

Introduction to “Domain Name Service” (DNS)

1. Host name to IP number mapping was originally done by downloading a static file
2. The UNIX version of this file is `/etc/hosts` (the file we ftp'd in was called `hosts.txt`)



Introduction to the Domain Name Service (DNS)

3. The central file was maintained by the Stanford Research Institute Network Information Center (SRI-NIC)



Introduction to the Domain Name Service (DNS)

4. As the Internet grew this scheme became unworkable
 - ☞ The size of the file became too large
 - ☞ The load on SRI-NIC site became too heavy
 - ☞ The file was always inconsistent with reality
 - ☞ Hostname collisions became frequent (anyone could name their machine “whitehouse.gov” if they wanted to)



Overview of DNS

In 1984 Paul Mockapetris of USC designed the architecture of DNS. It's based on the idea of "resource records".



Overview of DNS

The InterNIC was set up to manage DNS; however, this responsibility was given over to ICANN (Internet Corporation for Assigned Names and Numbers), and now the “InterNIC” is just a website. One of the most important activities of ICANN is to accredit registrars.



Overview of DNS

Today, there are hundreds of registrars, and prices for domain names have dropped under \$10.



Features

- 👉 Local control: each segment is updated locally
- 👉 Global access: each segment is available (almost) immediately to the rest of the world upon update



Features

- ☞ Robustness: achieved through replication
- ☞ Adequate performance: is achieved through caching



Software

- ☞ Servers: called name servers, contain information about some segment of the network and make it available to clients (“BIND” = “Berkeley Internet Name Daemon”, includes “named”, libraries, “nslookup”, “dig”, “host”)



Software

- ☞ Client: resolvers, a set of library routines that resolve names by accessing a server (originally a separate library, like `libresolv.a`, now usually part of `libc.a`)



Software

- Domain name server software is also available for non-UNIX platforms, such as Windows 2000/2003 and Macintosh OS X.



Domain structure

- ➡ Similar to the structure of a hierarchical file system
- ➡ The root's name is the null label “ ” but is written as a single dot “.”



Domain structure

- ➡ Each node represents a 'domain'
- ➡ Every domain is named



Domain structure

- 👉 The full domain name is the sequence of labels from the domain to the root, separated by periods



Domain structure

- 👉 Unlike a file system pathname the name is read from leaf to root (right to left rather than left to right)

`xi.cs.fsu.edu`



Domain management

- Each domain may be managed by a different organization
- The organization may divide itself into subdomains



Domain management

- ☞ Then delegate responsibility for maintaining them
- ☞ ICANN (currently) manages the “provisioning” of top-level domains



Domain management

What is ICANN?

The Internet Corporation for Assigned Names and Numbers (ICANN) is responsible for managing and coordinating the Domain Name System (DNS) to ensure that every address is unique and that all users of the Internet can find all valid addresses. It does this by overseeing the distribution of unique IP addresses and domain names. It also ensures that each domain name maps to the correct IP address.

ICANN is also responsible for accrediting the domain name registrars. "Accredit" means to identify and set minimum standards for the performance of registration functions, to recognize persons or



Spring 2009

entities meeting those standards, and to enter into an accreditation agreement that sets forth the rules and procedures applicable to the provision of Registrar Services.



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Host names

- ➡ Each host on a network has a domain
- ➡ The domain points to information about the host



Host names

☞ This may include:

- ☞ An IP address (A records)
- ☞ Mail routing information (MX records)



Host names

➡ Aliases which point to the real (“canonical”) host name (CNAME records)



The domain name space

- ☞ There may be any number of branches at a node
- ☞ Some implementations limit the tree's depth



The domain name space

- ☞ Each name may contain up to 63 characters
- ☞ The suggested length is 12 or less characters



The domain name space

- ☞ A domain name that is written relative to the root is called a 'fully-qualified domain name' - FQDN
- ☞ Names without trailing dots ("leading dots") are sometimes interpreted as relative to some domain other than root



The domain name space

- ☞ Sibling nodes must have unique names
- ☞ The name of a domain is the domain name of the node at the top of the domain (example `purdue.edu`)



The domain name space

- ➡ Again, similar to a file system
- ➡ A node is in multiple domains



The domain name space

- ☞ So, a domain is just a subtree of the domain name space (“subdomain”)
- ☞ Must not use “_”, although other similar naming schemes (**prominently, such as NIS**) have allowed this.



