

**ICANN**  
COMMUNITY FORUM

64

**KOBE**

9–14 March 2019



# Tutorial on Root Server System

Root Server System Advisory Committee | March 2019

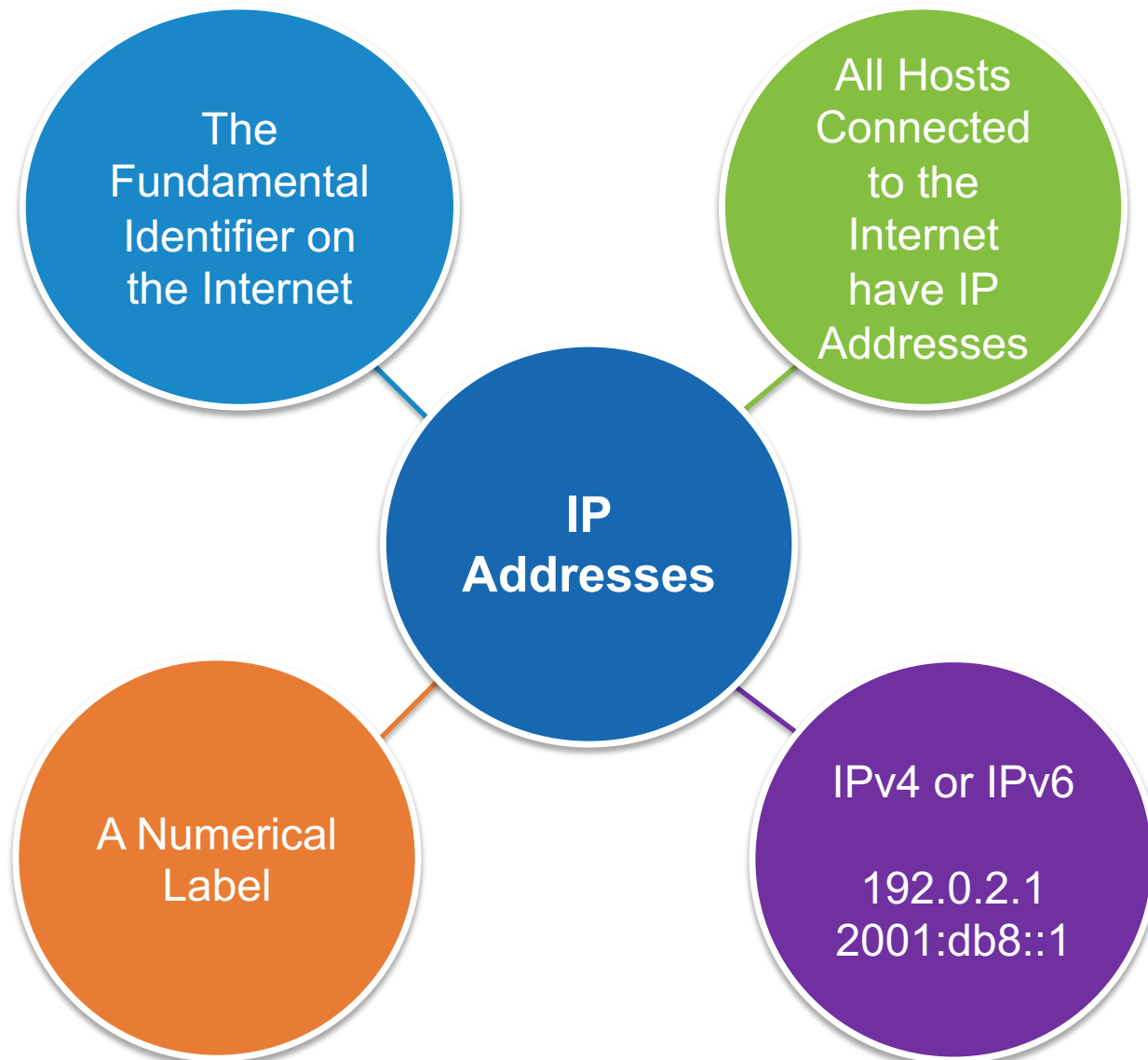


ICANN64

- ⦿ Overview of the Domain Name System
- ⦿ Explanation of Anycast
- ⦿ Root Server System Today and Its Features
- ⦿ RSSAC and Recent RSSAC Activities

