Welcome!

IP Services Workshop
- DNS & DNSSEC

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Introduction to DNS

Purpose of naming

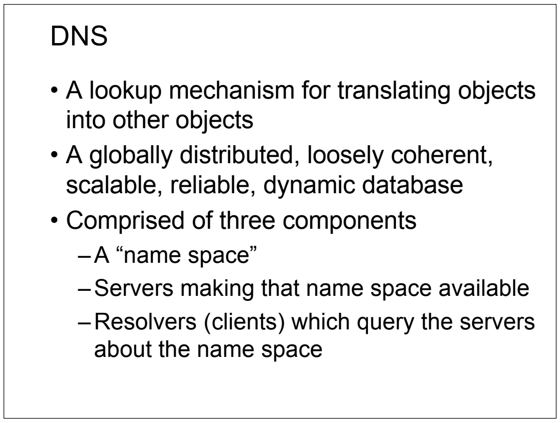
- Addresses are used to locate objects
- Names are easier to remember than numbers
- You would like to get to the address or other objects using a name
- **DNS provides a mapping from names to resources of several types**

Names and addresses in general

- An address is how you get to an endpoint
  - Typically, hierarchical (for scaling):
    - 950 Milton Street, Brisbane City, QLD 4064
    - 204.152.187.11, +617-3858-3188
- A “name” is how an endpoint is referenced
  - Typically, no structurally significant hierarchy
    - “David”, “Tokyo”, “apnic.net”

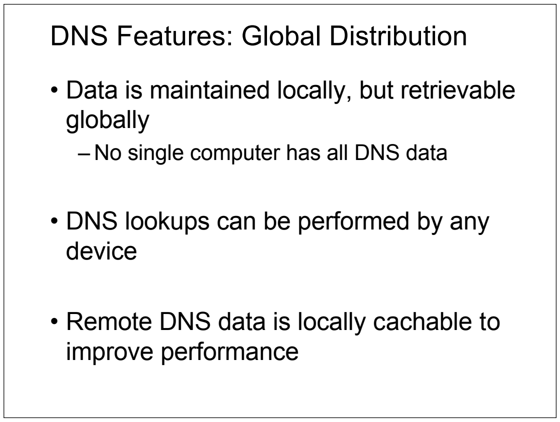
Naming History

- 1970’s ARPANET
  - Host.txt maintained by the SRI-NIC
  - pulled from a single machine
  - Problems
    - traffic and load
    - Name collisions
    - Consistency
- DNS created in 1983 by Paul Mockapetris (RFCs 1034 and 1035), modified, updated, and enhanced by a myriad of subsequent RFCs



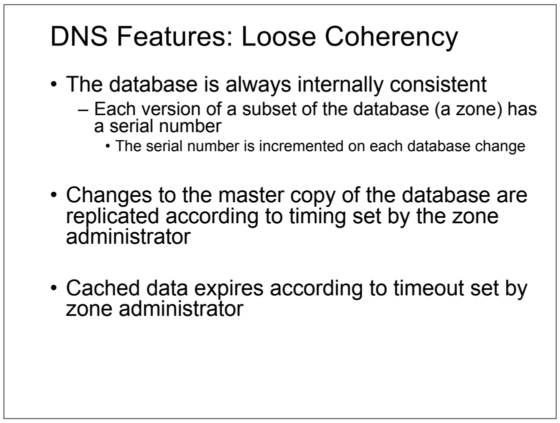
DNS

- A lookup mechanism for translating objects into other objects
- A globally distributed, loosely coherent, scalable, reliable, dynamic database
- Comprised of three components
  - A “name space”
  - Servers making that name space available
  - Resolvers (clients) which query the servers about the name space



