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BGP Security Webinars

Internet Routing Registry

Webinar

RIPE NCC Learning & Development



**This session is
being recorded**

Agenda



- Introduction to Internet Routing Registry
- BGP Routing Policy and RPSL
- Tools and Automation
- Limitations of the IRR System

Take the poll!

What is the **Internet Routing Registry** (IRR)?



2 min.



Introduction to the Internet Routing Registry

Section 1



What is the IRR system?

- IRR - the Internet Routing Registry
- Public routing policy databases
 - Used to register routing information
 - Declaration of BGP announcements, connected peers and routing policies
- Many IRR databases exist
 - Mostly **mirroring** each other
 - RIPE, APNIC, RADB, JPIRR, Level3, NTTCom, among others

<https://irr.net>

Why register routing information?



Is that ASN authorised to **originate** that address range?



Why register routing information?



Document your routing policy

- Associate network prefixes with an **origin AS**



Helps to filter unauthorised announcements

- **Mitigates** route hijacks and denial of service



Many transit providers and IXPs **require** it

- They build their filters based on the Routing Registry



IRRs support routing security!

- Improve stability and consistency of routing
- Provide a global view of routing policies
- Automation of creating BGP filters
- Network troubleshooting

Routing Registry Objects



route

aut-num

route6

inet-rtr

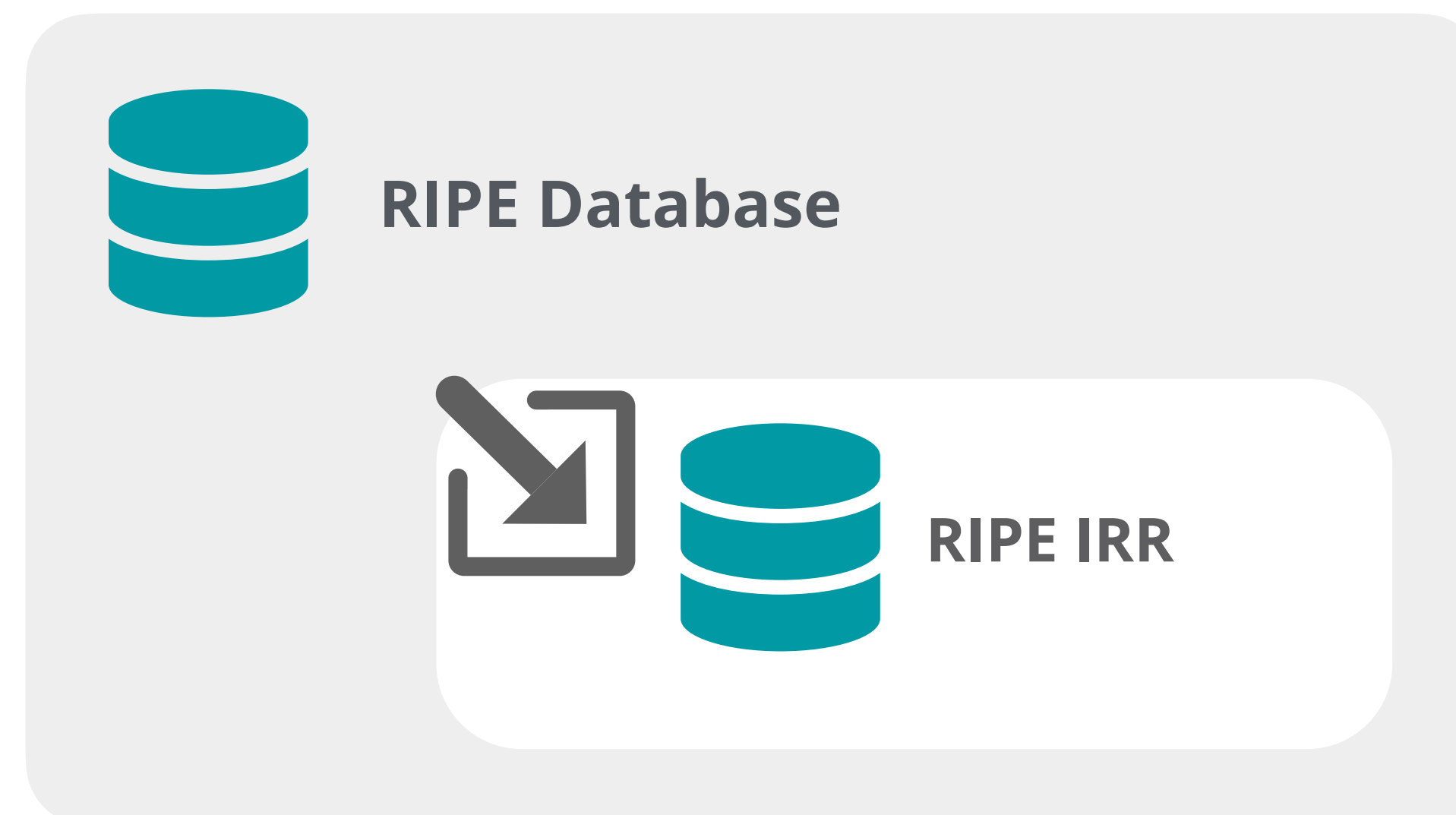
Set Objects





The RIPE Routing Registry

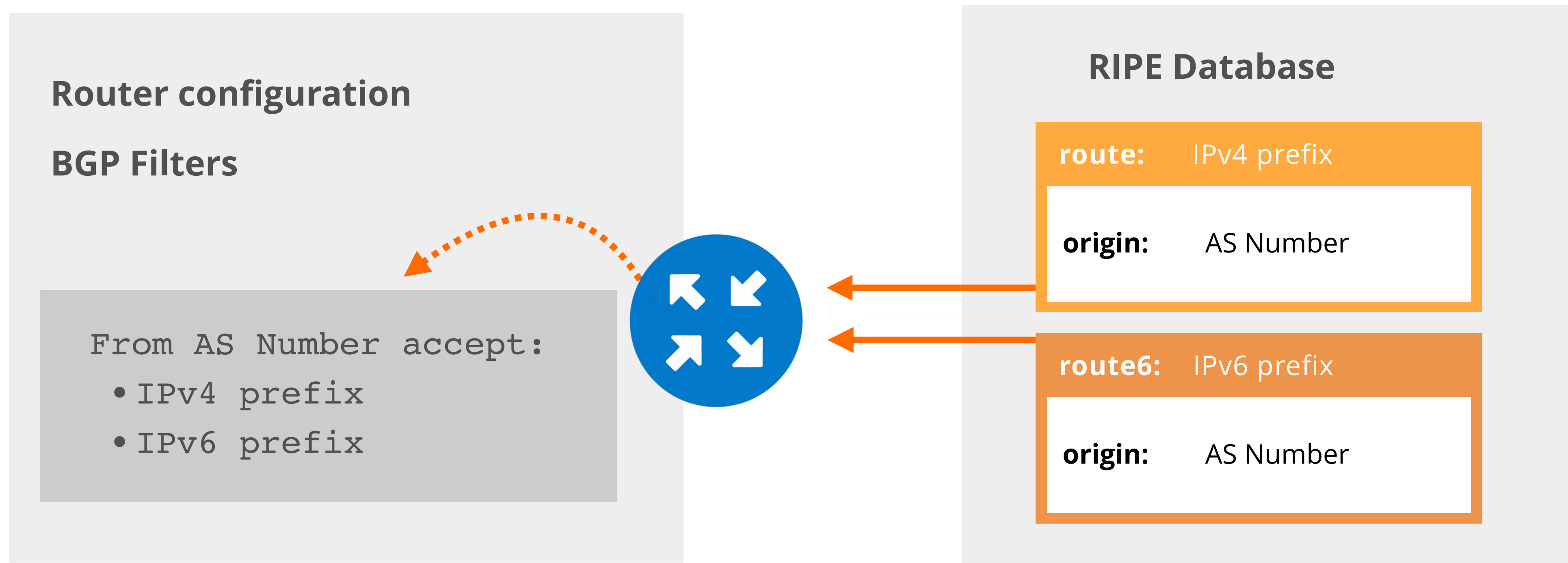
- The RIPE IRR is a subset of the RIPE Database
- Used for registering **routing policy information**
- Includes several objects
 - **route(6), aut-num, filter-set, route-set, ...**
- The RIPE Routing Registry is a part of the global IRR system





ROUTE(6) objects

- Contains routing information for IPv4/IPv6 address space
- **Specifies from which AS a certain prefix may be originated**
- Used for creating BGP filters





Authorisation rules for ROUTE(6) objects

- You need permission from:
 1. **inetnum** or **inet6num** objects
 2. **route** or **route6** objects

