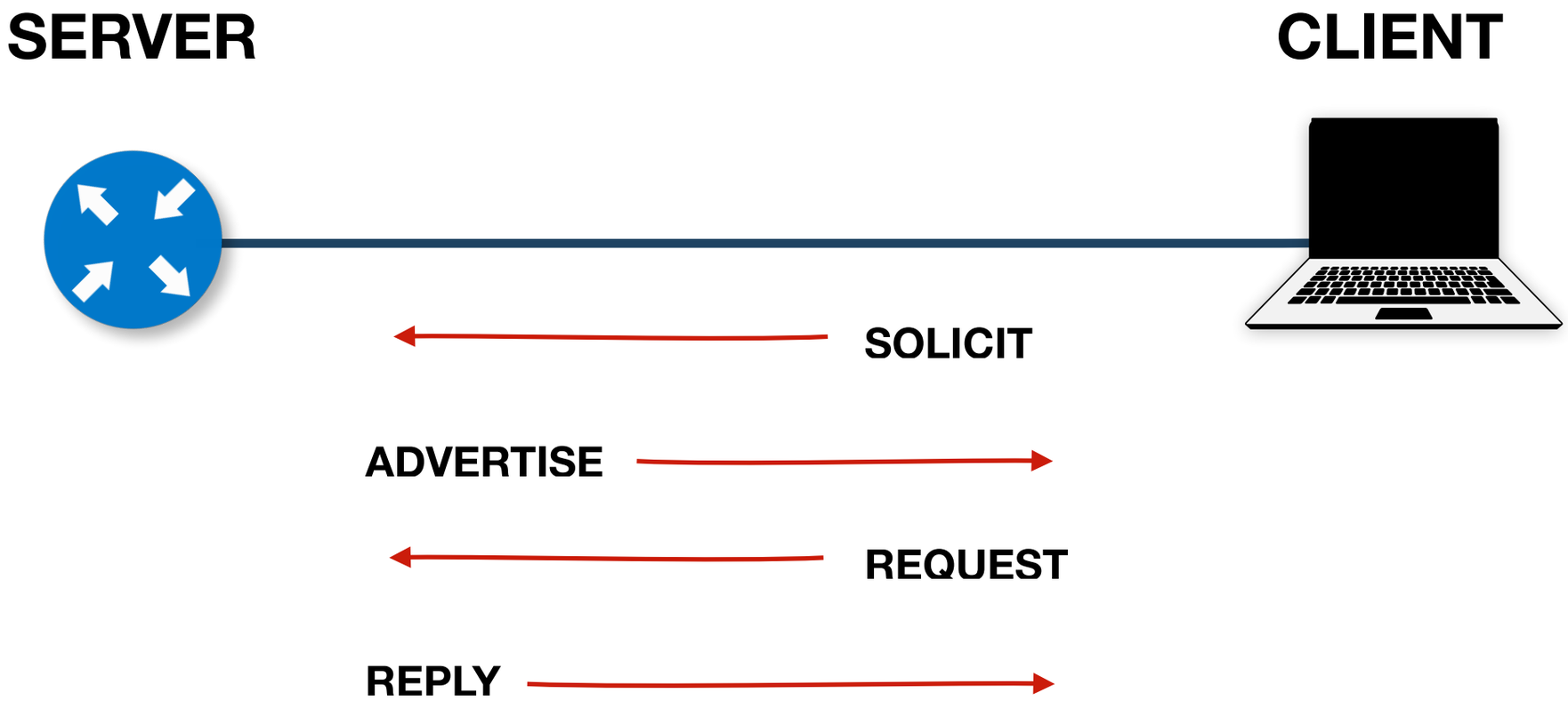
- **Responds to requests from clients to:**
  - Offer IPv6 addresses
  - Other configuration parameters (DNS servers…)
- **Listens on the following multicast addresses:**
  - All_DHCP_Relay_Agents_and_Servers (FF02::1:2)
  - All_DHCP_Servers (FF05::1:3)
- **Usually stores client’s state**

Stateful DHCPv6 Client and Relay

- **Client**
  - Initiates requests on a link to obtain configuration
  - Uses its link local address to connect the server
  - **Sends requests to FF02::1:2** multicast address

- **Relay agent**
  - A node that acts as an intermediary to deliver DHCP messages between clients and servers
  - On the same link as the client
  - **Listens on FF02::1:2** multicast address

Stateful DHCPv6 Messages



Stateless DHCPv6

- **Complements SLAAC configuration:**
  - I.e: host obtain the address using SLAAC and the DNS server address from DHCPv6
    - In dual-stack networks we can obtain IPv4 DNS server addresses from DHCPv4

- **Configure a DHCP pool with additional parameters:**
  - DNS Server
  - Domain name
  - NTP

- **Activated by “other configuration” flag in ND**

Stateless DHCPv6 Messages

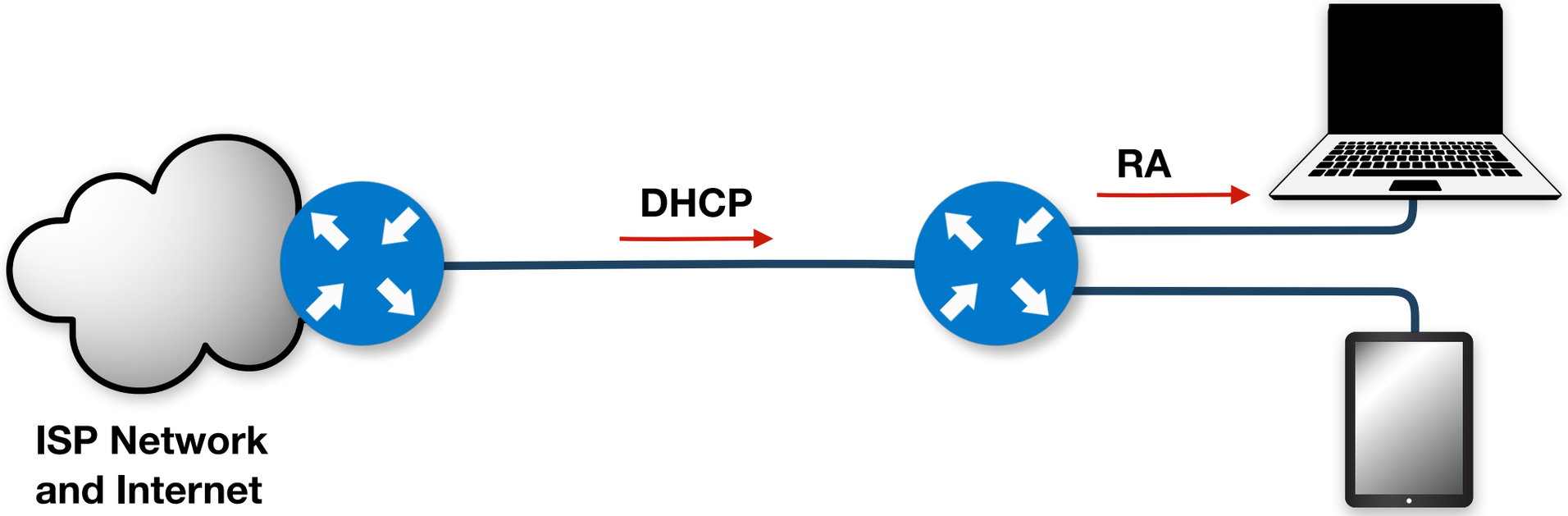
IPv6 Prefix Delegation

- **IPv4 deployments:**
  - ISP only has to deliver a public IPv4 address
    - NAT is used for translation using RFC1918

- **IPv6 deployments:**
  - IPv6 end-to-end reachability:
  - Home network gets its own IPv6 prefix (public address)
  - No NAT

