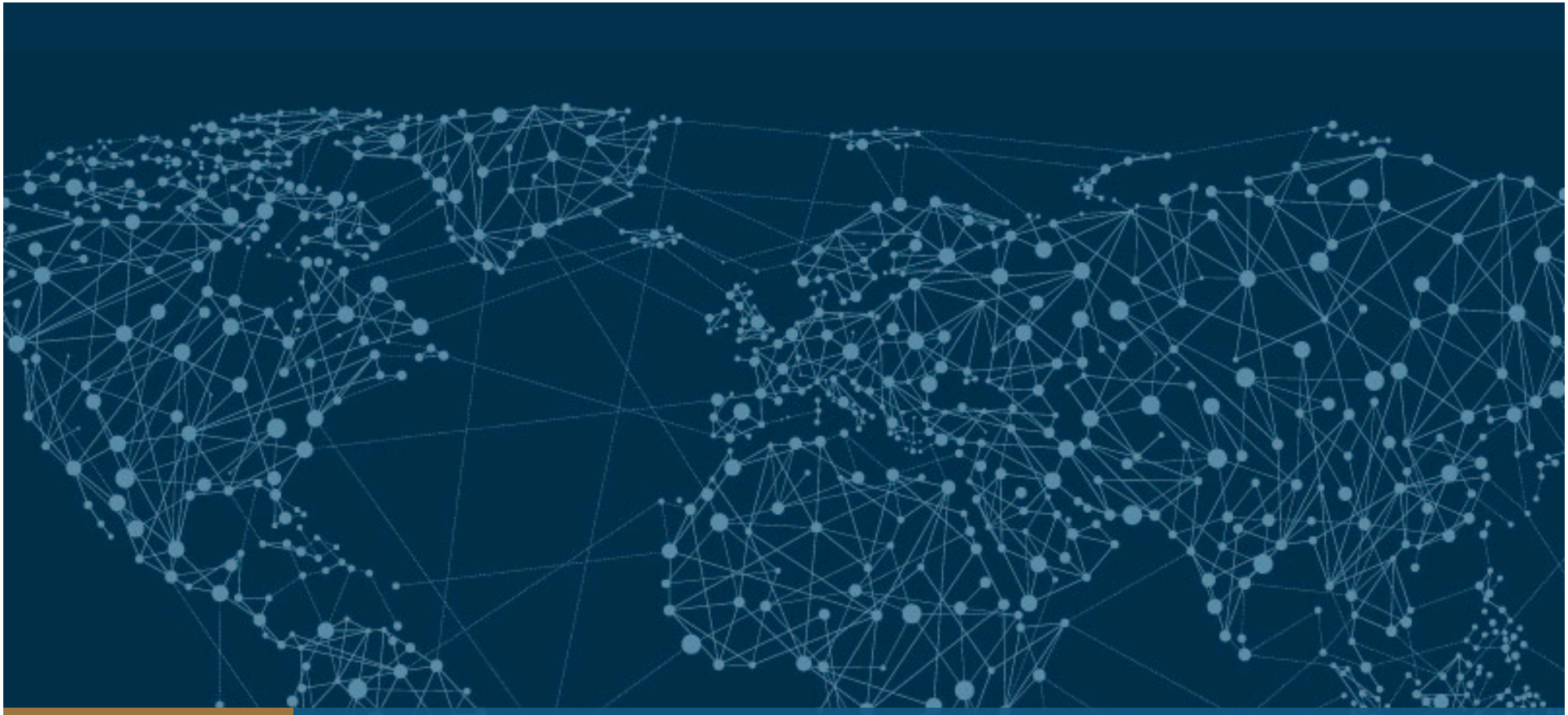
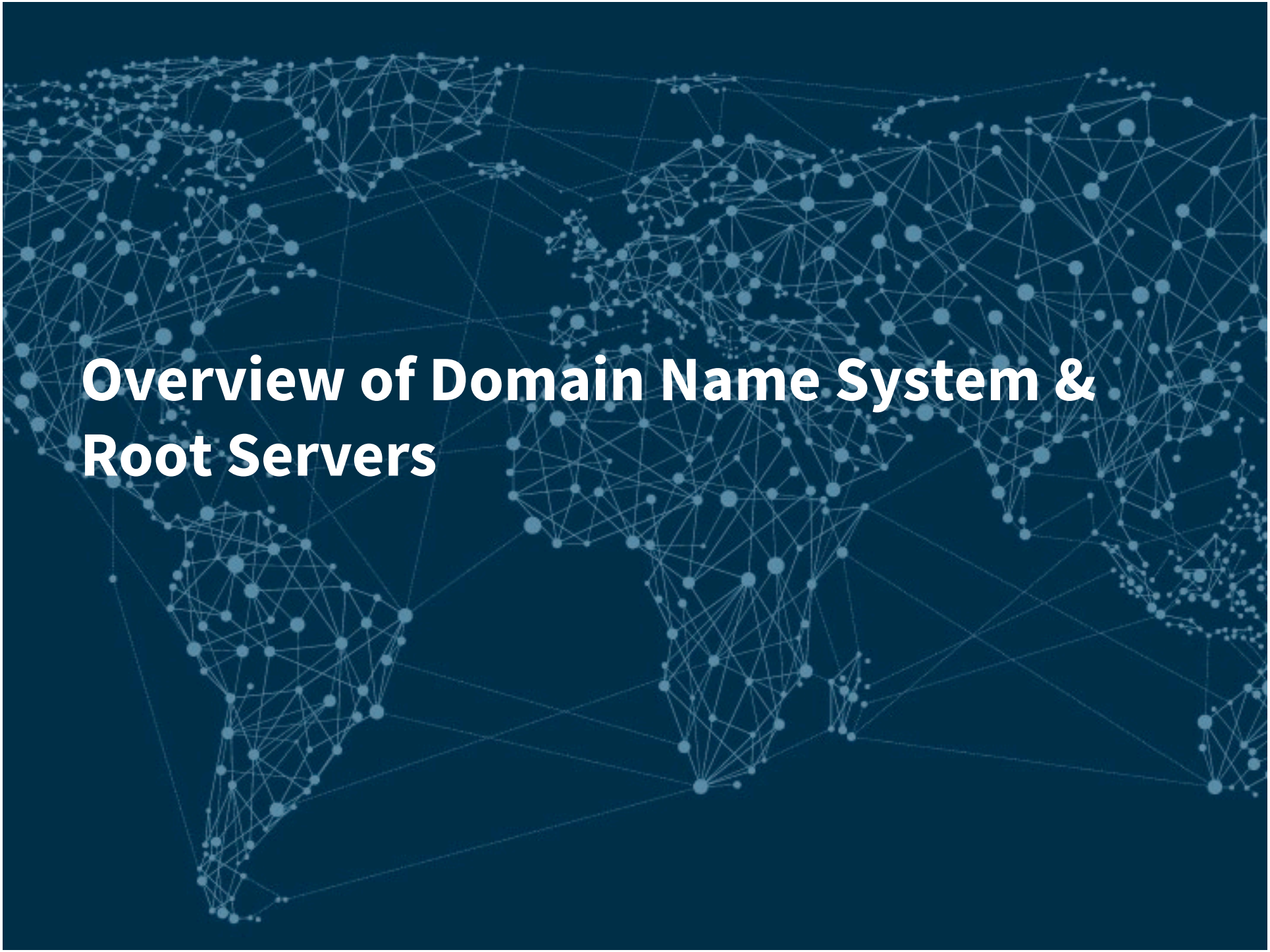


