Tutorial on Root Server System

December 2021
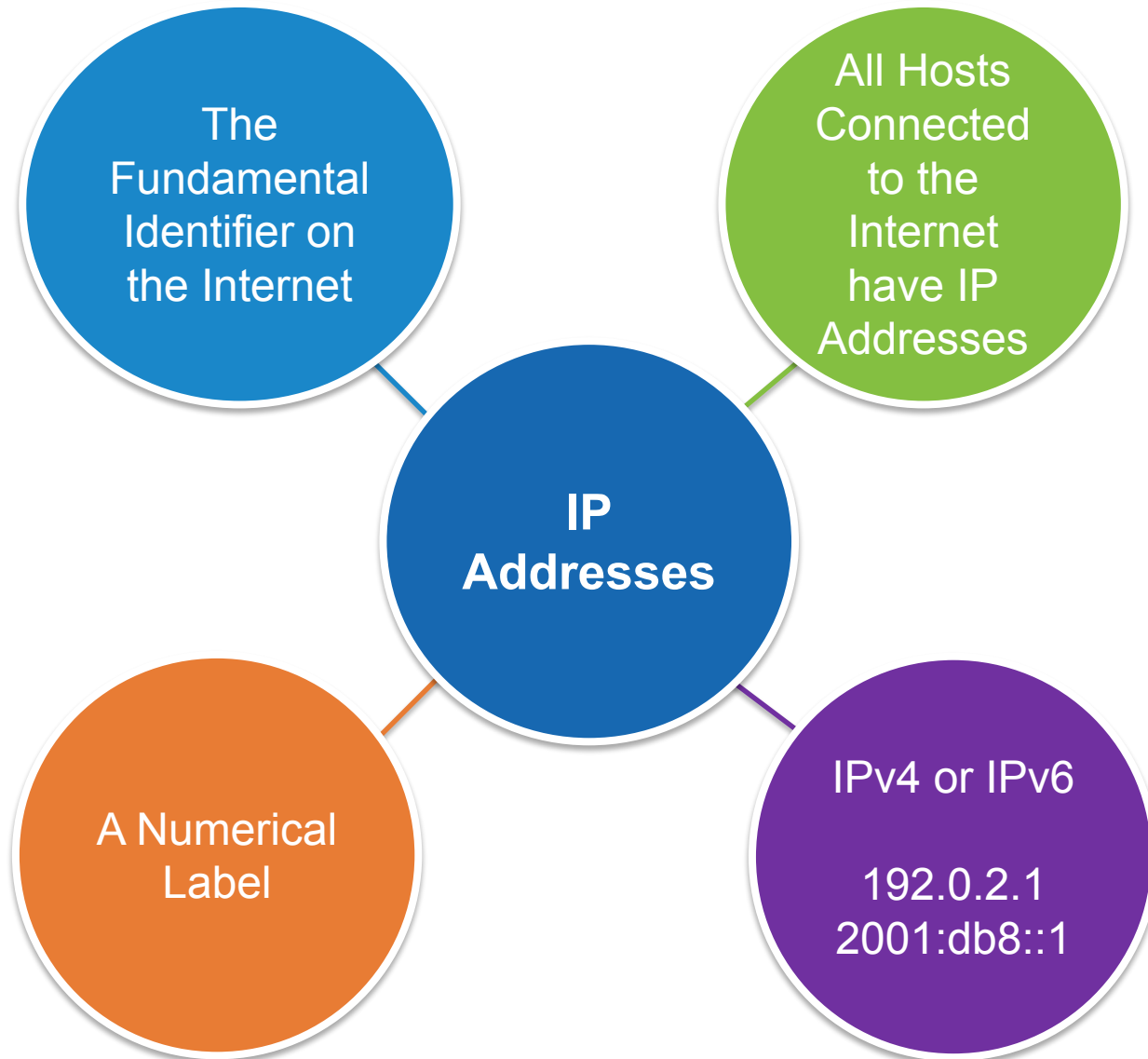
Internet Governance Forum 2021