1

Allocation

mnt-by: RIPE-NCC-HM-MNT
mnt-by: DEFAULT-LIR-MNT
mnt-routes: ANOTHER-MNT

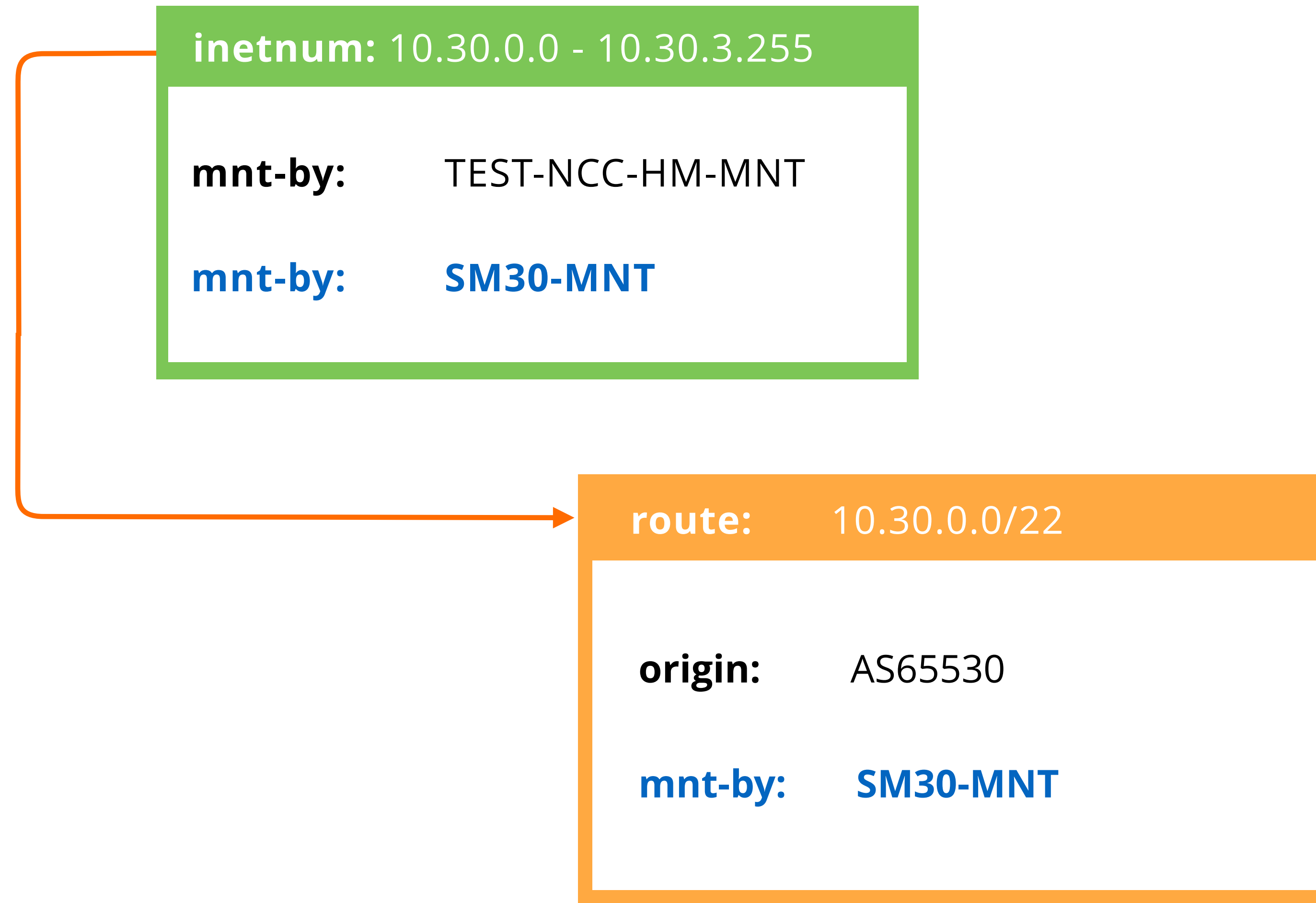
2

route(6)

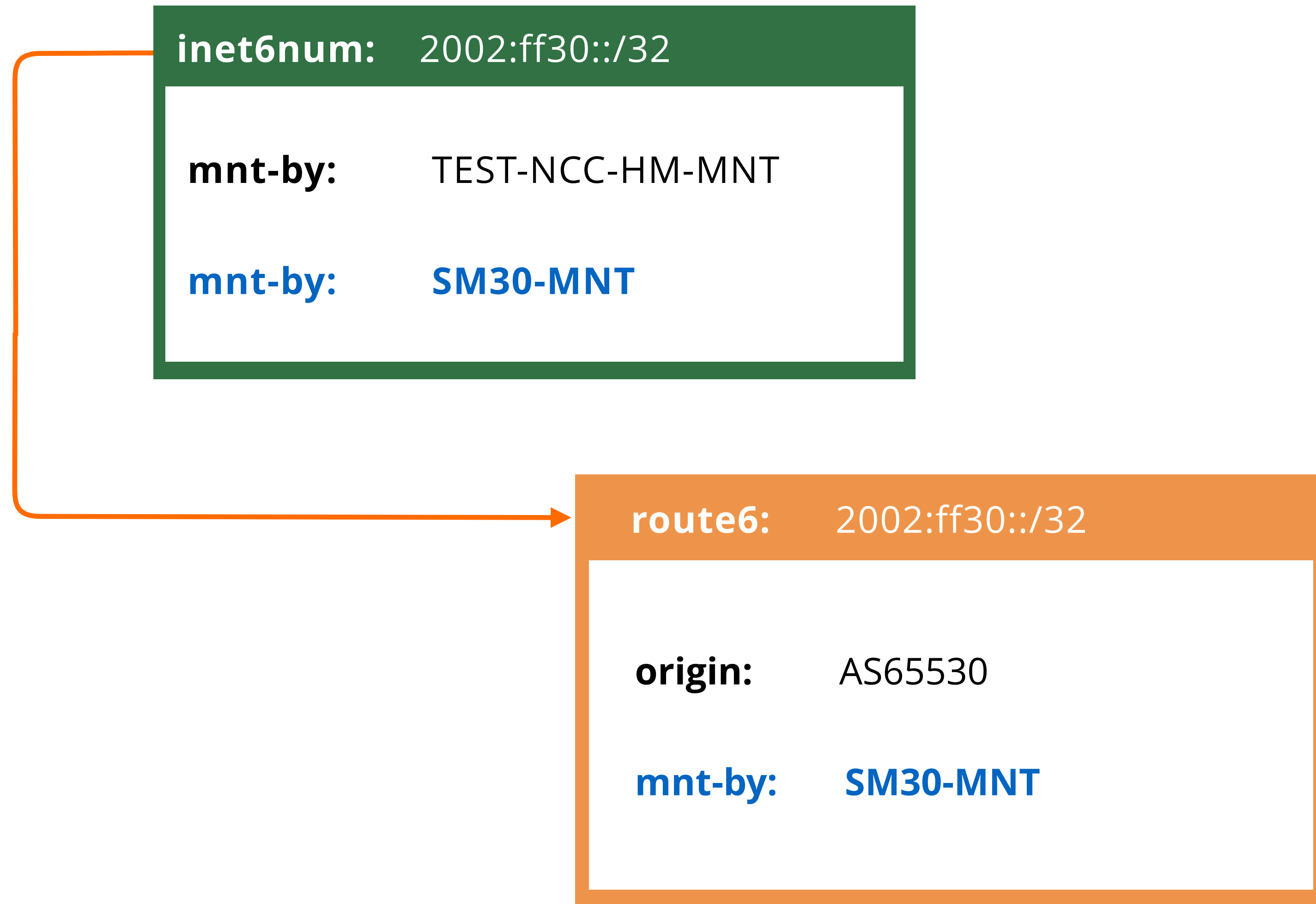
origin: AS12345
mnt-by: ANOTHER-MNT

* **mnt-routes** delegates the creation of **route(6)** objects

Registering IPv4 Routes



Registering IPv6 Routes



Take the poll!

What would happen if your **route(6)** objects were deleted?



2 min.

