

Domain Name System (DNS) Fundamentals

Network Startup Resource Center
www.nsrc.org



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Why Use Domain Name System?

Computers Use IP Addresses

Why Do We Need Names?

- Names are easier for people to remember
- Computers may be moved between networks, in which case their IP address will change.

HOSTS.TXT

The old way: A centrally-maintained file, distributed to all hosts on the Internet

- <i>SPARKY</i>	<i>128.4.13.9</i>
- <i>UCB-MAILGATE</i>	<i>4.98.133.7</i>
- <i>FTPHOST</i>	<i>200.10.194.33</i>
- ... etc	

This feature still exists:

- */etc/hosts* (UNIX)
- *c:\windows\hosts*

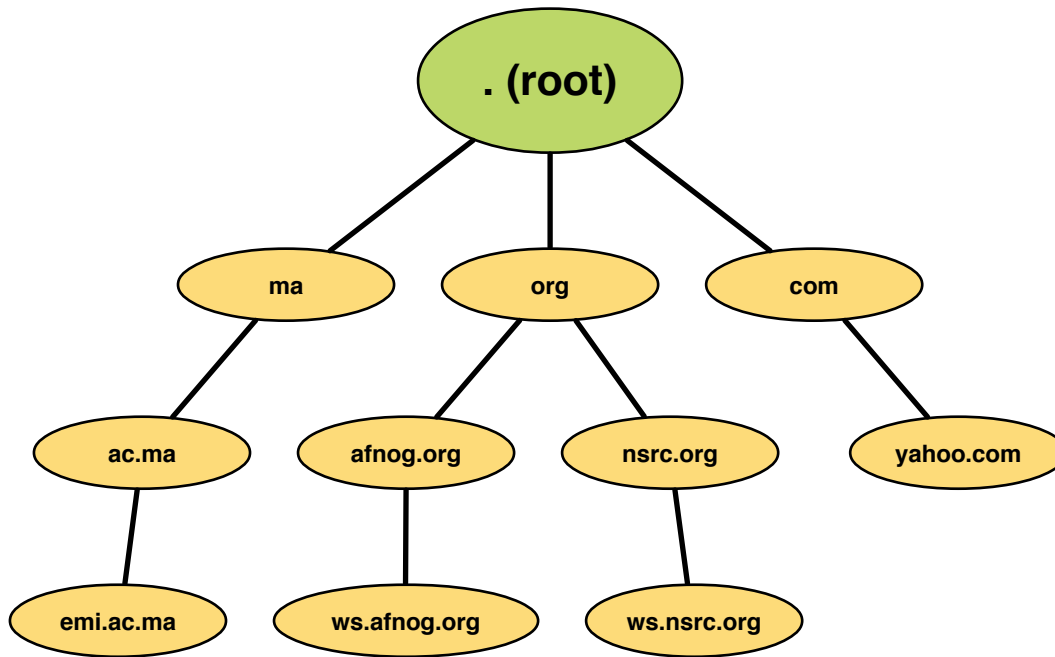
hosts.txt does not scale

- Huge file (traffic and load)
- Name collisions (name uniqueness)
- Consistency
- Always out of date
- Single point of Administration
- Did not scale well

