Introduction to the DNS system

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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 Charter Street, Redwood City CA, 94063
    - 204.152.187.11, +1-650-381-6003

- A “name” is how an endpoint is referenced
  - Typically, no structurally significant hierarchy
    - “David”, “Tokyo”, “itu.int”

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 reated 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

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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

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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 protocols can use either UDP or TCP
  - If UDP, DNS protocol handles retransmission, sequencing, etc.

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

DNS Concepts

- Next slides are about concepts
- After this set of slides you should understand
  - How the DNS is built
  - Why it is built the way it is
  - The terminology used throughout the course

Concept: DNS Names 1

- The namespace needs to be made hierarchical to be able to scale.
- The idea is to name objects based on
  - location (within country, set of organizations, set of companies, etc)
  - unit within that location (company within set of company, etc)
  - object within unit (name of person in company)

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Concept: DNS Names 2
How names appear in the DNS

Fully Qualified Domain Name (FQDN)

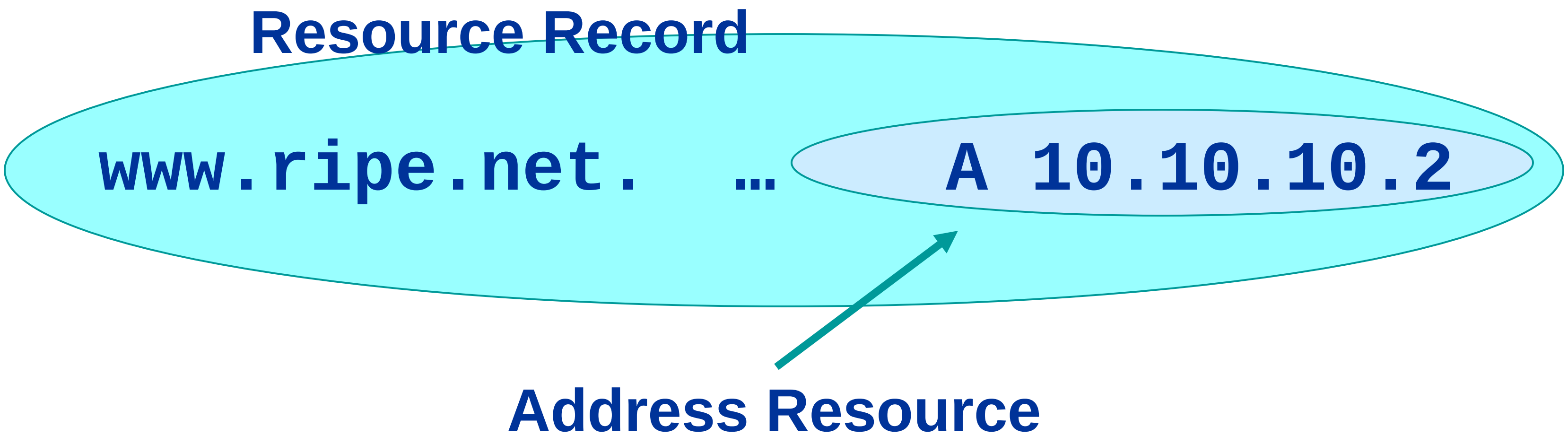
`WWW.RIPE.NET.`

Note the trailing dot

- 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

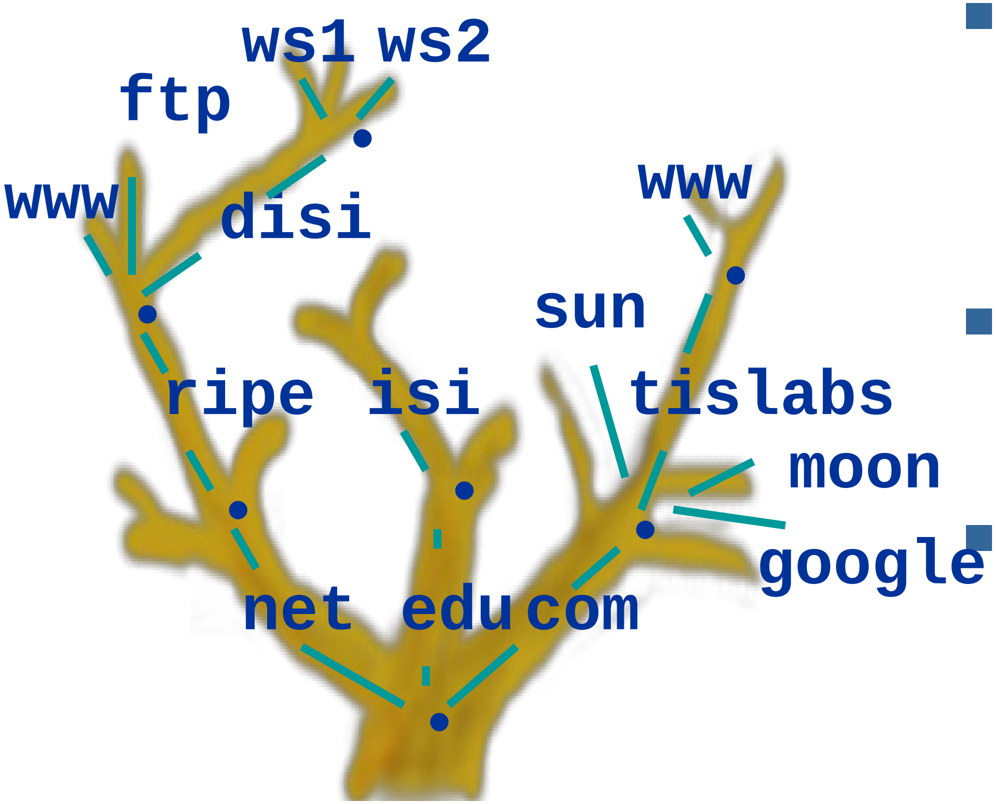
Concept: Resource Records

- The DNS maps names into data using Resource Records.



- More detail later

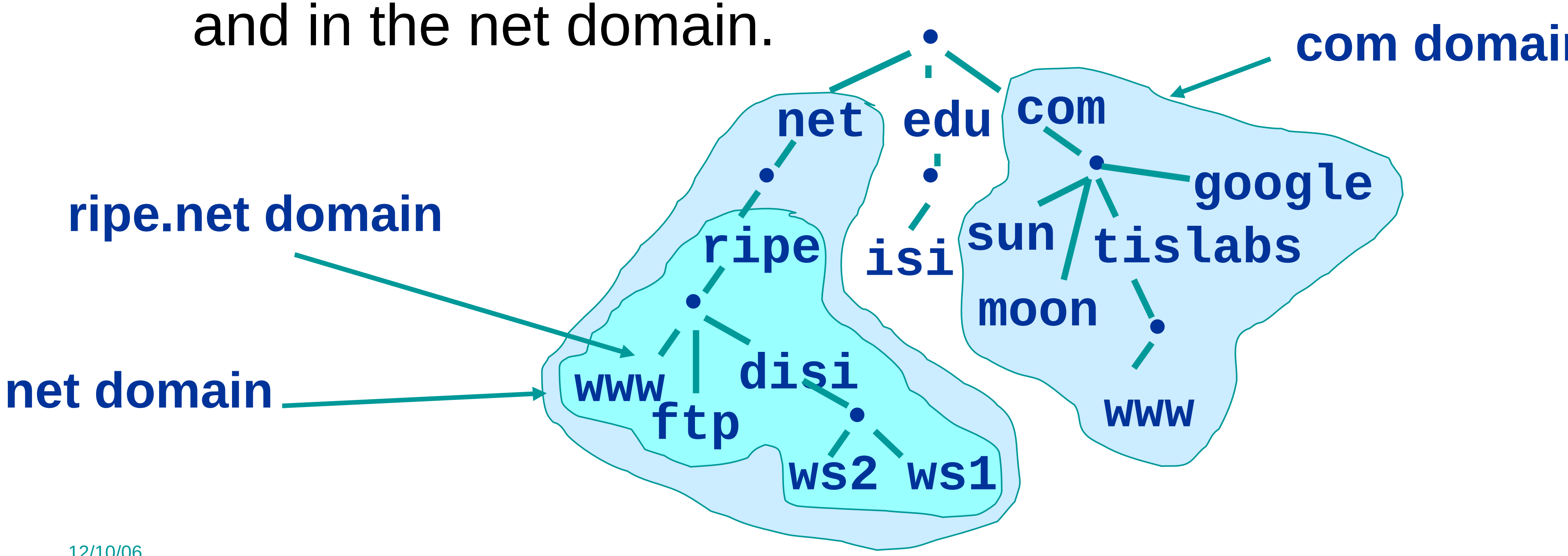
Concept: DNS Names 3



- Domain names can be mapped to a tree.
- New branches at the ‘dots’
- No restriction to the amount of branches.

