Domain Name System

History of DNS

- Before DNS
  - ARPAnet
    - *HOSTS.txt* contains all the hosts' information
    - Maintained by SRI's Network Information Center
      - In SRI-NIC host
  - Problems: Not scalable!
    - Traffic and Load
    - Name Collision
    - Consistency
- Domain Name System
  - Administration decentralization
  - 1984
    - Paul Mockapetris (University of Southern California)
    - RFC 882, 883 → 1034, 1035
      - 1034: Concepts and facilities
        - Updated by: 4033, 4034, 4035, 4343
      - 1035: Implementation and Specification
        - Updated by: 3658, 4033, 4034, 4035, 4343

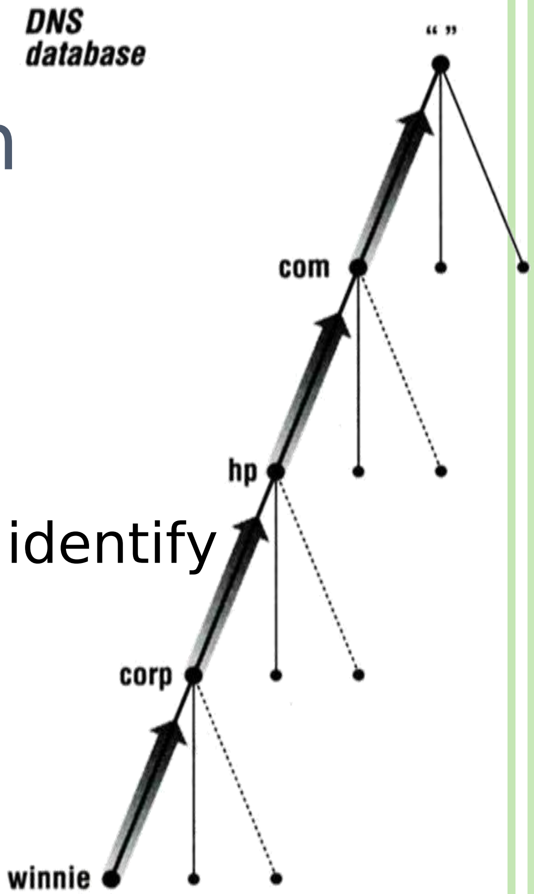
RFC Sourcebook:
http://www.networksorcery.com/enp/default.htm

DNS Introduction
– DNS Specification

- Make domain name system as
  - Distributed database
    - Each site maintains segment of DB
    - Each site open self information via network
  - Client-Server architecture
    - Name servers provide information (Name Server)
    - Clients make queries to server (Resolver)
  - Tree architecture
    - Each subtree ➔ “***domain***”
    - Domain can be divided in to “***subdomain***”

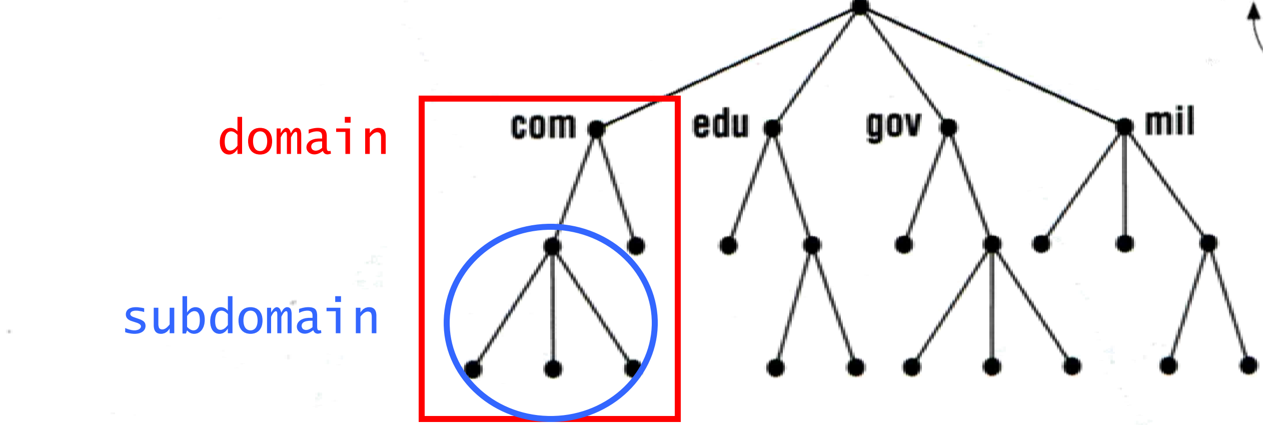
DNS Introduction
– Domain and Subdomain

- DNS Namespace
  - A tree of domains
- Domain and subdomain
  - Each domain has a “domain name” to identify its position in database
    - EX: nctu.edu.tw
    - EX: cs.nctu.edu.tw