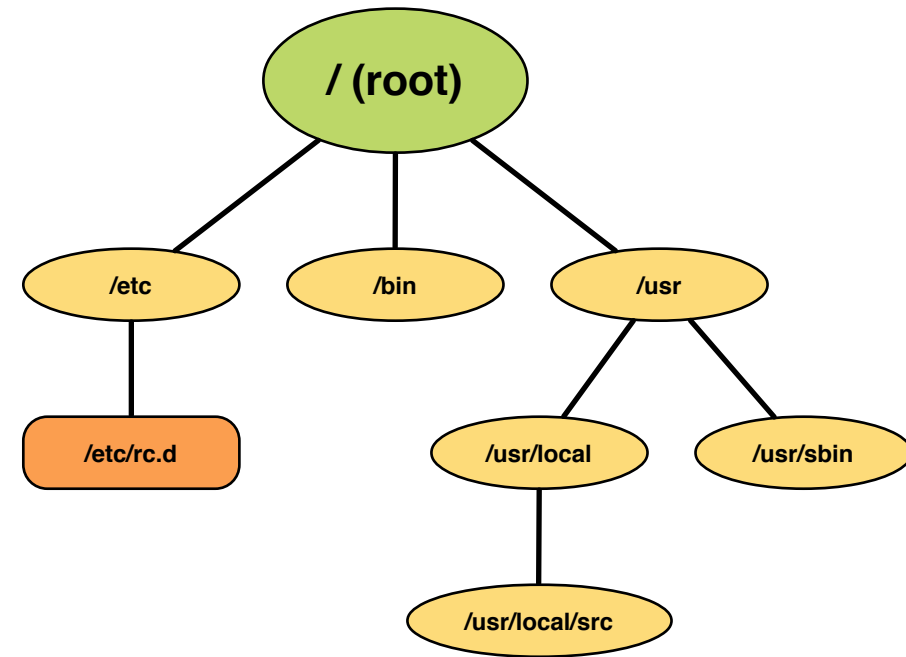
The Domain Name System was Born

- DNS is a distributed database for holding name to IP address (and other) information
- Distributed:
 - Shares the Administration
 - Shares the Load
- Robustness & improved performance through
 - replication
 - and caching
- Employs a client-server architecture
- A critical piece of the Internet's infrastructure

DNS is Hierarchical



DNS Database



Unix Filesystem

It forms a tree structure

DNS is Hierarchical (continued)

- Globally unique names
- Administered in zones (parts of the tree)
- You can give away ("delegate") control of part of the tree underneath you
- Example:
 - nsrc.org on one set of nameservers
 - ws.nsrc.org on a different set
 - noc.ws.nsrc.org on another set

Domain Names are (almost) Unlimited

- Max 255 characters total length
- Max 63 characters in each part
 - RFC 1034, RFC 1035
- If a domain name is being used as a host name, you should abide by some restrictions
 - RFC 952 (old!)
 - a-z 0-9 and minus (-) only
 - No underscores (_)

Using the DNS

- A Domain Name (like `www.ws.afnog.org`) is the KEY to look up information
- The result is one or more RESOURCE RECORDS (RRs)
- There are different RRs for different types of information
- You can ask for the specific type you want, or ask for "any" RRs associated with the domain name

Commonly Seen Resource Records (RRs)

- A (address): map hostname to IPv4 address
- AAAA (quad A): map a hostname to IPv6 address
- PTR (pointer): map IP address to hostname
- MX (mail exchanger): where to deliver mail for *user@domain*
- CNAME (canonical name): map alternative hostname to real hostname
- TXT (text): any descriptive text
- NS (name server), SOA (start of authority): used for delegation and management of the DNS itself

A Simple Example

- Query: **nsrc.org.**
- Query type: **A**
- Result:

nsrc.org. 83855 IN A 128.223.157.19

- **In this case a single RR is found, but in general, multiple RRs may be returned.**
 - (IN is the "class" for INTERNET use of the DNS)

Possible Results From A Query

- POSITIVE
 - one or more RRs found
- NEGATIVE
 - definitely no RRs match the query
- SERVER FAIL
 - cannot find the answer
- REFUSED
 - not allowed to query the server

Reverse Lookups

- Look up the name for an IP address
- Convert the IP address to dotted-quad
- Reverse the four parts
- Add ".in-addr.arpa." to the end; special domain reserved for this purpose

e.g. to find name for 128.223.157.19

Domain name: 19.157.223.128.in-addr.arpa.

