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Tutorial on Root Server System

Root Server System Advisory Committee | November 2019



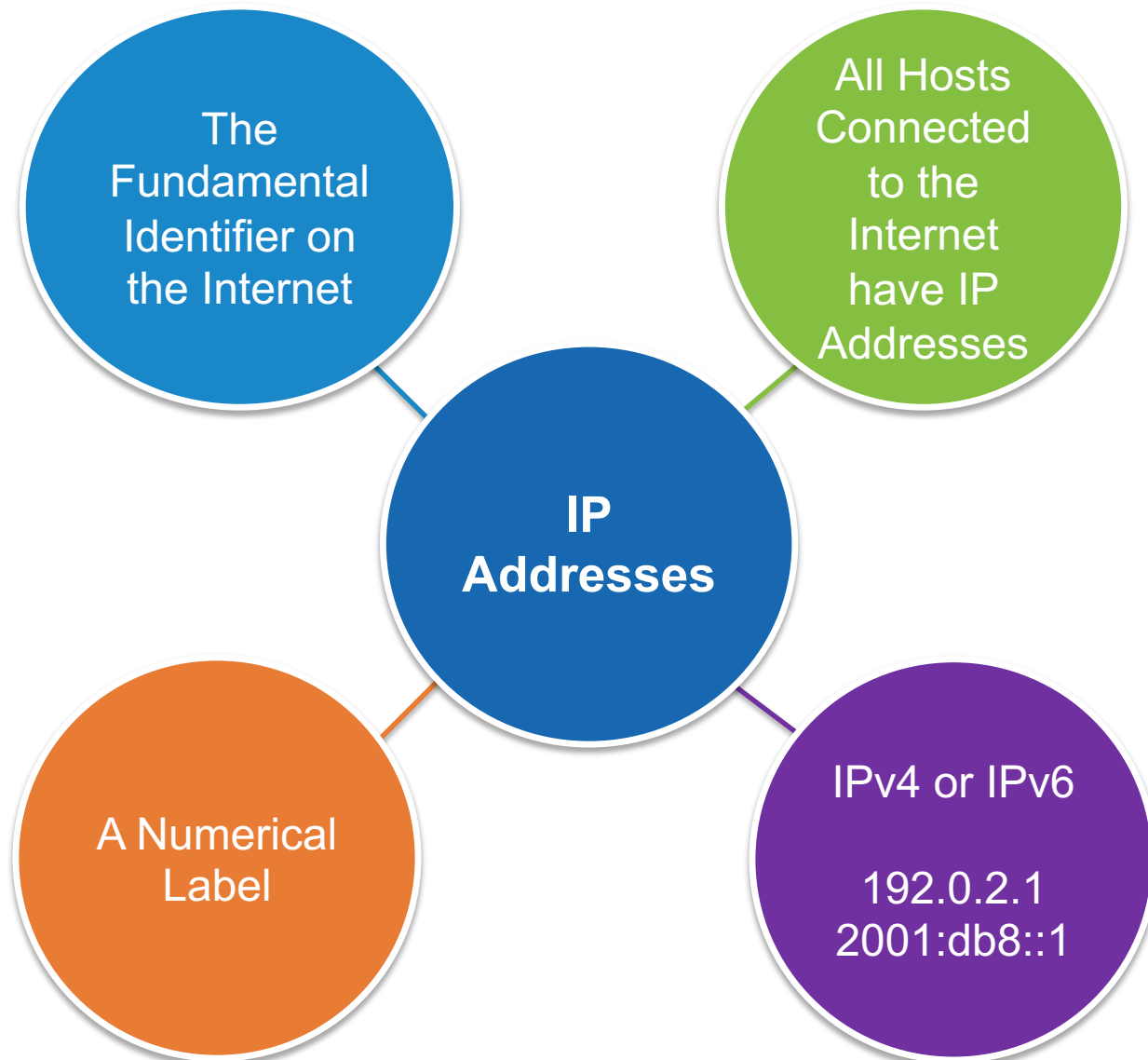
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Outline

- ⦿ 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



Why DNS?