Tutorial on Root Server System

Root Server System Advisory Committee | October 2015

Outline

1. Overview of Domain Name System
2. History of Root Server System
3. Root Server System today & Its Features
4. Recent RSSAC Activities



Overview of Domain Name System & Root Servers

Recap: Identifiers on the Internet

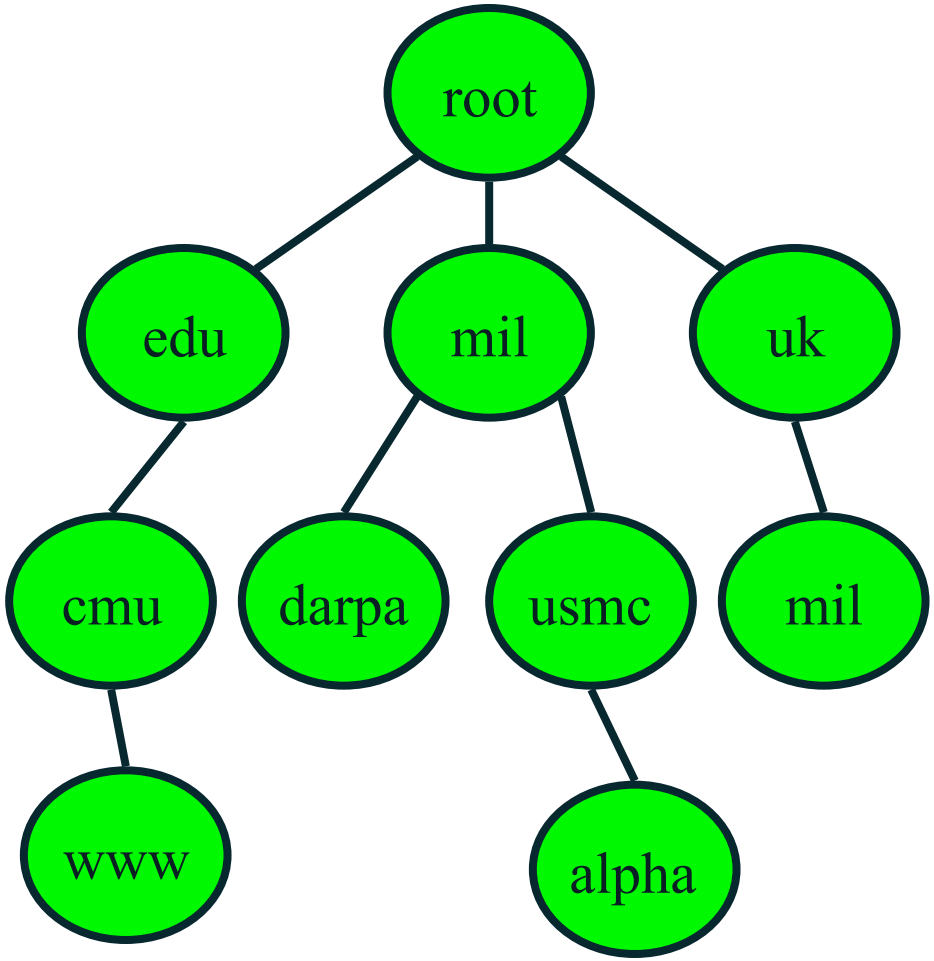
- The fundamental identifier on the internet is an IP address.
- Each host (or sometimes group of hosts) connected to the Internet has a unique IP address
- IPv4 or IPv6 (128.2.42.52, 2607:fb28::4)
- Uniqueness guaranteed through allocation from a single pool (IANA-RIR system) and careful management within a network

Why DNS?

