"How It Works"

The Regional Internet Registry System
Agenda

• Overview of the Regional Internet Registry System (RIR)
• Policy Development Process
• Internet Number Resources (IPv4, IPv6 and ASNs)
• Routing
• Noteworthy Developments
• RIR Services and Tools
The Regional Internet Registry (RIR) System
Brief History
Internet Number Resource (IP) Administration

• **1980s to 1990s**
  • US DoD contracted administration of **names, numbers, and protocols** to University of Southern California’s ISI
    • Contract run by Jon Postel; function called Internet Assigned Numbers Authority (IANA)
    • Registration/support contracted to SRI International, later to Network Solutions (NSI)
  • Regionalization begins – **RIR** system forms
  • **IP number resource** administration split from Domain Name System (DNS)
  • US Govt separates administration of commercial Internet (InterNIC) from the military Internet (DDN NIC)
Early Registrations

Early IP address space referred to as "legacy space"

- Internet number resources allocated liberally
- Organizations made simple request; no contract required
- The Internet rapidly expanded, distribution could not be managed this way
RIR

Manages the allocation, administration and registration of Internet number resources in a specific region of the world
Who Are the RIRs?
Core Functions of an RIR

- Manage and distribute Internet Number Resources (IPv4 & IPv6 addresses and Autonomous System numbers (ASNs))
- Maintain directory services including Whois, Whowas, and routing registries
- Provide reverse DNS
- Support Internet infrastructure through:
  - Technical coordination
  - Community driven policy process
  - Training & capacity building
The RIRs are...

Independent
- No government oversight

Not-for-profit
- 100% community funded
- Fee for services, not number resources

Membership-based
- Open to all number resource holders (e.g. Internet service providers (ISPs), governments, corporations)

Community developed policies
- Member-elected governing boards
- Open and transparent
Each RIR community sets the policies by which that RIR registers and distributes resources. Each RIR is established under the legal framework of a specific country. The five RIRs fulfill a specific function in the global Internet governance system.

Each RIR operates in accordance with three factors.
RIR Policy Development Process

INCLUSIVE

Evaluate

Anyone can participate

Need

‘BOTTOM UP’

CONSensus

Implement

INTERNET Community Proposes & Approves Policy

Documented & Published Decisions, Policies, & PDP

TRANSPARENT

Discuss
- **Mission**
  - To coordinate and support joint activities of the Regional Internet Registries (RIRs) to provide and promote the Joint Internet Numbers Registry

- **Vision**
  - To be the flagship and global leader for collaborative Internet number resource management as a central element of an open, stable and secure Internet

[https://www.nro.net/](https://www.nro.net/)
NRO Publications

- **Global Internet Number Statistics**
  - Internet Number Resources Status Report (updated quarterly)
  - Global stats on IPv4, IPv6, ASN (updated daily)
  - RPKI Adoption Reports by IPv4, IPv6, economy (updated daily)
  - [https://www.nro.net/statistics](https://www.nro.net/statistics)

- **Comparative Policy Overview**
  - Updated quarterly
  - Information on RIRs Membership policies (access to delegation and registration services)
  - [https://www.nro.net/rir-comparative-policy-overview](https://www.nro.net/rir-comparative-policy-overview)
ICANN’s Multistakeholder Model

ICANN follows a multistakeholder model in which individuals, non-commercial stakeholder groups, industry, and governments play important roles in its community-based, consensus-driven, policy-making approach. Learn how our multistakeholder model functions.

Supporting Organizations

Three Supporting Organizations develop and recommend policies concerning the Internet's technical management within their areas of expertise. They are the Address Supporting Organization (ASO), the Country Code Names Supporting Organization (ccNSO) and the Generic Names Supporting Organization (GNSO).

Governance Accountability

The ICANN Board of Directors has the ultimate authority to approve or reject policy recommendations, while the Nominating Committee (NomCom) and Ombuds assure inclusive representation and accountability.