ICANN

Outline

- Overview of the Domain Name System

- 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
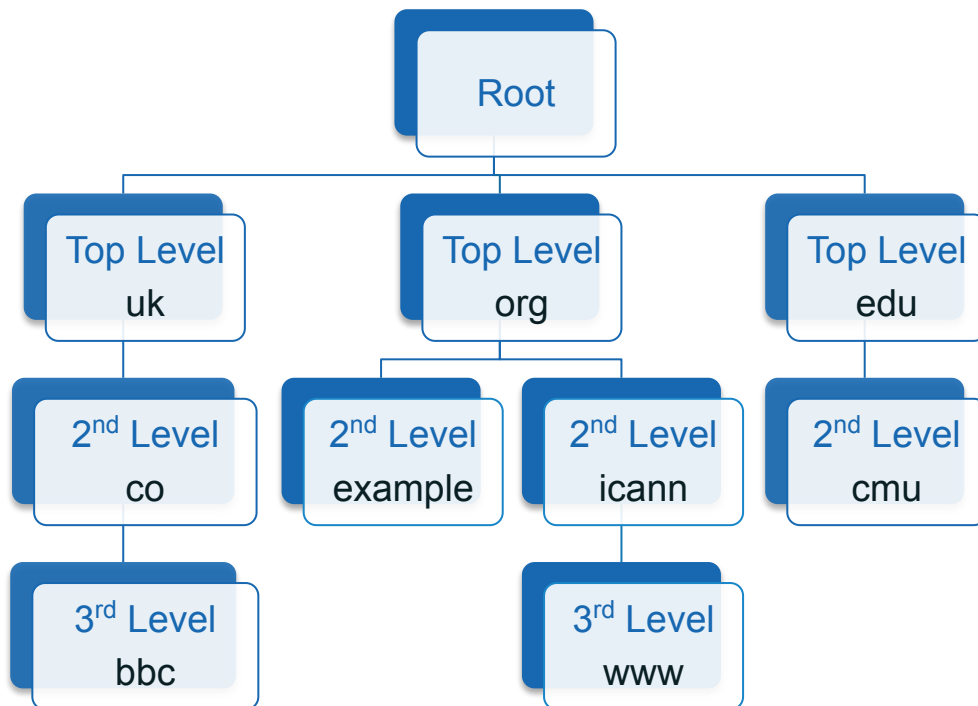2001:db8::1

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 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 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 1000 physical instances

- Purely technical role to serve the root zone

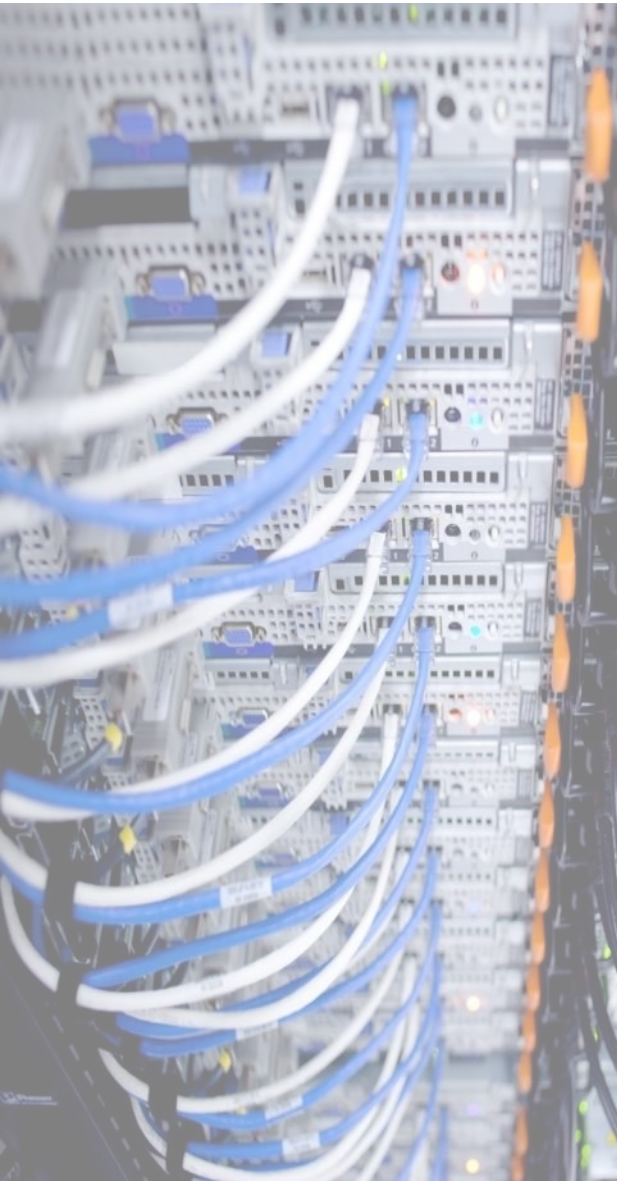- Responsibility of the root server operators

