

The Internet Route Registry and You: A Tier 1 Network Perspective

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AS2914

What is the Internet Route Registry?

- A distributed database of route and route-related information.
- Objects are defined in the Route Policy Specification Language (RPSL - RFC 2622, RFC 4012)
- The objects in the database are publicly available for service providers and other users to utilize for various purposes

Why is a Route Registry Important?

- **Standard Format:** Allows you to define your routing information in a standard format
- **Simplified ACL Creation:** Service Providers can create BGP ACLs based upon route registry information, often in an automated way without having to open a ticket.
- **Keeping the Routing Table Secure:** BGP ACLs help to minimize routing mistakes on your network (or customer networks) from propagating to the global routing table.

Who Provides Route Registry Services?

Service Providers	Regional Internet Registries (RIR)	3rd Parties
BBOI (host.net)	AFRINIC (Africa)	ALTDB
BELL (Bell Canada)	APNIC (Asia/Pacific)	JPIRR (JPNIC)
GT (Bell Canada)	ARIN (North America)	RADB
LEVEL3	RIPE (Europe)	RGNET
NTTCOM		TC (bgp.net.br)

Partial list above, full list and contact info at <http://irr.net/docs/list.html>

Quick Route Registry Tutorial

The Three Essential Route Registry Objects

Maintainer

Defines the person or group responsible for updating route registry objects

Route

Defines an route/AS Number relationship

AS-SET

Defines your customer cone
(Customers that peer with you)

Maintainer Object Attributes

Required

```
$ whois -h rr.ntt.net MAINT-NTTCOM-BB
mntner:      MAINT-NTTCOM-BB
descr:      NTT Communications Global IP Network
maintainer
admin-c:     JH636-ARIN
tech-c:      JH636-ARIN
upd-to:      ip-eng-reports@us.ntt.net
mnt-nfy:     ip-eng-reports@us.ntt.net
auth:        MD5-PW XXXXXX
remarks:     contacts per RFC2142:
remarks:     Abuse / UCE reports abuse@ntt.net
remarks:     Security issues security@ntt.net
notify:      ip-eng-routing@us.ntt.net
mnt-by:      MAINT-NTTCOM-BB
changed:     tboudreau@us.ntt.net 20151028
source:      NTTCOM
```

Maintainer
Handle

Description

Admin
Contact

Auth Error
Recipient

Authentication
Scheme

Last Update

Route
Registry DB

Tech Contact

Remarks

Notify
Maintainer

Notify

Optional:

Basic Maintainer Object

```
mntner:      MAINT-NTTCOM-BB
descr:       NTT Communications Global IP Network maintainer
admin-c:     JH636-ARIN
upd-to:      ip-eng-reports@us.ntt.net
auth:        MD5-PW XXXXXXXXXX
mnt-by:      MAINT-NTTCOM-BB
changed:     tboudreau@us.ntt.net 20151028
source:      NTTCOM
```

For most Route Registries, this object is emailed to the route registry DB-Admin for creation. The creation of the Maintainer object is a manual process.

Route Object Attributes

Required

```
route: 200.15.0.0/16
descr: NTT Communications - NTTB-200-015
origin: AS2914
remarks: this is non-portable space, no exceptions
remarks: contacts per RFC2142:
remarks: Abuse / UCE reports abuse@ntt.net
remarks: Security issues security@ntt.net
mnt-by: MAINT-NTTCOM-BB
changed: brian@ntt.net 20151118
source: NTTCOM
```

Route (CIDR)

Description

Origin AS
Number

Maintainer

Last Update

Route
Registry DB

Optional: Remarks

Basic Route Objects

IPv4

```
route:      200.15.248.0/24
descr:      ABC Corporation
origin:      AS97
mnt-by:      MAINT-NTTCOM-RA
changed:     brian@ntt.net 20151118
source:      NTTCOM
```

