ICANN 75

ANNUAL GENERAL

KUALA LUMPUR

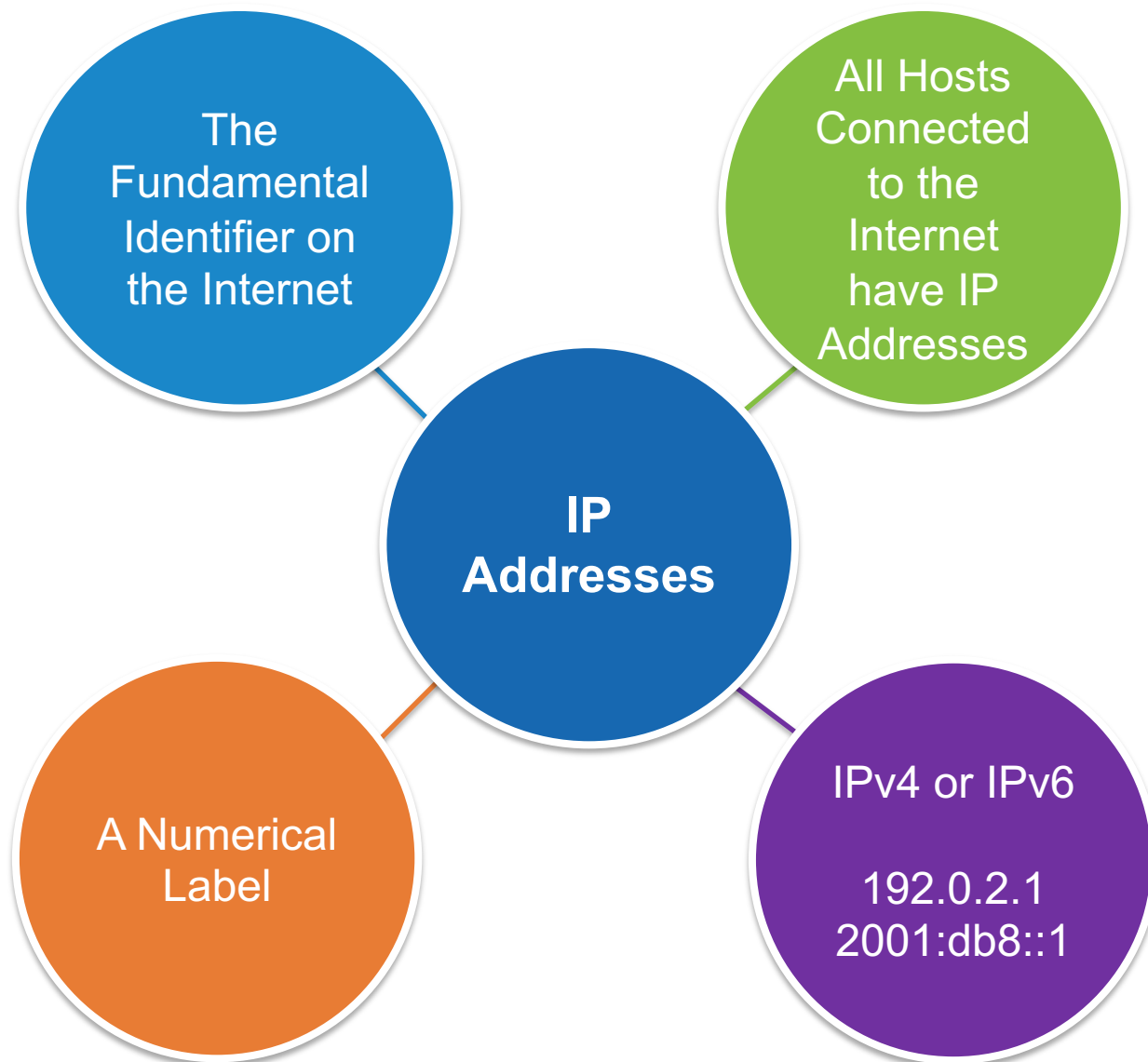# Root Server System Information Session
September 20, 2022

Outline

- Overview of the Domain Name System

- Explanation of Anycast

- Root Server System Today

- RSSAC and RSSAC Caucus

- Root Server System Evolution

Overview of the Domain Name System

Recap: Identifiers on the Internet

The Fundamental Identifier on the Internet

All Hosts Connected to the Internet have IP Addresses

IP Addresses

A Numerical Label

IPv4 or IPv6

192.0.2.1
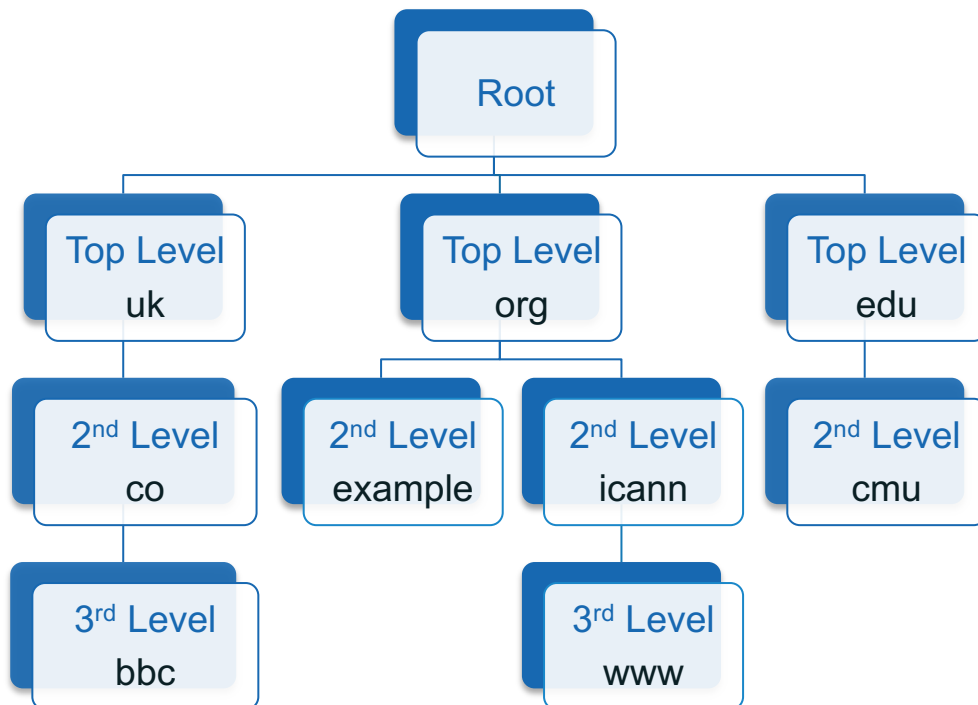2001:db8::1

Why DNS?

