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"How It Works" The Regional Internet Registry System

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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

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The Regional Internet Registry (RIR) System

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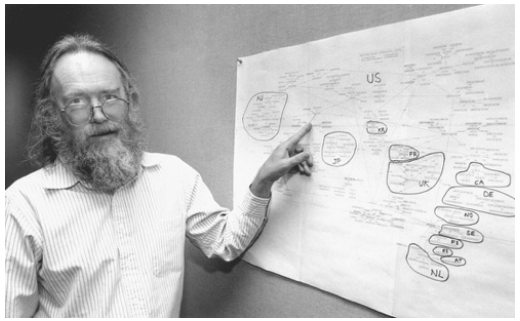
Brief History
Internet Number Resource (IP) Administration

- **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)



Jon Postel

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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

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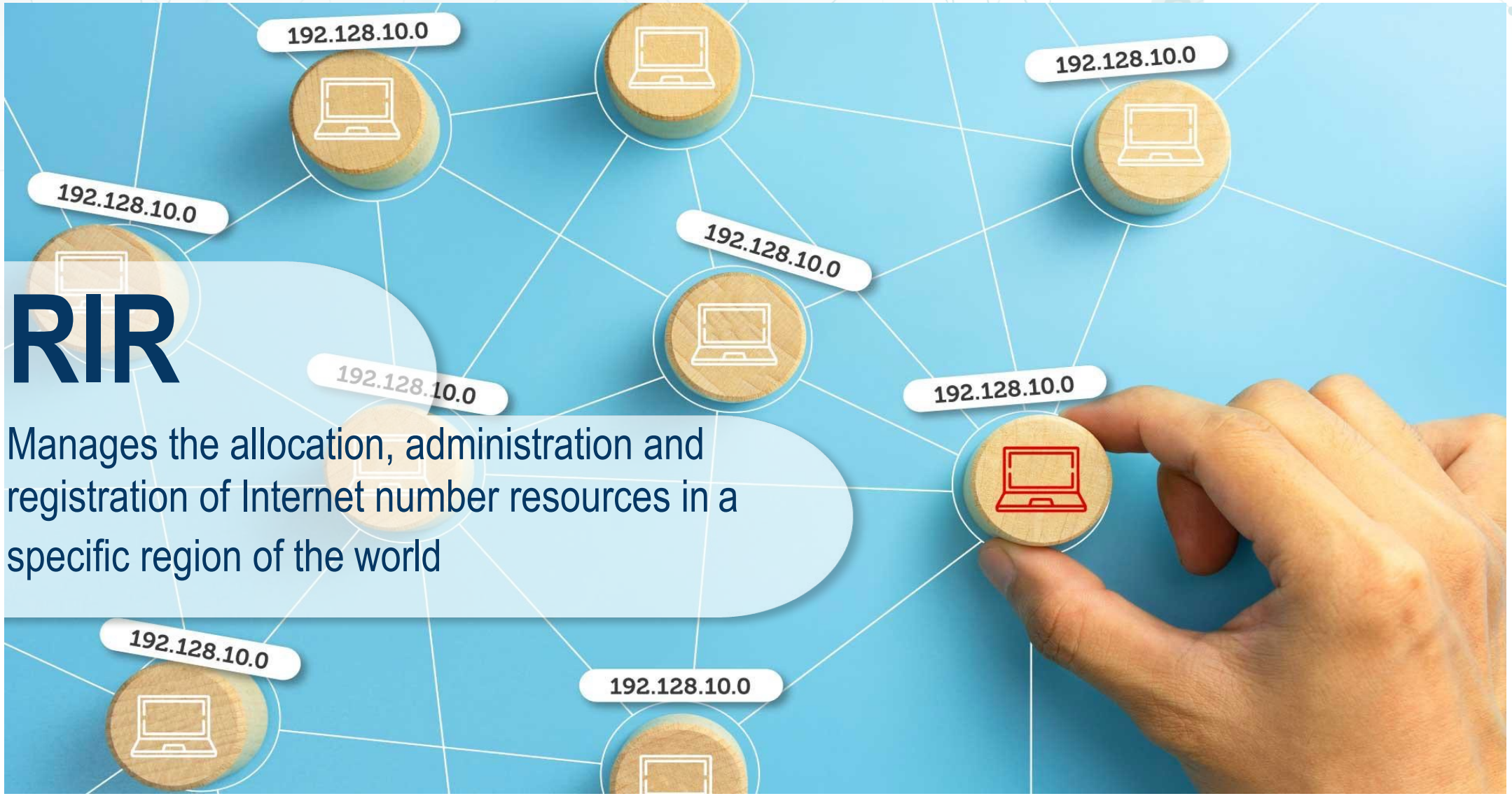

RIR

Manages the allocation, administration and registration of Internet number resources in a specific region of the world

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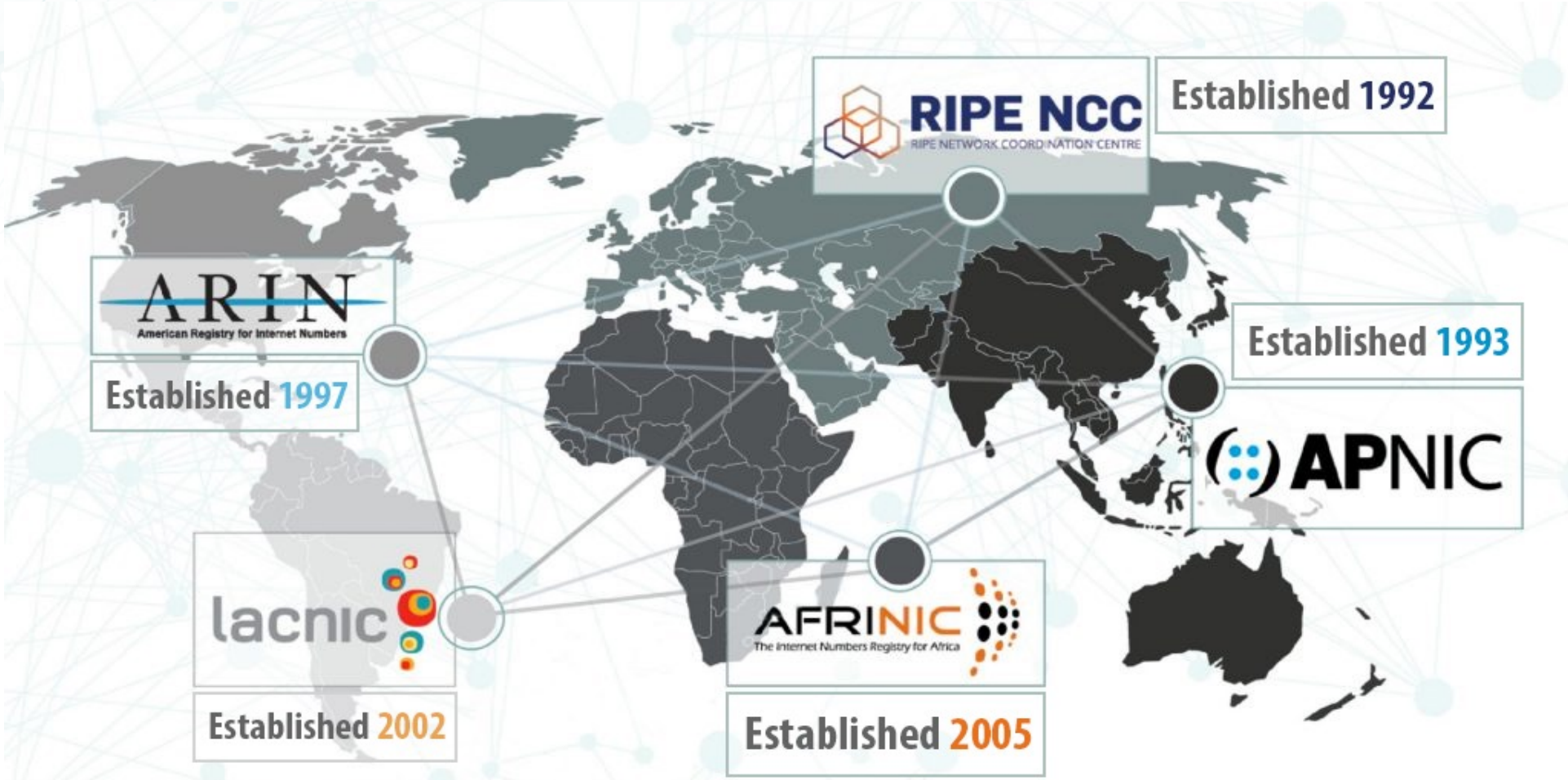
Who Are the RIRs?