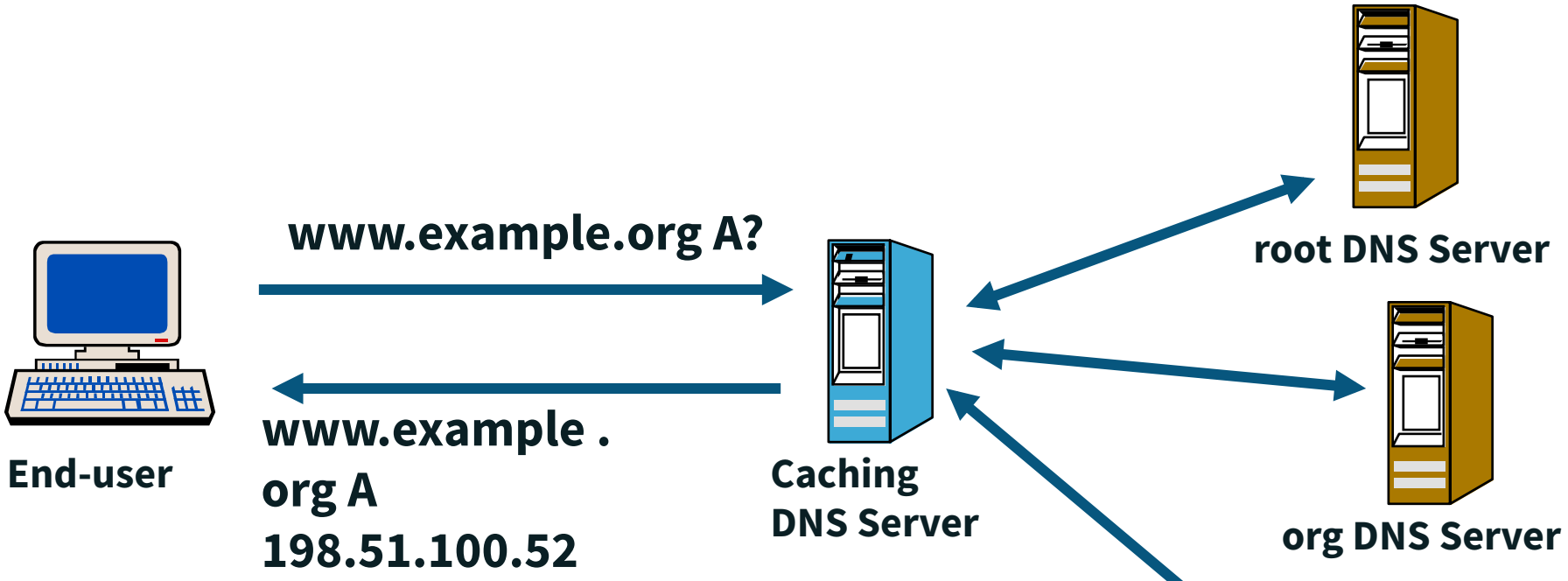
- ORIGINAL PROBLEM: IP addresses are hard to remember, and often change
- MODERN PROBLEM: IP addresses may also be shared, or multiple IP addresses may serve as entry points to a particular service; which one to use?

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
  - And many other mappings (mail servers, IPv6, reverse…)
- Globally distributed, loosely coherent, scalable, dynamic database



Domain Name Resolution Process



1. Root Servers are at the entry point to the system
2. Caching is used throughout to avoid repetitive queries
3. The DNS resolution precedes the actual transaction the user want to do (web, mail, voip call, etc.)

Domain Name Resolution Process

- Root servers only know who you need to ask next.
  - .com=>list of servers
  - .net => list of servers
  - .org => list of servers
  - ……
- Caching of previous answers means there is less need to query the root servers after the first question

Some Modern Refinements to DNS

- DNSSEC (Security extensions)
  - Cryptographic signatures on DNS data
  - Reduces risk of “spoofing”
  - Client has to validate
- Privacy enhancements
  - Queries can leak information
  - Standards being extended to reduce this
- Anycast
  - Lets multiple servers share IP address
  - Improves latency and resilience

Root servers vs. Root zone

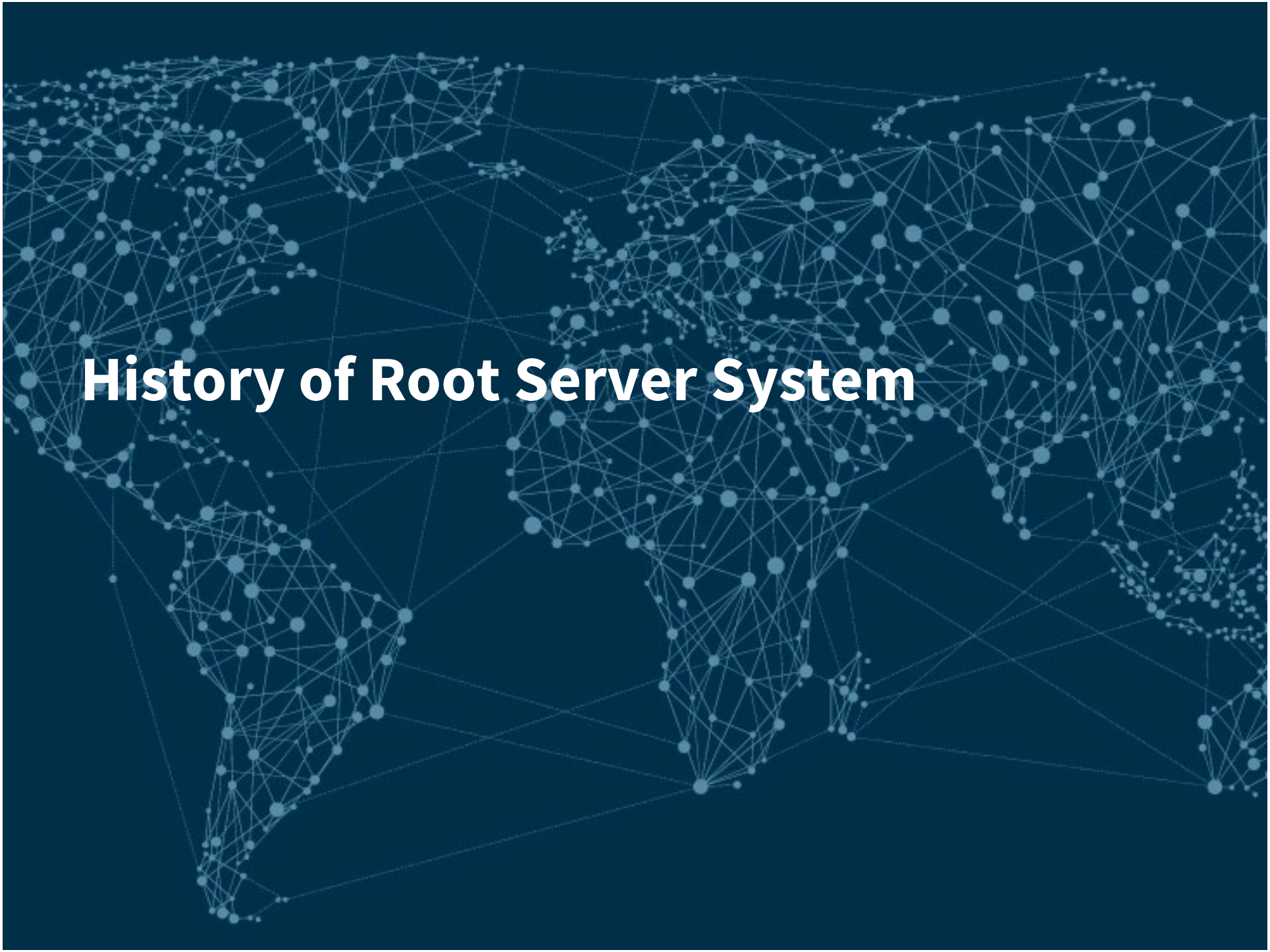
- Root servers
  - Provide the service
  - Currently limited to 13 names
    - [a-m].root-servers.net
    - Purely technical role = serve the root zone
    - Responsibility of the root server operators
- Root zone
  - Is the list of TLDs and nameservers for “the next step”
  - Created/managed by ICANN, per community policy
  - Compiled & distributed by Verisign to all root server operators.