# Overview of the Domain Name System

# Recap: Identifiers on the Internet



## Original Problem

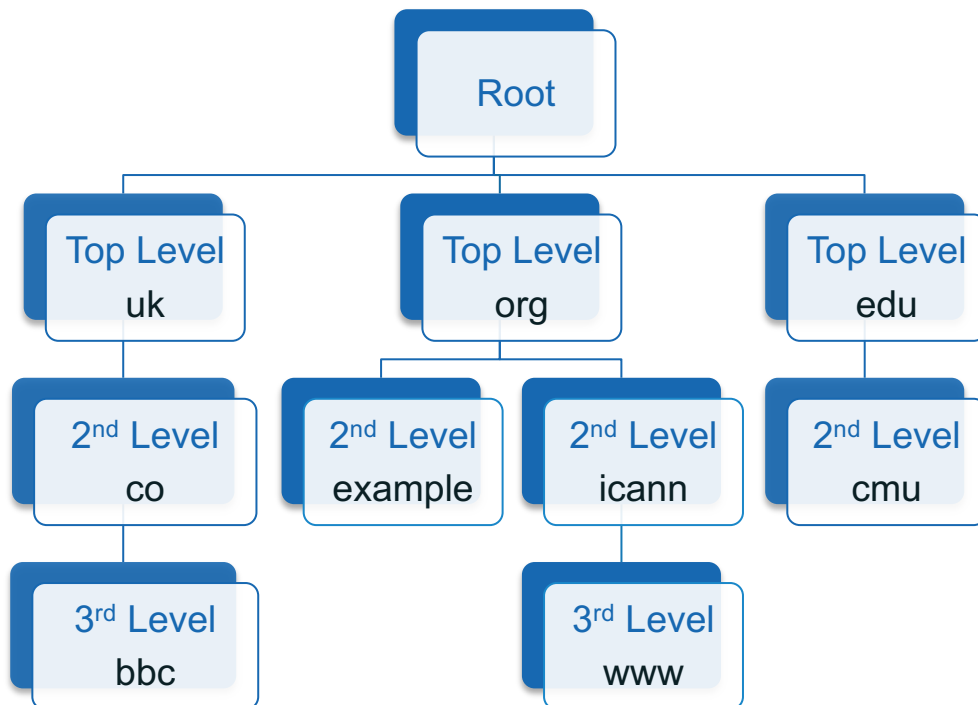
- IP addresses are hard to remember.
- IP addresses often change.

## 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



# Root Zone vs. Root Server System

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## 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 database content in the root servers

## Root Server System

- Responds with data from the root zone
- Currently distributed with 13 identities from over 1000 instances at physical locations worldwide
- Purely technical role to serve the root zone
- Responsibility of the root server operators



# Definitions

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- 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)

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- 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.