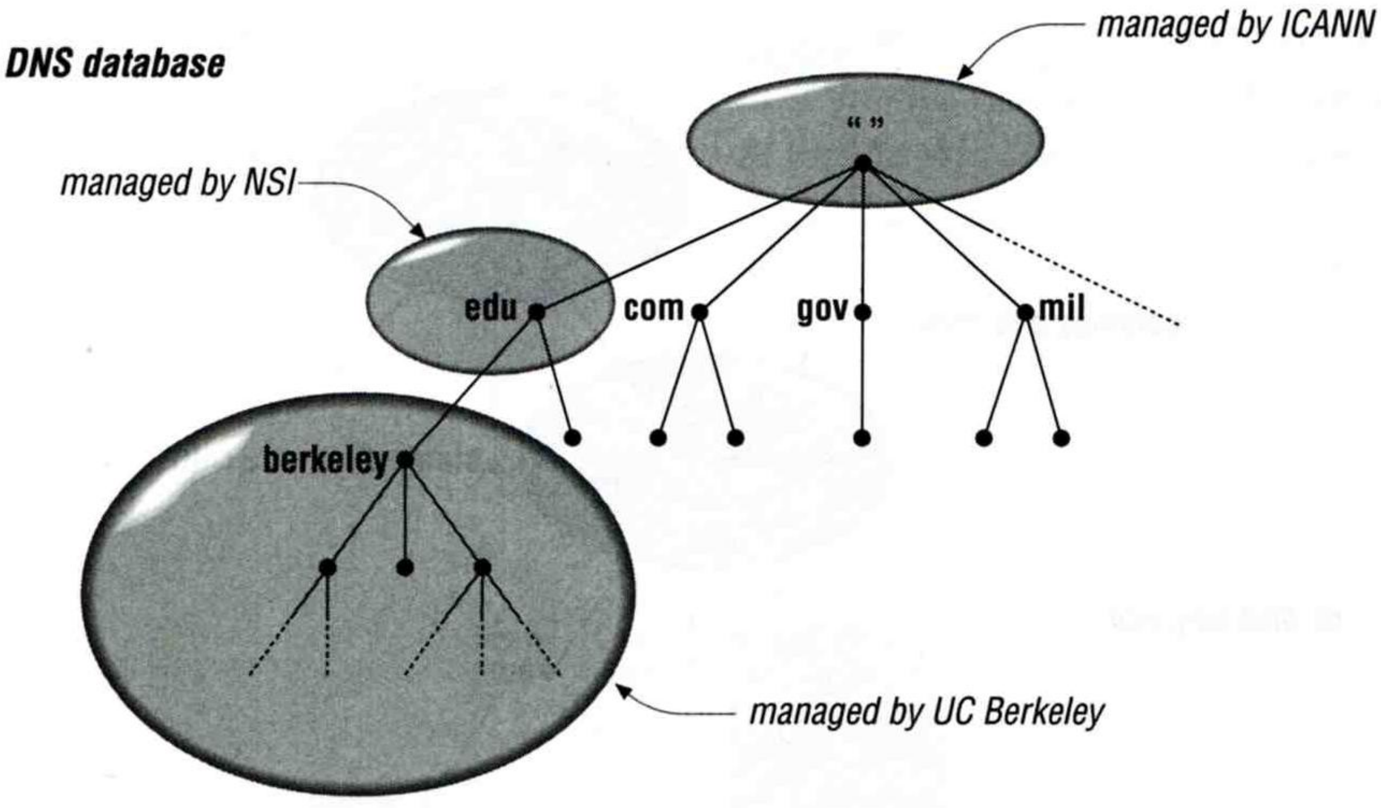
winnie.corp.hp.com

DNS database



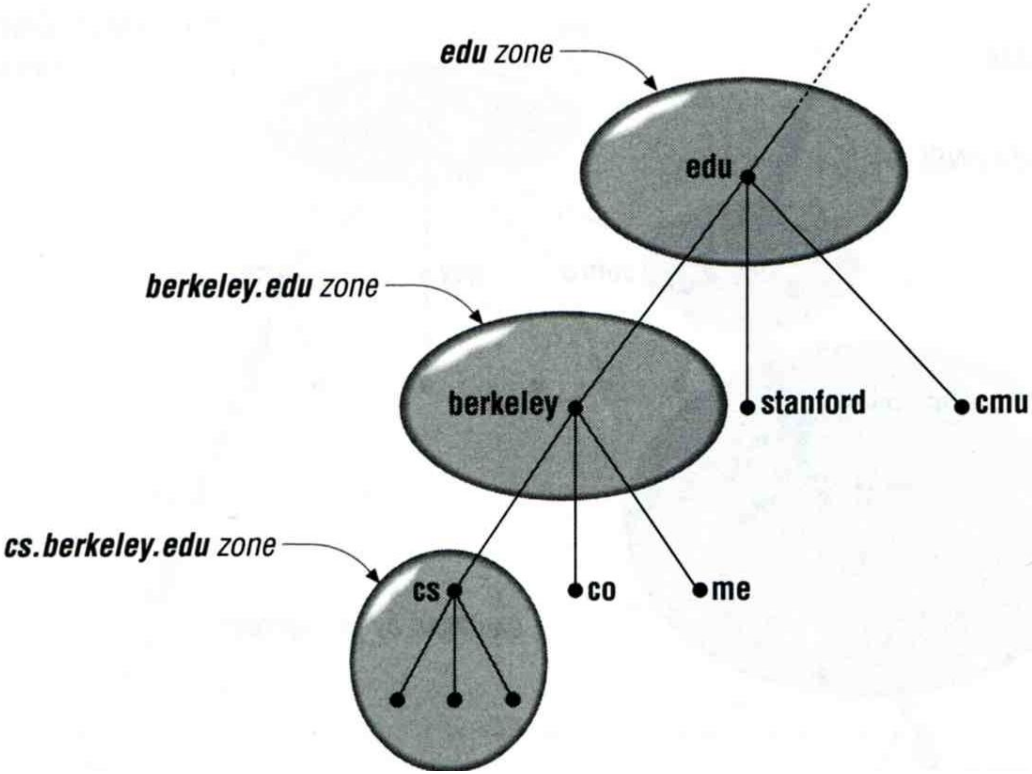
DNS Introduction – Delegation

- Administration delegation
  - Each domain can delegate responsibility to subdomain



DNS Introduction
– Administrated Zone

- Zone
  - Autonomously administered piece of namespace
    - Once the subdomain becomes a zone, it is independent to it's parent

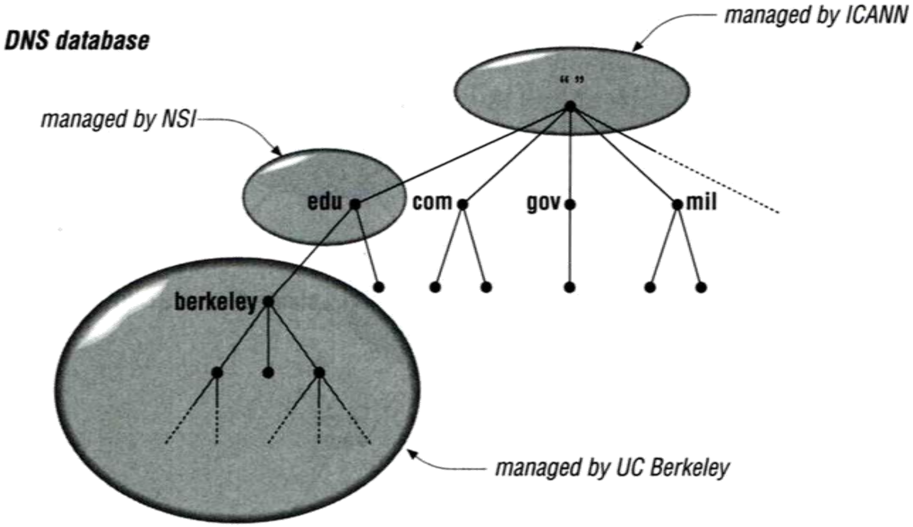


DNS Introduction
– Implementation of DNS

- JEEVES
  - Written by Paul Mockapetris for "TOPS-20" OS of DEC
- BIND
  - Berkeley Internet Name Domain
  - Written by Kevin Dunlap for 4.3 BSD UNIX OS

The DNS Namespace (1)

- A inverted tree (Rooted tree)
  - Root with label "."



- Domain level
  - Top-level or First level
    - Child of the root
  - Second-level
    - Child of a First-level domain
- Domain name limitation
  - 63-characters in each component and
  - Up to 255-characters in a complete name

The DNS Namespace (2)

- gTLDs
  - generic Top-Level Domains, including:
  - com: commercial organization, such as ibm.com
  - edu: educational organization, such as purdue.edu
  - gov: government organization, such as nasa.gov
  - mil: military organization, such as navy.mil
  - net: network infrastructure providing organization, such as hinet.net
  - org: noncommercial organization, such as x11.org
  - int: International organization, such as nato.int

ICANN – Internet Corporation for Assigned Names and Numbers
http://www.icann.org/

The DNS Namespace (3)

- New gTLDs launched in year 2000:

aero:	for air-transport industry
biz:	for business
coop:	for cooperatives
info:	for all uses
museum:	for museum
name:	for individuals
pro:	for professionals

The DNS Namespace (4)

- Other than US, ccTLD
  - country code TLD (ISO 3166)
    - Taiwan → tw
    - Japan → jp
  - Follow or not follow US-like scheme
    - US-like scheme example
      - edu.tw, com.tw, gov.tw
    - Other scheme
      - co.jp, ac.jp

The DNS Namespace (5)

- Zone
  - Autonomously administered piece of namespace

- Two kinds of zone files
  - Forward Zone files
    - Hostname-to-Address mapping
    - Ex:
      - bsd1   IN   A   140.113.235.131
  - Reverse Zone files
    - Address-to-Hostname mapping
    - Ex:
      - 131.235.113.140 IN PTR bsd1.cs.nctu.edu.tw.

BIND

- BIND
  - the Berkeley Internet Name Domain system
- Main versions
  - BIND4
    - Announced in 1980s
    - Based on RFC 1034, 1035
  - BIND8
    - Released in 1997
    - Improvements including:
      - efficiency, robustness and security
  - BIND9
    - Released in 2000
    - Enhancements including:
      - multiprocessor support, DNSSEC, IPv6 support, etc
  - BIND10
    - The next generation of BIND
    - Modularity, Customizability, Clusterization,
      Integration with customer workflow, Resilience, Runtime control
    - https://www.isc.org/bind10/project