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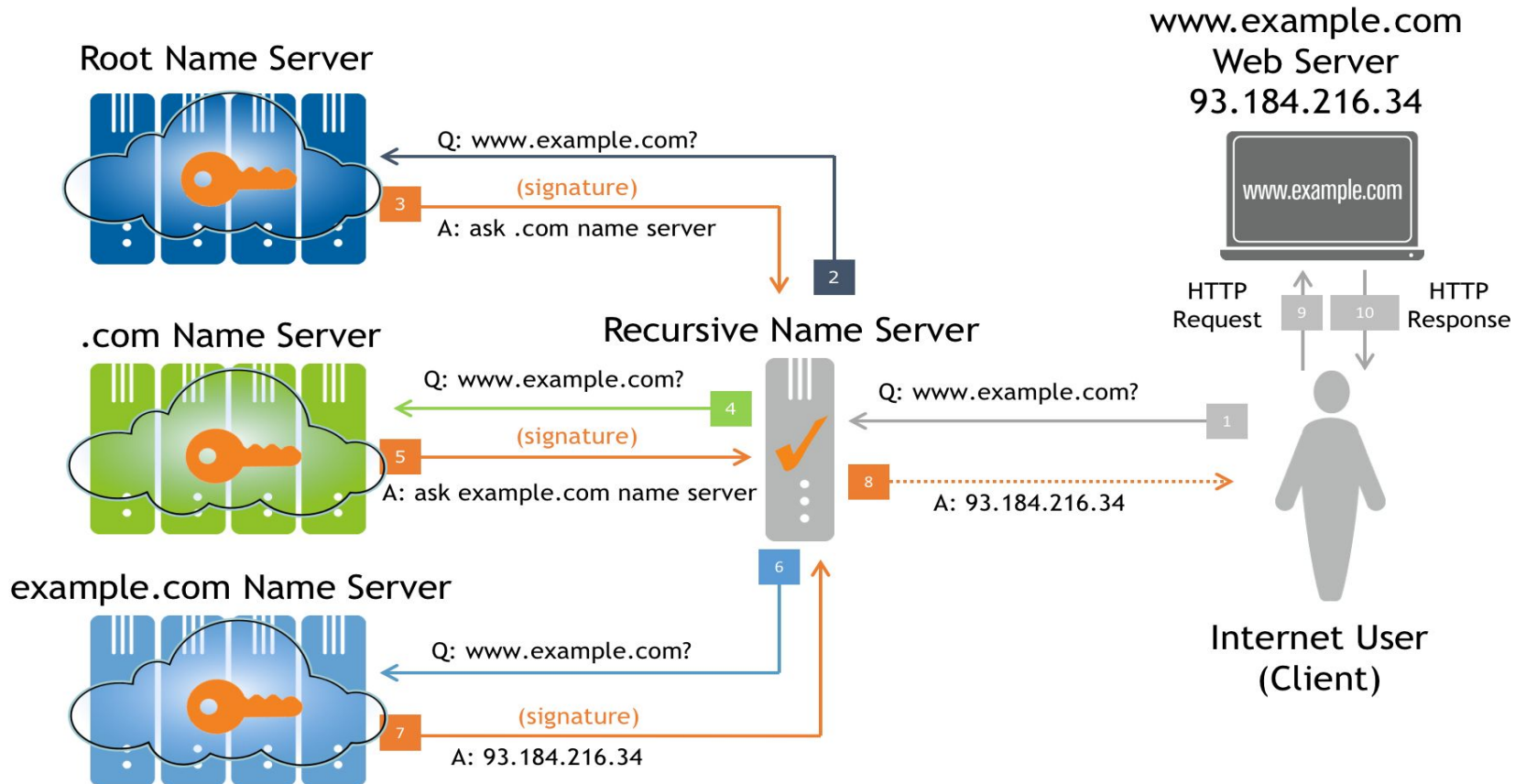
- Root Servers are at the entry point to the system.
- Caching is used throughout to avoid repetitive queries.
- The DNS resolution precedes the actual transaction the users want to do (web, mail, voip call, etc.).

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

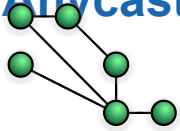|	
DNSSEC (security extensions)	• Cryptographic signatures on DNS data • Reduces risk of "spoofing" • Resolver should validate the answers
Privacy Enhancements	• Queries can leak information • Standards work is ongoing to address this • Query name minimization, DNS-over-TLS (DoT) & DNS-over-HTTPS (DoH)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

Unicast vs. Anycast

Unicast

- Packets from sources all go to the same destination

- A single instance serves all sources

Anycast

- Multiple instances serve the same data to all sources

- Sources reach destination based on intermediate routing policies

- Sources get the data faster

- Offers some protection from DDoS attacks

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.
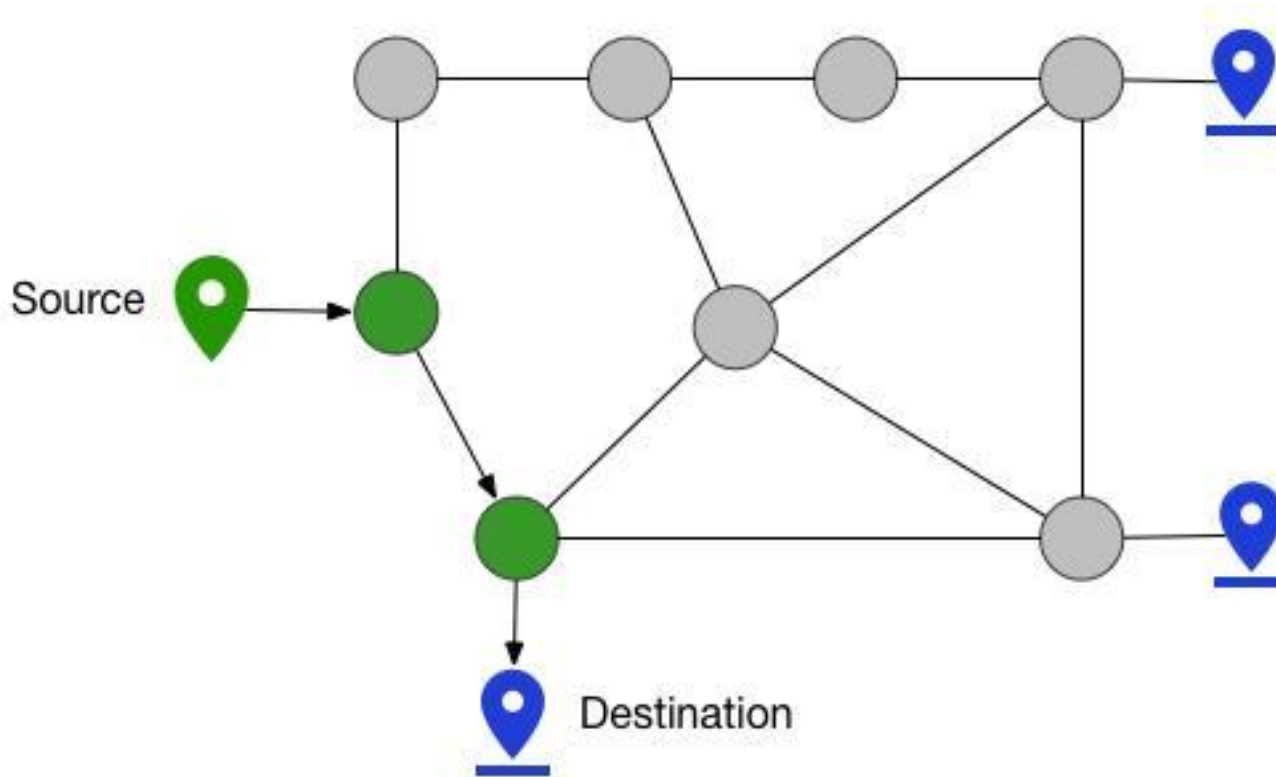
Root Server System Today