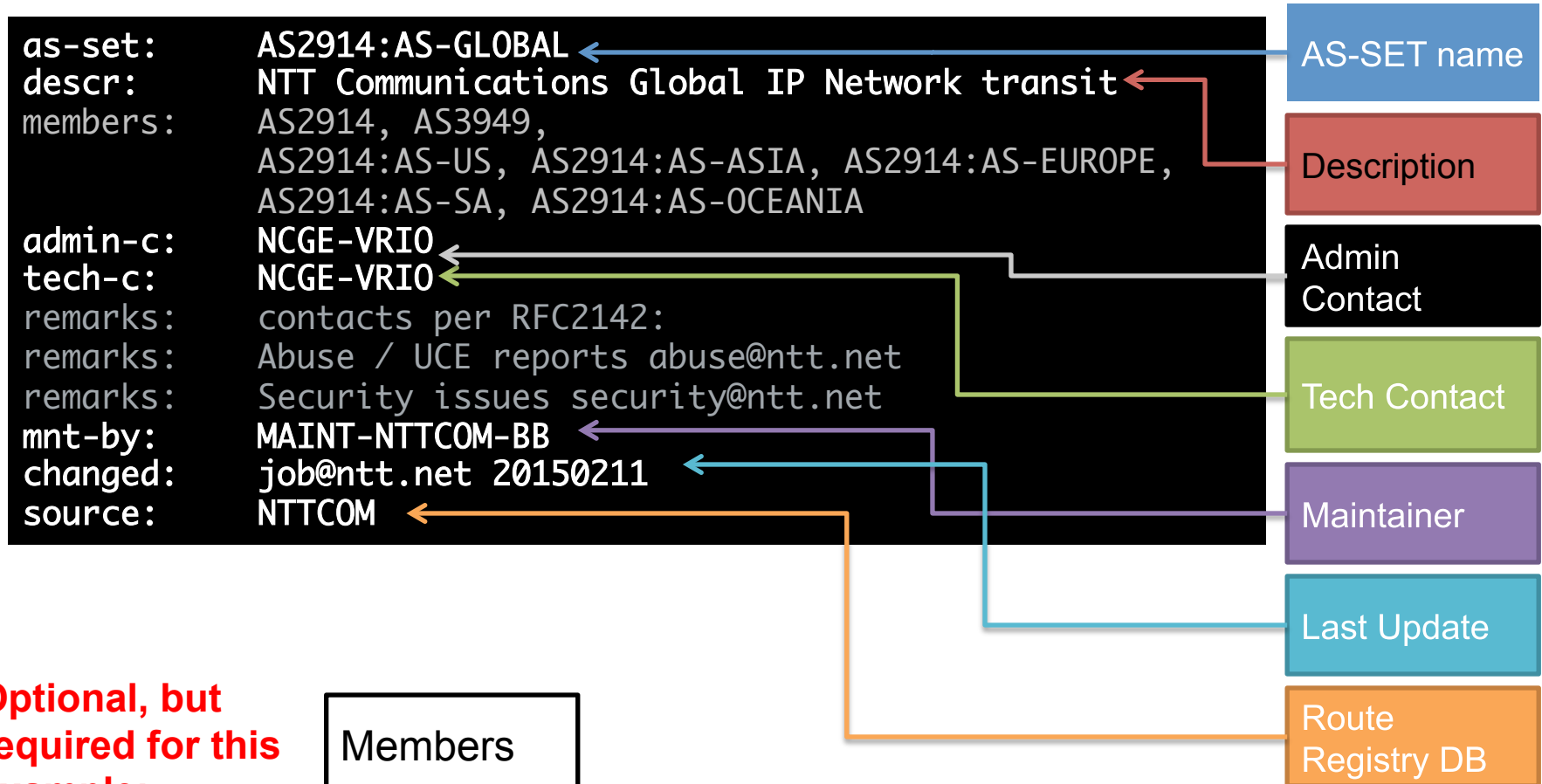
IPv6

```
route6:     2001:418:FFAA::/48
descr:      ABC Corporation
origin:      AS97
mnt-by:      MAINT-NTTCOM-RA
changed:     brian@ntt.net 20151118
source:      NTTCOM
```

Note: “route6”
is used for
IPv6 objects

For most route registries, this object is emailed to the route registry DB-Admin for creation. The addition/modification/deletion is automated.