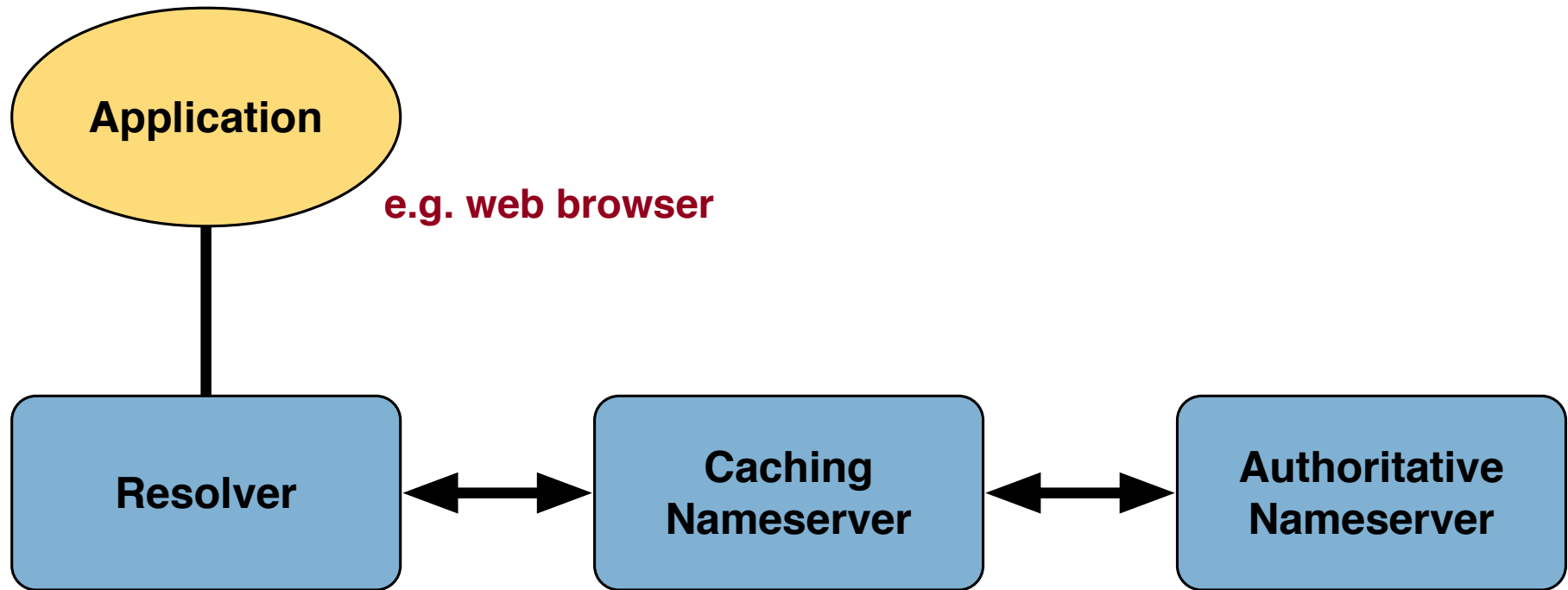
Query Type: PTR

Result: nsrc.org.

DNS is a Client Server Application

- (Of course - it runs across a network)
- Requests and responses are normally sent in UDP packets, port 53
- Occasionally uses TCP, port 53
 - For large requests (larger than 512-bytes) e.g. zone transfer from master to slave or IPv6 AAAA (quad A) record.

The Three Roles of DNS



The Three Roles of DNS

- RESOLVER
 - Takes app request, creates a UDP packet, sends to cache
- CACHING NAMESERVER
 - Returns the answer if already known
 - Or searches for an authoritative server with information
 - Caches the result for future queries
 - Also known as RECURSIVE nameserver
- AUTHORITATIVE NAMESERVER
 - Contains information put into the DNS by domain owner

The Three Roles of DNS

- The SAME protocol is used for
 - resolver ↔ cache
 - cache ↔ auth NS communication
- One name server can be caching & authoritative
- It still performs only one role for each incoming query
- It's NOT RECOMMENDED to use one server for both
 - we will see why later

Role 1: The Resolver

- A piece of software which formats a DNS request into a UDP packet, sends it to a cache, and decodes the answer
- Usually a shared library (e.g. libresolv.so under Unix) because so many applications need it
- EVERY host needs a resolver - e.g. every Windows workstation has one

How does the name server find a caching resolver?