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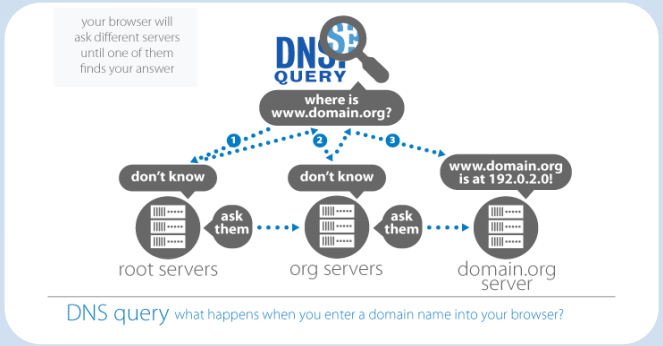
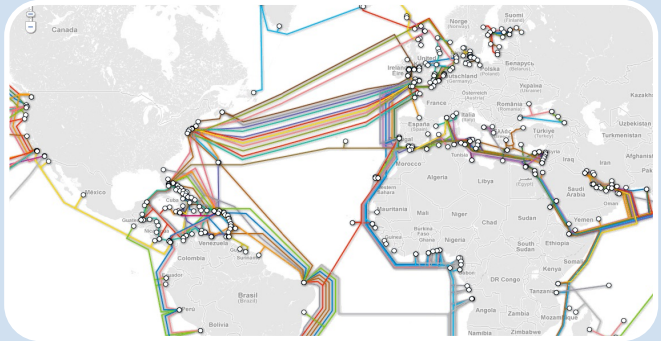
Core Functions of an RIR





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

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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

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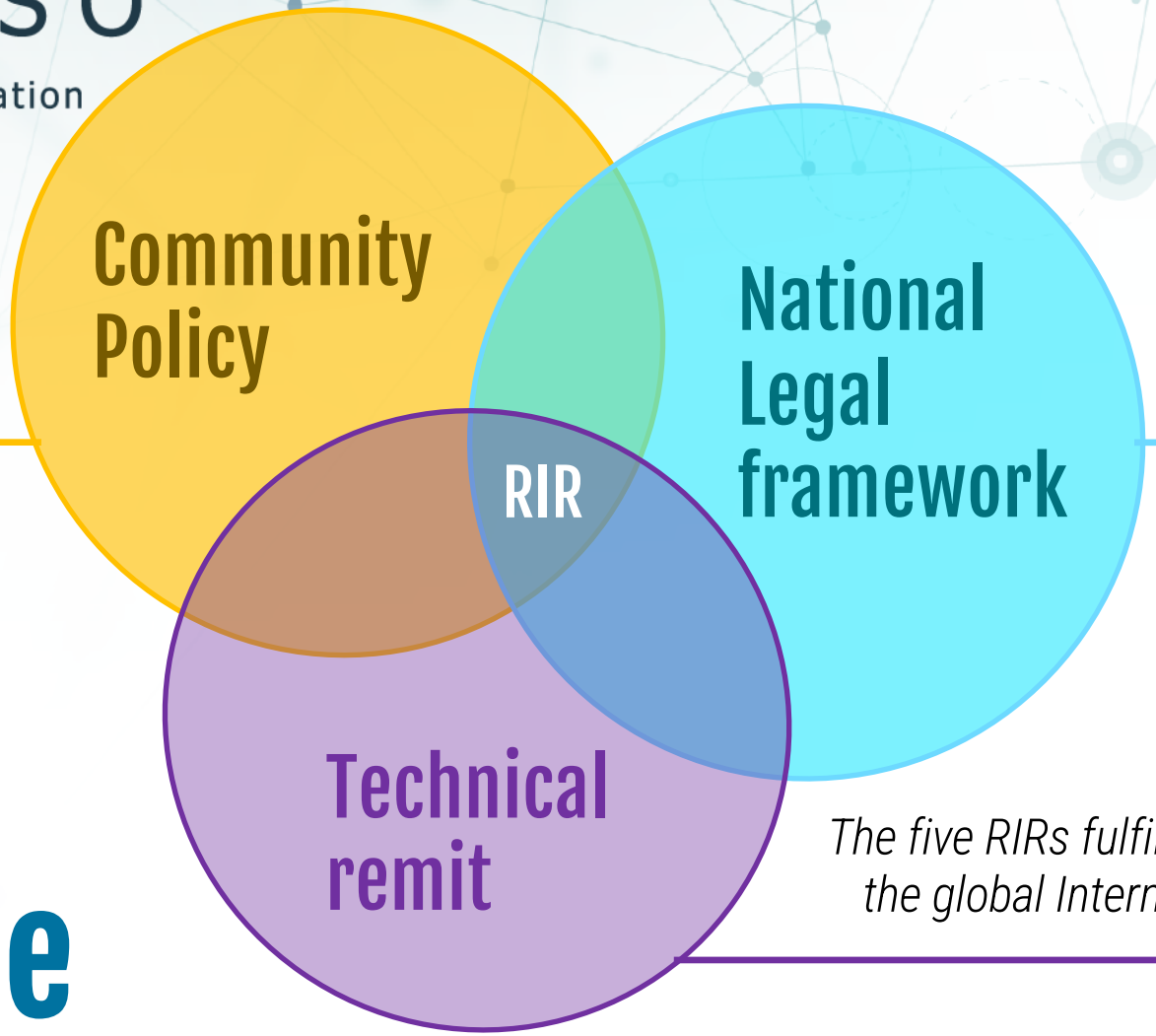
RIR Governance

