Directory Services

PRINCIPLES – NIS – LDAP – DNS

LiU expanding reality

Labs and deadlines

- AMD ->Intel
- Just nu uppgraderar vi kernel
  - Hoppas det löser interupts ->slött nätverk
- Deadlines
  - http://www.ida.liu.se/~TDDI41/timetable/index.en.shtml
- Om jag glömmer (vilket jag gör) säg till mig om att lägga ut föreläsningsslides

What is a directory?

Fundamental properties

- Maps keys to values
- Relatively frequent lookups
- Relatively infrequent updates

Examples

- Phone book
- Office directory
- User database
- List of contacts

Directories in Linux

User database

- /etc/passwd, /etc/shadow

Group database

- /etc/group

Host names

- /etc/hosts

Network names

- /etc/network

Protocol names

- /etc/protocols

Service names

- /etc/services

RPC program numbers

- /etc/rpc

Known ethernet addresses

- /etc/ethers

Automount maps

- /etc/auto.master

Standard implementation: local files

The scalability problem

Example

- 13000 users and 5000 hosts
- Passwords valid for 30 days
- 50% of changes made at 8-10

→ One change every 28.8 seconds

→ Propagation time: 0.00567s

Problems

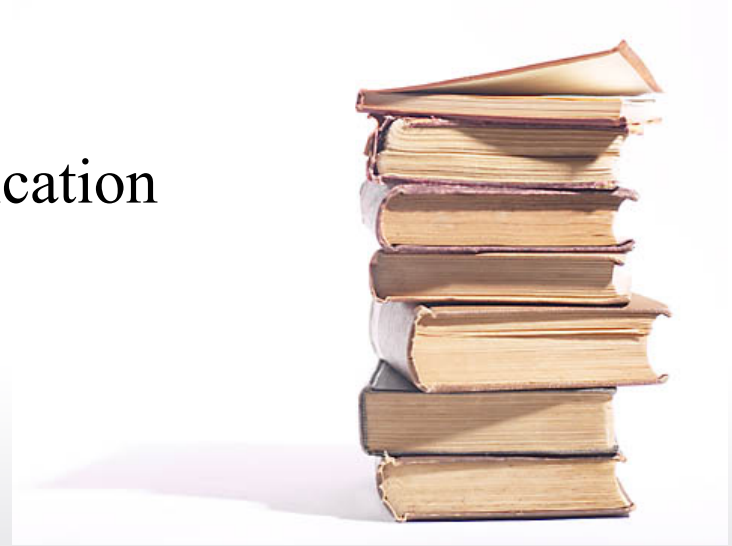
- Performance issues
- Hosts that are down
- Other propagation failures
- Simultaneous updates

What is a directory service

A specialized database

- Attribute-value type information
- More reads than updates
- Consistency problems are sometimes OK

- No transactions or rollback
- Support for distribution and replication
- Clear patterns to searches



Directory services

Components

- A data model
- A protocol for searching
- A protocol for reading
- A protocol for updating
- Methods for replication
- Methods for distribution

Common directory services

- DNS
- X.500 Directory Service
- Network Information Service
- NIS+
- Active Directory (Windows NT)
- NDS (Novell Directory Service)
- LDAP (Lightweight X.500)

Directory services

Global directory service

- Context: entire network or entire internet
- Namespace: uniform
- Distribution: usually
- Examples: DNS, X.500, NIS+, LDAP

Local directory service

- Context: intranet or smaller
- Namespace: non-uniform
- Examples: NIS, local files

Directory services in Linux

Alias: name services

- /etc/nsswitch.conf selects service
- Several services per directory
- Modular design/implementation

Examples from /etc/nsswitch.conf

```
users   files,nis
users   nis[notfound=return],files
hosts   dns,files
```

NIS, NIS+, LDAP

Network Information Service

Domain (NIS domain)

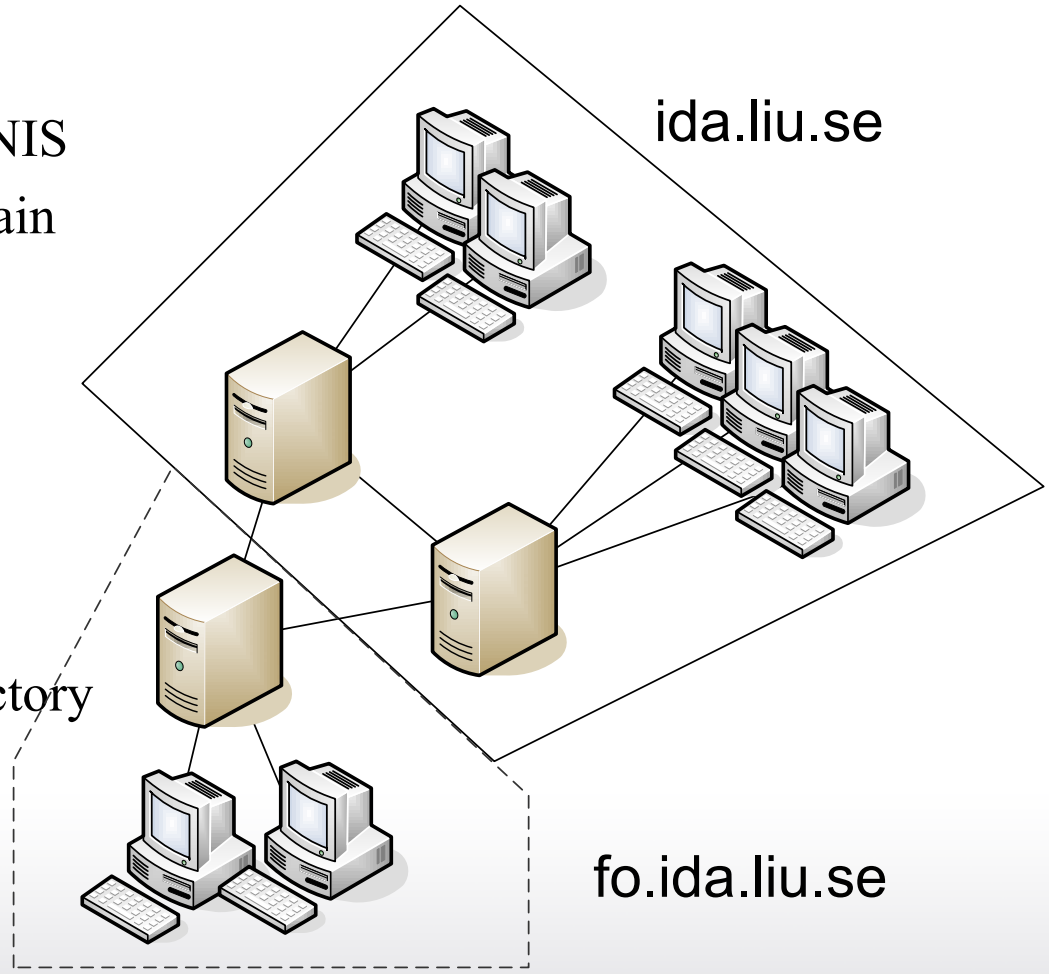
- Systems administered with NIS
- No connection to DNS domain