Concept: Domains

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



com domai

ripe.net domain

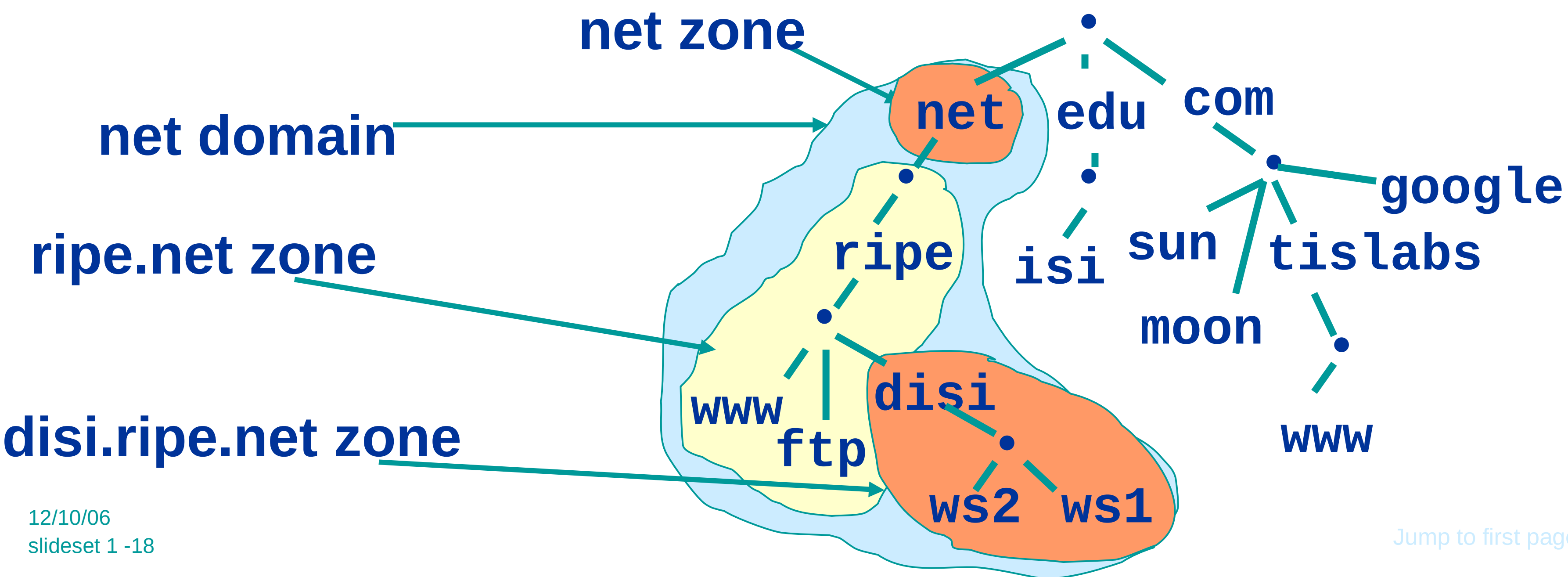
net domain

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



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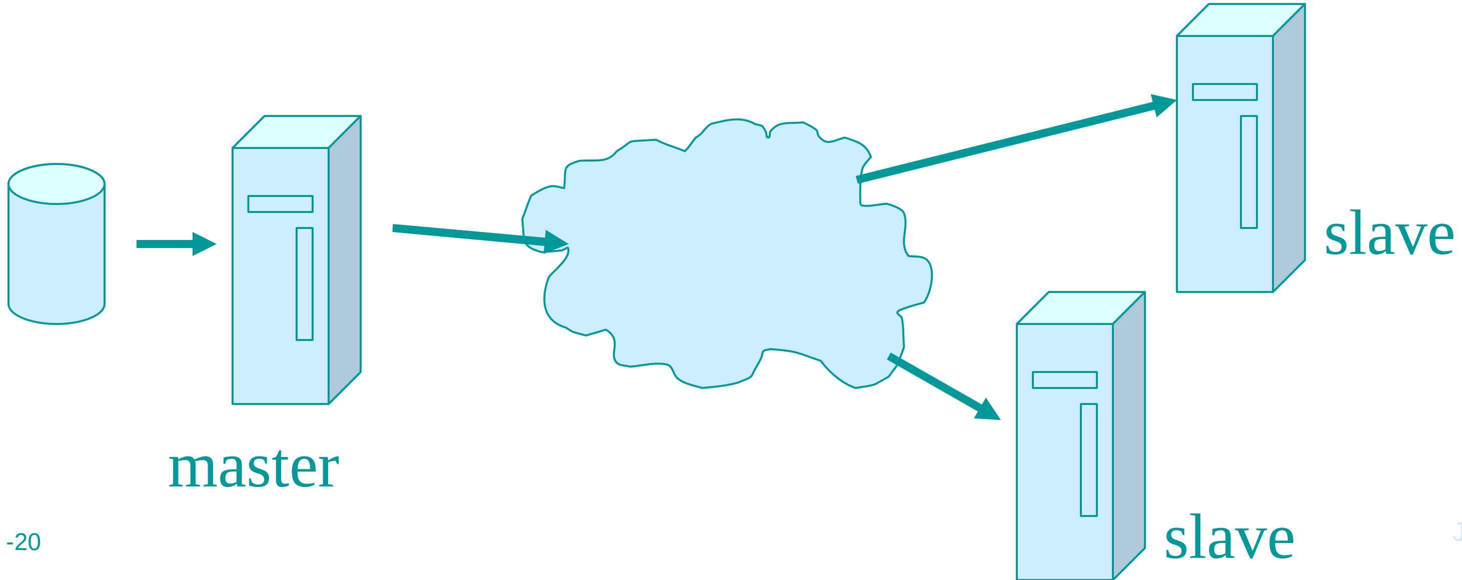
Concept: Name Servers