BIND
– components

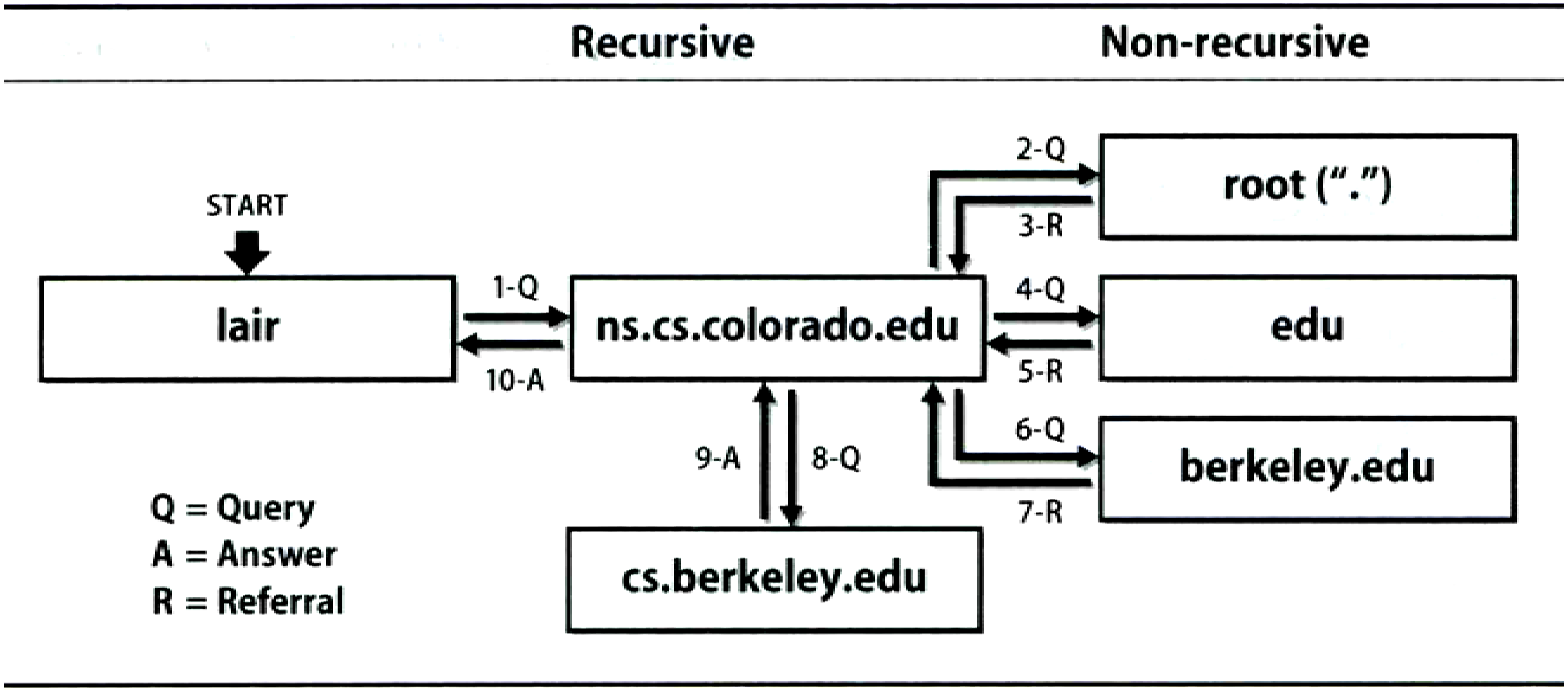
- Three major components
  - named
    - Daemon that answers the DNS query
  - Library routines
    - Routines that used to resolve host by contacting the servers of DNS distributed database
      - Ex: res_query, res_search, ...etc.
  - Command-line interfaces to DNS
    - Ex: nslookup, dig, hosts

BIND
– named (1)

- Categories of name servers
  - Based on a name server’ s source of data
    - Authoritative: official representative of a zone
      - Master: get zone data from disk
      - Slave: copy zone data from master
    - Nonauthoritative: answer a query from cache
      - caching: cashes data from previous queries
  - Based on the type of data saved
    - Stub: a slave that copy only name server data (no host data)
  - Based on the type of answers handed out
    - Recursive: do query for you until it return an answer or error
    - Nonrecursive: refer you to the authoritative server
  - Based on the query path
    - Forwarder: performs queries on behalf of many clients with large cache

BIND – named (2)

- Recursive query process
  - Ex: query lair.cs.colorado.edu → vangogh.cs.berkeley.edu, name server "ns.cs.colorado.edu" has no cache data



BIND – named (3)

- Nonrecursive referral
  - Hierarchical and longest known domain referral with cache data of other zone’ s name servers’ addresses
  - Ex:
    - Query lair.cs.colorado.edu from a nonrecursive server
    - Whether cache has
      - Name servers of cs.colorado.edu, colorado.edu, edu, root
  - The resolver libraries do not understand referrals mostly. They expect the local name server to be recursive

BIND – named (4)

- Caching
  - Positive cache
  - Negative cache
    - No host or domain matches the name queried
    - The type of data requested does not exist for this host
    - The server to ask is not responding
    - The server is unreachable of network problem
- negative cache
  - 60% DNS queries are failed
  - To reduce the load of root servers, the authoritative negative answers must be cached

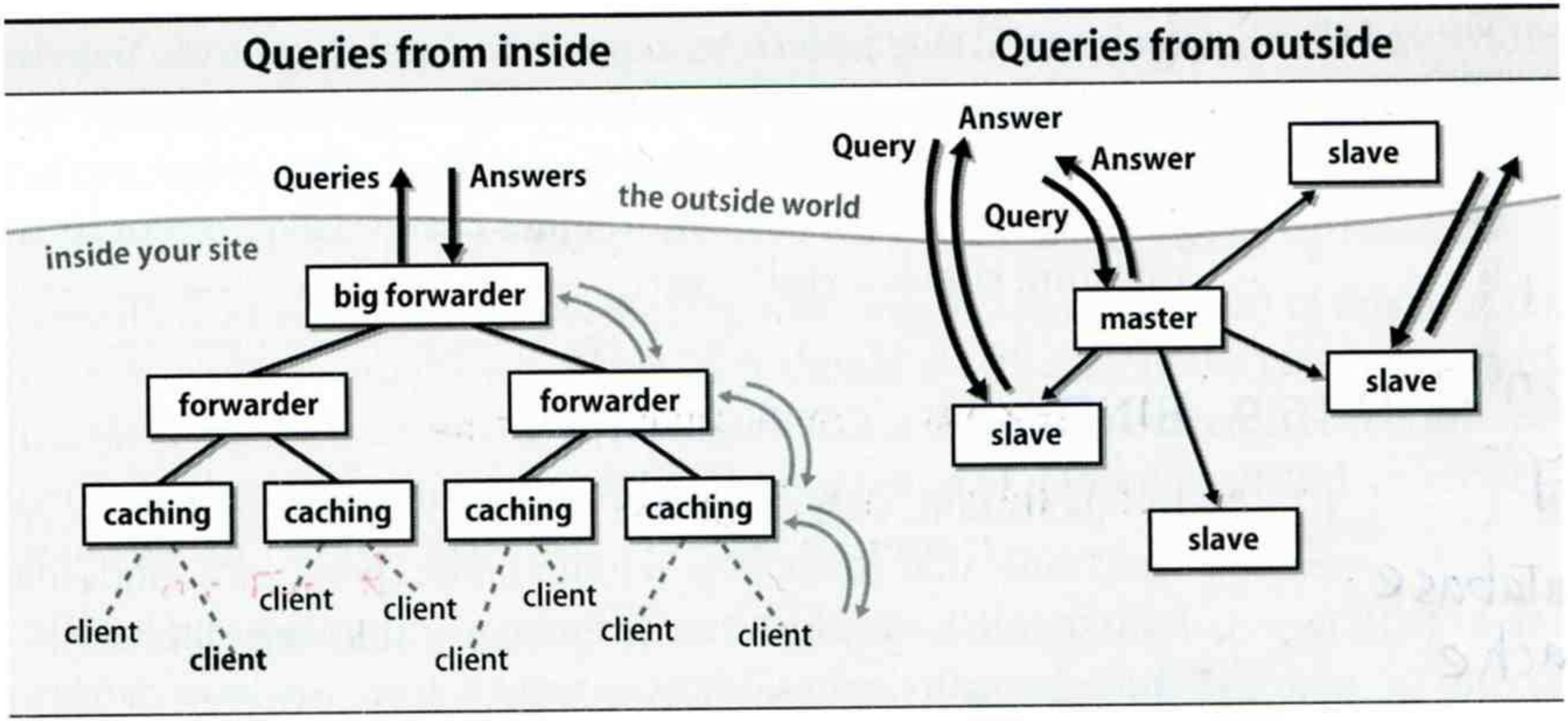
BIND – named (5)