Original Problem

- **IP addresses are hard to remember.**

- **IP addresses often change.**

Modern Problem

- **IP addresses may also be shared.**

- **Multiple IP addresses may serve as entry points to a single service. Which IP address to use?**

The Domain Name System

A look up mechanism for translating objects into other objects

```
                    Root
         ┌───────────┼───────────┐
    Top Level    Top Level    Top Level
       uk           org          edu
        │        ┌────┴────┐       │
    2nd Level  2nd Level 2nd Level 2nd Level
       co       example    icann     cmu
        │                   │
    3rd Level           3rd Level
       bbc                 www
```

name-to-IP Address
www.example.org ➡ 198.51.100.52

Many Other Mappings
Mail Servers
IPv6
Reverse

A globally distributed, loosely coherent, scalable, dynamic database

Definitions

- Root Service
  - The collective services provided by all the server instances managed by all of the root server operators.

- Root Server System (RSS)
  - The set of root servers that collectively implements the root service.

- Root Zone
  - The DNS zone at the top of the DNS hierarchy. It has no parent and contains all the information necessary to contact the TLDs under it.

- Root Server Anycast Instance
  - One network location responding to DNS queries on a root server operator's IP address.

Definitions (roles)

- Root Zone Administrator (RZA)
  - Organization responsible for managing the data contained within the root zone, which involves assigning the operators of top-level domains and maintaining their technical and administrative details.

- Root Zone Maintainer (RZM)
  - Organization responsible for accepting service data from the Root Zone Administrator, formatting it into zone file format, cryptographically signing it, and distributing it to the Root Server Operators.

- Root Server Operator (RSO)
  - An organization responsible for managing the root service on IP addresses specified in the root zone and the root hints file.

Root Zone vs. Root Server System

Root Zone

- The starting point: the list of TLDs and their nameservers

- Managed by ICANN, per community policy

- Compiled & distributed by the Root Zone Maintainer to all root server operators

- The information served by the root servers

Root Server System

- Responds with data from the root zone

- Currently distributed from 26 IP addresses, 13 IPv4 and 13 IPv6, from over 1500 instances

- Purely technical role to serve the root zone

- Responsibility of the root server operators

Domain Name Resolution Process
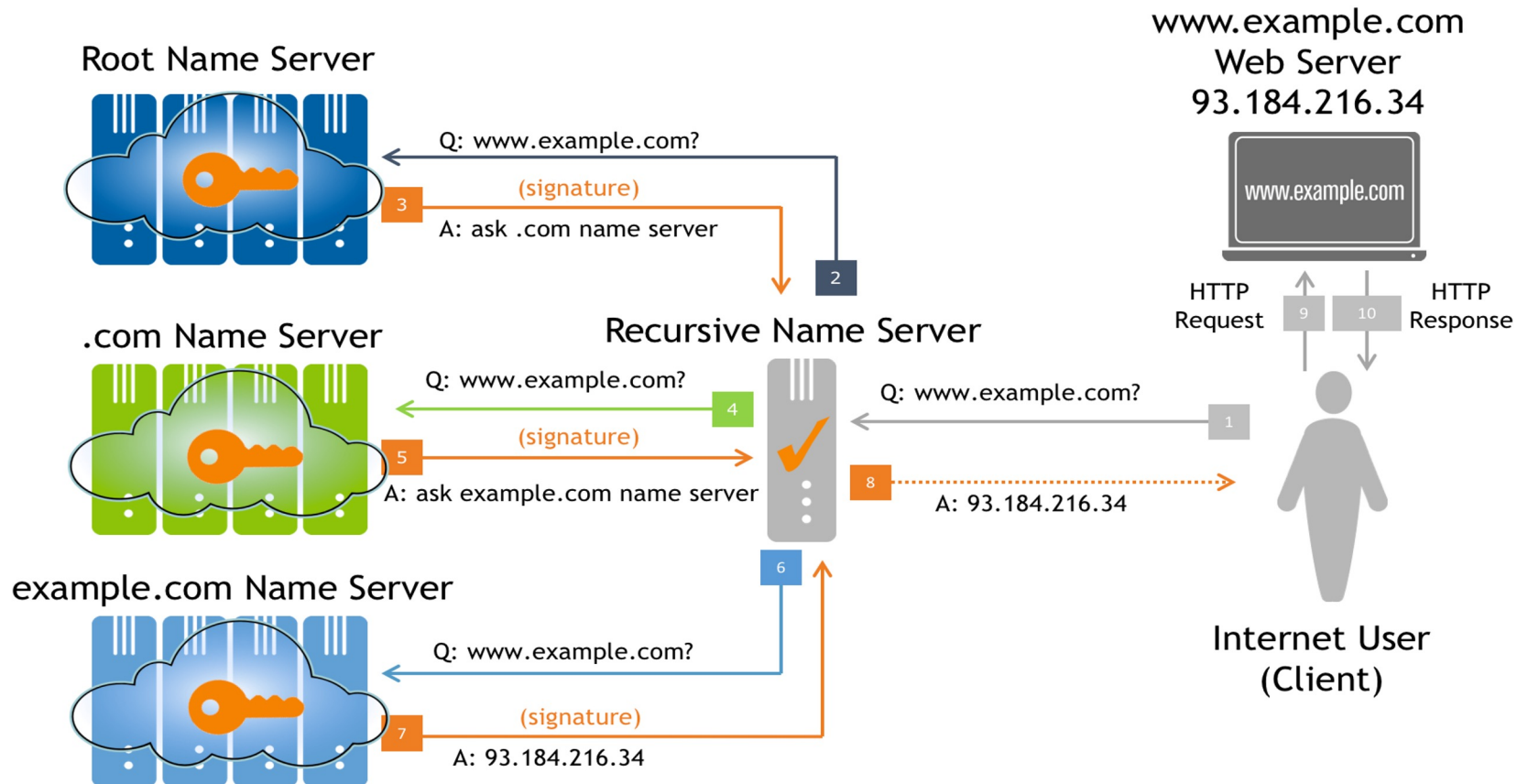
- Root Servers are at the entry point to the system.
- Caching is used throughout to avoid repetitive queries.
- The DNS resolution precedes the actual transaction the users want to do (web, mail, voip call, etc.).

Domain Name Resolution Process

Root servers only know what servers need to be asked next.

For names ending in..