NIS server

- Server that has information accessible through NIS
- Serves one or more domains

NIS client

- Host that uses NIS as a directory service for something



NIS

Protocol

- RPC based
- No security
- No updates
- Replication support

Replication

- Master/slave servers

Distribution

- No distribution support!

Data model

- Directories known as **maps**
- Simple key-value mapping
- Values have no structure

passwd.byname	
donkn	1002:*:203
johne	1003:trzQw
alatu	2031:kprrT
johmc	2032:bRelZ
edwyo	2033:*:204
ricst	2034:vvldk
petde	2232:*:204
larwa	3021:*:204

NIS

Master server

- Maps built from text files
- Maps in /var/yp
- Maps built with make
- Maps stored in binary form
- Replication to slaves with yppush

Slave servers

- Receive data from master
- Load balancing and failover

Processes/commands

- ypserv Server process
- ypbind Client process
- ypcat To view maps
- ypmatch To search maps
- ypwhich Show status
- yppasswdd Change password

NIS

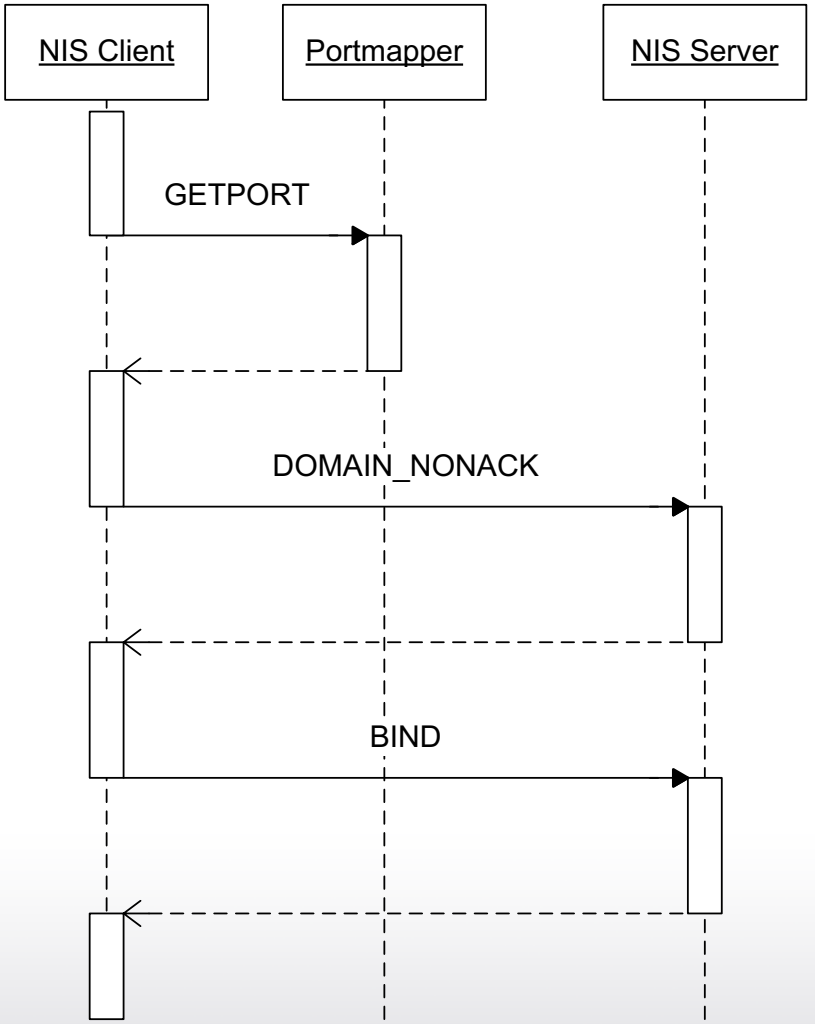
NIS client

- Knows its NIS domain
- Binds to a NIS server

Two options

- Broadcast
- Hard coded NIS-server

- **ypbind**



NIS

Scalability problems

- Flat namespace
- No distribution

Security problems

- No access control
- Broadcast for binding
- Patched as an afterthought

Primitive protocol

- No updates
  - Hack for password change
- Search only on key
- Primitive data model

Solution: NIS+

NIS+

Scalability

- Hierarchical namespace
- Distributed administration

Security

- Authentication of server, client and user
- Access control on per-cell level

New protocol

- Updates through NIS+
- General searches
- Data model with real tables

So why is NIS+ not used?