Growth of the Root Server System

1983-1986:

4 Addresses

1987:

7 Addresses

1991:

8 Addresses

1993:

9 Addresses

1998:
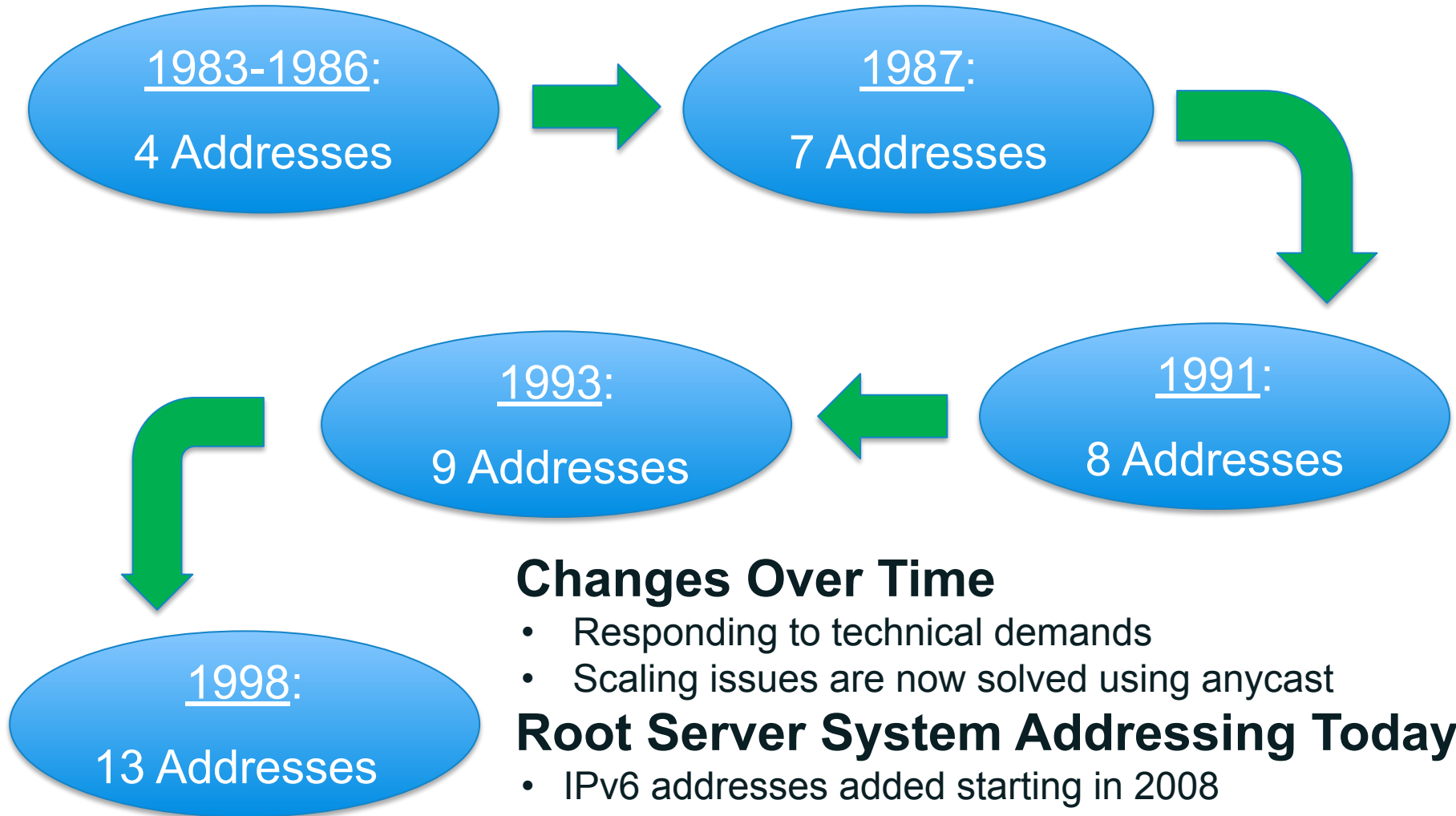
13 Addresses

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 1000 physical Instances

Root Server Identifiers Today - 2019

