

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

Brian Foust

Sr. Director, Customer Solutions  
NTT Communications Global IP Network

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 ( <a href="http://host.net">host.net</a> )	AFRINIC (Africa)	ALTDB
BELL (Bell Canada)	APNIC (Asia/Pacific)	JPIRR (JPNIC)
GT (Bell Canada)	ARIN (North America)	RADB
LEVEL3	RIPE (Europe)	RGNET
NTTCOM		TC ( <a href="http://bgp.net.br">bgp.net.br</a> )

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

```
$ 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
```

Required

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
```

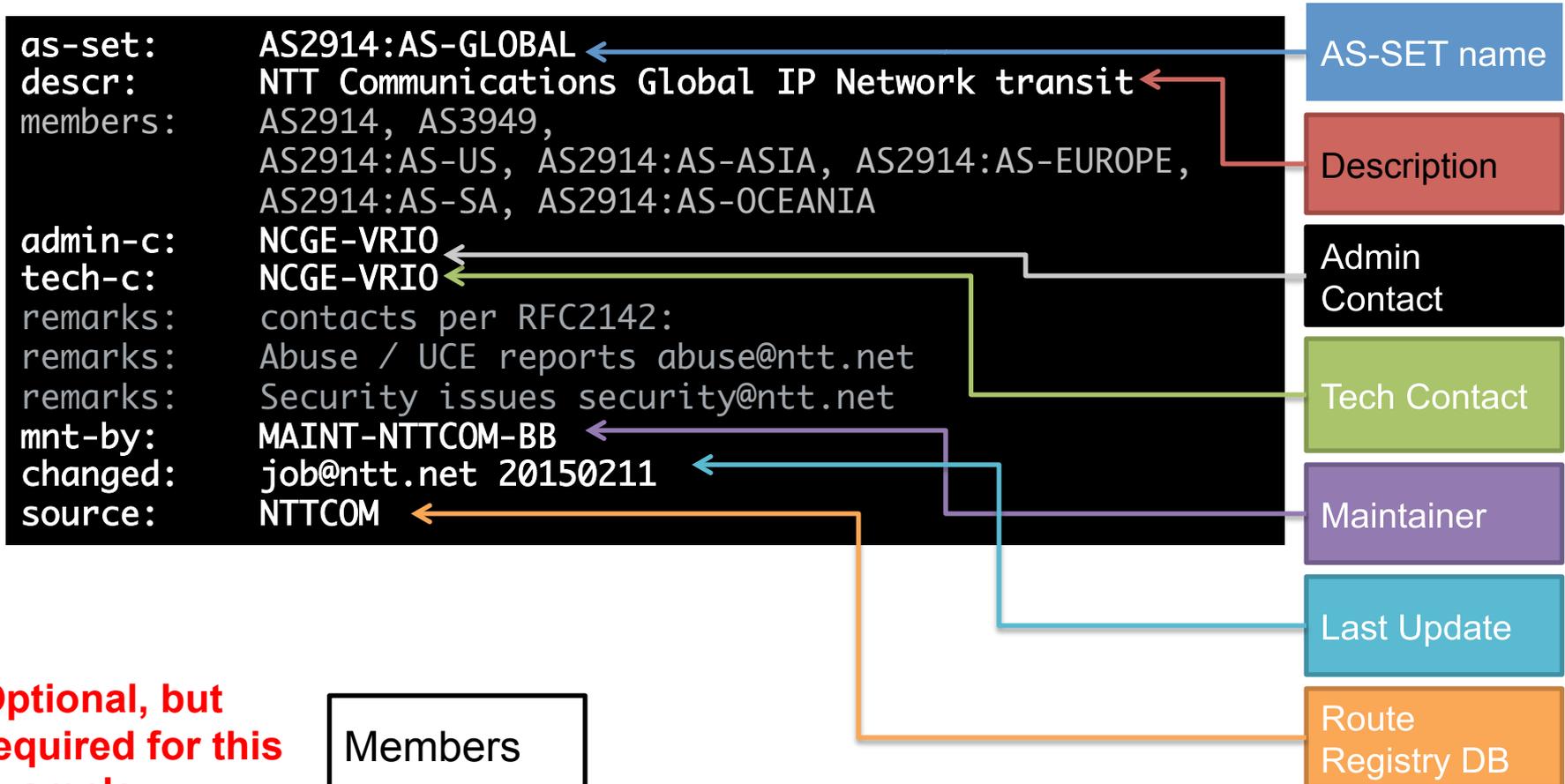
IPv6