- Root name servers
  - List in named.root file of BIND (/etc/namedb/named.root)

```
.                        3600000  IN  NS    A.ROOT-SERVERS.NET.
A.ROOT-SERVERS.NET.      3600000      A     198.41.0.4
A.ROOT-SERVERS.NET.      3600000      AAAA  2001:503:BA3E::2:30
.                        3600000      NS    B.ROOT-SERVERS.NET.
B.ROOT-SERVERS.NET.      3600000      A     192.228.79.201
.                        3600000      NS    C.ROOT-SERVERS.NET.
C.ROOT-SERVERS.NET.      3600000      A     192.33.4.12
.                        3600000      NS    D.ROOT-SERVERS.NET.
D.ROOT-SERVERS.NET.      3600000      A     128.8.10.90
.                        3600000      NS    E.ROOT-SERVERS.NET.
E.ROOT-SERVERS.NET.      3600000      A     192.203.230.10
.                        3600000      NS    F.ROOT-SERVERS.NET.
F.ROOT-SERVERS.NET.      3600000      A     192.5.5.241
F.ROOT-SERVERS.NET.      3600000      AAAA  2001:500:2f::f
.                        3600000      NS    G.ROOT-SERVERS.NET.
G.ROOT-SERVERS.NET.      3600000      A     192.112.36.4
.                        3600000      NS    H.ROOT-SERVERS.NET.
H.ROOT-SERVERS.NET.      3600000      A     128.63.2.53
H.ROOT-SERVERS.NET.      3600000      AAAA  2001:500:1::803f:235
.                        3600000      NS    I.ROOT-SERVERS.NET.
I.ROOT-SERVERS.NET.      3600000      A     192.36.148.17
.                        3600000      NS    J.ROOT-SERVERS.NET.
J.ROOT-SERVERS.NET.      3600000      A     192.58.128.30
J.ROOT-SERVERS.NET.      3600000      AAAA  2001:503:C27::2:30
.                        3600000      NS    K.ROOT-SERVERS.NET.
K.ROOT-SERVERS.NET.      3600000      A     193.0.14.129
K.ROOT-SERVERS.NET.      3600000      AAAA  2001:7fd::1
.                        3600000      NS    L.ROOT-SERVERS.NET.
L.ROOT-SERVERS.NET.      3600000      A     199.7.83.42
.                        3600000      NS    M.ROOT-SERVERS.NET.
M.ROOT-SERVERS.NET.      3600000      A     202.12.27.33
M.ROOT-SERVERS.NET.      3600000      AAAA  2001:dc3::35
```

BIND
– named (6)

- How to arrange your DNS servers?
  - Ex:



The DNS Database

- A set of text files such that
  - Maintained and stored on the domain’ s master name server
  - Two types of entries
    - Resource Records (RR)
      - Used to store the information of
      - The real part of DNS database
    - Parser commands
      - Used to modify or manage other RR data

http://en.wikipedia.org/wiki/List_of_DNS_record_types

The DNS Database – Parser Commands

- Commands must start in first column and be on a line by themselves

- $ORIGIN domain-name
  - Used to append to un-fully-qualified name
- $INCLUDE file-name
  - Separate logical pieces of a zone file
  - Keep cryptographic keys with restricted permissions
- $TTL default-ttl
  - Default value for time-to-live filed of records
- $GENERATE start-stop/[step] lhs type rhs
  - Used to generate a series of similar records
  - Can be used in only CNAME, PTR, NS record types

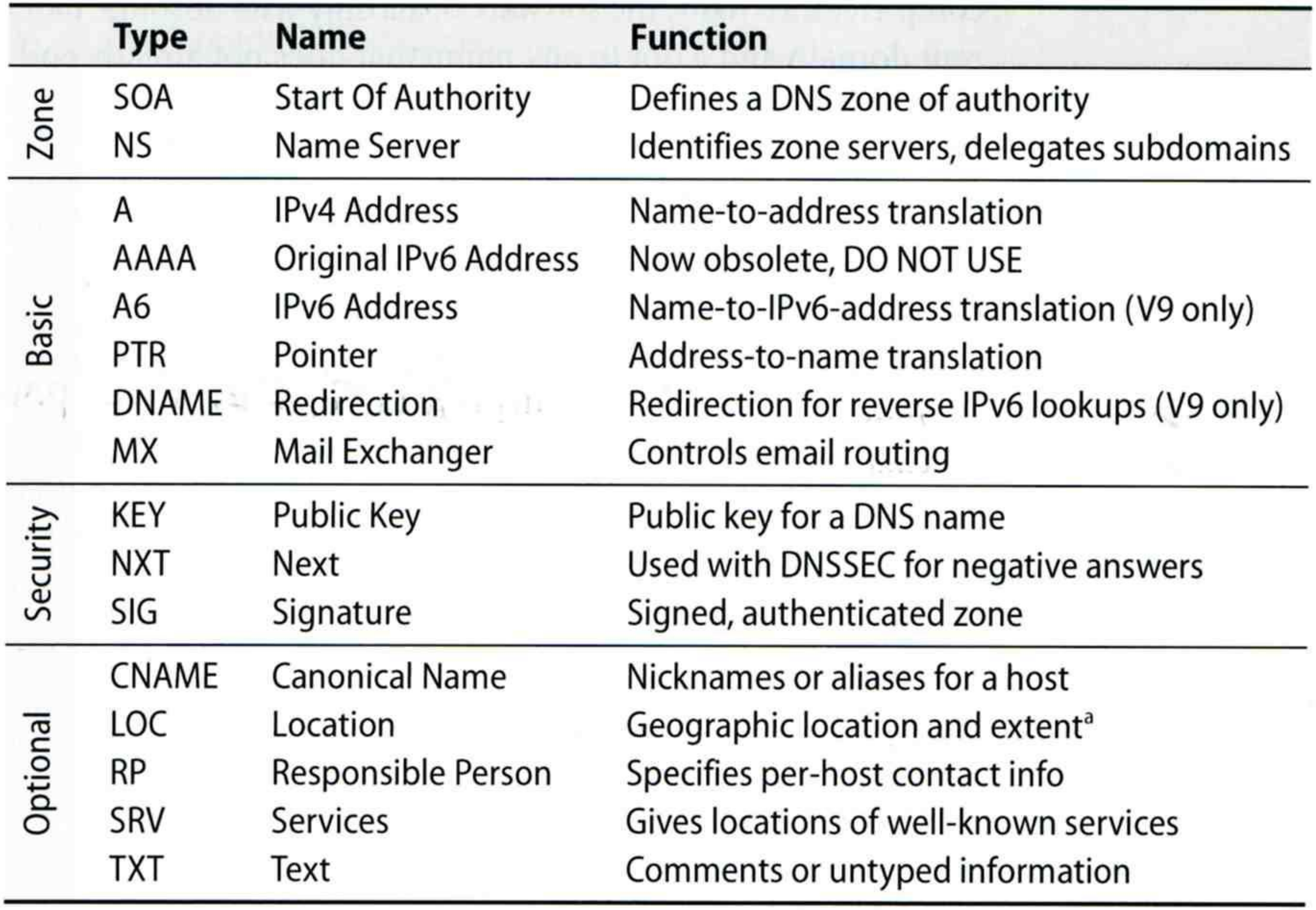
The DNS Database – Resource Record (1)

- Basic format
  - [name] [ttl] [class] type data
    - name: the entity that the RR describes
    - ttl: time in second of this RR’s validity in cache
    - class: network type
      - IN for Internet
      - CH for ChaosNet
      - HS for Hesiod
  - Special characters
    - ; (comment)
    - @ (The current domain name)
    - () (allow data to spam lines
    - * (wild card character, *name* filed only)

The DNS Database – Resource Record (2)

- Type of resource record discussed later
  - Zone records:
    identify domains and name servers
    - **SOA**
    - **NS**
  - Basic records:
    map names to addresses and route mail
    - **A**
    - **PTR**
    - **MX**
  - Optional records:
    extra information to host or domain
    - **CNAME**
    - **TXT**
    - **LOC**
    - **SRV**

The DNS Database – Resource Record (3)



	Type	Name	Function
Zone	SOA	Start Of Authority	Defines a DNS zone of authority
	NS	Name Server	Identifies zone servers, delegates subdomains
Basic	A	IPv4 Address	Name-to-address translation
	AAAA	Original IPv6 Address	Now obsolete, DO NOT USE
	A6	IPv6 Address	Name-to-IPv6-address translation (V9 only)
	PTR	Pointer	Address-to-name translation
	DNAME	Redirection	Redirection for reverse IPv6 lookups (V9 only)
	MX	Mail Exchanger	Controls email routing
Security	KEY	Public Key	Public key for a DNS name
	NXT	Next	Used with DNSSEC for negative answers
	SIG	Signature	Signed, authenticated zone
Optional	CNAME	Canonical Name	Nicknames or aliases for a host
	LOC	Location	Geographic location and extent[a]
	RP	Responsible Person	Specifies per-host contact info
	SRV	Services	Gives locations of well-known services
	TXT	Text	Comments or untyped information

