Distributed, but... still needs coordination

Little central coordination between ISPs — everyone makes their own (commercially-driven) decisions — with informal coordination

Other aspects need centralized organization:

- DNS and name registration (e.g., .com and .org)
- IP + MAC allocation
- WHOIS records for IP addresses
- Port Numbers
- Protocol Identifiers
Proposed Standard Socket Numbers

I propose that there be a czar (me?) who hands out official socket numbers for use by standard protocols. This czar should also keep track of and publish a list of those socket numbers where host specific services can be obtained. I further suggest that the initial allocation be as follows:

<table>
<thead>
<tr>
<th>Sockets</th>
<th>Assignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-63</td>
<td>Network wide standard functions</td>
</tr>
<tr>
<td>64-127</td>
<td>Host specific functions</td>
</tr>
<tr>
<td>128-239</td>
<td>Reserved for future use</td>
</tr>
<tr>
<td>240-255</td>
<td>Any experimental function</td>
</tr>
</tbody>
</table>

and within the network wide standard functions the following particular assignment be made:

<table>
<thead>
<tr>
<th>Socket</th>
<th>Assignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Telnet</td>
</tr>
<tr>
<td>3</td>
<td>File Transfer</td>
</tr>
<tr>
<td>5</td>
<td>Remote Job Entry</td>
</tr>
<tr>
<td>7</td>
<td>Echo</td>
</tr>
<tr>
<td>9</td>
<td>Discard</td>
</tr>
</tbody>
</table>
IANA (Internet Assigned Numbers Authority)

Non-profit organization that oversees globally unique identifiers:

- IP Address Allocation
- ASN Allocation
- Protocol IDs
- Time Zone Database

In addition, IANA is responsible for administering data in root nameservers

- Root Zone (including DNSSEC)
- Special Zones (.int, .arpa)
IANA History

IANA emerged organically — was originally run by two individuals, Jon Postel and Joyce Reynolds. UCLA → USC Information Sciences Institute (ISI)

IANA becomes official in ~1988 when DARPA provides funding to USC-ISI to maintain IANA's functions

In 1998, USC transfers control to ICANN, a new non-profit responsible for coordinating Internet namespace and addressing
Robustness principle

In computing, the robustness principle is a design guideline for software that states: "be conservative in what you do, be liberal in what you accept from others". It is often reworded as: "be conservative in what you send, be liberal in what you accept". The principle is also known as Postel's law, after Jon Postel, who used the wording in an early specification of TCP.¹
ICANN Today

ICANN originally operated under contract from U.S. Department of Commerce. U.S. relinquished control in March 2016 — now completely independent

- Prior to 2016, DoC provided oversight, verifying changes to DNS
- Also pursuant to an agreement with IETF over their functions

ICANN is managed by a 16-member board of directors:
- 8 members selected by a nominating committee on which all the constituencies of ICANN are represented;
- 6 representatives of its Supporting Organizations,
- 1 at-large seat filled by an at-large organization;
- (1) President / CEO, appointed by the board
ICANN vs. IANA vs. PTI

From 1998 to 2016, ICANN directly managed IANA (under contract from U.S. Government)

In 2016, ICANN established Public Technical Identifiers (PTI), an independent organization that manages the technical operations of IANA

PTI is an affiliate of ICANN and is contacted by ICANN to perform those operations
Domains/TLDs
Top Level Domains (TLDs)

**Generic TLDs**: originally 7 gTLDs (predate ICANN) from the 1980s: .com, .org, .net, .int, .edu, .gov, and .mil

Domain names may be registered in {.com, .net, and .org} without restriction; the other four have limited purposes.

**Infrastructure TLDs**: .arpa used for reverse DNS pointer lookups

**ccTLDs**: In 1994, IANA started to assign two letter country-code domains

**Generic Restricted**: (.biz, .name, .pro), can used only for specified purposes

**Sponsored**: .aero, .asia, .cat, .coop, .jobs, mobi, .tel, .travel, and .xxx can only be used by entities engaged within specific industry; (Added in 2000s)

In 2010, ~22 gTLDs total + ~250 ccTLDs
.gov TLD

https://github.com/cisagov/dotgov-data

.gov data

The .gov top-level domain is operated so that the online services of US-based government organizations are easy to identify on the internet. In support of that aim, we publish .gov domain data publicly.