Hosts

- ☞ Where are the hosts?
- ☞ A domain name is just an index into the DNS database



Hosts

- ☞ The 'hosts' are domain names that point to individual machine information
- ☞ The hosts are related 'logically' usually by geography or organization



Hosts

- ☞ They are NOT necessarily related by network or IP address or hardware type
- ☞ You could have 10 different hosts on 10 different networks in ten different countries all in the same domain (hp.com)



Hosts

- ☞ Nodes at the leaves of the tree usually represent individual hosts
- ☞ Interior nodes may point to both host information and to subdomain information For example, “hp.com” is both the name of a domain and the name of a machine that routes mail



The domain name space

Terms

- »→ top-level domain (TLD): a child of root (edu)
- »→ first-level domain: a child of root (edu)
- »→ second-level domain: a child of 1st level domain (fsu.edu)



The domain name space



The domain name space

- ☞ Naming rules - the original 7 top-level domains were:
 - ☞→ com - commercial organizations
 - ☞→ edu - educational organizations
 - ☞→ gov - governmental bodies
 - ☞→ mil - military organizations
 - ☞→ net - networking organizations
 - ☞→ org - non-commercial organizations
 - ☞→ int - international organizations



The domain name space

☞ International names (ISO 3166-1 names)

- ☞→ 2-letter designations are reserved for each country (e.g.:
DE - Germany, DK - Denmark, CH - Switzerland)
- ☞→ Each country may organize its domain space however
it wishes



The domain name space

- For example, Australia uses `edu.au` and `com.au`
- And Britain uses `co.uk` - corporations, `ac.uk` - academic community
- And the U.S. uses states: `fl.us`, then cities: `tlh.fl.us`



Name servers

Zones

- A program that stores information about the domain name space is called a Domain Name Server
- A name server generally has complete information about some part of the domain name space



Name servers

- The subspace is called a 'zone'
- The server is said to have 'authority' for one or more zones
- What is the difference between a zone and a domain?
[A domain may be composed of one or more zones, but not vice versa]



Name servers

☞ Types of name servers

☞→ Primary master → Gets the data for its zones from flat data (text) files



Name servers

- Secondary master
 - Gets the data for its zone from another server
 - It periodically updates its local data by copying the primary master's files
 - This is called a 'zone transfer'



Name servers

- Generally keep more than one name server for any given zone (1) Redundancy: fault tolerance (2) Load: localize it as much as possible



Name service clients

- ☞ These are the clients that access name servers
- ☞ In BIND these are a set of library routines



Name service clients

- ☞ These are compiled (or linked via shared library) into ssh, sftp, scp, telnet, etc. so that these programs will use DNS to resolve names (“gethostbyname()” and others)



Duties of a simple resolver

- ☞ Sometimes called a 'stub resolver'
- ☞ Querying a name server
- ☞ Interpreting the response
- ☞ Resend a response
- ☞ Returning a reply to the program that it is servicing



How does the name server resolve names

- ☞ If the name is in the name server's zone then it can give the resolver an immediate 'authoritative' response



How does the name server resolve names

- ☞ If not, then the name server must search the domain name space for an answer



Root name servers

- 👉 Technical operation information about the root servers can be found at <http://www.root-servers.org/>
- 👉 The root name servers are authoritative for the top-level domains (edu, org, us, dk, etc.)