AUT-NUM



aut-num: AS12345

```
as-name: YOUR-AS-NAME
org:     ORG-EE2-RIPE
import:  from AS1010 accept ANY
export:  to AS1010 announce AS12345
import:  from AS987 accept ANY
export:  to AS987 announce AS12345
admin-c: DV789-RIPE
tech-c:  JS123-RIPE
status:  ASSIGNED
mnt-by:  RIPE-NCC-END-MNT
mnt-by:  DEFAULT-LIR-MNT
source:  RIPE
```

Registers **who** holds that AS Number

Defines the routing policy for an AS

- **Import** - specifies which routes you accept
- **Export** - specifies which routes you announce

Set Objects

- Objects can be grouped in sets
 - **as-set** : Defines a set of aut-num objects
 - **route-set** : Defines a set of routes
 - **filter-set** : Defines a set of routes that will be filtered
 - **rtr-set** : Defines a set of routers
 - **peering-set** : Defines a set of peerings

as-set: AS65530:AS-EXAMPLE

members: AS1

members: AS2, AS3, AS4

admin-c: JD1-RIPE

mnt-by: LIR-MNT

route-set: RS-EXAMPLE

members: 98.32.162.0/24

members: 128.223.0.0/16

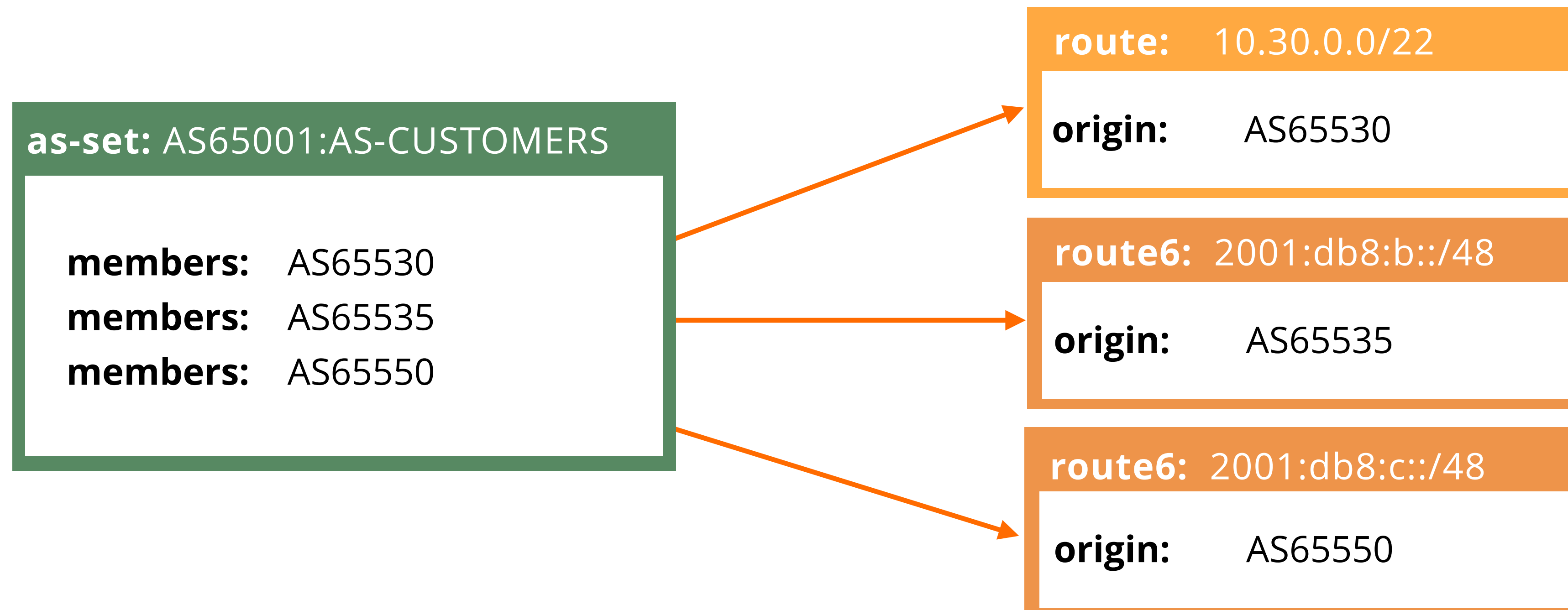
admin-c: JD1-RIPE

mnt-by: LIR-MNT

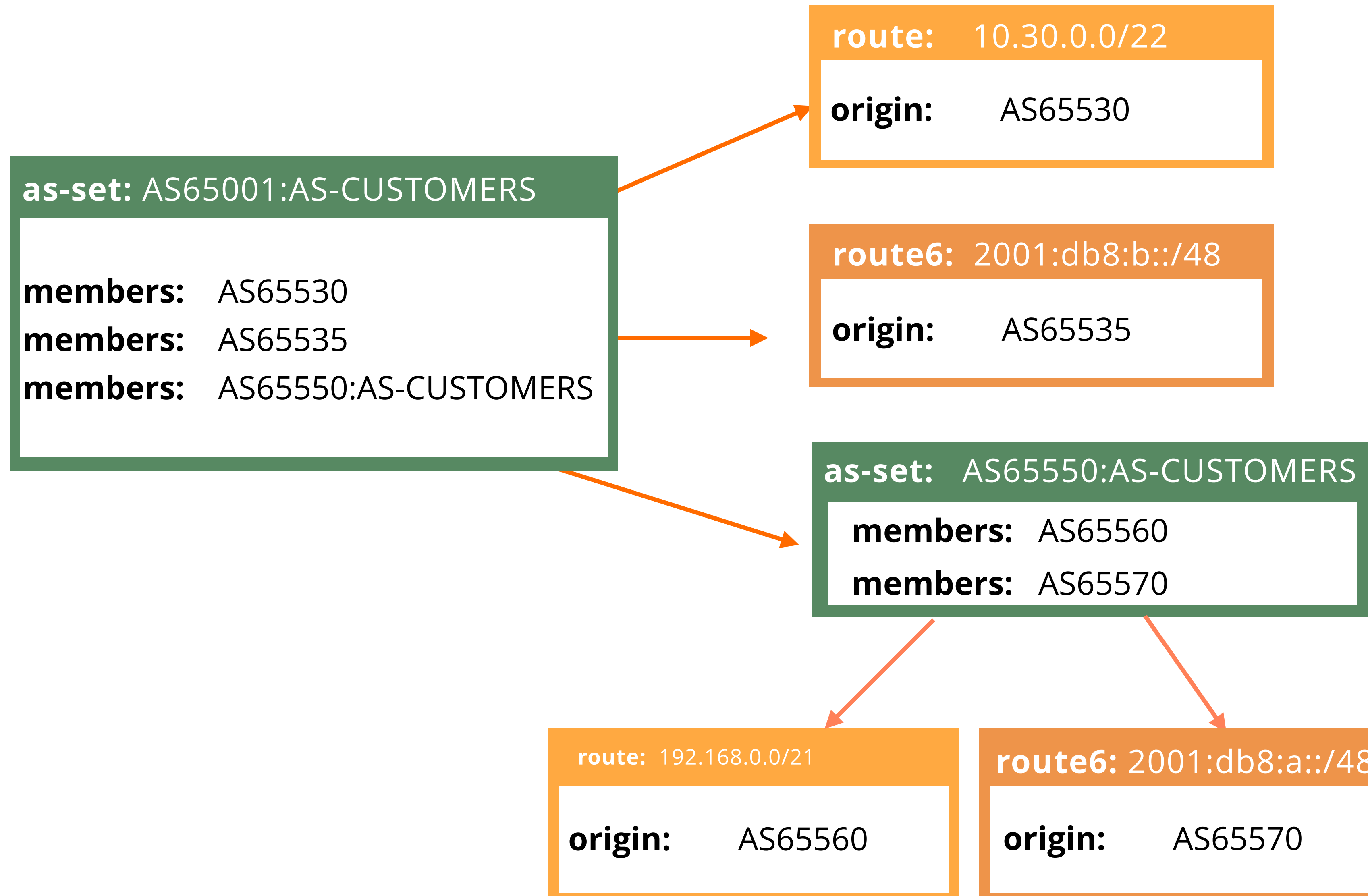
AS-SET



- Existing as-set names
 - can be short (AS-TEST) or hierarchical (AS33333:AS-TEST)
- It is now mandatory to use hierarchical names
 - Creation of the object is authorised by the ASN holder



AS-SET



ROUTE-SET



- Name must begin with “rs-”
- Defines a set of prefixes
 - The members are prefixes or other route sets

```
route-set: rs-martians
```

```
descr: routes not accepted from any peer
```

```
members: 0.0.0.0/0, # default route  
0.0.0.0/0^32, # host routes  
224.0.0.0/3^+, # multicast routes  
127.0.0.0/8^9-32, . . .
```

FILTER-SET



- Name must begin with “**fltr-**”
- Set of routes that will be filtered

```
filter-set : fltr-martian
```

```
descr:      Special use and reserved IPv4 prefixes.
```

```
filter:    { 0.0.0.0/8^+,  
                10.0.0.0/8^+,100.64.0.0/10^+,  
                127.0.0.0/8^+ , 169.254.0.0/16^+ ,  
                172.16.0.0/12^+ , 192.0.0.0/24^+,
```