This repository contains the official, full list of registered domains in the .gov zone. The US Government's executive, legislative, and judicial branches are represented, as are US-based state, territory, tribal, city, and county governments.

Two files are updated daily (when there is activity):

- `current-full.csv` – a CSV of all domains, including federal domains
- `current-federal.csv` – a CSV of only federal domains
New gTLD Program

In 2011, ICANN introduced a new TLD program

For a fee of $185,000, companies can create and control new gTLDs that reflect both brand (e.g., .acme) and product niche (e.g., .widgets).

Today, there are ~1,241 registered TLDs

Full of wonderful additions like...

.pizza, .beer, .george, .sucks, .google, .xyz, .wow, .unicorn, .blue
Who runs Root Servers?

IANA only controls the data in the authoritative root DNS servers.

It does not run the root servers themselves.

<table>
<thead>
<tr>
<th>HOSTNAME</th>
<th>IP ADDRESSES</th>
<th>OPERATOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.root-servers.net</td>
<td>198.41.0.4, 2001:503:ba3e::2:30</td>
<td>Verisign, Inc.</td>
</tr>
<tr>
<td>c.root-servers.net</td>
<td>192.33.4.12, 2001:500:2::c</td>
<td>Cogent Communications</td>
</tr>
<tr>
<td>d.root-servers.net</td>
<td>199.7.91.13, 2001:500:2d:d</td>
<td>University of Maryland</td>
</tr>
<tr>
<td>e.root-servers.net</td>
<td>192.203.230.10, 2001:500:a8::e</td>
<td>NASA (Ames Research Center)</td>
</tr>
<tr>
<td>g.root-servers.net</td>
<td>192.112.36.4, 2001:500:12::d0d</td>
<td>US Department of Defense (NIC)</td>
</tr>
<tr>
<td>h.root-servers.net</td>
<td>198.97.190.53, 2001:500:1::53</td>
<td>US Army (Research Lab)</td>
</tr>
<tr>
<td>i.root-servers.net</td>
<td>192.36.148.17, 2001:fe5::3</td>
<td>Netnod</td>
</tr>
<tr>
<td>k.root-servers.net</td>
<td>193.0.14.129, 2001:7fd::1</td>
<td>RIPE NCC</td>
</tr>
<tr>
<td>l.root-servers.net</td>
<td>199.7.83.42, 2001:500:8f:42</td>
<td>ICANN</td>
</tr>
<tr>
<td>m.root-servers.net</td>
<td>202.12.27.33, 2001:dc3::35</td>
<td>WIDE Project</td>
</tr>
</tbody>
</table>
Verisign and .com TLD

IANA/ICANN doesn't run the TLDs either — they approve and delegate control by issuing NS records that point to other providers.

Historically, SRI and then Network Solutions controlled .com TLD.

In 2000, Verisign acquired Network Solutions and became the registry for .com, .net, and .org.

Verisign continues to be the provider under ICANN regulation/contract:

- ICANN sets terms like the maximum that Verisign can change registrars.
  - Was $7.85 since 2012, $8.39 since 2021. Will likely rise to $10.26 by the end of 2026.
.Org Dispute

In 2003, Verisign transferred control of .org TLD to the Internet Society (ISOC)
- Widely understood that the reason was to financially support ISOC
- In 2018, PIR’s (subsidiary) revenue from .org was over $92 MM
- Technically, PIR contracts the work out to Afilias, who runs a bunch of TLDs

ISOC tried to sell PIR to PE firm Ethos Capital in 2018 (1.13B), but transfer required ICANN's approval

Significant external concern — including from California AG's Office

ICANN ultimately blocked the transfer
Welcome to CZDS!

The Centralized Zone Data Service (CZDS) is an online portal where any interested party can request access to the Zone Files provided by participating generic Top-Level Domains (gTLDs).

Please check back often as new gTLDs will be added once they are delegated. If you are looking for the zone file of a TLD that is not listed in CZDS, please contact the Registry Operator directly and ask for their Zone File Agreement. For reference, ICANN.org maintains a list of Registries.