Root name servers

Operator	Location	IP
Verisign	VA	198.41.0.4
ISI	CA	192.228.79.201 2001:478:65::53



Root name servers

Operator	Location	IP
Cogent	VA; CA; NY; IL	192.33.4.12
UMD	MD	128.8.10.90
NASA	CA	192.203.230.10



Root name servers

Operator	Location	IP
ISC	Canada; CA; NY; Spain; Hong Kong Italy; NZ Brazil; China SK; Russia; Taipei Dubai; France; Singapore Portugal; ZA	192.5.5.241 2001:500::1035



Root name servers

Operator	Location	IP
ISC (cont'd)	Tel Aviv; Jakarta Germany; Japan CZ; Netherlands Kenya; India Britain; Chile Pakistan	



Root name servers

Operator	Location	IP
DOD NIC	VA	192.112.36.4
Army	MD	128.63.2.53 2001:500:1::803f:235



Root name servers

- ☞ They can point you to the name servers for each of the top-level domains
- ☞ They, in turn can point you to their subdomains, etc. until the name is resolved



Root name servers

- ☞ This scheme puts a lot of importance on the root-level servers



Recursion

- ☞ The first name server can make multiple requests
- ☞ Successive requests refer the first server to another machine
- ☞ A local server generally responds to a 'recursive query'



Recursion

- ☞ This is because the local 'dumb' resolver is not smart enough to follow any referrals
- ☞ A recursive query places most of the work on a single name server



Recursion

- ☞ When a recursive query is made the name server is obliged to go find the answer or return an error message



Mapping addresses to names (“reverse lookups”)

- ☞ What if you have an IP number and want to find the host name?
 - ⇒ This is useful to make output more readable
 - ⇒ Used for some security checks



Mapping addresses to names (“reverse lookups”)

- ☞ This was easy with the old `/etc/hosts` tables
- ☞ The DNS data is indexed by name



Mapping addresses to names (“reverse lookups”)

- ⇒ Could do an exhaustive search
- ⇒ The clever solution



Mapping addresses to names (“reverse lookups”)

- ➡ Create a part of the domain name space that uses addresses as names



Mapping addresses to names (“reverse lookups”)

➡ For example type:

```
# nslookup 128.186.120.2
```

```
Server:                128.186.120.179
```

```
Address:              128.186.120.179#53
```

```
2.120.186.128.in-addr.arpa
```

```
name = diablo.cs.fsu.edu.
```



Mapping addresses to names (“reverse lookups”)

Now, as you can see, newer **nslookup** versions will do this automatically. (Of course, you get many versions today of **nslookup** that announce that nslookup is “deprecated” .)



Caching

- ➡ Each time a local name server processes a recursive query it learns a lot of information
- ➡ This is cached which speeds up successive queries



Caching

☞ Example:

- ☞ Say our server has already looked up the address of `eecs.berkeley.edu`
- ☞ This means it has cached the name servers for both `eecs.berkeley.edu` and `berkeley.edu`
- ☞ If we now make a query for `baobab.cs.berkeley.edu` the local server can skip the root-level query and go right to `berkeley.edu`



Caching

☞ time to live (TTL)

☞ TTL is the amount of time that information is cached before it is discarded



Caching

- ☞ The trade-off is between consistency and performance
- ☞ Remember, caching is also performed by other actors: in particular, **nscd** can cache names, and it uses its *own* TTLs, not those of the actual RRs. Applications such as browsers often also do a good bit of caching of ip values.



Configuring DNS: Client side

Setting up clients

👉 `configure /etc/resolv.conf`

```
domain cs.fsu.edu
; nu.cs.fsu.edu
nameserver 128.186.121.10
; mailer.cc.fsu.edu
nameserver 128.186.6.103
; trantor.umd.edu
nameserver 128.8.10.14
```



Overview of DNS

The client will try the nameservers in order: “nu”, then “mailer”, then “trantor”

- ☞ you can comment out nu and/or mailer then use nslookup and see results
- ☞ or put a bogus address in the first entry to see if the resolver tries number 2
- ☞ the changes take effect immediately



```
nslookup chi
Server:   TRANTOR.UMD.EDU
Address:  128.8.10.14

Name:     chi.cs.fsu.edu
Address:  128.186.121.20
```