Original Problem

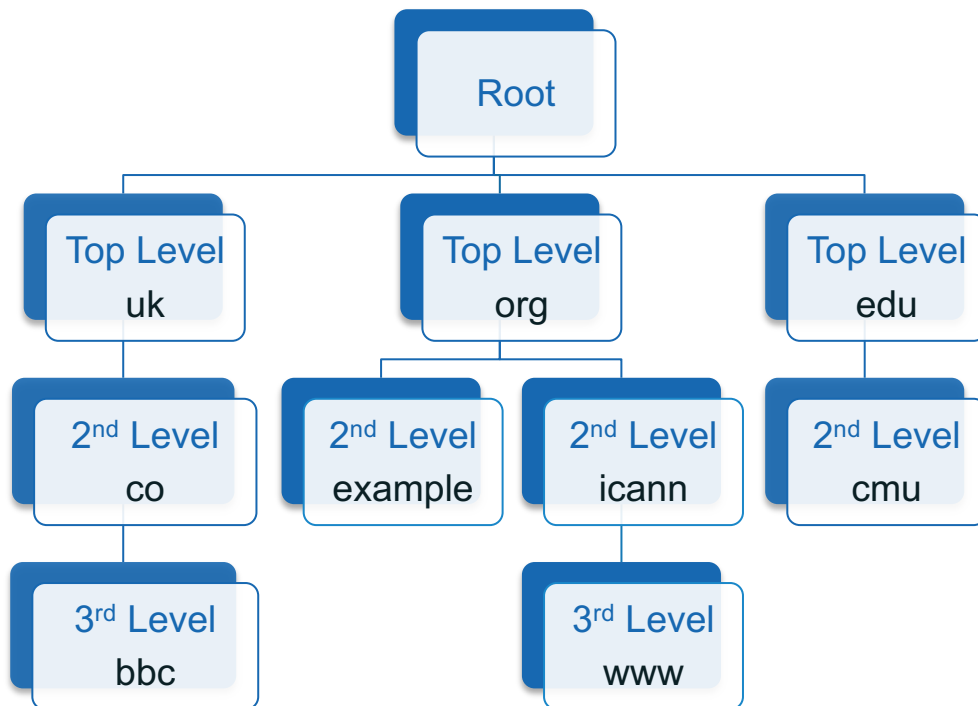
- IP addresses are hard to remember.
- IP addresses often change.

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



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 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

