

Week 9: Application Layer

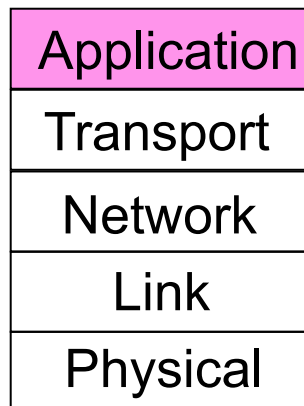
Internet Technologies COMP90007

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Semester 2, 2020

The Last Layer in Hybrid Stack

- **Application Layer**
- We will look at key implementations to study this: **Domain Name System** first



DNS (Domain Name System)

■ Problem?

- IP address (32 bit), e.g., 121.7.106.83 – used for addressing datagrams
- **www.yahoo.com – used by humans**

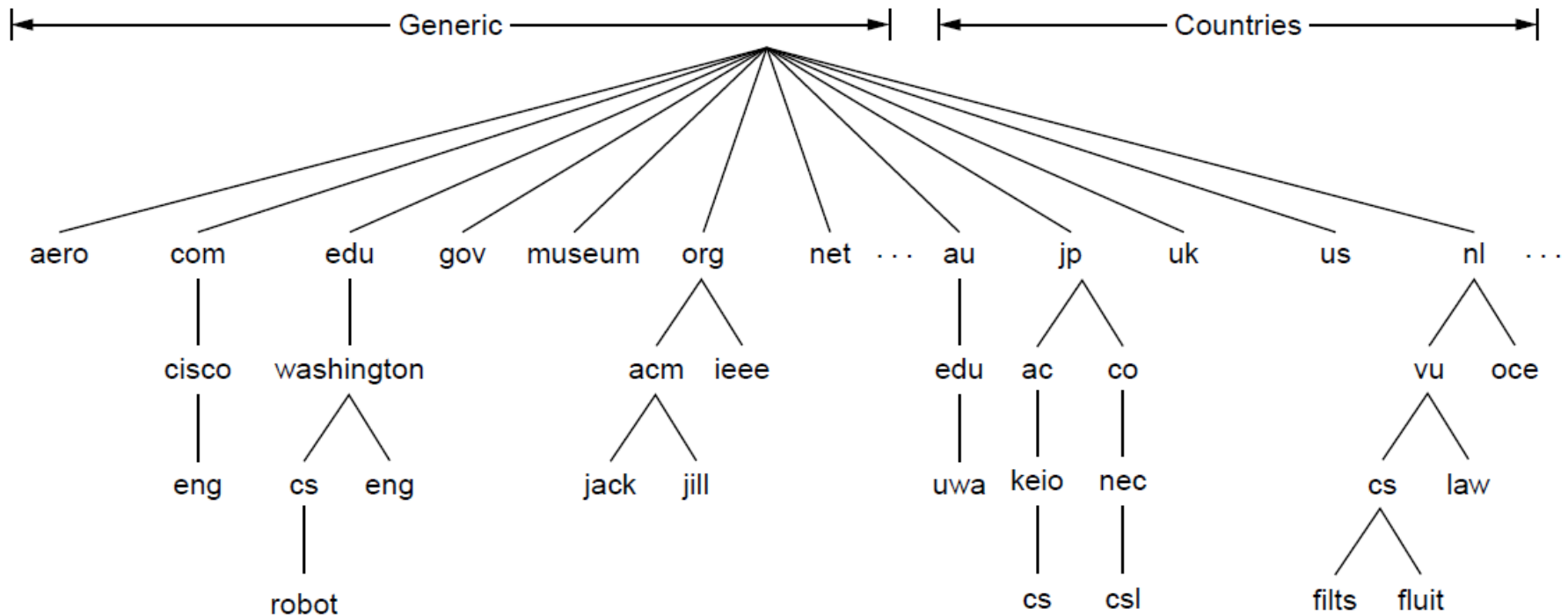
■ Question: how do you map between IP address and name, and vice versa?

■ Domain Name System:

- *distributed database* implemented in a hierarchy of many *name servers*
- *application-layer protocol* that allows a host to query the database in order to *resolve* names (address/name translation)
- used by other application-layer protocols (http, ftp, smtp)

Conceptual Divisions of DNS Namespace

- A hierarchical naming convention; the top of the hierarchy is managed by ICANN (*The Internet Corporation for Assigned Names and Numbers*).



↖ The computer *robot.cs.washington.edu*

Name Space

- Internet historically divided into over 250 top-level domains (TLD).

Domain	Intended use	Start date	Restricted?
com	Commercial	1985	No
edu	Educational institutions	1985	Yes
gov	Government	1985	Yes
int	International organizations	1988	Yes
mil	Military	1985	Yes
net	Network providers	1985	No
org	Non-profit organizations	1985	No
aero	Air transport	2001	Yes
biz	Businesses	2001	No
coop	Cooperatives	2001	Yes
info	Informational	2002	No
museum	Museums	2002	Yes
name	People	2002	No
pro	Professionals	2002	Yes
cat	Catalan	2005	Yes
jobs	Employment	2005	Yes
mobi	Mobile devices	2005	Yes
tel	Contact details	2005	Yes
travel	Travel industry	2005	Yes
xxx	Sex industry	2010	No

Why not centralize DNS?

