NAME RESOLUTION

Characteristics of Domain Names

- Large database (proportional to number of users)
- Queries are much more frequent than updates
- Query rate is very high (millions/second?)
- Most data changes slowly (local exceptions)
- Access is more important than timeliness
- Strong shift in names that are queried most?
  - “nearby” to “remote”
Zones in the Domain Name System

DNS Name Servers

- **authoritative name server:**
  - designated repository for a host’s IP address and name
  - performs name/address translation for that host name

- **local authoritative name servers:**
  - each ISP, university, company, etc., has **local (default) name server** authoritative for its own hosts, routers, etc.
  - resolvers always query a local name server to resolve any host name
DNS: Using Hierarchy for Resolving

- To resolve non-local name:
  - local name server queries .com server -- “what server is authority for www.cnn.com?”
  - .com server returns name and IP address of server it knows is closest match to query.
  - local server sends same query to twdns-01.ns.aol.com
  - process can be iterated until the local authoritative name server is found and responds

DNS Resolution - Iterated Query

nslookup www.cs.cmu.edu

resolver

local server

root

ns + A records
DNS Records

DNS: distributed database storing Resource Records (RR)

RR format: <name, value, type, time_to_live>

- Type=A
  - name is hostname
  - value is IP address

- Type=NS
  - name is domain (e.g. foo.com)
  - value is name of authoritative name server for this domain

- Type=CNAME
  - name is an alias name for some "canonical" (the real) name
  - value is canonical name

- Type=MX
  - value is name of mail server host associated with name

DNS Protocol and Messages

DNS protocol: query and reply messages, both with same message format

- identification: 16 bit # for query, reply to query uses same # for matching
- flags:
  - query or reply
  - reply is authoritative
  - etc.
**DNS Protocol and Messages**

<table>
<thead>
<tr>
<th>Identification</th>
<th>Flags</th>
<th>Number of Questions</th>
<th>Number of Answer RRs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>number of authority RRs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>questions</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(variable number of questions)</td>
</tr>
</tbody>
</table>

Name, type fields for a query
RRs that answer (resolve) the name, may not be present
RRs for authoritative servers
additional information (usually the IP address of authoritative servers)

Try it yourself: an interactive resolver program for XP is `nslookup`. In a Command Prompt window, use C:
```bash
> nslookup
```
Gives usage information.
Hint: configure window with 50 lines, turn on debugging

**Example Reply from .edu Zone Server**

Note: the reply message has been formatted by the resolver program `host` for printing and differs slightly from the from given on the previous slide.

```
> host -v www.ohsu.edu
Trying null domain
rcode = 0 (Success), ancount=2
For authoritative answers, see:
  ohsu.edu       73748 IN   NS       steele.ohsu.edu
  ohsu.edu       73748 IN   NS       fremont.ohsu.edu
  ohsu.edu       73748 IN   NS       medgon.ohsu.edu
  ohsu.edu       73748 IN   NS       cse.ogi.edu
Additional information:
  steele.ohsu.edu 73748 IN   A       137.53.1.40
  fremont.ohsu.edu 73748 IN   A       137.53.1.30
  medgon.ohsu.edu  91302 IN   A       137.53.203.5
  cse.ogi.edu     122220 IN   A       129.95.20.2
```

name | time to live (seconds) | type | value
DNS Database Maintenance

- Updates (e.g., edit file)
- Force Refresh
- Zone Data Changed?
- Zone Data Refresh
- Zone Server (alt.)*

Controls (in records):
- refresh timestamp
- refresh interval (e.g., 3 hours)
- retry frequency (e.g., 10 minutes)
- expiration (e.g., 24 hours)

* must have at least one alternate for each zone

DNS: Root Name Servers

- Root name server:
  - Contacted by local name server that can't resolve name
  - Provides pointers to authoritative servers at lower level of name hierarchy
- 13 “conventional” root name servers worldwide
- 20+ copies of “F-server” worldwide reached by specialized BGP routing

Root Server Distribution, 2003
Root Server Distribution - 2016

13 root servers operated by 12 independent organizations

www.root-servers.org

Generic TLD Servers Distribution -2006 (.com,.net)

Figure 2: Server Locations for .com and .net and Areas of Redundant Connectivity

13 independent sites

### Generic TLD Servers Distribution -2006 (.org,.info,.mobi)

**Figure 3:** Server Locations for .org, .info, and .mobi and Areas of Redundant Connectivity


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### Summary of TLD server locations – 2006

<table>
<thead>
<tr>
<th>gTLD</th>
<th>Locations by Country or U.S. State</th>
</tr>
</thead>
<tbody>
<tr>
<td>.com</td>
<td>Australia, Brazil, Canada, Japan, South Korea, Netherlands, Sweden, Singapore, United Kingdom, and the following states in the United States: California, Florida, Georgia, New York, Virginia, and Washington.</td>
</tr>
<tr>
<td>.coop</td>
<td>United Kingdom and the following states in the United States: California, Florida, and Massachusetts.</td>
</tr>
<tr>
<td>.edu</td>
<td>Netherlands, Singapore, and the following states in the United States: California, Florida, Georgia, and Virginia.</td>
</tr>
<tr>
<td>.gov</td>
<td>Canada, Germany, and the following states in the United States: California, Florida, New Jersey, Pennsylvania, and Texas.</td>
</tr>
<tr>
<td>.info</td>
<td>India, Hong Kong, South Africa, United Kingdom, and the following states in the United States: California, Illinois, and Virginia.</td>
</tr>
<tr>
<td>.int</td>
<td>Netherlands, United Kingdom, and California in the United States.</td>
</tr>
<tr>
<td>.jobs</td>
<td>Netherlands, Singapore, and the following states in the United States: California, Florida, Georgia, and Virginia.</td>
</tr>
<tr>
<td>.mil</td>
<td>The following states in the United States: California, Maryland, Virginia, and other unknown locations.</td>
</tr>
<tr>
<td>.mobi</td>
<td>India, Hong Kong, South Africa, United Kingdom, and the following states in the United States: California, Illinois, and Virginia.</td>
</tr>
<tr>
<td>.museum</td>
<td>Sweden and California in the United States.</td>
</tr>
<tr>
<td>.name</td>
<td>Singapore, United Kingdom, and the following states in the United States: California, Florida, Georgia, and Virginia.</td>
</tr>
<tr>
<td>.net</td>
<td>Australia, Brazil, Canada, Japan, South Korea, Netherlands, Sweden, Singapore, United Kingdom, and the following states in the United States: California, Florida, Georgia, and Virginia.</td>
</tr>
<tr>
<td>.org</td>
<td>India, Hong Kong, South Africa, United Kingdom, and the following states in the United States: California, Illinois, and Virginia.</td>
</tr>
<tr>
<td>.pro</td>
<td>Canada and the following states in the United States: Illinois and Texas.</td>
</tr>
<tr>
<td>.travel</td>
<td>Australia, Hong Kong, Netherlands, New Zealand, Singapore, United Kingdom, and the following states in the United States: California, Florida, Georgia, New York, Virginia, and Washington.</td>
</tr>
</tbody>
</table>

The Top-Level Zone Servers

DNS Root Servers

The Verisign TLD servers answer 18,000,000,000 queries per day in 2006.

F server (CA) answered 272,000,000 queries per day in 2003 (others similar).

Recent Optimizations

- ISP or large enterprise zone servers use zone-transfer protocol to copy root or TLD databases periodically (e.g., several times per day)
  - Configure local zone servers to bypass root servers

- Co-location (hosting) of ISP or enterprise zone databases at TLD sites
  - Leverage optimized hardware, software, facilities for running servers