The 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

History of DNS – Domain Name System

> Domain Name System

- Administration decentralization
- 1984
  - Paul Mockapetris (University of Southern California)
  - RFC 882, 883 → 1034, 1035
    - > 1034: Concepts
    - > 1035: Implementation and Specification

RFC Sourcebook:
http://www.networksorcery.com/enp/default0304.htm

History of DNS – DNS Specification

> Make domain name system as

- **Distributed database**
  - Each site maintains segment of DB
  - Each site open self information via network

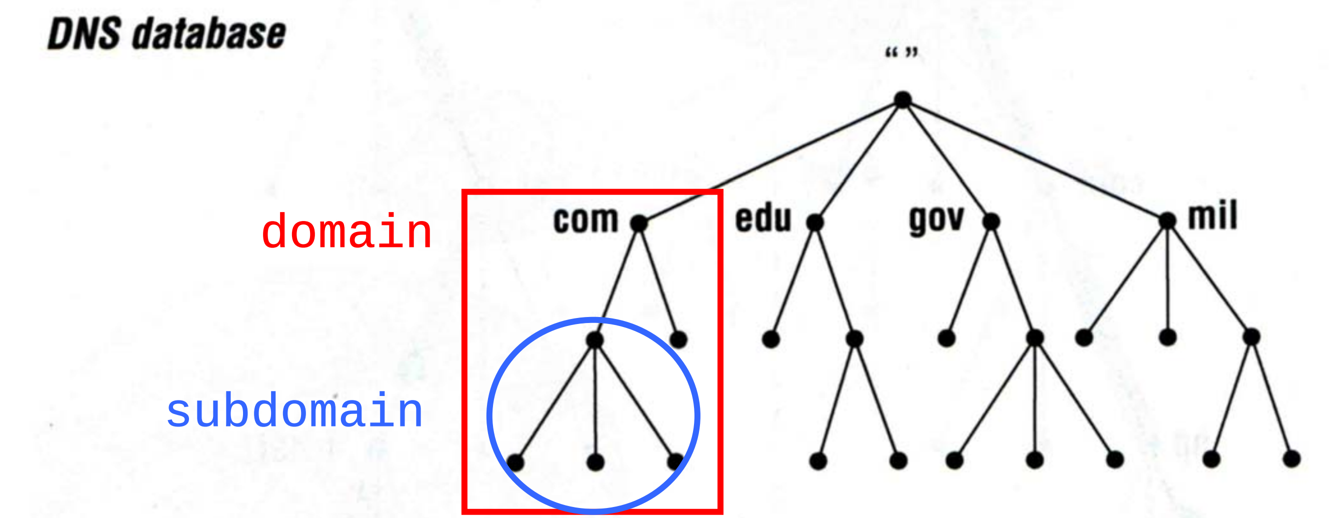
- **Client-Server architecture**
  - Name servers provide information (Name Server)
  - Clients make queries to server (Resolver)

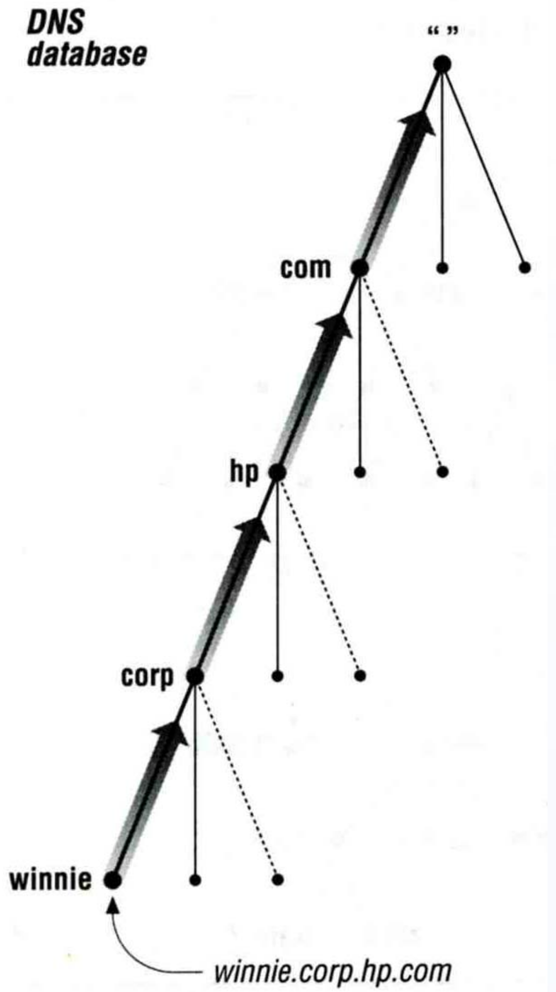
- **Tree architecture**
  - Each subtree ➔ “***domain***”
  - Domain can be divided in to “***subdomain***”