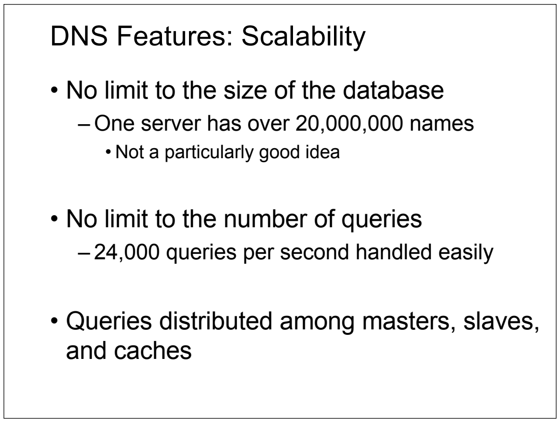
DNS Features: Global Distribution

- Data is maintained locally, but retrievable globally
  - No single computer has all DNS data
- DNS lookups can be performed by any device
- Remote DNS data is locally cachable to improve performance



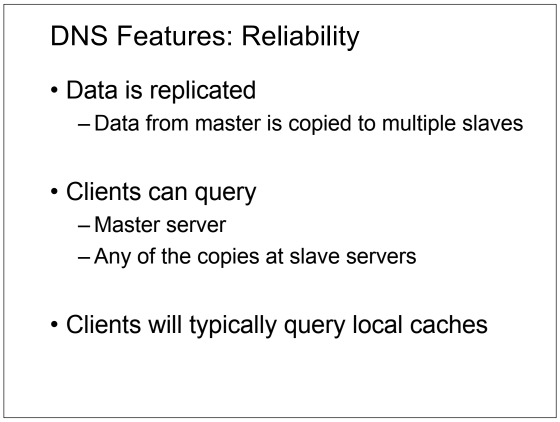
DNS Features: Loose Coherency

- The database is always internally consistent
  - Each version of a subset of the database (a zone) has a serial number
    - The serial number is incremented on each database change
- Changes to the master copy of the database are replicated according to timing set by the zone administrator
- Cached data expires according to timeout set by zone administrator



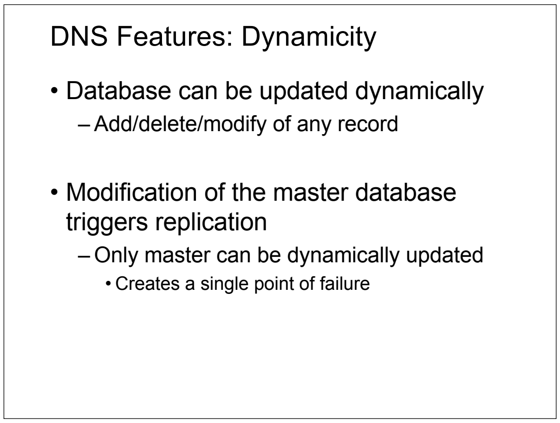
DNS Features: Scalability

- No limit to the size of the database
  - One server has over 20,000,000 names
    - Not a particularly good idea
- No limit to the number of queries
  - 24,000 queries per second handled easily
- Queries distributed among masters, slaves, and caches



DNS Features: Reliability

- Data is replicated
  - Data from master is copied to multiple slaves
- Clients can query
  - Master server
  - Any of the copies at slave servers
- Clients will typically query local caches



DNS Features: Dynamicity

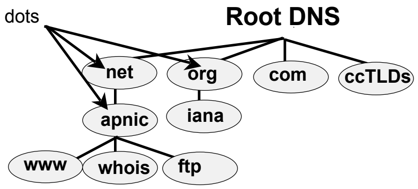
- Database can be updated dynamically
  - Add/delete/modify of any record
- Modification of the master database triggers replication
  - Only master can be dynamically updated
    - Creates a single point of failure

Concept: DNS Names

- How names appear in the DNS
  - Fully Qualified Domain Name (FQDN)
    - **`WWW.APNIC.NET.`**
  - labels separated by dots
- DNS provides a mapping from FQDNs to resources of several types
- Names are used as a key when fetching data in the DNS

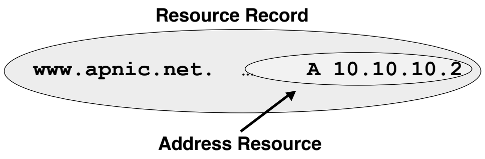
Concept: DNS Names contd.