AS-SET Object Attributes



Optional, but
required for this
example:

Members

Optional:

Remarks

Basic AS-SET Object

```
as-set:      AS97:AS-GLOBAL
descr:      ABC Corporation Customers
members:     AS97, AS3939:AS-GLOBAL
admin-c:     NCGE-VRIO
tech-c:      NCGE-VRIO
mnt-by:      MAINT-NTTCOM-RA
changed:     brian@ntt.net 20151118
source:      NTTCOM
```

Members can be
a combination of
AS Numbers and
AS-SET

For most route registries, this object is emailed to the route registry DB-Admin for creation. The addition/modification/deletion is automated.

Object Management

Add

Change

Delete

```
password:  changeMe!  
route:     200.15.248.0/24  
descr:     ABC Corporation  
origin:    AS97  
mnt-by:    MAINT-NTTCOM-RA  
changed:   brian@ntt.net 20151118  
source:    NTTCOM
```

```
password:  changeMe!  
route:     200.15.248.0/24  
descr:     ABC Corporation  
origin:    AS97  
mnt-by:    MAINT-NTTCOM-RA  
changed:   brian@ntt.net 20151118  
source:    NTTCOM  
delete:    a good reason
```

For most route registries, this object is emailed to the route registry DB-Admin for creation. The addition/modification/deletion is automated.

Example Automated Submission

Email

To: auto-dbm@rr.ntt.net

password: ABC123
route: 200.15.250.0/24
descr: Foust Test Prefix
origin: AS97
mnt-by: MAINT-NTTCOM-RA
changed: brian@ntt.net 20151118
source: NTTCOM

route: 200.15.251.0/24
descr: Foust Test Prefix
origin: AS3939
mnt-by: MAINT-NTTCOM-RA
changed: brian@ntt.net 20151118
source: NTTCOM
delete: No longer needed

as-set: AS97:AS-GLOBAL
descr: Foust Test AS-SET
members: AS97,AS3939-AS-GLOBAL
admin-c: NCGE-VRIO
tech-c: NCGE-VRIO
mnt-by: MAINT-NTTCOM-RA
changed: brian@ntt.net 20151118
source: NTTCOM

Confirmation

From: db-admin@rr.ntt.net
Date: November 23, 2015 at 2:37:51 PM CST
To: brian@ntt.net
Subject: readding test objects

Your transaction has been processed by the IRRd routing registry system.

Diagnostic output:

-

The submission contained the following mail headers:

- From: brian@ntt.net
- Subject: readding test objects
- Date: Mon, 23 Nov 2015 14:37:50 -0600
- Msg-Id: <203A6DBC-B5A6-43B7-90A8-1F1DB86EE398@ntt.net>

ADD OK: [route] 200.15.250.0/24 AS97
DEL OK: [route] 200.15.251.0/24 AS3939
ADD OK: [as-set] AS97:AS-GLOBAL

-

The NTT Communications Global IP Network Routing Registry is operated by db-admin@rr.ntt.net. Whois queries to rr.ntt.net (primary) or rr1.ntt.net (backup).

see <http://us.ntt.net/about/policy/> for more information.

Avoid Proxy Objects

```
route: XX.YY.240.0/22
descr: Proxy route registration for XXXXXX
origin: AS4XXX6
mnt-by: maint-asXXXXX
changed: noc@abcde.com 20080428 #06:07:41Z
source: RADB
```

```
route: XX.YY.240.0/22
descr: Proxy-registered route object
origin: AS4XXX6
remarks: This route object is for an XXXXXXXX customer route
remarks: which is being exported under this origin AS.
remarks:
remarks: This route object was created because no existing
remarks: route object with the same origin was found, and
remarks: since some InfoRelay peers filter based on these
objects
remarks: this route may be rejected if this object is not
created.
remarks:
remarks: Please contact noc@XXXXXXXX.com if you have any
remarks: questions regarding this object.
mnt-by: MAINT-ASXXXXY
changed: irr@XXXXXX.com 20101208
source: ALTDB
```

Avoid Proxy Objects

- Created by a third party on behalf of the origin ASN
- Can be removed by a third party without notice to the origin ASN

Route Registry Queries

Most Commonly Queried using 'whois'.