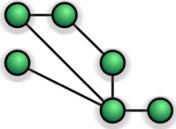
# Domain Name Resolution Process

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

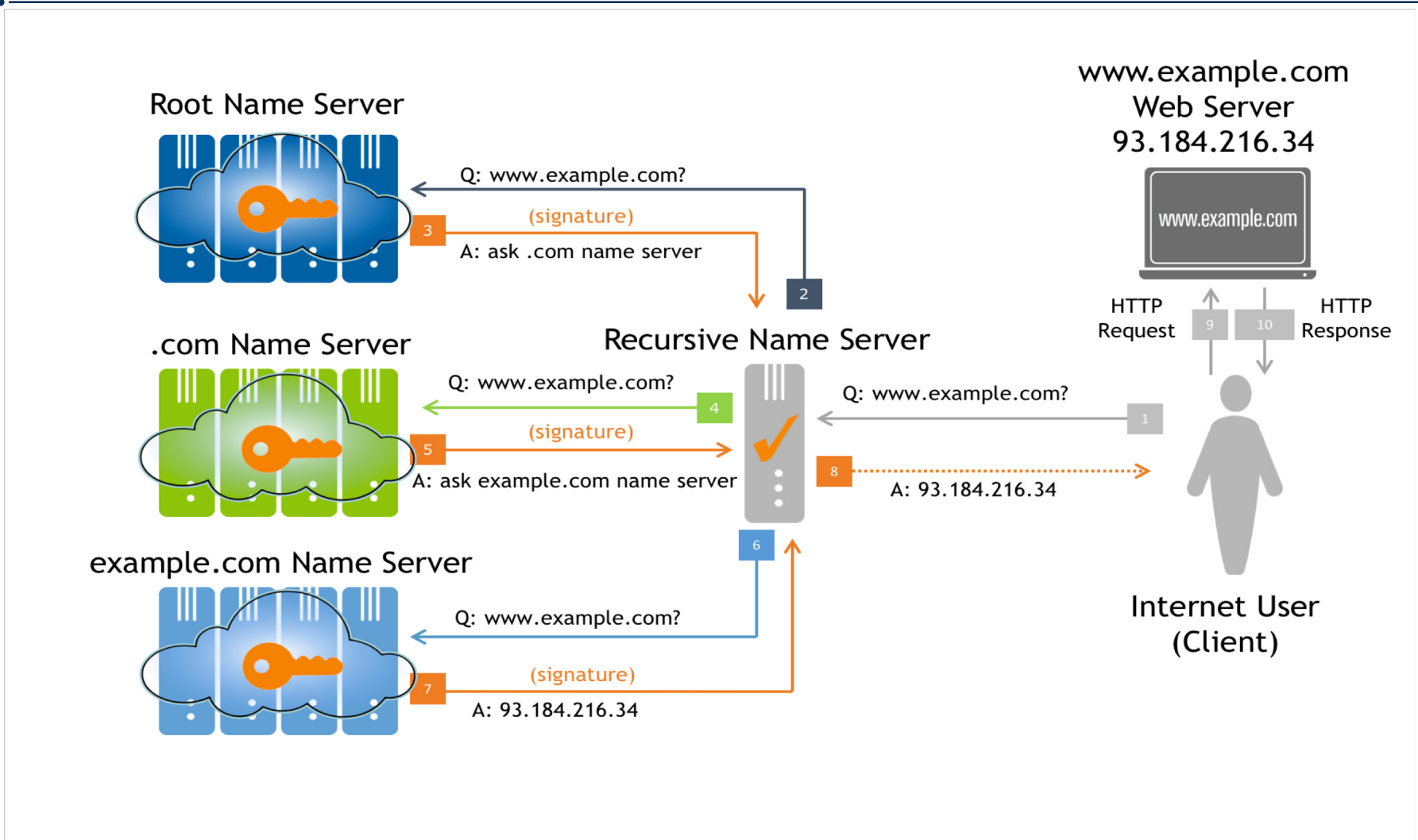
- .com → list of .com servers
- .net → list of .net servers
- .org → list of .org servers

Caching of previous answers means there is less need to query the root servers after the first question.

# Some Modern Refinements to DNS

<p><b>DNSSEC</b> (security extensions)</p> 	<ul style="list-style-type: none"><li>• Cryptographic signatures on DNS data</li><li>• Reduces risk of “spoofing”</li><li>• Resolver should validate the answers</li></ul>
<p><b>Privacy Enhancements</b></p> 	<ul style="list-style-type: none"><li>• Queries can leak information</li><li>• Standards work is ongoing to address this</li><li>• DNS-over-TLS (DoT)</li></ul>
<p><b>Anycast</b></p> 	<ul style="list-style-type: none"><li>• Multiple servers share a single IP address</li><li>• Improves latency and resilience</li><li>• Protects against DDoS attacks</li></ul>