.com ➡ list of .com servers

.net ➡ list of .net servers

.org ➡ list of .org servers

Caching of previous answers means once information about a TLD is known, it is unnecessary to ask a root server again for up to 2 days

Some Modern Refinements to DNS

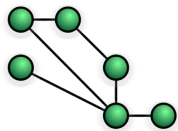|	
DNSSEC (security extensions)	• Cryptographic signatures on DNS data • Reduces risk of "spoofing" • Resolver should validate the answers
Privacy Enhancements	• Queries can leak information • Standards work is ongoing to address this • Query name minimization, DNS-over-TLS (DoT) & DNS-over-HTTPS (DoH)
Anycast	• Multiple servers share a single IP address • Improves latency and resilience • Protects against DDoS attacks

Explanation of Anycast

Unicast vs. Anycast

Unicast

- Packets from sources all go to the same destination

- A single instance serves all sources

- DDoS attack traffic all goes to single instance

Anycast

- Multiple instances serve the same data to all sources

- Sources reach destination based on intermediate routing policies

- Sources get the data faster

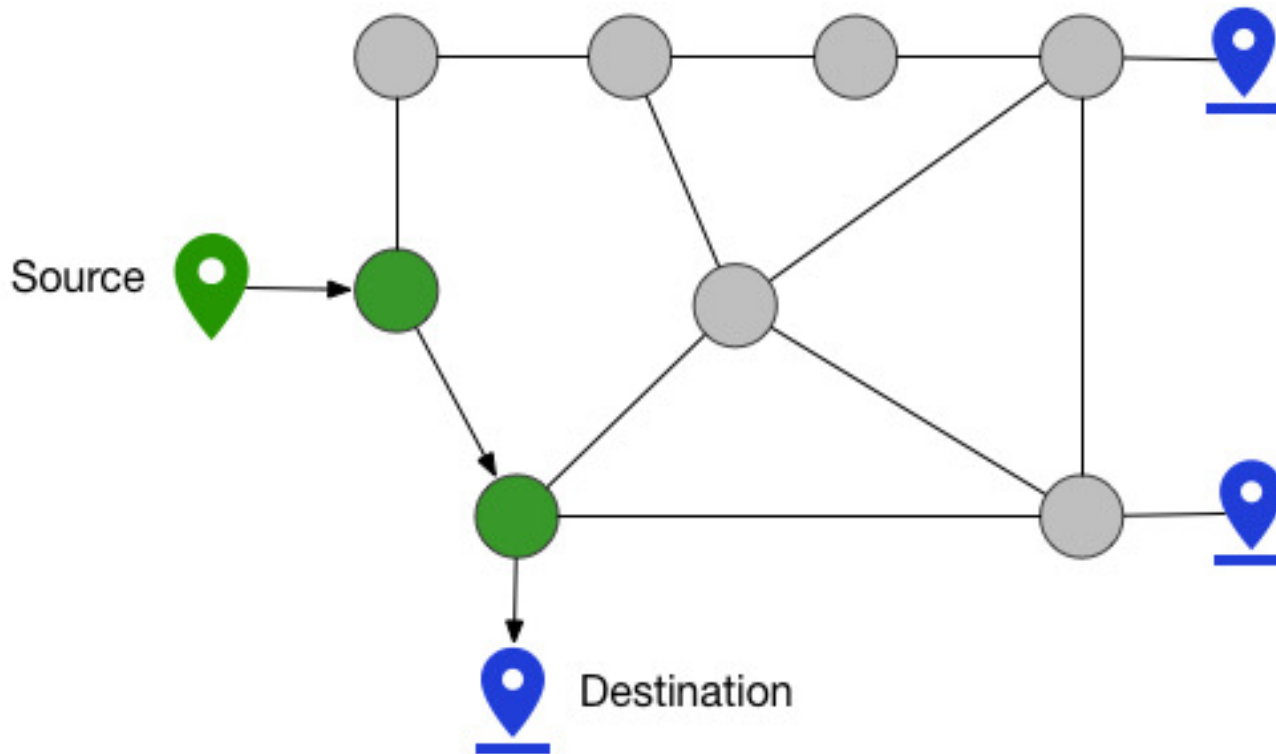- DDoS attack traffic is sent to the closest instance

Unicast

Traffic takes shortest route to single destination.
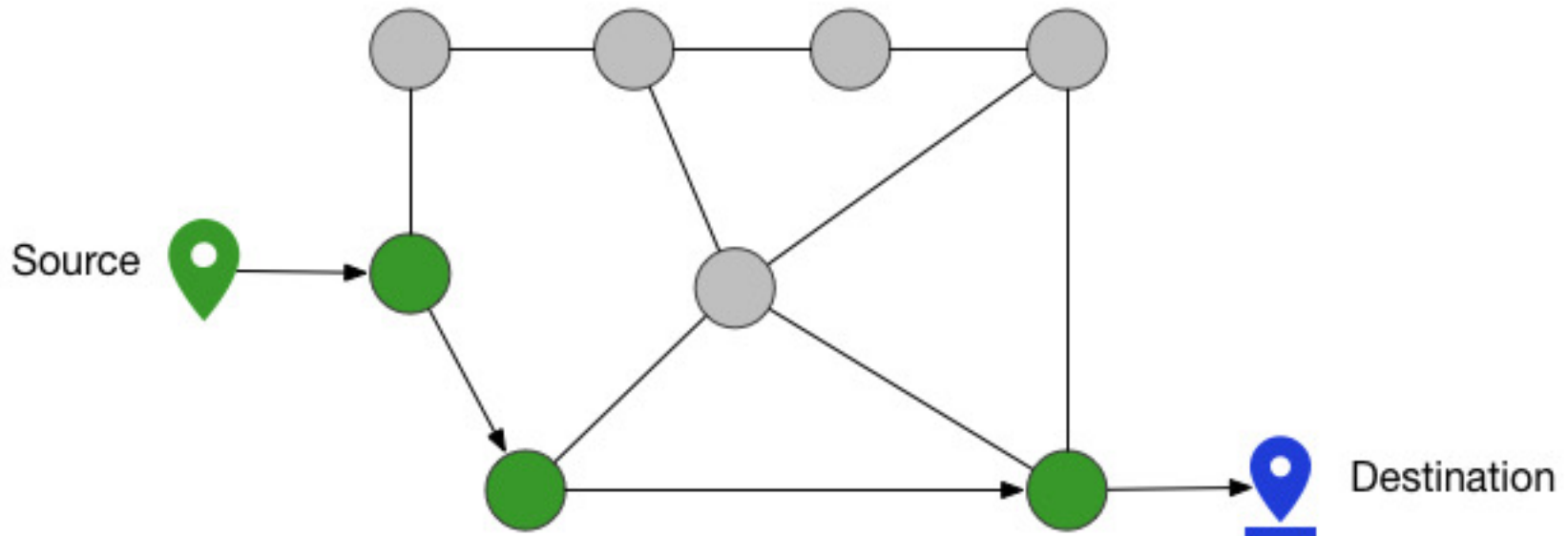
Anycast

