FOUNDATION OF WEB DEVELOPMENT

Domain Name System (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**

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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”

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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Exercise

- Is DNS security critical?
- What would happen if it is not:
  - Confidential?
  - High integrity?
  - Available?

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
    - However, client does not know current number for zone apriori
- 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

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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)

Concept: DNS Names 2
How names appear in the DNS

Fully Qualified Domain Name (FQDN)

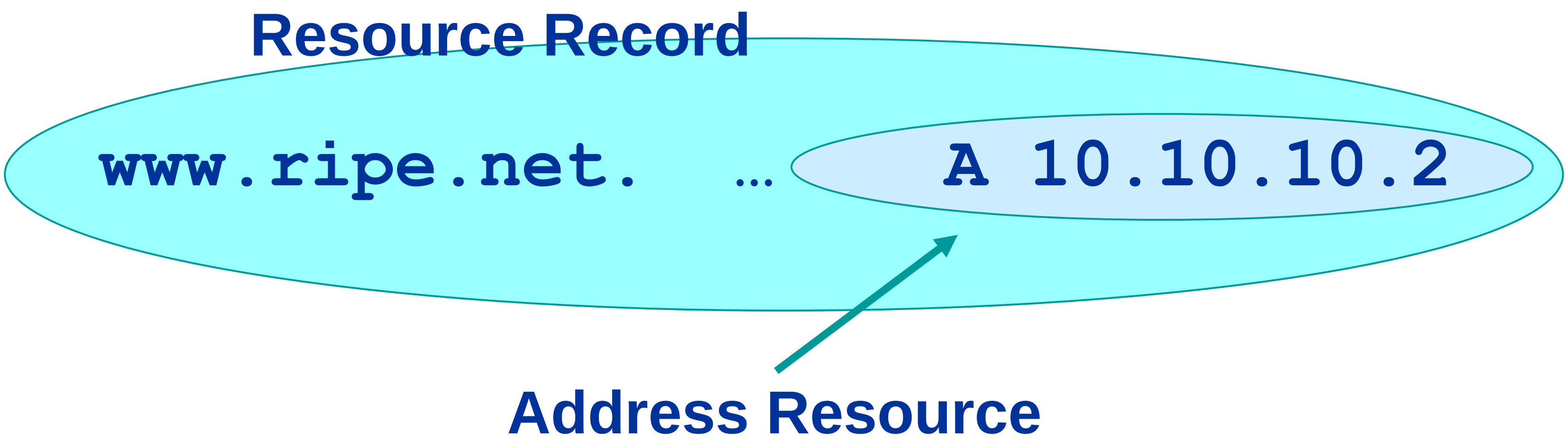
WWW.RIPE.NET.

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.



