CSE 265:
System & Network Administration

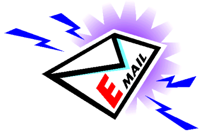
- DNS – The Domain Name System
  - What does DNS do?
  - The DNS namespace
  - BIND software
  - How DNS works
  - DNS database
  - Testing and debugging (tools)

What does DNS do?

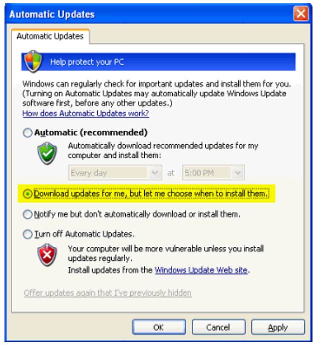
- Provides hostname – IP lookup services
  - www.lehigh.edu = 128.180.2.57
- DNS defines
  - A hierarchical namespace for hosts and IP addresses
  - A distributed database of hostname and address info
  - A “resolver” – library routines that query this database
  - Improved routing for email
  - A mechanism for finding services on a network
  - A protocol for exchanging naming information
- DNS is essential for any org using the Internet

What uses DNS?

- Any application that operates over the Internet
- Such as
  - email
    - Spam filters
  - WWW
  - FTP
  - IRC, IM
  - Windows update
  - telnet, ssh



Logan Lape - Gizmodo



Automatic Updates

Automatic Updates

Help protect your PC

Windows can regularly check for important updates and install them for you. (Turning on Automatic Updates may automatically update Windows Update software first, before any other updates.)

How does Automatic Updates work?

○ Automatic (recommended)

Automatically download recommended updates for my computer and install them:

Every day at 5:00 PM

● Download updates for me, but let me choose when to install them.

○ Notify me but don't automatically download or install them.

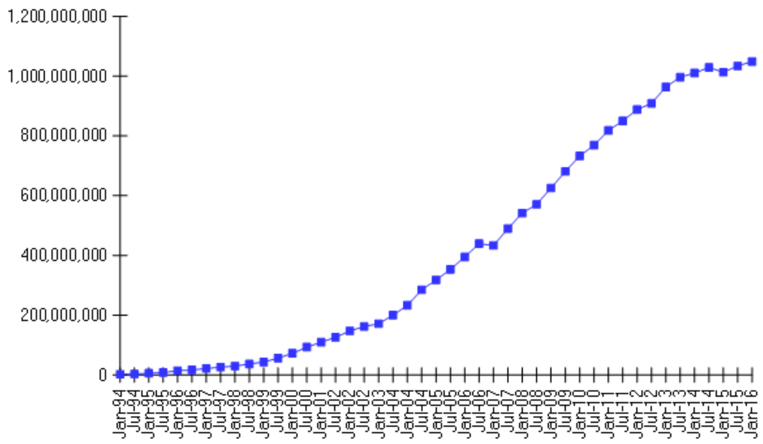
○ Turn off Automatic Updates.

Your computer will be more vulnerable unless you install updates regularly.

Install updates from the Windows Update Web site.

Offer updates again that I've previously hidden

Internet Domain Survey Host Count



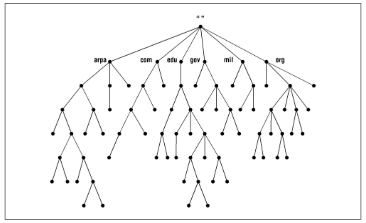
Source: Internet Systems Consortium (www.isc.org)

Common country codes

Code	Country	Code	Country
au	Australia	hu	Hungary
br	Brazil	jp	Japan
ca	Canada	md	Moldovia
cc	Cocos Islands	mx	Mexico
ch	Switzerland	nu	Niue
de	Germany	se	Sweden
fi	Finland	tm	Turkmenistan
fr	France	tv	Tuvalu
hk	Hong Kong	us	United States

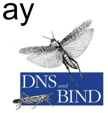
- See http://www.iana.org/domains/root/db/

The DNS namespace



Some illustrations from O'Reilly's *DNS & Bind*

- A tree of “domains”
- Root is “.” (dot), followed by top-level (root-level) domains
- Two branches of tree
  - One maps hostnames to IP addresses
  - Other maps IP address back to hostnames
- Two types of top-level domain names used today
  - gTLDs: generic top-level domains
  - ccTLDs: country code top-level domains



Domain name management

- Network Solutions (now VeriSign) used to manage .com, .org, .net, and .edu directly
- VeriSign now manages infrastructure for .com, .net, .tv, .name and .cc
  - Dozens of others manage country codes and other top-level domains
- Organizations can now register with many different registrars (even when VeriSign manages the underlying database)
- Domain holders must have two name servers authoritative for the domain

Generic top-level domains

Domain	Purpose	Domain	Purpose
com	Companies	aero	Air transport industry
edu	Educational institutions	biz	Businesses
gov	(US) government agencies	coop	Cooperatives
mil	(US) military agencies	info	Unrestricted
net	Network providers	jobs	Human resources folks
org	Nonprofit organizations	museum	Museums
int	International organizations	name	Individuals
arpa	IP address lookup	pro	Professionals (attorneys, etc.)