- Domain names can be mapped to a tree
- New branches at the ‘dots’



Concept: Resource Records

- The DNS maps names into data using Resource Records.

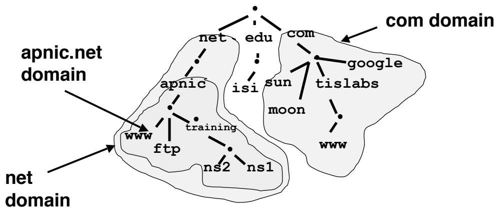


- More detail later

Concept: Domains

- Domains are “namespaces”
- Everything below *.com* is in the com domain
- Everything below *apnic.net* is in the apnic.net domain and in the net domain

Concept: Domains



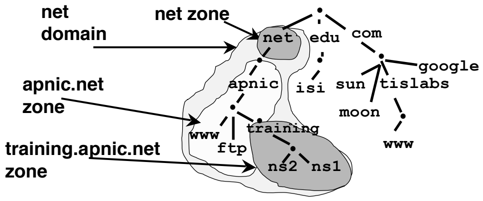
Delegation

- Administrators can create subdomains to group hosts
  - According to geography, organizational affiliation or any other criterion
- An administrator of a domain can delegate responsibility for managing a subdomain to someone else
  - But this isn’t required
- The parent domain retains links to the delegated subdomain
  - The parent domain “remembers” who it delegated the subdomain to

Concept: Zones and Delegations

- Zones are “administrative spaces”
- Zone administrators are responsible for portion of a domain’s name space
- Authority is delegated from a parent and to a child

Concept: Zones and Delegations



Concept: Name Servers

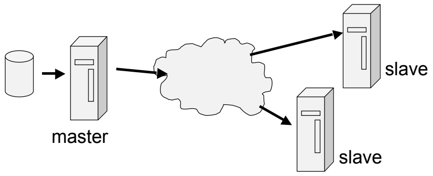
- Name servers answer ‘DNS’ questions
- Several types of name servers
  - Authoritative servers
    - master (primary)
    - slave (secondary)
  - (Caching) recursive servers
    - also caching forwarders
  - Mixture of functionality

Concept: Name Servers contd.

- Authoritative name server
  - Give authoritative answers for one or more zones
  - The master server normally loads the data from a zone file
  - A slave server normally replicates the data from the master via a zone transfer

Concept: Name Servers contd.

- Authoritative name server



Concept: Name Servers contd.

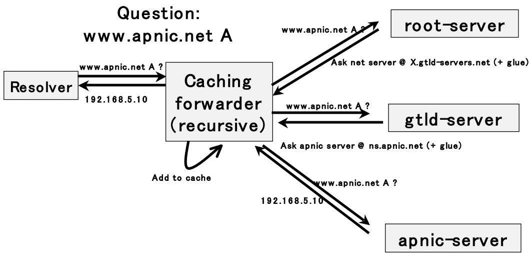
- Recursive server
  - Do the actual lookups; ask questions to the DNS on behalf of the clients
  - Answers are obtained from authoritative servers but the answers forwarded to the clients are marked as not authoritative
  - Answers are stored for future reference in the cache

Concept: Resolvers

- Resolvers ask the questions to the DNS system on behalf of the application
- Normally implemented in a system library (e.g, libc)

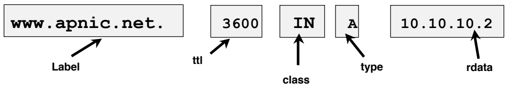
```
gethostbyname(char *name);
gethostbyaddr(char *addr, int len, type);
```