Some providers may have web interfaces available to query.

```
$> whois -h rr.ntt.net AS2914:AS-GLOBAL
```

```
[Querying rr.ntt.net]
```

```
[rr.ntt.net]
```

```
as-set:      AS2914:AS-GLOBAL
```

```
descr:      NTT Communications Global IP Network transit customers
```

```
members:    AS2914, AS3949,  
            AS2914:AS-US, AS2914:AS-ASIA, AS2914:AS-EUROPE,  
            AS2914:AS-SA, AS2914:AS-OCEANIA
```

```
admin-c:    NCGE-VRIO
```

```
tech-c:     NCGE-VRIO
```

```
remarks:    contacts per RFC2142:
```

```
remarks:    Abuse / UCE reports abuse@ntt.net
```

```
remarks:    Security issues security@ntt.net
```

```
mnt-by:     MAINT-NTTCOM-BB
```

```
changed:    job@ntt.net 20150211
```

```
source:     NTTCOM
```


Route Registry Queries

Most Commonly Queried using 'whois'.

Some providers may have web interfaces available to query.

```
$> whois -h rr.ntt.net 200.15.0.0
```

```
route:      200.15.0.0/16
descr:      NTT Communications - NTTB-200-015
origin:      AS2914
remarks:     this is non-portable space, no exceptions
remarks:     contacts per RFC2142:
remarks:     Abuse / UCE reports abuse@ntt.net
remarks:     Security issues      security@ntt.net
mnt-by:      MAINT-NTTCOM-BB
changed:     brian@ntt.net 20151118
source:      NTTCOM
```

See <http://www.radb.net/support/query2.php> for additional query options

Auditing Route Registry Records using IRR Explorer

IRR Explorer

Explore Route Registry and BGP data in near real-time

- **Search by:**
 - Prefix (v4/v6 CIDR)
 - AS Number
 - AS-SET
- **Results:**
 - Compare results from multiple route registries with the global routing table with advice on how to resolve issues.



<http://irrexplorer.nlnog.net>

IRR Explorer: Queries

Prefix

Search for route objects and BGP information for a specific network prefix and subnets