LDAP

Protocol

- TCP-based
- Fine-grained access control
- Support for updates
- Flexible search protocol

Replication

- Replication is possible

Distribution

- Distributed management is possible

Data model

- Based on X.500
- Object-oriented
- Objects can be extended freely
- Attribute-based data model
- Hierarchical namespace

Example of user

NIS+ table ”passwd.org_dir.example.com”

name	passwd	uid	gid	gecos	home	shell
davby	*LK*	1211	1200	David	/home/davby	/bin/sh
fsmith	3x1231v76T89N	1329	1200	Fran	/home/fsmith	/bin/sh

NIS table passwd.byname (user name as key):

davby	davby:*:1211:1200:David:/home/davby:/bin/sh
fsmith	fsmith:*:1329:1200:Fran:/home/fsmith:/bin/sh

Example of user

```
dn: uid=fsmith,ou=employees,dc=example,dc=com
objectclass: person
objectclass: organizationalPerson
objectclass: inetOrgPerson
uid: fsmith
givenname: Fran
sn: Smith
cn: Fran Smith
cn: Frances Smith
telephonenumber: 510-555-1234
roomnumber: 122G
o: Example Corporation International
mailRoutingAddress: fsmith@example.com
mailhost: mail.example.com
userpassword: {crypt}3x1231v76T89N
uidnumber: 1329
gidnumber: 1200
homedirectory: /home/fsmith
loginshell: /bin/sh
```

The future

LDAP is taking over

- NIS is too insecure, doesn't scale and is inflexible
- NIS+ is hard to implement and doesn't exist on many OSes
- X.500 is too complex and has a bad reputation
- Other options have similar problems

DNS

DNS: Data model

- Functional: NAME → { TYPE → RDATA }
- Relational: (NAME, TYPE, RDATA)

Resource record

NAME	TYPE	RDATA
ida.liu.se	A	130.236.177.25
ida.liu.se	MX	0 ida.liu.se
ida.liu.se	**NS**	**ns.ida.liu.se**
ida.liu.se	NS	ns1.liu.se
ida.liu.se	NS	ns2.liu.se
ida.liu.se	NS	nsauth.isy.liu.se

DNS: TYPE & RDATA

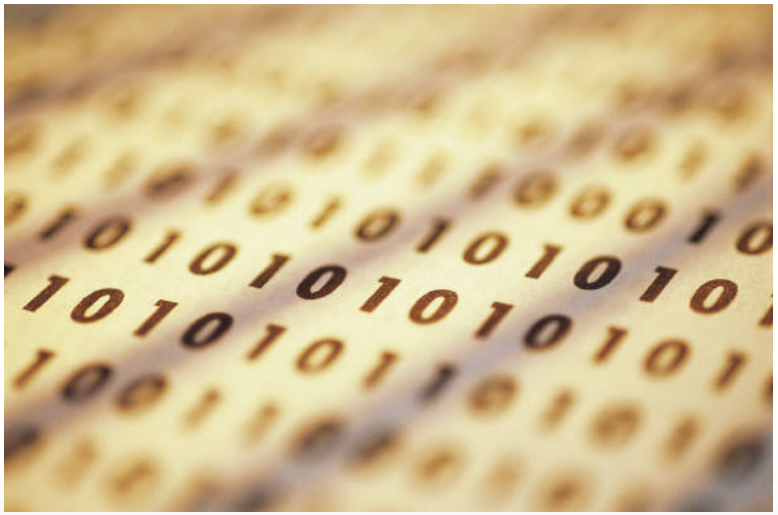
TYPE

- SOA – Start of authority
- NS – Name server
- MX – Mail exchanger
- A – Address
- AAAA – IPv6 address
- PTR – Domain name pointer
- CNAME – Canonical name
- TXT – Text

… and many more

RDATA

- Binary data, hardcoded format
- TYPE determines format



DNS: Namespace

Names

- Dot-separated parts
  - one.part.after.another

FQDN

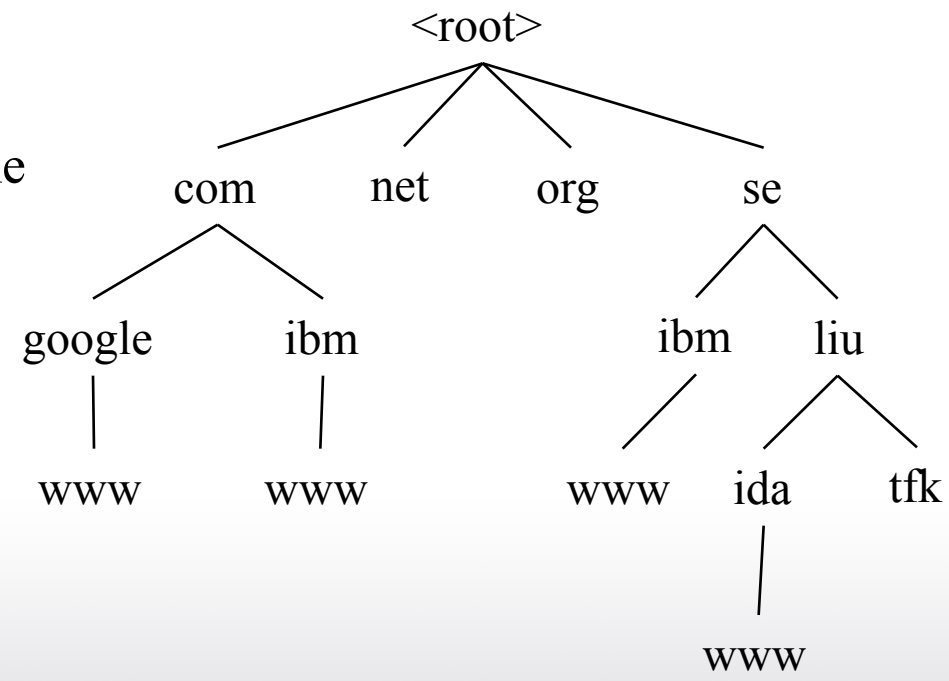
- Fully Qualified Domain Name
- Complete name
- Always ends in a dot

Partial name

- Suffix of name implicit
- Does not end in a dot

Namespace

- Global and hierarchical



DNS: Replication

Secondary/slave nameserver

- Indicated by NS RR
- Data transfer with AXFR/IXFR

Questions

- How does a slave NS know when there is new information?
- How often should a slave NS attempt to update?
- How long is replicated data valid?