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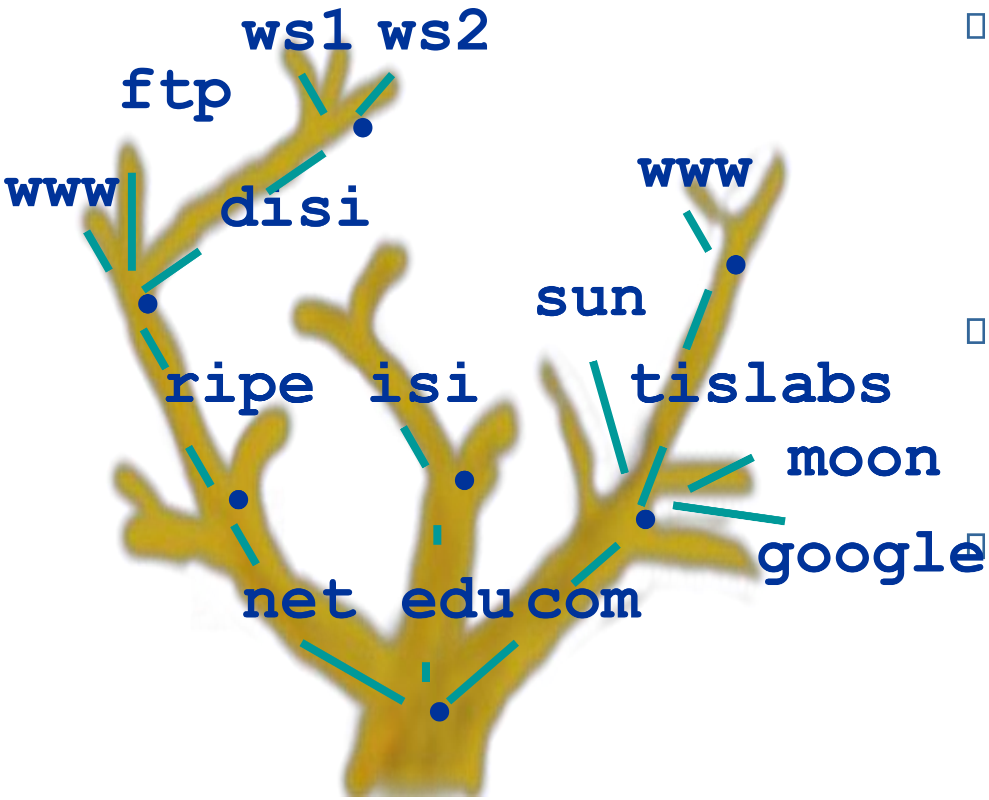
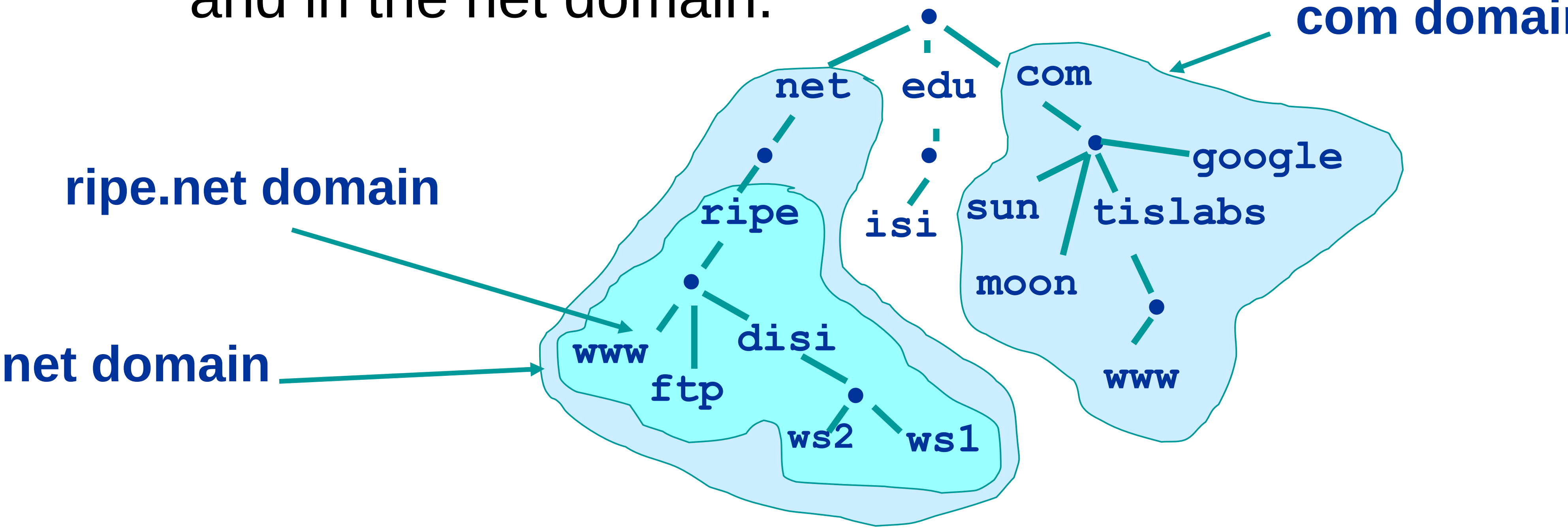
DNS Name Hierarchy