- Traffic takes shortest route to closest destination.
- Intermediate routing policies determine the destination for a source.
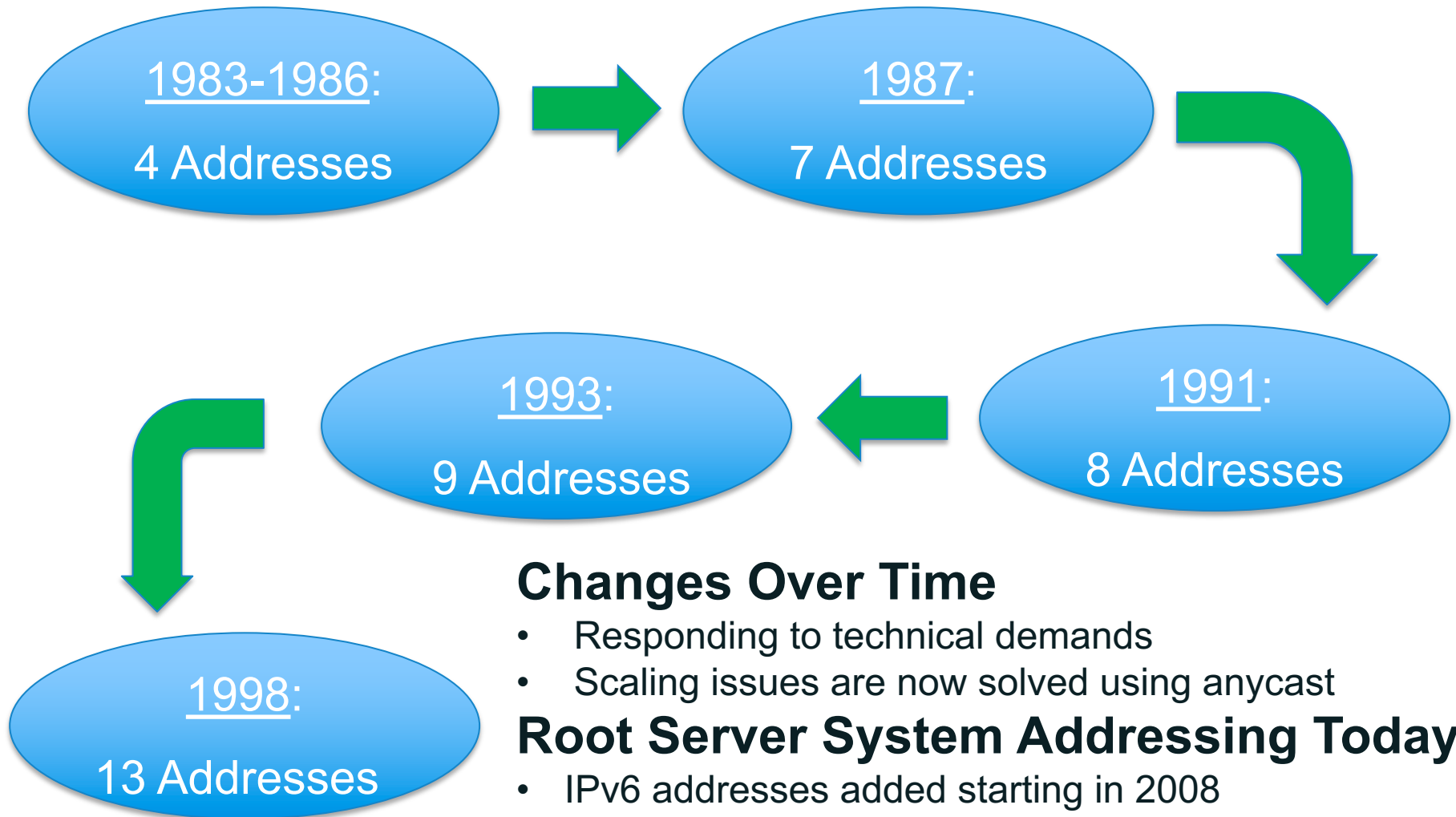- Path is shortened and data is delivered more quickly.

Anycast Under DDoS Attacks

- DDoS attack traffic also takes shortest route to closest destination, thus gets distributed across all destinations.
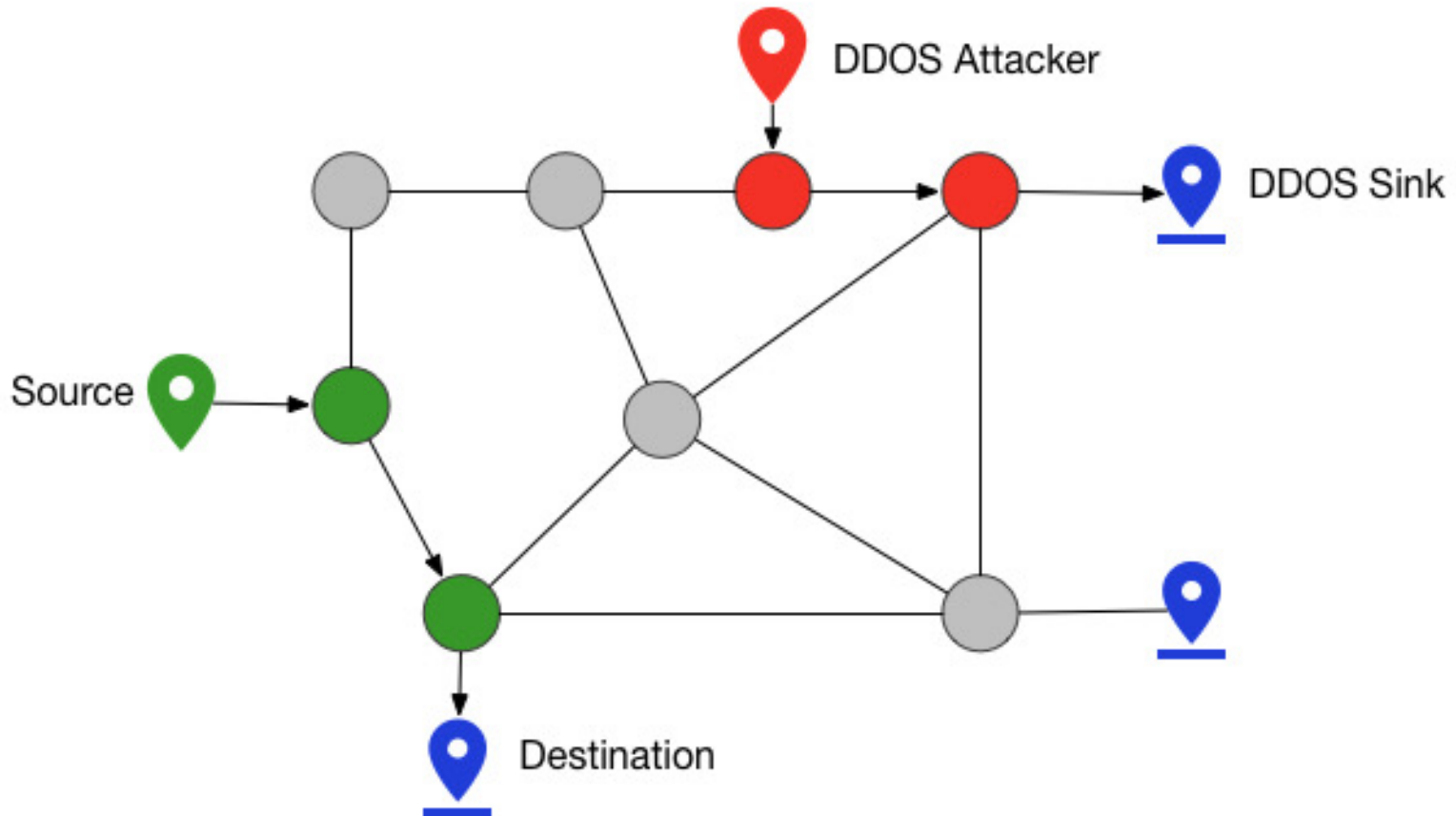
Root Server System Today