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

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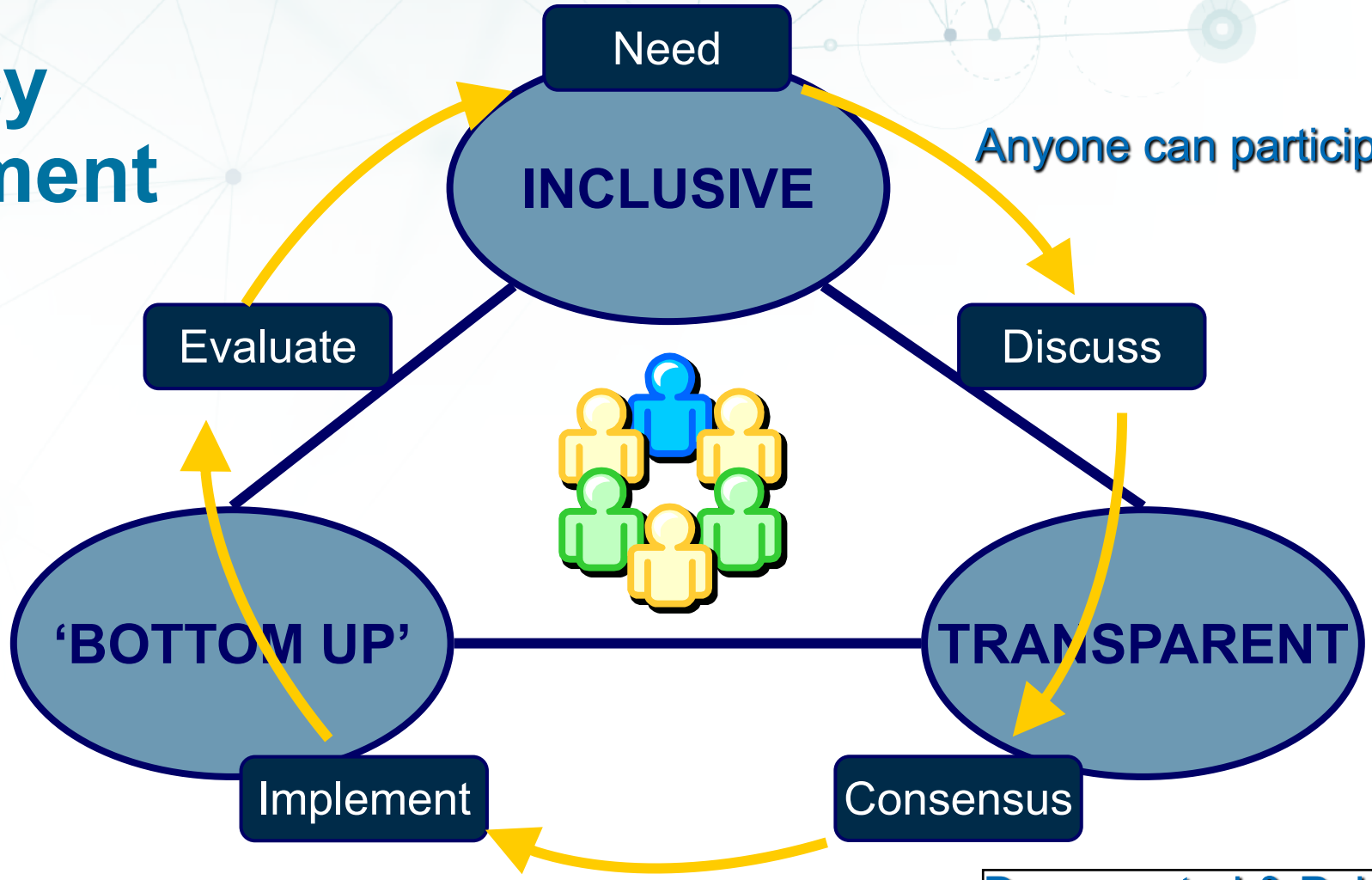
RIR Policy Development Process



Internet Community
Proposes & Approves Policy

Documented & Published
Decisions, Polices, & PDP

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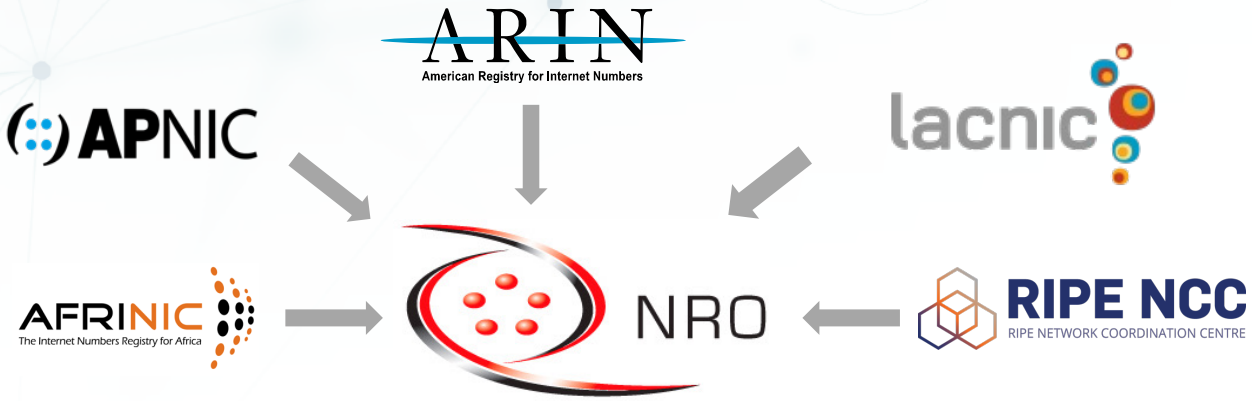
Number Resource Organization (NRO)



- **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/

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

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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.

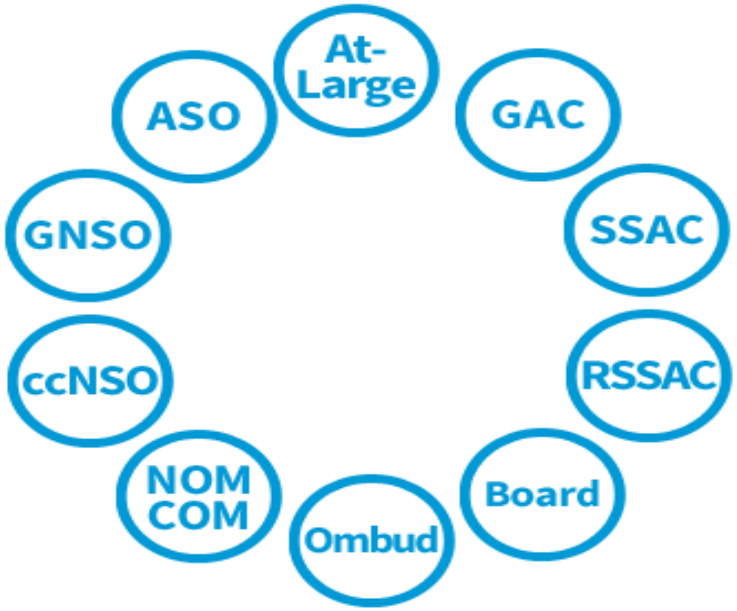
Learn how our multistakeholder model functions