Example

```
sysi-00:~# host -t ns ida.liu.se
ida.liu.se  NS  nsauth.isy.liu.se
ida.liu.se  NS  ns.ida.liu.se
ida.liu.se  NS  ns1.liu.se
```

Rule of thumb

- Every zone needs at least two nameservers

DNS: Distribution

Delegation

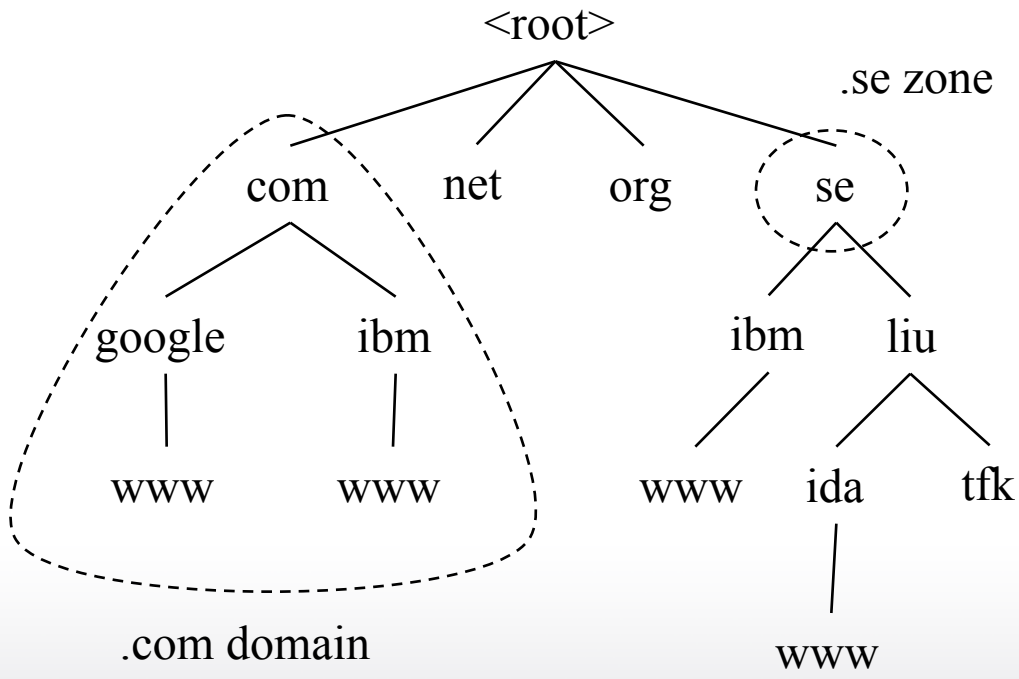
- A NS can delegate responsibility for a subtree to another NS
- Only **entire** subtrees can be delegated

Zone

- The part of the namespace that a NS is authoritative for
- Defined by SOA and NS

Domain

- A subtree of the namespace



DNS: Delegation

Delegating NS

- **NS record** for delegated zone
- A record (**glue**) for NS when needed

Delegated-to NS

- **SOA record** for the zone

Example

```
a.example.com  NS   ns2.x.com

b.x.com     NS   ns.b.x.com
ns.b.x.com  A    10.1.2.3

b.x.com     SOA (
          ns.b.x.com
          dns.x.com
          20040909001
          24H 2H 1W 2D
          )
```

DNS: Delegation

Format of SOA

- MNAME Master NS
- RNAME (email) Responsible
- SERIAL Serial number
- REFRESH Refresh interval
- RETRY Retry interval
- MINIMUM TTL for negative reply

SERIAL

- Increase for every update
- Date format common
  - 2004090901

REFRESH/RETRY

- How often secondary NS updates the zone

MINIMUM

- How long to cache NXDOMAIN

DNS: Cacheing

Cacheing creates scalability

- Cacheing reduces tree traversal
- Cacheing of A and PTR reduce duplicate DNS queries

Cache parameters

- TTL – Set per RR
- Negative TTL – Set in SOA

Example

```
$TTL 4H   SOA (
      MNAME RNAME
      SERIAL REFRESH
      RETRY 1H )
      24H   NS   ns
ns    24H   A    10.1.2.3
```

Choosing good cache parameters is vital

DNS: The server

Recursive/iterative

- Does the server offer recursion?
- To which clients is it offered?