History of DNS – Domain and Subdomain

> DNS Namespace
  - A tree of domains

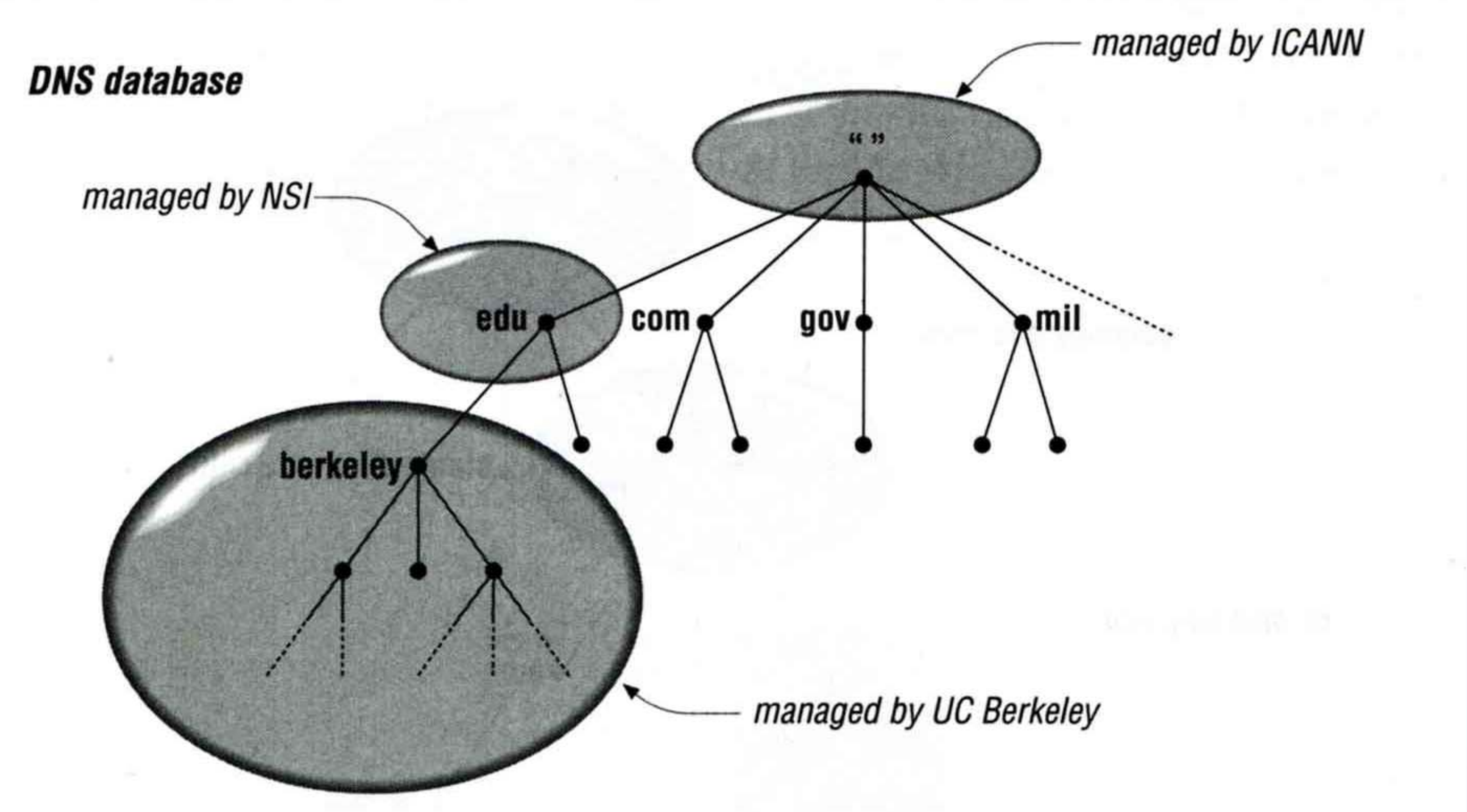
> Domain and subdomain
  - Each domain has a “domain name” to identify its position in database
    - EX: nctu.edu.tw
    - EX: csie.nctu.edu.tw





History of DNS – Delegation

- Administration delegation
  - **Each domain can delegate responsibility to subdomain**