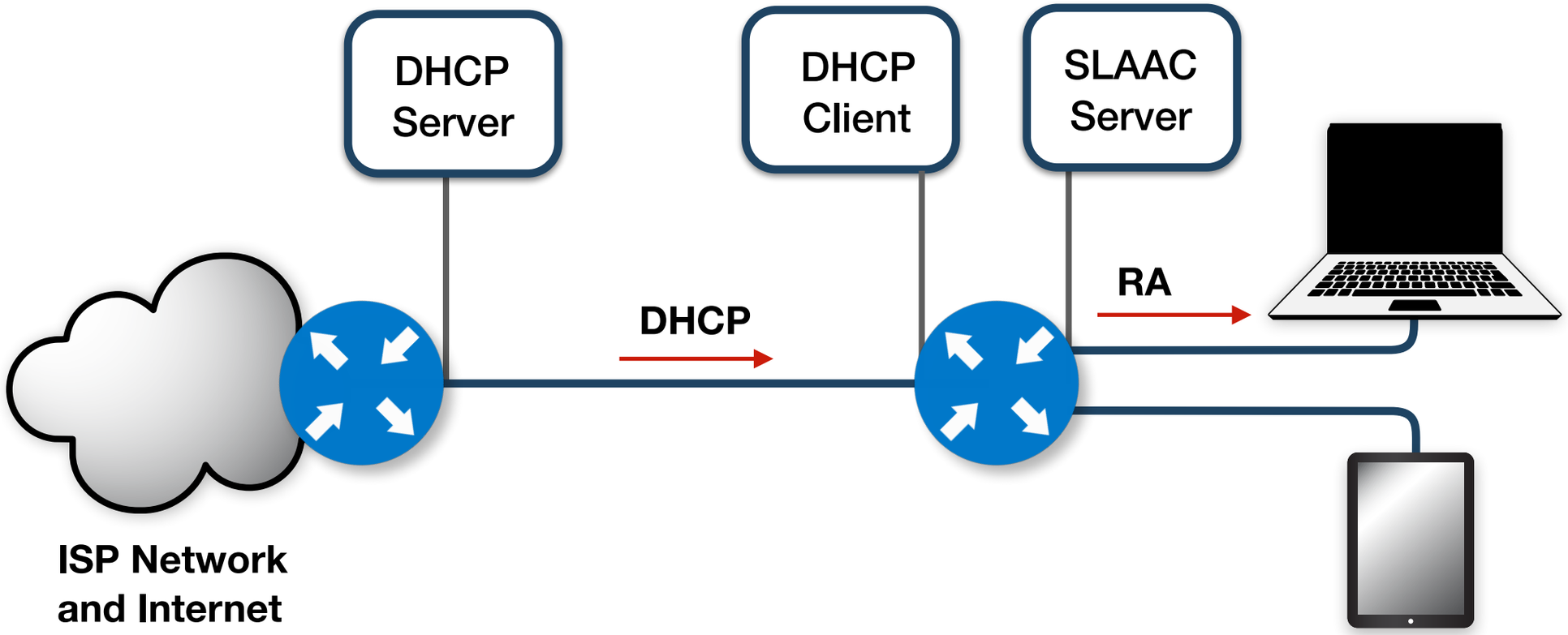
DHCPv6 Prefix Delegation

- ISP assigns a block of addresses for delegation to customers (e.g. /48)
- Customer assigns /64 prefixes to LAN interfaces

