PART XXIII

DOMAIN NAME SYSTEM (DNS)

Names For Computers

- Humans prefer pronounceable names rather than numeric addresses

- Two possibilities

  - Flat namespace

  - Hierarchical namespace

Naming Hierarchy

- Two possibilities

    - According to network topology

    - By organizational structure (independent of physical networks)

- Internet uses the latter

Internet Hierarchy

In a TCP/IP internet, hierarchical machine names are assigned according to the structure of organizations that obtain authority for parts of the namespace, not necessarily according to the structure of the physical network interconnections.

Internet Domain Names

- Flexible hierarchy

    - Universal naming scheme (same everywhere)

    - Each organization determines internal naming structure

- Mechanism known as *Domain Name System* (*DNS*)

- Name assigned to a computer known as *domain name*

Domain Name Syntax

- Set of *labels* separated by delimiter character (period)

- Example

$$cs \textbf{.} purdue \textbf{.} edu$$

- Three labels: *cs*, *purdue*, and *edu*

- String *purdue* **.** *edu* is also a domain

- Top-level domain is *edu*

Original Top-Level Domains

| Domain Name	Assigned To
com	Commercial organizations
edu	Educational institutions (4-year)
gov	Government institutions
mil	Military groups
net	Major network support centers
org	Organizations other than those above
arpa	Temporary ARPANET domain (obsolete)
int	International organizations
country code	Each country (geographic scheme)

- Meaning assigned to each

- Three domains considered generic
  .com
  .net
  .org

New Top-Level Domains

Domain Name	Assigned To
aero	Air-Transport Industry
biz	Businesses
coop	Non-Profit Cooperatives
info	Unrestricted
museum	Museums
name	Individuals
pro	Professionals (accountants, lawyers, physicians)

- Proponents argued (incorrectly) that DNS would collapse without additional TLDs

- New TLDs created legal nightmare

Illustration Of Part Of The DNS Tree
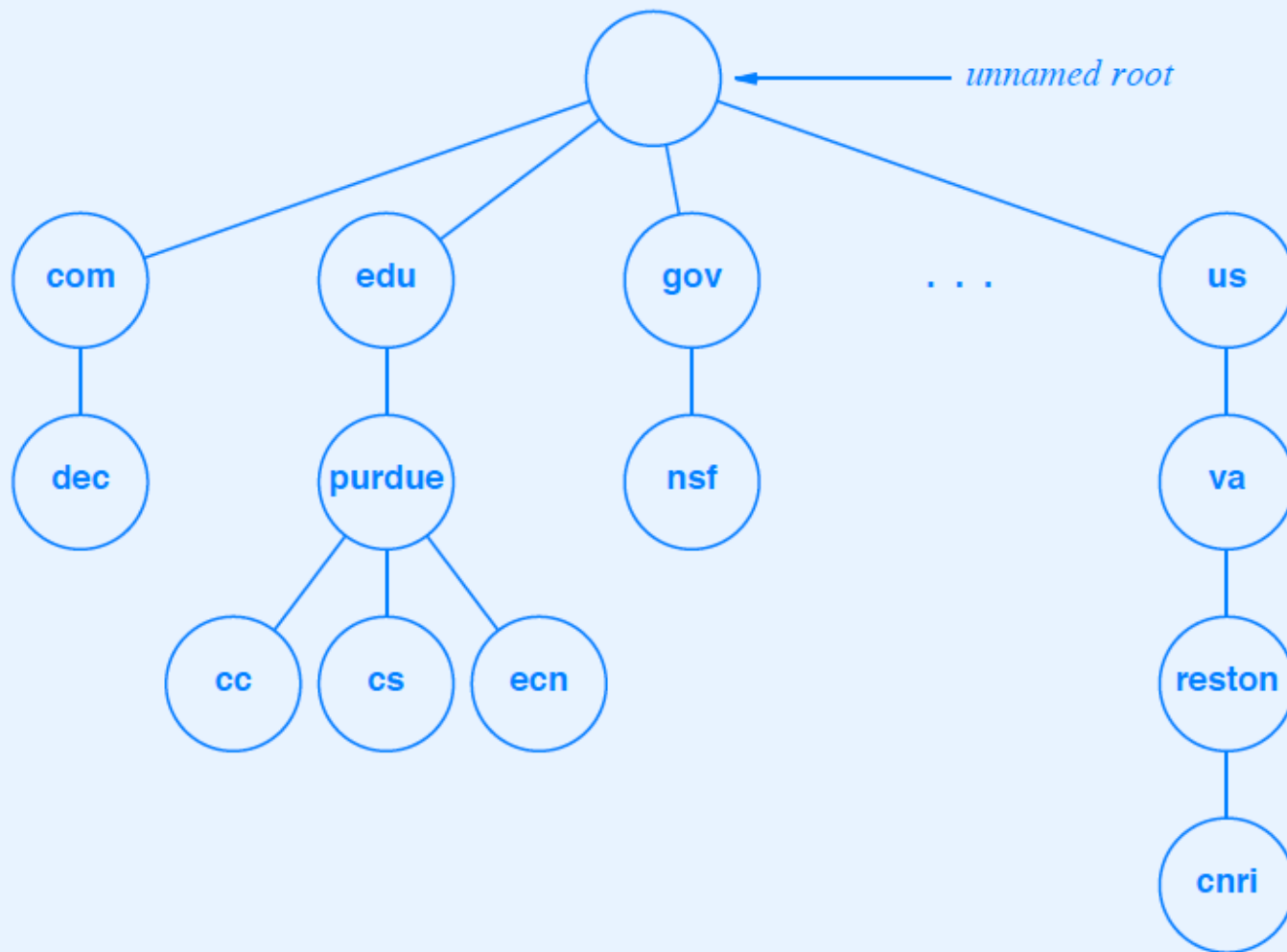
Authority For Names

