DNS

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Introduction

Domain Name System

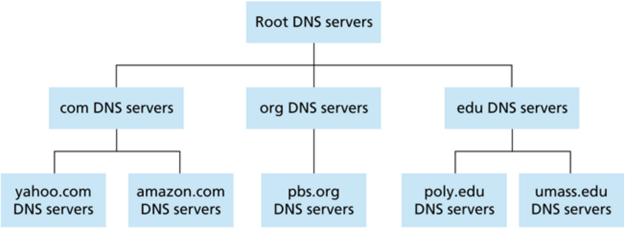
- people like to use names for computers (www.byu.edu), but computers need to use numbers (128.187.22.132)
- the Domain Name System (DNS) is a distributed database providing this service
    - a program send a query a local name server
    - the local name server contacts other servers as needed
- many DNS services
    - host name to IP address translation
    - host aliasing (canonical name versus alias names)
    - lookup mail server for a host
    - load distribution - can provide a set of IP addresses for one canonical name

Demonstration: dig

Names

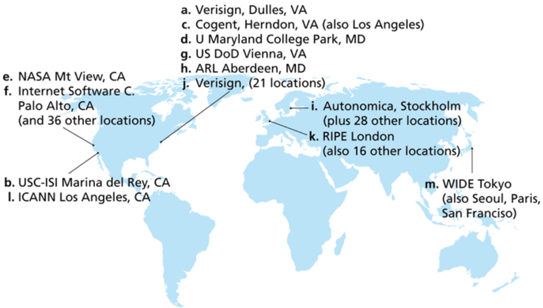
- domain name: top-level domain (TLD) + one or more subdomains
  - example: cs.byu.edu
- host name: a domain name with one or more IP addresses associated with it
- TLDs
  - ccTLD: country codes (.us, .uk, .tv)
  - gTLD: generic (.com, .edu, .org, .net, .gov, .mil)
  - iTLD: infrastructure (.arpa)
  - see full list at ▸ Wikipedia
- may be 127 levels deep, 63 characters per label, 255 characters per name

DNS Hierarchy



- root, top-level domain (TLD), and local name servers
- each level represents a *zone*

Root Name Servers



- can be contacted by any local name server that can not resolve a name
- refers the local name server to another server down the hierarchy
- only 13 of them worldwide

Details at ▸ Wikipedia

Top-level Domain (TLD) Name Servers

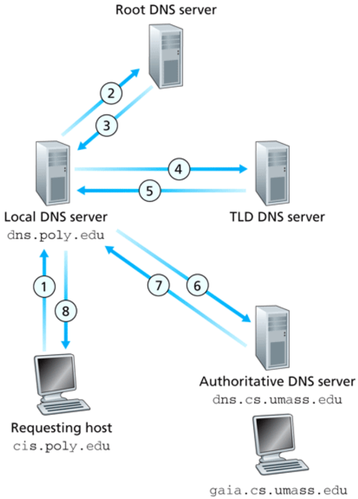
- responsible for .com, .org, .net, .edu, .name, .info, etc, as well as all country domains (.uk, .fr, .jp, .us, etc)
- refer name queries to local name servers
- .com is run by Verisign
- .net is run by Verisign
- .edu is run by Educause (operated by Educause)
- .org is run by Public Interest Registry (operated by Afilias)

Local and Authoritative Name Servers

- local name server
  - run by a given organization, for its domain
  - resolve queries from hosts in the domain, forwarding them up the hierarchy as needed
- authoritative name server
  - provides answers to queries from hosts outside the domain for the zone
  - often the same as the local name server
- a local name server can be a caching-only name server – it is not authoritative for any domain, it simply makes queries for hosts and caches DNS responses