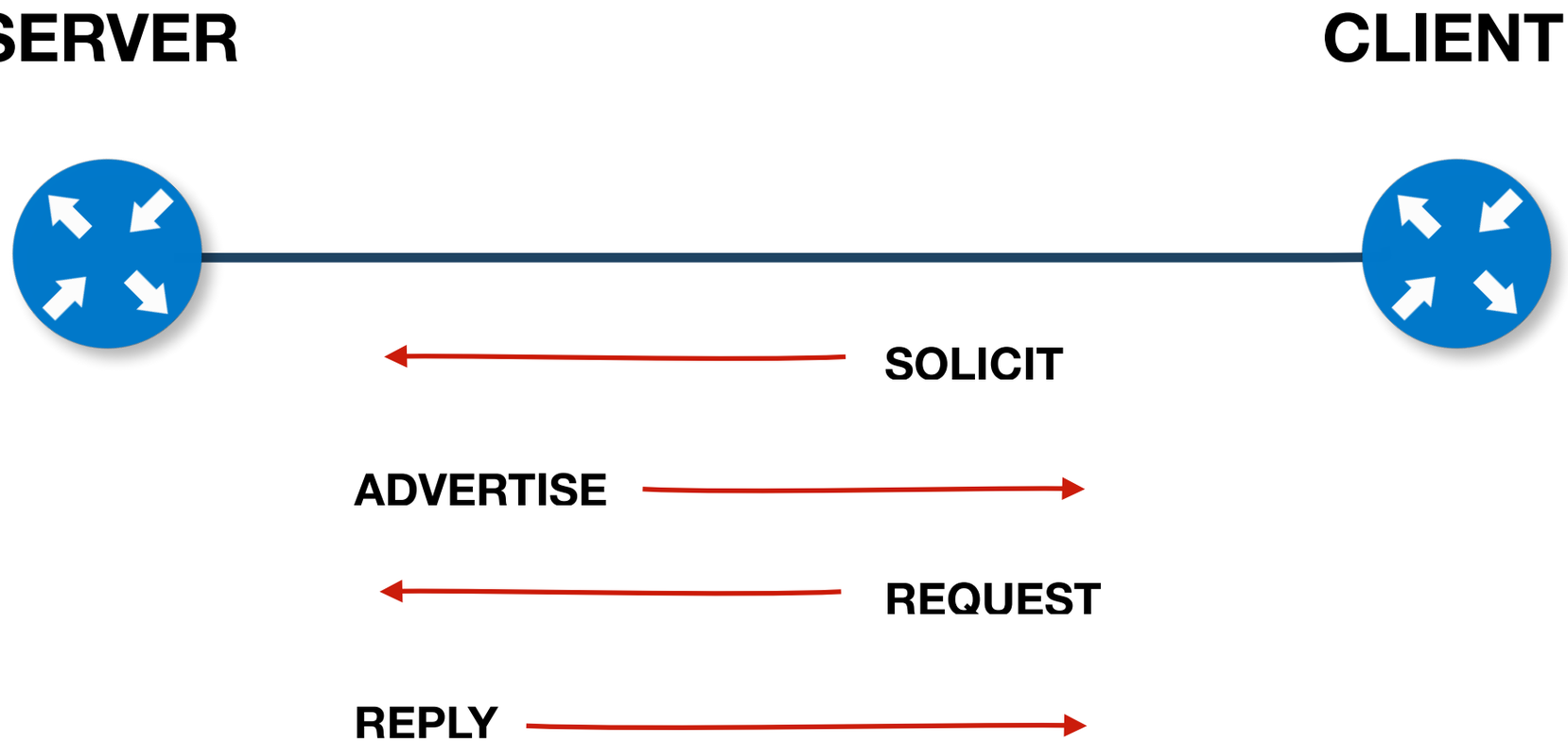


DHCPv6 Prefix Delegation

- Provider edge as delegating DHCP server
- CPE as DHCP client and IPv6 router



DHCPv6 PD Messages

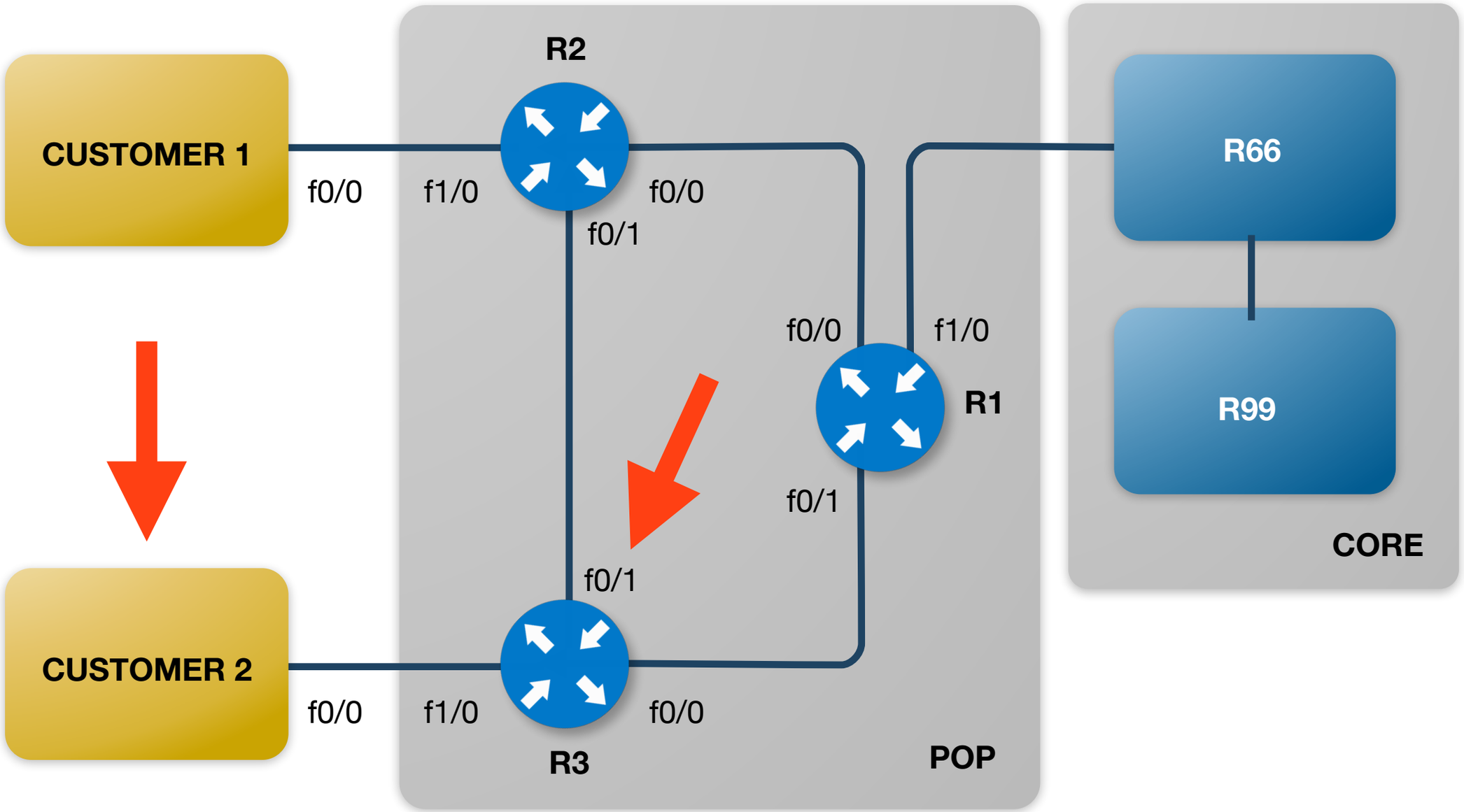


Questions

DHCPv6-PD

12 - Exercise

DHCPv6


CUSTOMER 1
f0/0
R2
f1/0
f0/0
f0/1
R66
R99
CORE
f0/0
f1/0
R1
f0/1
f0/1
CUSTOMER 2
f0/0
f1/0
f0/0
R3
POP

DHCPv6-PD Router Configuration

- DHCP pool named “DHCP_CUSTOMERS” references local pool “DHCP_POOL”
- DHCP_POOL details about the address pool

```
ipv6 dhcp pool DHCP_CUSTOMERS
 prefix-delegation pool DHCP_POOL
!
interface f1/0
 ipv6 address 2001:ffXX:0:ff02::b/64
 ipv6 dhcp server DHCP_CUSTOMERS
 no shutdown
!
ipv6 local pool DHCP_POOL 2001:ffXX:ff02::/48 56
```

DHCPv6-PD CPE Configuration

- ISP facing interface is the DHCP client
- LAN facing interface is the IPv6 router sending RA message

```
interface f0/0
 ipv6 address 2001:ffXX:0:ff02::a/64
 ipv6 dhcp client pd PREFIX
 no shutdown
!
interface f0/1
 ipv6 address PREFIX ::1:0:0:0:1/64
 no shutdown
```

Summary

- We have now distributed an IPv6 prefix to Customer 2
- Customer has distributed prefixes to LAN interfaces automatically
- Can you find the client DUID address?

Challenge: DHCPv6-PD with static assignment

12 - Exercise

DHCPv6-PD with Static Assignment

- Assign to Customer 2 static prefix:
  - 2001:ffXX:ff02:AB00::/56

Questions

Security

13 - Section

IPv6 Security - Why Does It Matter?

- Most operating systems have IPv6 enabled by default nowadays
- IPv6 is present in your IPv4-only networks
  - tunnels
  - autoconfiguration on hosts
- **The default IPv6 policies will not be what you need**
- **Often everything open**

Subnet Scanning

- **In IPv6, scanning the whole address space is not possible anymore, but people use:**
  - words (dead, beef, babe, cafe)
  - lower numbers (::1, ::2, ::3)
  - IPv4 based addresses (2001:db8::192:168:1:1/128)

Subnet Scanning

- Scanning multicast addresses
  - ff02::1 - all hosts
  - ff05::5 - all DHCP servers
  - ff05::2 - all routers

- You can use easy to remember addresses, but remember that scanning will work the same as in IPv4

ICMPv6

- ICMPv6 is used to report errors, ping and discover others (Neighbor Discovery)

- ICMPv6 is an integral part of IPv6

- Disabling ICMPv6 will break your network

Firewall Filtering and ICMPv6

- IPv6 border filter example

Action	Src	Dst	ICMPv6 type	ICMPv6 Code	Name
Permit	Any	A	128	0	echo reply
Permit	Any	A	129	0	echo request
Permit	Any	A	1	0	no route to dest
Permit	Any	A	2	0	packet too big
Permit	Any	A	3	0	TTL exceded
Permit	Any	A	4	0	parameter problem

IPv6 Headers

- In IPv6, the header of a packet can be extended
- Extension headers are used for routing, fragmentation, IPSEC, etc.
- Some Intrusion Detection Systems find it hard to figure out where layer 4 starts and the extension header ends

IPSec

- IPSec in IPv6 is the same as in IPv4
- There is nothing automatically secure in IPv6
- IPSec “support” is mandatory in IPv6
  - Not IPSec usage
  - PKI infrastructure costs time and money

RA Guard

- RFC6105
- Implement on a L2 switch, so they can filter out rogue or misconfigured routers sending router advertisements
- **Filtering based on:**
  - MAC address
  - Port where the RA was received
  - IP source address

Hosts

- Hosts can get an IPv6 address unnoticed
- Hosts can set up tunnels
- Keep software up-to-date
- Host security controls should inspect IPv4 and

IPv6

- Firewalls
- VPN clients

Routers

- Protect **vty** lines

```
ipv6 access-list line-vty-in
 remark company management prefix
 permit ipv6 2001:db8:0:1::/64 any
```

```
line vty 0 15
 ipv6 access-class line-vty-in in
```

- Use a /127 for point-to-point links if possible

IPv6 Bogons

- **Documentation prefix**
  - 2001:db8::/32
- **6bone**
  - 3ffe::/16
  - Returned to the IANA pool
- **Cymru bogon list (very long!)**
  - Also available as BGP feed
  - https://www.team-cymru.org/Services/Bogons/fullbogons-ipv6.txt

Questions

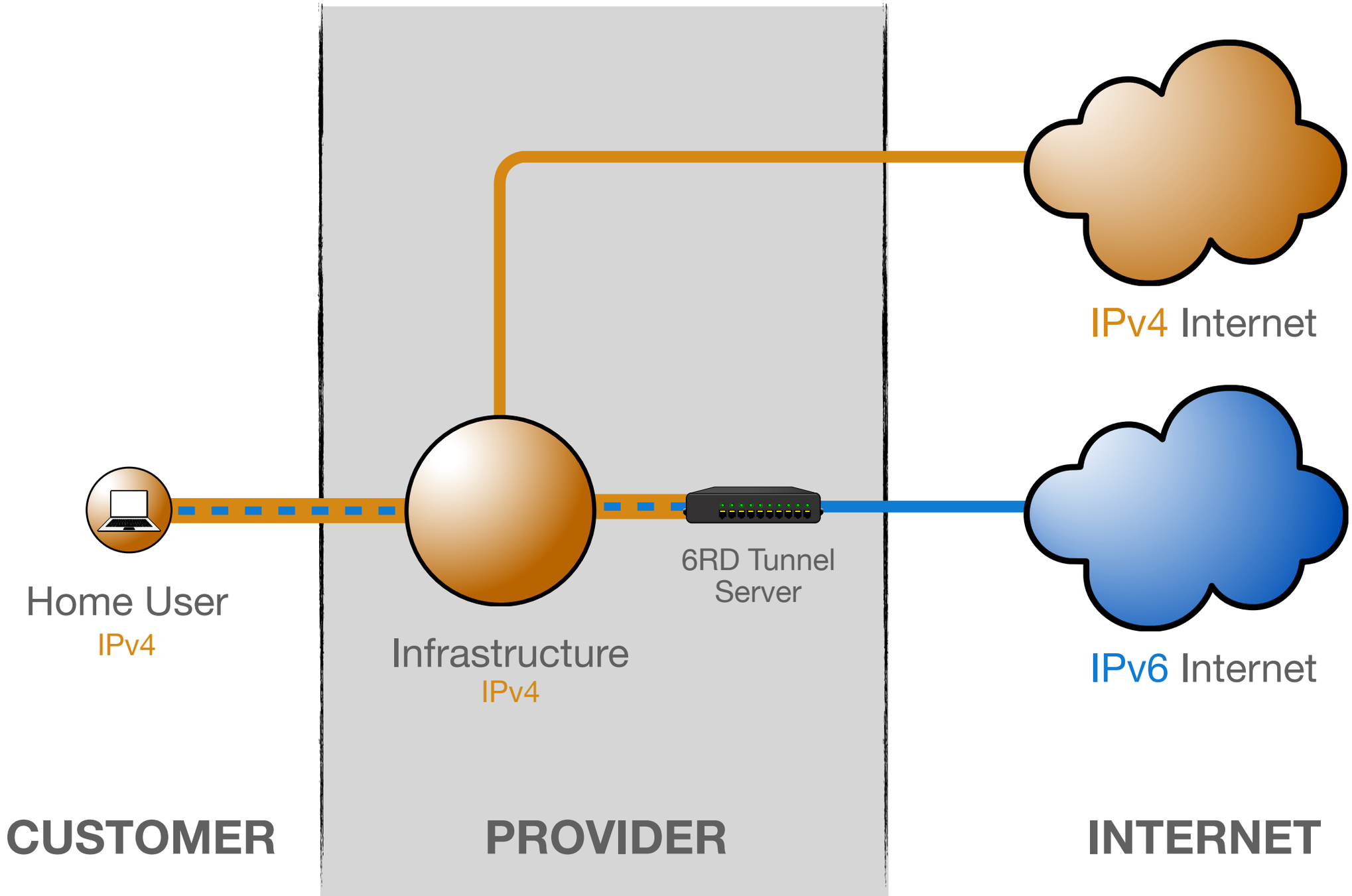
Configuring 6rd

14 - Section

6rd

- **Quite similar to 6to4**
  - Encodes the IPv4 address in the IPv6 prefix
- **Uses address space assigned to the operator**
- **The operator has full control over the relay**
- **Traffic is symmetric across a relay**
  - Or at least stays in your domain
- **Can work with both public and private space**
- **Needs additional software for signalling**