Authoritative/nonauthorit…

- Authoritative: first-hand information
- Otherwise: cached information

Review

- **Recursive**: the nameserver gives a definite answer, but may ask other nameservers in order to generate it
- **Iterative**: the nameserver gives a definite answer only for locally known information; otherwise it generates a referral

DNS: The client

Client requirements

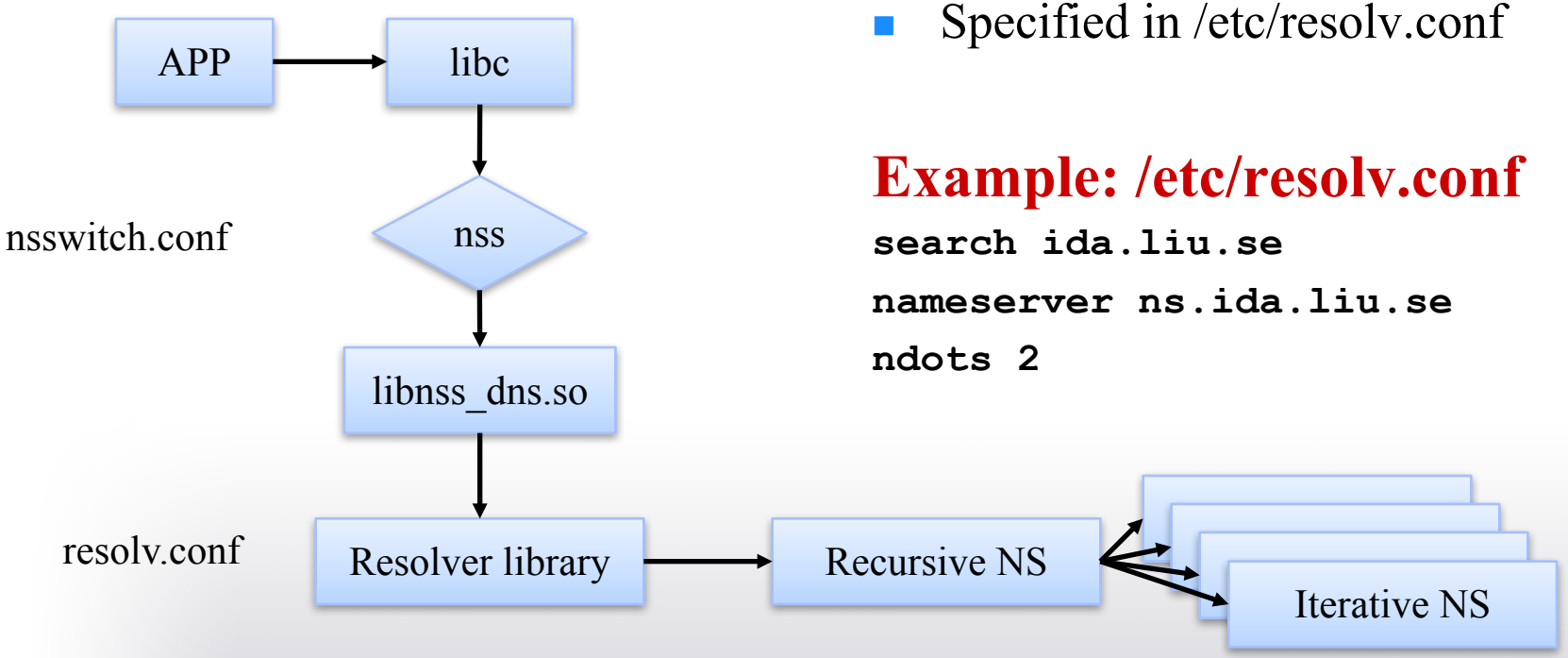
- Use a recursive NS (resolver)
- Use partially qualified names

Partially qualified names

- Add suffix if there are fewer than *n* dots in the name (**ndots**)

Name server (resolver)

- Specified in /etc/resolv.conf



Example: /etc/resolv.conf

```
search ida.liu.se
nameserver ns.ida.liu.se
ndots 2
```

DNS: Root Name Server

Handles the root zone

- Data generated by ICANN
- Data distributed by Verisign
- Distribution from *hidden master*

Why no more than 13?

Thirteen services

- Some are anycast
- Over 60 servers

	Operator	Locations
A	VeriSign	Dulles VA
B	ISI	Marina Del Rey CA
C	Cogent Communications	Herndon VA; Los Angeles; New York City; Chicago
D	University of Maryland	College Park MD
E	NASA Ames	Mountain View CA
F	Internet Systems Consortium, Inc.	Ottawa; Palo Alto; San Jose, CA; New York City; San Francisco; Madrid; Hong Kong; Los Angeles; Rome; Auckland; Sao Paulo; Beijing; Seoul; Moscow; Taipei; Dubai; Paris; Singapore; Brisbane; Toronto; Monterrey; Lisbon; Johannesburg;Tel Aviv; Jakarta; Munich;
G	U.S. DOD NIC	Vienna VA
H	U.S. Army Research Lab	Aberdeen MD
I	Autonomica/NORDUnet	Stockholm; Helsinki; Milan; London; Geneva; Amsterdam; Oslo; Bangkok; Hong Kong; Brussels; Frankfurt
J	VeriSign Global Registry Services	Dulles VA (2 locations); Mountain View CA; Seattle WA; Amsterdam; Atlanta GA; Los Angeles CA; Miami; Stockholm; London; Tokyo; Seoul; Singapore; Sterling VA (2 locations, standby)
K	RIPE NCC	London; Amsterdam; Frankfurt; Athens; Doha (Quatar)
L	ICANN	Los Angeles
M	WIDE Project	Tokyo; Seoul (KR); Paris (FR)

DNS: CNAME

Canonical name

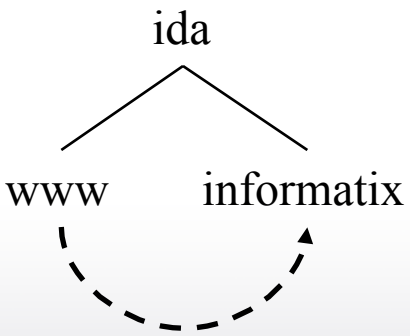
- Pointer within namespace
- *Johansson: See Johnson*

CNAME Whoopsie 1

```
www CNAME informatix
www A 130.236.177.12
```

CNAME Whoopsie 2

```
ida.liu.se. NS ns.ida.liu.se.
ns CNAME vitalstatistix
vitalstatistix A 130.236.177.12
```