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

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

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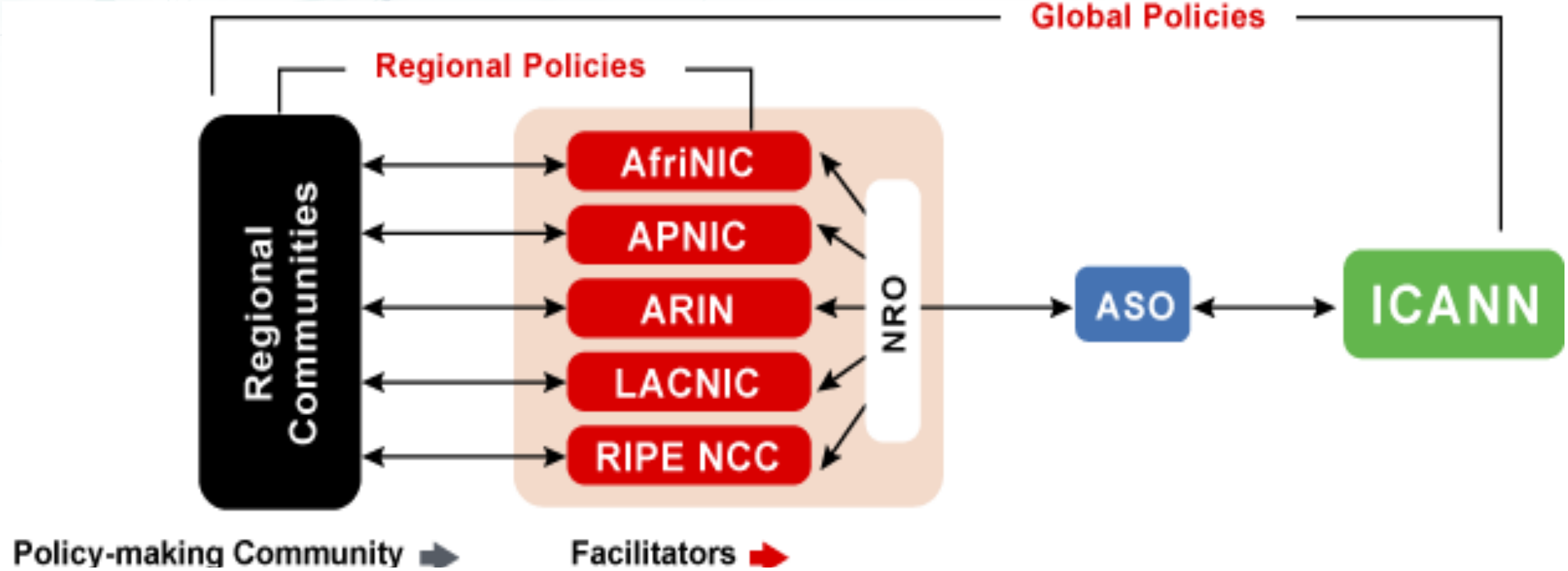
Global Policy Development Process



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Internet Number Resources

IPv4, IPv6, Autonomous System Numbers (ASNs)

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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= ~4.4 billion
  - e.g. 205.150.58.7
- **IPv6**
  - 128-bit addresses; written in hexadecimal
  - 2^128= ~50 octillion for each of the roughly 6.5 billion people alive
  - e.g. 2001:0503:0C27:0000:0000:0000:0000:0000

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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*** *t*o control routing within their networks and to exchange routing information with other Internet Service Providers (ISPs)

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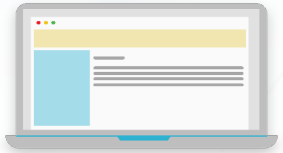
IP Addresses are *Not* Domain Names

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

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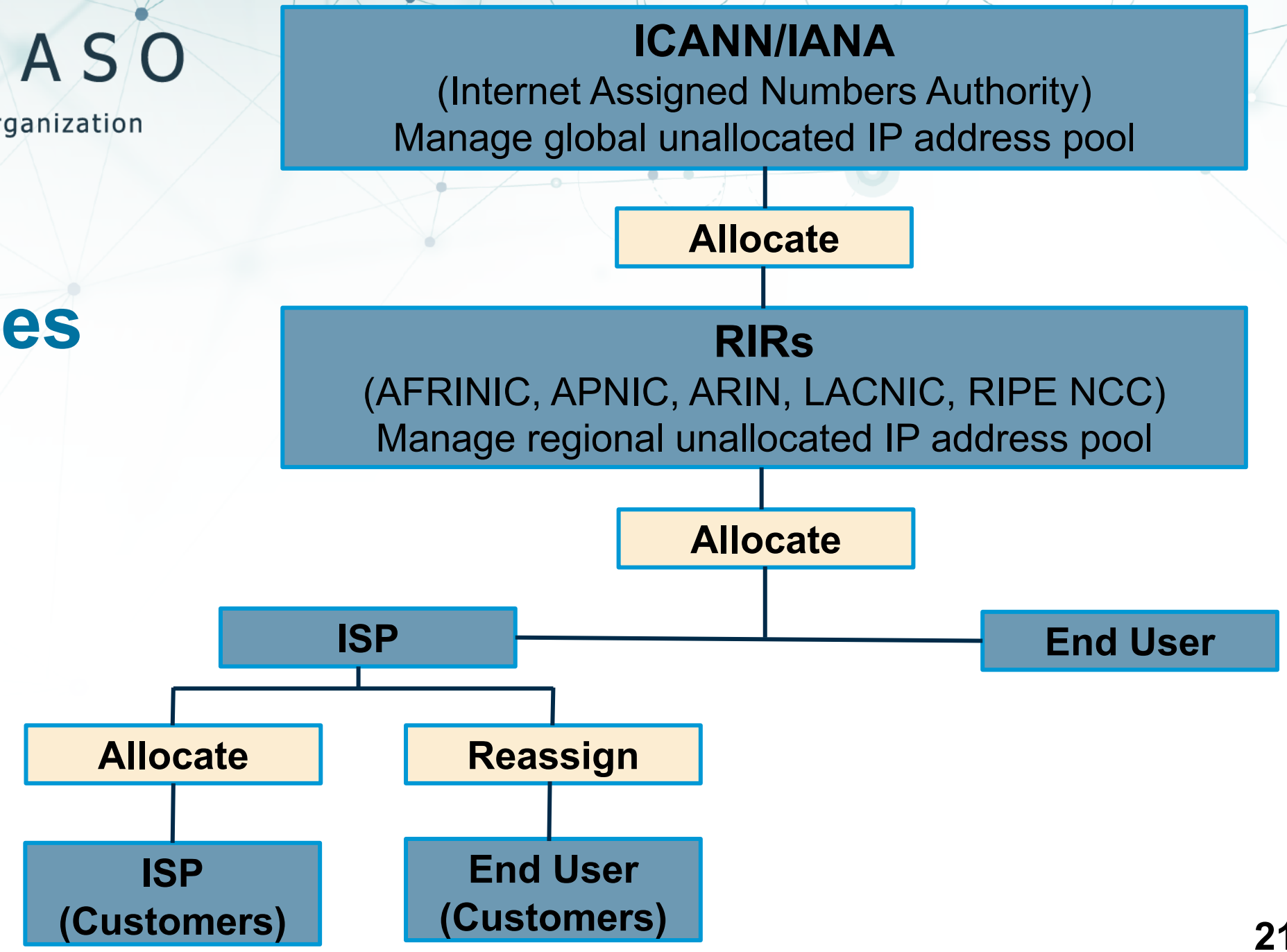
How IP Addresses Are Issued