6rd


IPv4 Internet
6RD Tunnel Server
IPv6 Internet
Home User
IPv4
Infrastructure
IPv4
CUSTOMER
PROVIDER
INTERNET

6rd Lab

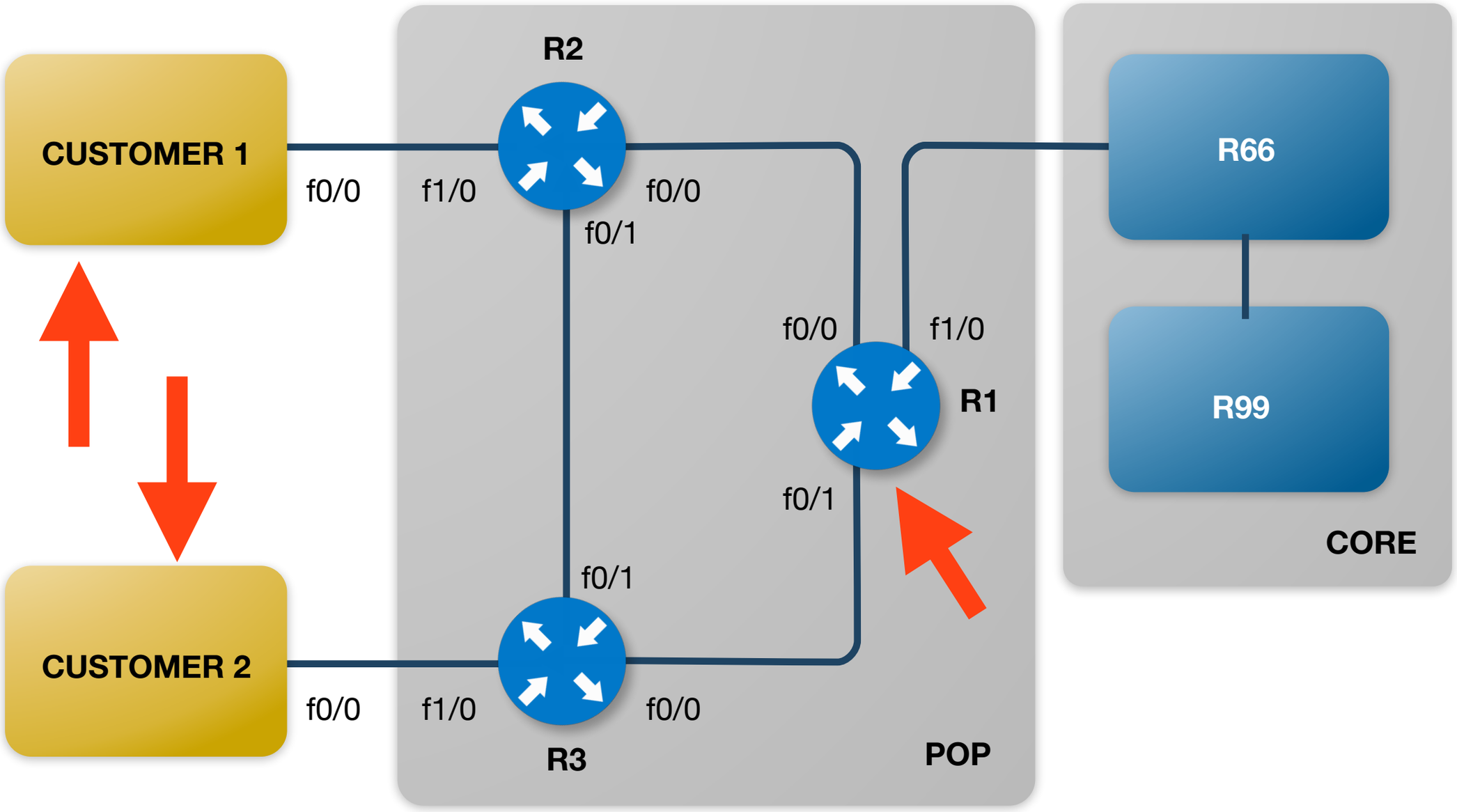
- **In this lab we will set up 6rd**
  - Routers R2 and R3 cannot do IPv6
  - R1 has IPv6 and is the 6rd Border Relay (BR)
  - The customers will get IPv6 using 6rd

- **IPv4 is already set up**
- **This is a different configuration from the previous exercises, we will start from the beginning**

6rd Lab

- **Step 1**: Determine which addresses to use
- **Step 2**: Configure R1 as a 6rd Border Router
- **Step 3**: Configure C1 and C2 to use the Border Router
  - We will configure 6rd manually on the client

6rd Lab


CUSTOMER 1
f0/0
R2
f1/0
f0/0
f0/1
f0/0
f1/0
R1
f0/1
R66
R99
CORE
f0/1
CUSTOMER 2
f0/0
f1/0
f0/0
R3
POP

6rd Lab: Step 1

- **Determine the 6rd mapping:**
  - Which IPv4 addresses will be able to use the BR?
  - How will IPv4 addresses be mapped to the IPv6 prefix?
  - Which address will the BR get?

6rd Lab: Step 1

- **We provide 6rd for 10.X.0.0/22**
- **We use 2001:ffXX:ff00::/42 for the 6rd setup**
  - The last 10 bits in the IPv4 address are used in the mapping

6rd Lab: BR IPv4 Address

- **The border router must have an IPv4 address in the IPv4 range**
  - In this example we use 10.X.3.255
- **The BR must also have the first IPv6 address in its own mapped IPv6 range**
  - 10.X.3.255 → 2001:ffXX:ff00::/42

6rd Lab: Configuring the BR

- Configure the IPv4 address on an extra loopback interface

```
interface loopback6
 ip address 10.X.3.255 255.255.255.255
 no shutdown
```

6rd Lab: Configuring the BR

- We configure 6rd as a tunnel

```
interface tunnel6
 tunnel source loopback6
 tunnel mode ipv6ip 6rd
 tunnel 6rd ipv4 prefix-len 22
 tunnel 6rd prefix 2001:ffXX:ff00::/42
 ipv6 address 2001:ffXX:ff3f:f000::/128 anycast
```

6rd Lab: Configuring the BR

- Configure routes to the tunnel and our own /52

```
ipv6 route 2001:ffXX:ff00::/42 tunnel6
ipv6 route 2001:ffXX:ff3f:f000::/52 Null0
```

6rd Lab: BR Summary

- Add an IPv4 address on an extra loopback
- Add a tunnel interface (6rd)
- Route the IPv6 prefix of the 6rd tunnel
- Route the IPv6 address

6rd Lab: Configuring Customers

- Do the basic setup for IPv6:

```
ipv6 unicast-routing
ipv6 cef
```

6rd Lab: Configuring Customers

- **Create a variable for the prefix**
  - Because we don’t know what we will get from the BR

```
ipv6 general-prefix DELEGATED_PREFIX 6rd tunnel6
```

- **This “DELEGATED_PREFIX” will be automatically set to the right 6rd prefix**

6rd Lab: Configuring Customers

- Set up 6rd tunnel

```
interface tunnel6
 tunnel source f0/0
 tunnel mode ipv6ip 6rd
 tunnel 6rd ipv4 prefix-len 22
 tunnel 6rd prefix 2001:ffXX:ff00::/42
 tunnel 6rd br 10.X.3.255
 ipv6 address DELEGATED_PREFIX ::/128 anycast
```

- The “DELEGATED_PREFIX” is used for the address

6rd Lab: Configuring Customers

- Set up 6rd and default route

```
ipv6 route 2001:ffXX:ff00::/42 tunnel6
ipv6 route ::/0 tunnel6 2001:ffXX:ff3f:f000::
```

- Set up interfaces

```
interface loopback 0
 ipv6 address DELEGATED_PREFIX ::1/128

interface f0/1
 ipv6 address DELEGATED_PREFIX 0:0:0:1::/64 eui-64
 no ipv6 redirects
```