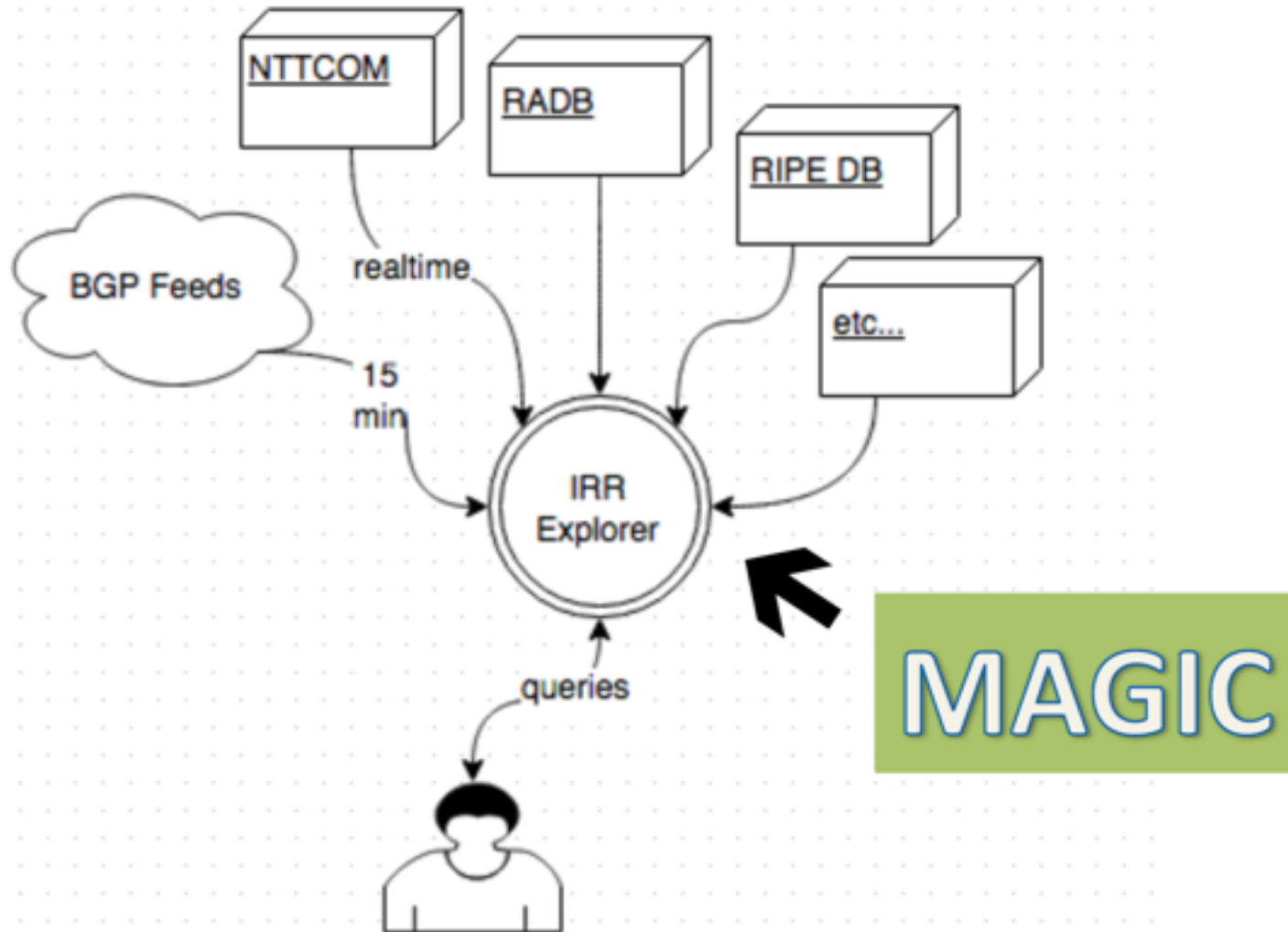
AS Number

Search for route objects and BGP information by AS Number

AS-SET

Search for route objects and BGP information by AS-SET

IRR Explorer Overview



IRR Explorer Usage: Output

Prefixes		Route Registries								Advice
prefix	bgp	nttcom	radb	ripe_managed	level3	altdb	arin	ripe	savvis	advice
116.51.0.0/16	17645	17645								Looks good: BGP origin consistent with AS in route-objects
116.51.16.0/20	2914	2914								Looks good: BGP origin consistent with AS in route-objects
116.51.16.0/21		2914								Not seen in BGP, but (legacy?) route-objects exist, consider clean-up
116.51.19.0/24		3949								Not seen in BGP, but (legacy?) route-objects exist, consider clean-up
116.51.20.0/24		3949								Not seen in BGP, but (legacy?) route-objects exist, consider clean-up
128.127.164.0/24	200072	3949		✓				200072		Proper RIPE DB object, but foreign objects also exist, consider removing these. BGP origin does not match all IRR entries.
128.127.165.0/24	200072	3949		✓				200072		Proper RIPE DB object, but foreign objects also exist, consider removing these. BGP origin does not match all IRR entries.
128.127.166.0/23	200072			✓				200072		Perfect
128.127.166.0/24		3949		✓						Route objects in foreign registries exist, but no BGP origin. Consider moving IRR object to RIPE DB or deleting them.
128.127.167.0/24		3949		✓						Route objects in foreign registries exist, but no BGP origin. Consider moving IRR object to RIPE DB or deleting them.
134.97.0.0/16	28748			✓				28748		Perfect
		3949		✓				3320		Not seen in BGP, but (legacy?) route-objects exist, consider clean-up
				✓						Prefix is in DFZ, but NOT registered in any IRR and should go into RIPE!
				✓						Prefix is in DFZ, but NOT registered in any IRR and should go into RIPE!