The DNS Database
– Resource Record (4)

- SOA: Start Of Authority
  - Defines a DNS zone of authority, each zone has exactly one SOA record.
  - Specify the name of the zone, the technical contact and various timeout information
  - Format:
    - **[zone] IN SOA [server-name] [administrator’ s mail] (serial, refresh, retry, expire, ttl)**
  - Ex:

;	means comments
@	means current domain name
( )	allow data to span lines
*	Wild card character

```
$TTL 3600;
$ORIGIN cs.nctu.edu.tw.
@       IN      SOA     csns.cs.nctu.edu.tw.    root.cs.nctu.edu.tw.     (
                        2009051102              ; serial number
                        1D                      ; refresh time for slave server
                        30M                     ; retry
                        1W                      ; expire
                2H      )               ; minimum
```

The DNS Database – Resource Record (5)

- NS: Name Server
  - Identify the authoritative server for a zone
  - Usually follow the SOA record
  - Every authoritative name servers should be listed both in current domain and parent domain zone files
    - Delegation purpose
    - Ex: cs.nctu.edu.tw and nctu.edu.tw

```
$TTL 3600;
$ORIGIN cs.nctu.edu.tw.
@       IN      SOA     csns.cs.nctu.edu.tw.    root.cs.nctu.edu.tw.    (
                        2009051102              ; serial number
                        1D                      ; refresh time for slave server
                        30M                     ; retry
                        1W                      ; expire
                2H      )               ; minimum
        IN      NS      dns.cs.nctu.edu.tw.
        IN      NS      dns2.cs.nctu.edu.tw.
```

The DNS Database – Resource Record (6)

- A record: Address
  - Provide mapping from hostname to IP address
  - Ex:

```
$ORIGIN cs.nctu.edu.tw.
@       IN      NS      dns.cs.nctu.edu.tw.
        IN      NS      dns2.cs.nctu.edu.tw.
dns     IN      A       140.113.235.107
dns2    IN      A       140.113.235.103

www     IN      A       140.113.235.111
```

The DNS Database – Resource Record (7)

- PTR: Pointer
  - Perform the reverse mapping from IP address to hostname
  - Special top-level domain: in-addr.arpa
    - Used to create a naming tree from IP address to hostnames

```
$TTL 259200;
$ORIGIN 235.113.140.in-addr.arpa.
@       IN      SOA     cs.nctu.edu.tw. root.cs.nctu.edu.tw.    (
                        2009050801              ; serial
                        1D                      ; refresh time for secondary server
                        30M                     ; retry
                        1W                      ; expire
                        2H)                     ; minimum
        IN      NS      dns.cs.nctu.edu.tw.
        IN      NS      dns2.cs.nctu.edu.tw.
$ORIGIN in-addr.arpa.
103.235.113.140         IN PTR csmailgate.cs.nctu.edu.tw.
107.235.113.140         IN PTR csns.cs.nctu.edu.tw.
```

The DNS Database
– Resource Record (8)

- MX: Mail exchanger
  - Direct mail to a mail hub rather than the recipient’ s own workstation
  - Ex:

```
$TTL 3600;
$ORIGIN cs.nctu.edu.tw.
@       IN      SOA     csns.cs.nctu.edu.tw.    root.cs.nctu.edu.tw.    (
                        2009051102              ; serial number
                        1D                      ; refresh time for slave server
                        30M                     ; retry
                        1W                      ; expire
                2H      )               ; minimum
        IN      NS      dns.cs.nctu.edu.tw.
        IN      NS      dns2.cs.nctu.edu.tw.
        7200   IN   MX  5 csmx1.cs.nctu.edu.tw.
        7200   IN   MX  5 csmx2.cs.nctu.edu.tw.
        60     IN   MX  10 csmx3.cs.nctu.edu.tw.

csmx1                   IN      A       140.113.235.104
csmx2                   IN      A       140.113.235.105
csmx3                   IN      A       140.113.235.119
```

The DNS Database
– Resource Record (9)

- CNAME: Canonical name
  - Add additional names to a host
  - CNAME record can nest eight deep in BIND
  - Ex:

```
www                   IN        A          140.113.209.63
                      IN        A          140.113.209.77
penghu-club           IN        CNAME      www
King                  IN        CNAME      www

R21601                IN        A          140.113.214.31
superman              IN        CNAME      r21601
```

The DNS Database – Resource Record (10)

- TXT: Text
  - Add arbitrary text to a host’ s DNS records

```
$TTL 3600;
$ORIGIN cs.nctu.edu.tw.
@       IN      SOA     csns.cs.nctu.edu.tw.    root.cs.nctu.edu.tw.    (
                        2009051102              ; serial number
                        1D                      ; refresh time for slave server
                        30M                     ; retry
                        1W                      ; expire
                2H      )               ; minimum
        IN      NS      dns.cs.nctu.edu.tw.
        IN      NS      dns2.cs.nctu.edu.tw.

        IN      TXT    “Department of Computer Science”
```

The DNS Database
– Resource Record (11)

- LOC: Location
  - Describe the geographic location and physical size of a DNS object
  - Format:
    - name [ttl] IN LOC latitude longitude [altitude [size [hp [vp]]]]
      - latitude 緯度
      - longitude 經度
      - altitude 海拔
      - size: diameter of the bounding sphere
      - hp: horizontal precision
      - vp: vertical precision

```
caida.org.          IN          LOC          32 53 01 N 117 14 25 W 107m 30m 18m 15m
```

The DNS Database
– Resource Record (12)

- SRV: Service
  - Specify the location of services within a domain
  - Format:
    - _service._proto.name [ttl] IN SRV pri weight port target
  - Ex:

```
; don’t allow finger
_finger._tcp                      SRV        0          0          79          .
; 1/4 of the connections to old, 3/4 to the new
_ssh._tcp             SRV        0          1          22          old.cs.colorado.edu.
_ssh._tcp             SRV        0          3          22          new.cs.colorado.edu.
; www server
_http._tcp            SRV        0          0          80          www.cs.colorado.edu.
                      SRV        10         0          8000        new.cs.colorado.edu
; block all other services
*._tcp                SRV        0          0          0           .
*._udp                SRV        0          0          0           .
```

```
x:~ -lwhsu- dig _http._tcp.update.freebsd.org SRV

; <<>> DiG 9.3.3 <<>> _http._tcp.update.freebsd.org SRV
;; global options:  printcmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 22121
;; flags: qr rd ra; QUERY: 1, ANSWER: 6, AUTHORITY: 6, ADDITIONAL: 0

;; QUESTION SECTION:
;_http._tcp.update.freebsd.org. IN      SRV

;; ANSWER SECTION:
_http._tcp.update.freebsd.org. 3595 IN  SRV     1 50 80 update5.FreeBSD.org.
_http._tcp.update.freebsd.org. 3595 IN  SRV     1 5 80 update1.FreeBSD.org.
_http._tcp.update.freebsd.org. 3595 IN  SRV     1 10 80 update3.FreeBSD.org.
_http._tcp.update.freebsd.org. 3595 IN  SRV     1 10 80 update6.FreeBSD.org.
_http._tcp.update.freebsd.org. 3595 IN  SRV     1 15 80 update2.FreeBSD.org.
_http._tcp.update.freebsd.org. 3595 IN  SRV     1 35 80 update4.FreeBSD.org.

;; AUTHORITY SECTION:
org.                    35745   IN      NS      B0.ORG.AFILIAS-NST.org.
org.                    35745   IN      NS      B2.ORG.AFILIAS-NST.org.
org.                    35745   IN      NS      C0.ORG.AFILIAS-NST.INFO.
org.                    35745   IN      NS      D0.ORG.AFILIAS-NST.org.
org.                    35745   IN      NS      A0.ORG.AFILIAS-NST.INFO.
org.                    35745   IN      NS      A2.ORG.AFILIAS-NST.INFO.

;; Query time: 2 msec
;; SERVER: 127.0.0.1#53(127.0.0.1)
;; WHEN: Wed May 13 18:05:25 2009
;; MSG SIZE  rcvd: 419
```

The DNS Database – Resource Record (13)