The Root server operators

- 12 different professional engineering groups focused on
  - Reliability and stability of the service
  - Accessibility to all Internet users
  - Technical cooperation
  - Professionalism
- Diverse organizations and operations
  - Technically
  - Organizationally
  - Geographically

The Root server operators (2)

- The operators are not involved in:
  - Policy making
  - Data modification
    - Publishers, not authors or editors
- The operators are involved in:
  - Careful operational evolution of service (expansion as the Internet expands)
  - Evaluating and deploying suggested technical modifications
  - Making every effort to ensure stability and robustness


History of Root Server System

First Root Servers (1983-1986)

Name	IP Address	Software	Organization
SRI-NIC	10.0.0.51 26.0.0.73	JEEVES	Software Research International
ISIB	10.3.0.52	JEEVES	Information Sciences Institute, University of Southern California
ISIC	10.0.0.52	JEEVES	Information Sciences Institute, University of Southern California
BRL-AOS	192.5.25.82 128.20.1.2	BIND	Ballistic Research Laboratory, US Army

Additional Root Servers - 1987

Name	IP Address	Software	Organization
SRI-NIC.ARPA	10.0.0.51 26.0.0.73	JEEVES	Software Research International
A.ISI.EDU	26.2.0.103	JEEVES	Information Sciences Institute, University of Southern California
BRL-AOS.ARPA	192.5.25.82 128.20.1.2	BIND	Ballistic Research Laboratory, US Army
C.NYSER.NET	128.213.5.17	BIND	RPI
TERP.UMD.EDU	10.1.0.17 128.8.10.90	BIND	University Of Maryland
GUNTER-ADAM.ARPA	26.1.0.13	JEEVES	U.S. Air Force Networking Group
NS.NASA.GOV	128.102.16.10	BIND	NASA Ames

Expanding Root Service outside US (1991)

Original Name	New Name	IP Address	Software	Organization
SRI-NIC.ARPA	NS.NIC.DDN.MIL	192.67.67.53	JEEVES	Software Research International
A.ISI.EDU	A.ISI.EDU	26.2.0.103 128.9.0.107	JEEVES	ISI
BRL-AOS.ARPA	AOS.BRL.MIL	192.5.25.82 128.20.1.2	BIND	BRL, US Army
C.NYSER.NET	C.NYSER.NET	192.33.4.12	BIND	RPI
TERP.UMD.EDU	TERP.UMD.EDU	10.1.0.17 128.8.10.90	BIND	University Of Maryland
GUNTER-ADAM.ARPA	GUNTER-ADAM.AF.MIL	26.1.0.13	JEEVES	U.S. Air Force Networking Group
NS.NASA.GOV	NS.NASA.GOV	128.102.16.10	BIND	NASA Ames
NIC.NORDU.NET	NIC.NORDU.NET	192.36.148.17	BIND	NORDUNet

Renaming root severs to root-servers.net (1994-1995)

- By April 1993, the size of root hints response was approaching the 512 byte limit
- Bill Manning, Mark Kosters and Paul Vixie devised a plan to rename all the root servers from individual names to [a-i].root-servers.net
- IANA approved the plan and renaming was done in phases at the end of 1995
- Moving root servers to root-servers.net allowed for DNS label compression, thus four new root servers were added in 1997 to serve exclusively the root zone