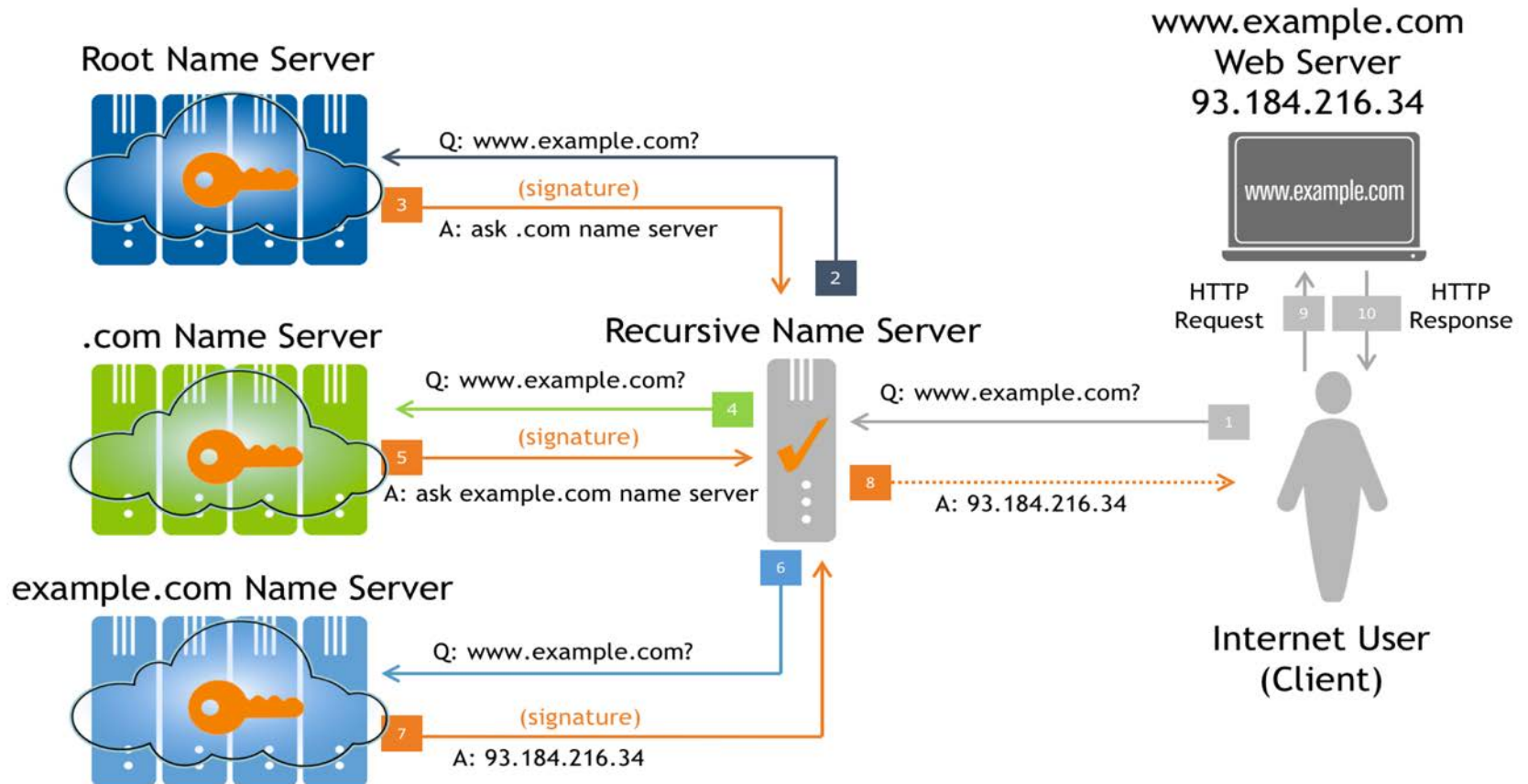
Root Zone

- 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 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)



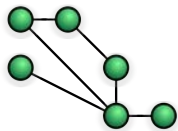
- Cryptographic signatures on DNS data
- Reduces risk of “spoofing”
- Resolver should validate the answers

**Privacy
Enhancements**



- Queries can leak information
- Standards work is ongoing to address this
- DNS-over-TLS (DoT)

Anycast



- Multiple servers share a single IP address
- Improves latency and resilience
- Protects against DDoS attacks

Explanation of Anycast

Unicast vs. Anycast

Unicast

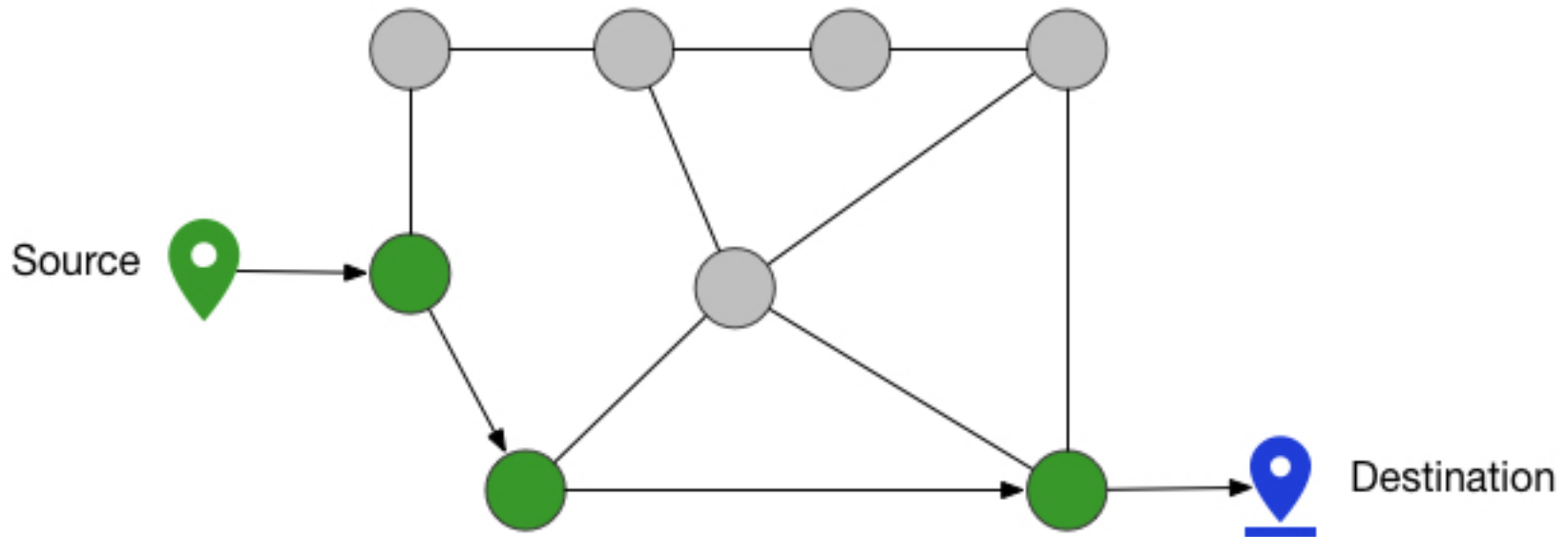
- Packets from sources all go to the same destination
- A single instance serves all sources
- DDoS attack traffic all goes to single instance