- 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 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 recursive server

- Recursive servers do the actual lookups; they 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);
```

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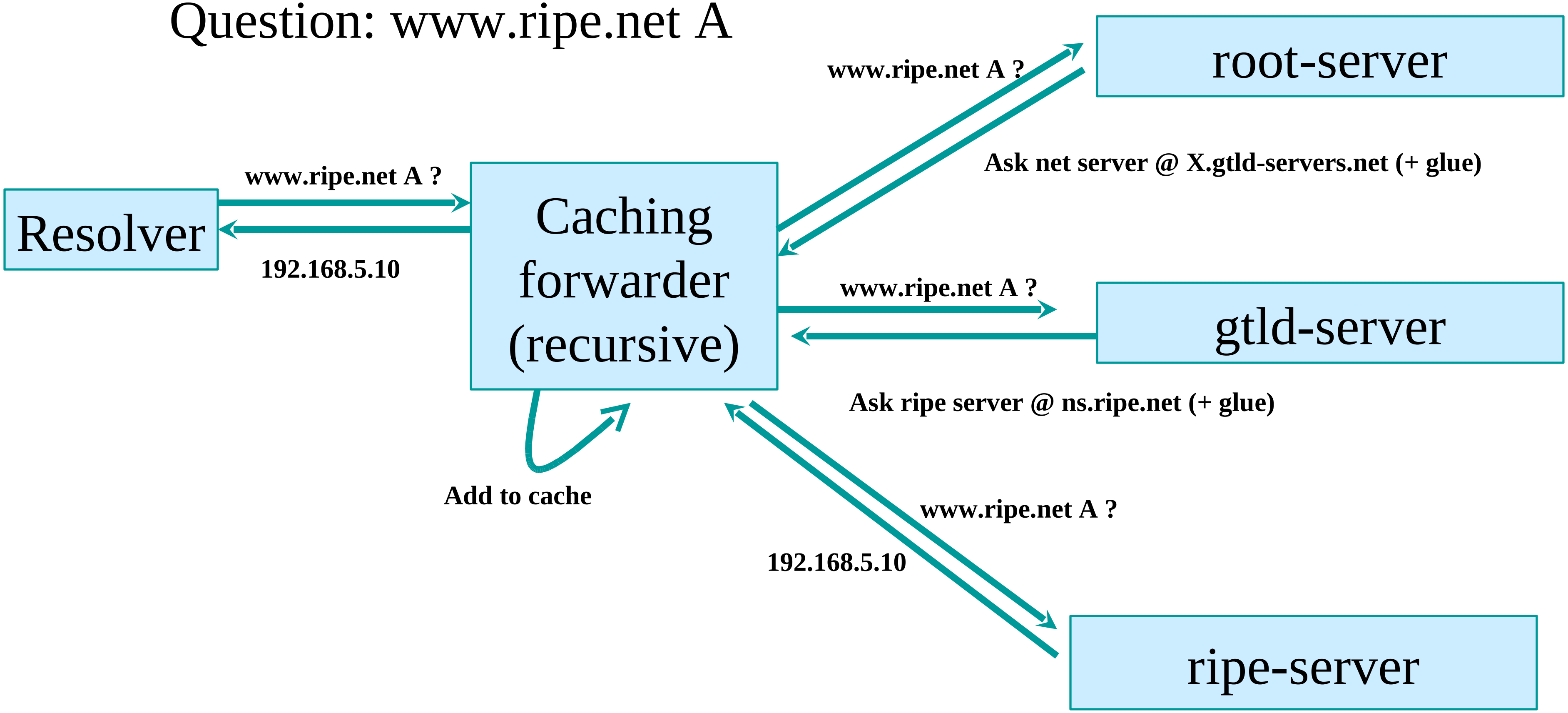
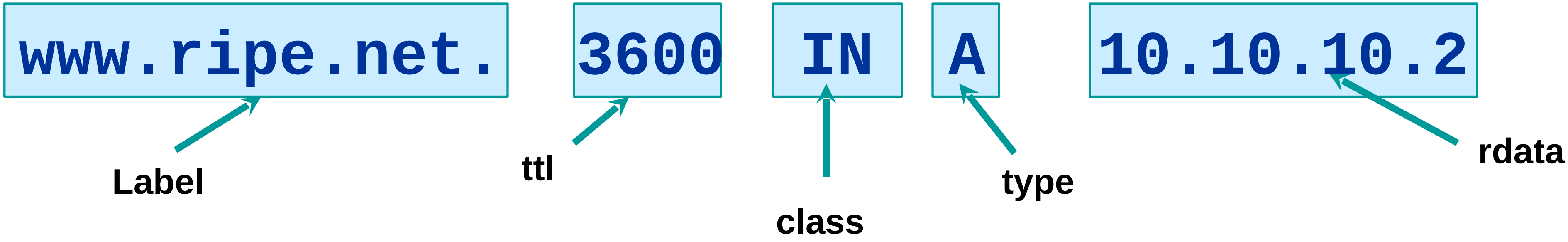
Concept: Resolving process & Cache

Question: www.ripe.net A



Concept: Resource Records (more detail)

- 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



www.ripe.net. 3600 IN A 10.10.10.2

Label

ttl

class

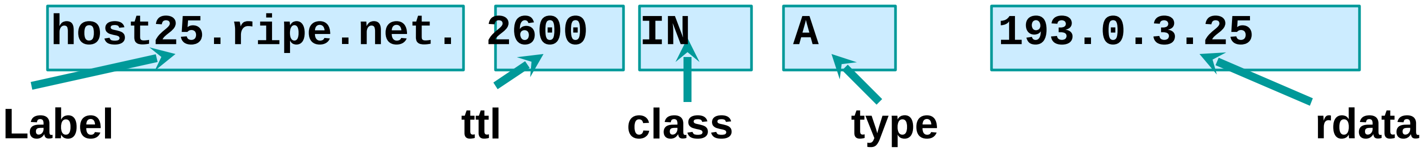
type

rdata

Example: RRs in a zone file

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

pinkje.ripe.net. 3600  IN     A      193.0.1.162
```