Advisory Committees

Four Advisory Committees serve as formal advisory bodies to the ICANN Board. They are made up of representatives from the Internet community to advise on a particular issue or policy area and include: At-Large Advisory Committee (“At-Large”), DNS Root Server System Advisory Committee (RSSAC), Governmental Advisory Committee (GAC), and Security and Stability Advisory Committee (SSAC).

https://www.icann.org/community
ICANN ASO AC (Address Council)

<table>
<thead>
<tr>
<th>Who is it:</th>
<th>NRO Number Council</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is it?</td>
<td>Number Resource Advisory Council</td>
</tr>
<tr>
<td>How is it Organized?</td>
<td>15 Members [3 From Each Region]</td>
</tr>
<tr>
<td></td>
<td>– 2 Elected at Large</td>
</tr>
<tr>
<td></td>
<td>– 1 Appointed by RIR Board</td>
</tr>
<tr>
<td></td>
<td>• RIR &amp; ICANN Observers</td>
</tr>
<tr>
<td>Term of Office</td>
<td>Different for every RIR</td>
</tr>
<tr>
<td>What Does it Do?</td>
<td>Advise ICANN Board on Internet Numbers</td>
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<tr>
<td></td>
<td>• Overseeing the Global Policy Development Process</td>
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<tr>
<td></td>
<td>• Appoint ICANN Board Members (2)</td>
</tr>
<tr>
<td></td>
<td>• Appoint member to ICANN NomCom (1)</td>
</tr>
</tbody>
</table>
Global Policy Development Process
Internet Number Resources

IPv4, IPv6, Autonomous System Numbers (ASNs)
**Internet Protocol (IP) Addresses**

**IP address** – unique numerical address assigned to every device connected to a TCP/IP network that facilitates moving data across the network

- **IPv4**
  - 32-bit addresses; written in dotted decimal
  - \(2^{32} = \sim 4.4 \text{ billion}\)
  - e.g. 205.150.58.7

- **IPv6**
  - 128-bit addresses; written in hexadecimal
  - \(2^{128} = \sim 50 \text{ octillion for each of the roughly 6.5 billion people alive}\)
  - e.g. 2001:0503:0C27:0000:0000:0000:0000:0000
Autonomous System Numbers (ASNs)

Globally unique numbers used to exchange routing information between neighboring autonomous systems (AS) and to identify the AS itself.

- An **autonomous system** is a group of IP networks administered under the umbrella of a single entity
- **Routing** is the act of moving information (packets) across an internetwork from a source to a destination
- Network operators must have an **ASN** to control routing within their networks and to exchange routing information with other Internet Service Providers (ISPs)
IP Addresses are Not Domain Names

**IP address**
- [Identifier]
- e.g. 2001:0db8:85a3:0000:0000:8a2e:0370:7334

- Computers recognize **numbers**
- Identifies a device on the Internet
- Used for routing (moves information across an inter-network from a source to a destination)
- Every device directly connected to the Internet requires a unique IP address

**DNS name**
- [Reference]
- e.g. www.nro.net

- People recognize **names**
- Maps host name to unique IP address
- A means of storing and retrieving information about hostnames and IP addresses in a distributed database
How IP Addresses Are Issued

ICANN/IANA
(Internet Assigned Numbers Authority)
Manage global unallocated IP address pool

Allocate

RIRs
(AFRINIC, APNIC, ARIN, LACNIC, RIPE NCC)
Manage regional unallocated IP address pool

Allocate

ISP

Allocate

ISP (Customers)

Reassign

End User

End User (Customers)
Routing
The Internet relies on two critical systems:

- **DNS** - translates domain names to IP addresses (forward lookup) and IP addresses to domain names (reverse lookup)
- **Routing** – forwards IP data packets across the network from source to destination

These critical systems are not secure
- Subject to misconfigurations and nefarious activity

Traditional options for verifying routing
- Internet Routing Registry (IRR)
- Letters of Authority (LOAs)
- Seems "legit" (informal arrangement between ISPs)
The Internet is a Series of Networks
A Network of Networks

- Mobile network
- Internet backbone
- Satellite/wireless network
- Copper/fibre network