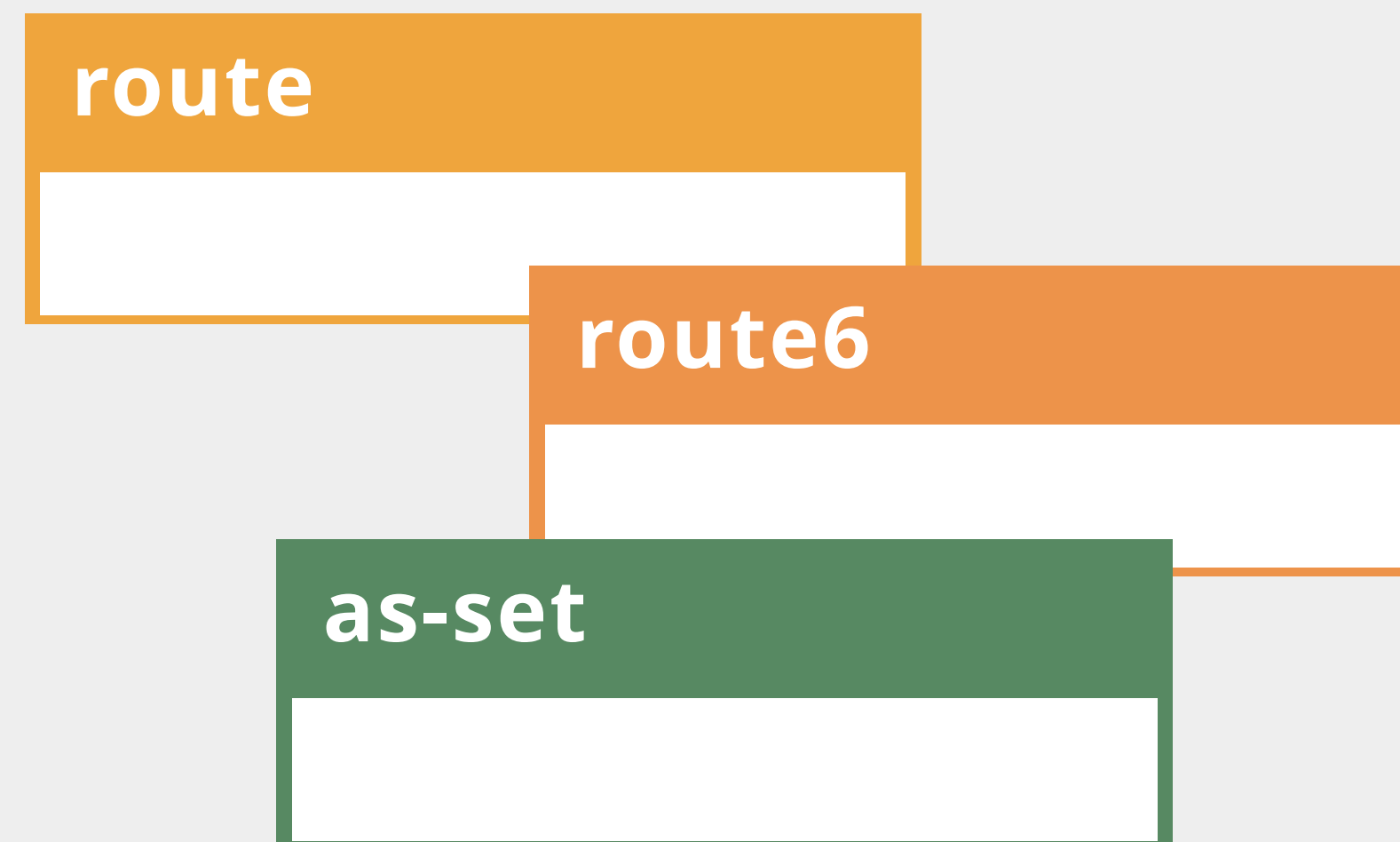


Demo Time!

Let's create RIPE Database objects!



- A **route** object
- A **route6** object
- An **as-set** object





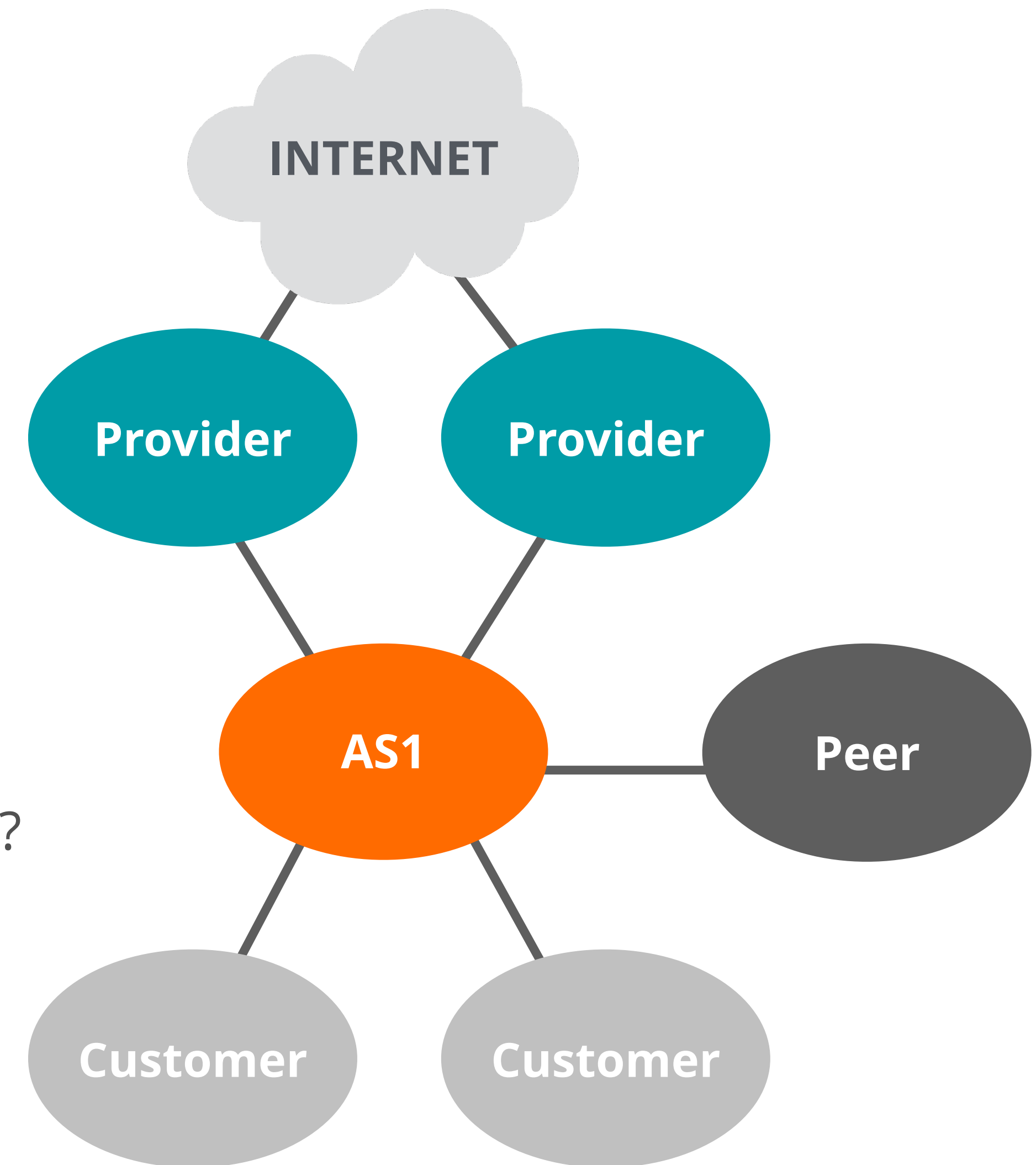
BGP Routing Policy and RPSL

Section 2



What is a Routing Policy?

- Who are your BGP peers? Which ASes?
 - Customer, Provider, Peer
- What is your BGP relationship with them?
 - Customer, Provider, Peer
- What are your routing decisions?
 - Which prefixes to accept?
 - Which prefixes to announce?
 - Which prefixes will be preferred in case of multiple routes?