- Glue record – Link between zones
  - Parent zone needs to contain the NS records for each delegated zone
  - Ex: In zone files of nctu, it might contain:

```
cs                  IN        NS        dns.cs.nctu.edu.tw.
                    IN        NS        dns2.cs.nctu.edu.tw.
dns.cs              IN        A         140.113.235.107
dns2.cs             IN        A         140.113.235.103

ee                  IN        NS        ns.ee.nctu.edu.tw.
                    IN        NS        dns.ee.nctu.edu.tw.
                    IN        NS        reds.ee.nctu.edu.tw.
ns.ee               IN        A         140.113.212.150
dns.ee              IN        A         140.113.11.4
reds.ee             IN        A         140.113.202.1
```

- Lame delegation
  - DNS subdomain administration has delegate to you and you never use the domain or parent domain’s glue record is not updated

BIND Configuration

named in FreeBSD

- startup
  - Edit /etc/rc.conf
    - named_enable=“YES”
  - Manual utility command
    - % rndc {stop | reload | flush …}
      - In old version of BIND, use ndc command
- Configuration files
  - /etc/namedb/named.conf
    - Configuration file
  - /etc/namedb/named.root
    - DNS root server cache hint file
  - Zone data files
- See your BIND version
  - % dig @127.0.0.1 version.bind txt chaos
    - `version.bind.          0       CH      TXT     "9.3.3"`

BIND Configuration
– named.conf (1)

- /etc/namedb/named.conf
  - Roles of this name server
    - Master, slave, or stub
  - Global options
  - Zone specific options

- named.conf is composed of following statements:
  - include, options, server, key, acl, zone, view, controls, logging, trusted-keys

BIND Configuration – named.conf (2)

- Address Match List
  - A generalization of an IP address that can include:
    - An IP address
      - Ex. 140.113.17.1
    - An IP network with CIDR netmask
      - Ex. 140.113/16
    - The ! character to do negate
    - The name of a previously defined ACL
    - A cryptographic authentication key
  - Example:
    - {!1.2.3.4; 1.2.3/24;};
    - {128.138/16; 198.11.16/24; 204.228.69/24; 127.0.0.1;};

BIND Configuration
– named.conf include

- The “include” statement
  - Used to separate large configuration file
  - Another usage is used to separate cryptographic keys into a restricted permission file
  - Ex:

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

```
-rw-r--r--   1 root   wheel   4947 Mar  3  2006 named.conf
-rw-r-----   1 bind   wheel     92 Aug 15  2005 rndc.key
```

BIND Configuration
– named.conf acl

- The “acl” statement
  - Define a class of access control
  - Define before they are used
  - Syntax

```
 acl acl_name {
   address_match_list
 };
```

  - Predefined acl classes
    - any, localnets, localhost, none
  - Example

```
acl CSnets {
    140.113.235/24; 140.113.17/24; 140.113.209/24;
140.113.24/24;
};
acl NCTUnets {
   140.113/16; 10.113/16; 140.126.237/24;
};

allow-transfer {localhost; CSnets; NCTUnets};
```

BIND Configuration – named.conf key

- The “key” statement
  - Define a encryption key used for authentication with a particular server
  - Syntax

```
key key-id {
   algorithm string;
   secret string;
}
```

  - Example:

```
key serv1-serv2 {
       algorithm hmac-md5;
       secret “ibkAlUA0XXAXDxWRTGeY+d4CGbOgOIr7n63eizJFHQo=”
}
```

  - This key is used to
    - Sign DNS request before sending to target
    - Validate DNS response after receiving from target

BIND Configuration
– named.conf option (1)

- The “option” statement
  - Specify global options
  - Some options may be overridden later for specific zone or server
  - Syntax:

```
options {
   option;
   option;
}
```

- There are about 50 options in BIND9
  - version “There is no version.”; [real version num]
    - version.bind.   0   CH   TXT   “9.3.3”
    - version.bind.   0   CH   TXT   “There is no version.”
  - directory “/etc/namedb/db”;
    - Base directory for relative path and path to put zone data files

BIND Configuration – named.conf option (2)

- notify yes | no [yes]
  - Whether notify slave sever when relative zone data is changed
- also-notify 140.113.235.101; [empty]
  - Also notify this non-NS server
- recursion yes | no [yes]
  - Recursive name server
- allow-recursion {address_match_list }; [all]
  - Finer granularity recursion setting
- check-names {master|slave|response action};
  - check hostname syntax validity
    - Letter, number and dash only
    - 64 characters for each component, and 256 totally
  - Action:
    - ignore: do no checking
    - warn: log bad names but continue
    - fail: log bad names and reject
  - default action
    - master fail
    - slave warn
    - response ignore

BIND Configuration – named.conf option (3)

- listen-on port ip_port address_match_list; [53, all]
  - NIC and ports that named listens for query
  - Ex: listen-on port 5353 {192.168.1/24;};
- query-source address ip_addr port ip_port; [random]
  - NIC and port to send DNS query
- forwarders {in_addr; …}; [empty]
  - Often used in cache name server
  - Forward DNS query if there is no answer in cache
- forward only | first; [first]
  - If forwarder does not response, queries for forward only server will fail
- allow-query address_match_list; [all]
  - Specify who can send DNS query to you
- allow-transfer address_match_list; [all]
  - Specify who can request zone transfer to you
- blackhole address_match_list; [empty]
  - Reject queries and would never ask them for answers

BIND Configuration – named.conf option (4)

- transfer-format one-answer | many-answers; [many-answers]
  - Ways to transfer data records from master to slave
  - How many data records in single packet
- transfers-in num; [10]
- transfers-out num; [10]
  - Limit of the number of inbound and outbound zone transfers concurrently
- transfers-per-ns num; [2]
  - Limit of the inbound zone transfers concurrently from the same remote server
- transfer-source IP-address;
  - IP of NIC used for inbound transfers
- serial-queries num; [4]
  - Limit of simultaneous inquiries for serial number of a zone

BIND Configuration – named.conf server

- The “server” statement
  - Tell named about the characteristics of its remote peers
  - Syntax

```
server ip_addr {
   bogus no|yes;
   provide-ixfr yes|no;  (for master)
   request-ixfr yes|no;  (for slave)
   transfers num;
   transfer-format many-answers|one-answer;
   keys { key-id; key-id};
};
```

  - ixfr
    - Incremental zone transfer
  - transfers
    - Limit of number of concurrent inbound zone transfers from that server
    - Server-specific transfers-in
  - keys
    - Any request sent to the remote server is signed with this key

BIND Configuration
– named.conf zone (1)

- The “zone” statement
  - Heart of the named.conf that tells named about the zones that it is authoritative
  - zone statement format varies depending on roles of named
    - Master or slave
  - Basically

```
Syntax:
zone "domain_name" {
        type master | slave| stub;
        file "path”;
        masters {ip_addr; ip_addr;};
        allow-query {address_match_list};              [all]
        allow-transfer { address_match_list};          [all]
        allow-update {address_match_list};             [empty]
};
```

BIND Configuration – named.conf zone (2)

- Master server zone configuration

```
zone "ce.nctu.edu.tw" IN {
    type master;
    file "named.hosts";
    allow-query { any; };
    allow-transfer { localhost; CS-DNS-Servers; };
    allow-update { none; };
};
```

- Slave server zone configuration

```
zone "cs.nctu.edu.tw" IN {
    type slave;
    file "cs.hosts";
    masters { 140.113.235.107; };
    allow-query { any; };
    allow-transfer { localhost; CS-DNS-Servers; };
};
```

BIND Configuration
– named.conf zone (3)

- Forward zone and reverse zone

```
zone "cs.nctu.edu.tw" IN {
    type master;
    file "named.hosts";
    allow-query { any; };
    allow-transfer { localhost; CS-DNS-Servers; };
    allow-update { none; };
};
```

```
zone "235.113.140.in-addr.arpa" IN {
    type master;
    file "named.235.rev";
    allow-query { any; };
    allow-transfer { localhost; CS-DNS-Servers; };
    allow-update { none; };
};
```

BIND Configuration
– named.conf zone (4)

- Example
  - In named.hosts, there are plenty of A or CNAME records

```
…
bsd1                  IN      A       140.113.235.131
csbsd1                IN      CNAME   bsd1
bsd2                  IN      A       140.113.235.132
bsd3                  IN      A       140.113.235.133
bsd4                  IN      A       140.113.235.134
bsd5                  IN      A       140.113.235.135
…
```