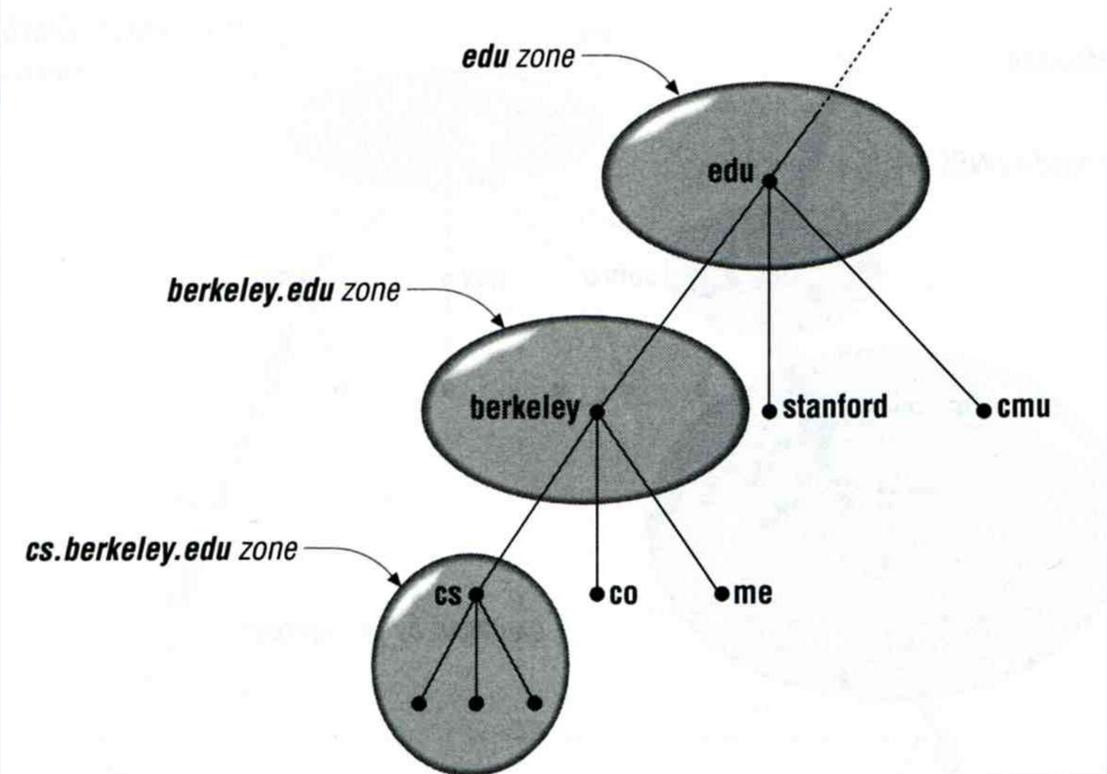


History of DNS – Administrated Zone

> Zone

– **Autonomously administered piece of namespace**

- Once the subdomain becomes a zone, it is independent to it's parent

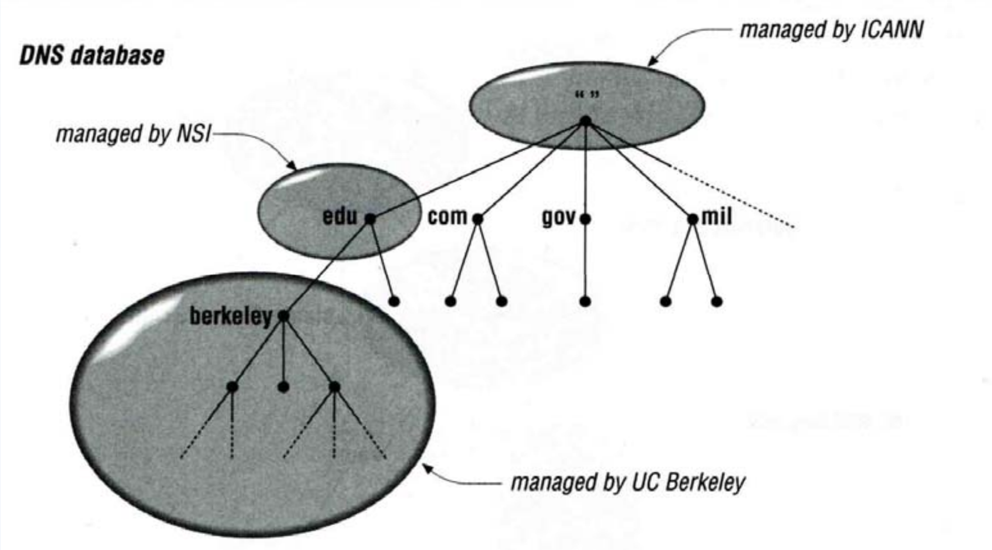


History of DNS – Implementation of DNS

- 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



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
  - name: for individuals
  - pro: for professionals

The DNS Namespace (4)

- Other than US, ccTLD
  - **country code TLD (ISO 3166)**
    - Ex: Taiwan → tw
    - Ex: 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:
      - magpie IN A 140.113.209.21
  - **Reverse Zone files**
    - Address-to-Hostname mapping
    - Ex:
      - 21.209.113.140 IN PTR magpie.csie.nctu.edu.tw.

The DNS Namespace (6)

- Domain name limitation
  - 63-characters in each component and
  - Up to 255-characters in a complete name