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

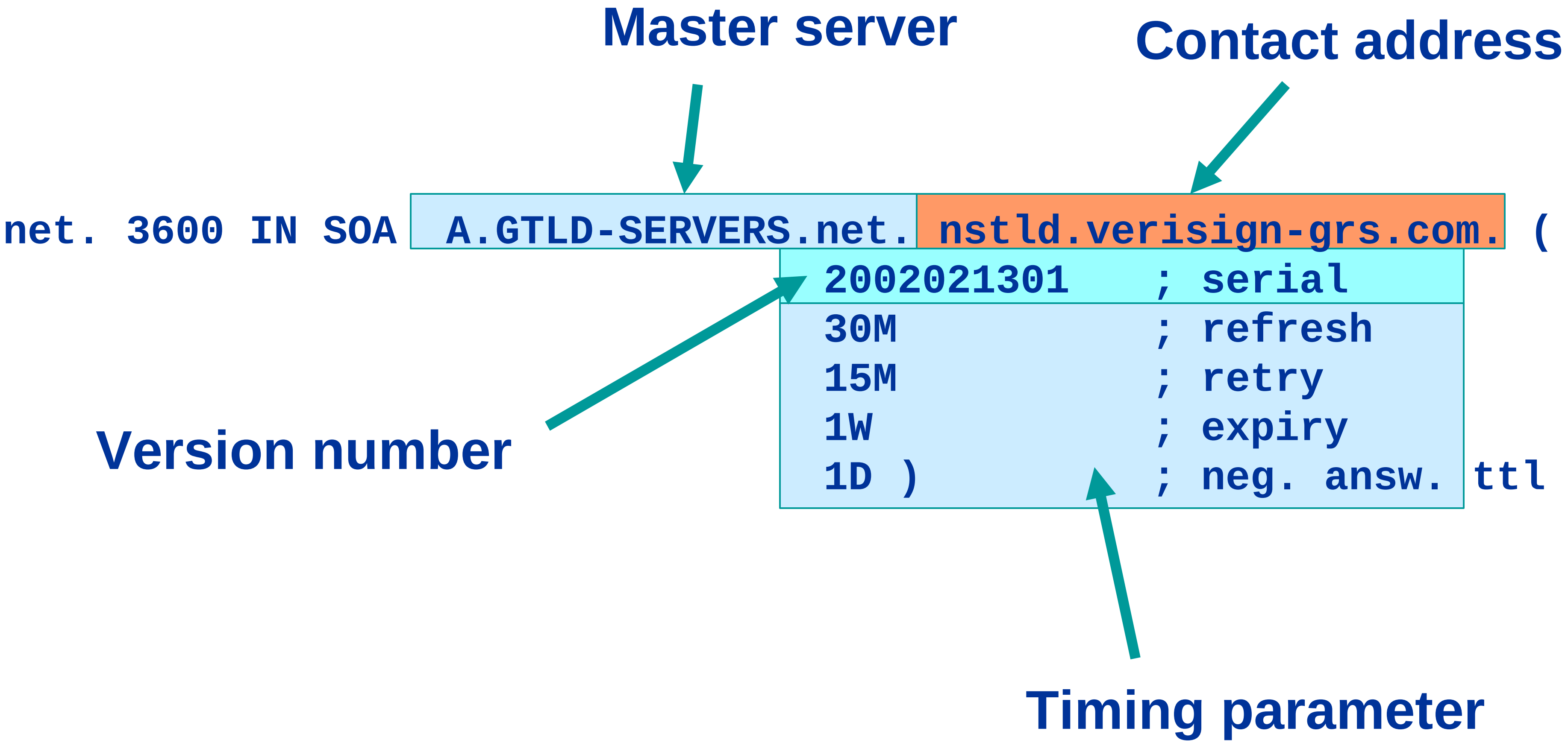
Resource Record: SOA and NS

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

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



Master server

Contact address