- It has to be explicitly configured (statically, or via DHCP etc)
- Must be configured with the IP ADDRESS of a cache (why not name?)
- Good idea to configure more than one cache, in case the first one fails

Which Cache Should You Use?

- Must have PERMISSION to use it
 - e.g. cache at your ISP, or your own
- Prefer a nearby cache
 - Minimises round-trip time and packet loss
 - Can reduce traffic on your external link, since often the cache can answer without contacting other servers
- Prefer a reliable cache
 - Perhaps your own?

Resolvers Can Have Default Domains

- If "foo.bar" fails, then retry query as "foo.bar.mydomain.com"
- Can save typing but adds confusion
- May generate extra unnecessary traffic
- Usually best avoided

Example: Unix Resolver Configuration

/etc/resolv.conf

nameserver 10.10.0.254

domain ws.nsrc.org

search ws.nsrc.org

That's all you need to configure a resolver

Testing DNS

- Just put "www.google.com" in a web browser?
- Why is this not a good test?

Testing DNS with Dig

- "dig" is a program which just makes DNS queries and displays the results
- Better than "nslookup", "host" because it shows the raw information in full

```
dig nsrc.org.
```

```
-- defaults to query type "A"
```

```
dig nsrc.org. mx
```

```
-- specified query type
```

```
dig @128.223.157.19 nsrc.org. mx
```

```
-- send to particular cache (overrides  
/etc/resolv.conf)
```


The Trailing Dot

dig nsrc.org. 

- Prevents any default domain being appended
- Always use it when testing DNS
 - only on domain names, not IP addresses or e-mail addresses

Anatomy of a DNS Query

```
[field@term /usr/home/field]$ dig @zoe.dns.gh. downloads.dns.gh. a
; <<>> DiG 9.7.0-P1 <<>> @zoe.dns.gh. downloads.dns.gh. a
; (1 server found)
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 34963
;; flags: qr aa rd ra; QUERY: 1, ANSWER: 2, AUTHORITY: 3, ADDITIONAL: 0
```

```
;; QUESTION SECTION:
```

```
;downloads.dns.gh.                IN      A
```

```
;; ANSWER SECTION:
```

```
downloads.dns.gh.    3600    IN      CNAME    zoe.dns.gh.
```

```
zoe.dns.gh.          3600    IN      A         147.28.0.23
```

```
;; AUTHORITY SECTION:
```

```
dns.gh.              3600    IN      NS       zoe.dns.gh.
```

```
dns.gh.              3600    IN      NS       mantse.gh.com.
```

```
dns.gh.              3600    IN      NS       snshq902.ghanatel.com.gh.
```

```
;; ADDITIONAL SECTION:
```

```
zoe.dns.gh.          3600 IN      AAAA     2001:418:1::23
```

```
;; Query time: 287 msec
```

```
;; SERVER: 147.28.0.23#53(147.28.0.23)
```

```
;; WHEN: Tue Apr 17 08:04:58 2012
```

```
;; MSG SIZE rcvd: 173
```

Understanding Output from dig

- STATUS
 - NOERROR: 0 or more RRs returned
 - NXDOMAIN: non-existent domain
 - SERVFAIL: cache could not locate answer
 - REFUSED: query not available on cache server
- FLAGS
 - AA: Authoritative answer (not from cache)
 - You can ignore the others
 - QR: Query/Response (1 = Response)
 - RD: Recursion Desired
 - RA: Recursion Available
- ANSWER: number of RRs in answer

Understanding Output from dig

- Answer section (RRs requested)
 - Each record has a Time To Live (TTL)
 - Says how long the cache will keep it
- Authority section
 - Which nameservers are authoritative for this domain
- Additional section
 - More RRs (typically addresses for authoritative nameservers)
 - AAAA (“quad A”) record or the IPv6 address
- Total query time
- Check which server gave the response!
 - If you make a typing error, the query may go to a default server

Practical Exercise

- Configure Unix resolver
- Issue DNS queries using 'dig'
- Use tcpdump to show queries being sent to cache