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

BIND – components of BIND

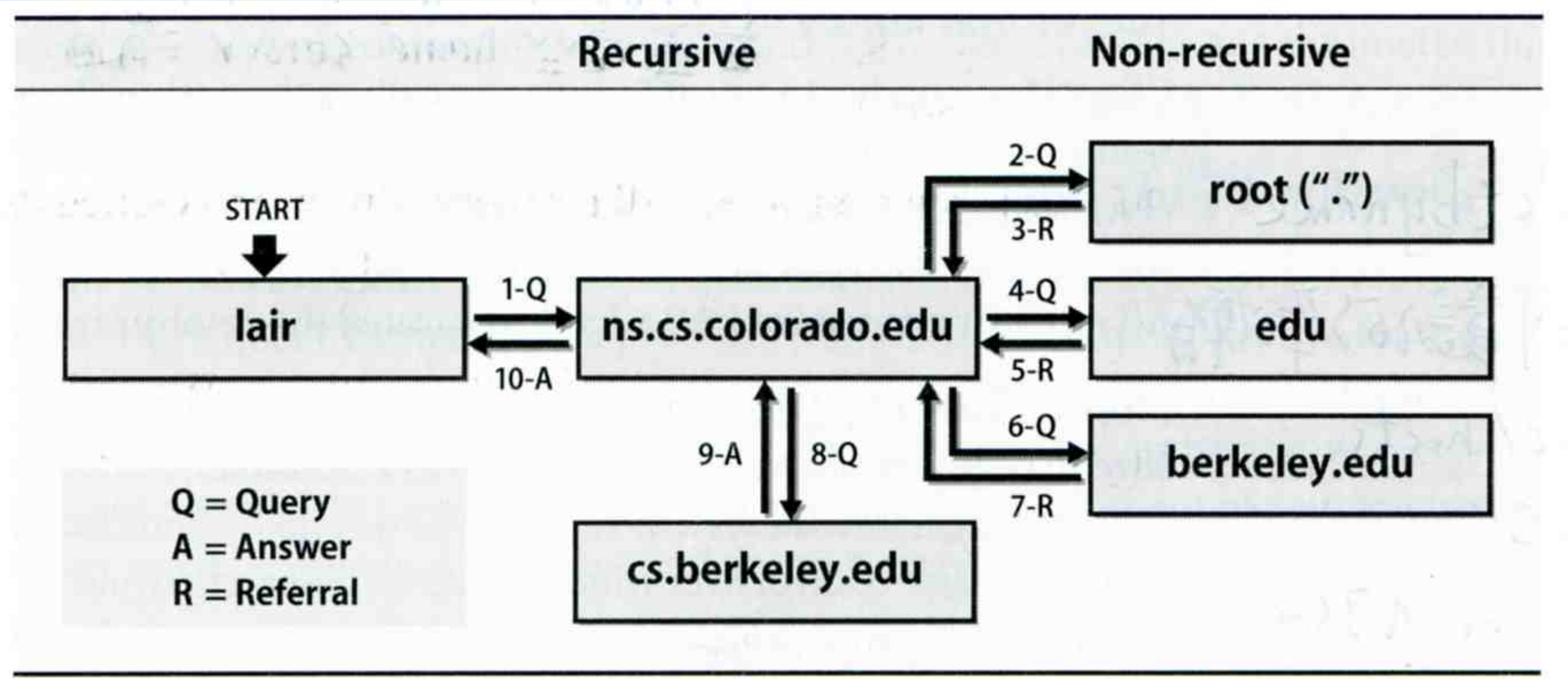
- Three major components
  - **named**
    - Daemon that answers the DNS query
  - **Library routines**
    - Routines that used to resolve host by contacting the servers of DNS distributed database
      - Ex: res_query, res_search, …etc.
  - **Command-line interfaces to DNS**
    - Ex: nslookup, dig,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

BIND components – 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 components – 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 components – 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 components – 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 components – named (5)

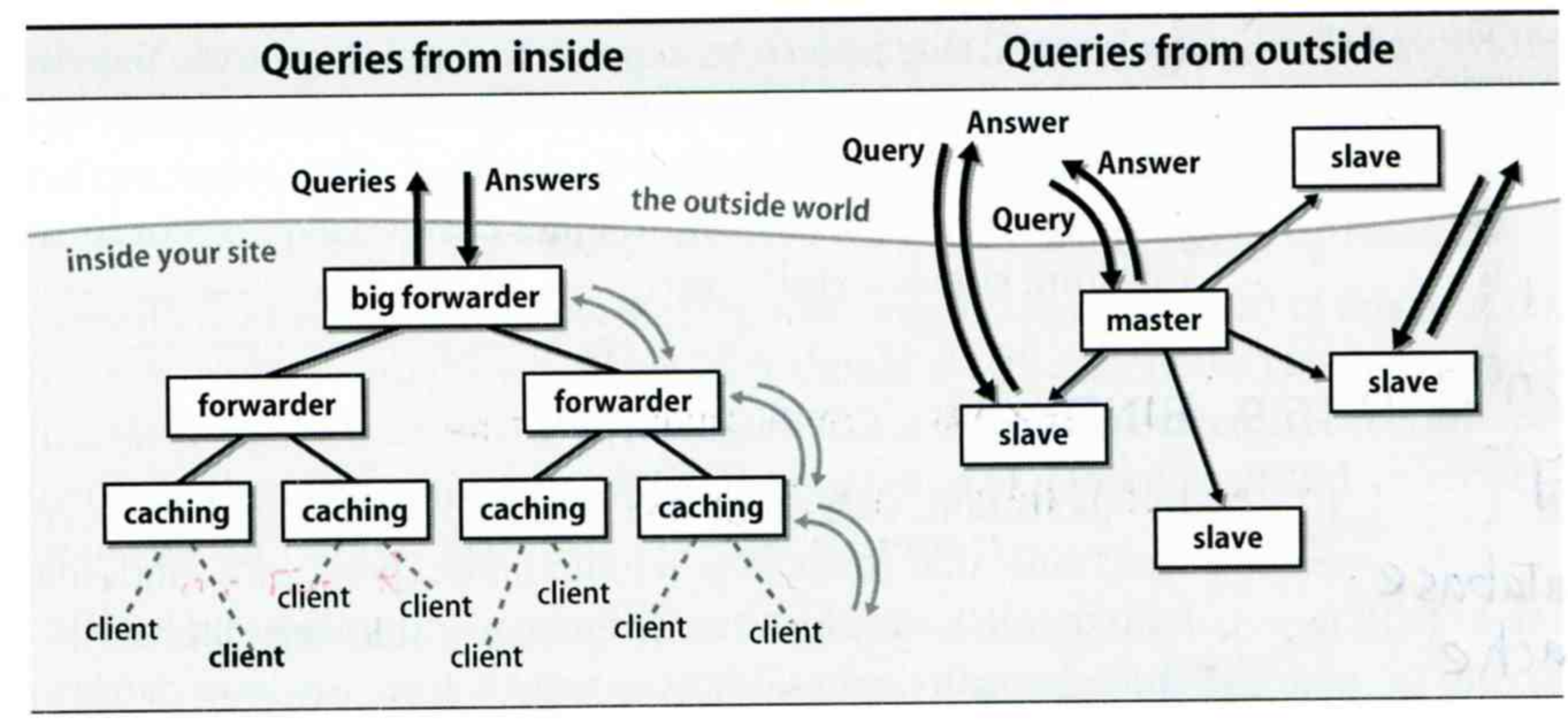
- Root name servers
  - List in named.root file of BIND

```
tytsai@tybsd:/etc/namedb> grep -v "^;" named.root
.                         3600000  IN  NS    A.ROOT-SERVERS.NET.
A.ROOT-SERVERS.NET.       3600000      A     198.41.0.4
.                         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
.                         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
.                         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
.                         3600000      NS    K.ROOT-SERVERS.NET.
K.ROOT-SERVERS.NET.       3600000      A     193.0.14.129
.                         3600000      NS    L.ROOT-SERVERS.NET.
L.ROOT-SERVERS.NET.       3600000      A     198.32.64.12
.                         3600000      NS    M.ROOT-SERVERS.NET.
M.ROOT-SERVERS.NET.       3600000      A     202.12.27.33
```