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

Version number

Timing parameter

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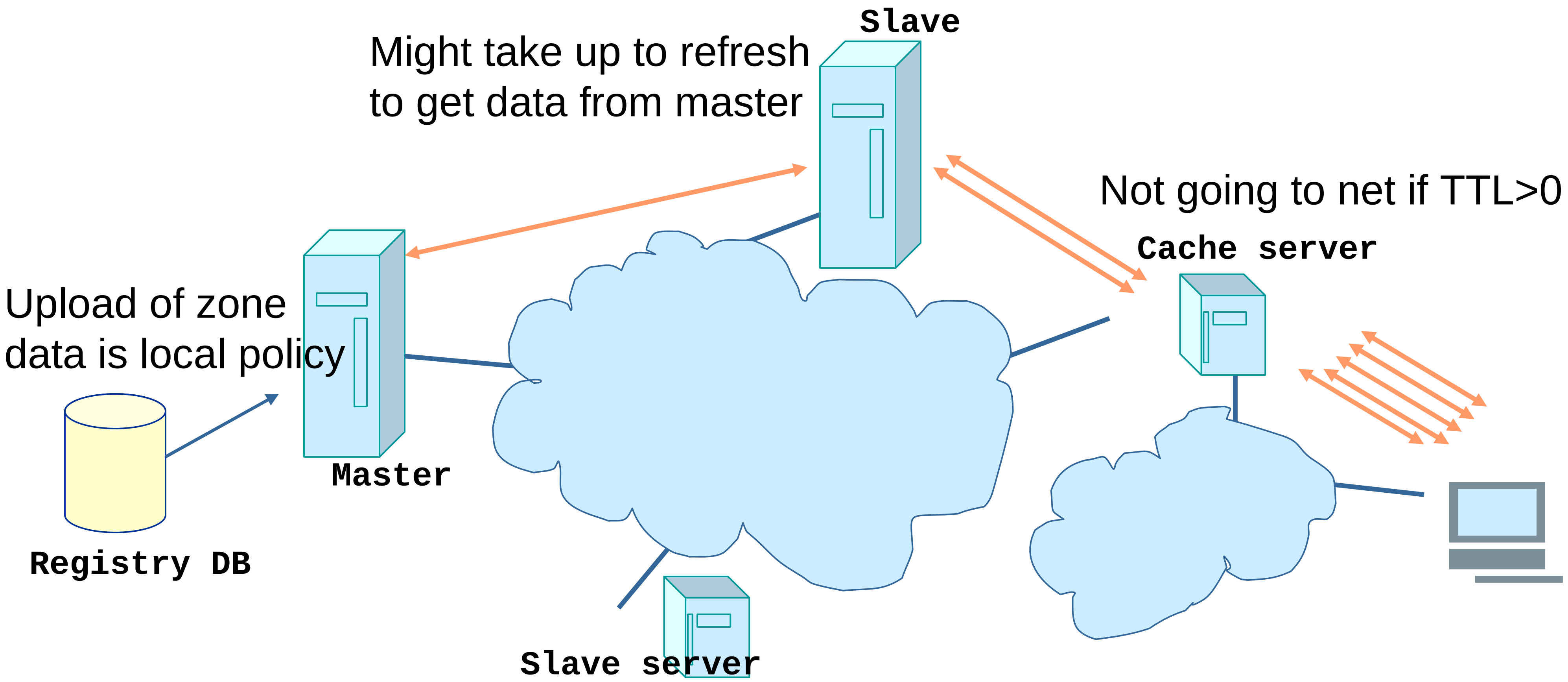
Concept: TTL and other Timers

- 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 in DNS do not propagate instantly!