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

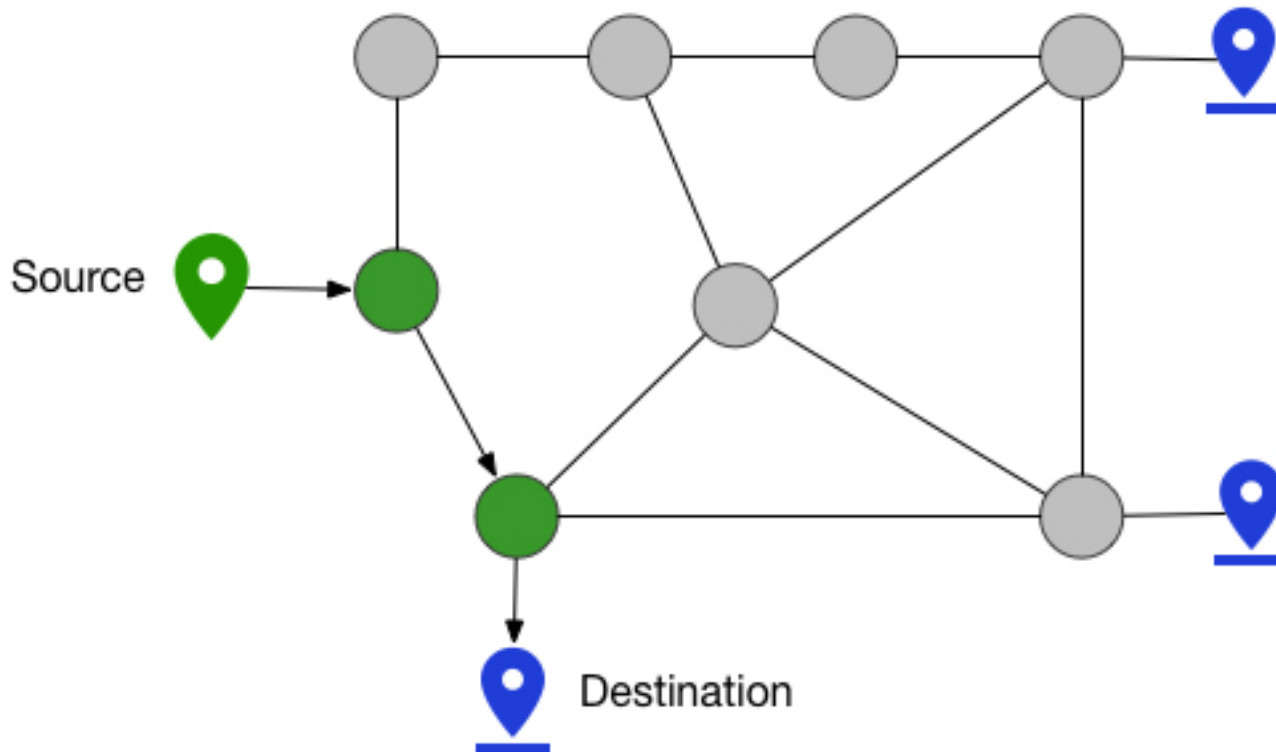
Unicast

Traffic takes shortest route to single destination.