DNS Server architecture

> How to set up your name servers

– **Ex:**



The DNS Database (1)

- 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

The DNS Database (2)

> 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

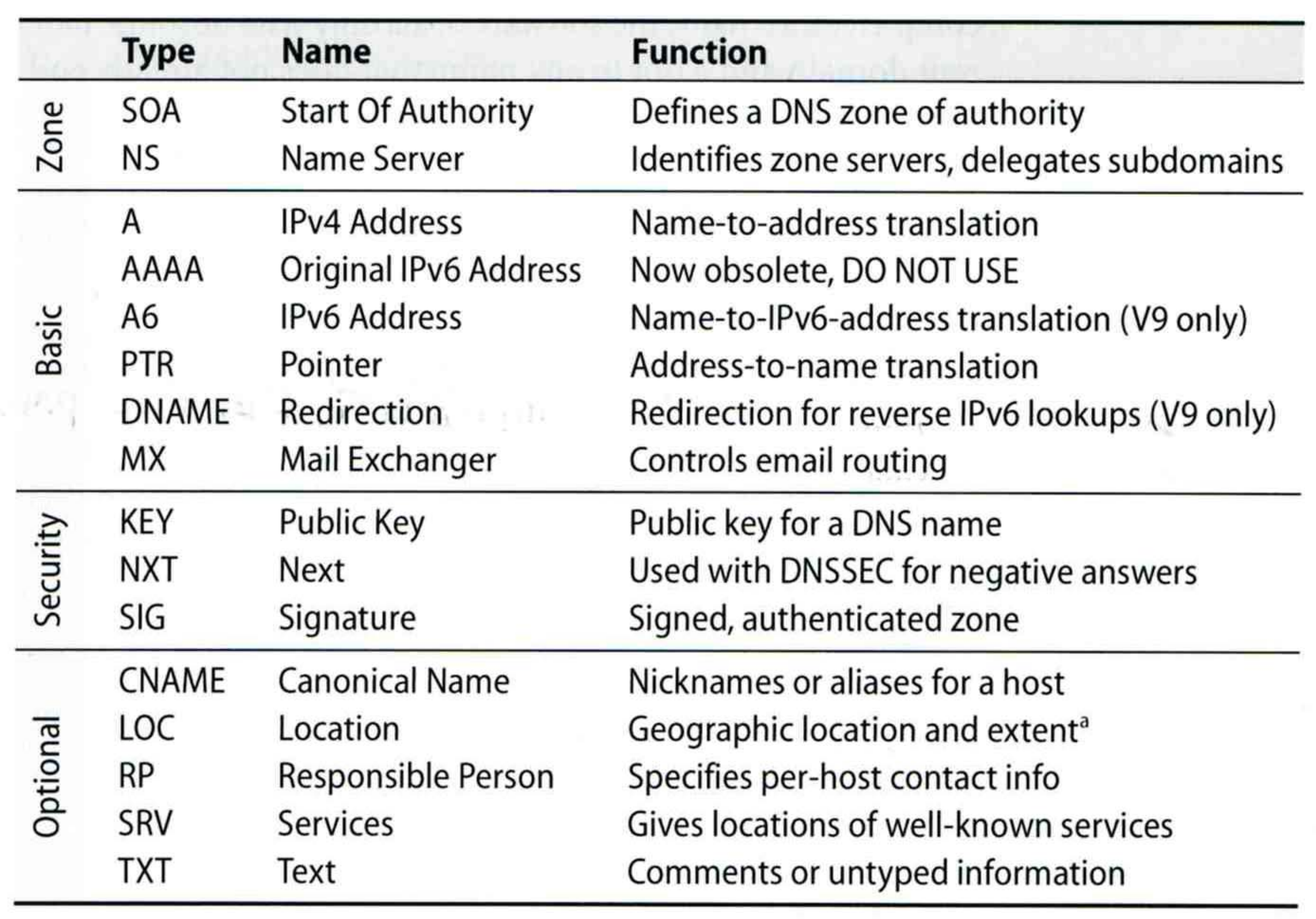
Resource Record (1)

- 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)

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

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

Resource Record – The SOA record

> 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**
- **Ex:**

```
$TTL 259200;
$ORIGIN csie.nctu.edu.tw.
@       IN      SOA     csie.nctu.edu.tw.       root.csie.nctu.edu.tw.  (
                    2005020201  ; serial number for slave server
                    1D          ; refresh time for slave server
                    30M         ; retry if master no response
                    1W          ; expire if master die
                    2H      )   ; minimum time to live for negative answer
```