* We recommend using Chrome browser for the best downloading zone file experience.
## Zone Files

### WSEC DNS: Protecting recursive DNS resolvers from poisoning attacks

```
$ORIGIN example.com.

0 IN SOA ns1.example.com hm.example.com. ( 2001062502 ; serial \
 21600 ; refresh after 6 hours \
 3600 ; retry after 1 hour \
 604800 ; expire after 1 week \
 600 ) ; minimum TTL 10 minutes

IN NS ns1.example.com.
IN NS ns2.example.com.
IN TXT "v=spf1 a mx -all"
IN MX 10 mail.example.com.

* IN A 10.0.1.1
* IN A 10.0.1.100
ns1 IN A 10.0.1.2
ns2 IN A 10.0.1.3
mail IN A 10.0.1.4
www IN A 10.0.1.6
www IN AAAA 2001:db8::3
www IN TXT "This is our website"
*._web IN A 10.0.1.7
ftp IN CNAME www

; ; RRs added for enabling WSEC DNS are reported below
;
* 86400 IN TXT "|wsecdns-enabled|"; WSEC
*._web 86400 IN TXT "|wsecdns-enabled|"; WSEC
*._test__wsecdns_ 86400 IN TXT "|wsecdns-enabled|"; WSEC

*._wsecdns_ IN CNAME example.com.; WSEC
*._wsecdns_.ns1 IN CNAME ns1; WSEC
*._wsecdns_.ns2 IN CNAME ns2; WSEC
*._wsecdns_.mail IN CNAME mail; WSEC
*._wsecdns_.www IN CNAME www; WSEC
*._wsecdns_.ftp IN CNAME ftp; WSEC

*._test__wsecdns_ IN CNAME _test__wsecdns_; WSEC
*._test__wsecdns_.ns1 IN CNAME _test__wsecdns_; WSEC
*._test__wsecdns_.ns2 IN CNAME _test__wsecdns_; WSEC
*._test__wsecdns_.mail IN CNAME _test__wsecdns_; WSEC
*._test__wsecdns_.www IN CNAME _test__wsecdns_; WSEC
*._test__wsecdns_.ftp IN CNAME _test__wsecdns_; WSEC
```
Zone Files

Zone Files for .com only provide NS records and associated glue records:
- They don’t know anything about subdomains! How do you find them?
IP Addresses
IANA allocates blocks of IP addresses to **regional Internet registries** (RIRs).

The 5 RIRs are informally liaised through an independent non-profit **Number Resource Organization** (NRO)
Regional Internet Registries

IANA  Internet Assigned Numbers Authority

AFRINIC  APNIC  ARIN  lacnic  RIPE NCC

Member  Member  NIR  Member  Member  Member

Member  Member
RIR IPv4 Allocation Rates

RIRs were allocating IPs at tremendous rate — especially in Asia.
IPv4 Allocations

IANA ran out unallocated IP blocks in January 2011

RIRs ran out soon after:
- APNIC — April 2011
- LACNIC — June 2014
- ARIN — Sept 2015
- AFRINIC — April 2017
- RIPE — Nov 2019
Reclaiming Unused IPv4 Address Space

Some organizations have returned unused address space

- Stanford returned 36.0.0.0/8 and kept only 5 x /16s by 2000

- MIT sold half of 18.0.0.0/8 to Amazon in 2017.
  Had only ever used 2 of the 16 million IPs they owned

❓ How much of IPv4 is advertised? You can check your routing table.
IP Markets

It's permissible to transfer ownership (i.e., sell) IP blocks larger than a /24

Transfers are approved by RIRs (e.g., ARIN or RIPE) — ensures that destination organization has good reason for the number of IPs purchased

https://auctions.ipv4.global/
ipv4marketgroup.com
Protocols
IETF: Internet Engineering Task Force

IETF is a standards organization that is responsible for the technical standards that make up the Internet protocol suite

Publish RFCs — Request for Comment — that document individual protocols

There is no membership: Anyone can participate by joining working group mailing list or attending an IETF meeting in person

Until a few years ago, IETF wasn’t a real organization — was managed by Internet Society (ISOC) — another non-profit (the one that owns .org)
1. Introduction

Almost every IETF participant knows the aphorism from Dave Clark's 1992 plenary presentation [Clark] regarding how we make decisions in the IETF:

   We reject: kings, presidents and voting.

   We believe in: rough consensus and running code.

That is, our credo is that we don't let a single individual dictate decisions (a king or president), nor should decisions be made by a vote, nor do we want decisions to be made in a vacuum without practical experience. Instead, we strive to make our decisions by the consent of all participants, though allowing for some dissent (rough consensus), and to have the actual products of engineering (running code) trump theoretical designs.