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Routing

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Core Internet Functions: DNS & 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)

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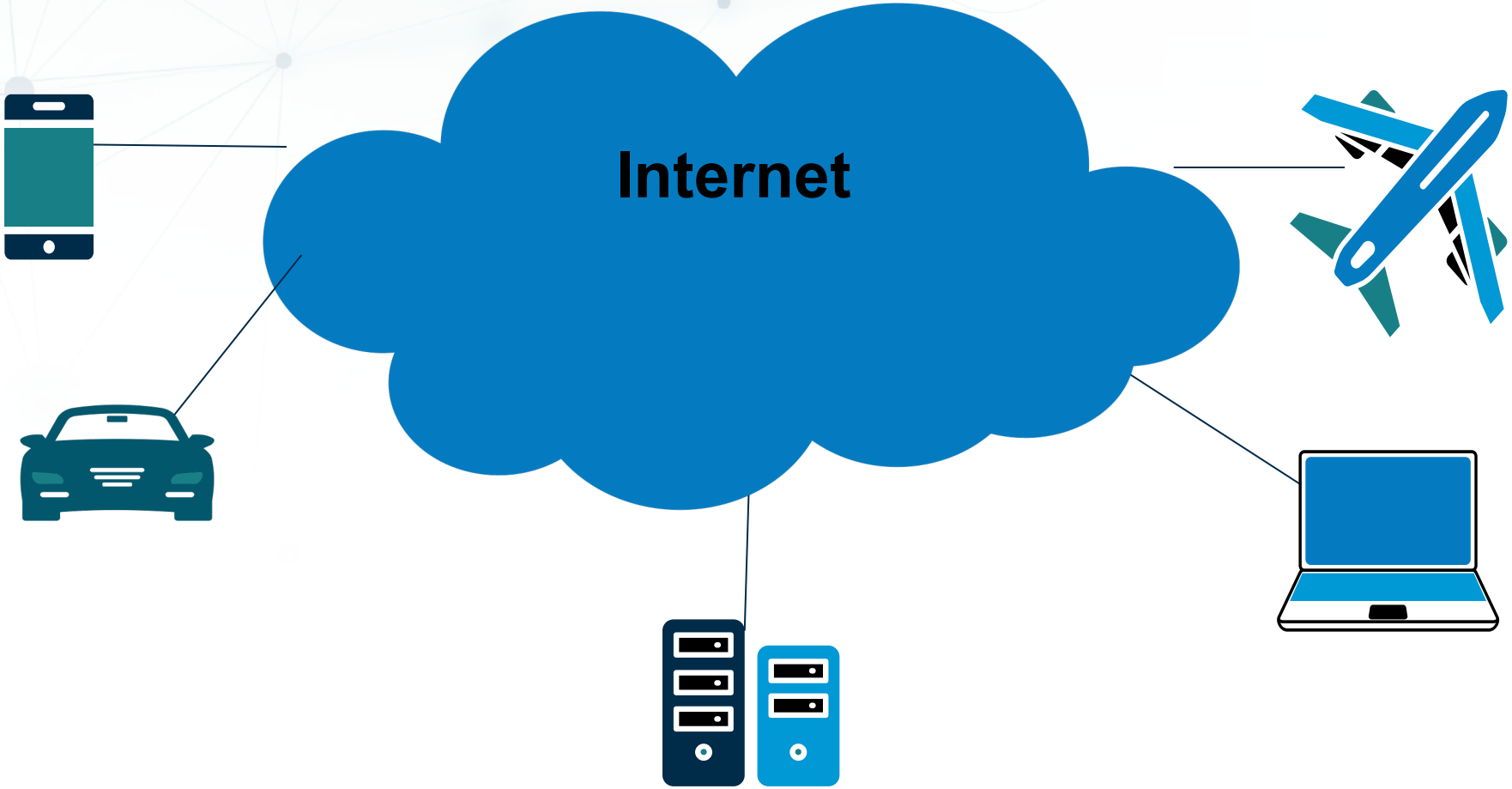
The Internet is a Series of Networks



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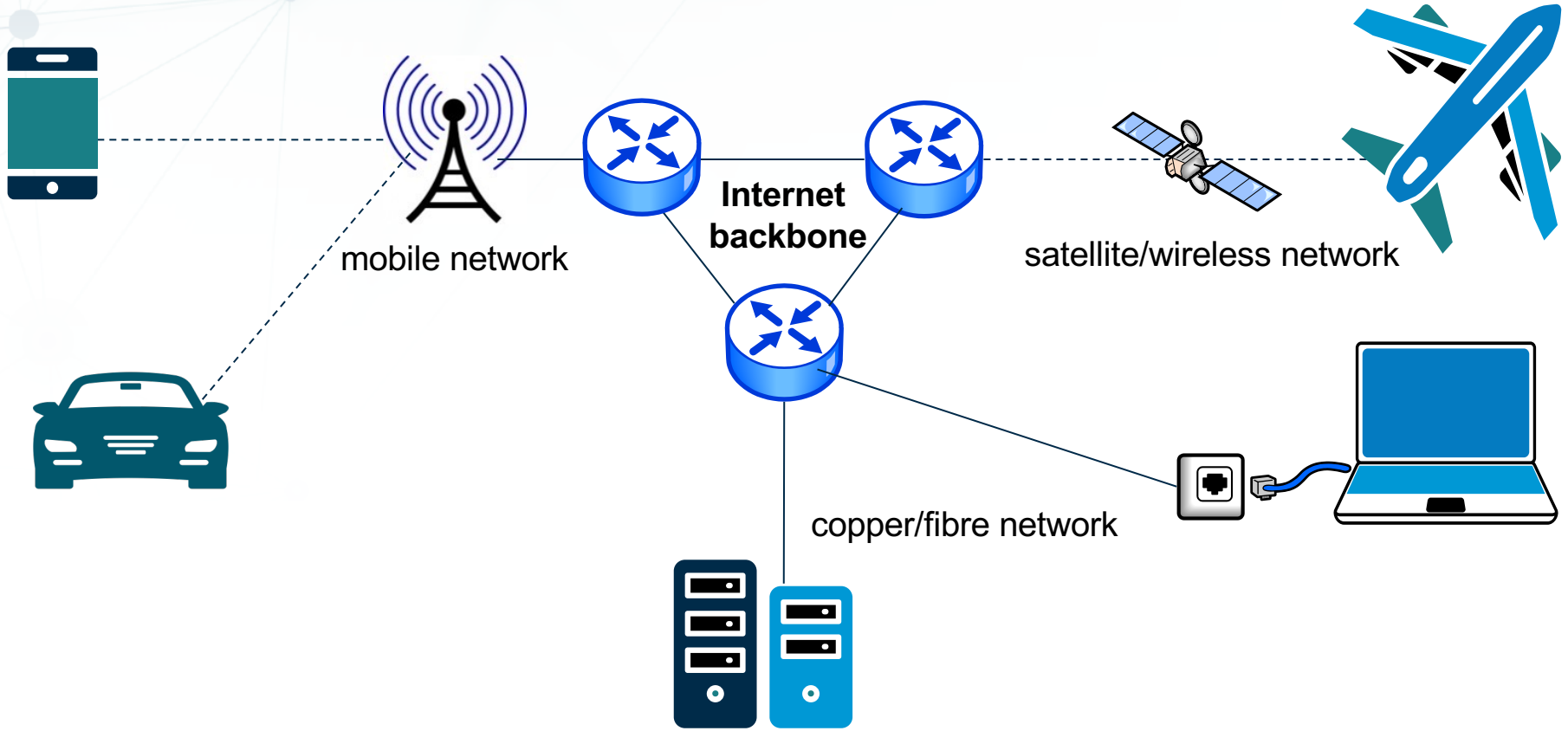
A Network of Networks



