CS 372 Lecture #13

The Application Layer:

- Domain Name Services (dns)

Note: Many of the lecture slides are based on presentations that accompany
Computer Networking: A Top Down Approach, 6th edition,
by Jim Kurose & Keith Ross, Addison-Wesley, 2013.

Addresses in an internet

- Every host that is connected to any network has a unique hardware address
  - 12 hexadecimal digits, assigned by the manufacturer of the network interface device
    - e.g., 90e612a73d
  - used at the physical layer
  - not practical for internet addressing
- IANA assigns internet protocol (IP) network addresses to service providers, etc., to be managed hierarchically
  - e.g., 128.192.0.0 (IP version 4)
- Service providers assign IP addresses to individual subscribers, and bind these IP addresses to subscriber hardware addresses.
  - e.g., 128.192.35.172 (IPv4 dotted-decimal notation)
- Much more later about IP addressing (IPv4 and IPv6)

The need for naming

- All applications use IP addresses through the TCP/IP protocol software
- Numeric addresses are easy for computers to manage
- … but difficult for humans to remember:
  - e.g., 128.192.35.172   (dotted-decimal)
  - binary form is 10000000110000000010001110101100

- The computer needs binary addresses
- Humans "need" mnemonics
- Domain Name System (DNS) provides translation between symbolic names and IP addresses

Structure of DNS names

- Each name consists of a sequence of alphanumeric components separated by periods
- Examples:
  - comcast.com
  - www.oregonstate.edu
  - www.cnn.com
  - classes.engr.oregonstate.edu
- Note: There is not a correspondence between the DNS name's individual components and the fields of an IP address in dotted-decimal notation

Structure of DNS names

- Names are hierarchical, with most significant component on the right
  - Top-Level Domain (TLD)
- Second from right is the domain name within the TLD
  - Approved by a global authority

Structure of DNS names

- Other names may be added by the organization that owns the name
  - hierarchical structure
- Left-most component is computer name
- NOTE: www does not necessarily imply web services.
  - It's just a computer name in a domain.

