Naming

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NAMES & ADDRESSES
Types of Identifiers

- **Names**
  - for human consumption
  - location independent

- **Addresses**
  - used internally in system
  - encoding aids in locating entity

Saltzer’s (1977) Naming Objectives

- Share objects by references to names
- Multiple, independent name *creators*
- Sharing (and naming) *independent of location*
  - Objects can move without changing names or embedded references to names
- Object references can proceed *even if some systems are down or isolated*
Lampson’s (1986) Name Resolution Service adds:

- Universal (all distributed objects)
- Arbitrary number of names and administrative organizations
- Long duration with many changes in the name space and its configuration
- Mistrust among users

Names and Name Contexts

```
root context
  |     |
  |  usr |
  |  src |

"usr" context
  |     |
  | jasleen |

"src" context
  |     |
  | foo |

"jasleen" context
  |     |
  | foo.c |

object
  |     |
  | foo.c |
```

```
/usr/jasleen/foo.c
/src/foo/foo.c
```

```
//usr/jasleen/
```

```
/usr/jasleen/
```
Internet Names and Addresses

- **Internet Names**
  - Human consumable, location independent, identifiers for hosts, service aliases, etc.
  - examples:
    - swift
    - capefear.cs.unc.edu
    - www.amazon.com

- **Internet Addresses**
  - 32 bit integer (IPv4) or 128 bits (IPv6)
  - identifies connection to Internet
    - synonymous with network interface
  - examples:
    - 152.2.128.19
    - 152.2.128.25
    - 208.33.218.15
Domain Name System

- Primary functions:
  - Map domain names for machines to Internet addresses
    - maps name to list of addresses \{0, 1, ..., N\}
    - e.g.,
      - capefear.cs.unc.edu \rightarrow 152.2.128.19
      - swift \rightarrow 152.2.128.25
      - www.llbean.com \rightarrow \{65.124.170.23, 65.126.254.23\}
  - Map domain names for service aliases (e.g., mail) to Internet addresses
    - mail.cs.unc.edu \leftrightarrow wren.cs.unc.edu \leftrightarrow 152.2.128.86

DOMAIN NAMES
Hierarchy & Value
Name Hierarchy in DNS

name = “dot” separated catenation of domain names along path toward the root
e.g.,
  unc.edu
  cs.unc.edu
  capefear.cs.unc.edu

Top Level Domains

Generic Domains
- Current
  - .com, .org, .net, .edu, .gov, .mil, .int, .biz, .info, .name, .pro, .mobi
- Special Sponsored names
  - .aero, .coop, .museum, .jobs, .travel

Country Code Domains
  (.uk, .de, .jp, .us, .cn, .in, etc.)
Growth of DNS Registrations

Internet Domain Survey Host Count

July 2014: 1,028,544,414

Source: Internet Systems Consortium (www.isc.org)

Names Became Valuable!


Net Address Sold at Auction for $823,456

LOS ANGELES, Aug. 9 (AP) — Bidding for use of the Internet address Drugs.com jumped wildly every few minutes before an auction closed with an offer of $823,456.

The business that submitted the winning bid on Friday wanted to remain anonymous.

Several large drug companies and well-heeled speculators had expressed an interest, according to Eric Maciver, a 21-year-old Internet entrepreneur in Mesa, Ariz., who helped an option on the Drugs.com domain name.

"The bidder will emerge as someone of note," possibly at a news conference in a week or so, said Steve Newman, executive vice president of the on-line broker Great Domains. Great Domains, based in Los Angeles, was joined by Dotbroker.com in conducting the auction.

Other Internet names currently up for auction include Loans.com, which has a high bid of $500,000.

"We're going to set an end date in two or three weeks," Mr. Newman said of the Loans.com name auction.

GIVE TO THE FRESH AIR FUND
Names Became More Valuable!


Sale: Web Address, Unused, Not Cheap

By SABRA CHARTRAND

The Internet address www.fiu.com is for sale, and its seller thinks it is worth $1.4 million.

The address does not lead to a World Wide Web site, and it never has. Its estimated value seems to arise mostly because such an easy-to-remember destination is available for sale at all.