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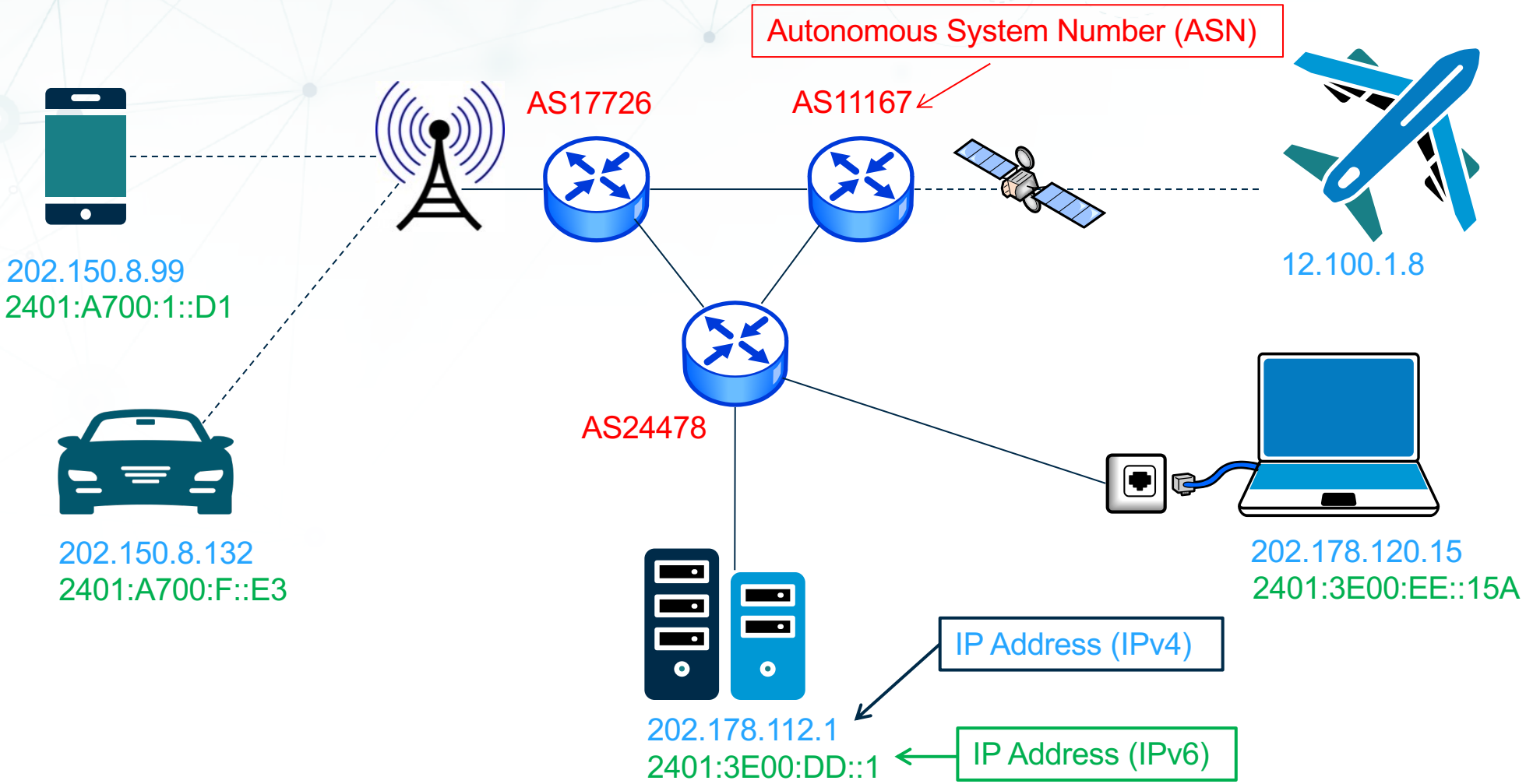
Networks That Use Standard Protocols



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Noteworthy Developments

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Global IPv4 Depletion at IANA – Feb 2011

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

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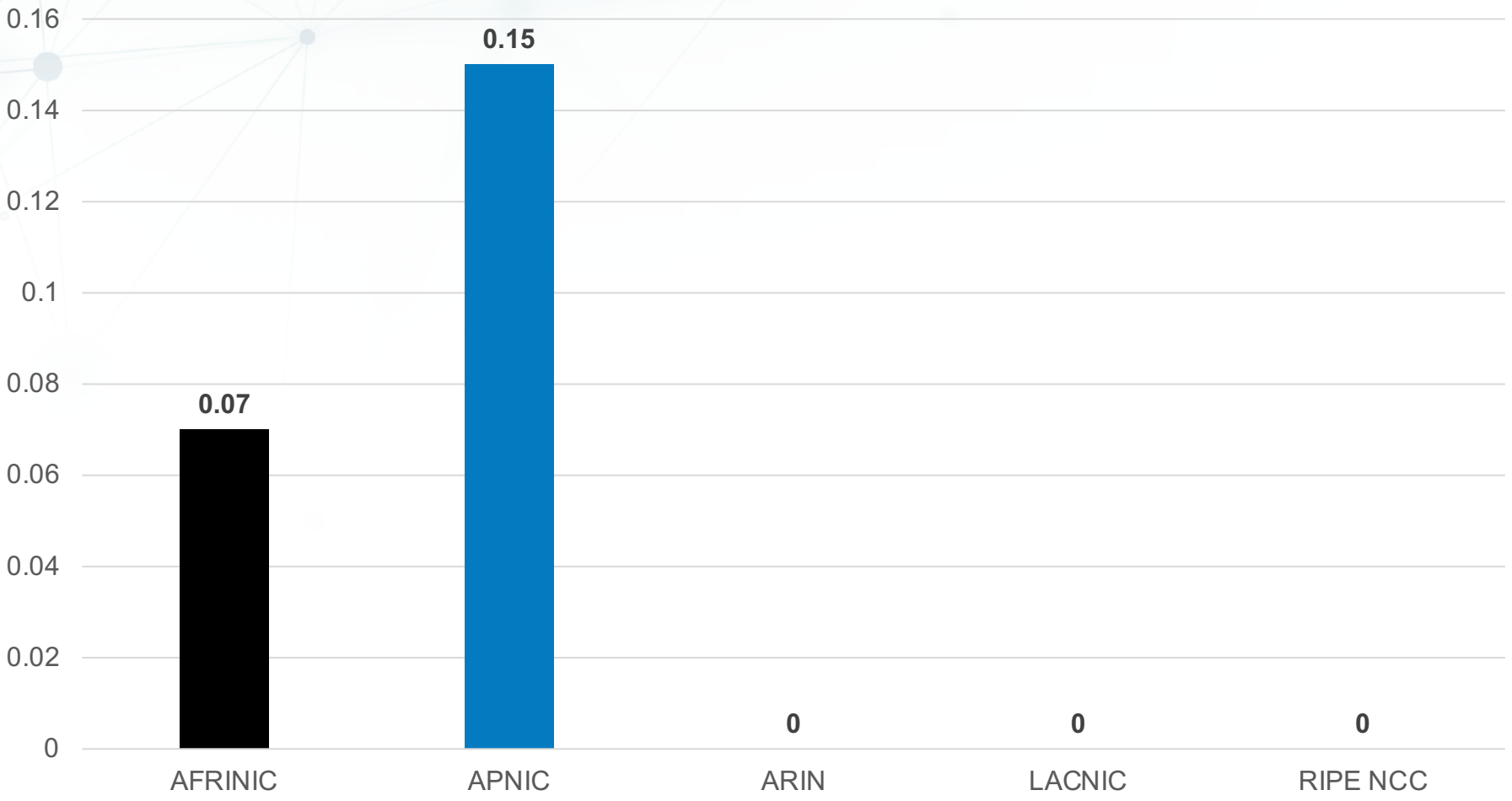
Available IPv4 Space in each RIR