Concept: Resolving process & Cache



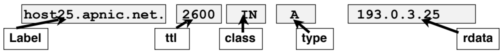
Concept: Resource Records

- Resource records consist of it's name, it's TTL, it's class, it's type and it's RDATA
- TTL is a timing parameter
- IN class is widest used
- There are multiple types of RR records
- Everything behind the type identifier is called rdata



Example: RRs in a zone file

```
apnic.net. 7200 IN      SOA     ns.apnic.net. admin.apnic.net.
                       (
                           2001061501     ; Serial
                           43200  ; Refresh 12 hours
                           14400  ; Retry 4 hours
                           345600 ; Expire 4 days
                           7200   ; Negative cache 2 hours )

apnic.net.          7200  IN    NS      ns.apnic.net.
apnic.net.          7200  IN    NS      ns.ripe.net.

whois.apnic.net.    3600  IN    A       193.0.1.162
```



```
host25.apnic.net.   2600  IN    A       193.0.3.25
```

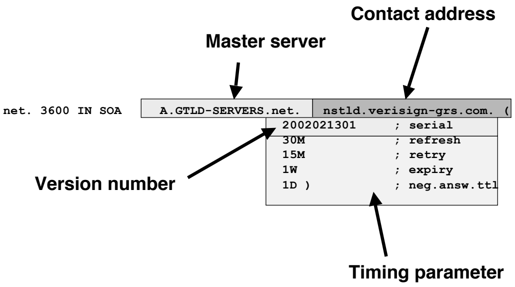
Resource Record: SOA and NS

- The SOA and NS records are used to provide information about the zone itself
- The NS indicates where information about a given zone can be found

```
apnic.net. 7200  IN    NS      ns.apnic.net.
apnic.net. 7200  IN    NS      ns.ripe.net.
```

- The SOA record provides information about the start of authority, i.e. the top of the zone, also called the APEX

Resource Record: SOA



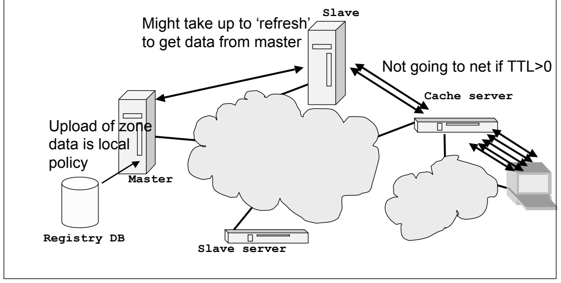
```
net. 3600 IN SOA   A.GTLD-SERVERS.net.  nstld.verisign-grs.com. (
                        2002021301     ; serial
                        30M            ; refresh
                        15M            ; retry
                        1W             ; expiry
                        1D )           ; neg.answ.ttl
```

Concept: TTL and other Timers

- TTL is a timer used in caches
  - An indication for how long the data may be reused
  - Data that is expected to be 'stable' can have high TTLs
- SOA timers are used for maintaining consistency between primary and secondary servers

Places where DNS data lives

- Changes do not propagate instantly



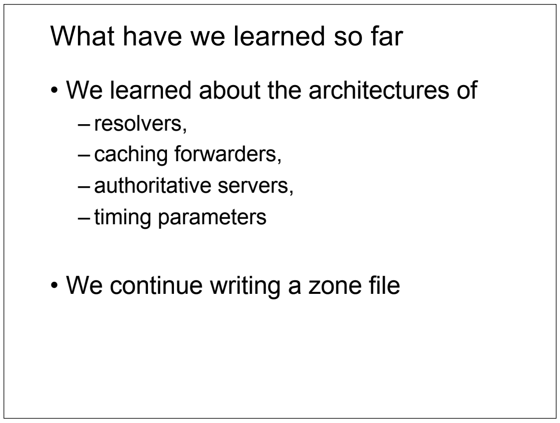
Might take up to 'refresh' to get data from master