- 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

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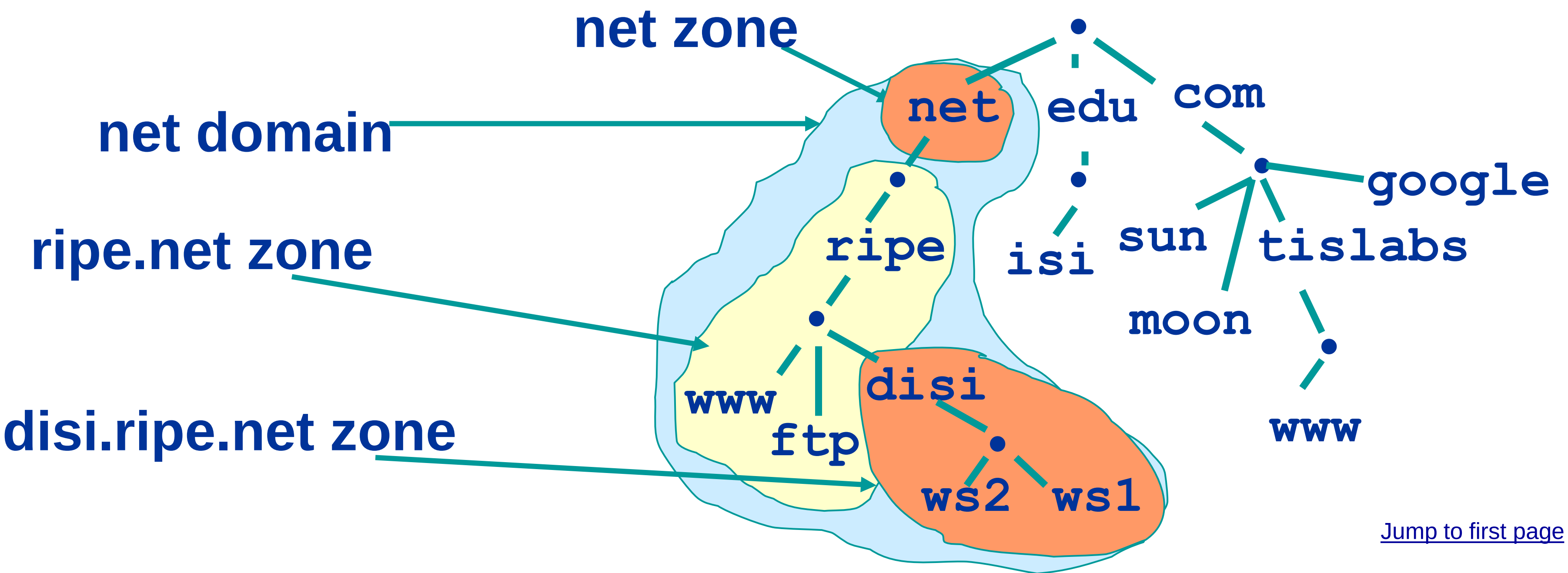
Delegation

- 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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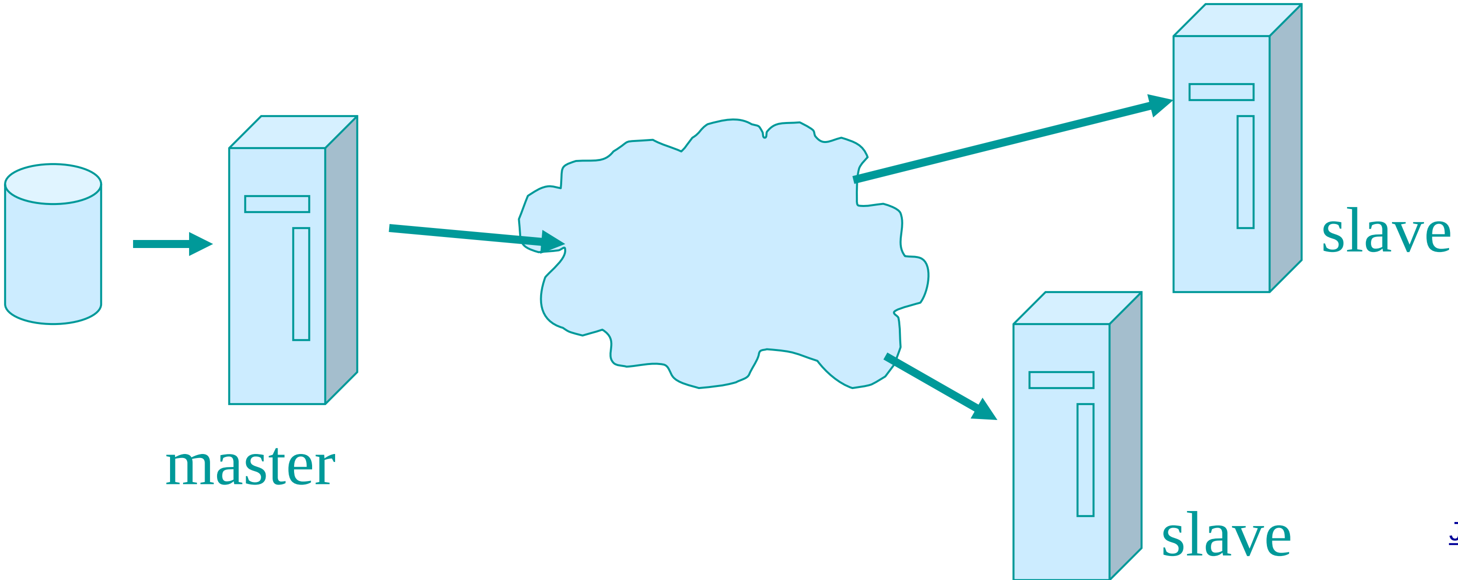
Name Servers