Growth of the Root Server System

1983-1986:

4 Addresses

➡

1987:

7 Addresses

1993:

9 Addresses

⬅

1991:

8 Addresses

1998:

13 Addresses

Changes Over Time

- Responding to technical demands
- Scaling issues are now solved using anycast

Root Server System Addressing Today

- IPv6 addresses added starting in 2008
- 26 IP addresses, 13 IPv4 and 13 IPv6
- Served from over 1500 Instances

Root Server Identifiers Today - 2019

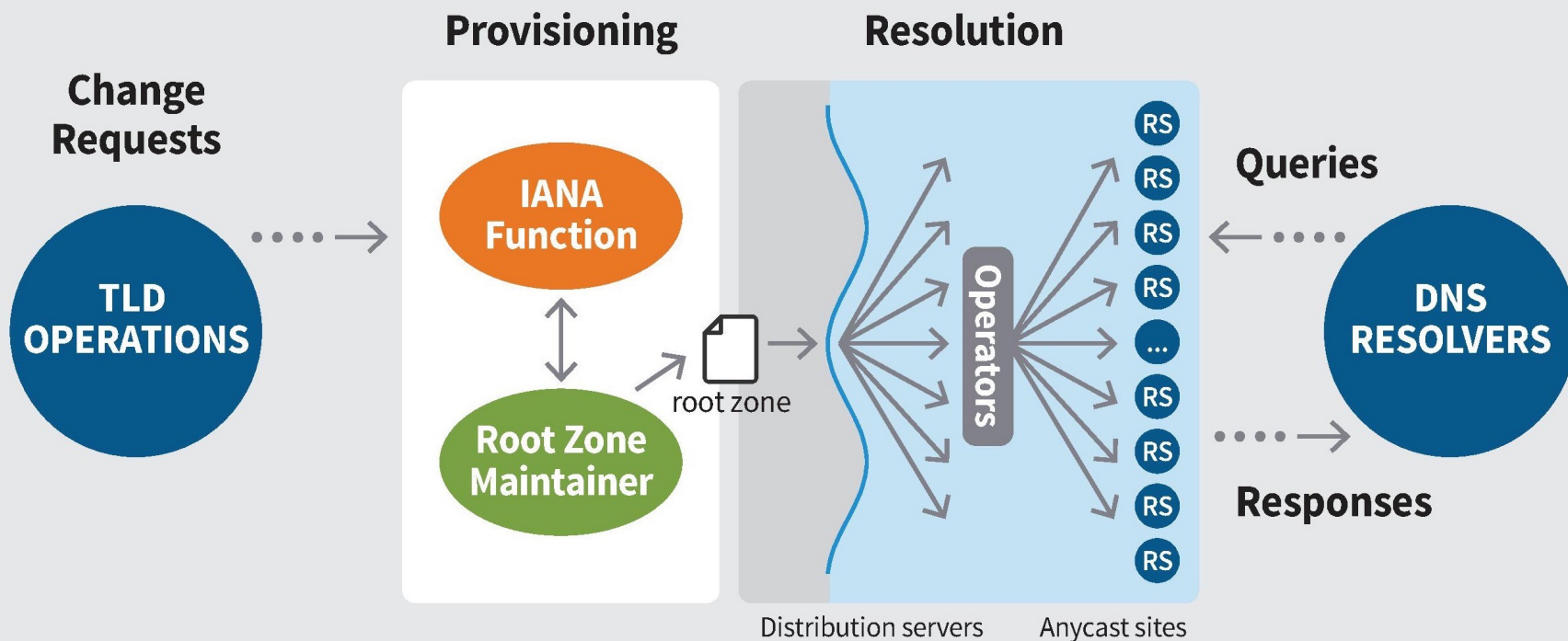| Hostname	IP Addresses	Manager
a.root-servers.net	198.41.0.4, 2001:503:ba3e::2:30	VeriSign, Inc.
b.root-servers.net	199.9.14.201, 2001:500:200::b	University of Southern California (ISI)
c.root-servers.net	192.33.4.12, 2001:500:2::c	Cogent Communications
d.root-servers.net	199.7.91.13, 2001:500:2d::d	University of Maryland
e.root-servers.net	192.203.230.10, 2001:500:a8::e	NASA (Ames Research Center)
f.root-servers.net	192.5.5.241, 2001:500:2f::f	Internet Systems Consortium, Inc.
g.root-servers.net	192.112.36.4, 2001:500:12::d0d	US Department of Defence (NIC)
h.root-servers.net	198.97.190.53, 2001:500:1::53	US Army (Research Lab)
i.root-servers.net	192.36.148.17, 2001:7fe::53	Netnod
j.root-servers.net	192.58.128.30, 2001:503:c27::2:30	VeriSign, Inc.
k.root-servers.net	193.0.14.129, 2001:7fd::1	RIPE NCC
l.root-servers.net	199.7.83.42, 2001:500:9f::42	ICANN
m.root-servers.net	202.12.27.33, 2001:dc3::35	WIDE Project