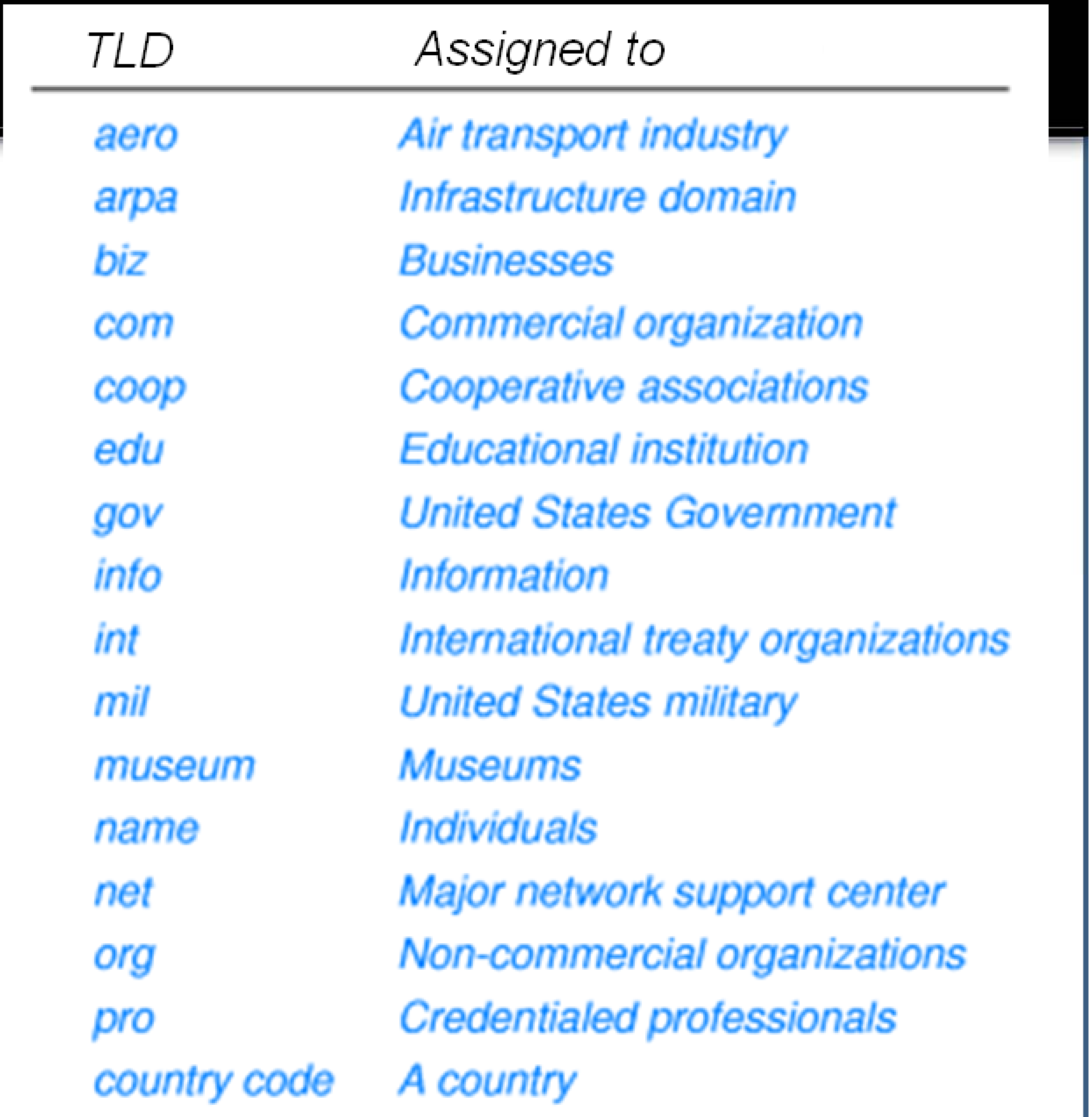
Structure of DNS names

- Organizations apply for names in a TLD. E.G.:
  - oregonstate.edu
  - mozilla.com
- Organizations determine own internal structure. E.G.:
  - eecs.oregonstate.edu
  - classes.eecs.oregonstate.edu
  - www.mozilla.com
  - en-US.www.mozilla.com

IP/DNS authority

- IP addresses and "root zone" TLDs coordinated by IANA (**Internet Assigned Numbers Authority**)
  - http://www.iana.org
- Information database (**whois**), dispute resolution, etc., managed by InterNIC (**Internet Network Information Center**)
  - http://www.internic.net
- High-level management of Internet names and addresses handled by ICANN (**Internet Corporation for Assigned Names and Numbers**)
  - http://www.icann.org
- .com TLD managed by Network Solutions
  - http://www.networksolutions.com
- .edu TLD managed by Educause
  - http://www.educause.edu

“Traditional” top-level domains (TLD)



TLD	Assigned to
aero	Air transport industry
arpa	Infrastructure domain
biz	Businesses
com	Commercial organization
coop	Cooperative associations
edu	Educational institution
gov	United States Government
info	Information
int	International treaty organizations
mil	United States military
museum	Museums
name	Individuals
net	Major network support center
org	Non-commercial organizations
pro	Credentialed professionals
country code	A country

New gTLD (generic TLD)

- In 2012, ICANN started taking applications for new TLD names.
  - Application fee: US$185,000.00
    - Additional fees may apply
  - Approval process: 9 – 20 months
  - 1,930 applications submitted
    - mostly company names (e.g., .canon, .progressive, …)
    - … and professions (e.g., .attorney, .doctor, …)
- These should be showing up soon.

Geographic structure

http://www.iana.org/domains/root/db#

- TLDs are USA-centric
- Geographic TLDs (ccTLD) are used for organizations in other countries.

Examples:

TLD	Country
.uk	United Kingdom
.cn	China
.in	India
.jp	Japan
.pg	Papua New Guinea
.cl	Chile
.ke	Kenya

- Note: some countries sell their ccTLDs
  - e.g., www.verisign.tv
    - .tv was once owned by Tuvalu

Geographic structure

- Countries define their own internal hierarchy:
- .ac.jp and .edu.au are used for academic organizations in Japan and Australia, respectively
- DNS domains are logical concepts and need not correspond to physical location of organizations
  - E.G., chinatoday.com is hosted partly in Beijing, partly in San Francisco