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

Resource Record – The NS record

> 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: csie.nctu.edu.tw and nctu.edu.tw

```
$TTL 259200;
$ORIGIN csie.nctu.edu.tw.
@          IN     SOA    csie.nctu.edu.tw.     root.csie.nctu.edu.tw.  (
                  2005020201  ; serial number for slave server
                  1D          ; refresh time for slave server
                  30M         ; retry if master no response
                  1W          ; expire if master die
                  2H     )    ; minimum time to live for negative answer

           IN     NS     dns.csie.nctu.edu.tw.
           IN     NS     dns2.csie.nctu.edu.tw.
           IN     NS     dns3.csie.nctu.edu.tw.
```

Resource Record – The A record

> Address

– Provide mapping from hostname to IP address

– Ex:

```
            IN     NS     dns.csie.nctu.edu.tw.
            IN     NS     dns2.csie.nctu.edu.tw.
            IN     NS     dns3.csie.nctu.edu.tw.

dns         IN     A     140.113.17.5
dns2        IN     A     140.113.209.2
dns3        IN     A     140.113.209.7

www    36000   IN     A   140.113.209.63
               IN     A   140.113.209.77
```

Resource Record – The PTR record

- 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 209.113.140.in-addr.arpa.
@       IN      SOA     csie.nctu.edu.tw.      root.csie.nctu.edu.tw.  (
                        2005013101      ; serial
                        1D              ; refresh time for secondary server
                        30M             ; retry
                        1W              ; expire
                        2H     )        ; minimum
        IN      NS      dns.csie.nctu.edu.tw.
        IN      NS      dns2.csie.nctu.edu.tw.
        IN      NS      dns3.csie.nctu.edu.tw.
$ORIGIN in-addr.arpa.
1.209.113.140   IN PTR operator.csie.nctu.edu.tw.
2.209.113.140   IN PTR ccserv.csie.nctu.edu.tw.
3.209.113.140   IN PTR netnews2.csie.nctu.edu.tw.
4.209.113.140   IN PTR alumni.csie.nctu.edu.tw.
```

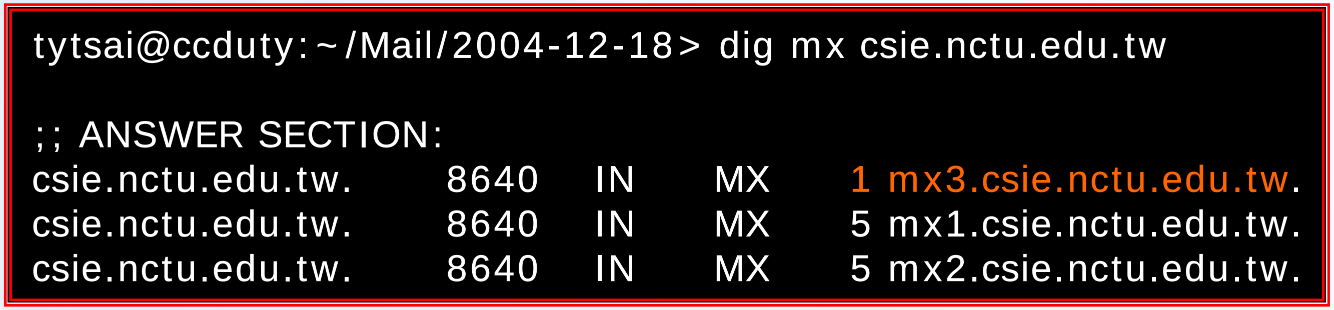
Resource Record – The MX record (1)

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

```
$ORIGIN csie.nctu.edu.tw.
@       IN      SOA     csie.nctu.edu.tw.       root.csie.nctu.edu.tw.  (
                        2005020201      ; serial number
                        1D              ; refresh time for slave server
                        30M             ; retry
                        1W              ; expire
                        2H      )       ; minimum
        IN      NS      dns.csie.nctu.edu.tw.
        IN      NS      dns2.csie.nctu.edu.tw.
        IN      NS      dns3.csie.nctu.edu.tw.
        8640  IN  MX  1 mx3.csie.nctu.edu.tw.
        8640  IN  MX  5 mx2.csie.nctu.edu.tw.
        8640  IN  MX  5 mx1.csie.nctu.edu.tw.
mx1     IN      A       140.113.17.201
mx2     IN      A       140.113.235.201
mx3     IN      A       140.113.17.203
```

Resource Record – The MX record (2)

- Where to send the mail?
  - **When you want to send the mail to tytsai@csie.nctu.edu.tw, the MTA will:**
    - First, lookup up the mail exchanger of “csie.nctu.edu.tw”
      - % dig mx csie.nctu.edu.tw
      - If there is any servers, choose the higher preference one
      - If this preferred one can not be connected, choose another
      - If all the mx servers can not be connected, mail it directly to the host
      - Ex:



```
tytsai@ccduty:~/Mail/2004-12-18> dig mx csie.nctu.edu.tw

;; ANSWER SECTION:
csie.nctu.edu.tw.       8640    IN      MX      1 mx3.csie.nctu.edu.tw.
csie.nctu.edu.tw.       8640    IN      MX      5 mx1.csie.nctu.edu.tw.
csie.nctu.edu.tw.       8640    IN      MX      5 mx2.csie.nctu.edu.tw.
```

Resource Record – The CNAME record

> Canonical name

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

