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?

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

Partial list above, full list and contact info at [http://irr.net/docs/list.html](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: MAINT-NTTCOM-BB
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

Optional:
- Tech Contact
- Remarks
- Notify Maintainer
- Notify
<table>
<thead>
<tr>
<th>Key</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>mntner</td>
<td>MAINT-NTTCOM-BB</td>
</tr>
<tr>
<td>descr</td>
<td>NTT Communications Global IP Network maintainer</td>
</tr>
<tr>
<td>admin-c</td>
<td>JH636-ARIN</td>
</tr>
<tr>
<td>upd-to</td>
<td><a href="mailto:ip-eng-reports@us.ntt.net">ip-eng-reports@us.ntt.net</a></td>
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<tr>
<td>auth</td>
<td>MD5-PW XXXXXXXXXX</td>
</tr>
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<td>mnt-by</td>
<td>MAINT-NTTCOM-BB</td>
</tr>
<tr>
<td>changed</td>
<td><a href="mailto:tboudreau@us.ntt.net">tboudreau@us.ntt.net</a> 20151028</td>
</tr>
<tr>
<td>source</td>
<td>NTTCOM</td>
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</tbody>
</table>

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.
<table>
<thead>
<tr>
<th>Attribute</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>route:</td>
<td>200.15.0.0/16</td>
</tr>
<tr>
<td>descr:</td>
<td>NTT Communications - NTTB-200-015</td>
</tr>
<tr>
<td>origin:</td>
<td>AS2914</td>
</tr>
<tr>
<td>remarks:</td>
<td>this is non-portable space, no exceptions</td>
</tr>
<tr>
<td>remarks:</td>
<td>contacts per RFC2142:</td>
</tr>
<tr>
<td>remarks:</td>
<td>Abuse / UCE reports <a href="mailto:abuse@ntt.net">abuse@ntt.net</a></td>
</tr>
<tr>
<td>remarks:</td>
<td>Security issues <a href="mailto:security@ntt.net">security@ntt.net</a></td>
</tr>
<tr>
<td>mnt-by:</td>
<td>MAINT-NTTCOM-BB</td>
</tr>
<tr>
<td>changed:</td>
<td><a href="mailto:brian@ntt.net">brian@ntt.net</a> 20151118</td>
</tr>
<tr>
<td>source:</td>
<td>NTTCOM</td>
</tr>
</tbody>
</table>

**Required:**
- Route (CIDR)
- Description
- Origin AS Number
- Maintainer
- Last Update
- Route Registry DB

**Optional:** Remarks
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

**as-set:** AS2914:AS-GLOBAL
**descr:** NTT Communications Global IP Network transit
**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

Optional, but required for this example:

- **Members**
  - AS2914:AS-GLOBAL
  - NTT Communications Global IP Network transit
  - NCGE-VRIO
  - NCGE-VRIO
  - abuse@ntt.net
  - security@ntt.net
  - MAINT-NTTCOM-BB
  - job@ntt.net 20150211
  - NTTCOM

Optional:

- **Remarks**
Basic AS-SET Object

```
as-set:    AS97:AS-GLOBAL
descr:     ABC Corporation Customers
members:   AS97, AS3939:AS-GLOBAL
admin-c:  NCGE-VRI0
tech-c:   NCGE-VRI0
mnt-by:   MAINT-NTTCOM-RA
changed:  brian@ntt.net 20151118
source:   NTTCOM
```

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

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.
Example Automated Submission

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**

**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:** 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 XXXXXXX customer route  
**remarks:** which is being exported under this origin AS.  
**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  
**remarks:** objects  
**remarks:** this route may be rejected if this object is not  
**created.**  
**remarks:** Please contact noc@XXXXXXX.com if you have any  
**remarks:** questions regarding this object.  
**mnt-by:** MAINT-ASXXXXY  
**changed:** irr@XXXXXX.com 20101208  
**source:** ALTDB
Route Registry Queries