Root Servers Today - 2022
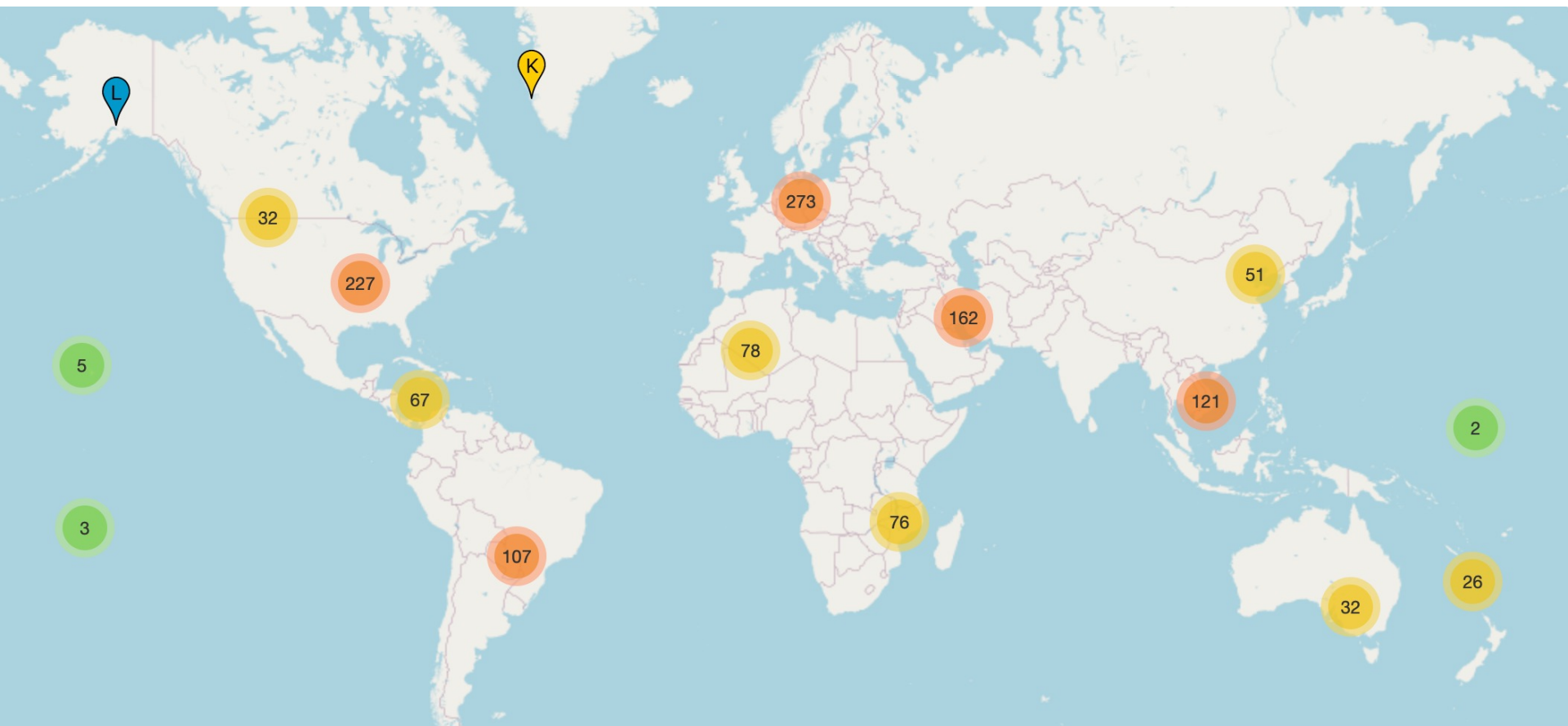
Over 1500 instances around the world – https://root-servers.org/

Root Zone Management and Resolution

ROOT ZONE PROVISIONING, DISTRIBUTION, AND RESOLUTION

Provisioning

Resolution

Change Requests

IANA Function

TLD OPERATIONS

Root Zone Maintainer

root zone

Operators

RS
RS
RS
RS
...
RS
RS
RS
RS

Queries

DNS RESOLVERS

Responses

Distribution servers   Anycast sites

Root Server Operators

Twelve different professional engineering groups focused on

- Reliability and stability of the service

- Accessibility for all Internet users

- Technical cooperation

- Professionalism

Diverse organizations and operations

- Technically

- Organizationally

- Geographically

- Funding Models

Root Server Operators (continued)

Operators ARE involved with

- Careful operational evolution of service

- Evaluating and deploying suggested technical modifications

- Making every effort to ensure stability, robustness and reachability

Operators ARE NOT involved with

- Policy making

- Data modification -- Operators are publishers, not authors or editors

Coordination Between Root Server Operators

Root Server Operators coordinate through

- Industry Meetings and Internet Bodies
  - RSSAC/ICANN, IETF, RIPE, NANOG, DNS-OARC, APNIC, ARIN, AFNOG

- Diverse Communications tools

- Sharing data

- Periodic Activities to Support Emergency Response Capabilities

Commitments of the Root Server Operators

RSSAC020: Client Side Reliability of Root DNS Data

- Every instance of the root server system serves the same data

- That data originates from the IANA

- The DNS is a hierarchy with a single globally unique root

- All clients of the root server system are treated equally

- The RSSAC supports the continued deployment of DNSSEC

Myths Corrected

Myth	Reality
Root servers control where Internet traffic goes.	Routers control where Internet traffic goes.
Most DNS queries ARE handled by a root server.	Most DNS queries are NOT handled by a root server.
Administration of the root zone and service provision are the same thing.	Administration of the root zone is separate from service provision.
The root server identifiers have special meaning.	None of the root server identifiers are special.
There are only 13 root servers.	There are more then 1500 instances globally, but only 13 technical identifiers.
The root server operators conduct operations independently.	The collective root server operators coordinate root service operation as a whole.
Root server operators only receive the TLD portion of a query.	Root server operators **frequently** receive the entire query.

The Root Server System and Your Networks

- Check your routes to instances
  - Typically want 3-4 nearby instances

- Turn on DNSSEC validation in resolvers
  - Ensures signed data is unmodified

- Participate in and contribute to the RSSAC Caucus
  - Where technical advice is created

- Interested in hosting an Anycast instance?
  - Talk to an RSSAC member after this presentation
  - Send mail to ask-rssac@icann.org

RSSAC and RSSAC Caucus

What is RSSAC?