- Authority delegated down the tree

- Example

    - Purdue University registers under top level domain *.edu* and receives authority for domain *purdue .edu*

    - Computer Science Department at Purdue registers with the Purdue authority, and becomes the authority for *cs .purdue .edu*

    - Owner of a lab in the CS Department registers with the departmental authority, and becomes the authority for *xinu .cs .purdue .edu*

DNS Database

- Record has (name, class)

- Class specifies type of object (e.g., computer, email exchanger)

- Consequence:

A given name may map to more than one item in the domain system. The client specifies the type of object desired when resolving a name, and the server returns objects of that type.
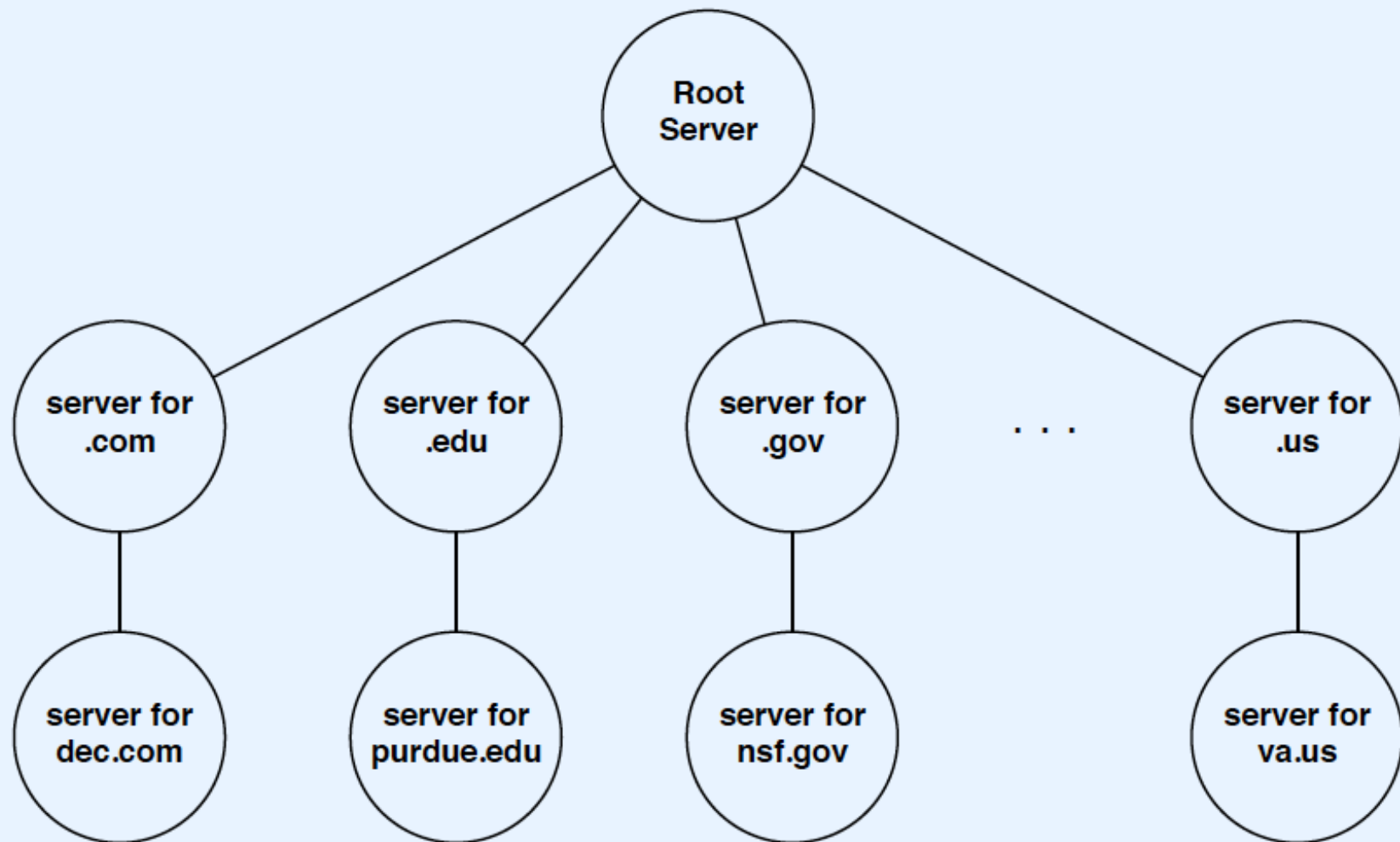
Mapping Domain Names To Addresses