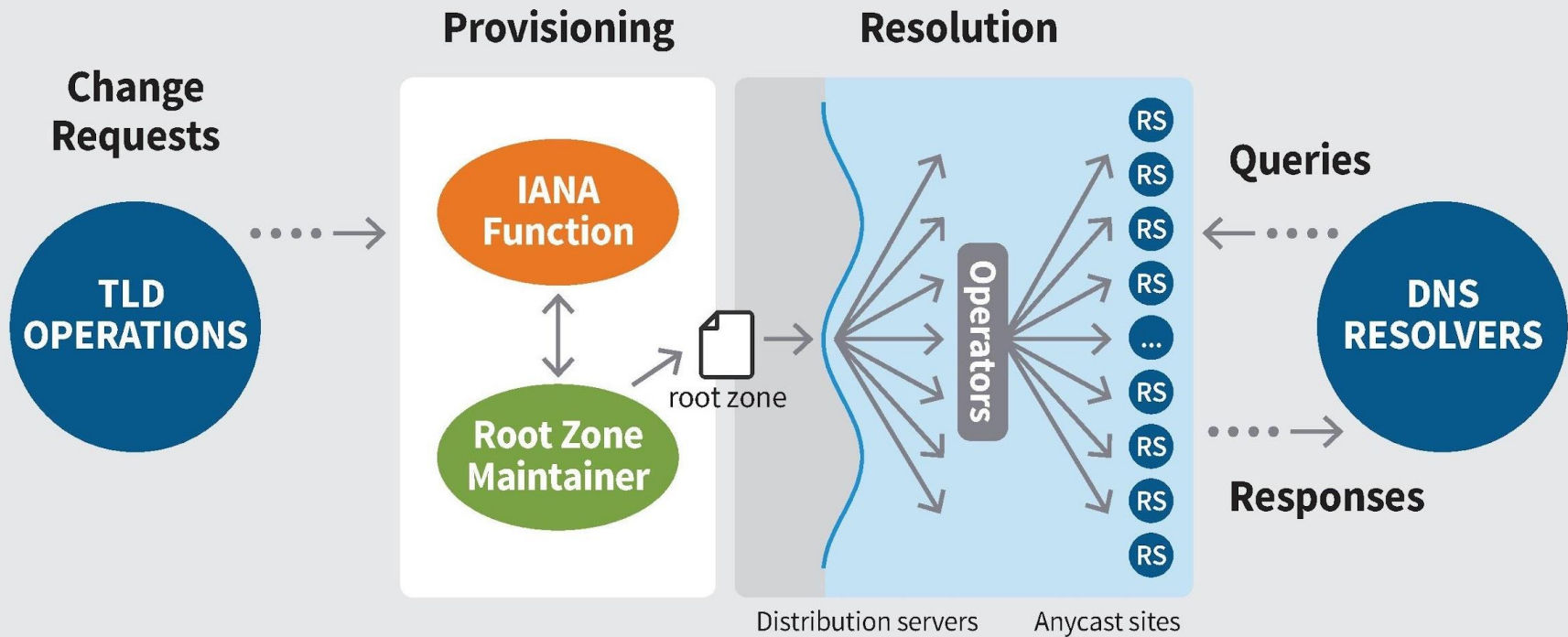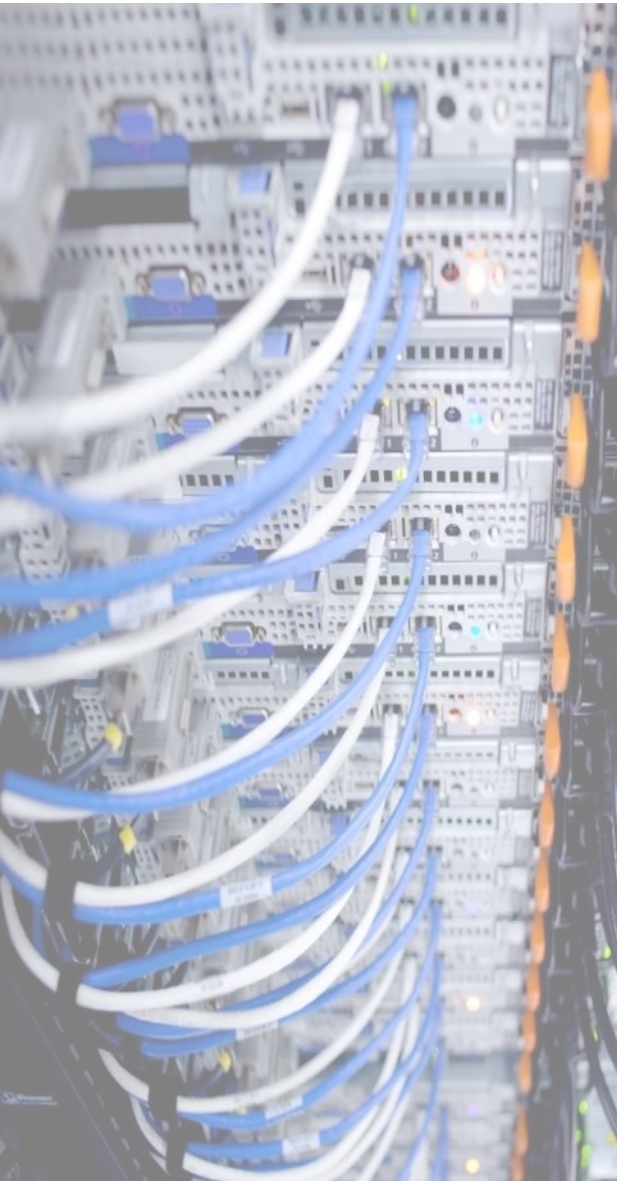| Hostname	IP Addresses	Manager
a.root-servers.net	198.41.0.4, 2001:503:ba3e::2:30	VeriSign, Inc.
b.root-servers.net	199.9.14.201, 2001:500:200::b	University of Southern California (ISI)