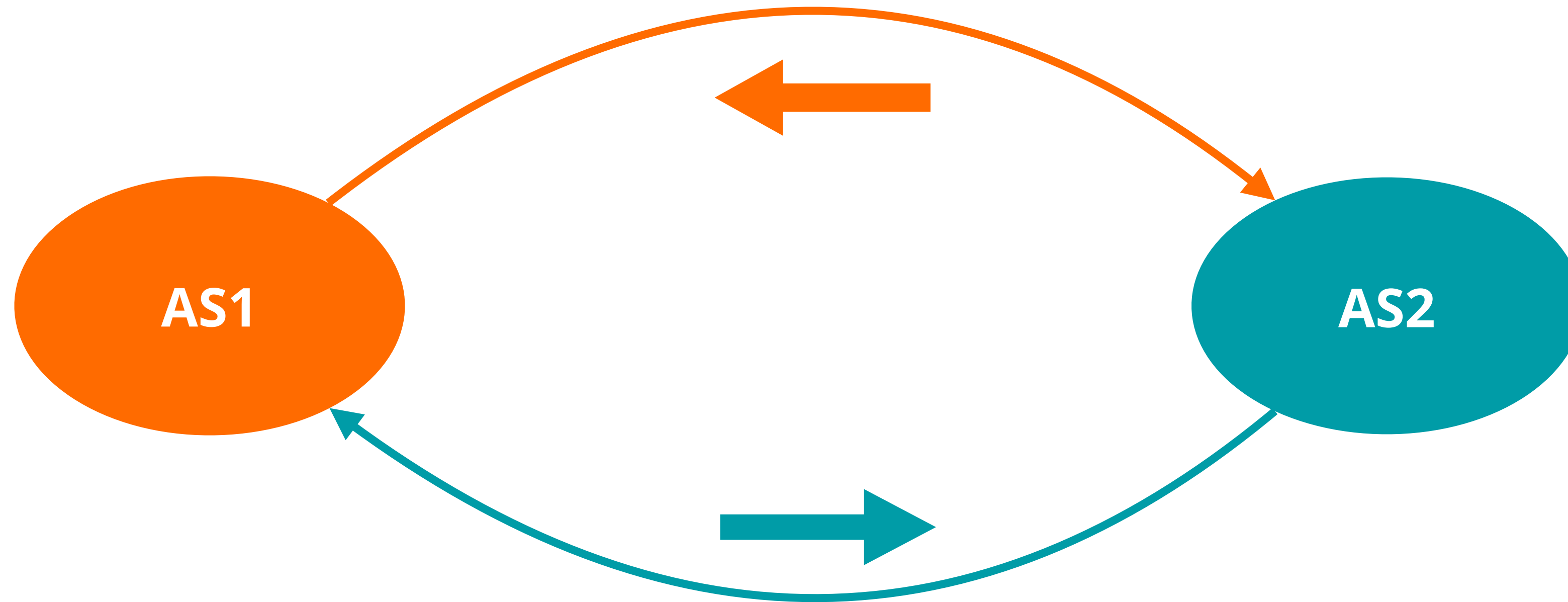


IRRs use RPSL Language

- **RPSL - Routing Policy Specification Language**
- Allows network operators to specify their routing policies
 - Generic way to describe BGP configuration in the IRR
 - Not vendor-specific
- Originated from a RIPE Document (RIPE-181)
- Can be translated into router configuration

RFC 2622 - Routing Policy Specification Language
RFC 2650 - Using RPSL in Practice

Defining Routing Policy in RPSL

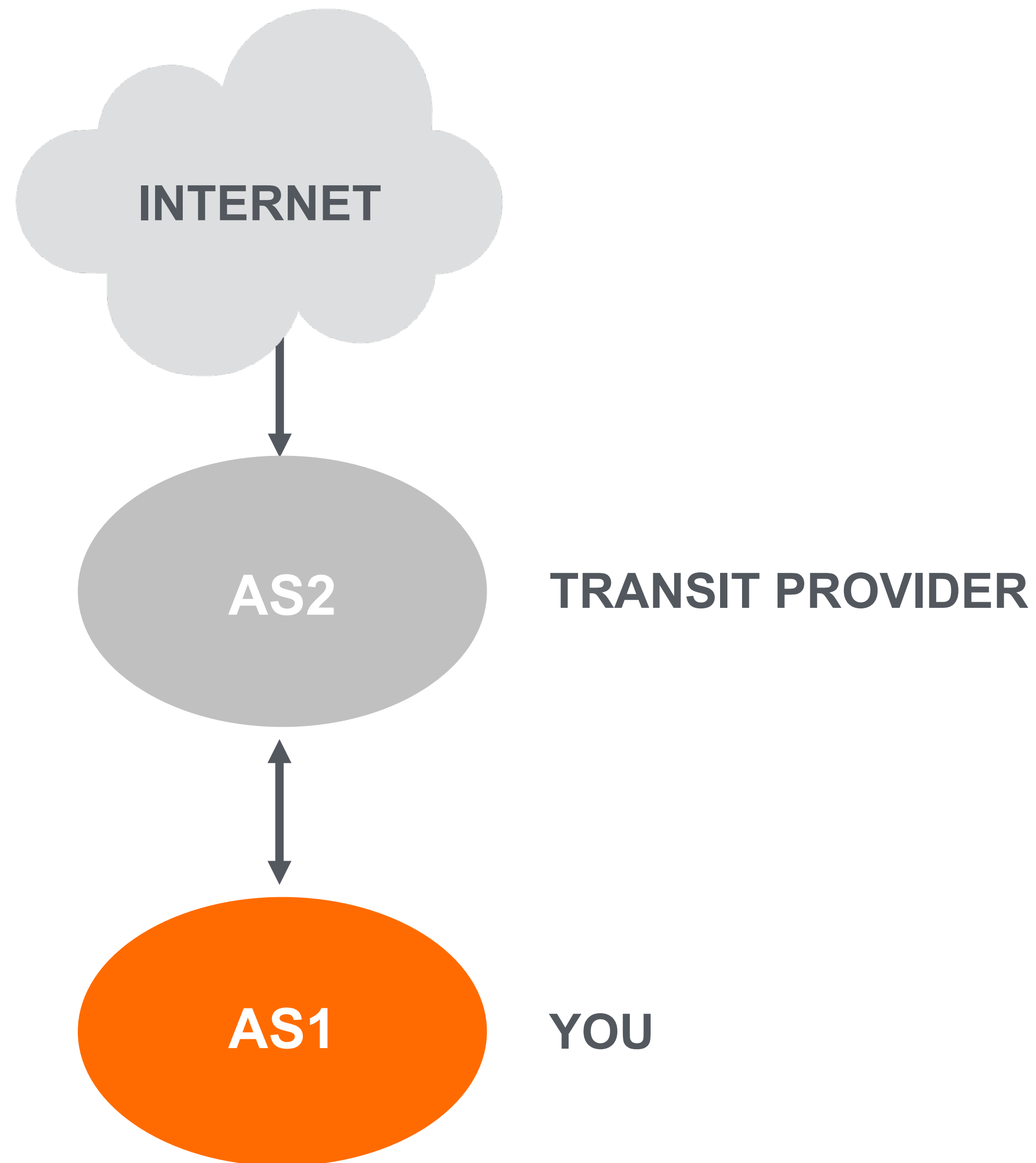


```
aut-num: AS1
```

```
import: from AS2 accept AS2
```