- 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

Authoritative name servers

- 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



Recursive Name Servers

- 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

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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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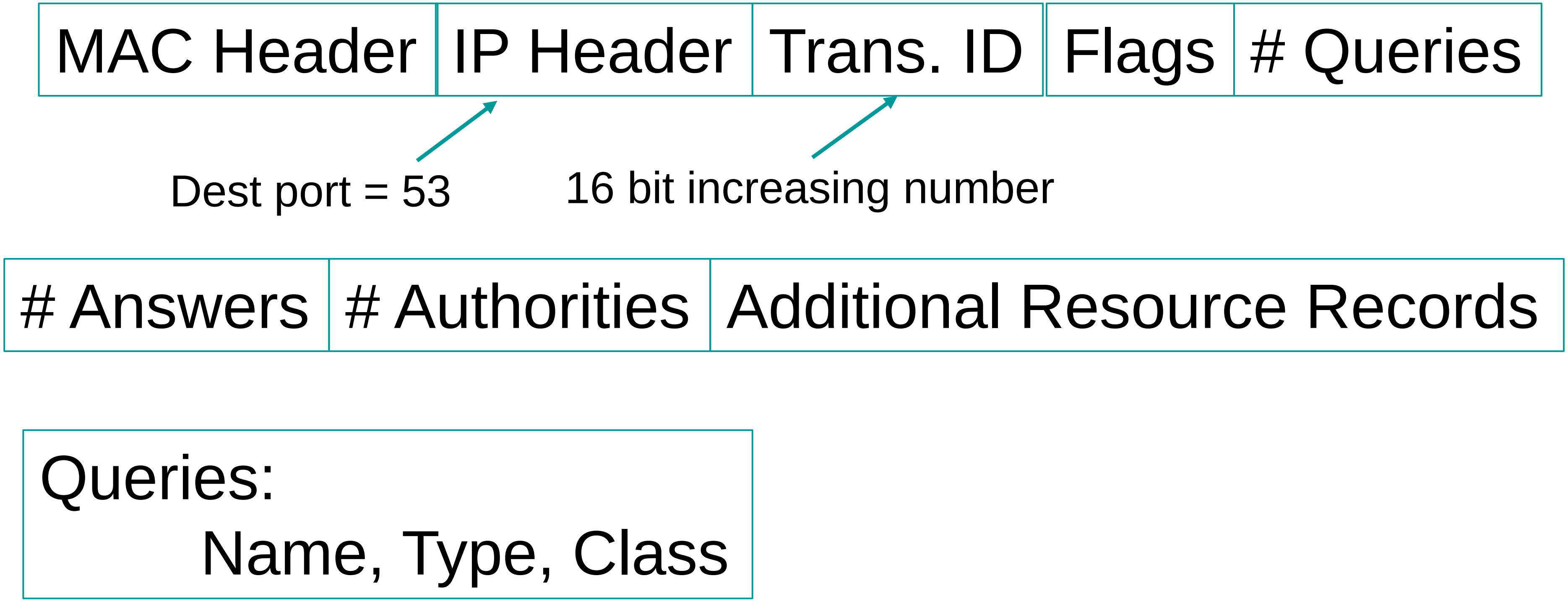
DNS Query Format

- Operates over UDP, destination port is 53



MAC Header | IP Header | Trans. ID | Flags | # Queries

Dest port = 53

16 bit increasing number

# Answers | # Authorities | Additional Resource Records

Queries:
Name, Type, Class

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DNS Flags

- 16 bits that identify the type of DNS record
  - Bit 1: query or response
  - Bit 2-5:Standard or inverse (lookup name of IP addr)
  - Bit 6: Is answer authoritative
  - Bit 7: Truncation
  - Bit 8: Query recursively
  - Bit 9: recursion available
  - Bits 10/12: reserved
  - Bit 11: Authority was auth. by sending server
  - Bits 13-16: error reporting