c.root-servers.net	192.33.4.12, 2001:500:2::c	Cogent Communications
d.root-servers.net	199.7.91.13, 2001:500:2d::d	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
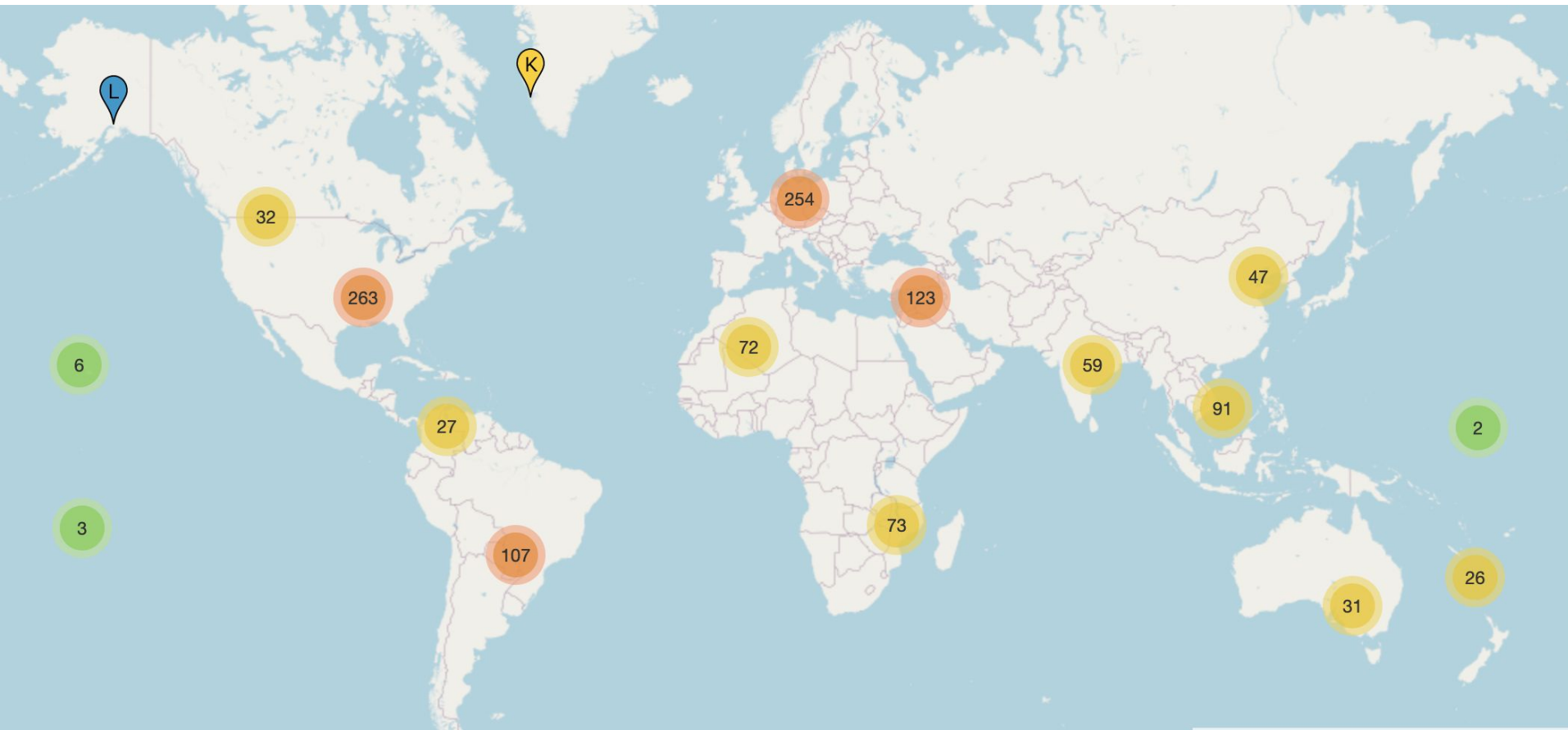
Over 1000 instances around the world – https://root-servers.org/