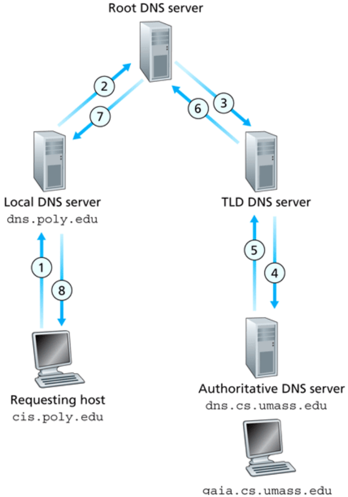
Queries and Caching

Iterated Query



- local name server contacts root name server if it doesn't have the mapping
- iterated query: each server that doesn't know the mapping tells the local name server the identity of the next server in the hierarchy that can answer the query

Recursive Query



- recursive query: root name server (and other servers) may forward the query for the local name server and return the reply when done
- puts a heavier load on the root name server
- query type indicates whether it is recursive or iterative, name servers are *not* required to support recursive queries

Reverse Mappings

- what if you want to lookup the name associated with an IP address?
- this is very useful for authenticating that someone comes from an authorized domain, e.g. check that they can send email through your server
- addresses turned into a name by reversing dotted-decimal notation and appending IN-ADDR.ARPA
  - 128.187.22.132 ⇒ 132.22.187.128.IN-ADDR.ARPA
- TLD server in charge of .ARPA
- when IP addresses are assigned, the authoritative name server is also assigned a prefix from the reverse mapping space

Caching

- any name server that learns a mapping caches it
- cache entries time out after some time – timeout value set by the authoritative name server
- TLD servers usually cached in a local name server, so root name server not visited often

Replication

- an organization typically wants to replicate its authoritative DNS server in case it fails or needs maintenance
- define a master and various secondary servers for the zone
- secondary servers must poll master for updates to the zone and perform a “zone transfer”
- RFC 2136 specifies mechanisms for dynamically updating DNS entries (e.g. for hosts using DHCP, mobile hosts)

Protocol

DNS Records

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RR format: (name, value, type, ttl)
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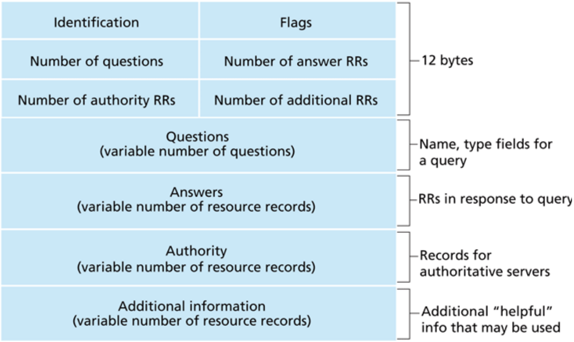
- type=A
  - name is a host name
  - value is an IP address
- type=CNAME
  - name is an alias for the real name
  - value is the canonical name
  - e.g. ilab.cs.byu.edu is really carmelo.cs.byu.edu
- type=MX
  - name is a host name
  - value is the name of the mail server associated with the name
- type=NS
  - name is a domain
  - value is IP address of authoritative domain server for this domain

DNS Messages



Identification	Flags
Number of questions	Number of answer RRs
Number of authority RRs	Number of additional RRs

12 bytes

Questions (variable number of questions) — Name, type fields for a query

Answers (variable number of resource records) — RRs in response to query

Authority (variable number of resource records) — Records for authoritative servers

Additional information (variable number of resource records) — Additional "helpful" info that may be used

- query and reply messages use same format
- identification is 16 bits, unique to the query, reply uses the same number
- flags
  - query or reply
  - recursion desired
  - recursion available
  - reply is authoritative (vs cached)

Adding DNS Records

- example: register the new name *zappala.org*
- register the name at a registrar (e.g., GoDaddy)
- provide registrar with names and IP addresses of your authoritative name server (primary and secondary - comes from hosting service)
- registrar inserts two RRs into the .com TLD server
  - (zappala.org, ns1.namecheap.com, NS)
  - (ns1.namecheap.com, 64.65.1.112, A)
- authoritative name server adds a Type A record and a Type MX record for zappala.org