- But today there are an abundance of top-level domains
  - .black, .blue, .airforce, .agency, .audio, etc.
- See http://www.iana.org/domains/root/db/

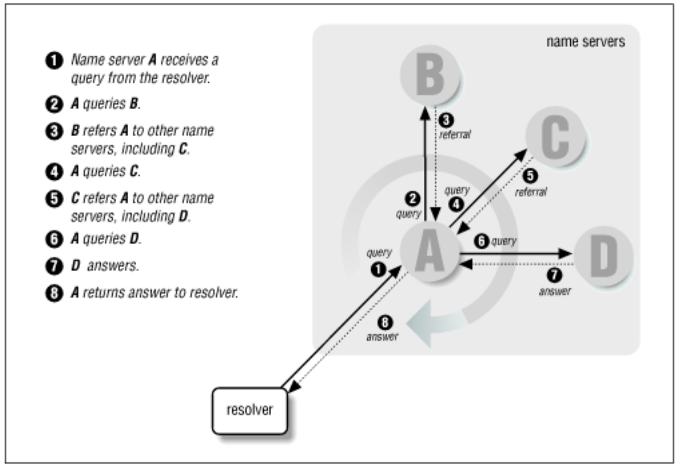
How DNS works

- A client calls gethostbyname(), which is part of the resolver library
- The resolver library sends a lookup request to the first nameserver that it knows about (from /etc/resolv.conf)
- If the nameserver knows the answer, it sends it back to the client
- If the nameserver doesn't know, it either
  - asks the next server, or
  - returns a failure, and suggests that the client contact the next server

Selecting a domain name

- Most good (short) names in .com and other old gTLDs are already in use
- Domain names are up to 63 characters per segment (but a 12 character length limit is recommended), and up to 255 chars overall
- Identify two authoritative name servers
- Select a registrar, and pay ~$1-$35/year for registration

Resolving process

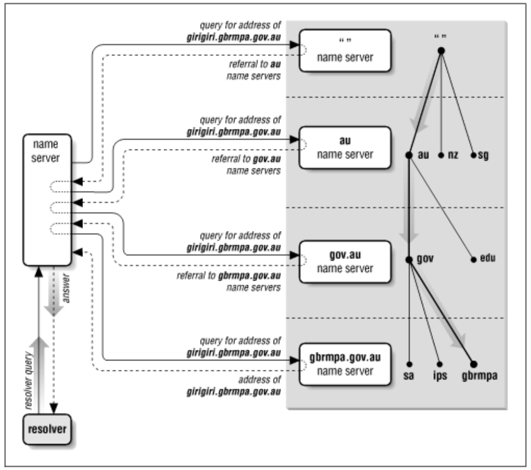


1. Name server **A** receives a query from the resolver.
2. **A** queries **B**.
3. **B** refers **A** to other name servers, including **C**.
4. **A** queries **C**.
5. **C** refers **A** to other name servers, including **D**.
6. **A** queries **D**.
7. **D** answers.
8. **A** returns answer to resolver.

BIND software

- Berkeley Internet Name Domain system
  - By far, the most popular nameserver [Measurement Factory 2010 study]
- Three components
  - a daemon called named that answers queries
  - library routines that resolve host queries by contacting DNS servers
  - command-line utilities (nslookup, dig, host)

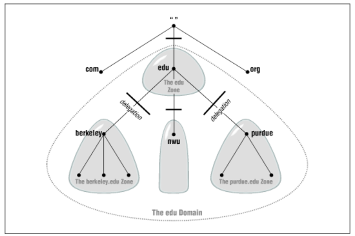
Example resolution

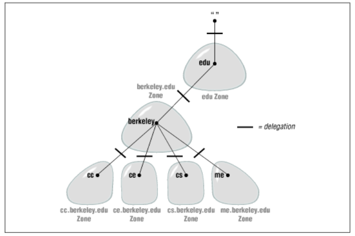


query for address of girigiri.gbrmpa.gov.au
" " name server
referral to au name servers
" "
query for address of girigiri.gbrmpa.gov.au
au name server
referral to gov.au name servers
au
nz
sg
name server
query for address of girigiri.gbrmpa.gov.au
gov.au name server
referral to gbrmpa.gov.au name servers
gov
edu
query for address of girigiri.gbrmpa.gov.au
gbrmpa.gov.au name server
address of girigiri.gbrmpa.gov.au
sa
ips
gbrmpa
answer
resolver query
resolver