- **Measured in /8s**



As of 12/23

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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.

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IPv6 Deployment

- 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%

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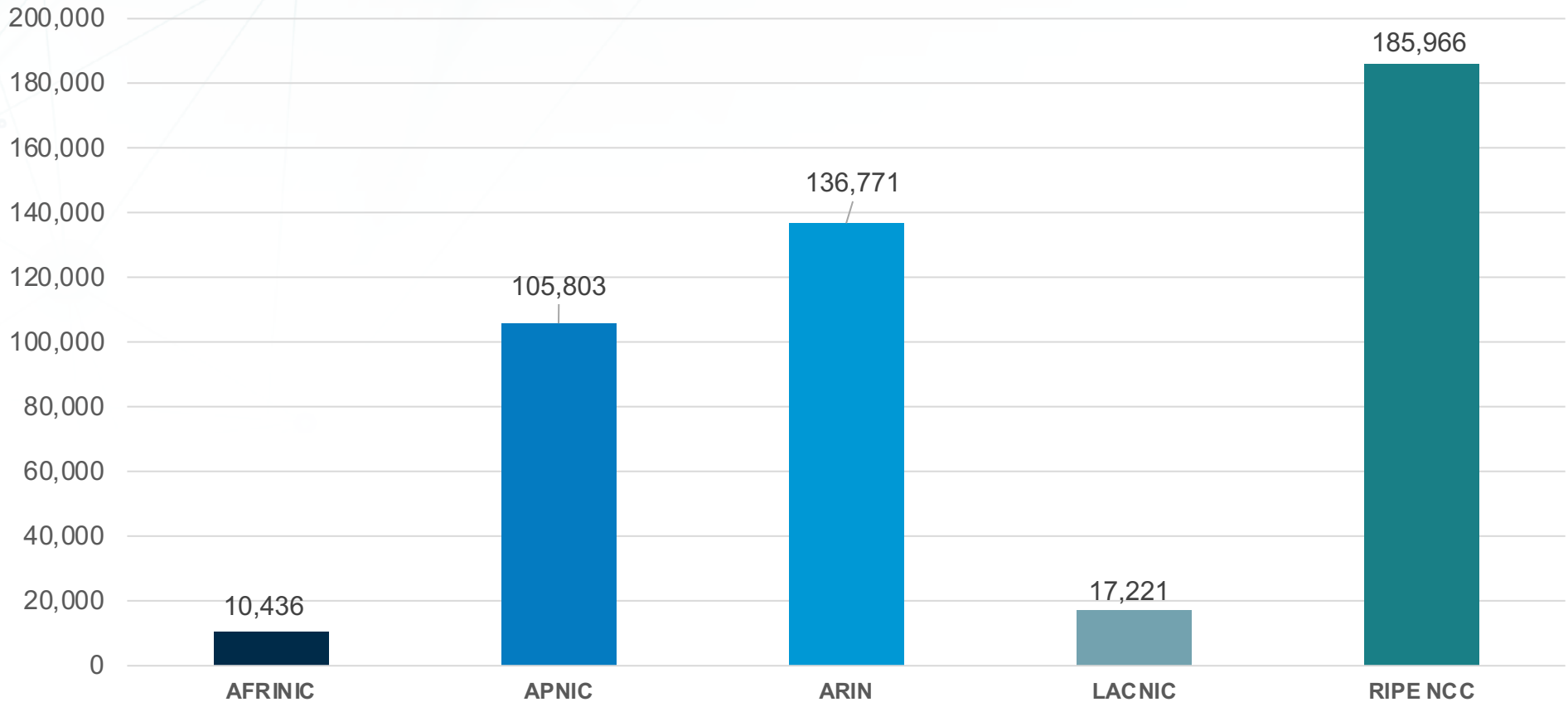
Total IPv6 Space Currently Allocated