# 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.).

# 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

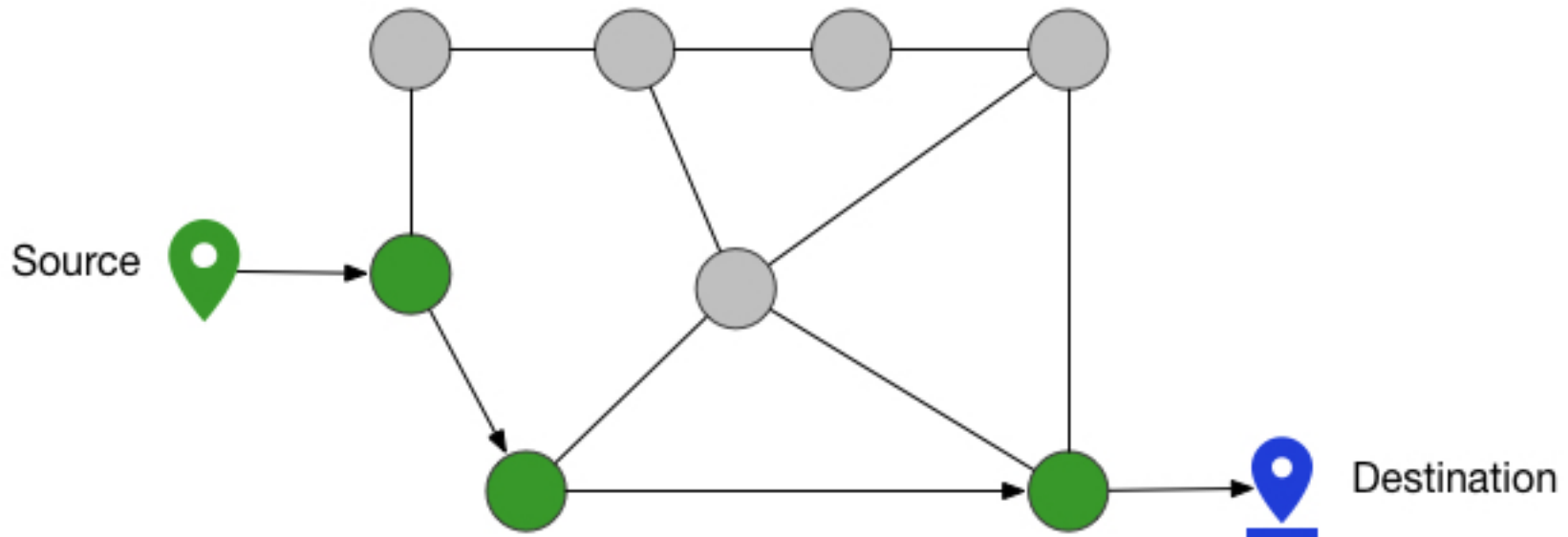
## Anycast

- 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