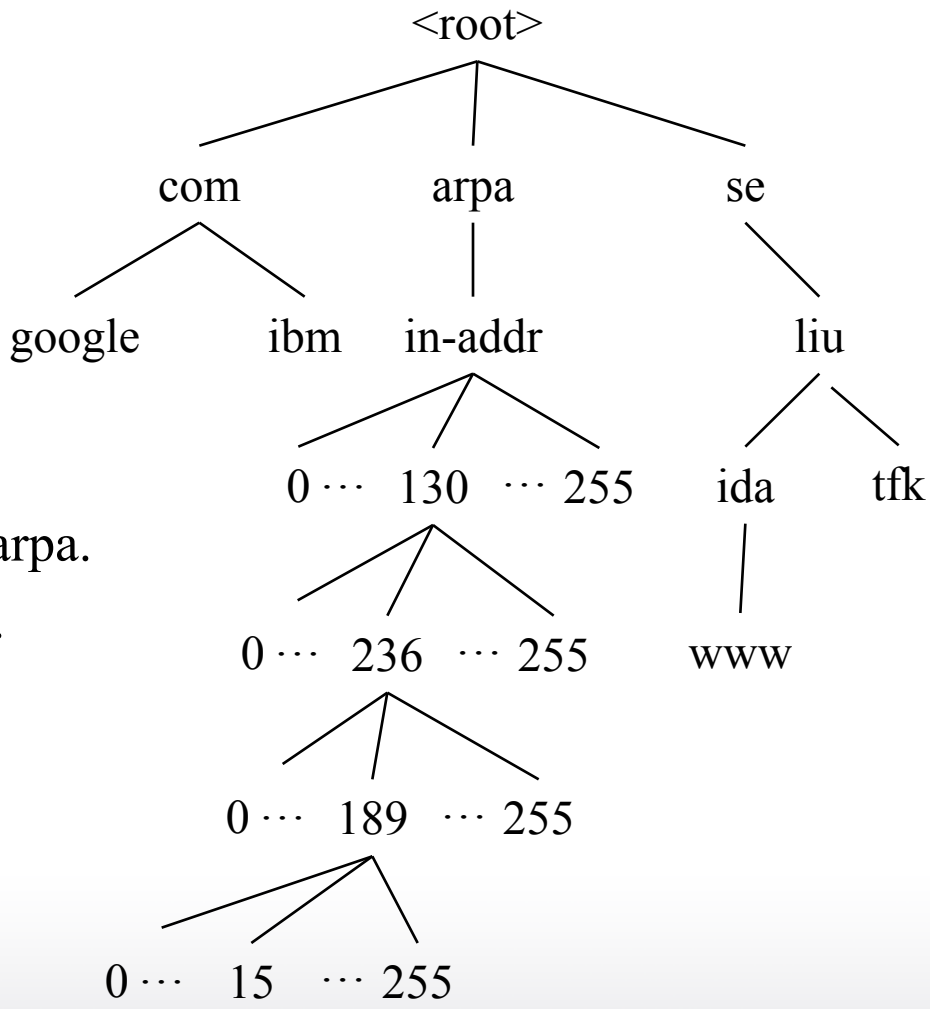


www.ida.liu.se CNAME informatix.ida.liu.se

DNS: PTR

Address-to-name mapping

- Same RR type for IPv4 och IPv6
- ”A big reverse zone in the sky”



IPv4: in-addr.arpa.

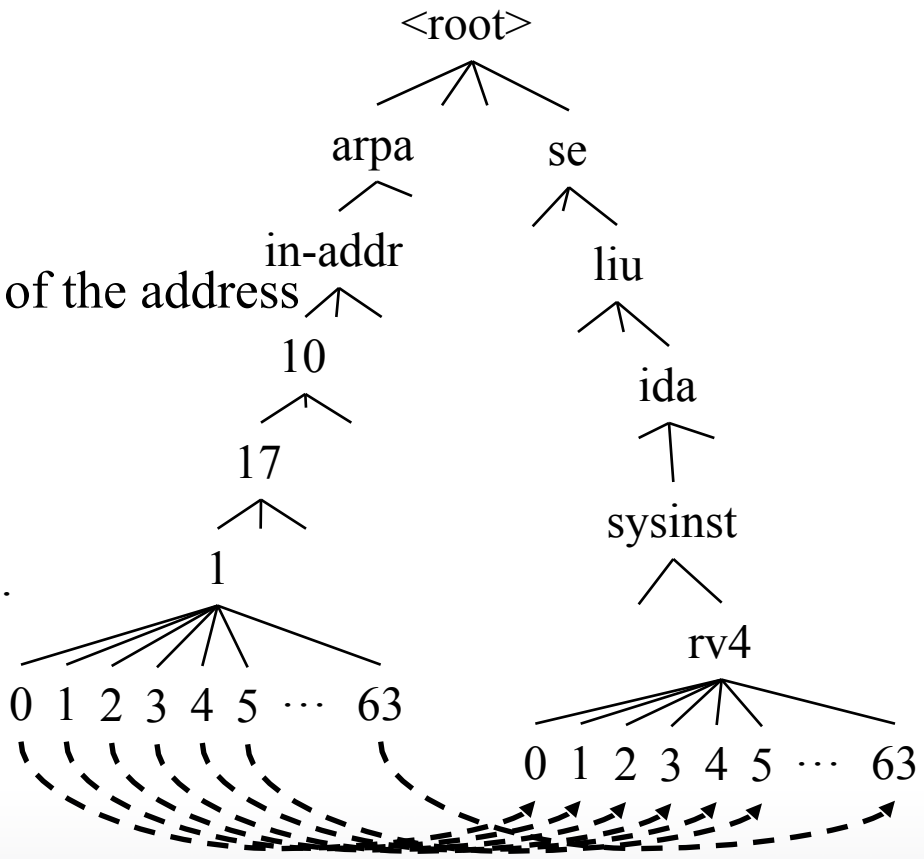
- Reverse address and add in-addr.arpa.
- *A.B.C.D* → *D.C.B.A*.in-addr.arpa.
- Same as any other name in DNS!
  - Same lookup, cache etc.
  - CNAME works too

```
15.189.236.130.in-addr.arpa. PTR sysi-05.sysinst.ida.liu.se.
```

DNS: Delegation in in-addr.arpa.