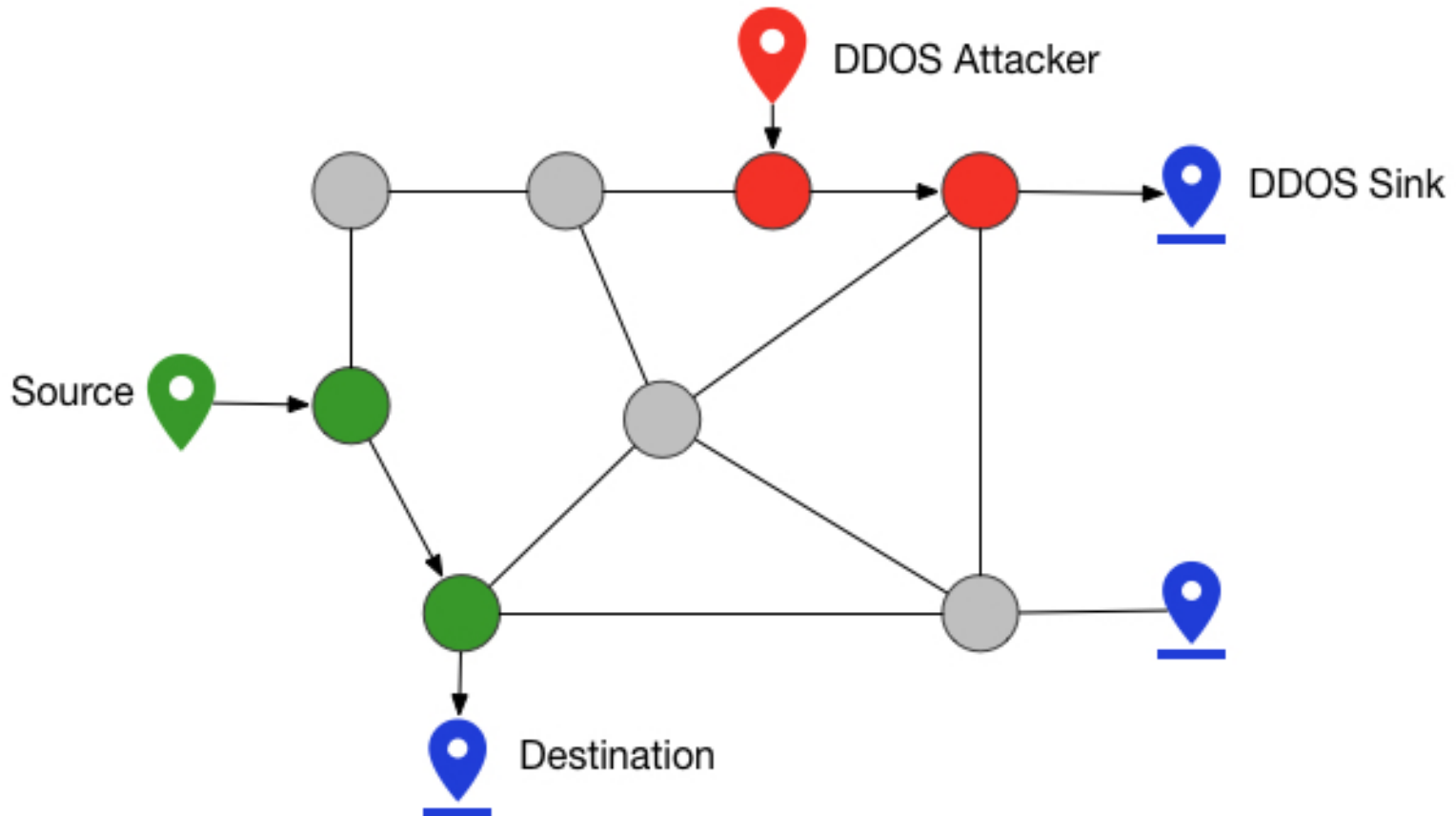
Anycast

- 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.