```
www      36000        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
```

Resource Record – The TXT record

> Text

- Add arbitrary text to a host’s DNS records

```
$TTL 259200;
$ORIGIN csie.nctu.edu.tw.
@       IN      SOA     csie.nctu.edu.tw.      root.csie.nctu.edu.tw.  (
                        2005020201  ; serial number for slave server
                        1D          ; refresh time for slave server
                        30M         ; retry if master no response
                        1W          ; expire if master die
                        2H      )   ; minimum time to live for negative answer
        IN      TXT  “Department of Computer Science and Information Engineering”
```

Resource Record – The LOC record

> 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
```

Resource Record – The SRV record

> 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       .
```

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:

```
csie            IN      NS      dns.csie.nctu.edu.tw.
                IN      NS      dns2.csie.nctu.edu.tw.
                IN      NS      dns3.csie.nctu.edu.tw.
dns.csie        IN      A       140.113.17.5
dns2.csie       IN      A       140.113.209.2
dns3.csie       IN      A       140.113.209.7
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

- Lame: 跛腳
  - 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.bin txt chaos
    - version.bind. 0 CH TXT "9.3.1"

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
      - Eg: 140.113.17.1
    - An IP network with CIDR netmask
      - Eg: 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/db/rndc.key″;

-rw-r--r--   1 root   wheel   6582 Oct 11   2004 named.conf
-rw-r-----   1 bind   wheel   167 Nov 14   2002 rndc.key
```

BIND Configuration – named.conf acl

- The “acl” statement
  - Define a class of access control
  - Syntax

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

  - Define before they are used
  - Predefined acl classes
    - any, localnets, localhost, none
  - Ex:

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

allow-transfer {localhost; CSIEnets; 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 “9.3.1”
    - 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 **140.113.209.10;** **[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 "csie.nctu.edu.tw" IN {
    type master;
    file "named.hosts";
    allow-query { any; };
    allow-transfer { localhost; CSIE-DNS-Servers; };
    allow-update { none; };
};
```

- Slave server zone configuration

```
zone "csie.nctu.edu.tw" IN {
    type slave;
    file "csie.hosts";
    masters { 140.113.209.1; };
    allow-query { any; };
    allow-transfer { localhost; CSIE-DNS-Servers; };
};
```

BIND Configuration – named.conf zone (3)

- Forward zone and reverse zone

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

```
zone "209.113.140.in-addr.arpa" IN {
    type master;
    file "named.209.rev";
    allow-query { any; };
    allow-transfer { localhost; CSIE-DNS-Servers; };
    allow-update { none; };
};
```

BIND Configuration – named.conf zone (4)

> Example

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

```
…
ccbsd1          IN    A        140.113.209.61
ccbsd2          IN    A        140.113.209.62
ccbsd3          IN    A        140.113.209.63
ccbsd4          IN    A        140.113.209.64
ccnews          IN    CNAME    ccbsd4
ccbsd5          IN    A        140.113.209.65
…
```

- In named.209.rev (named.208.rev, named.210.rev …), there are plenty of PTR records

```
…
61.209.113.140   IN PTR ccbsd1.csie.nctu.edu.tw.
62.209.113.140   IN PTR ccbsd2.csie.nctu.edu.tw.
63.209.113.140   IN PTR ccbsd3.csie.nctu.edu.tw.
64.209.113.140   IN PTR ccbsd4.csie.nctu.edu.tw.
65.209.113.140   IN PTR ccbsd5.csie.nctu.edu.tw.
66.209.113.140   IN PTR ccbsd6.csie.nctu.edu.tw.
68.209.113.140   IN PTR ccbsd8.csie.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;
};
```

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

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
  - Ex:

```
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     r216.csie.nctu.edu.tw root.r216.csie.nctu.edu.tw.   (
                          2005050401        ; Serial
                          3600                ; Refresh
                          900               ; Retry
                          7D                ; Expire
                          2H )              ; Minimum
          IN      NS      ns.r216.csie.nctu.edu.tw.
254       IN      PTR     ns.r216.csie.nctu.edu.tw.
1         IN      PTR     machine1.r216.csie.nctu.edu.tw.
2         IN      PTR     www.r216.csie.nctu.edu.tw.
…
```

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.r216.csie.nctu.edu.tw. IN A 192.168.2.35
        - pc2.r216.csie.nctu.edu.tw. 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.r216.csie.nctu.edu.tw.
        - 222.2.168.192.in-addr.arpa. IN PTR pc2.r216.csie.nctu.edu.tw.
        - …
    - Add glue records about the name servers of sub-domain
      - Ex: in zone db of “r216.csie.nctu.edu.tw”
        - sub1 IN NS ns.sub1.r216.csie.nctu.edu.tw.
        - ns.sub1 IN A 192.168.2.1
      - Ex: in zone db of “168.192.in-addr.arpa.”
        - 2 IN NS ns.sub1.r216.csie.nctu.edu.tw.
        - 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.r216.csie.nctu.edu.tw.
  - **192.168.3.64 ~ 192.168.3.127**
    - ns.sub2.r216.csie.nctu.edu.tw.
  - **192.168.3.128 ~ 192.168.3.191**
    - ns.sub3.r216.csie.nctu.edu.tw.
  - **192.168.3.192 ~ 192.168.3.255**
    - ns.sub4.r216.csie.nctu.edu.tw.