DNS: Domain Name System

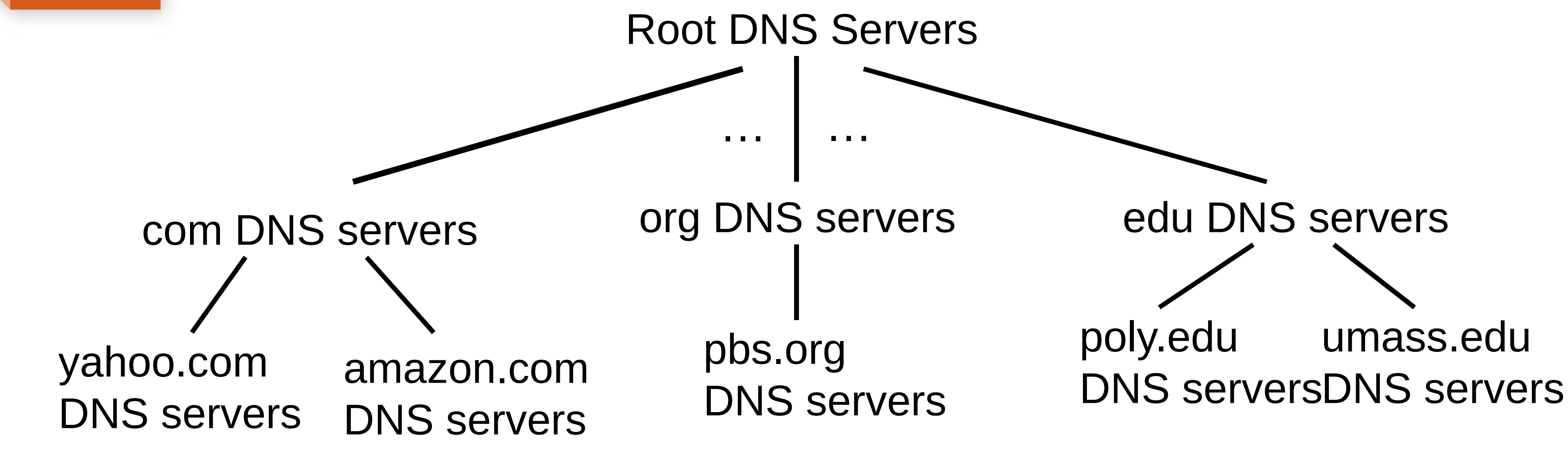
- *distributed database*: implemented in hierarchy of many *name servers*
- *application-layer protocol*: running at host, routers, & name servers to *resolve* names (address/name translation)

DNS services

- hostname to IP address translation
- Web server aliasing
  - Canonical, alias names
- mail server aliasing
- load distribution

Discussion question: Lookups would be faster if there were one massive central database instead of having to search a hierarchical distributed database. Why not centralize DNS?

DNS: a distributed, hierarchical database



Root DNS Servers

… …

com DNS servers

org DNS servers

edu DNS servers

yahoo.com
DNS servers

amazon.com
DNS servers

pbs.org
DNS servers

poly.edu
DNS servers

umass.edu
DNS servers

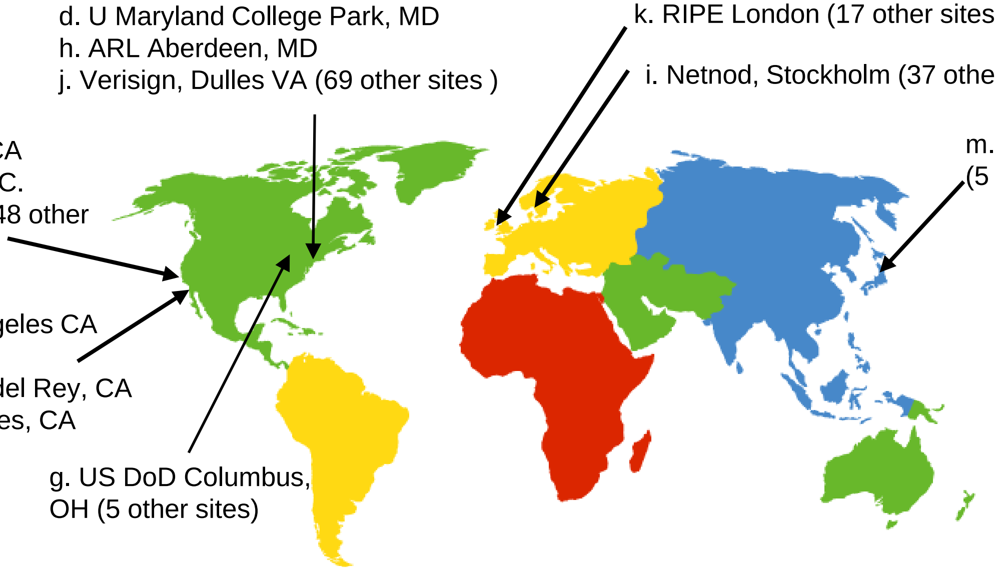
Example: Client wants IP for www.amazon.com

1st approximation:

- client queries root server to find .com DNS server
- client queries .com DNS server to get amazon.com DNS server
- client queries amazon.com DNS server to get IP address for www.amazon.com