Root Zone Management and Resolution

ROOT ZONE PROVISIONING, DISTRIBUTION, AND RESOLUTION

Provisioning   Resolution

Change Requests

TLD OPERATIONS

IANA Function

Root Zone Maintainer

root zone

Operators

RS RS RS RS RS ... RS RS RS RS

Queries

DNS RESOLVERS

Responses

Distribution servers   Anycast sites
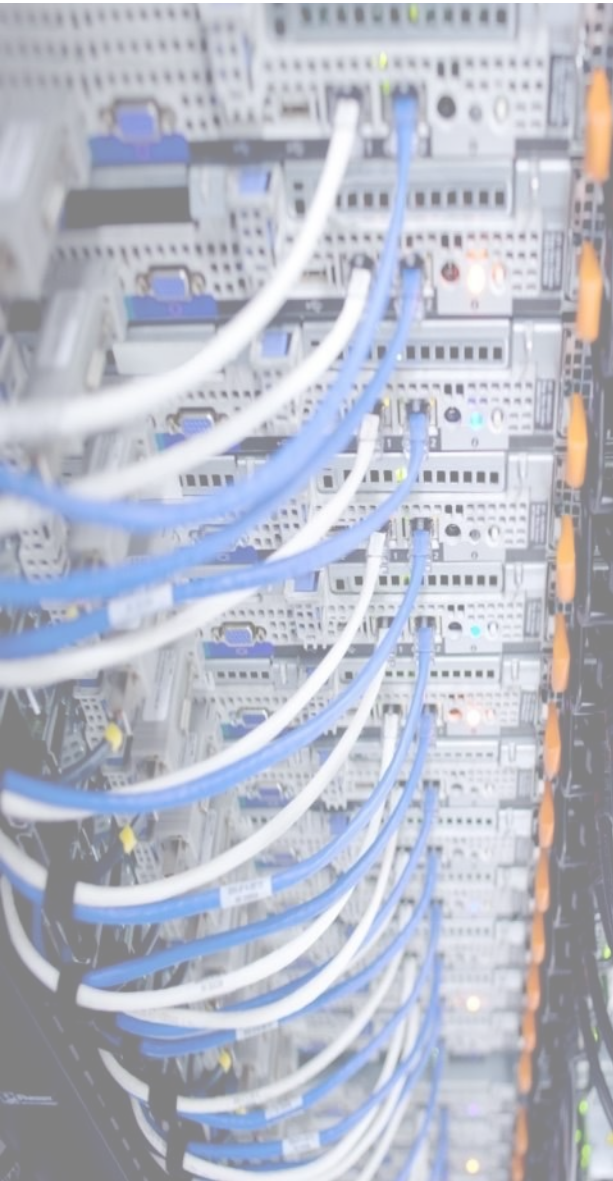
Root Server Operators

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 related to data

- 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 1000 servers 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 **usually** receive the entire query.

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
  - 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
Brad Verd
Verisign

RSSAC Caucus

- Members
    - Over 100 Technical 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
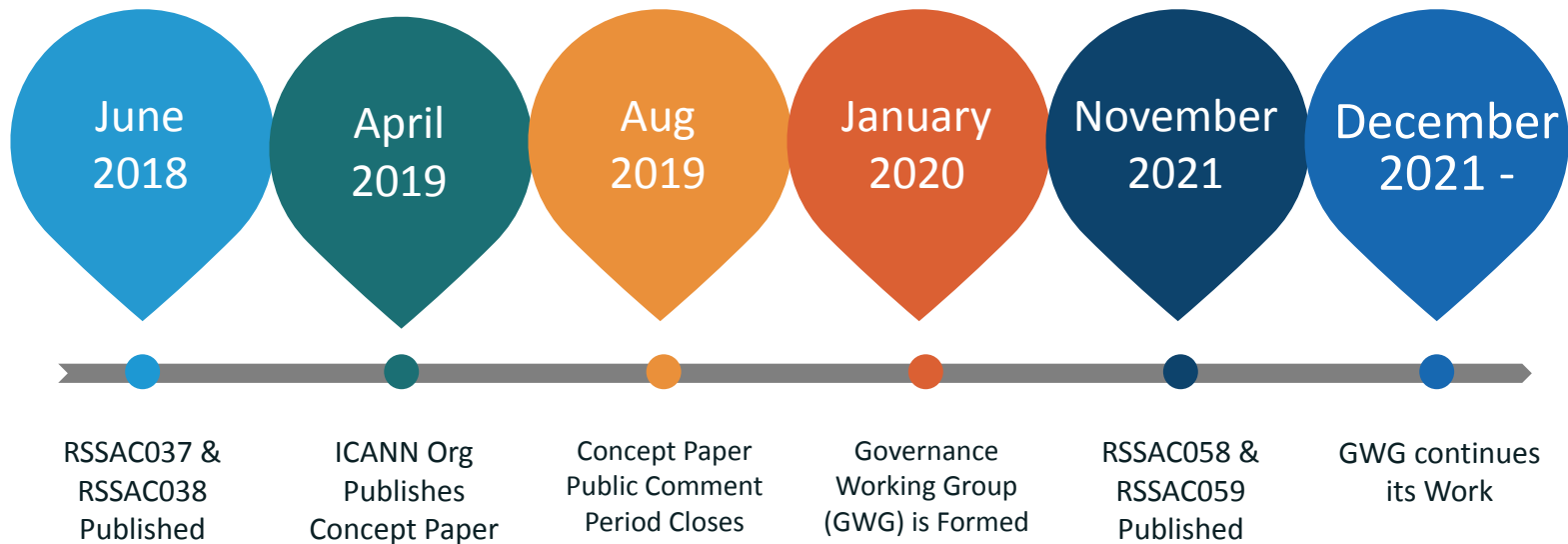- Operational procedures: RSSAC000