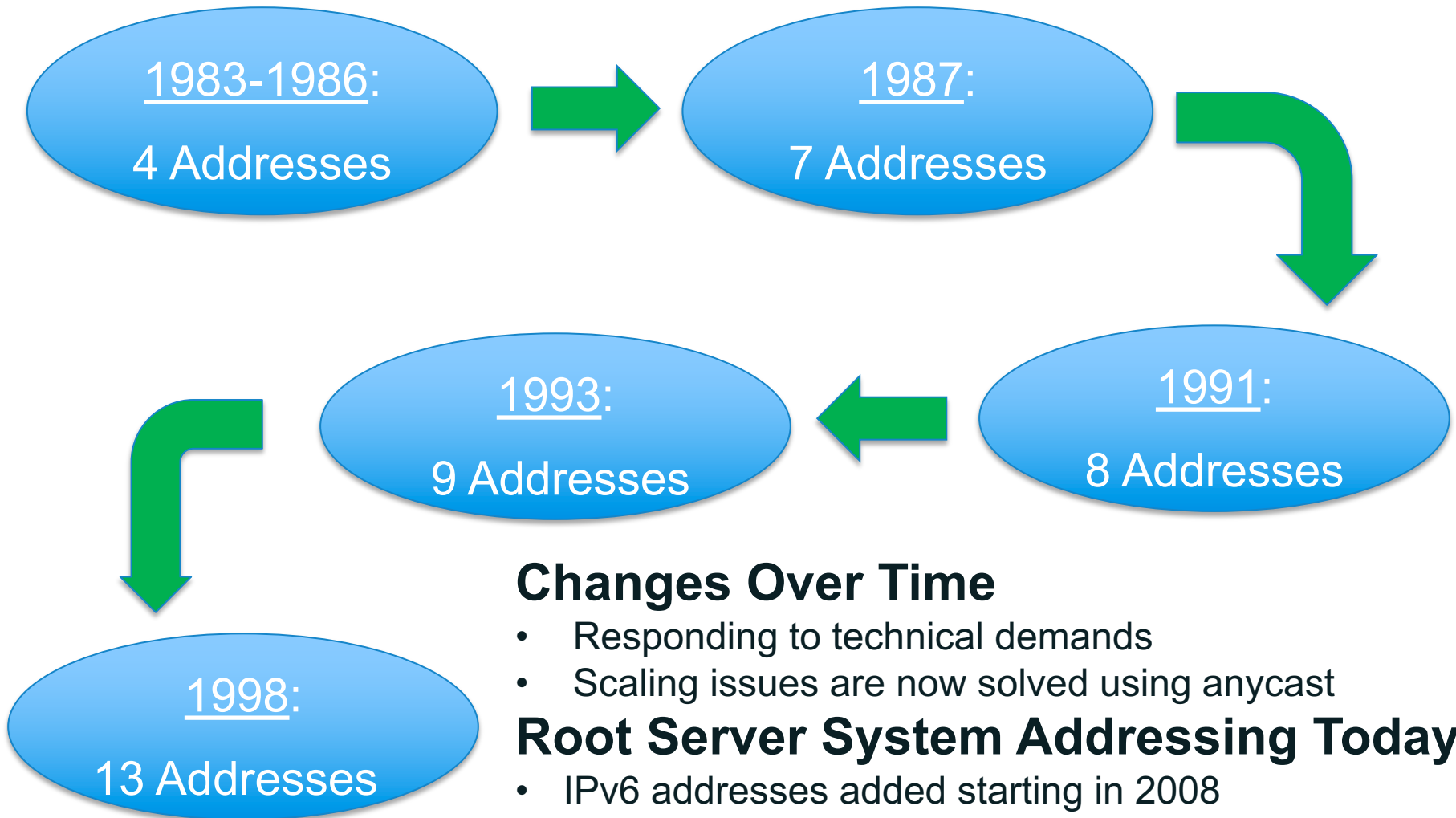
Anycast Under DDoS Attacks

- 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



Changes Over Time

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

Root Server System Addressing Today

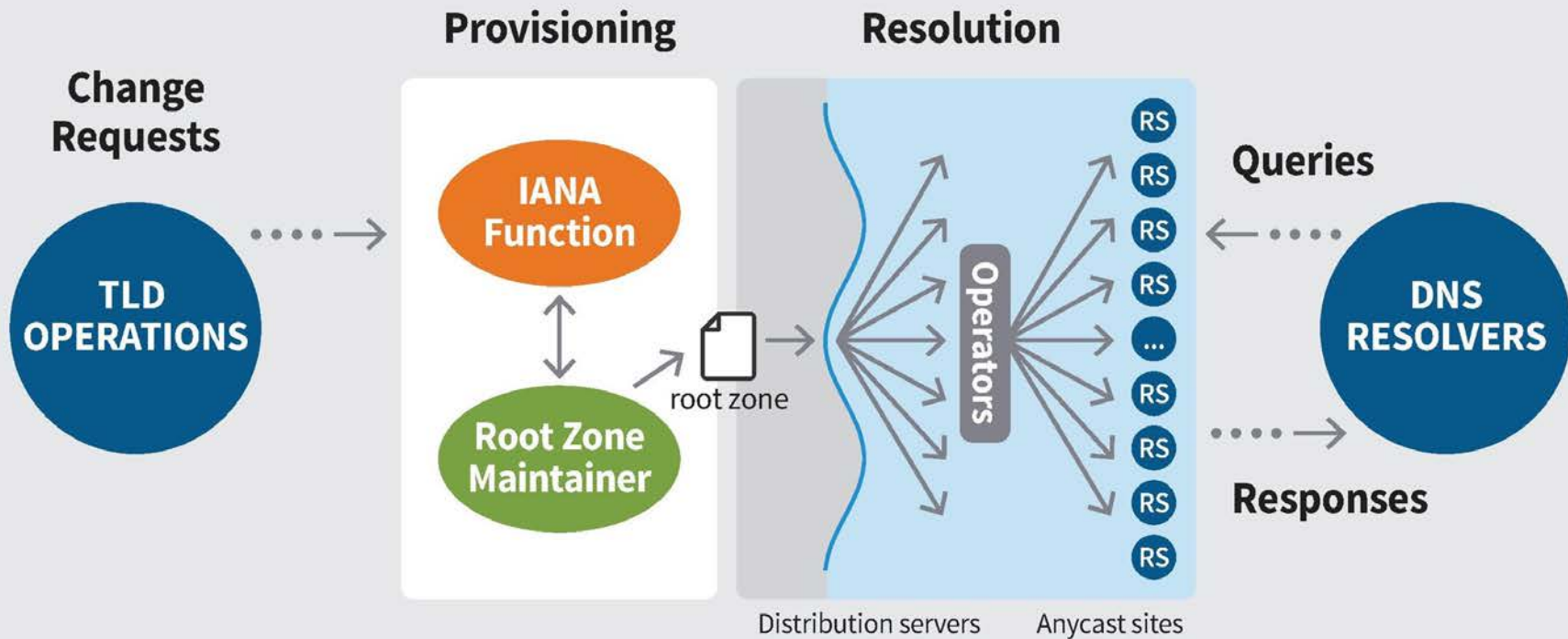
- IPv6 addresses added starting in 2008
- 26 IP addresses, 13 IPv4 and 13 IPv6
- Served from over 1000 physical Instances

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 Zone Management and Resolution

ROOT ZONE PROVISIONING, DISTRIBUTION, AND RESOLUTION



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

Features of the 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



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

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 identities have special meaning.	None of the root server identities are special.
There are only 13 root servers.	There are more than 1000 servers globally, but only 13 technical identities.
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.