History and Growth

ARPAnet

- use a text file to map names to addresses: hosts.txt
- to update an address
  - email your changes to the NIC
  - the NIC updates the hosts.txt file every few days
  - download the hosts.txt file via FTP
- problems
  - single point of failure
  - consistency
  - traffic volume
  - delay
  - maintenance

IANA

- Internet Addressing and Naming Authority
- assigns globally-unique names, addresses, ports, character encodings, and other parameters that require central administration
- run by Jon Postel at the Information Sciences Institute, which is affiliated with USC
  - wrote the original RFCs for IP, ICMP, TCP
  - wrote or edited 200+ RFCs
  - Postel's Law: be conservative in what you do, be liberal in what you accept from others
- funded by the Department of Defense

DNS

- 1984: Paul Mockapetris (ISI) defined the Domain Name System in 1984, RFCs 882 and 883 (later superseded by RFCs 1034 and 1035)
  - distributed database of name servers
  - application-layer protocol to query name servers
  - *end-to-end principle – keep the core of the network as simple as possible, put complex functionality at the edges*
- 1992: NSF awards a contract to Network Solutions for maintenance of gTLDs (.com, .org, .net, .edu): $100 to register a name
- 1998: government decides to privatize DNS
- 2000: transition to ICANN

ICANN

- about
  - formed to privatize functions of IANA
  - originally intended to have Jon Postel as CTO, but he died in 1998
  - California non-profit run out of ISI
- manages IANA functions
- establishes domain name policy
  - which gTLDs should be created (.biz, .info, .aero, .jobs, .travel) and which should not be allowed (.xxx)
  - settle domain name disputes for gTLDs
- criticism
  - governance - how board members are chosen, how meetings are held
  - policy - $50,000 fee to become a registrar, dispute resolution policies, more free market control of gTLDs
  - too much control by the US and its laws

Alternatives

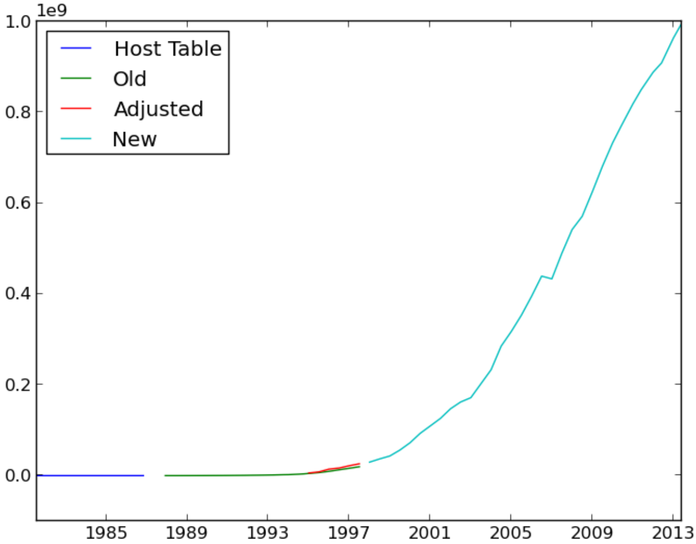
- anyone can setup an alternative DNS root system
  - run a set of root name servers
  - establish a set of TLDs
  - 24/7 reliable operation
- examples
  - ▸ OpenNIC: democratically governed
  - ▸ UnifiedRoot: free market

▸ Wikipedia

The Growth of DNS and the Internet

- how can we measure the size of the Internet?
  - can't count number of users who are on the net; must estimate
  - some hosts have multiple domain names and IP addresses
  - can't tell if some hosts are missing
- can't determine the exact size of the Internet or the number of users
- approximations
  - count domain names with IP addresses (old)
  - count IP addresses with domain names (new)

Internet Growth (1981-2013)


1e9
Host Table
Old
Adjusted
New