Renaming root severs to root-servers.net

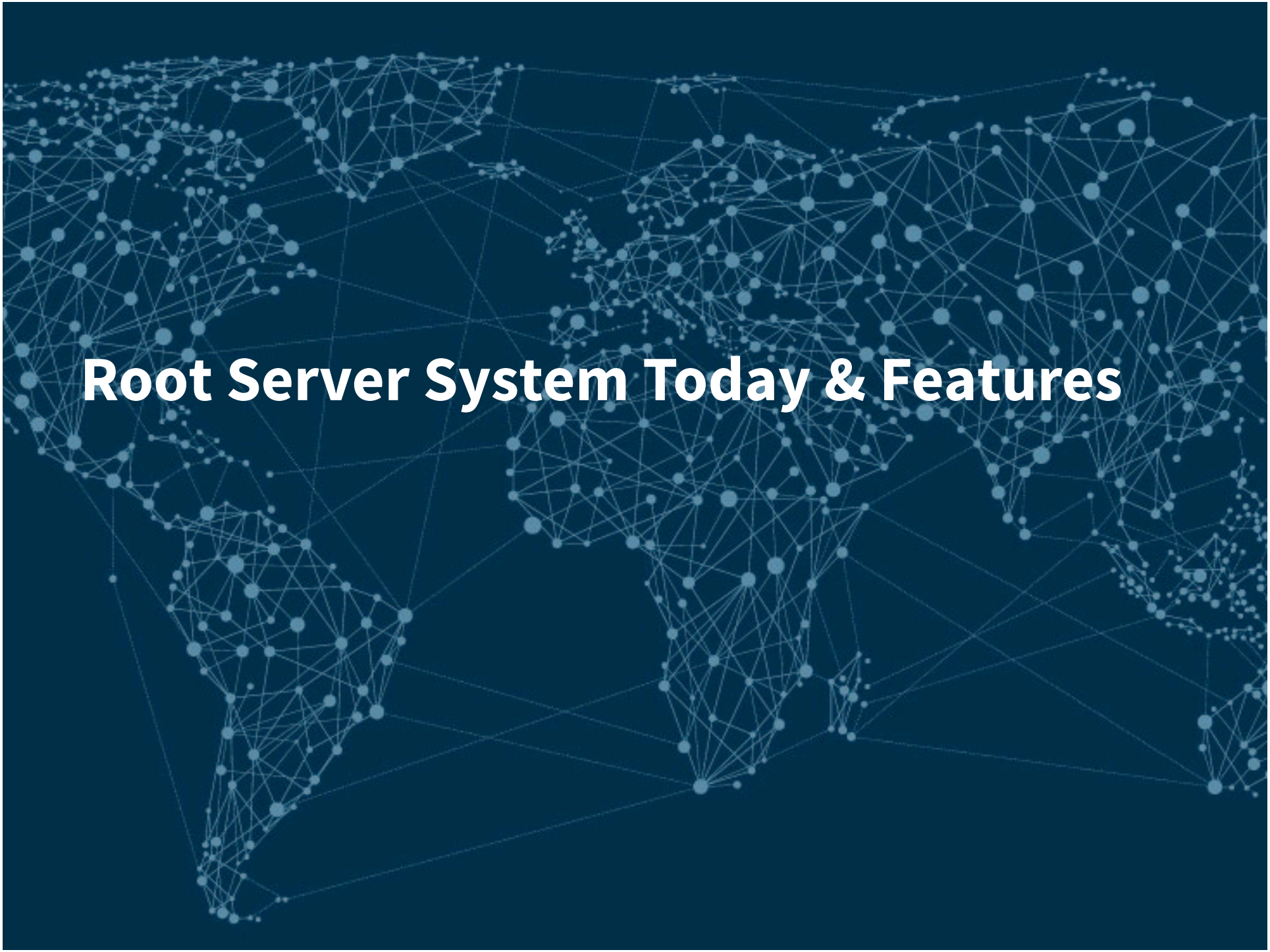
Original Name	New Name	Organization
NS.INTERNIC.NET	a.root-servers.net	Internic (operated by NSI)
NS1.ISI.EDU	b.root-servers.net	ISI
C.PSI.NET	c.root-servers.net	PSInet
TERP.UMD.EDU	d.root-servers.net	University of Maryland
NS.NASA.GOV	e.root-servers.net	NASA
NS.ISC.ORG	f.root-servers.net	Internet System Consortium (ISC)
NS.NIC.DDN.MIL	g.root-servers.net	DISA
AOS.ARL.ARMY.MIL	h.root-servers.net	Army Research Lab (ARL)
NIC.NORDU.NET	i.root-servers.net	NORDUnet

Adding four additional root servers (1996 – 1998)

- Postel used a set of criteria to select new root server operators
  - Need (Europe, Asia)
  - Connectivity (both internal and external)
  - Commitment to send and respond to traffic without filtering
  - Community consensus: The potential operator should demonstrate the widest possible support from the community being served
- In Europe, RIPE was chosen to run k.root-servers.net
  In Asia, WIDE was chosen to run m.root-servers.net

Root Server Planning after Postel's Death

- The root server operators met as a formal group and agreed on the following principles
  - Operate for the common good of the Internet reliability
  - The IANA as the source of the root data
  - Sufficient investment to operate responsibly
  - Proper notice and facilitate transition when needed
  - Recognition of the other operators