  - In named.235.rev, there are plenty of PTR records

```
…
131.235.113.140    IN     PTR    bsd1.cs.nctu.edu.tw.
132.235.113.140    IN     PTR    bsd2.cs.nctu.edu.tw.
133.235.113.140    IN     PTR    bsd3.cs.nctu.edu.tw.
134.235.113.140    IN     PTR    bsd4.cs.nctu.edu.tw.
135.235.113.140    IN     PTR    bsd5.cs.nctu.edu.tw.
…
```

BIND Configuration
– named.conf zone (5)

- Setting up root hint
  - A cache of where are the DNS root servers

```
zone “." IN {
    type hint;
    file "named.root";
};
```

- Setting up forwarding zone
  - Forward DNS query to specific name server, bypassing the standard query path

```
zone "nctu.edu.tw" IN {
    type forward;
    forward first;
    forwarders { 140.113.250.135; 140.113.1.1; };
};

zone "113.140.in-addr.arpa" IN {
    type forward;
    forward first;
    forwarders { 140.113.250.135; 140.113.1.1; };
};
```

BIND Configuration – named.conf view (1)

- The "view" statement
  - Create a different view of DNS naming hierarchy for internal machines
    - Restrict the external view to few well-known servers
    - Supply additional records to internal users
  - Also called "split DNS"
  - In-order processing
    - Put the most restrictive view first
  - All-or-nothing
    - All zone statements in your named.conf file must appear in the content of view

BIND Configuration
– named.conf view (2)

- Syntax

```
 view view-name {
        match_clients {address_match_list};
        view_options;
        zone_statement;
 };
```

- Example

```
view “internal” {
        match-clients {our_nets;};
        recursion yes;
        zone “cs.nctu.edu.tw” {
                type master;
                file “named-internal-cs”;
        };
};
view “external” {
 match-clients {any;};
        recursion no;
        zone “cs.nctu.edu.tw” {
                type master;
                file “named-external-cs”;
        };
};
```

BIND Configuration
– named.conf controls

- The “controls” statement
  - Specify how the named server listens for control message
  - Syntax

```
controls {
    inet ip_addr allow {address_match_list} keys {key-id;};
};
```

  - Example:

```
key "rndc_key" {
    algorithm       hmac-md5;
    secret "GKnELuie/G99NpOC2/AXwA==";
};
```

```
include   “/etc/named/rndc.key” ;
controls {
      inet 127.0.0.1  allow {127.0.0.1;}   keys {rndc_key;};
}
```

```
SYNOPSIS
       rndc [-c config-file] [-k key-file] [-s server] [-p port] [-V]
            [-y key_id] {command}
```

Updating zone files

- Master
  - Edit zone files
    - Serial number
    - Forward and reverse zone files for single IP
  - Do “rndc reload”
    - “notify” is on, slave will be notify about the change
    - “notify” is off, refresh timeout, or do “rndc reload” in slave
- Zone transfer
  - DNS zone data synchronization between master and slave servers
  - AXFR (all zone data are transferred at once, before BIND8.2)
  - IXFR (incremental updates zone transfer)
  - TCP port 53

Non-byte boundary (1)

- In normal reverse configuration:
  - named.conf will define a zone statement for each reverse subnet zone and
  - Your reverse db will contains lots of PTR records
  - Example:

```
zone "1.168.192.in-addr.arpa." {
    type master;
    file "named.rev.1";
    allow-query {any;};
    allow-update {none;};
    allow-transfer {localhost;};
};
```

```
$TTL     3600
$ORIGIN 1.168.192.in-addr.arpa.
@       IN      SOA     lwhsu.csie.net lwhsu.lwhsu.csie.net.   (
                        2007050401      ; Serial
                        3600            ; Refresh
                        900             ; Retry
                        7D              ; Expire
                        2H )            ; Minimum
        IN      NS      ns.lwhsu.csie.net.
254     IN      PTR     ns.lwhsu.csie.net.
1       IN      PTR     www.lwhsu.csie.net.
2       IN      PTR     ftp.lwhsu.csie.net.
…
```

Non-byte boundary (2)

- What if you want to delegate 192.168.2.0 to another sub-domain
  - Parent
    - **Remove** forward db about 192.168.2.0/24 network
      - Ex:
        ```
        pc1.lwhsu.csie.net.    IN   A    192.168.2.35
        pc2.lwhsu.csie.net.    IN   A    192.168.2.222
        …
        ```
    - **Remove** reverse db about 2.168.192.in-addr.arpa
      - Ex:
        ```
        35.2.168.192.in-addr.arpa.      IN   PTR   pc1.lwhsu.csie.net.
        222.2.168.192.in-addr.arpa.     IN   PTR   pc2.lwhsu.csie.net.
        …
        ```
    - Add glue records about the name servers of sub-domain
      - Ex: in zone db of "lwhsu.csie.net"
        ```
        sub1     IN          NS     ns.sub1.lwhsu.csie.net.
        ns.sub1  IN          A      192.168.2.1
        ```
      - Ex: in zone db of "168.192.in-addr.arpa."
        ```
        2        IN          NS     ns.sub1.lwhsu.csie.net.
        ns.sub1  IN          A      192.168.2.1
        ```

Non-byte boundary (3)

- What if you want to delegate 192.168.3.0 to four sub-domains (a /26 network)
  - 192.168.3.0 ~ 192.168.3.63
    - ns.sub1.lwhsu.csie.net.
  - 192.168.3.64 ~ 192.168.3.127
    - ns.sub2.lwhsu.csie.net.
  - 192.168.3.128 ~ 192.168.3.191
    - ns.sub3.lwhsu.csie.net.
  - 192.168.3.192 ~ 192.168.3.255
    - ns.sub4.lwhsu.csie.net.

- It is easy for forward setting
  - In zone db of lwhsu.csie.net

sub1	IN	NS	ns.sub1.lwhsu.csie.net.
ns.sub1	IN	A	1921.68.3.1
sub2	IN	NS	ns.sub2.lwhsu.csie.net.
ns.sub2	IN	A	192.168.3.65
…			

Non-byte boundary (4)

- Non-byte boundary reverse setting
  - Method1

```
$GENERATE 0-63        $.3.168.192.in-addr.arpa.              IN    NS
        ns.sub1.lwhsu.csie.net.
$GENERATE 64-127      $.3.168.192.in-addr.arpa.              IN    NS
        ns.sub2.lwhsu.csie.net.
$GENERATE 128-191     $.3.168.192.in-addr.arpa.              IN    NS
        ns.sub3.lwhsu.csie.net.
$GENERATE 192-255     $.3.168.192.in-addr.arpa.              IN    NS
        ns.sub4.lwhsu.csie.net.
```

And

```
zone “1.3.168.192.in-addr.arpa.” {
    type master;
    file “named.rev.192.168.3.1”;
};
```

```
; named.rev.192.168.3.1
@    IN    SOA    sub1.lwhsu.csie.net. root.sub1.lwhsu.csie.net.
    (1;3h;1h;1w;1h)
       IN    NS      ns.sub1.lwhsu.csie.net.
```

Non-byte boundary (5)

- Method2

```
$ORIGIN  3.168.192.in-addr.arpa.
$GENERATE  1-63             $          IN   CNAME      $.0-63.3.168.192.in-addr.arpa.
0-63.3.168.192.in-addr.arpa.           IN   NS           ns.sub1.lwhsu.csie.net.
$GENERATE  65-127 $                    IN   CNAME      $.64-127.3.168.192.in-addr.arpa.
64-127.3.168.192.in-addr.arpa.         IN   NS           ns.sub2.lwhsu.csie.net.
$GENERATE  129-191          $          IN   CNAME      $.128-191.3.168.192.in-addr.arpa.
128-191.3.168.192.in-addr.arpa.        IN   NS           ns.sub3.lwhsu.csie.net.
$GENERATE  193-255          $          IN   CNAME      $.192-255.3.168.192.in-addr.arpa.
192-255.3.168.192.in-addr.arpa.        IN   NS           ns.sub4.lwhsu.csie.net.

zone “0-63.3.168.192.in-addr.arpa.” {
   type master;
   file “named.rev.192.168.3.0-63”;
};
```

```
      ; named.rev.192.168.3.0-63
      @    IN    SOA    sub1.lwhsu.csie.net.  root.sub1.lwhsu.csie.net.  (1;3h;1h;1w;1h)
               IN    NS        ns.sub1.lwhsu.csie.net.
1        IN    PTR   www.sub1.lwhsu.csie.net.
2    IN    PTR   abc.sub1.lwhsu.csie.net.
…
```