```
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:

Optional:

# 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: reading 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: reading 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@XXXXXXXX.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

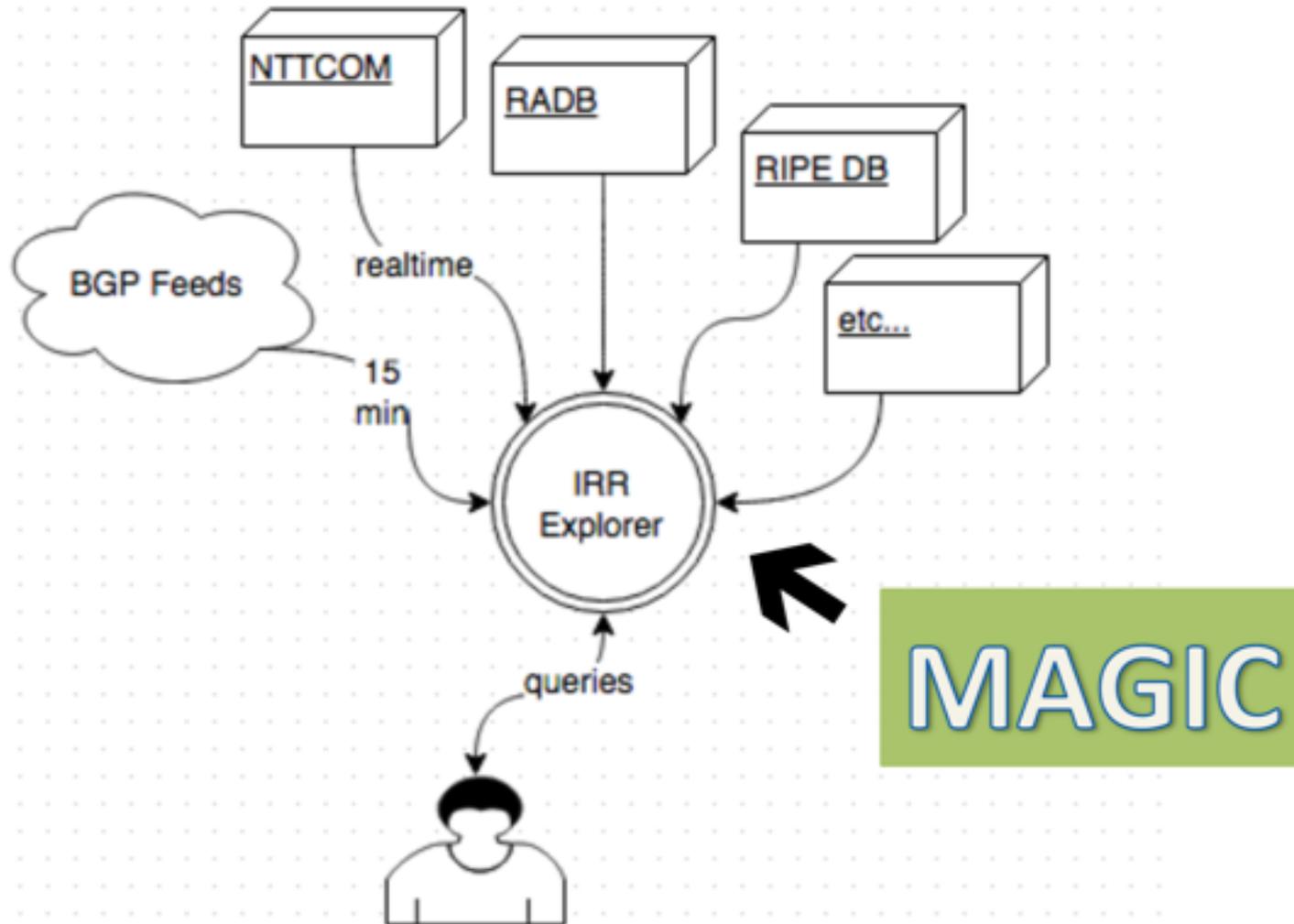
**AS Number**

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

Origin ASN

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!

Origin ASN by Route Object by Route Registry

# 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) (2914,3003)
003)
```

Displays all prefixes for the network selected

Routing Table view of prefix utilizing looking glass of [ring.nlnog.net](http://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
104.110.16.0/20	2914								Prefix in DFZ, but
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, but
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/](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](mailto:brian@ntt.net)