Delegation

- Impractical for high-level servers to know about all hosts (or even sub-domains) below
- Servers delegate specific zones to other servers
- Names and addresses of authoritative servers for the relevant zone are returned in referrals





Types of name servers

- Recursive vs. nonrecursive servers
  - Servers that allow recursive queries will do all the work
  - Nonrecursive servers will only return referrals or answers
- Authoritative vs. caching-only servers
  - Authoritative servers have the original data
  - Caching servers retain data previously seen for future use

What servers know

- All servers know about the 13 root servers
  - hardcoded (rarely changes!), or in hint file
  - a.root-servers.net ... m.root-servers.net
- Each root server knows about servers for every top-level domain (.com, .net, .uk, etc.)
- Each top-level domain knows the servers for each second-level domain within the top-level domain
- Authoritative servers know about their hosts

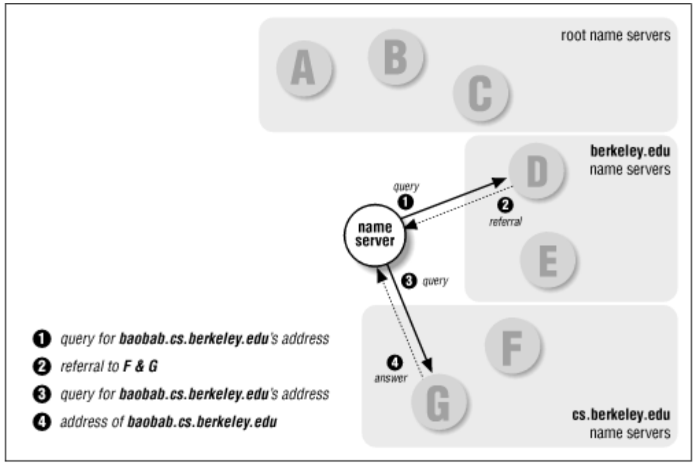
BIND client configuration

- Each host has /etc/resolv.conf which lists DNS servers
  - Can be set manually, or via DHCP
  - Example from sunlab:

```
search cse.lehigh.edu eecs.lehigh.edu
nameserver 128.180.120.6
nameserver 128.180.120.4
nameserver 128.180.2.9
```

- Servers must be recursive, and should have a cache
- Servers are contacted in order, only after timing out previous attempt

Caching reduces DNS load

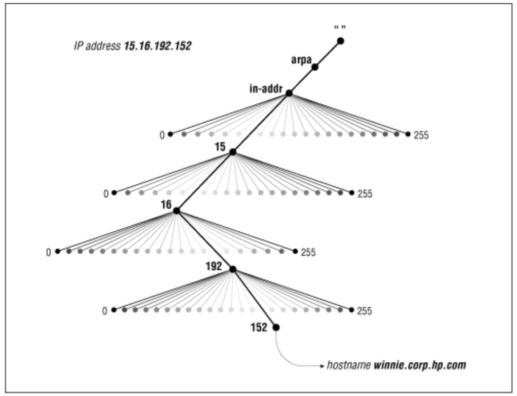

root name servers
A
B
C
berkeley.edu name servers
D
E
cs.berkeley.edu name servers
F
G
name server
1 query
2 referral
3 query
4 answer
1 query for baobab.cs.berkeley.edu's address
2 referral to F & G
3 query for baobab.cs.berkeley.edu's address
4 address of baobab.cs.berkeley.edu

BIND server issues

- named is typically started at boot time
- Configured using /etc/named.conf
- Can decide between
  - caching vs. authoritative
  - slave vs. master (per zone)
  - answering recursive or only iterative queries
- Lots more options
  - Who can access, what port, etc.

IP-to-hostname resolution

- IP resolution works essentially the same as hostname resolution
- Query for 15.16.192.152
  - Rendered as query for 152.192.16. 15.in-addr.arpa
- Each layer can delegate to the next



DNS on Linux

- Linux uses /etc/nsswitch.conf to determine what sources to use for name lookups

```
# /etc/nsswitch.conf
#
passwd:  files nisplus
shadow:  files nisplus
group:   files nisplus
hosts:   files dns
```

- Configuration is in /etc/named.conf
- Other files in /var/named

DNS database

- Exactly what data is stored?
- Resource records
  - Specify nameservers
  - Name to address translation
  - Address to name translation
  - Host aliases
  - Mail routing
  - Free text, location, etc.
- Format
  - [name] [ttl] [class] type data