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
- ask-rssac@icann.org interface

Root Server System Evolution

Root Server System Evolution Timeline

June 2018	April 2019	Aug 2019	January 2020	November 2021	December 2021 -
RSSAC037 & RSSAC038 Published	ICANN Org Publishes Concept Paper	Concept Paper Public Comment Period Closes	Governance Working Group (GWG) is Formed	RSSAC058 & RSSAC059 Published	GWG continues its Work

RSSAC037 Overview

- 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

RSSAC037 11 Principles

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.

- 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.

The RSSAC037 Model
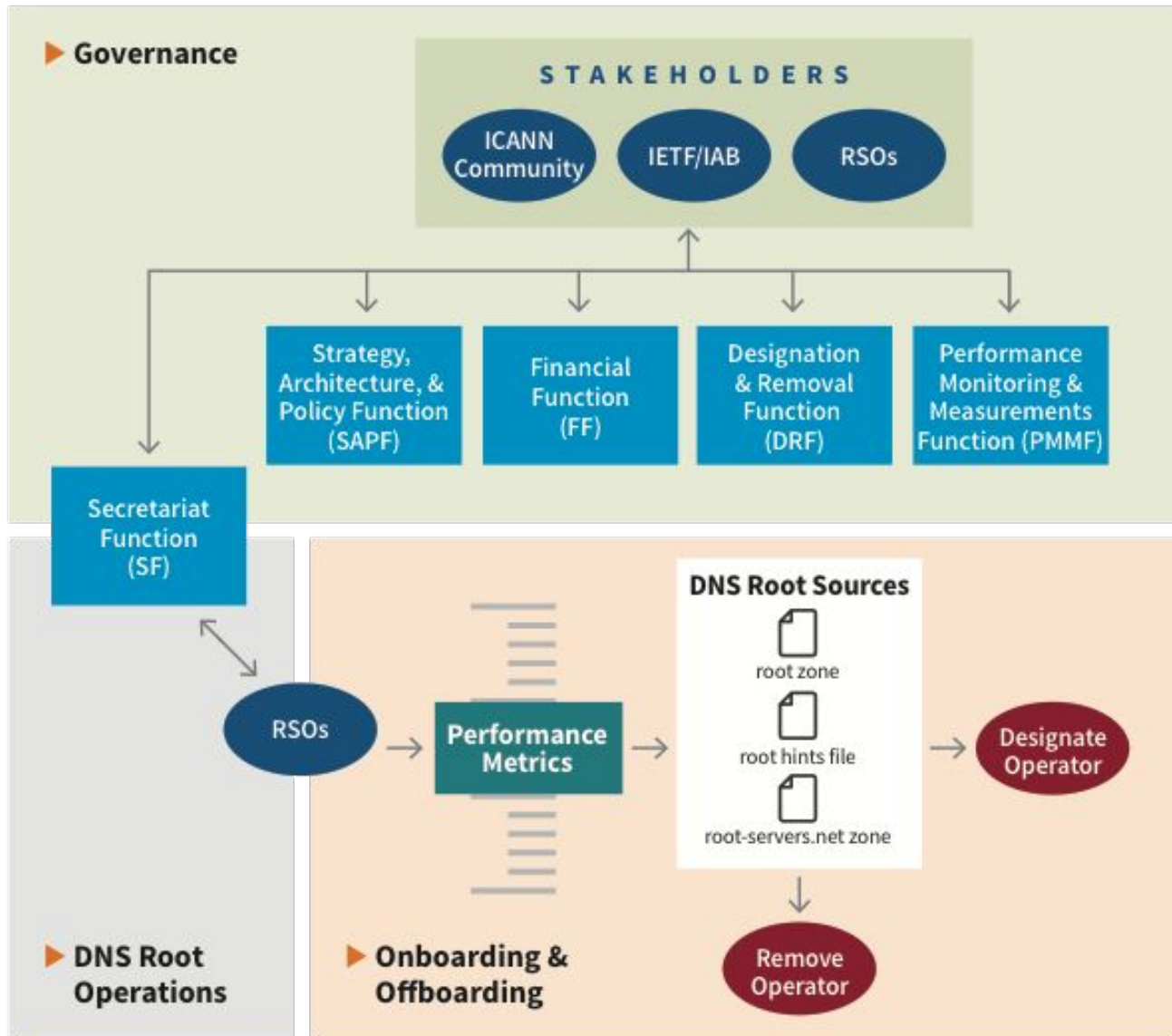
Governance Working Group (GWG)

- 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 GWG was tasked 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

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
  mailto: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
  mailto:rssac-membership@icann.org