IRR Explorer Usage: Detail

prefix	bgp	radb	nttcom
165.254.0.0/16	2914		2914

lg01: show route for 165.254.0.0/16 all

```
165.254.0.0/16
[DIGITALOCEAN7 09:45:57 from 5.101.110.2] * (100/-) [AS2914i]
  Type: BGP unicast univ
  BGP.origin: IGP
  BGP.as_path: 202018 2914
  BGP.next_hop: 5.101.110.2
  BGP.local_pref: 100
  BGP.community: (2914,410) (2914,1001) (2914,2000) (2914,3000)

[QUADRANET1 12:00:59 from 204.152.204.30] (100/-) [AS2914i]
  Type: BGP unicast univ
  BGP.origin: IGP
  BGP.as_path: 8100 2914
  BGP.next_hop: 204.152.204.30
  BGP.local_pref: 100
  BGP.community: (2914,410) (2914,1005) (2914,2000) (2914,3000)

[HIVANE 10:07:43 from 193.17.192.135] (100/-) [AS2914i]
  Type: BGP unicast univ
  BGP.origin: IGP
  BGP.as_path: 34019 30781 2914
  BGP.next_hop: 193.17.192.135
  BGP.med: 5
  BGP.local_pref: 100
  BGP.community: (2914,410) (2914,1001) (2914,2000) (2914,3000) (2914,4003)
003)
```

Displays all
prefixes for the
network
selected

Routing Table
view of prefix
utilizing looking
glass of
ring.nlnog.net

Prefix: 165.254.0.0/16

Matching prefixes

prefix	bgp	radb	nttcom
165.254.0.0/16	2914		2914
165.254.1.0/25	35994		35994
165.254.10.0/23	54750		54750
165.254.10.0/24			54750
165.254.101.0/24	22691	22691	
165.254.102.64/26	12008	12008	
165.254.103.0/26	12008	12008	
165.254.103.128/26	12008	12008	
165.254.103.192/26	12008	12008	
165.254.103.64/26	12008	12008	
165.254.107.0/24	30146		30146
165.254.108.0/24			
165.254.11.0/24			54750
165.254.117.0/24	393490	393490	393490

IRR Explorer: Advice

- IRR Explorer offers advice on how to resolve any potential issues
- **Green = Good**
 - Route objects are registered with the correct prefix length, origin ASN and announced from the same origin ASN as the route object.
- **Yellow = Caution**
 - Some sort of conflict between exists between the route objects and BGP table, and needs to be investigated.
- **Red = Warning**
 - The network is in the global routing table, but no route object exists. A route object needs to be created.
- **Blue = Informational**
 - Route object exists, but not in global routing table. Consider deleting route objects in this state.

IRR Explorer: Perfection

AS Number: 3333

Prefixes

prefix	▲	bgp	◆	ripe_managed	◆	ripe	◆	advice	◆
193.0.0.0/21		3333		✓		3333		Perfect	
193.0.10.0/23		3333		✓		3333		Perfect	
193.0.12.0/23		3333		✓		3333		Perfect	
193.0.18.0/23		3333		✓		3333		Perfect	
193.0.20.0/23		3333		✓		3333		Perfect	
193.0.22.0/23		3333		✓		3333		Perfect	
2001:67c:2e8::/48		3333		✓		3333		Perfect	

IRR Explorer: Make It A Part of Your Process

AS Number: 2914

Prefixes

prefix	bgp	radb	nttcom	ripe_managed	jpirr	altdb	level3	arin	advice
101.110.128.0/17	2914		2914						Looks good: BGP or
103.13.80.0/22	2914		2914						Looks good: BGP or
103.13.80.0/23	2914		2914						Looks good: BGP or
103.13.82.0/23	2914		2914						Looks good: BGP or
103.20.18.0/23	2914		2914						Looks good: BGP or
103.24.223.0/24	2914								Prefix in DFZ, but no
104.102.144.0/20	2914								Prefix in DFZ, but no route-object with correct origin anywhere
104.102.160.0/20	2914								Prefix in DFZ, but no route-object with correct origin anywhere
104.109.244.0/22	2914								Prefix in DFZ, but no route-object with correct origin anywhere
104.109.248.0/23	2914								Prefix in DFZ, but no route-object with correct origin anywhere
104.110.0.0/20	2914								Prefix in DFZ, but n
104.110.16.0/20	2914								Prefix in DFZ, bu
104.112.10.0/23						2914			Not seen in BGP,
104.112.12.0/22						2914			Not seen in BGP,
104.112.48.0/20						2914			Not seen in BGP,
104.112.64.0/20						2914			Not seen in BGP,
104.112.8.0/23						2914			Not seen in BGP,
104.112.80.0/20						2914			Not seen in BGP, bu
104.112.96.0/20						2914			Not seen in BGP, but (legacy?) route-objects exist, consider clean-up