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



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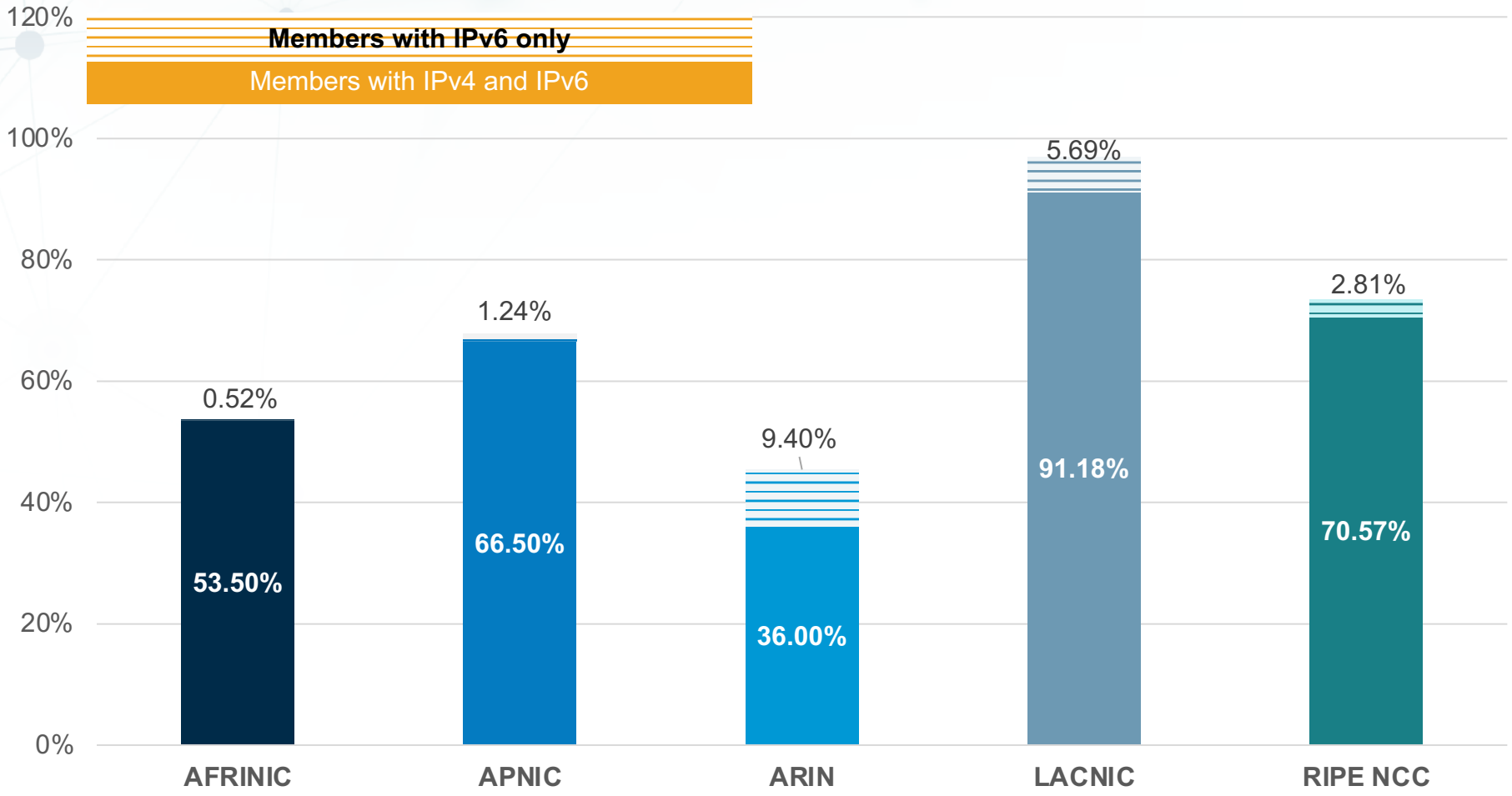
Percentage of RIR Members with IPv6



As of 12/23

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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

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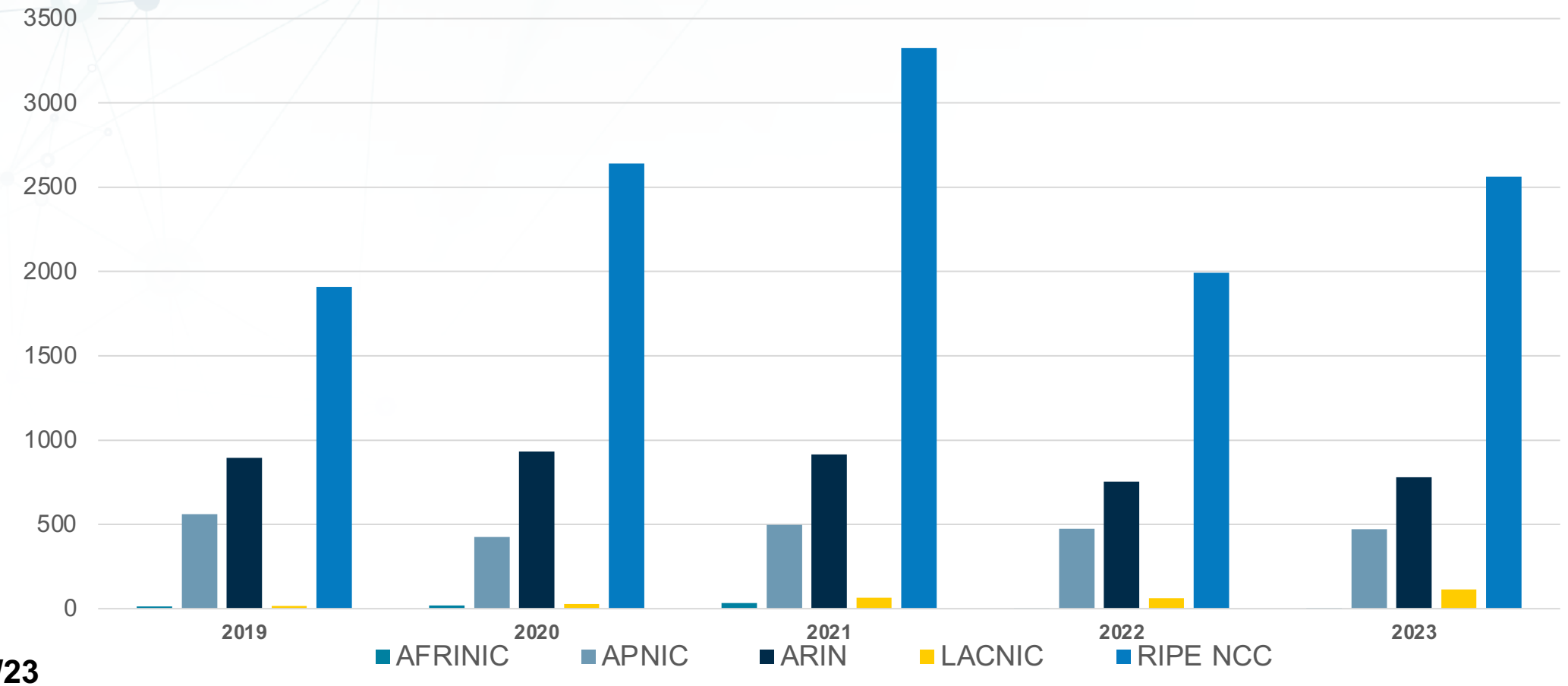
Intra-RIR IPv4 Transfers

- # of transfers per year



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Inter-RIR IPv4 Transfers

- **Total # of IPv4 transfers between RIRs**

# of transfers / # of addresses transferred	Recipient RIR: AFRINIC	APNIC	ARIN	LACNIC	RIPE NCC
Source RIR: AFRINIC		0	0	0	0
APNIC	0		159 / 1.32M	5 / .00743M	341 / 2.363M
ARIN	0	468 / 19.67M		25 / .026M	576 / 19.44M
LACNIC	0	1 / .002M	21 / .055M		29 / .054M
RIPE NCC	0	140 / 2.524M	230 / 4.074M	10 / .008M	

As of 12/23

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RIR Services and Tools

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Whois

Public directory service

- Used to query databases that store registered users of an Internet resource

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

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RIR Whois Information

- **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

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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

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Routing Security Tools

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

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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

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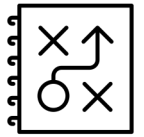
Why is RPKI Important?

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

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RPKI RIR Adoption

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

REGION	IPv4 ADOPTION	IPv6 ADOPTION
AFRINIC	28.65	7.89
APNIC	34.75	23.63
ARIN	31.42	63.23
LACNIC	50.31	49.38
RIPE NCC	66.48	38.18

https://ftp.ripe.net/pub/stats/ripencc/nro-adoption/latest/rir-adoption.txt

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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

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For More Information

APNIC	• https://www.apnic.net
AFRINIC	• https://www.afrinic.net
RIPE NCC	• https://www.ripe.net
ARIN	• https://www.arin.net
LACNIC	• https://www.lacnic.net

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