Resource record: name

[name] [ttl] [class] type data

- name is host or domain for the record
- Absolute names must end with a dot
- Relative names do not – the current domain is added (sometimes causing mistakes!)
  - www.cse.lehigh.edu.cse.lehigh.edu

Resource record: ttl

[name] **[ttl]** [class] type data

- The time to live (ttl) field specifies in seconds the time that the data item may still be cached
- Increasing the ttl (say to a week) decreases traffic and DNS load substantially
- Setting a value too low can hurt web site performance
- Typical values are in days or weeks

SOA record

```
cs.colorado.edu 86400 IN SOA ns.cs.colorado.edu. hostmaster.cs.colorado.edu.
   (
                              2001111300 ; serial number
                              7200       ; refresh (2 hours)
                              1800       ; retry (30 minutes)
                              604800     ; expire (1 week)
                              7200 )     ; minimum (2 hours)
```

- refresh = how often slave servers must check master
- retry = when the slave will try again after failure
- expire = how long data can be considered valid without master
- minimum = TTL for cached negative answers

Resource record: class

[name] [ttl] **[class]** type data

- Three values of class are supported
  - IN: Internet
    - default (and only one modern systems care about)
  - CH: ChaosNet
    - obsolete protocol used by obsolete machines
  - HS: Hesiod
    - database service built on top of BIND (from MIT)

NS record

```
lehigh.edu.        86400   IN     NS     cerberus.CC.lehigh.edu.
lehigh.edu.        86400   IN     NS     spot.CC.lehigh.edu.
lehigh.edu.        86400   IN     NS     rover.CC.lehigh.edu.

cse.lehigh.edu.    86400   IN     NS     kato.eecs.lehigh.edu.
cse.lehigh.edu.    86400   IN     NS     rosie.eecs.lehigh.edu.
cse.lehigh.edu.    86400   IN     NS     cerberus.cc.lehigh.edu.
cse.lehigh.edu.    86400   IN     NS     spot.cc.lehigh.edu.
cse.lehigh.edu.    86400   IN     NS     rover.cc.lehigh.edu.
```

- Can't tell whether the nameserver is master or slave (but it is definitely authoritative, not caching)

Resource record: type

[name] [ttl] [class] **type** data

- Many DNS record types
  - Zone
    - SOA: Start of authority (define a zone)
    - NS: Name server
  - Basic
    - A: IPv4 address (name to address translation)
    - AAAA: IPv6 address (name to address translation)
    - PTR: address-to-name translation
    - MX: Mail exchanger
  - Other
    - CNAME: Canonical name (implements aliases)

Dynamic updates to DNS

- DNS was originally designed for an environment in which hostnames (and other DNS info) changed slowly, if at all
- DHCP breaks this assumption
- Recent versions of BIND allow DHCP to notify BIND of address assignments

A and PTR records

```
rover.cc.lehigh.edu.    45355   IN     A       128.180.2.9
spot.cc.lehigh.edu.     45355   IN     A       128.180.1.3
cerberus.cc.lehigh.edu. 45355   IN     A        69.7.224.17
kato.eecs.lehigh.edu.   86400   IN     A       128.180.120.6
rosie.eecs.lehigh.edu.  86400   IN     A       128.180.120.4

6.120.180.128.in-addr.arpa.     7200 IN     PTR     kato.eecs.lehigh.edu.
4.120.180.128.in-addr.arpa.     7200 IN     PTR     rosie.eecs.lehigh.edu.
```

- lehigh.edu and 180.128.in-addr.arpa are different zones
  - each has own SOA and resource records
- Some apps require that A and PTR records match (for authentication)

Testing and debugging (tools)

- named supports lots of logging options
- typical BIND tools
  - nslookup (old, possibly deprecated)
  - host
  - dig
- whois – find domain and network registration info

MX and CNAME records

```
piper           IN   MX    10 piper
                IN   MX    20 mailhub
                IN   MX    50 boulder.colorado.edu.
xterm1          IN   MX    10 mailhub

ftp             IN   CNAME  anchor
www             IN   CNAME  anchor

www.cse.lehigh.edu.    6754    IN     CNAME   telstar.eecs.lehigh.edu.
```

- Every host should have MX records
- Machines that accept mail for others need to be configured to do so (e.g., mailhub)
- CNAMEs can nest eight deep in BIND

Other Issues

- Many aspects of DNS haven't been covered in lecture
  - Lots of details!
  - Security issues
  - IPv6
  - Internationalization – now supported!
- DNS is generally case-insensitive
- VeriSign Site Finder product
  - See http://cyber.law.harvard.edu/tlds/sitefinder/