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Types of resolvers

- Root servers
- TLD servers
- Resellers
- Individual Domains
- Internet Registries (must be ICANN registered)

Requirements for registration

- Satisfy top-level requirements
  - E.g. for .ca must be Canadian person, business, or organization
- Claim to the domain (WWF vs WWE)
  - First come first serve
- Must verify ownership of IP resources/name server resources
- Sign registrant agreement
- Authorization code (if transferring)

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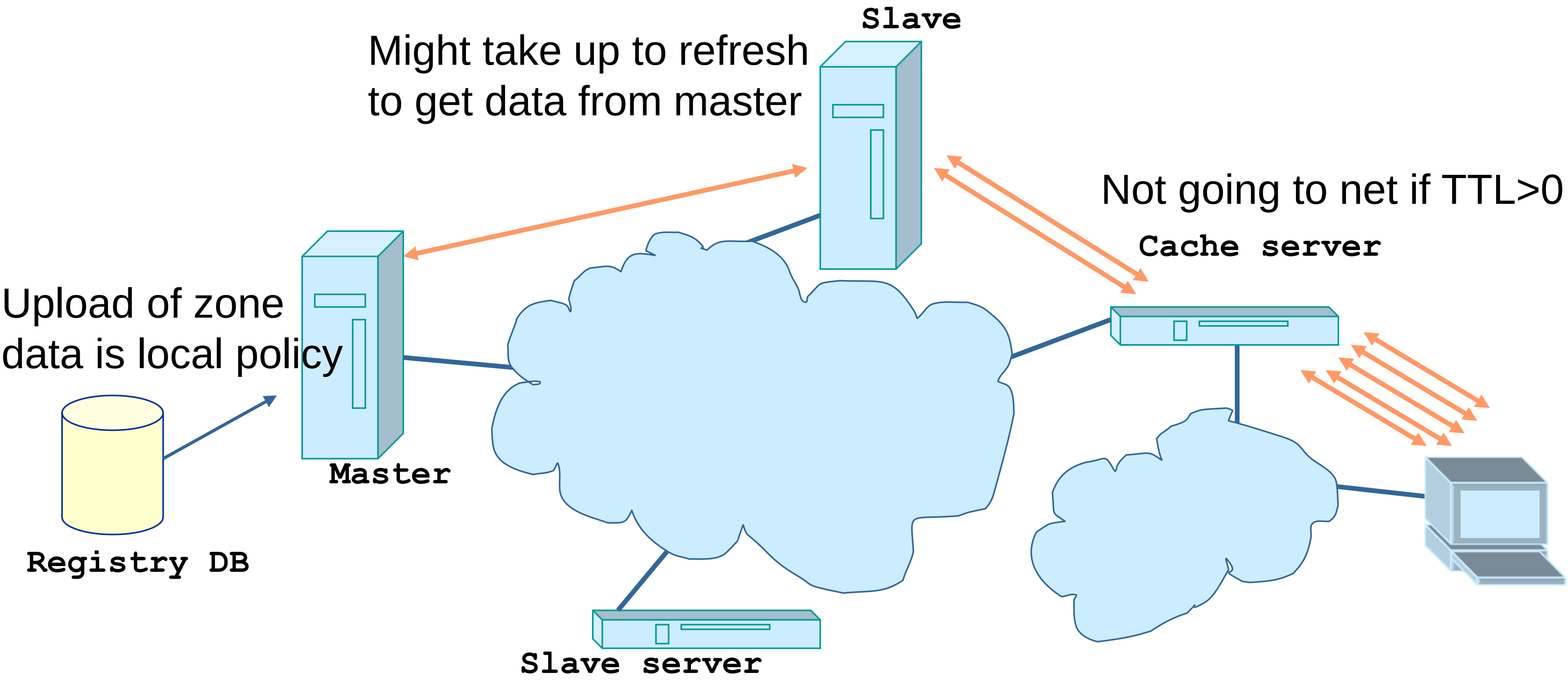
Places where DNS data lives

Changes in DNS 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

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

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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.

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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

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