ICANN | ASO
Address Supporting Organization
Networks That Use Standard Protocols

- **Autonomous System Number (ASN)**
- **IP Address (IPv4)**
- **IP Address (IPv6)**
Noteworthy Developments
Global IPv4 Depletion at IANA – Feb 2011

Each RIR received its last /8 IPv4 address block from IANA on 3 February 2011
Available IPv4 Space in each RIR

- Measured in /8s

<table>
<thead>
<tr>
<th>RIR</th>
<th>Available IPv4 Space in /8s</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFRINIC</td>
<td>0.07</td>
</tr>
<tr>
<td>APNIC</td>
<td>0.15</td>
</tr>
<tr>
<td>ARIN</td>
<td>0</td>
</tr>
<tr>
<td>LACNIC</td>
<td>0</td>
</tr>
<tr>
<td>RIPE NCC</td>
<td>0</td>
</tr>
</tbody>
</table>

As of 12/23
Post IPv4 Depletion

• **Movement to IPv6 has been steady**
  - ISPs rolling out IPv6
  - Steady increase in IPv6 traffic
  - Increase in IPv6 requests

• **Still high demand for IPv4**
  - All RIRs still receiving significant number of IPv4 requests
  - Customers increasingly turning to the IPv4 market for address space
  - Increase in fraudulent requests for IPv4 space
    • Submitting falsified business records, personal ID documents, etc.
Per ISOC, in 2023 the rate of IPv6 deployment increased the most it has since 2018, growing from 34% to 39% globally.
- IPv6 deployment has risen an average of 3.5% each year since December 2017

Google IPv6 statistics show ~40% of global Internet traffic is over IPv6.

APNIC Labs says most significant gains were measured in Asia Pacific region.
- IPv6 deployment across Asia increased from 37.2% at the end of 2022 to 42.3% at the end of 2023.
- Across the same time, Oceania increased from 31.9% to 37.2%.
Total IPv6 Space Currently Allocated

- Total IPv6 space allocated (in /32s) by RIR

As of 12/23
Percentage of RIR Members with IPv6

As of 12/23
IPv4 Transfer Market

• Developed due to on-going demand for rapidly depleting IPv4 addresses
  • Choices were:
    • Facilitate IPv4 market transfers through RIR policies
    • Watch a black market emerge with no registry interaction

• Needs-based IPv4 market transfer policies developed by communities
  • Allowed IPv4 holders to transfer space to qualified recipients

• RIR’s role
  • Ensure compliance with needs-based policies
  • Maintain the accuracy of the registry
    • RIRs not privy to any financial transaction information between parties
Intra-RIR IPv4 Transfers

- # of transfers per year

As of 12/23
### Inter-RIR IPv4 Transfers

<table>
<thead>
<tr>
<th>Source RIR</th>
<th>RIPE</th>
<th>LACNIC</th>
<th>ARIN</th>
<th>APNIC</th>
<th>AFRINIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>RIPE</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>LACNIC</td>
<td>140</td>
<td>230</td>
<td>21</td>
<td>25</td>
<td>10</td>
</tr>
<tr>
<td>ARIN</td>
<td>1</td>
<td>0.02M</td>
<td>0.5M</td>
<td>0.26M</td>
<td>0.008M</td>
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<tr>
<td>APNIC</td>
<td>468</td>
<td>19.67M</td>
<td>1.32M</td>
<td>1.974M</td>
<td>0.0743M</td>
</tr>
<tr>
<td>AFRINIC</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**Total # of IPv4 transfers between RIRs**

<table>
<thead>
<tr>
<th>Source RIR</th>
<th>RIPE</th>
<th>LACNIC</th>
<th>ARIN</th>
<th>APNIC</th>
<th>AFRINIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>RIPE</td>
<td>2.524M</td>
<td>4.074M</td>
<td>0.054M</td>
<td>0.054M</td>
<td>0</td>
</tr>
<tr>
<td>LACNIC</td>
<td>0.002M</td>
<td>0.055M</td>
<td>0.002M</td>
<td>0.002M</td>
<td>0</td>
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<td>ARIN</td>
<td>468</td>
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</tbody>
</table>