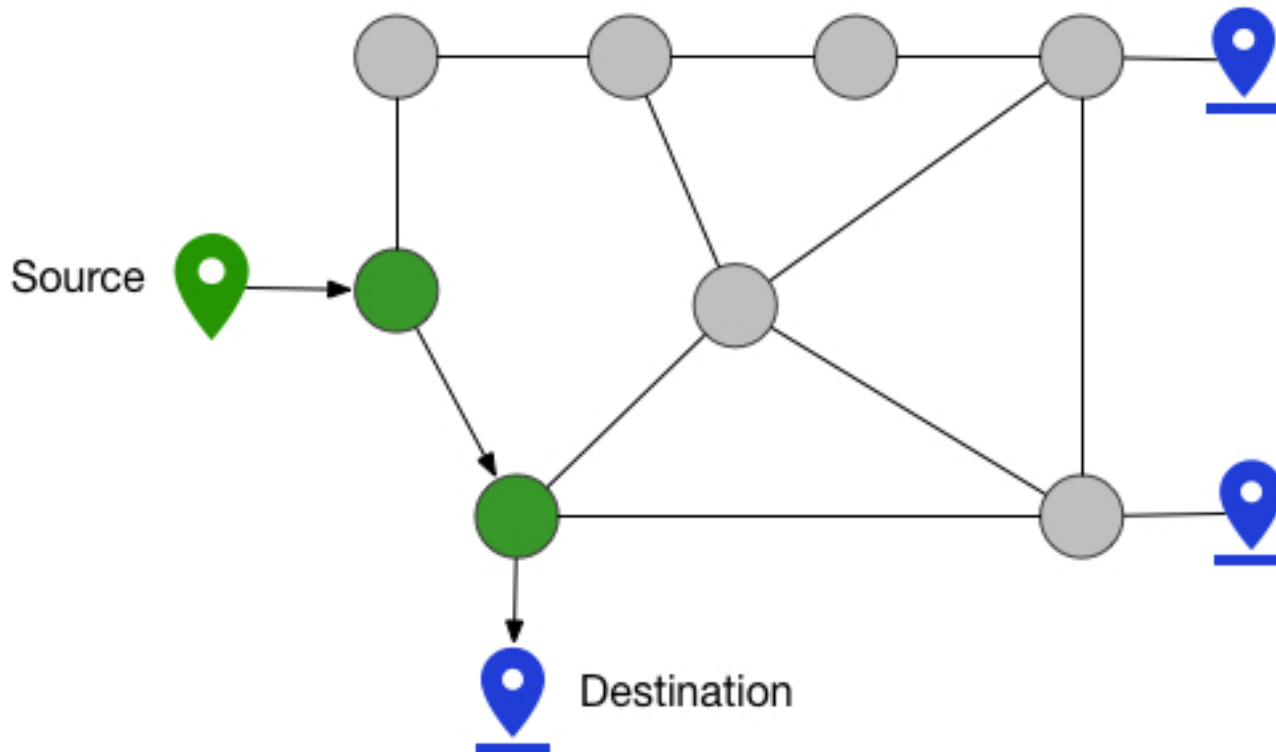
# Unicast

Traffic takes shortest route to single destination.



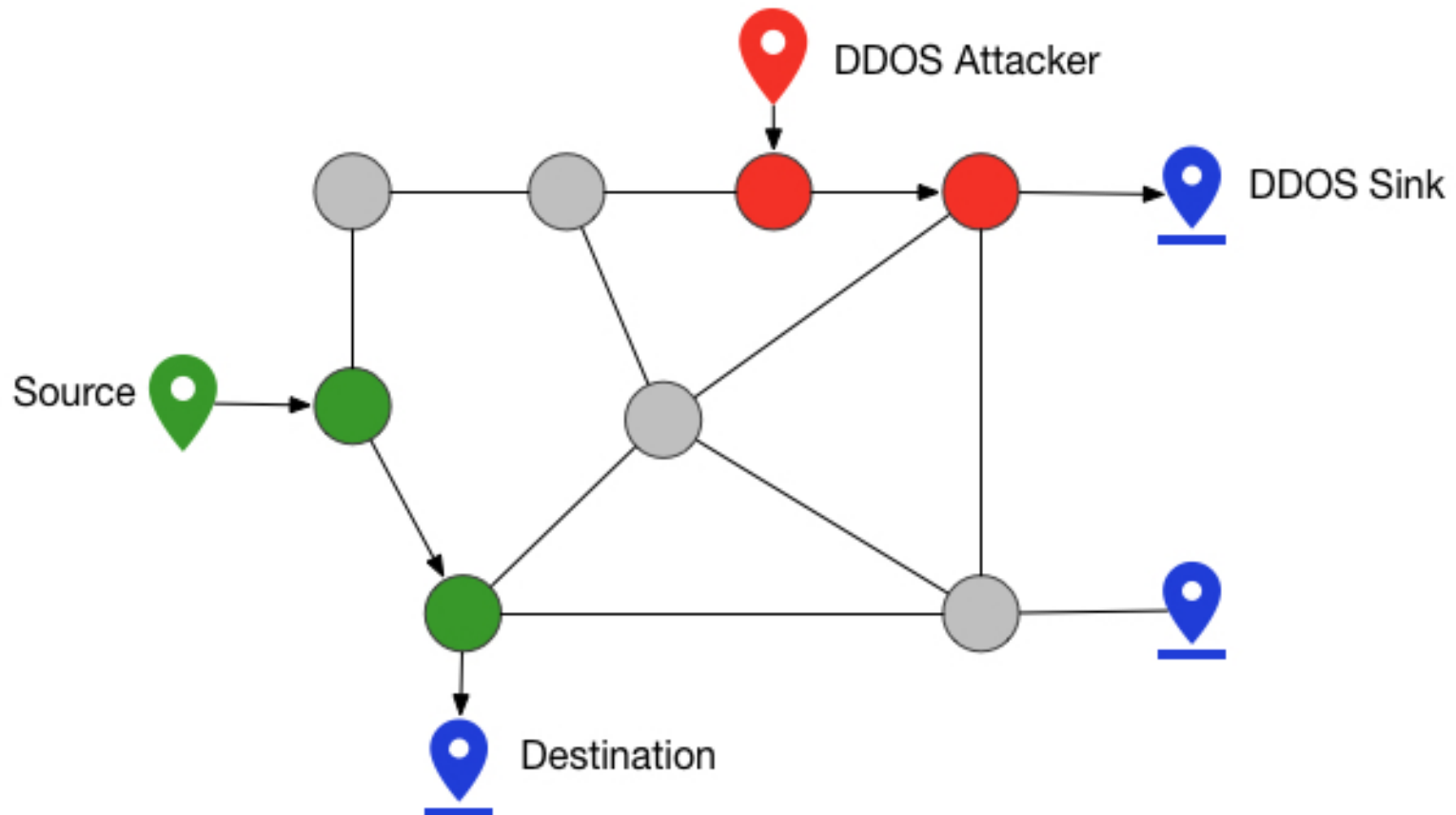
# Anycast

- 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.