- DNS uses a set of on-line servers

- Servers arranged in tree

- Given server can handle entire subtree

    - Example: ISP manages domain names for its clients (including corporations)

Terminology

- DNS server known as *name server*

- DNS client software known as *resolver*

Illustration Of Topology Among DNS Servers

In Practice

- Single server can handle multiple levels of the naming tree

- Example: root server handles all top-level domains

Domain Name Resolution

- Conceptually, must search from root of tree downward

- In practice

  - Every name server knows location of a root server

  - Only contacts root if no subdomain known

  - Lookup always starts with local server first (host can learn address of DNS server from DHCP)

Efficient Translation

- Facts

    - Most lookups refer to local names

    - Name-to-address bindings change infrequently

    - User is likely to repeat same lookup

- To increase efficiency

    - Initial contact begins with local name server

   - Every server caches answers (owner specifies cache timeout)

Domain Server Message Format

0	16	31

IDENTIFICATION	PARAMETER
NUMBER OF QUESTIONS	NUMBER OF ANSWERS
NUMBER OF AUTHORITY	NUMBER OF ADDITIONAL

QUESTION SECTION . . .
ANSWER SECTION . . .
AUTHORITY SECTION . . .
ADDITIONAL INFORMATION SECTION . . .

Parameter Bits

Bit of PARAMETER field	Meaning
0	Operation:
	0 Query
	1 Response
1-4	Query Type:
	0 Standard
	1 Inverse
	2 Server status request
	3 Completion (now obsolete)
	4 Notify
	5 Update
5	Set if answer authoritative
6	Set if message truncated
7	Set if recursion desired
8	Set if recursion available
9	Set if data is authenticated
10	Set if checking is disabled
11	Reserved
12-15	Response Type:
	0 No error
	1 Format error in query
	2 Server failure
	3 Name does not exist
	5 Refused
	6 Name exists when it should not
	7 RR set exists
	8 RR set that should exist does not
	9 Server not authoritative for the zone
	10 Name not contained in zone

Format Of Question Section

0	16	31
QUERY DOMAIN NAME ...		
QUERY TYPE		QUERY CLASS
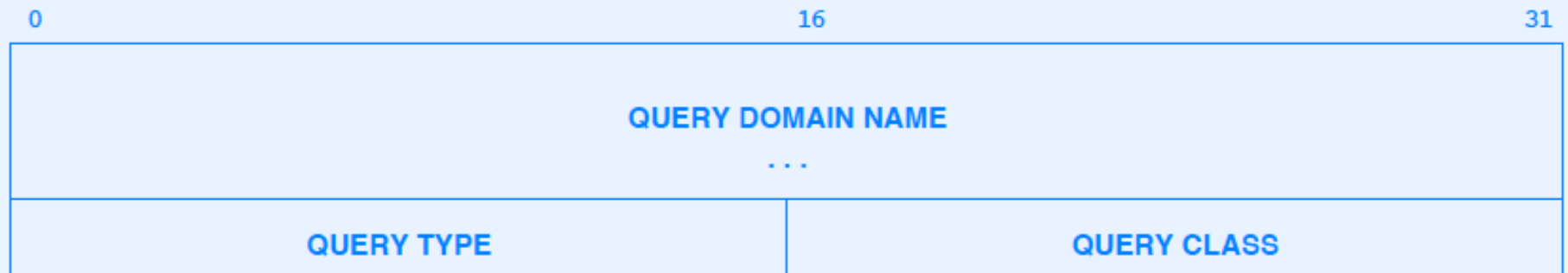
Format Of Resource Records