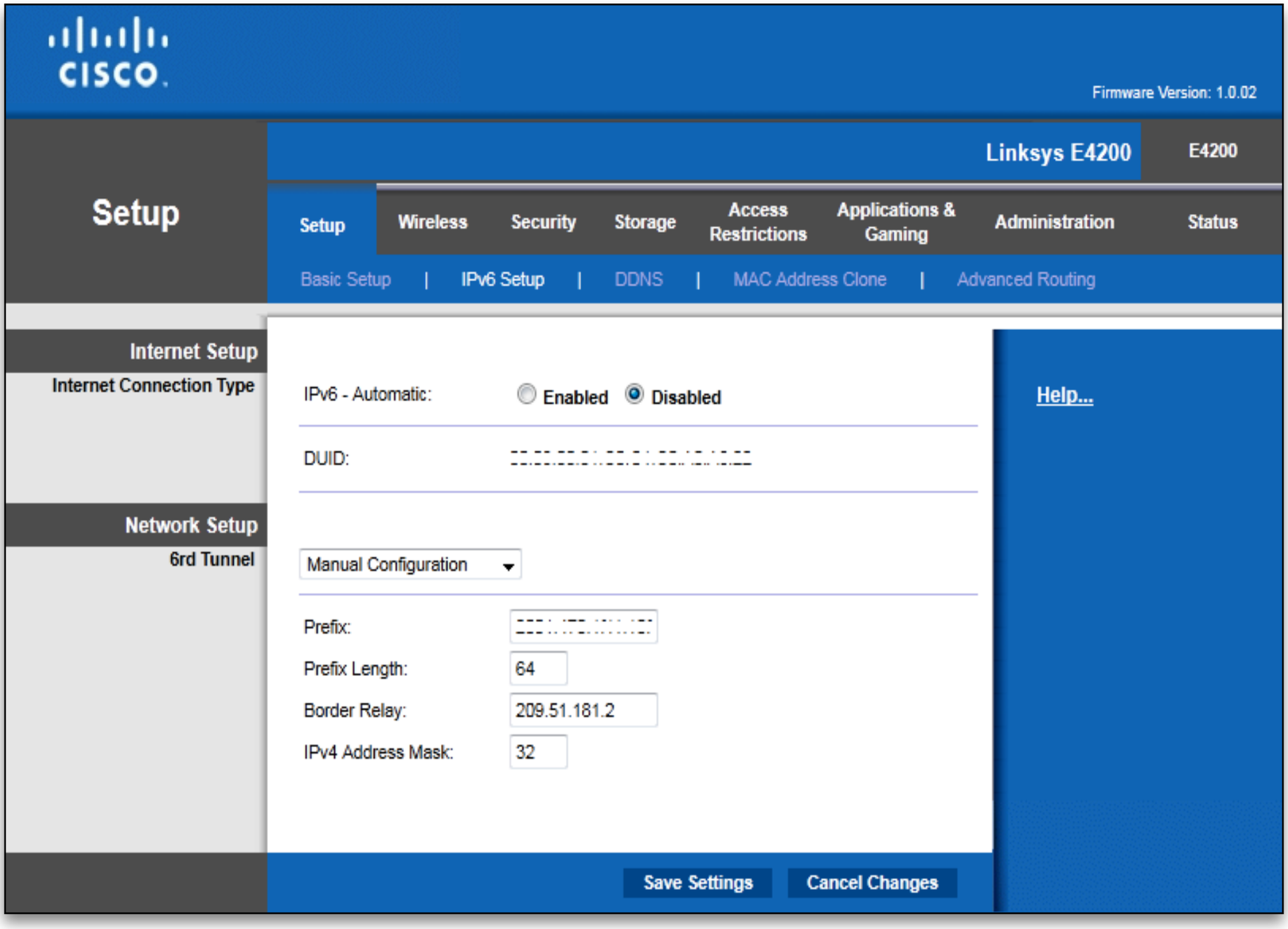
6rd Labs: Customers Summary

- Basic IPv6 configuration
- Define a prefix variable
- Set up the tunnel
- Set up routing
- Set addresses on interfaces

6rd Lab: Wrap Up

- You should now be able to ping all IPv6 nodes
- For example:
  - Border Relay
  - Core router?
  - Your neighbor?

6rd on a Linksys Router



Questions

IP Address Management

15 - Section

Why IP Address Management?

- **How do you currently keep track?**
  - There are many subnets in IPv6
  - Your spreadsheet might not scale
  - And you want to take care of DNS/reverse DNS

- **There are 524288 /48s in a /29**
- **That is 34359738368 /64s!**

Address Management

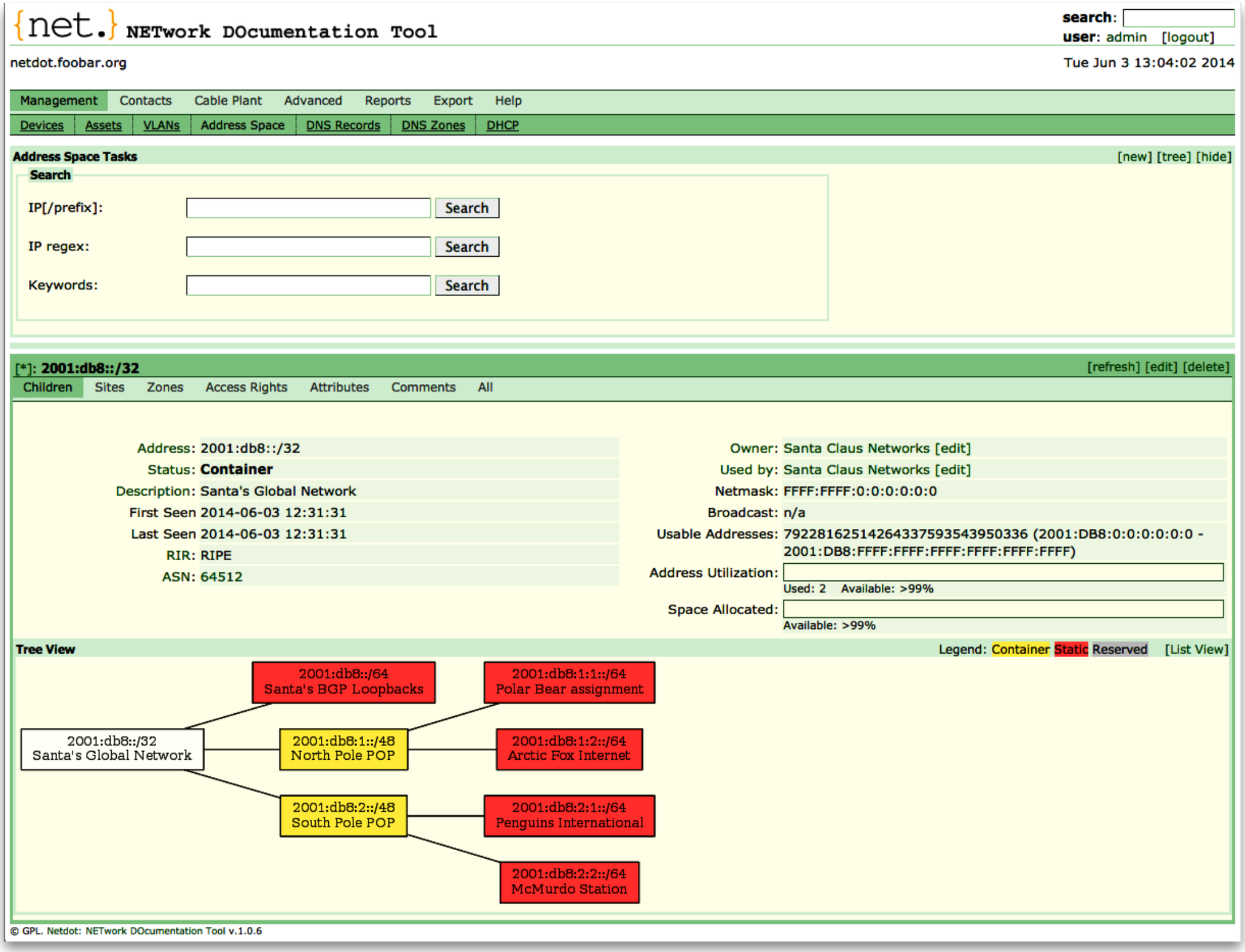
- **There are many open source IPv6 IPAM tools**
  - NetDot
  - GestióIP
  - phpIPAM
  - IPplan
  - NIPAP

- **And of course our own IP Analyser**

NetDot

- Device discovery via SNMP
- DNS and DHCP config management
- MAC address tracking
- BGP and AS Number tracking
- **Export scripts for**
  - Nagios
  - Smokeping
  - Cacti
  - RANCID