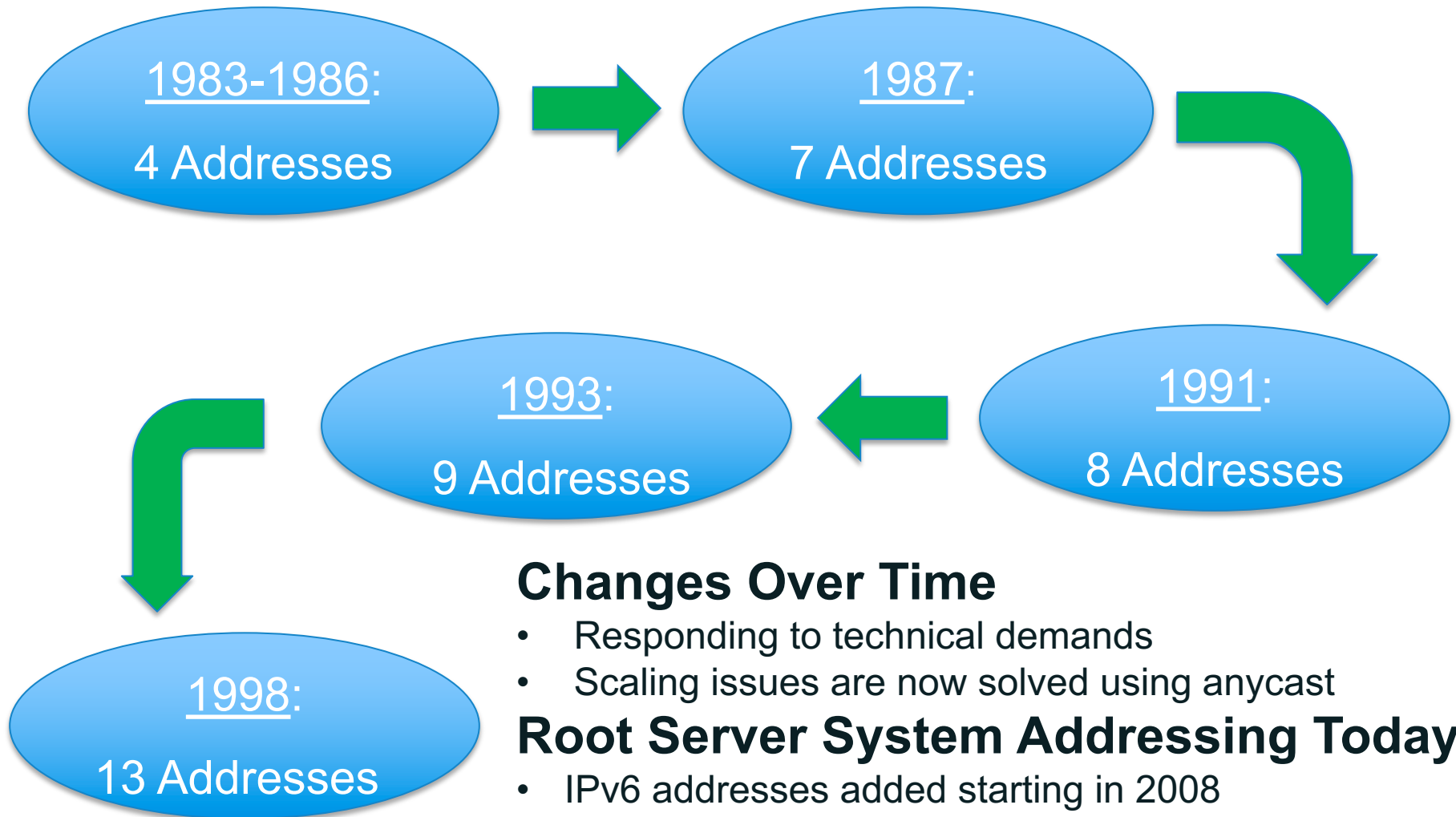
# Anycast Under DDoS Attacks

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



# Root Server System and Root Server Operators

# Growth of the Root Server System



## Changes Over Time

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