Because flu.com and virtually all of the other catchy Web addresses ending in “.com” have already been claimed, the value of such unused names has risen sharply. Into this speculative field have come a growing number of companies that have built businesses just by helping owners resell the names they no longer want or need.


That dynamic is the rise of resellers like GreatDomains.com and Afternic.com, which both charge a commission. At GreatDomains, where 25 domain names have asked prices of more than $1 million, that could mean an additional fee once the company takes 7 to 10 percent from sellers. Afternic charges 5 percent to buyers.

GreatDomains says its average auction brings in $10,000; Afternic’s is closer to $3,000.

Some Recent Prices

BuyDomains.com, GreatDomains.com, 8/20/07

- SoulSeek.com $4,550,000
- healthscare.com $3,999,000
- shrimp.com $3,000,000
- message.com $750,000
- BeatStreams.com $380,000
- streetmaps.com $375,000
- LuvHomes.com $359,000
- defy.com $350,000
- lovelife.com $350,000
- ConnectingStudents.com
- WorkSearch.com $318,000
- Fun4Mobile.com $265,000
- sourcecodes.com $250,000
- main.com $250,000
- Grappa.com $250,000
- TeamSpeak.net $240,000
- PopcornMachine.com $225,000
- Muertos.com $215,000
The story of .tv domain

Since 1999, Tuvalu has been able to earn over several million dollars a year marketing its Internet domain name through the American company .TV Corporation. Tuvalu’s unique suffix, "TV", attracts interest from many individuals, entities and television companies around the world, and some have been willing to pay large sums for internet addresses such as www.china.tv or www.nbc4.tv. The scheme got off to a rough start, but has now proven to be the largest source of income for the nation. http://www.tuvaluislands.com/about.htm

- videos.tv $250,000
- cinema.tv $250,000
- movie.tv $250,000
- trips.tv $250,000
- food.tv $125,000
- sx.tv $100,000
- channel.tv $85,000
- hamberger.tv $80,000

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

- com
- edu
- net
- arpa
- in-addr
- yahoo
- amazon
- unc
- cornell
- sprint
- bellsouth
- www
- cs
- ads
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

REPLY: edu (NS)

QUERY: www.cs.cmu.edu

REPLY: cmu.edu (NS)

QUERY: www.cs.cmu.edu

REPLY: cs.cmu.edu (NS)

QUERY: www.cs.cmu.edu

REPLY: 128.2.209.79 (A)

root

com

net

cmu

fa

unc

= 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

- message header
  - identification: 16 bit # for query, reply to query uses same # for matching
  - flags:
    - query or reply
    - reply is authoritative
    - etc.

Try it yourself: an interactive resolver program for XP is `nslookup`. In a Command Prompt window, use `C:`:

```
\> 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
```

DNS Database Maintenance

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 - 2006

Figure 1: Root Server Locations and Areas of Redundant Connectivity

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

32

Summary of all TLD server locations

<table>
<thead>
<tr>
<th>TLD</th>
<th>Locations by Country or U.S. State</th>
</tr>
</thead>
<tbody>
<tr>
<td>.aero</td>
<td>Switzerland, Germany, India, Hong Kong, United Kingdom, and the following states in the United States: California, Illinois, and Virginia</td>
</tr>
<tr>
<td>.biz</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>
<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, Virginia, and Washington</td>
</tr>
<tr>
<td>.coop</td>
<td>United Kingdom and the following states in the United States: California, Illinois, 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 state 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 Washington</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, Virginia, and Washington</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>


DNS PERFORMANCE

Impact of Caching
Performance of Object References

vs

Cache Design Issues

- **Size**
  - influences “hit ratio” (though DNS caches are typically not size-limited)
  - \( T_{\text{avg.}} = \text{hit\_ratio} \times T_{\text{avg.-cache}} + (1 - \text{hit\_ratio}) \times T_{\text{avg.-remote}} \)

- **Replacement**
  - free space for new data when full
  - Usually not critical for DNS caches, since most are not size-limited

- **(in)Validation**
  - does the cache hold “current” information?