- The role of the Root Server System Advisory Committee ("RSSAC") is to advise the ICANN community and Board on matters relating to the operation, administration, security, and integrity of the Internet's Root Server System.

- (This is a very narrow scope!)

What RSSAC Does and Does Not Do?

- RSSAC is a committee that produces advice – primarily to the Board but also to other ICANN bodies and other organizations involved in the overall DNS business.

- Root Server Operators are represented inside RSSAC, but RSSAC does not involve itself in operational matters.

RSSAC Organization

- RSSAC is composed of
  - Appointed representatives of the root server operators
  - Alternates to these
  - Liaisons

- RSSAC Caucus
  - Body of volunteer subject matter experts
  - Members confirmed by RSSAC based on statement of interest

RSSAC Leadership

RSSAC Chair
Fred Baker
ISC

RSSAC Vice-Chair
Ken Renard
Army Research Laboratory

RSSAC Liaisons

- Incoming Liaisons
  - IANA Functions Operator (PTI)
  - Root Zone Maintainer (Verisign)
  - Internet Architecture Board
  - Security and Stability Advisory Committee

- Outgoing Liaisons
  - ICANN Board
  - ICANN Nominating Committee
  - Customer Standing Committee
  - Root Zone Evolution Review Committee

RSSAC Caucus

- Members
  - Over 100 DNS Experts
  - Public statements of interest
  - Public credit for individual work

- Purpose
  - DNS experts who bring diverse expertise to publications
  - Transparency of who does the work
  - Framework for getting work done

- To apply, email rssac-membership@icann.org.
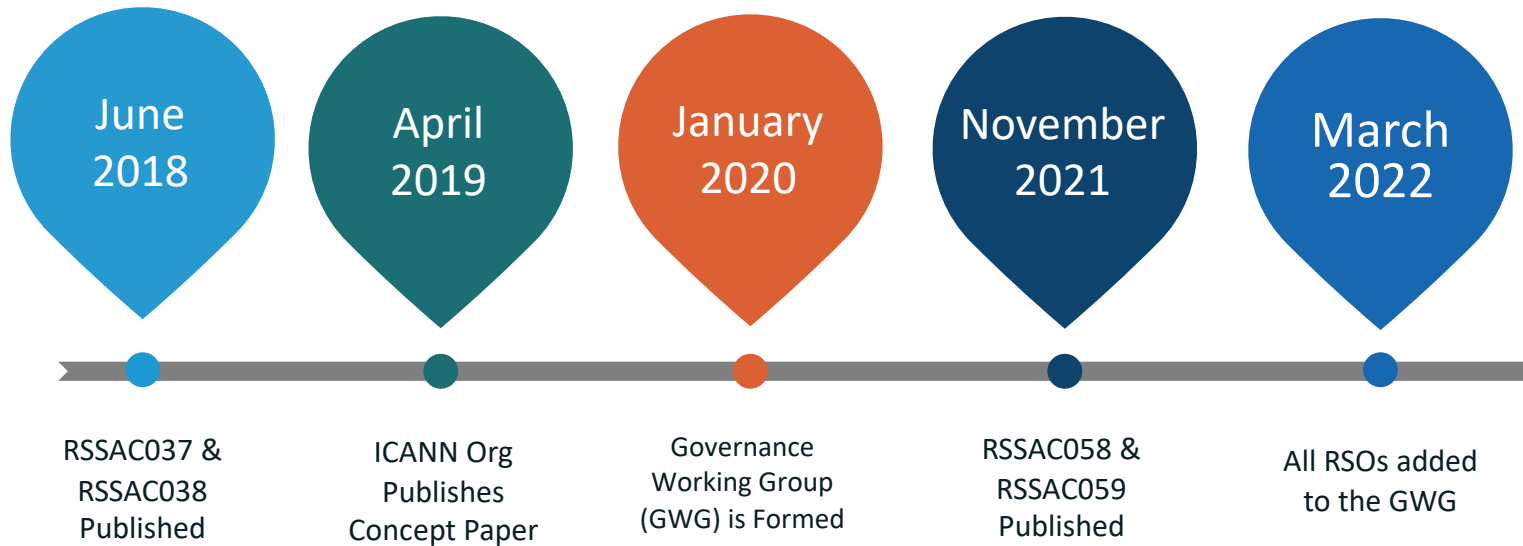
Transparency

RSSAC

- rssac.icann.org
- Caucus
- Publishing minutes & workshop reports
- Public RSSAC & Caucus Calendar
- RSSAC Public Meetings
- Meetings with other ICANN community groups
- Tutorials
- Liaison relationships
- Operational procedures: RSSAC000

RSOs

- www.root-servers.org
- Root-Ops Agendas
- RSSAC002 statistics
- RSOs participate in RSSAC
- Individual web pages
- Collaborative reports on major events
- RSSAC can respond to technical RSS questions

Root Server System Evolution

Root Server System Evolution Timeline

June 2018	April 2019	January 2020	November 2021	March 2022
RSSAC037 & RSSAC038 Published	ICANN Org Publishes Concept Paper	Governance Working Group (GWG) is Formed	RSSAC058 & RSSAC059 Published	All RSOs added to the GWG

- Defines eleven principles for the operation and evolution of the Root Server System

- Proposes an initial governance model (the RSSAC037 Model) for the Root Server System and its operators

- Demonstrates how the RSSAC037 Model works through a set of scenarios on designation and removal of operators

11 Principles from RSSAC037 / RSSAC055

1. To remain a global network, the Internet requires a globally unique public namespace.

2. IANA is the source of DNS root data.

3. The RSS must be a stable, reliable, and resilient platform for the DNS service to all users.

4. Diversity of the root server operations is a strength of the overall system.

5. Architectural changes should result from technical evolution and demonstrated technical need.

6. The IETF defines technical operation of the DNS protocol.

7. RSOs must operate with integrity and an ethos demonstrating a commitment to the common good of the Internet.

8. RSOs must be transparent.

9. RSOs must collaborate and engage with their stakeholder community.

10. RSOs must be autonomous and independent.

11. RSOs must be neutral and impartial.

Recommendations that complement RSSAC037.

The RSSAC recommends the ICANN Board:

1. Initiate a process to produce a final version of the Model based on RSSAC037.

2. Estimate costs of the RSS and developing the Model. Initial efforts should focus on developing a timeline.

3. Implement the final version of the Model based upon principles of accountability, transparency, sustainability, and service integrity.