DNS: root name servers

- Contacted by local name server that can not resolve name
- Root name server:
  - gets mapping from authoritative name server if name mapping not known, and returns mapping to local name server



c. Cogent, Herndon, VA (5 other sites)
d. U Maryland College Park, MD
h. ARL Aberdeen, MD
j. Verisign, Dulles VA (69 other sites)

k. RIPE London (17 other sites)

i. Netnod, Stockholm (37 other sites)

e. NASA Mt View, CA
f. Internet Software C.
Palo Alto, CA (and 48 other sites)

m. WIDE Tokyo
(5 other sites)

a. Verisign, Los Angeles CA
(5 other sites)
b. USC-ISI Marina del Rey, CA
l. ICANN Los Angeles, CA
(41 other sites)

g. US DoD Columbus, OH (5 other sites)

13 root name “servers” worldwide

DNS records

DNS: distributed database storing resource records (RR)

RR format: `(name, value, type, ttl)`

type=A

- **`name`** is hostname
- **`value`** is IP address

type=NS

- **`name`** is domain (e.g., foo.com)
- **`value`** is hostname of authoritative name server for this domain

type=CNAME

- **`name`** is alias name for some "canonical" (the real) name
- **`www.ibm.com`** is really **`servereast.backup2.ibm.com`**
- **`value`** is canonical name

type=MX

- **`value`** is name of mailserver associated with **`name`**

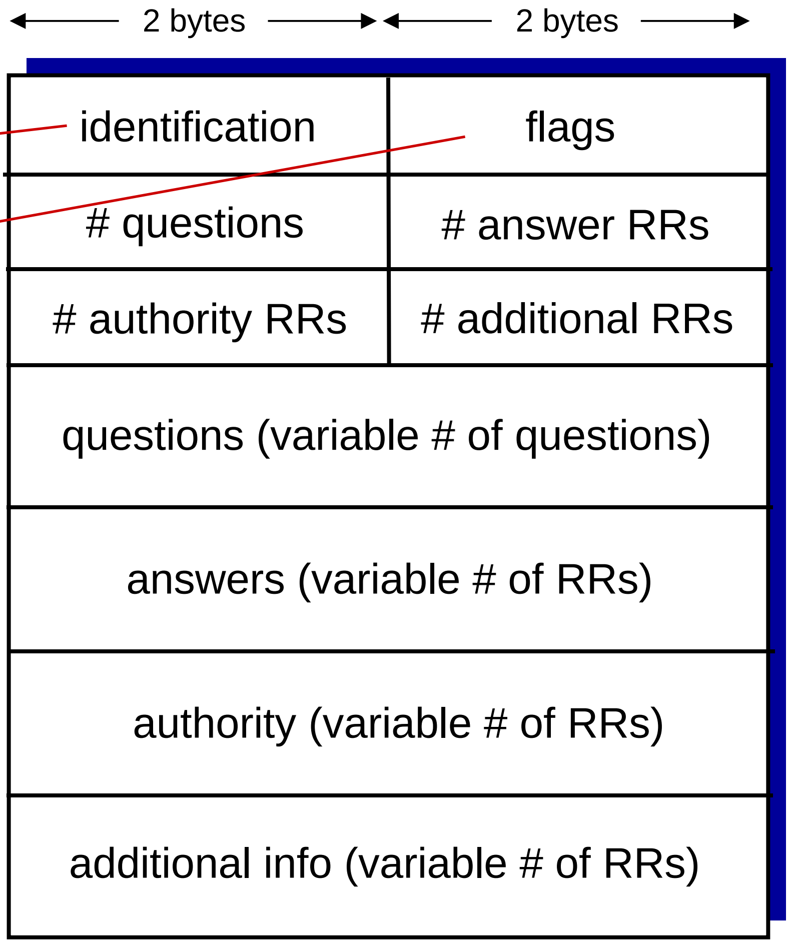
ttl=<seconds to remain in cache>

DNS protocol, messages

- *query* and *reply* messages, both with same *message format*

message header

- identification: 16 bit # for query, reply to query uses same #
- flags:
  - query or reply
  - recursion desired
  - recursion available
  - reply is authoritative



2 bytes

2 bytes

identification

flags

# questions

# answer RRs

# authority RRs

additional RRs

questions (variable # of questions)

answers (variable # of RRs)

authority (variable # of RRs)

additional info (variable # of RRs)

NOTE: **All multi-byte numeric values must be in big-endian order (network order).**

Discussion question: Why does DNS use UDP instead of (reliable) TCP?

Domain name ⇔ IP address Lookup, Reverse lookup

- http://remote.12dt.com/rns/
- http://www.dnsstuff.com/
- … and many others

Summary Lecture #13

- Definitions
  - IP address
  - Domain name
  - TLD
- DNS
  - Structure
  - Management
  - Lookups
  - Protocol, messages
- This concludes our coverage of the Application Layer
  - Next: the Transport Layer