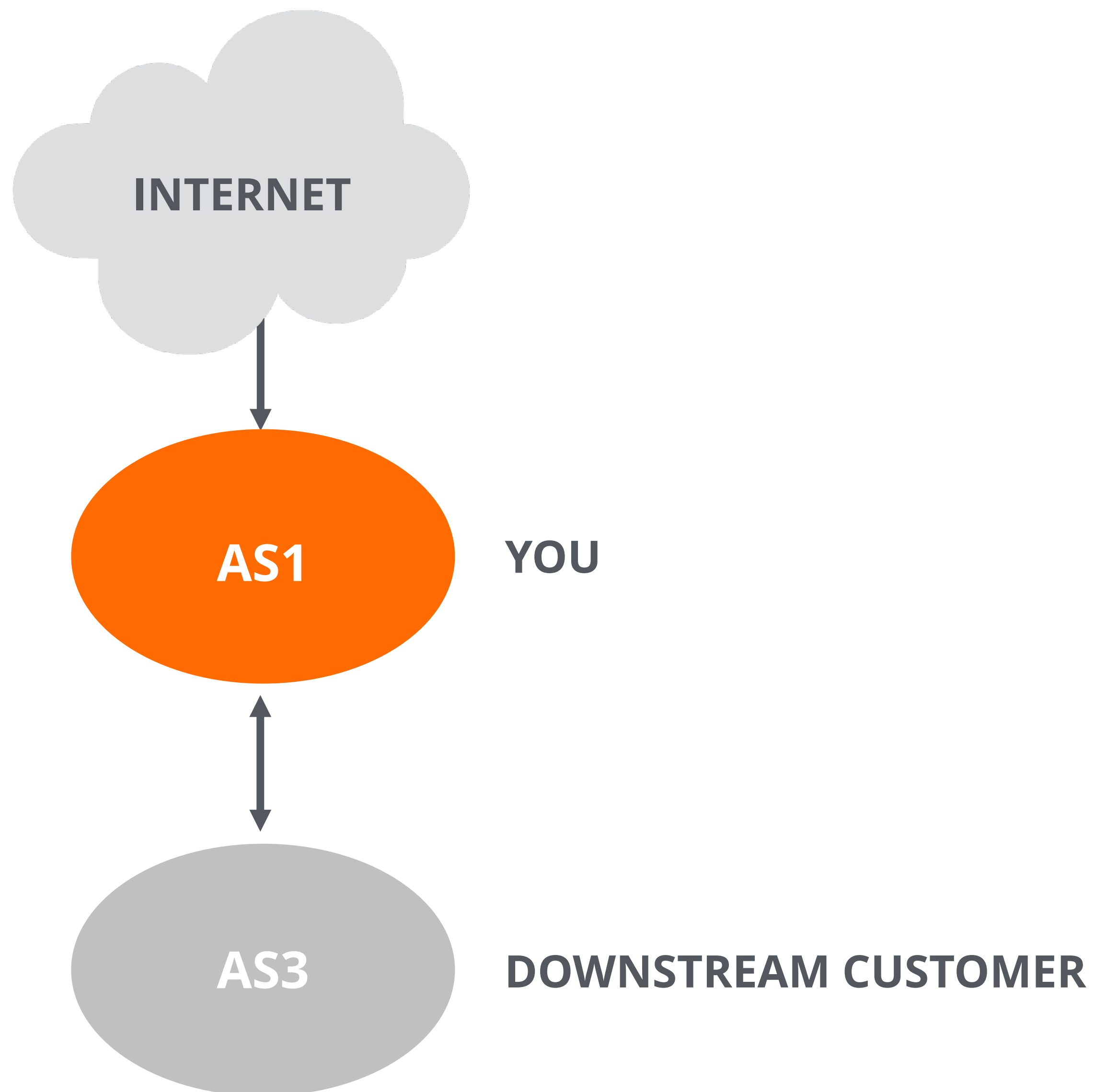
```
export: to AS2 announce AS1
```

Routing Policy with Transit



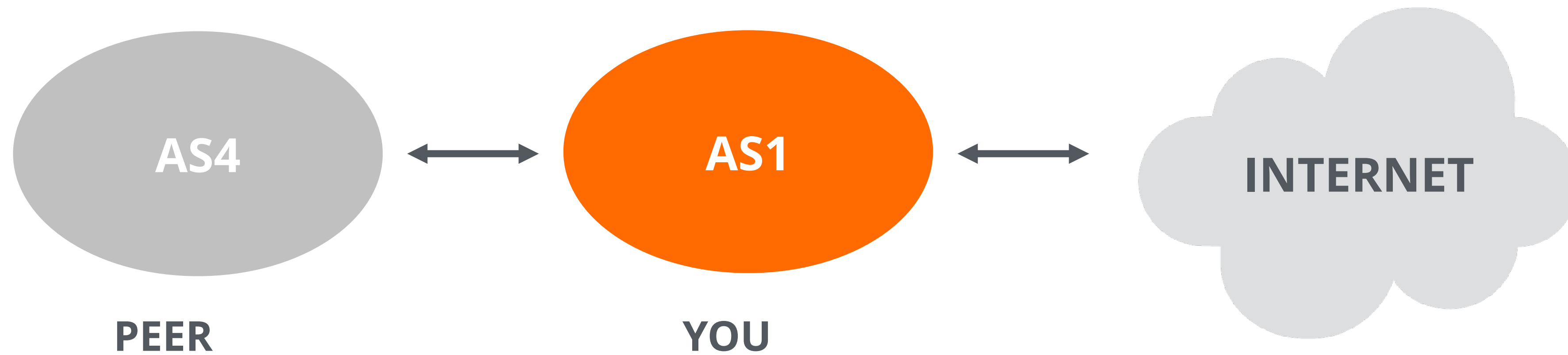
```
aut-num: AS1
import: from AS2 accept ANY
export: to AS2 announce AS1
```

Routing Policy with Customers



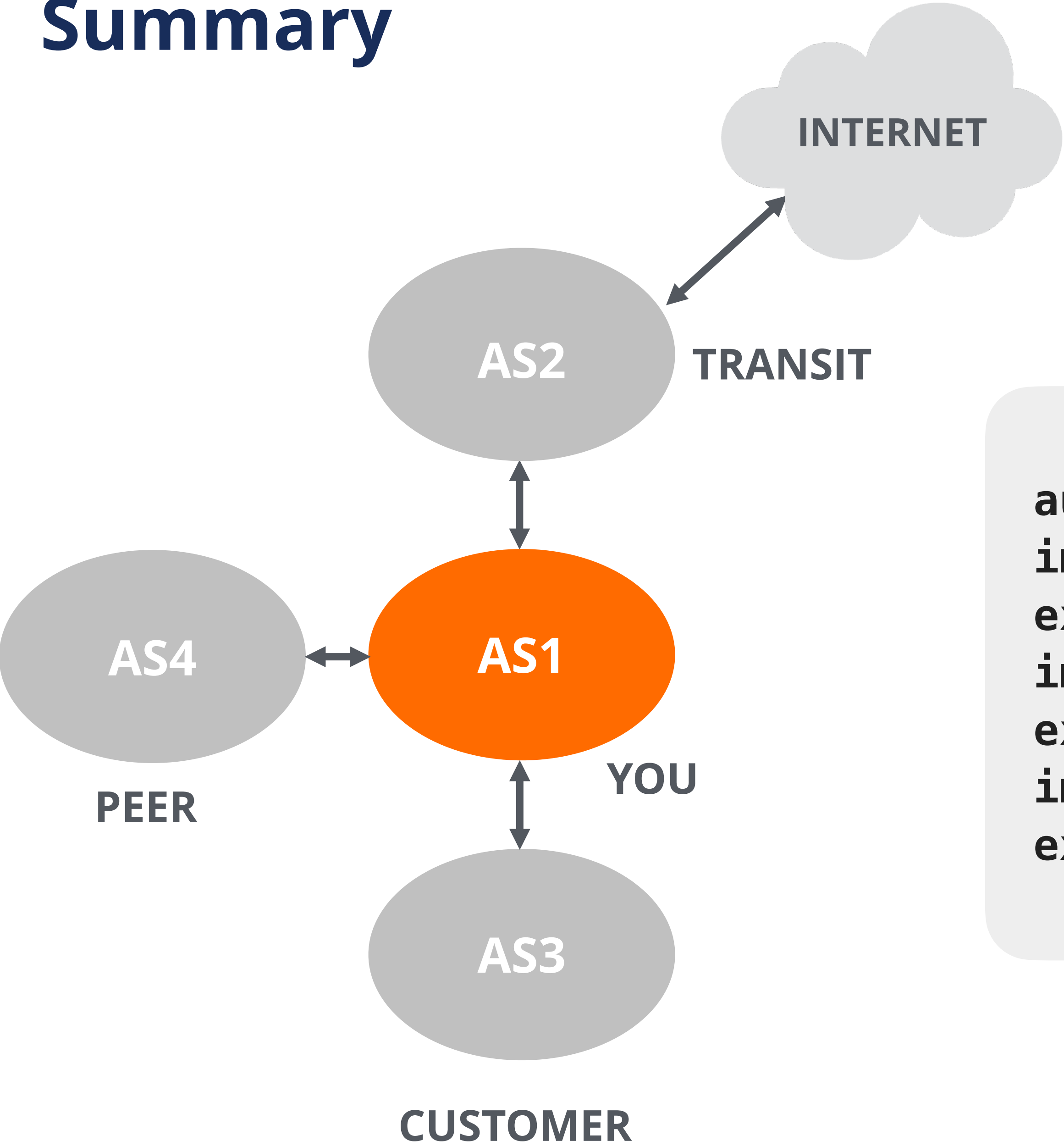
```
aut-num: AS1
import: from AS3 accept AS3
export: to AS3 announce ANY
```

Routing Policy with Peers



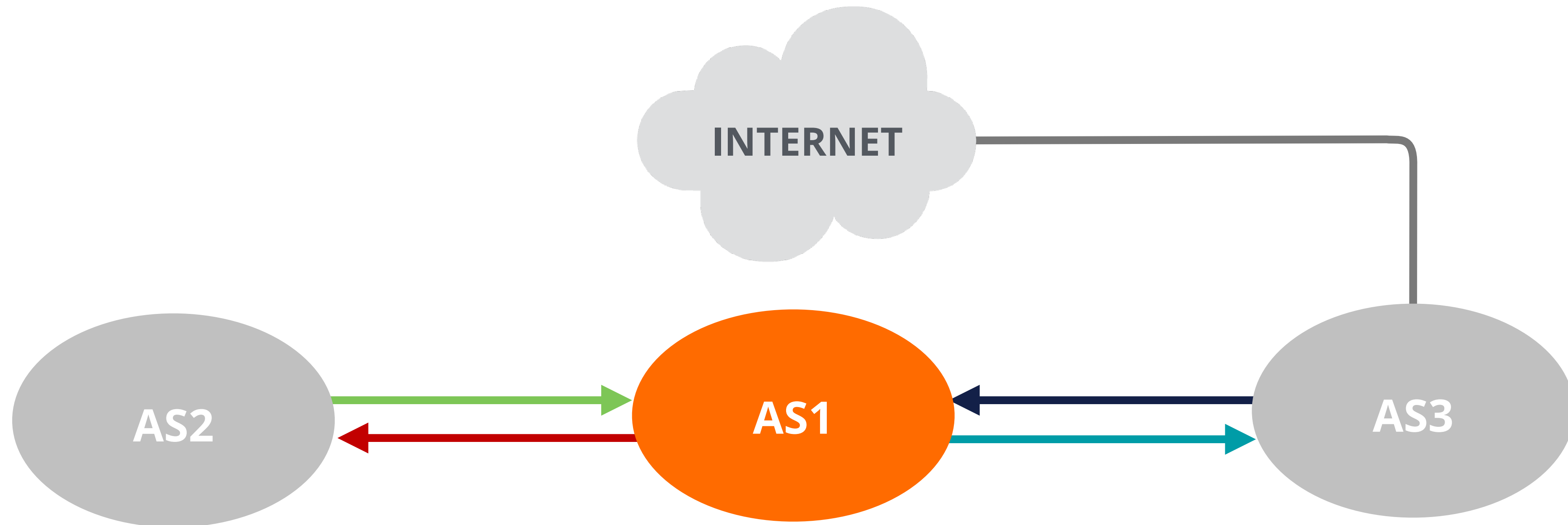
```
aut-num: AS1
import: from AS4 accept AS4
export: to AS4 announce AS1
```