The Root Server System and Your Networks

- Want 3-4 nearby instances
 - Increasing peering connections
- Turn on DNSSEC validation in resolvers
 - Ensures you are getting unmodified IANA data
- 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 Co-Chairs



Brad Verd
Verisign



Fred Baker
ISC

RSSAC Liaisons

- IANA Functions Operator (PTI)*
- Root Zone Maintainer (Verisign)*
- Internet Architecture Board*
- Security and Stability Advisory Committee*
- ICANN Board**
- ICANN Nominating Committee**
- Customer Standing Committee**
- Root Zone Evolution Review Committee**

* Inward Facing Liaison

**Outward Facing Liaison

<https://www.icann.org/groups/rssac>

- 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.

- Studying Modern Resolver Behaviors
 - Study the behaviour of existing deployed software and recursive resolvers through both code bases and available datasets
- Expectations of the Root Server System and Related Metrics
 - Define system-wide, externally verifiable metrics which demonstrate that the RSS as a whole is online, serving correct and timely responses to end users

Transparency

RSSAC

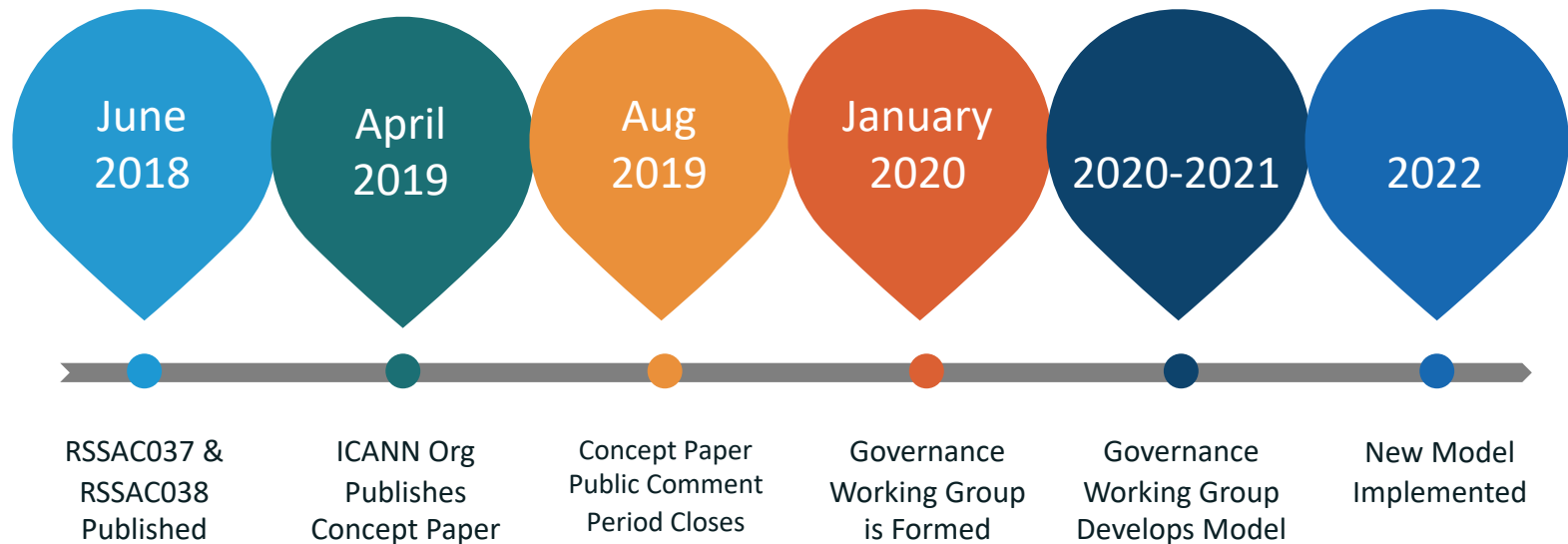
- rssac.icann.org
- Caucus
- Publishing minutes & workshop reports
- Public RSSAC & Caucus Calendar
- RSSAC Public Meetings
- Meetings with other ICANN community groups
- Tutorials
- Liaison relationships
- Operational procedures: RSSAC000