Consider making it part of your network management processes.

Consider utilizing IRR Explorer (or your own tool) to routinely audit your route registry info for accuracy.

Automation Tools Using Route Registry Data

NTT Automation using Route Registry Data

- NTT has an internally developed SDN platform called GUMS which performs automated network configuration functionality.
- GUMS uses Route Registry data to build the prefix lists
- NTT updates customer BGP prefix lists in an automated function nightly.
- **Workflow:**
 - 0100 UTC: BGP ACLs are generated by GUMS from all route registry data that exists at that time.
 - 0400 UTC: BGP ACLs are loaded to the routers by GUMS, and BGP sessions are soft cleared by GUMS
- **Result:** Customers maintain their BGP prefix list by utilizing the route registry. ACL loading is automated. No intervention required by the NTT NOC or the customer.

Open Source Tools to Assist with Automation

- Open source software exists to generate prefix lists from route registries
- Modify it to fit your internal systems, and/or
- Use as a standalone script to automate a specific process
- Takes only a few minutes to configure
- Put route objects to work for you!

BGPQ3

- **BGPQ3**

- <https://github.com/snar/bgpq3>

- BGP filter creation in the following formats:

- BIRD
 - IOS
 - IOS XR
 - JunOS
 - JSON

Consider using BGPQ3 together with something like Napalm (<https://github.com/spotify/napalm>) to automate loading of ACLs (and much more)

BGPQ3 :: ACL Example

- Create ACLs from Route Objects

```
$> bgpq3 -A -l AS15562-in AS-SNIJDERS
```

```
no ip prefix-list AS15562-in  
ip prefix-list AS15562-in permit 193.47.147.0/24  
ip prefix-list AS15562-in permit 194.33.96.0/24
```

```
$> bgpq3 -A -l AS15562-in AS-SNIJDERS -6
```

```
no ipv6 prefix-list AS15562-in  
ipv6 prefix-list AS15562-in permit 2001:67c:1b43::/48  
ipv6 prefix-list AS15562-in permit 2001:67c:208c::/48  
ipv6 prefix-list AS15562-in permit 2001:67c:2980::/48  
ipv6 prefix-list AS15562-in permit 2001:728:1808::/48  
ipv6 prefix-list AS15562-in permit 2a04:ec40:ff01::/48  
ipv6 prefix-list AS15562-in permit 2a04:ec40:ff02::/47 ge 48 le 48  
ipv6 prefix-list AS15562-in permit 2a04:ec40:ff04::/46 ge 48 le 48  
ipv6 prefix-list AS15562-in permit 2a04:ec40:ff09::/48  
ipv6 prefix-list AS15562-in permit 2a04:ec40:ff10::/48  
ipv6 prefix-list AS15562-in permit 2a04:ec40:ff12::/47 ge 48 le 48  
ipv6 prefix-list AS15562-in permit 2a04:ec40:ff14::/46 ge 48 le 48  
ipv6 prefix-list AS15562-in permit 2a04:ec40:ff18::/47 ge 48 le 48  
ipv6 prefix-list AS15562-in permit 2a04:ec40:ff20::/45 ge 48 le 48  
ipv6 prefix-list AS15562-in permit 2a04:ec40:ff28::/47 ge 48 le 48
```

IRR Powertools

•IRR Powertools

–<https://github.com/6connect/irrpt>

- Automated retrieval of prefixes registered behind an IRR Object.
- Automatic exclusion of bogon or other configured undesirable routes.
- Tracking and long-term recording of prefix changes through CVS.
- Automatic aggregation to optimize data and reduce unnecessary changes.
- E-mail updates, letting users know that their change was processed.
- E-mail alerts to the ISP, letting them know of new routing changes.
- Exporting of change data in e-mail form, for non-IRR using ISPs.
- Router config generation, for easy automated config deployment.