Not going to net if TTL>0

Upload of zone data is local policy

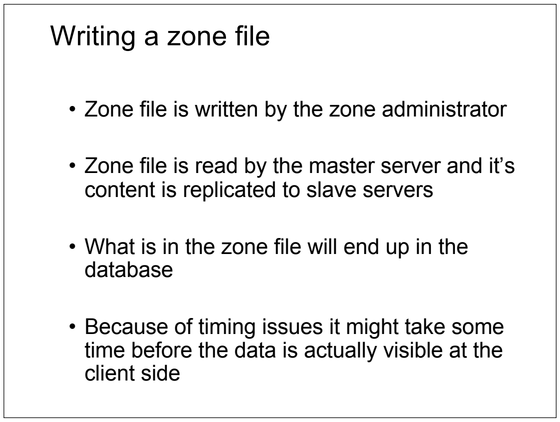
To remember...

- Multiple authoritative servers to distribute load and risk:
  - Put your name servers apart from each other
- Caches to reduce load to authoritative servers and reduce response times
- SOA timers and TTL need to be tuned to needs of zone. Stable data: higher numbers



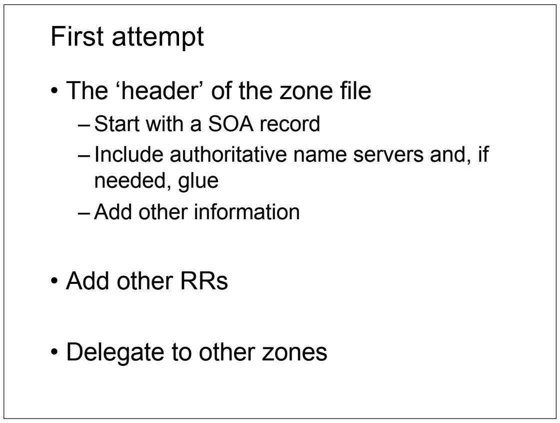
What have we learned so far

- We learned about the architectures of
  - resolvers,
  - caching forwarders,
  - authoritative servers,
  - timing parameters
- We continue writing a zone file



Writing a zone file

- Zone file is written by the zone administrator
- Zone file is read by the master server and it’s content is replicated to slave servers
- What is in the zone file will end up in the database
- Because of timing issues it might take some time before the data is actually visible at the client side



First attempt

- The ‘header’ of the zone file
  - Start with a SOA record
  - Include authoritative name servers and, if needed, glue
  - Add other information
- Add other RRs
- Delegate to other zones

The SOA record

Comments

```
apnic.net. 3600 IN SOA ns.apnic.net. ( admin\.email.apnic.net.
              2002021301     ; serial
              1h             ; refresh
              30M            ; retry
              1W             ; expiry
              3600 )         ; neg. answ. ttl
```

- admin.email@apnic.net ➡ admin\.email.apnic.net
- Serial number: 32bit circular arithmetic
  - People often use date format
  - To be increased after editing
- The timers above qualify as reasonable

Authoritative NS records and related A records

```
apnic.net.          3600 IN NS  NS1.apnic.net.
apnic.net.          3600 IN NS  NS2.apnic.net.
NS1.apnic.net.      3600 IN A   203.0.0.4
NS2.apnic.net.      3600 IN A   193.0.0.202
```

- NS record for all the authoritative servers
  - They need to carry the zone at the moment you publish
- A records only for “in-zone” name servers
  - Delegating NS records might have glue associated