Delegation

- Delegering of entire subtrees
- Subtrees at each dot
- In in-addr.arpa a dot after each octet of the address



Q: How to delegate partial subtrees corresponding to small subnets, e.g. 10.17.1.0/26?

A: Use CNAME to create a new zone that *can* be delegated!

A: Delegate each address as a separate zone

```
$GENERATE 1-63 $ CNAME $.rv4.sysinst.ida.liu.se.
```

DNS: The protocol

TCP or UDP

- Normally UDP port 53
- TCP if the reply is too large

DNS packet

- Header section — Flags etc.
- Query section — Queries to the server
- Answer section — Replies to the queries
- Authority section — Referrals to other NS
- Additional section — Extra data that may be useful (e.g. glue)

DNS: The protocol

Header section: flags

- QR Query or response
- OPCODE Type of quer
- AA Authoritative Answer
- TC TrunCation
- RD Recursion Desired
- RA Recursion Available
- Z Reserved
- RCODE Result code

Flags

- Set RD for recursive quer
- If AA is not set, reply is from cache
- If TC it set, the reply is too large for UDP

RCODE

- SERVFAIL Problem with NS
- NXDOMAIN No such name
- REFUSED Refuse to reply

DNS: The protocol

Question section

- Contains questions
- Also included in reply

Answer section

- Contains requested RRs
- Empty in referral replies

Authority section

- Indicates authoritative NS
- Never empty in referrals

Additional section

- RR related to response, but not part of response
- E.g. A for NS in authority section

```
sysi-00:~# dig www.ida.liu.se @a.ns.se
; <<>> DiG 9.2.4rc5 <<>> www.ida.liu.se @a.ns.se
;; global options:  printcmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 7059
;; flags: qr rd; QUERY: 1, ANSWER: 0, AUTHORITY: 4, ADDITIONAL: 4

;; QUESTION SECTION:
;www.ida.liu.se.                        IN      A

;; AUTHORITY SECTION:
liu.se.                 86400   IN      NS      ns2.liu.se.
liu.se.                 86400   IN      NS      sunic.sunet.se.
liu.se.                 86400   IN      NS      nsauth.isy.liu.se.
liu.se.                 86400   IN      NS      ns1.liu.se.

;; ADDITIONAL SECTION:
ns1.liu.se.             86400   IN      A       130.236.6.251
ns2.liu.se.             86400   IN      A       130.236.6.243
sunic.sunet.se.         86400   IN      A       192.36.125.2
nsauth.isy.liu.se.      86400   IN      A       130.236.48.9
```

```
sysi-00:~# dig www.ida.liu.se @nsauth.isy.liu.se
; <<>> DiG 9.2.4rc5 <<>> www.ida.liu.se @nsauth.isy.liu.se
;; global options:  printcmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 49836
;; flags: qr aa rd; QUERY: 1, ANSWER: 2, AUTHORITY: 4, ADDITIONAL: 4

;; QUESTION SECTION:
;www.ida.liu.se.                        IN      A

;; ANSWER SECTION:
www.ida.liu.se.         259200  IN      CNAME   informatix.ida.liu.se.
informatix.ida.liu.se.  259200  IN      A       130.236.177.26

;; AUTHORITY SECTION:
ida.liu.se.             259200  IN      NS      ns1.liu.se.
ida.liu.se.             259200  IN      NS      ns2.liu.se.
ida.liu.se.             259200  IN      NS      nsauth.isy.liu.se.
ida.liu.se.             259200  IN      NS      ns.ida.liu.se.

;; ADDITIONAL SECTION:
ns.ida.liu.se.          259200  IN      A       130.236.177.25
ns1.liu.se.             43200   IN      A       130.236.6.251
ns2.liu.se.             43200   IN      A       130.236.6.243
nsauth.isy.liu.se.      21600   IN      A       130.236.48.9
```

```
sysi-00:~# dig www.ibm.com @ns.ida.liu.se
; <<>> DiG 9.2.4rc5 <<>> www.ibm.com @ns.ida.liu.se
;; global options:  printcmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 38042
;; flags: qr rd ra; QUERY: 1, ANSWER: 6, AUTHORITY: 4, ADDITIONAL: 4

;; QUESTION SECTION:
;www.ibm.com.                   IN      A

;; ANSWER SECTION:
www.ibm.com.            1800    IN      A       129.42.21.99
www.ibm.com.            1800    IN      A       129.42.16.99
www.ibm.com.            1800    IN      A       129.42.17.99
www.ibm.com.            1800    IN      A       129.42.18.99

;; AUTHORITY SECTION:
ibm.com.                600     IN      NS      ns.austin.ibm.com.
ibm.com.                600     IN      NS      ns.watson.ibm.com.
ibm.com.                600     IN      NS      ns.almaden.ibm.com.

;; ADDITIONAL SECTION:
ns.austin.ibm.com.      70372   IN      A       192.35.232.34
ns.watson.ibm.com.      92202   IN      A       129.34.20.80
ns.almaden.ibm.com.     70372   IN      A       198.4.83.35
```