NetDot


{net.} NETwork DOcumentation Tool
search:
user: admin [logout]
netdot.foobar.org
Tue Jun 3 13:04:02 2014
Management Contacts Cable Plant Advanced Reports Export Help
Devices Assets VLANs Address Space DNS Records DNS Zones DHCP
Address Space Tasks
[new] [tree] [hide]
Search
IP[/prefix]:
Search
IP regex:
Search
Keywords:
Search
[*]: 2001:db8::/32
[refresh] [edit] [delete]
Children Sites Zones Access Rights Attributes Comments All
Address: 2001:db8::/32
Status: Container
Description: Santa's Global Network
First Seen 2014-06-03 12:31:31
Last Seen 2014-06-03 12:31:31
RIR: RIPE
ASN: 64512
Owner: Santa Claus Networks [edit]
Used by: Santa Claus Networks [edit]
Netmask: FFFF:FFFF:0:0:0:0:0:0
Broadcast: n/a
Usable Addresses: 79228162514264337593543950336 (2001:DB8:0:0:0:0:0:0 - 2001:DB8:FFFF:FFFF:FFFF:FFFF:FFFF:FFFF)
Address Utilization:
Used: 2 Available: >99%
Space Allocated:
Available: >99%
Tree View
Legend: Container Static Reserved [List View]
2001:db8::/32
Santa's Global Network
2001:db8::/64
Santa's BGP Loopbacks
2001:db8:1::/48
North Pole POP
2001:db8:1:1::/64
Polar Bear assignment
2001:db8:1:2::/64
Arctic Fox Internet
2001:db8:2::/48
South Pole POP
2001:db8:2:1::/64
Penguins International
2001:db8:2:2::/64
McMurdo Station
© GPL. Netdot: NETwork DOcumentation Tool v.1.0.6

GestióIP

- Web based IPAM software
- Structure based on Surfnet document
- Shows free ranges
- Incorporated VLAN management system
- **Host discovery via SNMP and DNS**
- **Multi lingual (Russian, Italian, French, Catalan, etc....)**
- **DNS zone file generator for forward and reverse zones**
  - Supporting BIND and tinydns zone files

GestióIP

networks advanced | hosts advanced | show networks | networks | VLANs | lines | import/export | manage | help | GestióIP

networks

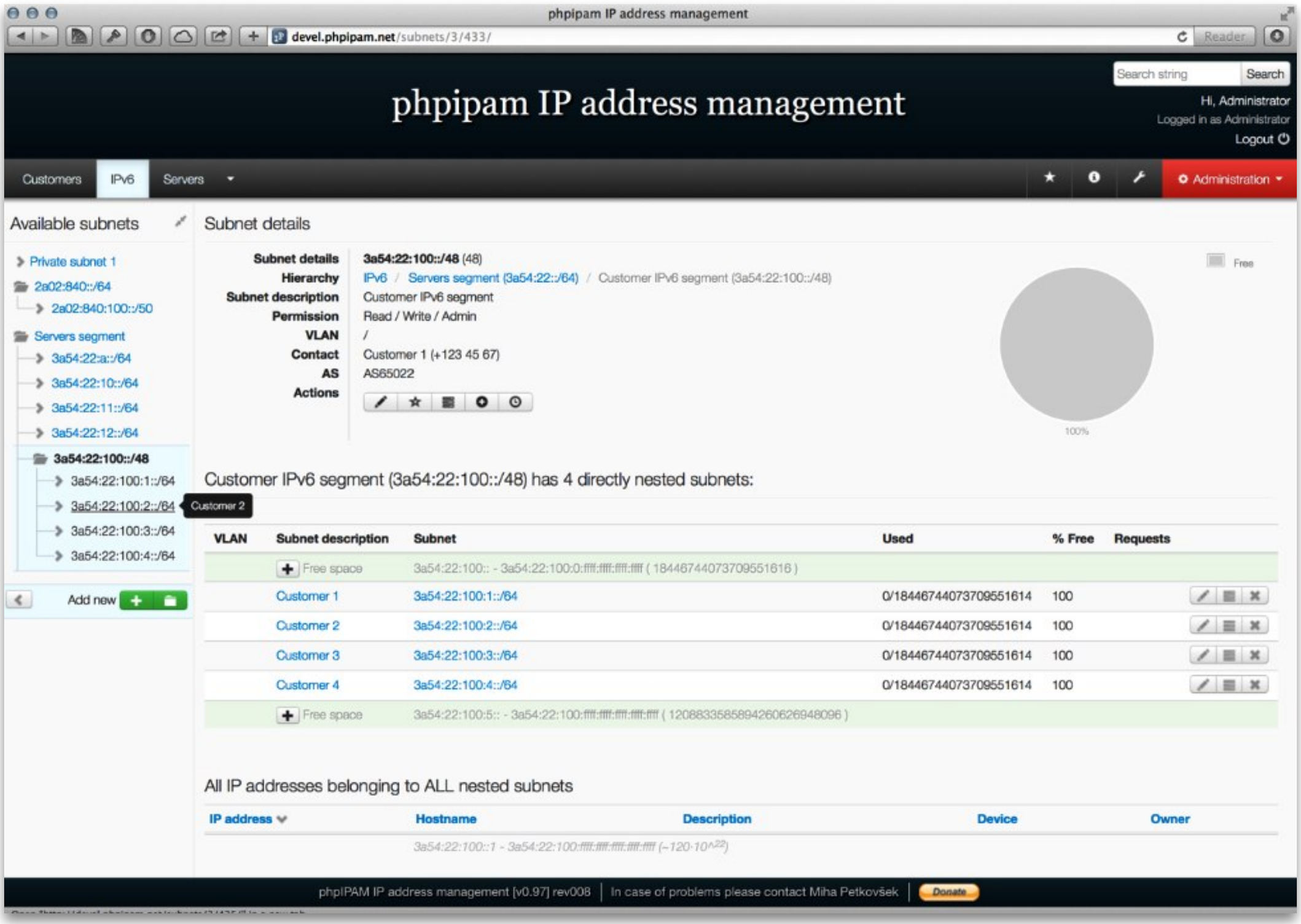
IP version v6 | site | category | show rootnets | show endnets | entries/page 500

network	BM	*	description	site	category	comment	sync	vlan	
2001:db8:12ef::	52			HH1					h i
2001:db8:12ef::	64		frontends I	HH1	prod		x	100 - frontends I	h i
2001:db8:12ef:1::	64		frontends II	HH1	prod	new frontends	x	371 - frontends II	h i
2001:db8:12ef:2::	64		backends	HH1	prod		x	114 - backends	h i
2001:db8:12ef:3::	64		sync LBs	HH1	prod				h i
2001:db8:12ef:4::	64		sync FWs	HH1	prod				h i
2001:db8:12ef:5::	64		management network devices	HH1	prod			400 - management pro	h i
2001:db8:12ef:6::	64		backup	HH1	prod			121 - backup pro	h i
2001:db8:12ef:7::	64		admins	HH1	corp				h i
2001:db8:12ef:8::	64		developers	HH1	corp				h i
2001:db8:12ef:9::	64		Virt	HH1	prod	Pool virtual addesses		125 - virt pro	h i
2001:db8:12ef:1000::	52			HH2					h i
2001:db8:12ef:1000::	64		frontends	HH2	pre		x	601 - frontends pre	h i
2001:db8:12ef:1001::	64		backends	HH2	pre		x	602 - backends pre	h i
2001:db8:12ef:1002::	64		management pre	HH2	pre			607 - management pre	h i
2001:db8:12ef:1003::	64		backup	HH2	pre			610 - backup pre	h i
2001:db8:12ef:1004::	64		virt pre	HH2	pre			688 - virt pre	h i
2001:db8:12ef:1005::	64		frontends	HH2	dev		x	901 - frontends dev	h i
2001:db8:12ef:1006::	64		backends	HH2	dev		x	902 - backends dev	h i
2001:db8:12ef:1007::	64		admins	HH2	corp				h i

phpIPAM

- **AJAX based using jQuery libraries**
  - PHP script, javascript and some HTML5/CSS3
  - Modern browser is preferred
- **E-mail notifications**
- **Displays free ranges and numbers of clients**
- **Import and export to XLS files**
- **Can pull info from the RIPE DB**
- **Does not update DNS server**