Slave
Might take up to refresh to get data from master
Not going to net if TTL>0
Cache server
Upload of zone data is local policy
Master
Registry DB
Slave server

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
What are we about to learn

- We learned about the architecture:
  - 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

Line break

Comments

```
secret-wg.org. 3600 IN SOA bert.secret-wg.org. (
                                 olaf\.kolkman.ripe.net.
                                 2002021301   ; serial
                                 1h           ; refresh
                                 30M          ; retry
                                 1W           ; expiry
                                 3600 )       ; neg. answ. ttl
```

- Olaf.Kolkman@ripe.net → olaf\.kolkman.ripe.net
- Serial number: 32bit circular arithmetic
  - People often use date format
  - To be increased after editing
- The timers above qualify as reasonable

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Authoritative NS records and related A records

```
secret-wg.org.              3600 IN NS  bert.secret-wg.org.
secret-wg.org.              3600 IN NS  NS2.secret-wg.org.
bert.secret-wg.org.         3600 IN A  193.0.0.4
NS2.secret-wg.org.          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.

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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

Intermezzo: MX record

- SMTP (simple mail transfer protocol) uses MX records to find the destination mail server.
- If a mail is sent to olaf@ripe.net the sending mail agent looks up ‘ripe.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.secret-wg.org. 3600 IN A 127.0.0.1

bert.secret-wg.org.  4500 IN A 193.0.0.4
www.secret-wg.org.   3600 IN CNAME bert.secret-wg.org.
```

- 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

```
secret-wg.org.             3600  IN SOA bert.secret-wg.org. (
                                        olaf\.kolkman.ripe.net.
                                        2002021301    ; serial
                                        1h            ; refresh
                                        30M           ; retry
                                        1W            ; expiry
                                        3600 )        ; neg. answ. Ttl
secret-wg.org.             3600 IN NS   bert.secret-wg.org.
secret-wg.org.             3600 IN NS   NS2.secret-wg.org.
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”
bert.secret-wg.org.        4500 IN A    193.0.0.4
NS2.secret-wg.org.         3600 IN A    193.0.0.202
localhost.secret-wg.org.    3600 IN A   127.0.0.1

bert.secret-wg.org.        3600 IN A     193.0.0.4
www.secret-wg.org.         3600 IN CNAME bert.secret-wg.org.
```

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Zone file format short cuts: repeating last name

```
secret-wg.org.           3600  IN SOA bert.secret-wg.org. (
                                      olaf\.kolkman.ripe.net.
                                      2002021301    ; serial
                                      1h            ; refresh
                                      30M           ; retry
                                      1W            ; expiry
                                      3600 )        ; neg. answ. Ttl
                         3600 IN NS   bert.secret-wg.org.
                         3600 IN NS   NS2.secret-wg.org.
                         3600 IN MX   50 mailhost.secret-wg.org.
                         3600 IN MX   150 mailhost2.secret-wg.org.

                         3600 IN LOC  ( 52 21 23.0 N 04 57 05.5 E
                                       0m 100m 100m 100m )
                         3600 IN TXT  “Demonstration and test zone”
bert.secret-wg.org.      3600 IN A    193.0.0.4
NS2.secret-wg.org.       3600 IN A    193.0.0.202

localhost.secret-wg.org.  4500 IN A    127.0.0.1

bert.secret-wg.org.      3600 IN A     193.0.0.4
www.secret-wg.org.       3600 IN CNAME bert.secret-wg.org.
```

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Zone file format short cuts: default TTL

```
$TTL    3600 ; Default TTL directive
secret-wg.org.          IN SOA bert.secret-wg.org. (
                                       olaf\.kolkman.ripe.net.
                                       2002021301    ; serial
                                       1h            ; refresh
                                       30M           ; retry
                                       1W            ; expiry
                                       3600 )        ; neg. answ. Ttl
                        IN NS   bert.secret-wg.org.
                        IN NS   NS2.secret-wg.org.
                        IN MX   50 mailhost.secret-wg.org.
                        IN MX   150 mailhost2.secret-wg.org.

                        IN LOC  ( 52 21 23.0 N 04 57 05.5 E
                                        0m 100m 100m 100m )
                        IN TXT  “Demonstration and test zone”
bert.secret-wg.org.     IN A    193.0.0.4
NS2.secret-wg.org.      IN A    193.0.0.202

localhost.secret-wg.org. IN A          127.0.0.1

bert.secret-wg.org. 4500 IN A     193.0.0.4
www.secret-wg.org.      IN CNAME bert.secret-wg.org.
```