0	16	31

RESOURCE DOMAIN NAME ...	
TYPE	CLASS
TIME TO LIVE	
RESOURCE DATA LENGTH	
RESOURCE DATA ...	
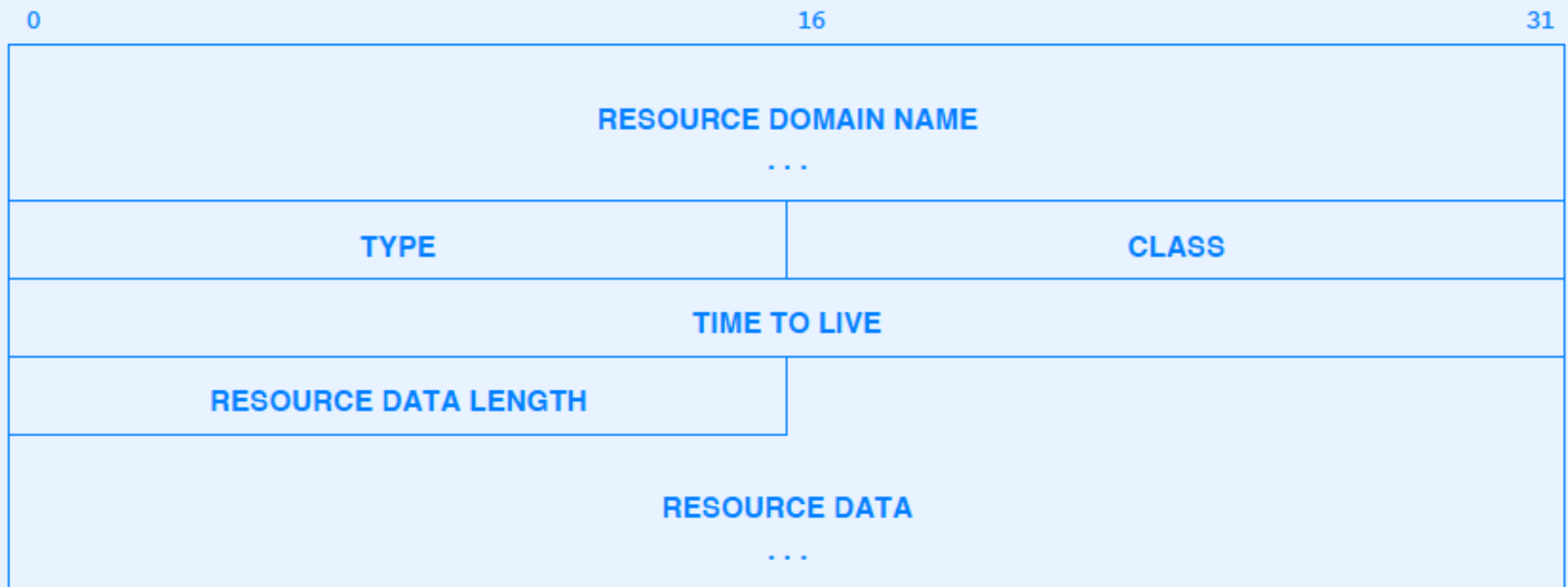
Abbreviation Of Domain Names

- DNS only recognizes full domain names

- Client software allows abbreviation

Example Of Domain Name Abbreviation

- Client configured with suffix list

    - .cs .purdue .edu

    - .cc .purdue .edu

    - .purdue .edu

    - *null*

- User enters abbreviation *xinu*

- Client tries the following in order

    - xinu. cs .purdue .edu

    - xinu. cc .purdue .edu

    - xinu. purdue .edu

    - xinu

The Point About Abbreviation

The Domain Name System only maps full domain names into addresses; abbreviations are not part of the Domain Name System itself, but are introduced by client software to make local names convenient for users.

Inverse Query

- Map in reverse direction

- Excessive overhead

- May not have unique answer

- Not used in practice

Pointer Query

- Special case of inverse mapping

- Convert IP address to domain name

- Trick: write IP address as a string and look up as a name

Example Of Pointer Query

- Start with dotted decimal address such as

$$aaa.bbb.ccc.ddd$$

- Rearrange dotted decimal representation as a string:

$$ddd.ccc.bbb.aaa.in\text{-}addr.arpa$$

- Look up using a *pointer query* type

Object Types That DNS Supports

Type	Meaning	Contents
A	Host Address	32-bit IP address
CNAME	Canonical Name	Canonical domain name for an alias
HINFO	CPU & OS	Name of CPU and operating system
MINFO	Mailbox info	Information about a mailbox or mail list
MX	Mail Exchanger	16-bit preference and name of host that acts as mail exchanger for the domain
NS	Name Server	Name of authoritative server for domain
PTR	Pointer	Domain name (like a symbolic link)
SOA	Start of Authority	Multiple fields that specify which parts of the naming hierarchy a server implements
TXT	Arbitrary text	Uninterpreted string of ASCII text
AAAA	Host Address	128-bit IPv6 address

Summary

- Domain Name System provides mapping from pronounceable names to IP addresses

- Domain names are hierarchical; top-level domains are dictated by a central authority

- Organizations can choose how to structure their domain names

- DNS uses on-line servers to answer queries

- Lookup begins with local server, which caches entries