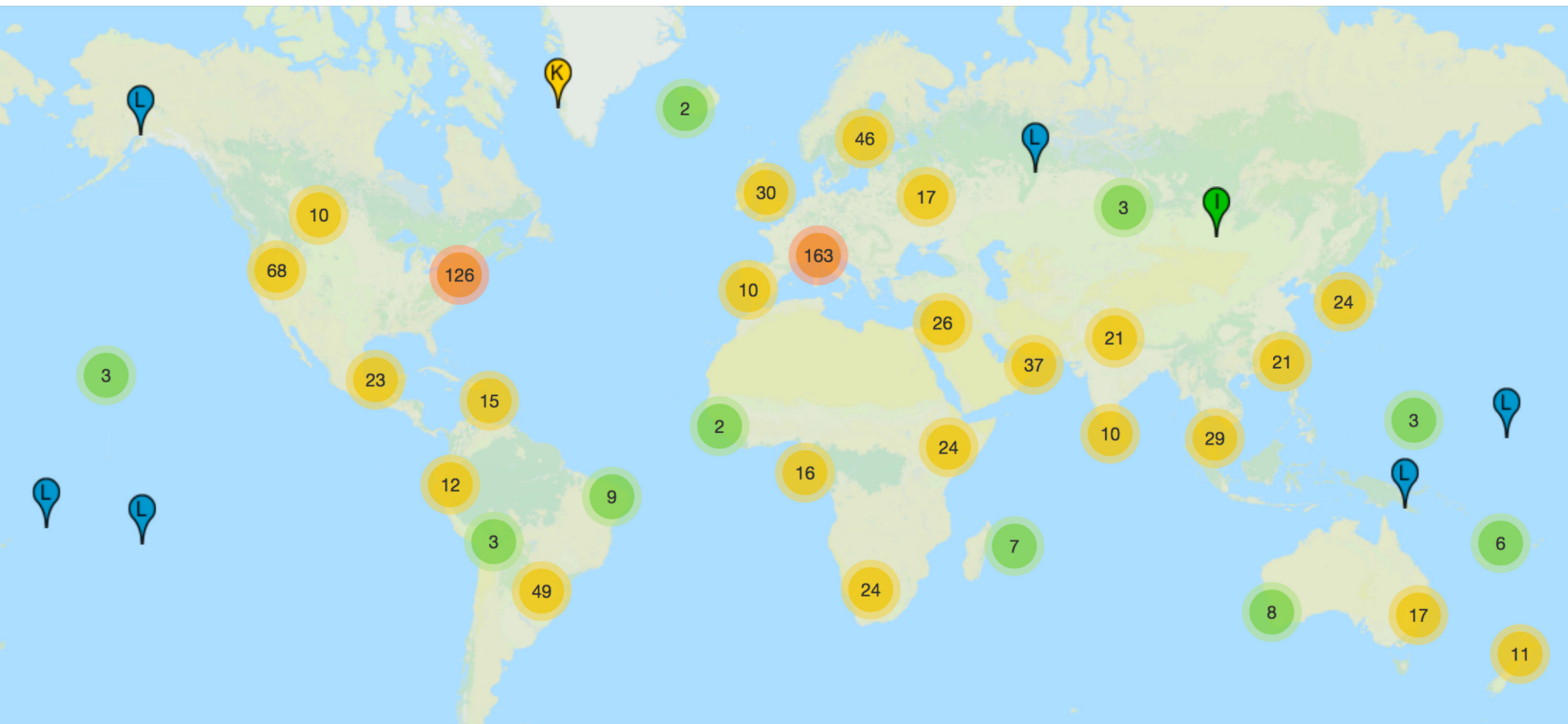
## Root Server System Addressing Today

- IPv6 addresses added starting in 2008
- 13 IPv4 and IPv6 Address Pairs
- Served from 1000+ International 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 - 2019