- **Location**
  - memory vs disk (speed vs size)
DNS Resolution with Cache

nslookup www.cs.cmu.edu

QUERY: www.cs.cmu.edu
REPLY: cs.cmu.edu (NS)
QUERY: www.cs.cmu.edu
REPLY: cmu.edu (NS)
QUERY: www.cs.cmu.edu
REPLY: edu (NS)

edu.                  NS      A.ROOT-SERVERS.NET       198.41.0.1
com                  NS      A.ROOT-SERVERS.NET       198.41.0.1
cmu.edu           NS      LANCELOT.NET.CMU.EDU   128.2.232.1
cs.cmu.edu      NS      MANGO.SRV.CS.CMU.EDU    128.2.222.180
www.cs.cmu.edu  A    128.2.209.79

DNS Resolution with Cache

nslookup ftp.cs.cmu.edu

QUERY: ftp.cs.cmu.edu
REPLY: cmu.edu (NS)
QUERY: ftp.cs.cmu.edu
REPLY: edu (NS)

edu.                  NS      A.ROOT-SERVERS.NET       198.41.0.1
com                  NS      A.ROOT-SERVERS.NET       198.41.0.1
cmu.edu           NS      LANCELOT.NET.CMU.EDU   128.2.232.1
cs.cmu.edu      NS      MANGO.SRV.CS.CMU.EDU    128.2.222.180
www.cs.cmu.edu  A    128.2.209.79
ftp.cs.cmu.edu      A    128.2.242.152
CDF of DNS Lookup Latency

J. Jung et al, DNS Performance and the Effectiveness of Caching, Proceedings of IMW 2001

DNS Latency with \( n \) Referrals

J. Jung et al, DNS Performance and the Effectiveness of Caching, Proceedings of IMW 2001

% Lookups with \( n \) referrals

<table>
<thead>
<tr>
<th>( n )</th>
<th>\text{mit-jan00}</th>
<th>\text{mit-dec00}</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>74.62%</td>
<td>81.17%</td>
</tr>
<tr>
<td>1</td>
<td>24.02%</td>
<td>17.86%</td>
</tr>
<tr>
<td>2</td>
<td>1.16%</td>
<td>0.87%</td>
</tr>
<tr>
<td>\geq 4</td>
<td>0.11%</td>
<td>0.07%</td>
</tr>
</tbody>
</table>

Avg # of queries \( \sim 1 \)
Most Popular Names vs % Requests

J. Jung et al, DNS Performance and the Effectiveness of Caching, Proceedings of IMW 2001

~ 46% names accessed only once. Implication?
**TTL Distribution**

J. Jung et al, DNS Performance and the Effectiveness of Caching, Proceedings of IMW 2001

How do large TTLs for NS records help?

**Is Caching Effective: Using Trace-driven Simulation**

- **Goal:** study effect of group size and TTLs on cache hit rates

- **Use traces to:**
  - Derive databases of:
    - IP-to-name mapping
    - largest-TTL values
  - Randomly divide TCP clients into groups of size $s$

- **Simulate a shared DNS cache for each group**
  - For each new TCP connection in the trace,
    - Use src IP addr to identify group
    - Use dest IP address to identify domain name client would have looked up
      - Since not all DNS queries would appear in the trace
    - Record hit/miss based on group’s simulated cache; update cache on miss

**Issues?**
- Multiple domain names map to same IP address
- Clients belong to several caching groups (multiple local DNS servers)
A-record Cache Sharing vs Hit Ratio

J. Jung et al, DNS Performance and the Effectiveness of Caching, Proceedings of IMW 2001

Most benefits of sharing obtained with 10-20 clients per cache

With no sharing, avg hit rate is 60-70%!
Zipf-like distribution of name popularity

A-record TTL vs Hit Ratio

J. Jung et al, DNS Performance and the Effectiveness of Caching, Proceedings of IMW 2001

Using small TTLs not likely to affect hit rates much

Same TTL simulated for all names
Is Caching Effective: Using Trace-driven Simulation

- Per-client or per-application caching of A records can almost entirely handle the job of reducing client-latency
- Not a good idea to reduce TTL values on NS-records (or for A-records for name servers)
  - Would increase the load on root and gTLD servers by a factor of 5!
  - Local proxy-based caching helps significantly reduce load on root servers

Mean DNS Time for 15,000 Names (from 75 Sites)


The Top-Level Zone Servers

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

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