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



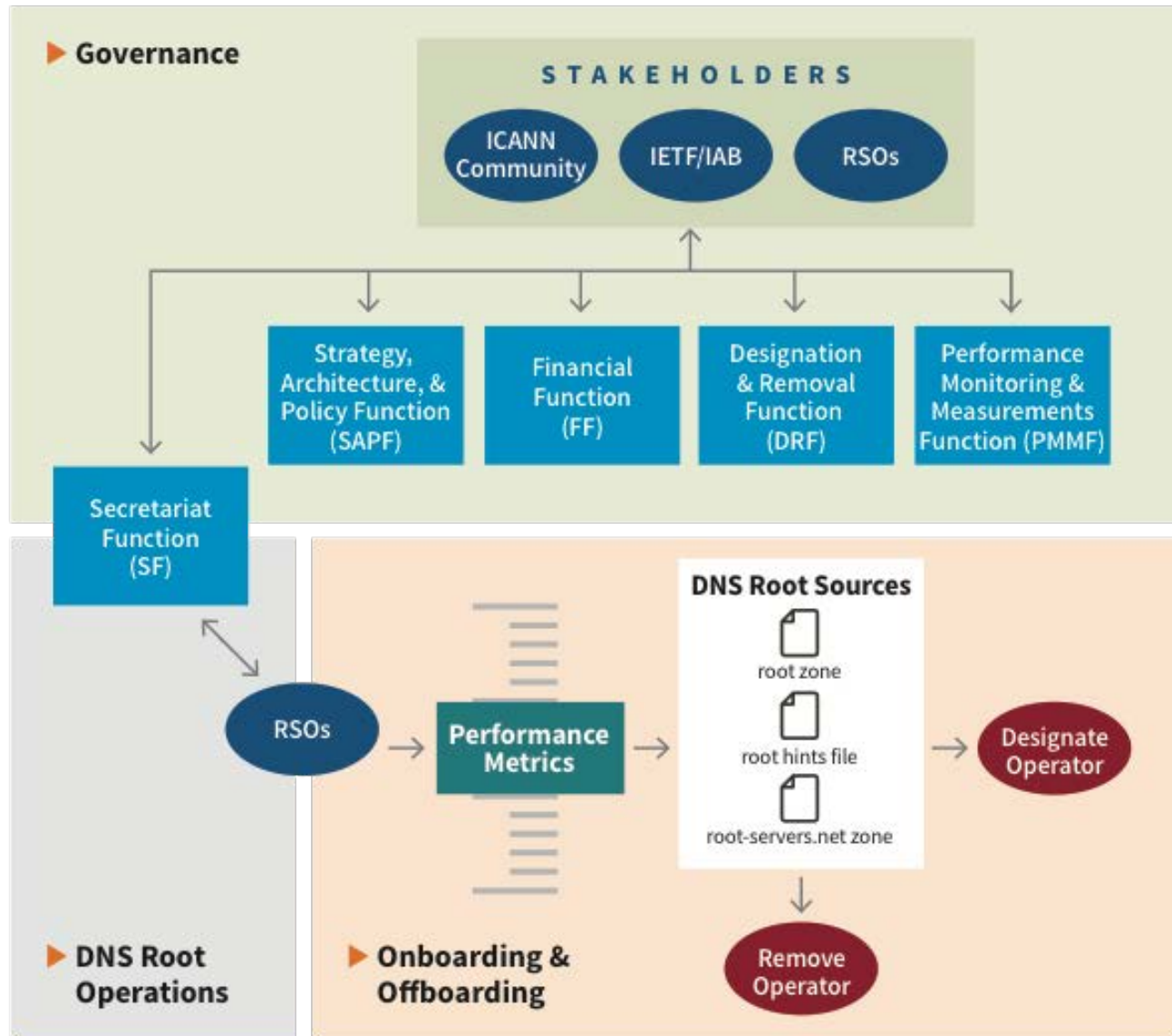
- Defines eleven principles for the operation and evolution of the Root Server System
- Proposes an initial governance model (the RSSAC037 Model) for the Root Server System and its operators
- Demonstrates how the RSSAC037 Model works through a set of scenarios on designation and removal of operators

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



Envisions the Concept Model based on the
RSSAC037 Model:

- Root Server System Governance Board (SAPF)
- Root Server System Standing Committee (PMMF)
- Root Server Operator Review Panel (DRF)
- ICANN org as Finance and Secretariat Functions

Concept Paper: Part II

Outlines a community-driven process to finalize a new cooperation and governance model for the RSS based on recommendation 1 in RSSAC038.

Phase 1: ICANN org is reviewing and evaluating RSSAC037 at the direction of the ICANN Board.

Phase 2: RSSAC037, Concept Paper, and Governance Working Group (GWG) documents are available for Public Comment.

Phase 3: This is the final phase of developing a new cooperation and governance model for the RSS. The implementation phase has two tracks:

- The *Structural Track* where the GWG develops a Model.
- The *Administrative Track* to plan for implementation of the GWG Model led by ICANN org.

Governance Working Group (GWG)

- Composed of representatives from the RSSAC, 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 tasks 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, and Public Comment feedback 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
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