- It is easy for forward setting
  - **In zone db of r216.csie.nctu.edu.tw**

```
sub1        IN      NS      ns.sub1.r216.csie.nctu.edu.tw.
ns.sub1     IN      A       1921.68.3.1
sub2        IN      NS      ns.sub2.r216.csie.nctu.edu.tw.
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.r216.csie.nctu.edu.tw.
$GENERATE 64-127    $.3.168.192.in-addr.arpa.       IN    NS      ns.sub1.r216.csie.nctu.edu.tw.
$GENERATE 128-191 $.3.168.192.in-addr.arpa.         IN    NS      ns.sub1.r216.csie.nctu.edu.tw.
$GENERATE 192-255 $.3.168.192.in-addr.arpa.         IN    NS      ns.sub1.r216.csie.nctu.edu.tw.
```

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.r216.csie.nctu.edu.tw. root.sub1.r216.csie.nctu.eud.tw. (
       1;3h;1h;1w;1h)
     IN    NS    ns.sub1.r216.csie.nctu.edu.tw.
```

Non-byte boundary (5)

- Method1

```
$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.r216.csie.nctu.edu.tw.
$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.r216.csie.nctu.edu.tw.
$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.r216.csie.nctu.edu.tw.
$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.r216.csie.nctu.edu.tw.

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.r216.csie.nctu.edu.tw. root.sub1.r216.csie.nctu.eud.tw. (
                                         1;3h;1h;1w;1h)
               IN    NS    ns.sub1.r216.csie.nctu.edu.tw.
          1    IN    PTR  www.sub1.r216.csie.nctu.edu.tw.
          2    IN    PTR  abc.sub1.r216.csie.nctu.edu.tw.
          …
```

BIND Security

Security – In named.conf

- 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 csie**

```
Kcsie.+157+52205.key
=====================
csie.  IN KEY 512 3 157 GKnELuie/G99NpOC2/AXwA==
```

```
Kcsie.+157+52205.private
========================
Private-key-format: v1.2
Algorithm: 157 (HMAC_MD5)
Key: GKnELuie/G99NpOC2/AXwA==
```

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

```
key dns1-dns2 {
    algorithm hmac-md5;
    secret “GKnELuie/G99NpOC2/AXwA==”
};
```

3. **Edit both named.conf of dns1 and dns2**

   – Suppose dns1 = 140.113.209.1, dns2 = 140.113.209.2

```
include  “dns1-dns2.key”
server 140.113.209.2 {
    keys {dns1-dns2;};
};
```

```
include  “dns1-dns2.key”
server 140.113.209.1 {
    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

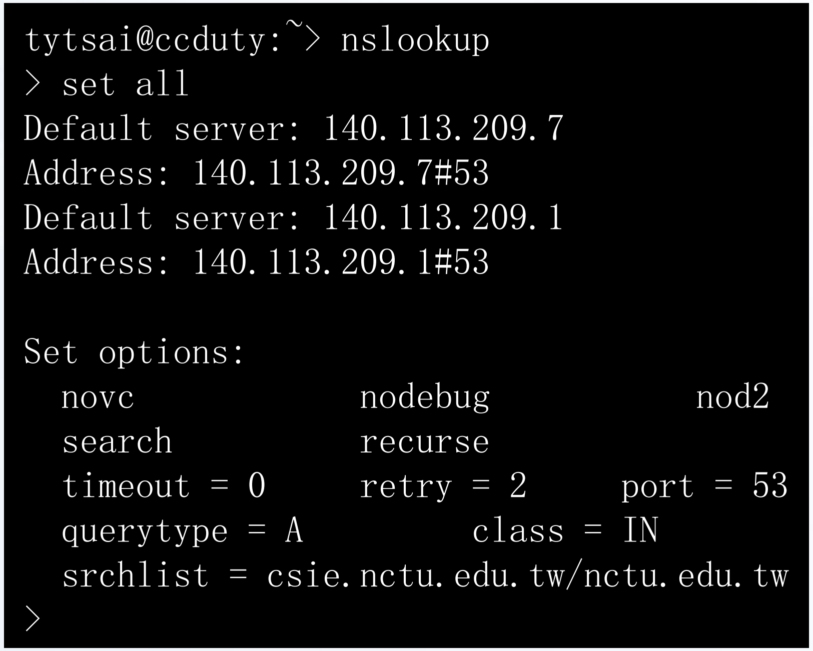
- Named debug level
  - **From 0 (debugging off) ~ 11 (most verbose output)**
  - **% named –d2 (start named at level 2)**
  - **% rndc trace (increase debugging level by 1)**
  - **% rndc trace 3 (change debugging level to 3)**
  - **% rndc notrace (turn off debugging)**

- 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

Tool-nslookup

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



```
tytsai@ccduty:~> nslookup
> set all
Default server: 140.113.209.7
Address: 140.113.209.7#53
Default server: 140.113.209.1
Address: 140.113.209.1#53

Set options:
  novc                nodebug           nod2
  search              recurse
  timeout = 0         retry = 2     port = 53
  querytype = A             class = IN
  srchlist = csie.nctu.edu.tw/nctu.edu.tw
>
```

Tool – dig

- Usage
  - % dig csie.nctu.edu.tw
  - % dig csie.nctu.edu.tw mx
  - % dig @ns.nctu.edu.tw csie.nctu.edu.tw mx
  - % dig –x 140.113.209.3
    - Reverse query

- Find out the root servers
  - % dig @a.root-servers.net . ns

Tool- host

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