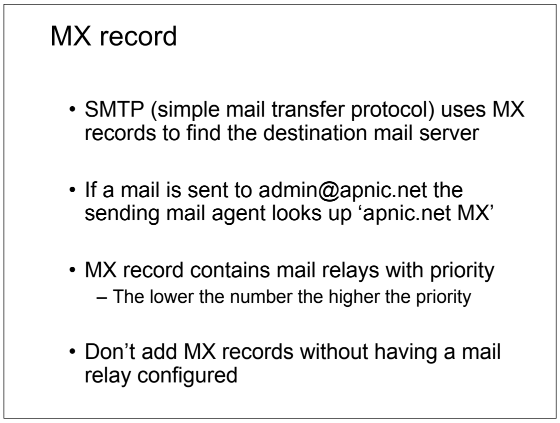
Other ‘APEX’ data

```
secret-wg.org. 3600 IN MX  50 mailhost.secret-wg.org.
secret-wg.org. 3600 IN MX  150 mailhost2.secret-wg.org.

secret-wg.org. 3600 IN LOC (
               52 21 23.0 N 04 57 05.5 E 0m 100m 100m 100m )
secret-wg.org. 3600 IN TXT  “Demonstration and test zone”
```

Examples:

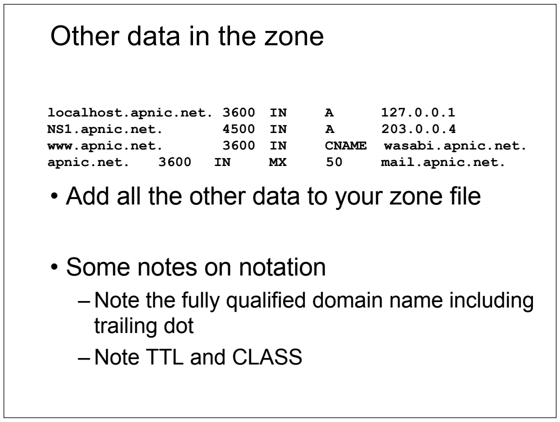
- MX records for mail
  (see next slide)
- Location records

TXT records
A records
KEY records for dnssec



MX record

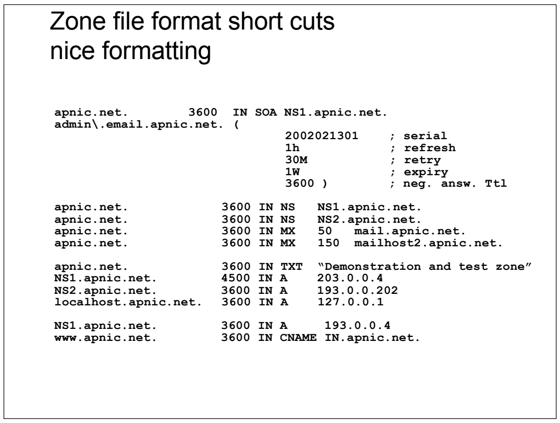
- SMTP (simple mail transfer protocol) uses MX records to find the destination mail server
- If a mail is sent to admin@apnic.net the sending mail agent looks up ‘apnic.net MX’
- MX record contains mail relays with priority
  - The lower the number the higher the priority
- Don’t add MX records without having a mail relay configured



Other data in the zone

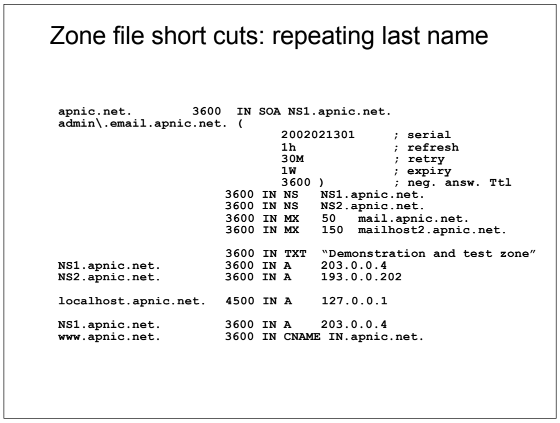
```
localhost.apnic.net. 3600  IN     A      127.0.0.1
NS1.apnic.net.       4500  IN     A      203.0.0.4
www.apnic.net.       3600  IN     CNAME  wasabi.apnic.net.
apnic.net.   3600   IN     MX     50     mail.apnic.net.
```