IRR Powertools :: ACL Example

- Create ACLs from route objects
- Cut and paste into your router

```
$> ./irrpt_pfxgen -f cisco 15562
```

```
conf t
no ip prefix-list CUSTOMER:15562
no ip prefix-list CUSTOMERv6:15562
ip prefix-list CUSTOMER:15562 permit 128.242.128.0/22 le 24
ip prefix-list CUSTOMER:15562 permit 128.242.132.0/22 le 24
ip prefix-list CUSTOMER:15562 permit 128.242.136.0/21 le 24
ip prefix-list CUSTOMER:15562 permit 165.254.255.0/24
ip prefix-list CUSTOMER:15562 permit 193.47.147.0/24
ip prefix-list CUSTOMER:15562 permit 194.33.96.0/24
ipv6 prefix-list CUSTOMERv6:15562 permit 2a04:ec40:ff01::/48
ipv6 prefix-list CUSTOMERv6:15562 permit 2a04:ec40:ff02::/47 le 48
ipv6 prefix-list CUSTOMERv6:15562 permit 2a04:ec40:ff04::/46 le 48
ipv6 prefix-list CUSTOMERv6:15562 permit 2a04:ec40:ff09::/48
ipv6 prefix-list CUSTOMERv6:15562 permit 2a04:ec40:ff10::/48
ipv6 prefix-list CUSTOMERv6:15562 permit 2a04:ec40:ff12::/47 le 48
ipv6 prefix-list CUSTOMERv6:15562 permit 2a04:ec40:ff14::/46 le 48
ipv6 prefix-list CUSTOMERv6:15562 permit 2a04:ec40:ff18::/47 le 48
ipv6 prefix-list CUSTOMERv6:15562 permit 2a04:ec40:ff20::/45 le 48
ipv6 prefix-list CUSTOMERv6:15562 permit 2a04:ec40:ff28::/47 le 48
ipv6 prefix-list CUSTOMERv6:15562 permit 2001:67c:1b43::/48
ipv6 prefix-list CUSTOMERv6:15562 permit 2001:67c:208c::/48
ipv6 prefix-list CUSTOMERv6:15562 permit 2001:67c:2980::/48
ipv6 prefix-list CUSTOMERv6:15562 permit 2001:728:1808::/48
end
write mem
```

Introduction to MANRS

MANRS

- **Mutually Agreed Norms for Routing Security (MANRS)**
 - <https://www.routingmanifesto.org/manrs/>
- **Created to Address Three Main Classes of Problems:**
 - Problems related to incorrect routing information;
 - Problems related to traffic with spoofed source IP addresses; and
 - Problems related to coordination and collaboration between network operators.
























MANRS

- How to Participate
 - Agree to support the MANRS principles and implement at least one of the actions for the majority of your infrastructure
 - Filtering
 - Anti-spoofing
 - Coordination
 - Global Validation
 - Sign up information and specifics found at <https://www.routingmanifesto.org/manrs/>

MANRS

Have yourself listed as a participant!

– <https://www.routingmanifesto.org/participants/>

	Country	ASNs	Filtering	Anti-spoofing	Coordination	Global Validation
IJ	JP	2497				
SpaceNet	DE	5539				
Algar Telecom	BR	16735, 53006, 27664				
LACNIC	UY	28000, 28001, 28002				
Sky	UK	5607				
SBTAP	IT	59715				

Summary

- Use the Route Registry to document your network in a standard way
- Build ACLs to help protect the global routing table
- Utilize IRR Explorer to compare the BGP table to route objects
- Utilize Open Source Tools (or write your own) to automate certain network tasks, such as generating prefix lists.
- Get recognized for your commitment to routing security by participating in MANRS

Thank You

Questions?

Contact: brian@ntt.net