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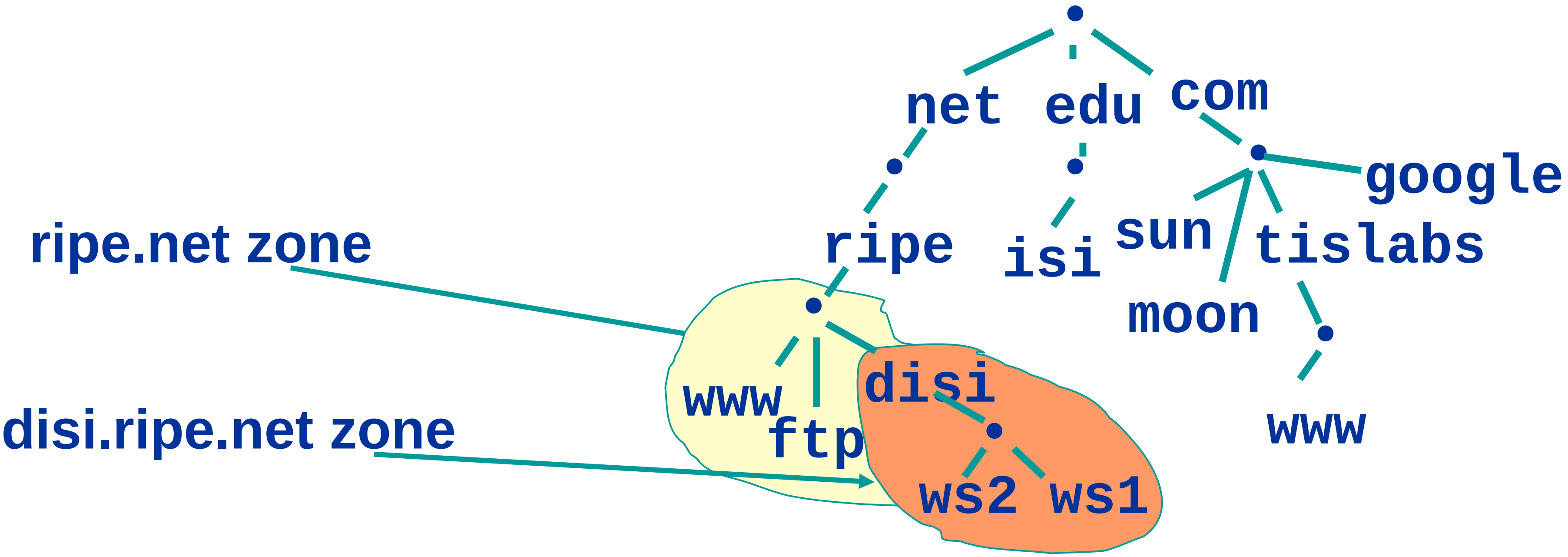
Zone file format short cuts: ORIGIN

```
$TTL   3600 ; Default TTL directive
$ORIGIN secret-wg.org.
@              IN SOA bert (
                                      olaf\.kolkman.ripe.net.
                                      2002021301     ; serial
                                      1h             ; refresh
                                      30M            ; retry
                                      1W             ; expiry
                                      3600 )         ; neg. answ. Ttl
                IN NS   bert
                IN NS   NS2
                IN MX   50 mailhost
                IN MX   150 mailhost2

                IN LOC  ( 52 21 23.0 N 04 57 05.5 E
                          0m 100m 100m 100m )
                       IN TXT  “Demonstration and test zone”
bert            IN A    193.0.0.4
NS2             IN A    193.0.0.202

localhost       IN A   127.0.0.1

bert      4500  IN A     193.0.0.4
www             IN CNAME bert
```

Delegating a zone (becoming a parent)

- Delegate authority for a sub domain to another party (splitting of disi.ripe.net from ripe.net)



Concept: Glue

- Delegation is done by adding NS records:

```
disi.ripe.net.    NS   ns1.disi.ripe.net.
disi.ripe.net.    NS   ns2.disi.ripe.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.disi.ripe.net. A 10.0.0.1
ns2.disi.ripe.net. A 10.0.0.2
```

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Concept: Glue (continued)

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

```
disi.ripe.net.      NS    ns1.disi.ripe.net.
disi.ripe.net       NS    ns2.ripe.net.
disi.ripe.net       NS    ns.bert.secret-wg.org.
ns1.disi.ripe.net.  A     10.0.0.1
```

Only this record needs glue

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Delegating disi.ripe.net. from ripe.net.

disi.ripe.net

- Setup minimum two servers
- Create zone file with NS records
- Add all disi.ripe.net data

ripe.net

- Add NS records and glue
- Make sure there is no other data from the disi.ripe.net. zone in the zone file.`

Becoming a child
In general

- Buy your domain at favorite registry
- Set up your name servers
- Register the name servers: your registry will communicate the name servers to the registrar who will make sure the name servers are published.
    - This process might take hours-days.
- Registrars may require a sensible setup

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