- Add all the other data to your zone file
- Some notes on notation
  - Note the fully qualified domain name including trailing dot
  - Note TTL and CLASS



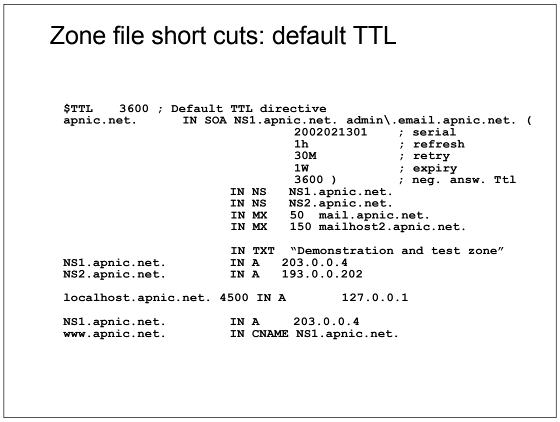
Zone file format short cuts nice formatting

```
apnic.net.        3600  IN SOA NS1.apnic.net.
admin\.email.apnic.net. (
                              2002021301    ; serial
                              1h            ; refresh
                              30M           ; retry
                              1W            ; expiry
                              3600 )        ; neg. answ. Ttl

apnic.net.            3600 IN NS   NS1.apnic.net.
apnic.net.            3600 IN NS   NS2.apnic.net.
apnic.net.            3600 IN MX   50   mail.apnic.net.
apnic.net.            3600 IN MX   150  mailhost2.apnic.net.

apnic.net.            3600 IN TXT  “Demonstration and test zone”
NS1.apnic.net.        4500 IN A    203.0.0.4
NS2.apnic.net.        3600 IN A    193.0.0.202
localhost.apnic.net.  3600 IN A    127.0.0.1

NS1.apnic.net.        3600 IN A     193.0.0.4
www.apnic.net.        3600 IN CNAME IN.apnic.net.
```



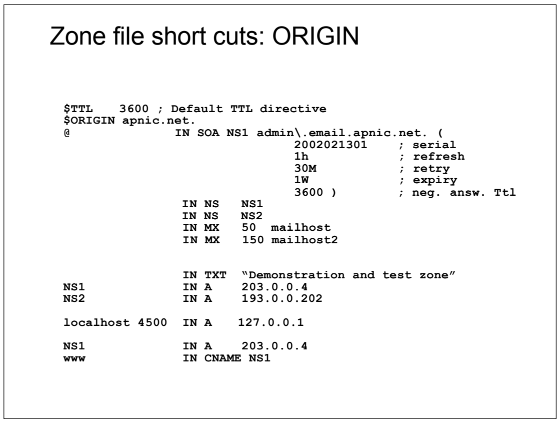
Zone file short cuts: repeating last name

```
apnic.net.        3600  IN SOA NS1.apnic.net.
admin\.email.apnic.net. (
                              2002021301     ; serial
                              1h             ; refresh
                              30M            ; retry
                              1W             ; expiry
                              3600 )         ; neg. answ. Ttl
                      3600 IN NS   NS1.apnic.net.
                      3600 IN NS   NS2.apnic.net.
                      3600 IN MX   50   mail.apnic.net.
                      3600 IN MX   150  mailhost2.apnic.net.

                      3600 IN TXT  "Demonstration and test zone"
NS1.apnic.net.        3600 IN A    203.0.0.4
NS2.apnic.net.        3600 IN A    193.0.0.202

localhost.apnic.net.  4500 IN A    127.0.0.1

NS1.apnic.net.        3600 IN A    203.0.0.4
www.apnic.net.        3600 IN CNAME IN.apnic.net.
```