As of 12/23
RIR Services and Tools
Public directory service
• Used to query databases that store registered users of an Internet resource

Whois

Differs in usage/content depending on the type of registry
• Number resource registries
• Domain name registries and registrars
• Routing registries

RIR’s Whois registry is still publicly accessible
• Publicly displayed registration data including:
  • IP number resources issued by RIRs or predecessor registry ("legacy" space)
  • Organizations and their contact info (mailing addresses, emails, phone numbers)
  • Original registration date and last updated date
  • Customer reassignment information (ISP customers)
  • Referential information to authoritative RIR
Future of Whois
Registration Data Access Protocol (RDAP)

- **RDAP** - new protocol for accessing registration data in a machine-readable way
  - Standardization (command, output & error structure)
  - Redirection capabilities (to authoritative server)
  - Support for user identification, authentication and access control
  - Supports Internationalization

- ICANN requires accredited registrars and gTLD registries to implement RDAP (in addition to port 43 WHOIS and web-based WHOIS)

- All RIRs and some DNRs have set up RDAP clients
The RIRs have deployed two technologies to help secure Internet routing:

• Resource Public Key Infrastructure (RPKI)
  • Security framework designed to improve/secure the Internet’s routing infrastructure
  • Verifies association between resource holders and their number resources

• Validated Internet Routing Registry (IRR)
  • Validation mechanisms added to IRR that guarantee routing announcements are published only by an authorized network
Resource Public Key Infrastructure (RPKI)

- Public key infrastructure framework designed to secure the Internet’s BGP routing infrastructure
- Cryptographically certifies network resources (AS Numbers & IP address prefixes) and route announcements
- Route Origin Authorizations (ROAs) define which AS is authorized to originate a prefix
- Provides stronger validation than existing technologies such as:
  - Internet Routing Registries (IRR)
  - Letters of Authority (LOA)
- 5 RIRs (NRO) collaborating on this cross-RIR project
Why is RPKI Important?

Establishes a **level of trust** that the RPKI information is authentic and is confirmed coming from the authorized holder of the resources.

The RPKI gives network operators a **method to make better judgments** on which is the valid source (origin) of a route announcement.

RPKI can **limit the impact** of a configuration mistake or nefarious activity of a bad actor.
# RPKI RIR Adoption

% of IP address space covered by RPKI certificates as of 12 Feb 2024

<table>
<thead>
<tr>
<th>REGION</th>
<th>IPv4 ADOPTION</th>
<th>IPv6 ADOPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFRINIC</td>
<td>28.65</td>
<td>7.89</td>
</tr>
<tr>
<td>APNIC</td>
<td>34.75</td>
<td>23.63</td>
</tr>
<tr>
<td>ARIN</td>
<td>31.42</td>
<td>63.23</td>
</tr>
<tr>
<td>LACNIC</td>
<td>50.31</td>
<td>49.38</td>
</tr>
<tr>
<td>RIPE NCC</td>
<td>66.48</td>
<td>38.18</td>
</tr>
</tbody>
</table>

Internet Routing Registry (IRR)

• Database of Internet route objects operated by individual organizations (e.g. RIRs)
  • Used to determine and share routing policies and announcements between network operators

• Ensures stability and consistency of Internet-wide routing
  • Provides mechanism for validating contents of announcements
  • Widely deployed to prevent accidental or intentional routing disturbances
  • Susceptible to error or manipulation

• RIRs working individually to add better validation processes to ensure accuracy and enhance security
For More Information

<table>
<thead>
<tr>
<th>Organization</th>
<th>Website</th>
</tr>
</thead>
<tbody>
<tr>
<td>APNIC</td>
<td><a href="https://www.apnic.net">https://www.apnic.net</a></td>
</tr>
<tr>
<td>AFRINIC</td>
<td><a href="https://www.afrinic.net">https://www.afrinic.net</a></td>
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