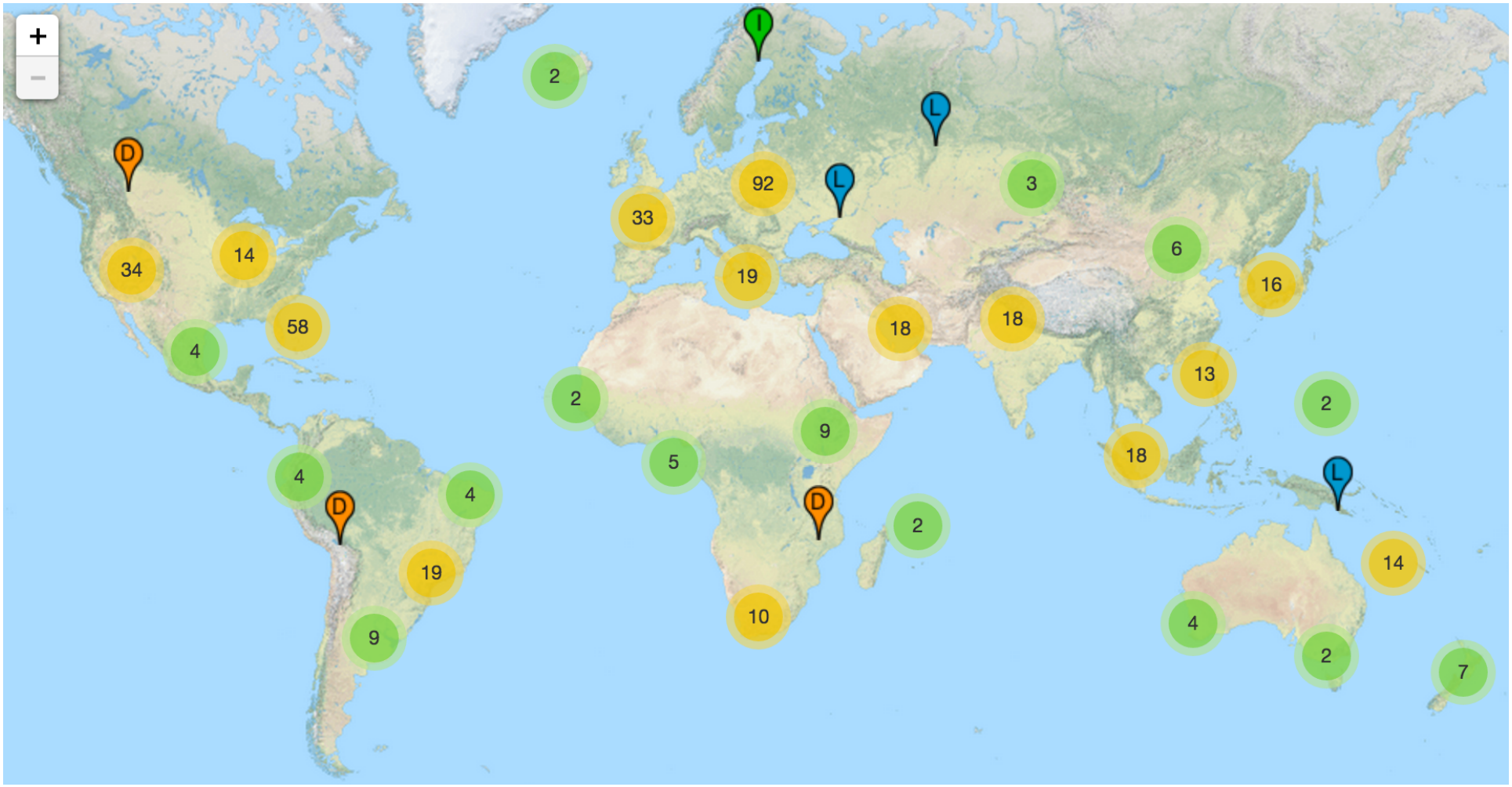


Root Server System Today & Features

Root Servers Today - 2015

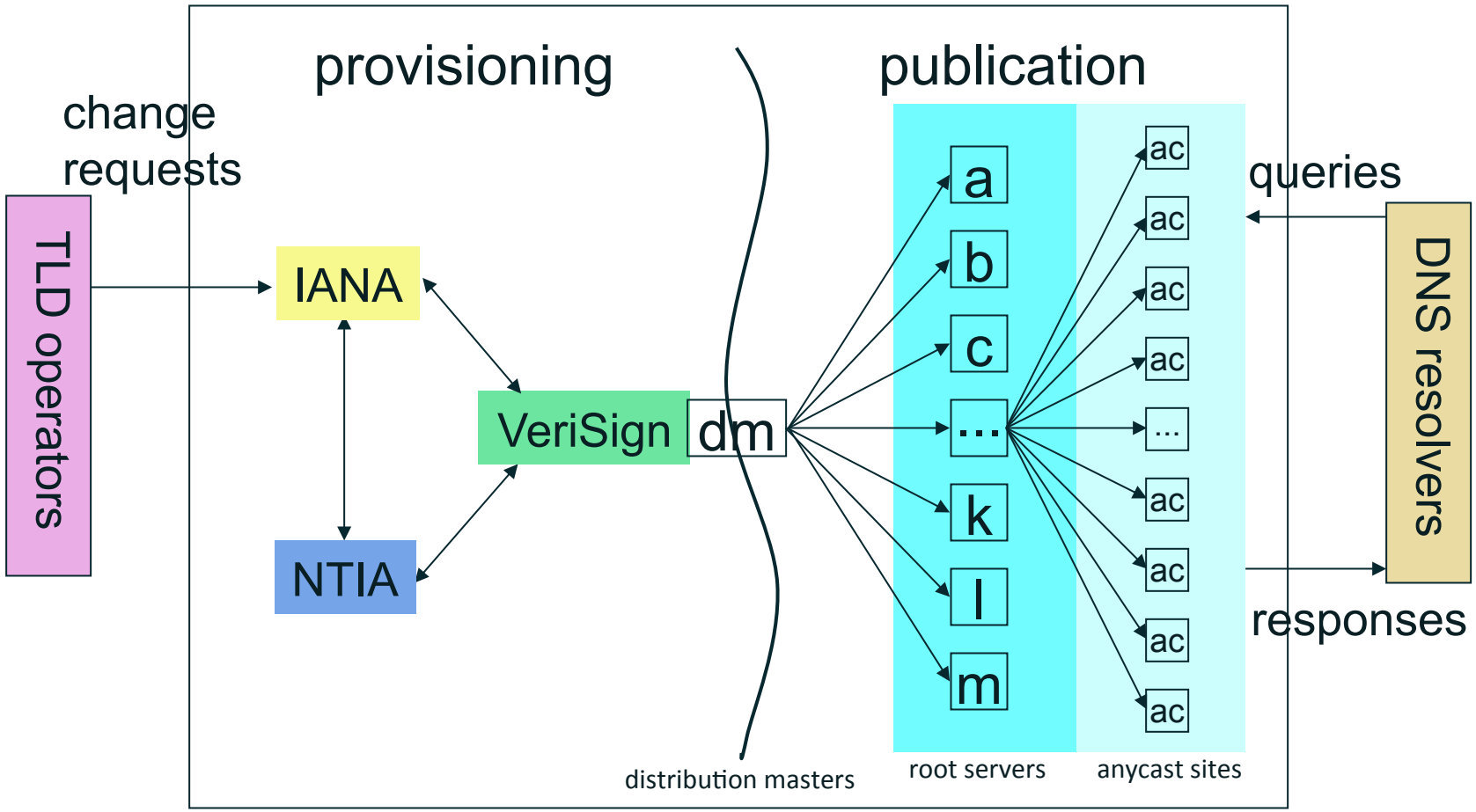
Hostname	IP Addresses	Manager
a.root-servers.net	198.41.0.4, 2001:503:ba3e::2:30	VeriSign, Inc.
b.root-servers.net	192.228.79.201, 2001:500:84::b	University of Southern California (ISI)
c.root-servers.net	192.33.4.12, 2001:500:2::c	Cogent Communications
d.root-servers.net	199.7.91.13, 2001:500:2d::d	University of Maryland
e.root-servers.net	192.203.230.10	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	US Department of Defence (NIC)
h.root-servers.net	128.63.2.53, 2001:500:1::803f:235	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, 2001:500:3::42	ICANN
m.root-servers.net	202.12.27.33, 2001:dc3::35	WIDE Project