Zone file short cuts: default TTL

```
$TTL    3600 ; Default TTL directive
apnic.net.      IN SOA NS1.apnic.net. admin\.email.apnic.net. (
                                2002021301    ; serial
                                1h            ; refresh
                                30M           ; retry
                                1W            ; expiry
                                3600 )        ; neg. answ. Ttl
                      IN NS   NS1.apnic.net.
                      IN NS   NS2.apnic.net.
                      IN MX   50  mail.apnic.net.
                      IN MX   150 mailhost2.apnic.net.

                      IN TXT  "Demonstration and test zone"
NS1.apnic.net.        IN A   203.0.0.4
NS2.apnic.net.        IN A   193.0.0.202

localhost.apnic.net. 4500 IN A       127.0.0.1

NS1.apnic.net.        IN A    203.0.0.4
www.apnic.net.        IN CNAME NS1.apnic.net.
```



Zone file short cuts: ORIGIN

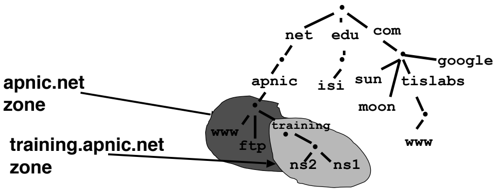
```
$TTL    3600 ; Default TTL directive
$ORIGIN apnic.net.
@              IN SOA NS1 admin\.email.apnic.net. (
                                2002021301    ; serial
                                1h            ; refresh
                                30M           ; retry
                                1W            ; expiry
                                3600 )        ; neg. answ. Ttl
                IN NS   NS1
                IN NS   NS2
                IN MX   50  mailhost
                IN MX   150 mailhost2


                IN TXT  "Demonstration and test zone"
NS1             IN A    203.0.0.4
NS2             IN A    193.0.0.202

localhost 4500  IN A   127.0.0.1

NS1             IN A    203.0.0.4
www             IN CNAME NS1
```

Zone file short cuts: Eliminate IN

```
$TTL    3600 ; Default TTL directive
$ORIGIN apnic.net.
@               SOA NS1 admin\.email.sanog.org. (
                                2002021301    ; serial
                                1h            ; refresh
                                30M           ; retry
                                1W            ; expiry
                                3600 )        ; neg. answ. Ttl
                NS   NS1
                NS   NS2
                MX   50  mailhost
                MX   150 mailhost2


                TXT  "Demonstration and test zone"
NS1             A    203.0.0.4
NS2             A    193.0.0.202

localhost 4500  A    127.0.0.1

NS1             A    203.0.0.4
www             CNAME NS1
```

Delegating a zone (becoming a parent)

- Delegate authority for a sub domain to another party (splitting of *training.apnic.net* from *apnic.net*)



Concept: Glue

- Delegation is done by adding NS records:

```
training.apnic.net.    NS ns1.training.apnic.net.
training.apnic.net.    NS ns2.training.apnic.net.
training.apnic.net.    NS ns1.apnic.net.
training.apnic.net.    NS ns2.apnic.net.
```

- How to get to ns1 and ns2… We need the addresses
- Add glue records to so that resolvers can reach ns1 and ns2

```
ns1.training.apnic.net. A 10.0.0.1
ns2.training.apnic.net. A 10.0.0.2
```

Concept: Glue contd.

- Glue is ‘non-authoritative’ data
- Don’t include glue for servers that are not in sub zones

```
training.apnic.net.    NS     ns1.training.apnic.net.
Training.apnic.net.    NS     ns2.training.apnic.net.

training.apnic.net.    NS     ns2.apnic.net.
training.apnic.net.    NS     ns1.apnic.net.
ns1.training.apnic.net. A  10.0.0.1
Ns2.training.apnic.net. A  10.0.0.2
```

Only this record needs glue

Delegating training.apnic.net. from apnic.net.

training.apnic.net

Setup minimum two servers

Create zone file with NS records

Add all training.apnic.net data

apnic.net

Add NS records and glue

Make sure there is no other data from the training.apnic.net. zone in the zone file

Questions ?