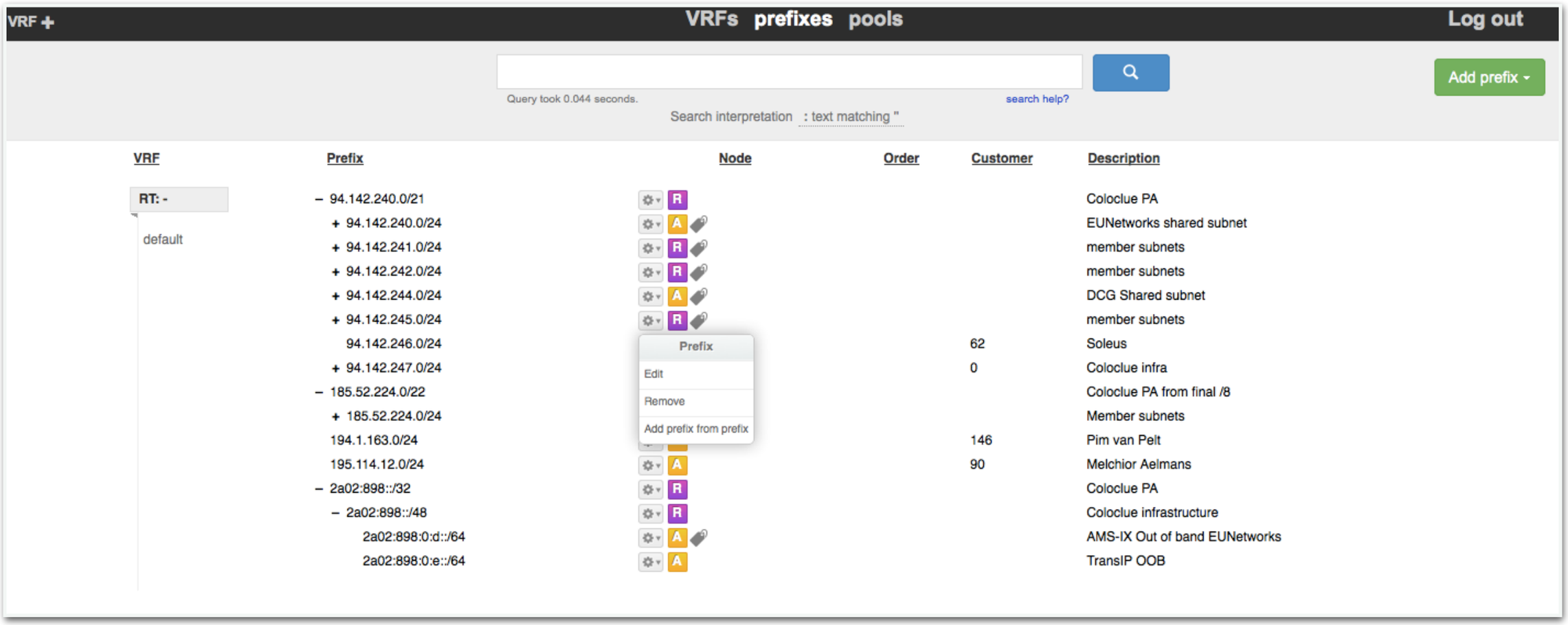
phpIPAM


phpipam IP address management
devel.phpipam.net/subnets/3/433/
Reader
phpipam IP address management
Search string
Search
Hi, Administrator
Logged in as Administrator
Logout
Customers
IPv6
Servers
Administration
Available subnets
Private subnet 1
2a02:840::/64
2a02:840:100::/50
Servers segment
3a54:22:a::/64
3a54:22:10::/64
3a54:22:11::/64
3a54:22:12::/64
3a54:22:100::/48
3a54:22:100:1::/64
3a54:22:100:2::/64
Customer 2
3a54:22:100:3::/64
3a54:22:100:4::/64
Add new
Subnet details
Subnet details
3a54:22:100::/48 (48)
Hierarchy
IPv6 / Servers segment (3a54:22::/64) / Customer IPv6 segment (3a54:22:100::/48)
Subnet description
Customer IPv6 segment
Permission
Read / Write / Admin
VLAN
/
Contact
Customer 1 (+123 45 67)
AS
AS65022
Actions
Free
100%
Customer IPv6 segment (3a54:22:100::/48) has 4 directly nested subnets:
VLAN
Subnet description
Subnet
Used
% Free
Requests
Free space
3a54:22:100:: - 3a54:22:100:0:ffff:ffff:ffff:ffff (18446744073709551616)
Customer 1
3a54:22:100:1::/64
0/18446744073709551614
100
Customer 2
3a54:22:100:2::/64
0/18446744073709551614
100
Customer 3
3a54:22:100:3::/64
0/18446744073709551614
100
Customer 4
3a54:22:100:4::/64
0/18446744073709551614
100
Free space
3a54:22:100:5:: - 3a54:22:100:ffff:ffff:ffff:ffff:ffff (1208833585894260626948096)
All IP addresses belonging to ALL nested subnets
IP address
Hostname
Description
Device
Owner
3a54:22:100::1 - 3a54:22:100:ffff:ffff:ffff:ffff:ffff (~120·10^22)
phpIPAM IP address management [v0.97] rev008
In case of problems please contact Miha Petkovšek
Donate

NIPAP

- Written in Python
- Web and CLI
- Integrated audit log
- IP request system
- **XML-RPC middleware**
  - Easy integration with other applications

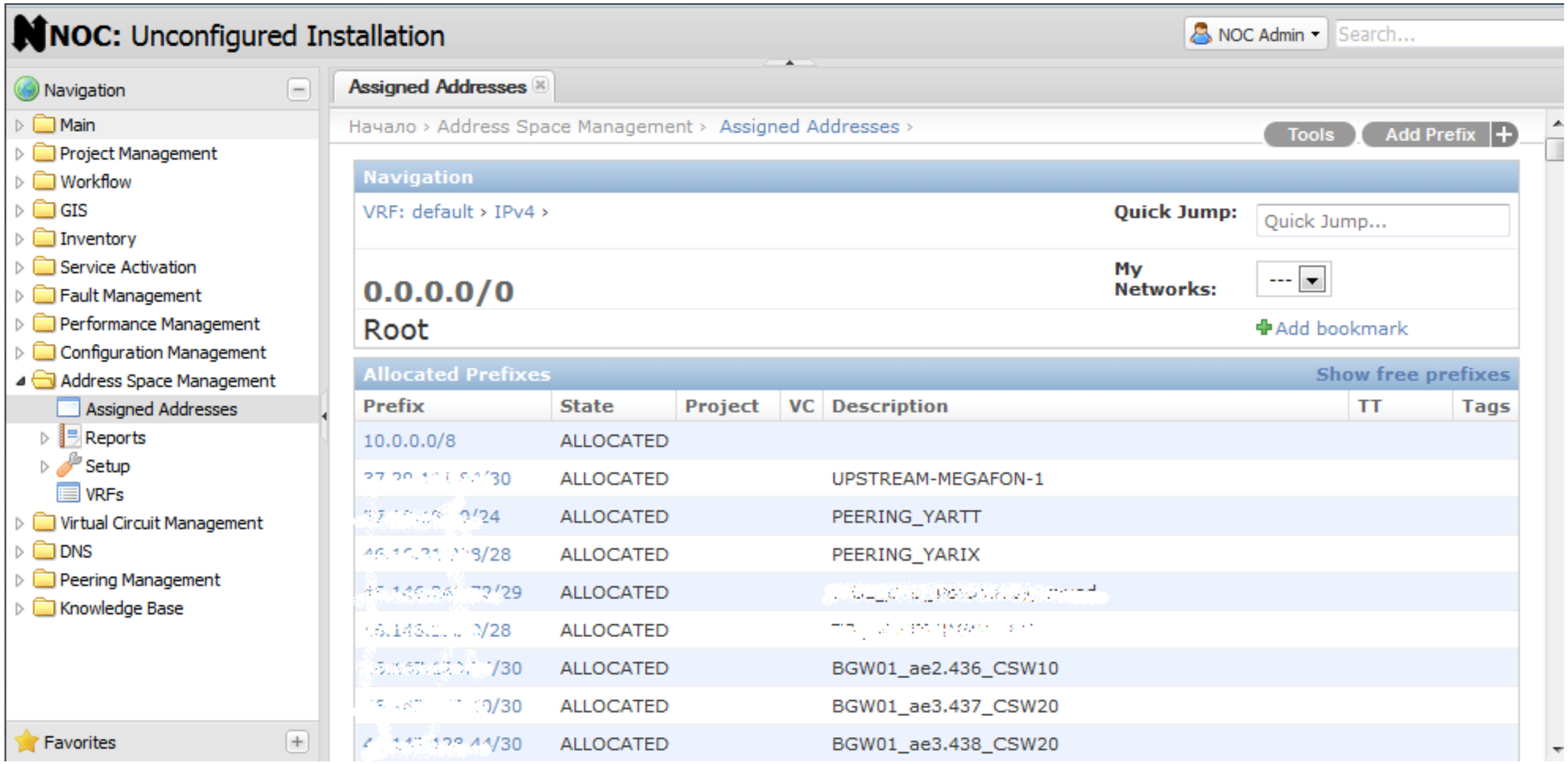
NIPAP


VRF +
VRFs prefixes pools
Log out
Query took 0.044 seconds.
search help?
Search interpretation : text matching ''
Add prefix
VRF
Prefix
Node
Order
Customer
Description
RT: -
default
– 94.142.240.0/21
+ 94.142.240.0/24
+ 94.142.241.0/24
+ 94.142.242.0/24
+ 94.142.244.0/24
+ 94.142.245.0/24
94.142.246.0/24
+ 94.142.247.0/24
– 185.52.224.0/22
+ 185.52.224.0/24
194.1.163.0/24
195.114.12.0/24
– 2a02:898::/32
– 2a02:898::/48
2a02:898:0:d::/64
2a02:898:0:e::/64
Prefix
Edit
Remove
Add prefix from prefix
Coloclue PA
EUNetworks shared subnet
member subnets
member subnets
DCG Shared subnet
member subnets
62
Soleus
0
Coloclue infra
Coloclue PA from final /8
Member subnets
146
Pim van Pelt
90
Melchior Aelmans
Coloclue PA
Coloclue infrastructure
AMS-IX Out of band EUNetworks
TransIP OOB