DNS: Commands

nslookup

- Look up names

host

- Look up data in DNS

dig

- Look up data in DNS
- Full access to protocol

whois

- Information about who has registered a domain
- Many versions – jwhois is nice

DNS: Server types

Master

- Source of DNS data
- Authoritative for zone

Forwarder

- Cache only
- Forwards queries

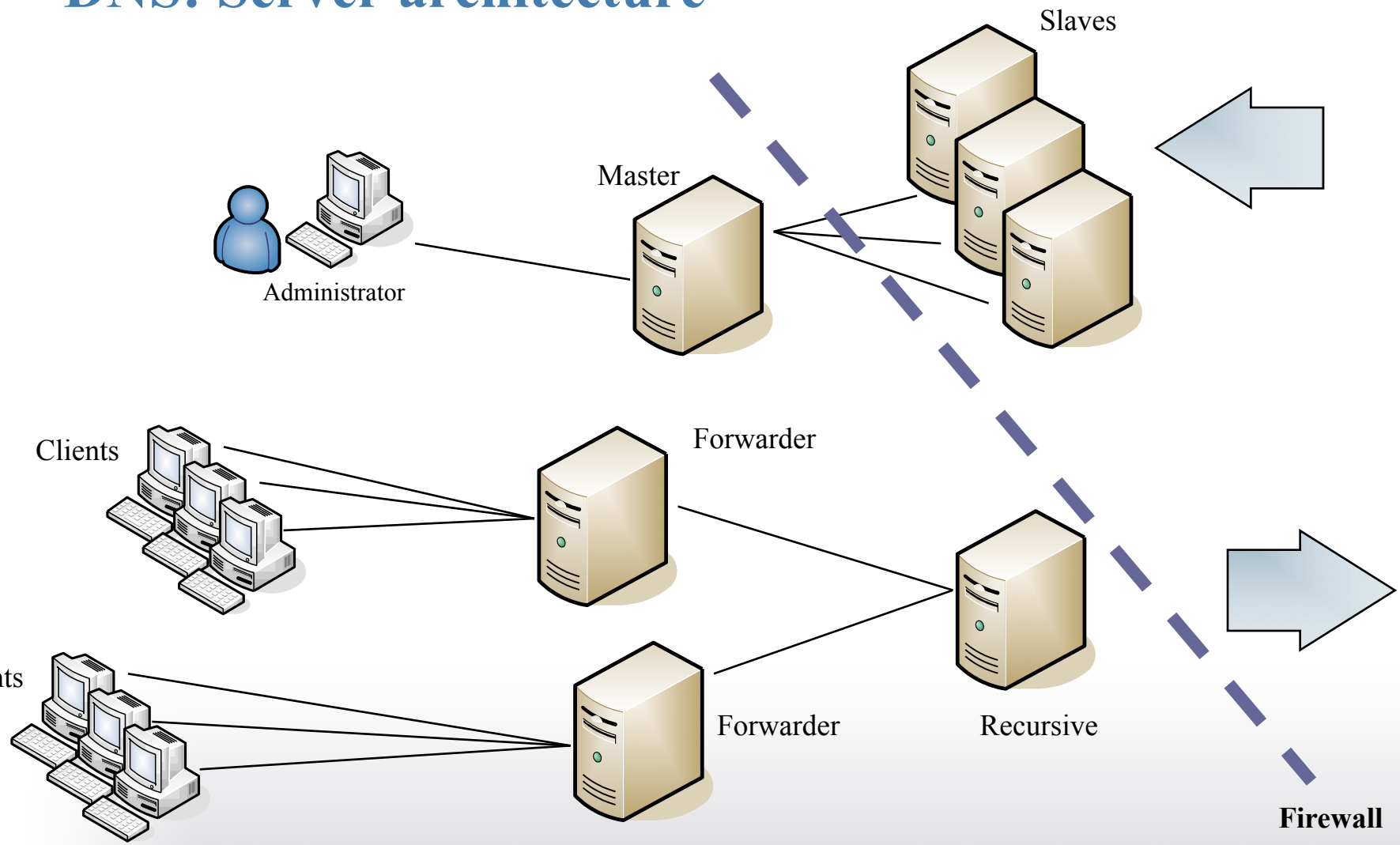
Secondary

- Authoritative for zone

Recursive-only

- Performs recursive queries

DNS: Server architecture



Zone configuration in BIND

Files

- named.conf
- Zone files

In Debian: /etc/bind

- named.conf
- named.conf.local
- named.conf.options
- Zones.rfc1812
- db.0
- db.127
- db.empty
- db.local
- db.root

named.conf

Zone definition (master)

```
zone ”sysinst.ida.liu.se” {
        type master;
        file ”/etc/bind/sysinst.zone”;
}
```

Options

- Who can query the server
- Who can update the server
- Which ports to use
- Which address to use

… and so on

Other stuff

- Options
- Access control

```
$TTL 3600

@               IN      SOA     (
                        sysinst-gw.ida.liu.se.
                        davby.ida.liu.se.
                        2006083100              ; Serial
                        3600                    ; Refresh 1h
                        1800                    ; Retry 30min
                        604800                  ; Expire
                        3600                    ; TTL
                        )

                IN      NS      sysinst-gw.ida.liu.se.
                IN      NS      ns.ida.liu.se.

                IN      MX      10 ida-gw.sysinst.ida.liu.se.

ida-gw          IN      A       130.236.189.1
debian          IN      CNAME   ida-gw
heretix         IN      A       130.236.189.62

$GENERATE 0-16 sysi-${0,2,d}    A       130.236.189.${10,,d}
$GENERATE 1-8 a$-gw             A       130.236.189.${29,,d}
$GENERATE 1-8 b$-gw             A       130.236.189.${37,,d}
$GENERATE 1-8 c$-gw             A       130.236.189.${45,,d}
```

More stuff in BIND

- Views
- Dynamic update
- DNSSEC

Directory Service Summary

Properties

- Search-optimized database
- Attribute-based data
- Distributed management for scalability
- Replication for performance and reliability
- Search protocol
- Update protocol

Common directory services

- DNS – Host names etc.
- NIS/NIS+ – Replace local files
- LDAP – General directory service