Root Servers Today - 2015



12 operators, 13 letters, close to 500 instances around the world

Root Zone Management



Features of Root server operators

- Diversity
  - Diversity of organizational structure (government labs, Universities, for profit companies, not for profit service)
  - Diversity of operational history
  - Diversity of hardware and software in use
  - Common best practices refer to minimum levels of
    - Physical system security
    - Overprovisioning of capacity
    - Professional and trusted staff

Features of Root server operators

- Cooperation and coordination
  - Within the diversity, cooperation takes place at industry meetings (IETF, RIPE, NANOG, DNS-OARC, APNIC, ARIN, AFNOG,…) and use of the Internet itself.
  - There is permanent infrastructure to respond to possible emergencies (telephone bridges, mailing lists, exchange of secure credentials)
  - Coordination within established Internet bodies (RSSAC within ICANN, participation in evolving the DNS standard through IETF, data-sharing through DNS-OARC)

Response to an evolving Internet

- As the Internet evolves new requirements are put on the DNS system
  - Root server operators analyze the impact of and adopt new uses and protocol extensions on the service
    - IDNs, DNSSEC, IPv6, …
  - Increasing robustness and responsiveness, as well as resilience
    - Wide deployment of distributed anycasts (currently over 400 sites around the world)

Myths corrected

- Root servers do not control where Internet traffic goes, routers do
- Not every DNS query is handled by a root server
- Administration of the root zone is separate from service provision
- None of the root server letters are special
- Root server operators are not hobbyists
- More than 13 servers. Only 13 technical entities
- No single organization controls the whole system. Emphasis on coordination over governance.

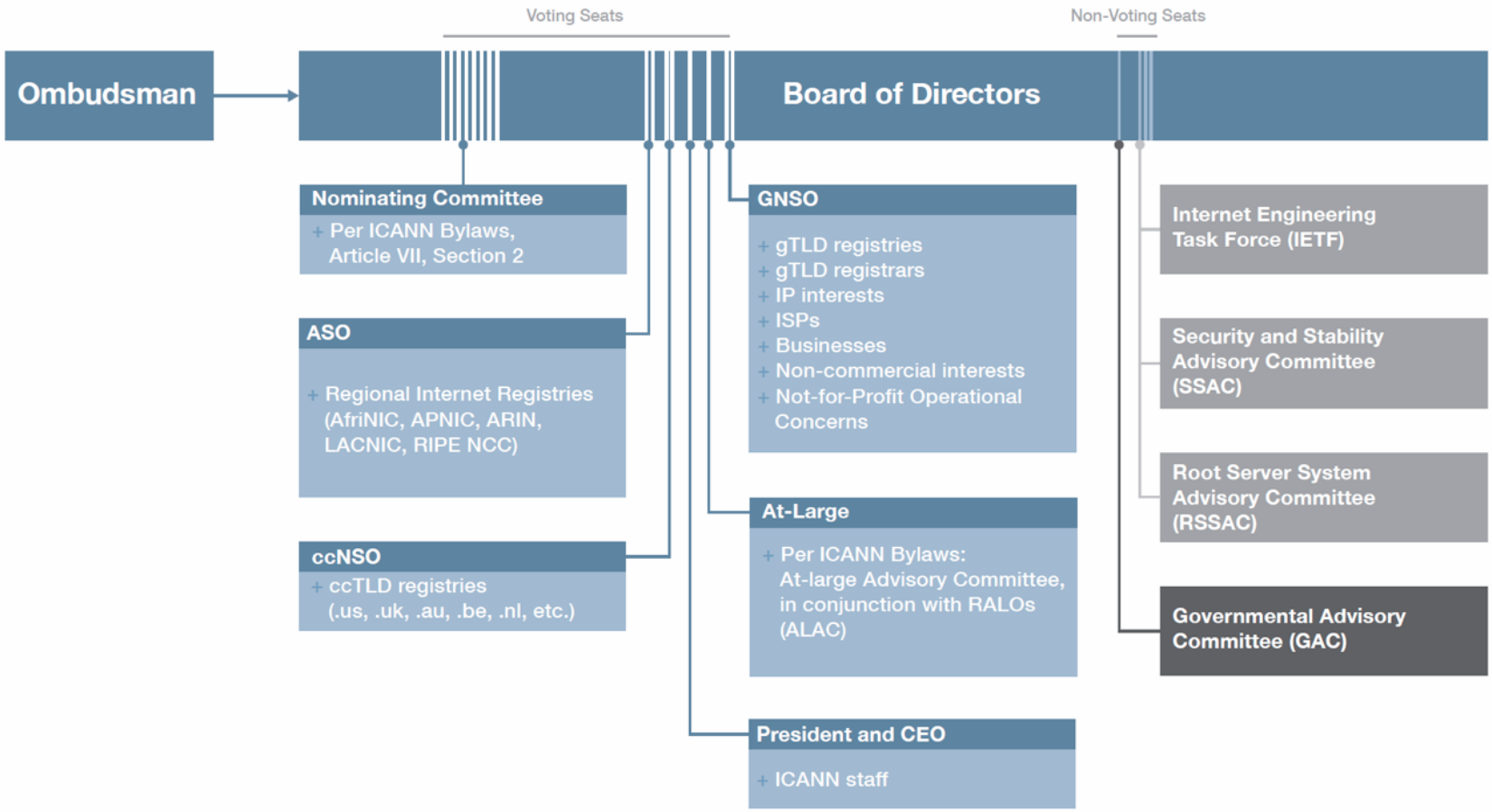
Recent RSSAC Activities

What is RSSAC?