The named.conf file

```
//  
// named.conf for Red Hat caching-nameserver  
//  
  
options {  
    directory "/var/named";  
    dump-file "/var/named/data/cache_dump.db";  
    statistics-file "/var/named/data/named_stats.txt";  
    /*  
    * If there is a firewall between you and nameservers you want  
    * to talk to, you might need to uncomment the query-source  
    * directive below. Previous versions of BIND always asked  
    * questions using port 53, but BIND 8.1 uses an unprivileged  
    * port by default.  
    */  
};
```




```
        */
        // query-source address * port 53;
};

//
// a caching only nameserver config
//
controls {
    inet 127.0.0.1 allow { localhost; } keys { rndckey; };
};

zone "." IN {
    type hint;
    file "named.ca";
};

zone "localdomain" IN {
    type master;
    file "localdomain.zone";
    allow-update { none; };
};
```



Spring 2009

};

```
zone "localhost" IN {  
    type master;  
    file "localhost.zone";  
    allow-update { none; };  
};
```

};

```
zone "0.0.127.in-addr.arpa" IN {  
    type master;  
    file "named.local";  
    allow-update { none; };  
};
```

};

```
zone "0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.  
     0.0.0.0.0.0.0.ip6.arpa" IN {  
    type master;  
    file "named.ip6.local";  
    allow-update { none; };  
};
```

};



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Spring 2009

```
zone "255.in-addr.arpa" IN {  
    type master;  
    file "named.broadcast";  
    allow-update { none; };  
};
```

```
zone "0.in-addr.arpa" IN {  
    type master;  
    file "named.zero";  
    allow-update { none; };  
};
```

```
include "/etc/rndc.key";
```



- ☞ Setting up a caching-only server: used to be more popular, now **nscd** is more popular
- ☞ Still it is very easy to do these days: **yum -y caching-nameserver**, then just turn on default installation **/etc/init.d/named start** and change **/etc/resolv.conf**

```
[root@sophie root]# nslookup  
> www.yahoo.com  
Server:                127.0.0.1
```



Address: 127.0.0.1#53

Non-authoritative answer:

www.yahoo.com canonical name = www.yahoo.akadns.net.

Name: www.yahoo.akadns.net

Address: 68.142.226.43

Name: www.yahoo.akadns.net

Address: 68.142.226.45

Name: www.yahoo.akadns.net

Address: 68.142.226.50

Name: www.yahoo.akadns.net

Address: 68.142.226.35

Name: www.yahoo.akadns.net



Address: 68.142.226.38

Name: www.yahoo.akadns.net

Address: 68.142.226.39

Name: www.yahoo.akadns.net

Address: 68.142.226.41

Name: www.yahoo.akadns.net

Address: 68.142.226.42

>



Logging and named

errors: like most daemons, **named** errors (and other information) are routed through syslog, which you control with `/etc/syslog.conf`:

```
# Log all kernel messages to the console.
# Logging much else clutters up the screen.
#kern.*                                     /dev/console

# Log anything (except mail) of level info or higher.
# Don't log private authentication messages!
*.info;mail.none;news.none;authpriv.none;cron.none           /var/log/messages
```



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The authpriv file has restricted access.

authpriv.*

/var/log/secure

Log all the mail messages in one place.

mail.*

/var/log/maillog

Log cron stuff

cron.*

/var/log/cron

Everybody gets emergency messages

*.emerg

*

Save news errors of level crit and higher in a special file.

uucp,news.crit

/var/log/spooler

Save boot messages also to boot.log

local7.*

/var/log/boot.log

#



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```
Feb 14 10:18:20 sophie named[7597]: zone localdomain/IN: loaded serial 42  
Feb 14 10:18:20 sophie named[7597]: zone localhost/IN: loaded serial 42  
Feb 14 10:18:20 sophie named[7597]: running
```



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DNS Security

- ☞ basic: remove HINFO fields
- ☞ “basic”: limit zone transfers
- ☞ use keys and **rndc**