Summary



```
aut-num: AS1
import: from AS2 accept ANY
export: to AS2 announce AS1 AS3
import: from AS3 accept AS3
export: to AS3 announce ANY
import: from AS4 accept AS4
export: to AS4 announce AS1 AS3
```


Building an aut-num object



aut-num: AS2

`import: from AS1 accept AS1`

`export: to AS1 announce AS2`

aut-num: AS1

`export: to AS2 announce AS1`

`import: from AS2 accept AS2`

`import: from AS3 accept ANY`

`export: to AS3 announce AS1`

aut-num: AS3

`export: to AS1 announce ANY`

`import: from AS1 accept AS1`



RPSLng

- **RPSL is older** than IPv6, the defaults are IPv4
- IPv6 was added later using a different syntax
- You have to **specify** that it's IPv6

```
aut-num: AS1
mp-import: afi ipv6.unicast from AS201 accept AS201
mp-export: afi ipv6.unicast to AS201 announce ANY
```

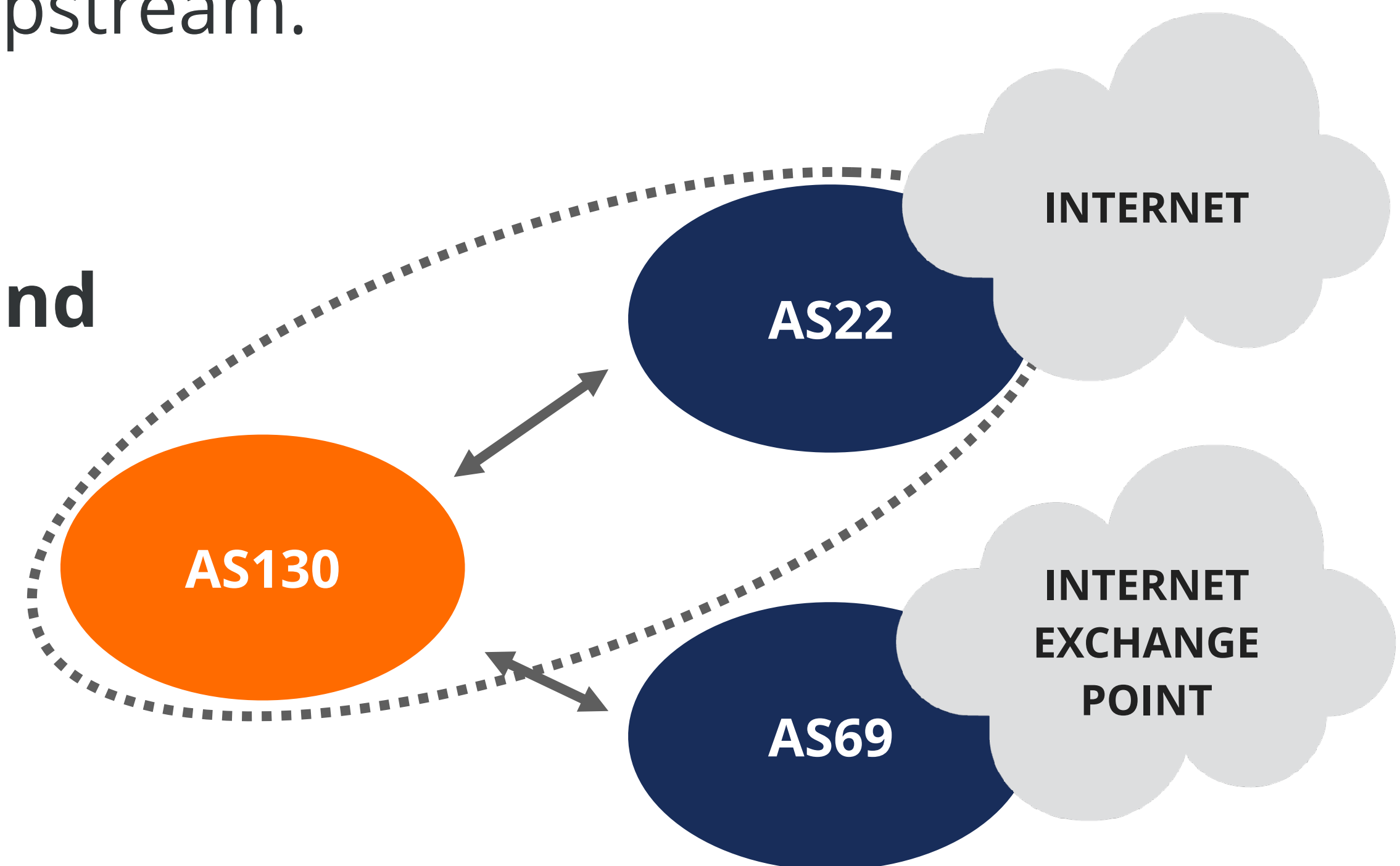
```
route-set: rs-customers
members: 192.0.2.0/24
mp-members: 2001:db8:abcd::/48
```



Take the poll!

AS130 is a stub network and **AS22** is its upstream.

What is the correct **inbound** and **outbound** policy for this BGP relationship?