NOC Project

- BSD licensed
- Complete OSS system
- Clean web interface
- DNS integration
- Reporting tools
- Quick view options (free space)
- Hierarchical user groups
- Large developer team

NOC Project

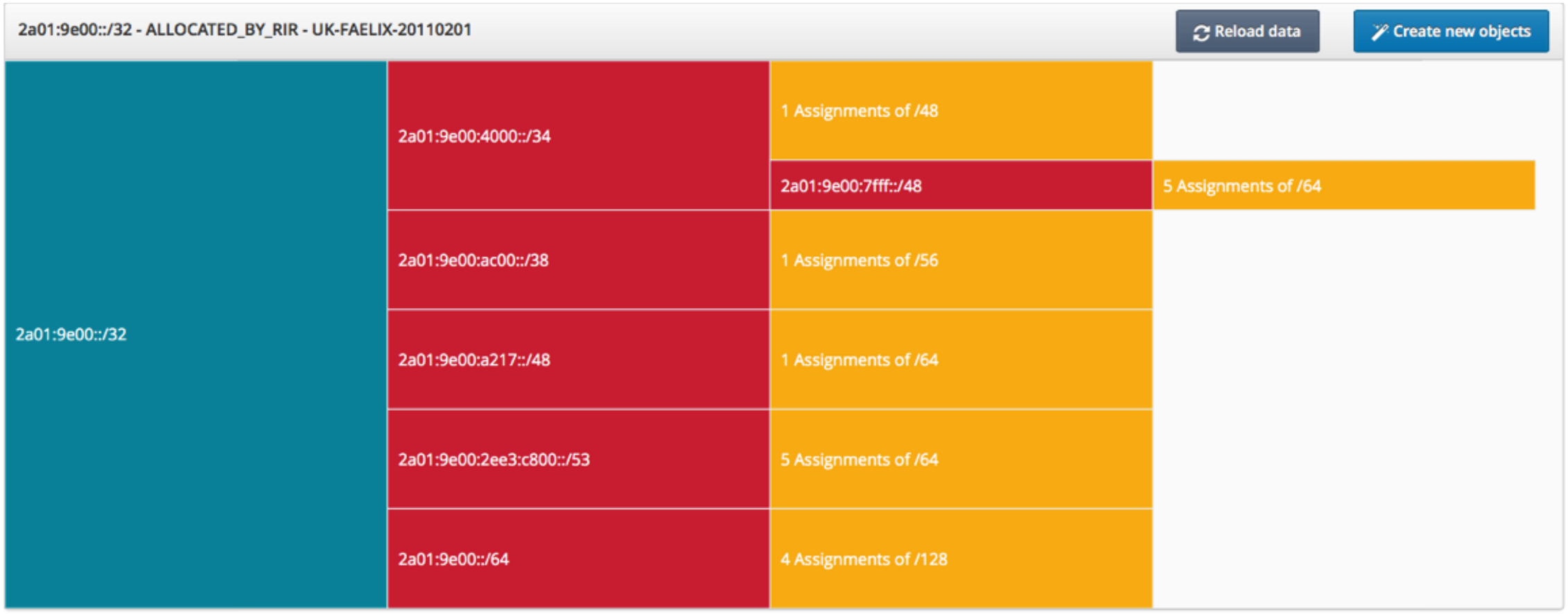

NOC: Unconfigured Installation
NOC Admin
Search...
Navigation
Main
Project Management
Workflow
GIS
Inventory
Service Activation
Fault Management
Performance Management
Configuration Management
Address Space Management
Assigned Addresses
Reports
Setup
VRFs
Virtual Circuit Management
DNS
Peering Management
Knowledge Base
Favorites
Assigned Addresses
Начало › Address Space Management › Assigned Addresses ›
Tools
Add Prefix
Navigation
VRF: default › IPv4 ›
Quick Jump:
Quick Jump...
My Networks:

0.0.0.0/0
Root
Add bookmark
Allocated Prefixes
Show free prefixes
Prefix
State
Project
VC
Description
TT
Tags
10.0.0.0/8 ALLOCATED
30 ALLOCATED UPSTREAM-MEGAFON-1
24 ALLOCATED PEERING_YARTT
8/28 ALLOCATED PEERING_YARIX
72/29 ALLOCATED
0/28 ALLOCATED
7/30 ALLOCATED BGW01_ae2.436_CSW10
0/30 ALLOCATED BGW01_ae3.437_CSW20
44/30 ALLOCATED BGW01_ae3.438_CSW20

IP Analyser

- **Available through the LIR Portal**
- **Get a visual insight into your RIPE Database objects**
  - Hierarchical view of **used** address space
- **Create new objects using an easy to use wizard**
  - Interface seamlessly with the RIPE Database
  - Explain the different options well
  - Use sensible defaults
  - Delete redundant objects directly from the UI

IP Analyser



More specific inet6nums

Filter on range...

inet6num	Status	Date	Size	AsgSize	Netname	
2a01:9e00:4000::/34	ALLOCATED_BY_LIR	03-02-2011	/34		UK-FAELIX-CUSTOMER	
2a01:9e00:ac00::/38	ALLOCATED_BY_LIR	04-02-2011	/38		UK-FAELIX-TUNNEL	
2a01:9e00:a217::/48	ALLOCATED_BY_LIR	03-02-2011	/48		UK-FAELIX-FAELIX	
2a01:9e00:7fff::/48	ALLOCATED_BY_LIR	23-06-2012	/48		UK-FAELIX-CROSSCONNECT	

Questions

Tips and Tools

16 - Section

RIPE NCC
Academy

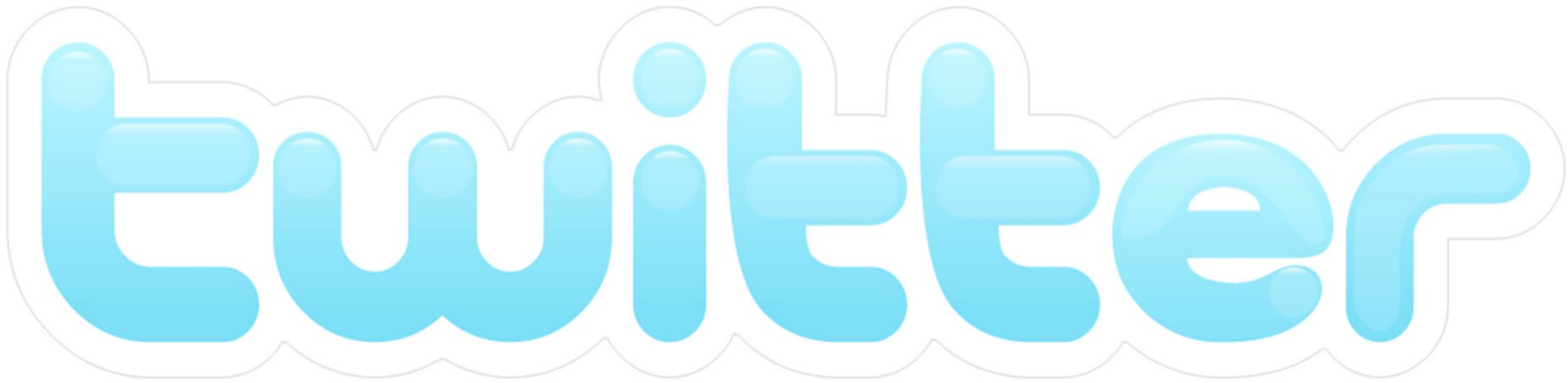
Graduate to the next level!

http://academy.ripe.net

Feedback!

https://www.ripe.net/lir-services/training/courses/advanced-ipv6/feedback-2016

Follow us!



@TrainingRIPENCC

Questions

The End!

Край

Y Diwedd

Fí

Finis

النهاية

Соңы

Վերջ

Liðugt

Ende

Finvezh

Кінець

Konec

Kraj

Ënn

Fund

پایان

Kpaj

Lõpp

Beigas

Vége

Son

An Críoch

הסוף

Endir

Fine

Sfârşit

Fin

Τέλος

Einde

Конец

Slut

Slutt

დასასრული

Pabaiga

Tmiem

Koniec

Fim

Amaia

Loppu