Most Commonly Queried using ‘whois’. Some providers may have web interfaces available to query.

```bash
$> 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-SA, AS2914:AS-OCEANIA  
admin-c:    NCGE-VRI0  
technical-c: NCGE-VRI0  
remarks:    contacts per RFC2142:  
            Abuse / UCE reports abuse@ntt.net  
            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 Usage: Output

#### Prefixes by Origin ASN

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Origin</th>
<th>ASN</th>
</tr>
</thead>
<tbody>
<tr>
<td>116.51.0.0/16</td>
<td>17645</td>
<td></td>
</tr>
<tr>
<td>116.51.16.0/20</td>
<td>2914</td>
<td></td>
</tr>
<tr>
<td>116.51.16.0/21</td>
<td>2914</td>
<td></td>
</tr>
<tr>
<td>116.51.20.0/24</td>
<td>3949</td>
<td></td>
</tr>
<tr>
<td>128.127.164.0/24</td>
<td>200072</td>
<td></td>
</tr>
<tr>
<td>128.127.165.0/24</td>
<td>200072</td>
<td></td>
</tr>
<tr>
<td>128.127.166.0/23</td>
<td>200072</td>
<td></td>
</tr>
<tr>
<td>128.127.167.0/24</td>
<td>200072</td>
<td></td>
</tr>
<tr>
<td>134.97.0.0/16</td>
<td>28748</td>
<td></td>
</tr>
</tbody>
</table>

#### Route Registries

<table>
<thead>
<tr>
<th>Prefix</th>
<th>ripe_managed</th>
<th>level3</th>
<th>altdb</th>
<th>arin</th>
<th>ripe</th>
<th>savvis</th>
</tr>
</thead>
<tbody>
<tr>
<td>116.51.0.0/16</td>
<td>17645</td>
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<td></td>
</tr>
<tr>
<td>116.51.16.0/20</td>
<td>2914</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>116.51.16.0/21</td>
<td>2914</td>
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<td></td>
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</tr>
<tr>
<td>116.51.20.0/24</td>
<td>3949</td>
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<tr>
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<td>134.97.0.0/16</td>
<td>28748</td>
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</tr>
</tbody>
</table>

#### Advice

- **Looks good: BGP origin consistent with AS in route-objects**
- **Not seen in BGP, but [legacy?] route-objects exist, consider cleanup**
- **Proper RIPE DB object, but foreign objects also exist, consider removing these. BGP origin does not match all IR objects.**
- **Prefix is in GFW, but NOT registered in any IRR and should go into RIPE!**
- **Prefix is in GFW, but NOT registered in any IRR and should go into RIPE!**
- **Prefixed is in GFW, but NOT registered in any IRR and should go into RIPE!**

---

*Origin ASN by Route Object by Route Registry*
IRR Explorer Usage: Detail

Displays all prefixes for the network selected

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

<table>
<thead>
<tr>
<th>Prefix</th>
<th>bgp</th>
<th>ripe_managed</th>
<th>ripe</th>
<th>advice</th>
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<tbody>
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<td>193.0.0.0/21</td>
<td>3333</td>
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</tr>
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<td>193.0.10.0/23</td>
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<td>✔️</td>
<td>3333</td>
<td>Perfect</td>
</tr>
<tr>
<td>193.0.12.0/23</td>
<td>3333</td>
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<td>3333</td>
<td>Perfect</td>
</tr>
<tr>
<td>193.0.18.0/23</td>
<td>3333</td>
<td>✔️</td>
<td>3333</td>
<td>Perfect</td>
</tr>
<tr>
<td>193.0.20.0/23</td>
<td>3333</td>
<td>✔️</td>
<td>3333</td>
<td>Perfect</td>
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<td>3333</td>
<td>Perfect</td>
</tr>
<tr>
<td>2001:67c:2e8::/48</td>
<td>3333</td>
<td>✔️</td>
<td>3333</td>
<td>Perfect</td>
</tr>
</tbody>
</table>
### IRR Explorer: Make It A Part of Your Process

**AS Number: 2914**

<table>
<thead>
<tr>
<th>Prefix</th>
<th>bgp</th>
<th>radb</th>
<th>nttcom</th>
<th>ripe_managed</th>
<th>jpirr</th>
<th>altdb</th>
<th>level3</th>
<th>arin</th>
<th>advice</th>
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<td>101.110.128.0/17</td>
<td>2914</td>
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<tr>
<td>103.13.80.0/22</td>
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<td>103.13.80.0/23</td>
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- 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!
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

```bash
$> 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

- 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

```bash
$> ./irrp_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/
Have yourself listed as a participant!

- [https://www.routingmanifesto.org/participants/](https://www.routingmanifesto.org/participants/)

<table>
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<th>Anti-spoofing</th>
<th>Coordination</th>
<th>Global Validation</th>
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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?

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