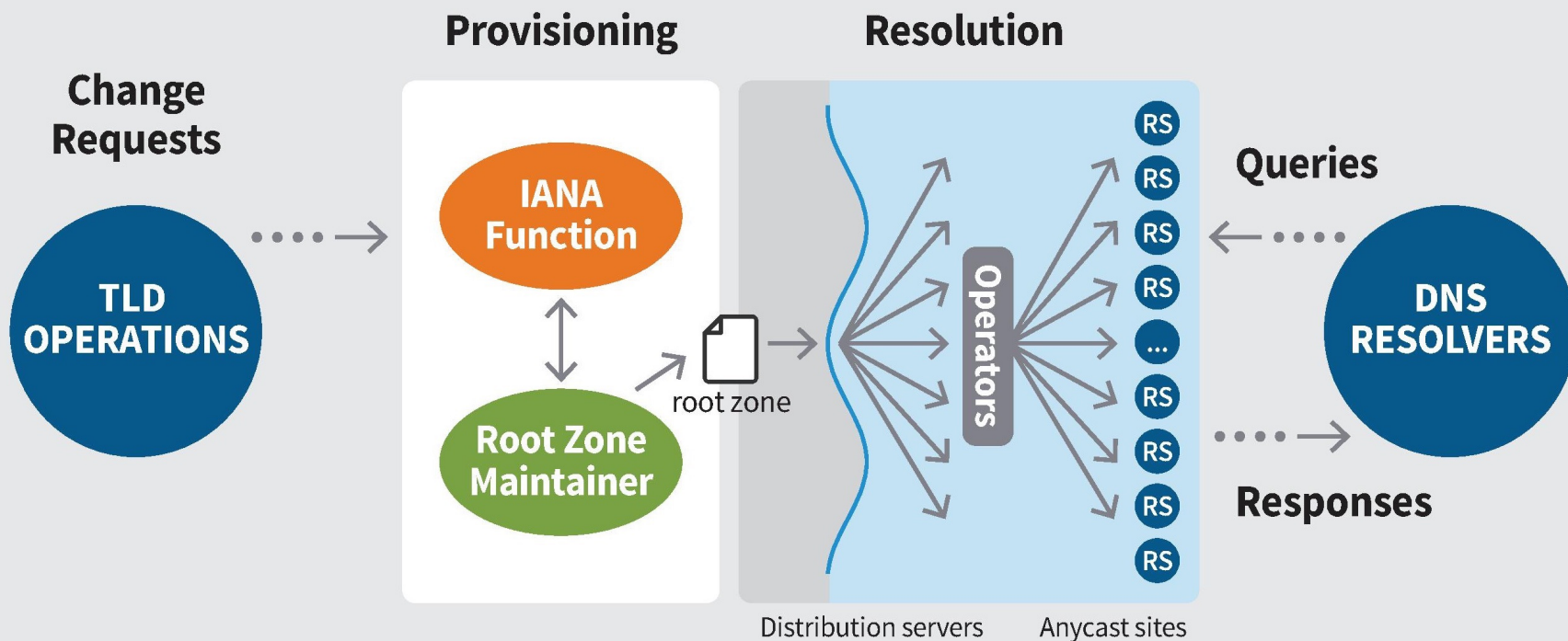


Over 1000 instances around the world – <http://root-servers.org/>



# Root Zone Management and Resolution

## ROOT ZONE PROVISIONING, DISTRIBUTION, AND RESOLUTION



# Principles of the Root Server System

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

# 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 cooperate and coordinate through

- **Industry Meetings and Internet Bodies**
  - RSSAC/ICANN, IETF, RIPE, NANOG, DNS-OARC, APNIC, ARIN, AFNOG
- **Communication tools**
  - Phone bridges, mailing lists, exchanging secure credentials
- **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 <b>usually</b> receive the entire query.

# The Root Server System and Your Networks

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- 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](mailto:ask-rssac@icann.org)



# RSSAC and Recent RSSAC Activities

# What is RSSAC?

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- 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?

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- 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 is here...



# RSSAC Organization

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- 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

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**Brad Verd**  
Verisign



**Fred Baker**  
ISC

- 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
  - 106 Technical Experts as of February, 2019
  - 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](mailto:rssac-membership@icann.org).

- Service Coverage of the Root Server System
- Studying Modern Resolver Behaviors
- Root Server System Metrics

# Transparency

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## RSSAC

- [rssac.icann.org](http://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](http://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](mailto:ask-rssac@icann.org) interface

# Questions?

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- **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