The RSSAC037 Model
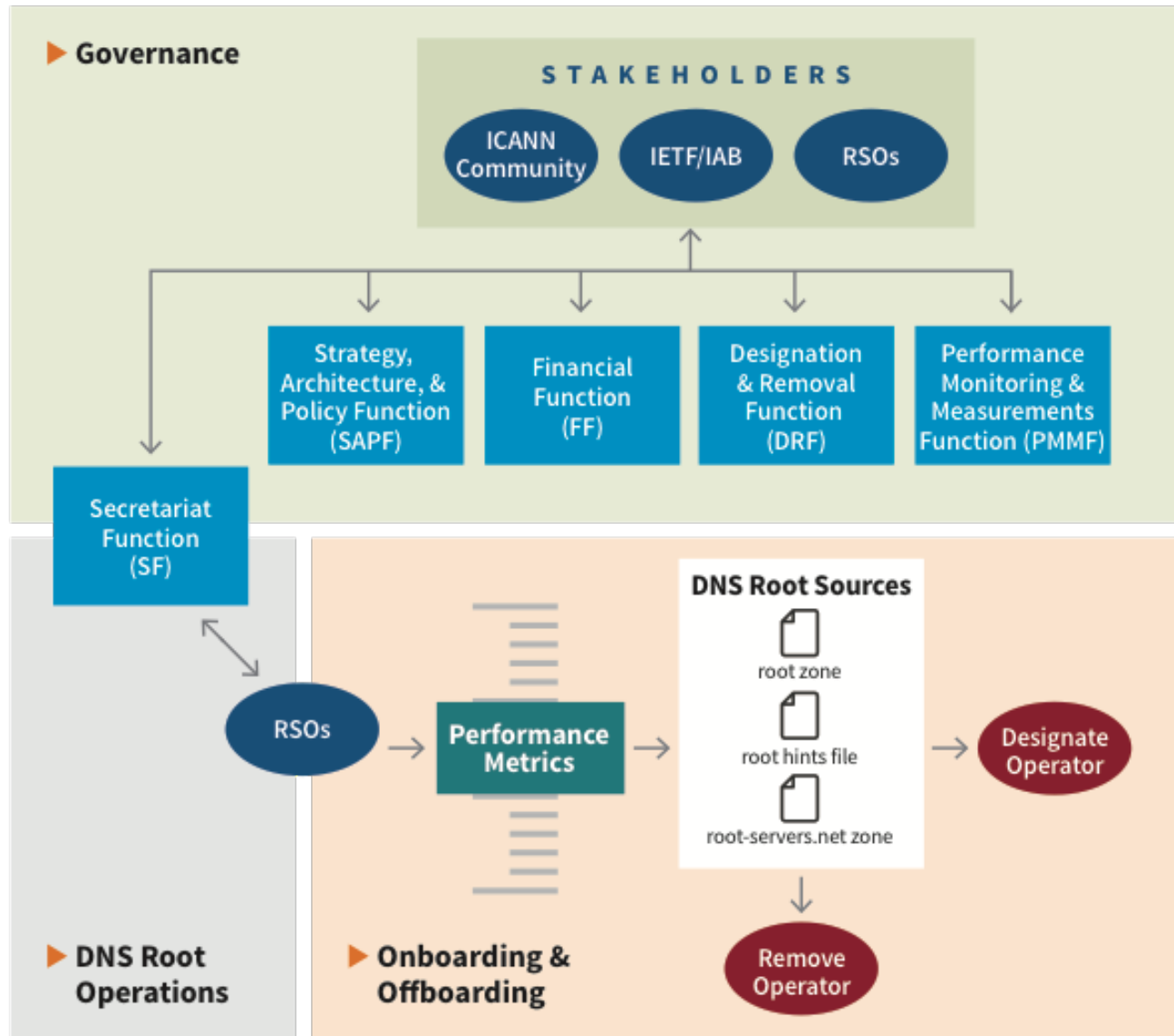
Governance Working Group (GWG)

- Composed of representatives from the RSOs, ccTLD Name Supporting Organization (ccNSO), the Internet Architecture Board (IAB), Registry Stakeholder Group, and the Security and Stability Advisory Committee (SSAC)
  - Liasons from the ICANN Board, the IANA, and the Root Zone Maintainer (RZM)
- Tasked with working out the details of the Model
- The Concept Paper tasked the GWG with
  - Committing to a timeline with clear milestones
  - Working openly and transparently
  - Seeking informed contributions when necessary
  - Embracing the principles outlined in RSSAC037
  - Refer to RSSAC037, Concept Paper, Public Comment feedback, and other relevant RSSAC publications as references

- RSSAC058: Success Criteria for the RSS Governance Structure
  - Contains success criteria for any proposed root server system governance structure (RSS GS).
  - These success criteria form a framework to assess the degree to which any proposed RSS GS conforms with previous RSSAC statements concerning RSS governance.

- RSSAC059: RSSAC Advisory on Success Criteria for the Root Server System Governance Structure
  - Contains recommendations on how these success criteria should be integrated with the recommendations in RSSAC038.

Related RSSAC Publications

- RSSAC042: RSSAC Statement on Root Server Operator Independence
  - Clarified and provided further information about principle 10 from RSSAC037, which states that "RSOs must be autonomous and independent."

- RSSAC047: RSSAC Advisory on Metrics for the DNS Root Servers and the Root Server System
  - Defined measurements, metrics, and thresholds that RSOs meet to provide a minimum level of performance. These thresholds and metrics are the RSSAC's input to a yet-to-be defined evaluation process for future RSOs.

- RSSAC049: RSSAC Statement on Joining the Empowered Community
  - Updated the recommendations in RSSAC038 to state that the RSO community would welcome becoming a member of the ICANN Empowered Community as part of the implementation of the recommendations in RSSAC038.

Related RSSAC Publications (continued)

- RSSAC055: Principles Guiding the Operation of the Public Root Server System
    - Restated the eleven principles from RSSAC037 and provided further clarification on each.

- RSSAC056: RSSAC Advisory on Rogue DNS Root Server Operators
    - Informed future RSS governance bodies about the types of RSO activity that might be considered rogue and the risks that these activities may pose to the Internet community.

Questions?

- **For more information on the RSSAC**
- Main webpage
  https://www.icann.org/groups/rssac
- Frequently Asked Questions
  https://www.icann.org/groups/rssac/faq
- For general questions
  ask-rssac@icann.org

- **For more information on the RSSAC Caucus**
- Main webpage
  https://www.icann.org/groups/rssac-caucus
- To apply send email to
  rssac-membership@icann.org