Tools and Automation

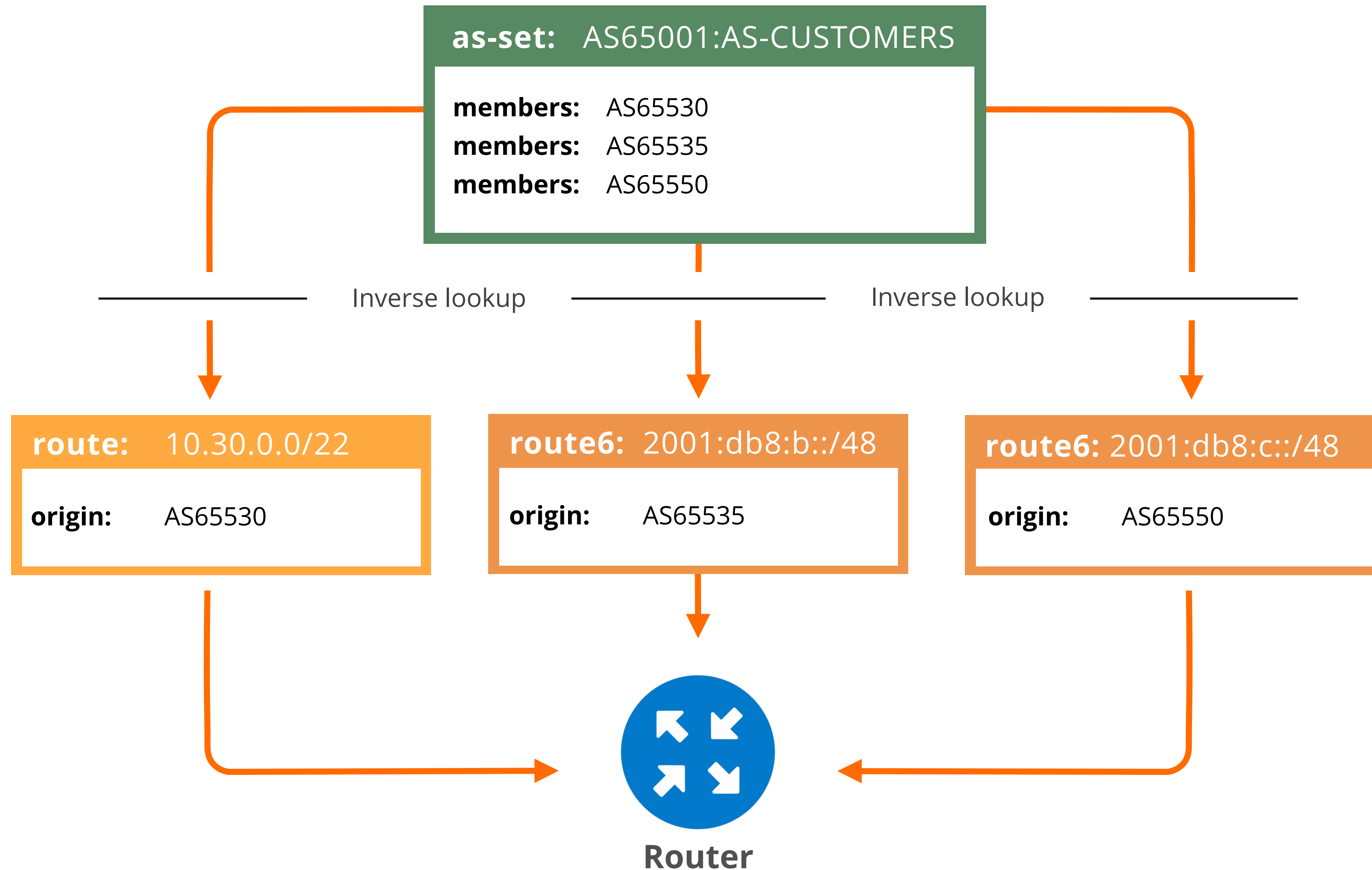
Section 3



IRRs & BGP Automation

- Tools available that get the policy data from the IRRs
 - Extract prefixes from **route(6)** objects
 - Query the IRRs over **whois** protocol
- Some can generate complete router configurations
- Most are open source tools
- Some are not well maintained

Generating a Prefix Filter





RPSL tools for BGP automation

- IRRToolset (written in C++)
 - <https://github.com/irrtoolset/irrtoolset>
- Rpsltool (perl)
 - <https://github.com/rfc1036/rpsltool>
- IRR Power Tools (PHP)
 - <https://github.com/6connect/irrpt>
- bgpq4 (C)
 - <https://github.com/bgp/bgpq4>
- Filtergen (Level 3)
 - <https://github.com/anchor/filtergen>
 - `whois -h filtergen.level3.net RIPE::ASxxx`

Tools to check IRR status



ASN or prefix to compare
3333

AS Routing Consistency

Prefixes Imports Exports

Show 25 entries Search:

prefix	In BGP (RIS)	RIPE IRR	Other IRRs	RPKI	VRP
193.0.0.0/21	yes	yes	no	😊	/21
193.0.10.0/23	yes	yes	no	😊	/23
193.0.12.0/23	yes	yes	no	😊	/23
193.0.18.0/23	yes	yes	no	😊	/23
193.0.20.0/23	yes	yes	no	😊	/23
193.0.22.0/23	yes	yes	no	😊	/23
193.230.194.0/24	no	no	no	😊	/24
2001:610:240::/42	no	no	no	😊	/42
2001:67c:2e8::/48	yes	yes	no	😊	/48
2a13:27c0:10::/44	no	no	no	😊	/44
2a13:27c0::/29	no	no	no	😊	/48

Showing 1 to 11 of 11 entries



<https://irrexplorer.nlnog.net/>

<https://stat.ripe.net>



Limitations of the IRR System

Section 4

Take the poll!

What are the **limitations** of the IRR system?

Choose all that apply.





The IRR system has some limitations!

- **IRRs may contain conflicting data**
 - Distributed databases that mirror each other
- **No central authority**
 - Who will verify the accuracy of the data?
- **No verification of holdership**
 - In some IRRs, you can create objects without checks
- **Not updated properly**
 - Information is missing, outdated or incorrect



IRR filters are good only if the IRR entries are correct!



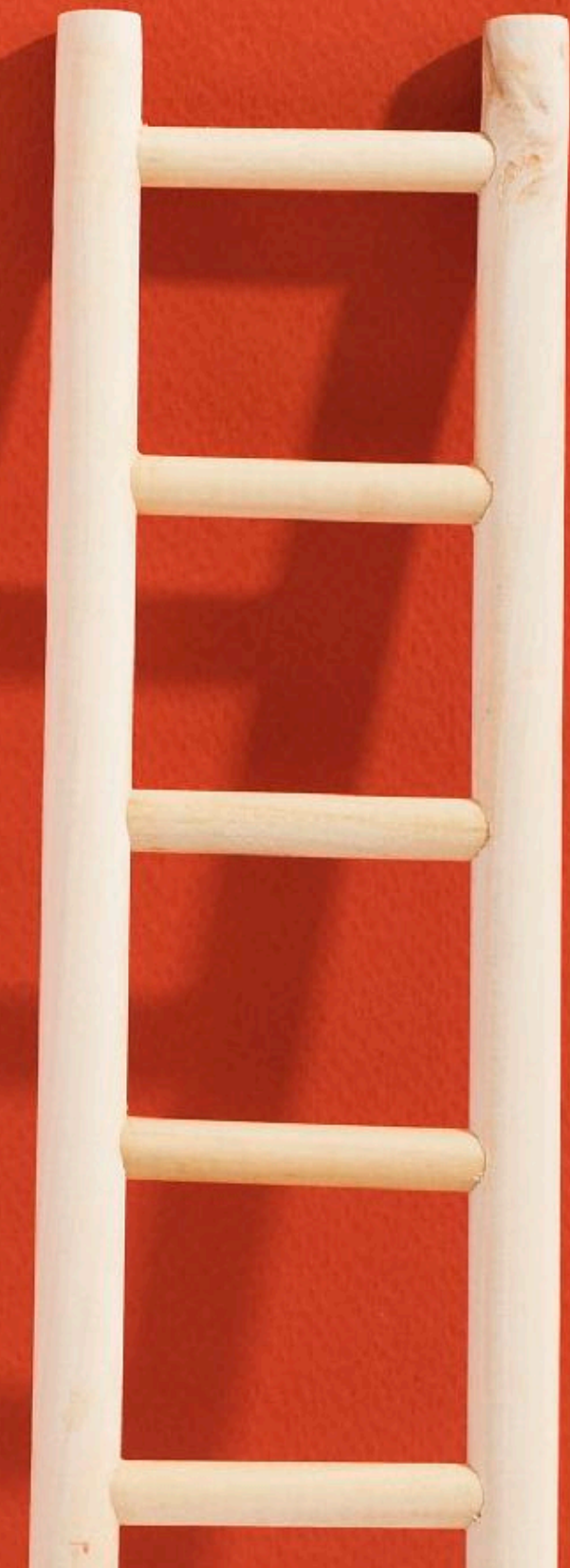
But remains widely used...

- RPKI was developed as a more secure alternative
 - Uses cryptography for verification of holdership
 - Covers more than 55% IPv4 and 55% IPv6 prefixes announced in BGP globally (03.2025)
- So, the IRR system is still widely used for BGP routing security!



Improving IRR accuracy

- IRR hygiene is essential
 - Check your BGP routing consistency
 - Do you have **route(6)** objects in IRRs?
- Keep your IRR information up to date
- Remove RPKI inconsistent records from IRR





Getting the complete picture

- Automation relies on the IRR being complete
- Small mistakes can have a big impact
- Check your output before using it
 - Be prepared to make manual overrides
- **Help others by documenting your routing policy!**



Questions



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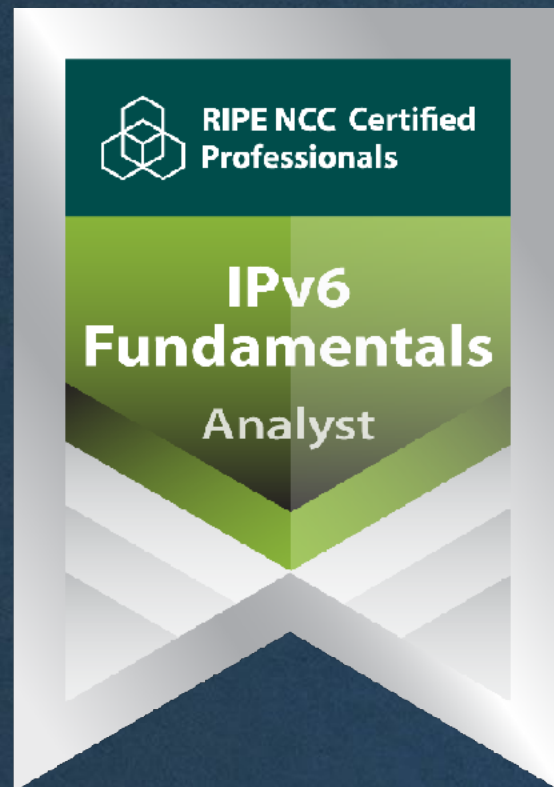


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