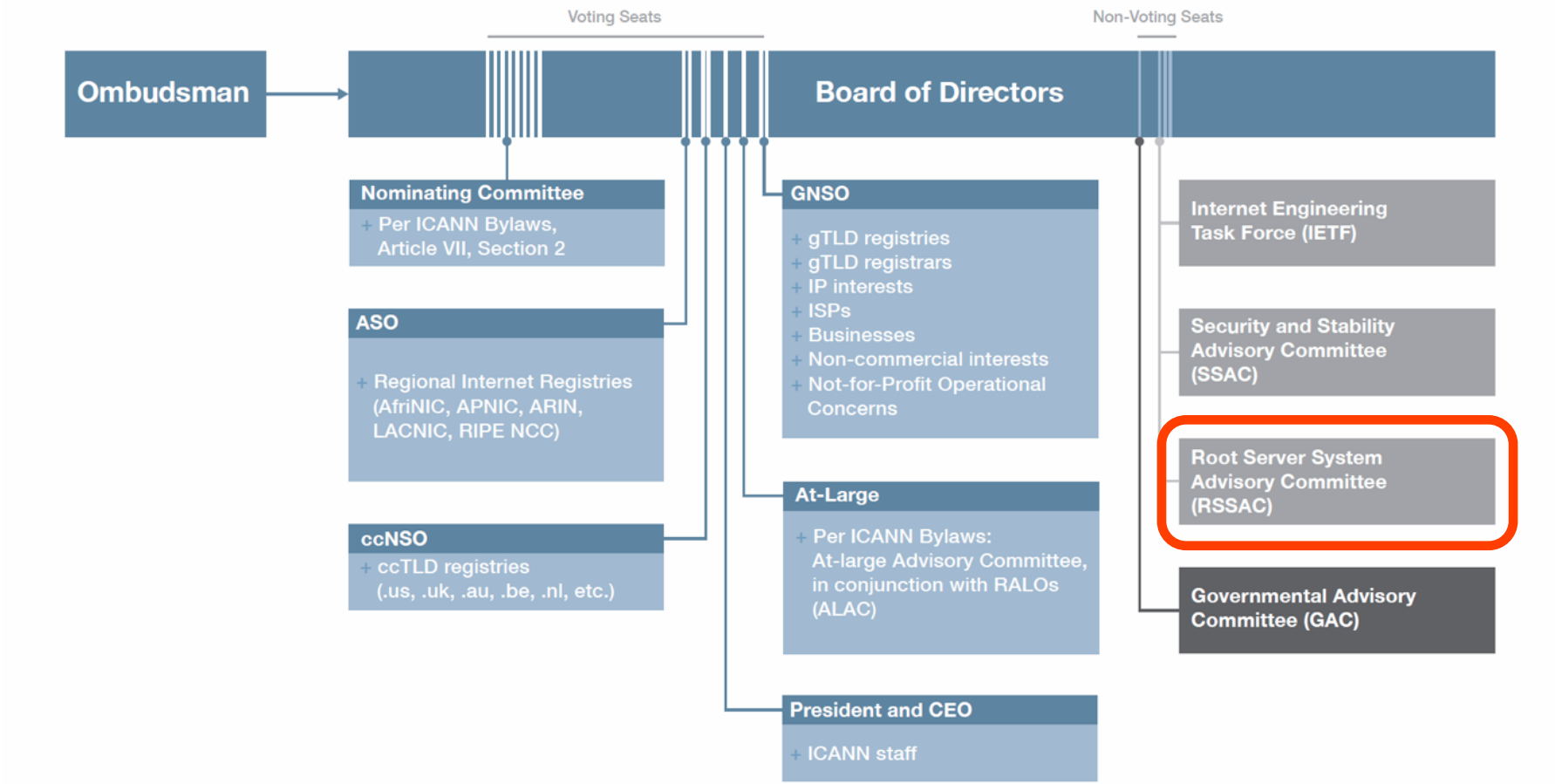
- The role of the Root Server System Advisory Committee ("RSSAC") is to advise the ICANN community and Board on matters relating to the operation, administration, security, and integrity of the Internet's Root Server System.

- (This is a very narrow scope!)

RSSAC is here …



RSSAC is here …



RSSAC organization

- RSSAC – composed of
  - Appointed representatives of the root server operators.
  - Alternates to these.
  - Liaisons.
- RSSAC Caucus
  - Body of volunteer subject matter experts.
  - Appointed by RSSAC

RSSAC co-chairs

Lars-Johan Liman, M.Sc.
Netnod
I-root

Tripti Sinha
University of Maryland
D-root

RSSAC Liaisons

- IANA Functions Operator (ICANN/IANA dept.)
- Root Zone Maintainer (Verisign)
- IANA Functions Administrator (US DoC NTIA)
- IAB (for the IETF)
- SSAC
- ICANN Board
- ICANN NomCom

https://www.icann.org/resources/pages/rssac-4c-2012-02-25-en

Caucus

- Purpose
  - Pool of experts who produce documents
    - Expertise, critical mass, broad spectrum
  - Transparency of who does the work
    - Who, what expertise, which other hats
  - Framework for getting work done
    - Results, leaders, deadlines
- Members
  - 67 Technical Experts (42% not from Root Server Operators)
  - Public statements of interest
  - Public credit for individual work
  - To apply, email rssac-membership@icann.org.

Recent RSSAC publications

- Reports
  - RSSAC001: Service Expectations of Root Servers [20 November 2014] (approved by RSSAC, held in publication in tandem with a complementary RFC by IAB)
  - RSSAC002: Advisory on Measurements of the Root Server System [20 November 2014]
  - RSSAC003: Report on Root Zone TTLs [16 September 2015]
- Statements
  - RSSAC Comment on ICG Proposal [4 September 2015]
  - RSSAC Comment on CCWG Work Stream 1 Report [5 June 2015]
  - IAB Liaison to RSSAC [12 February 2015]
  - RSSAC statement on the Increase of the DNSSEC Signature Validity Period of the DNS Root Zone [17 December 2014]

Current Caucus Work: Root Servers Naming Scheme Work Party

On 9 July 2015, the RSSAC chartered a work party to produce **"History and Technical Analysis of the Naming Scheme Used for Individual Root Servers"** with the following scope to:

1. Document the technical history of the names assigned to individual root servers;
2. Consider changes to the current naming scheme, in particular whether the names assigned to individual root servers should be moved into the root zone from the root-servers.net zone;
3. Consider the impact on the priming response of including DNSSEC signatures over root server address records;
4. Perform a risk analysis; and
5. Make a recommendation to root server operators, root zone management partners, and ICANN on whether changes should be made, and what those changes should be.

Work Party meets weekly and expects to finish is work in mid-November.