BIND Security

Security – named.conf security configuration

- Security configuration

Feature	Config. Statement	comment
allow-query	options, zone	Who can query
allow-transfer	options, zone	Who can request zone transfer
allow-update	zone	Who can make dynamic updates
blackhole	options	Which server to completely ignore
bogus	server	Which servers should never be queried

Security
– With TSIG (1)

- TSIG (Transaction SIGnature)
  - Developed by IETF (RFC2845)
  - Symmetric encryption scheme to sign and validate DNS requests and responses between servers
  - Algorithm in BIND9
    - HMAC-MD5, DH (Diffie Hellman)
  - Usage
    - Prepare the shared key with dnssec-keygen
    - Edit “key” statement
    - Edit “server” statement to use that key
    - Edit “zone” statement to use that key with:
      - allow-query
      - allow-transfer
      - allow-update

Security
– With TSIG (2)

- TSIG example (dns1 with dns2)
  1. % dnssec-keygen –a HMAC-MD5 –b 128 –n HOST cs

```
% dnssec-keygen -a HMAC-MD5 -b 128 -n HOST cs
Kcs.+157+35993
% cat Kcs.+157+35993.key
cs. IN KEY 512 3 157 oQRab/QqXHVhkyXi9uu8hg==
```

```
% cat Kcs.+157+35993.private
Private-key-format: v1.2
Algorithm: 157 (HMAC_MD5)
Key: oQRab/QqXHVhkyXi9uu8hg==
```

  2. Edit /etc/named/dns1-dns2.key

```
key dns1-dns2 {
    algorithm hmac-md5;
    secret “oQRab/QqXHVhkyXi9uu8hg==”
};
```

  3. Edit both named.conf of dns1 and dns2
     - Suppose dns1 = 140.113.235.107 dns2 = 140.113.235.103

```
include “dns1-dns2.key”
server 140.113.235.103 {
    keys {dns1-dns2;};
};
```

```
include “dns1-dns2.key”
server 140.113.235.107 {
    keys {dns1-dns2;};
};
```

BIND Debugging and Logging

Logging (1)

- Terms
  - Channel
    - A place where messages can go
    - Ex: syslog, file or /dev/null
  - Category
    - A class of messages that named can generate
    - Ex: answering queries or dynamic updates
  - Module
    - The name of the source module that generates the message
  - Facility
    - syslog facility name
  - Severity
    - Priority in syslog
- Logging configuration
  - Define what are the channels
  - Specify where each message category should go
- When a message is generated
  - It is assigned a “category”, a “module”, a “severity”
  - It is distributed to all channels associated with its category

Logging (2)

- The "logging" statement
  - Either "file" or "syslog" in channel sub-statement
    - size:
      - ex: 2048, 100k, 20m, 15g, unlimited, default
    - facility:
      - ex: local0 ~ local7
    - severity:
      - critical, error, warning, notice, info, debug, dynamic

```
logging {
    channel_def;
    channel_def;
    …
    category category_name {
        channel_name;
              channel_name;
        …
    };
};
```

```
channel channel_name {
    file path [versions num|unlimited] [size siznum];
    syslog facility;

    severity severity;
    print-category yes|no;
    print-severity yes|no;
    print-time yes|no;
};
```

Logging (3)

- Predefined channels

default_syslog	Sends severity info and higher to syslog with facility daemon
default_debug	Logs to file ‶named.run″, severity set to dynamic
default_stderr	Sends messages to stderr or named, severity info
null	Discards all messages

- Available categories

default	Categories with no explicit channel assignment
general	Unclassified messages
config	Configuration file parsing and processing
queries/client	A short log message for every query the server receives
dnssec	DNSSEC messages
update	Messages about dynamic updates
xfer-in/xfer-out	zone transfers that the server is receiving/sending
db/database	Messages about database operations
notify	Messages about the ‶zone changed″ notification protocol
security	Approved/unapproved requests
resolver	Recursive lookups for clients

Logging (4)

- Example of logging statement

```
logging {
    channel security-log {
        file ″/var/named/security.log″ versions 5 size 10m;
        severity info;
        print-severity yes;
        print-time yes;
    };
    channel query-log {
        file ″/var/named/query.log″ versions 20 size 50m;
        severity info;
        print-severity yes;
        print-time yes;
    };
    category default        { default_syslog; default_debug; };
    category general        { default_syslog; };
    category security       { security-log; };
    category client         { query-log; };
    category queries        { query-log; };
    category dnssec         { security-log; };
};
```

Debug

- Named debug level
  - From 0 (debugging off) ~ 11 (most verbose output)
  - % named –d2 (start named at level 2)
  - % rndc trace (increase debugging level by 1)
  - % rndc trace 3 (change debugging level to 3)
  - % rndc notrace (turn off debugging)

- Debug with “logging” statement
  - Define a channel that include a severity with “debug” keyword
    - Ex: severity debug 3
    - All debugging messages up to level 3 will be sent to that particular channel

Tools

Tools
– nslookup

- Interactive and Non-interactive
  - Non-Interactive
    - % nslookup cs.nctu.edu.tw.
    - % nslookup –type=mx cs.nctu.edu.tw.
    - % nslookup –type=ns cs.nctu.edu.tw. 140.113.1.1
  - Interactive
    - % nslookup
    - > set all
    - > set type=any
    - > set server host
    - > set lserver host
    - > set debug
    - > set d2

```
csduty:~ -lwhsu- nslookup
> set all
Default server: 140.113.235.107
Address: 140.113.235.107#53
Default server: 140.113.235.103
Address: 140.113.235.103#53
Default server: 140.113.1.1
Address: 140.113.1.1#53

Set options:
  novc                      nodebug         nod2
  search                    recurse
  timeout = 0               retry = 3       port = 53
  querytype = A             class = IN
  srchlist = cs.nctu.edu.tw/csie.nctu.edu.tw
>
```

Tools
– dig

- Usage
  - % dig cs.nctu.edu.tw
  - % dig cs.nctu.edu.tw mx
  - % dig @ns.nctu.edu.tw cs.nctu.edu.tw mx
  - % dig -x 140.113.209.3
    - Reverse query
- Find out the root servers
  - % dig @a.root-servers.net . ns

Tools – host

- host command
  - % host cs.nctu.edu.tw.
  - % host –t mx cs.nctu.edu.tw.
  - % host 140.113.1.1
  - % host –v 140.113.1.1

Miscellaneous

SSHFP record

- RFC4255
- ssh_config
  - VerifyHostKeyDNS   ask
- dns/sshfp

```
knight:~ -lwhsu- dig anoncvs.tw.freebsd.org sshfp

;; ANSWER SECTION:
anoncvs.tw.freebsd.org. 259200  IN      CNAME   freebsd.cs.nctu.edu.tw.
freebsd.cs.nctu.edu.tw. 3600    IN      SSHFP   2 1 2723C6CF4EF655A6A5BE86CC9E039F1762450FE9

knight:~ -lwhsu- cvs -d anoncvs@anoncvs.tw.freebsd.org:/home/ncvs co ports
The authenticity of host 'anoncvs.tw.freebsd.org (140.113.17.209)' can't be established.
DSA key fingerprint is e8:3b:29:7b:ca:9f:ac:e9:45:cb:c8:17:ae:9b:eb:55.
Matching host key fingerprint found in DNS.
Are you sure you want to continue connecting (yes/no)?
```

DNS Accept filters

- accf_dns(9)
  - buffer incoming DNS requests until the whole first request is present

```
options INET
options ACCEPT_FILTER_DNS
kldload accf_dns
```

- Currently only on 8-CURRENT

Other references & tools

- Administrator's Reference Manual
  - https://www.isc.org/software/bind/documentation
- FAQ
  - https://www.isc.org/faq/bind
- DNS for Rocket Scientists
  - http://www.zytrax.com/books/dns/
- Swiss army knife internet tool
  - http://www.robtex.com/
- DNS Network Tools
  - http://dnsstuff.com/