- Single point of failure
- Traffic volume
- Distant centralized database
- Maintenance
- Does not scale well

DNS Services

- hostname to IP **address translation**
- host **aliasing** – alias names for canonical names
 - e.g., canonical `relay1.westcoast.enterprise.com` aliased to `www.enterprise.com`
- mail server aliasing
 - e.g., `Bob@relay1.westcoast.hotmail.com` aliased to `Bob@hotmail.com`
- **load distribution**
 - *busy sites are replicated over multiple servers*
 - *a set of IP addresses is associated with one canonical name*
 - *DNS server rotates the order of the addresses to distribute the load*

Domain Name Characteristics

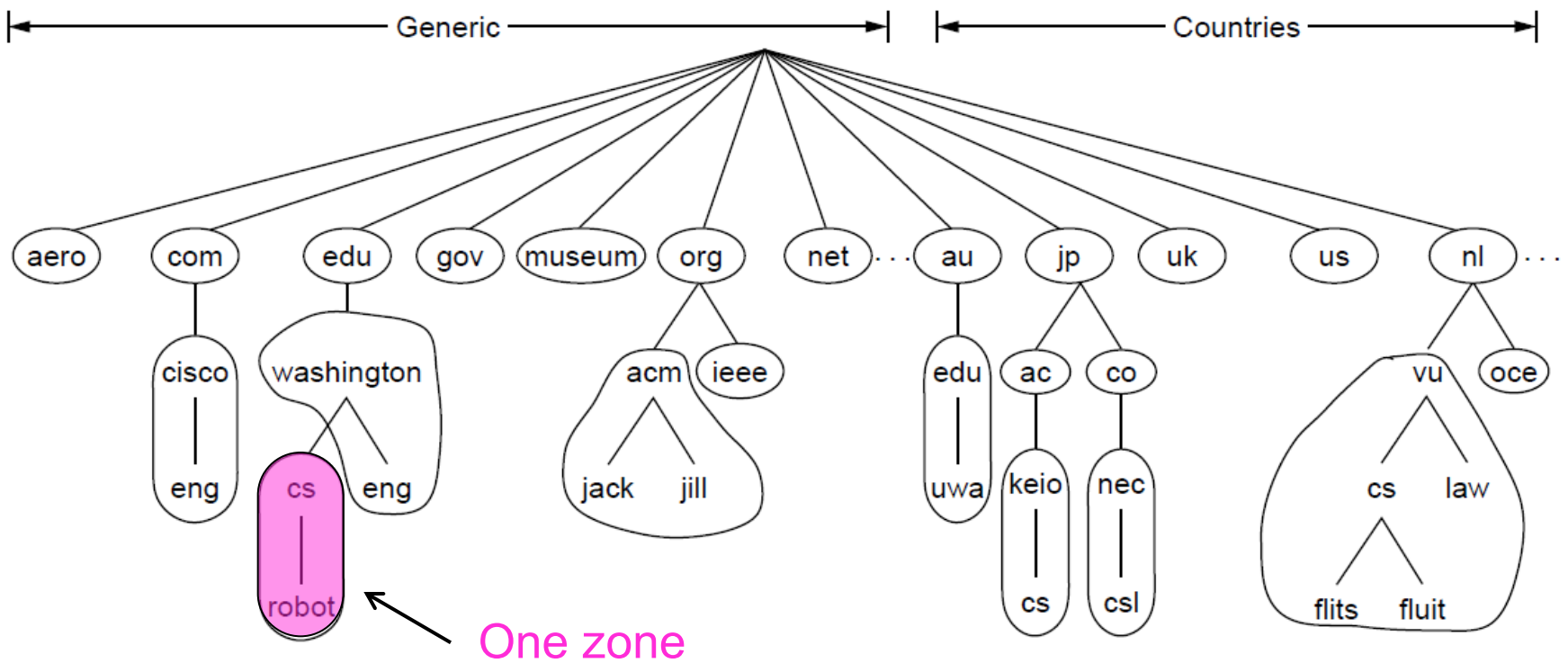
- Domain names:
 - ❑ Are case insensitive
 - ❑ Can have up to 63 characters per constituent
 - ❑ Can have up to 255 chars per path
 - ❑ Can be internationalised (since 1999)
- Naming conventions usually follow either organisational or physical boundaries eg.
 - ❑ au.ibm.com / uk.ibm.com (for email)
 - ❑ ibm.com.au / ibm.co.uk (for web)
- Absolute domain names ends in a “.”
- Relative domain names partially specify the location and can be used only within the context of an absolute domain name

Zone Name Servers

- DNS namespace divided into **non-overlapping zones**
- Each zone contains a part of the DNS tree and also name servers authoritative for that zone -
 - ❑ usually 2 name servers for a zone (called the primary and secondary name servers),
 - ❑ sometimes secondary is actually outside the zone (for reliability)
- Name servers are arranged in a hierarchical manner extending from a set of root servers

Name Servers

- The DNS name space is divided into nonoverlapping zones; each circled contains some part of the tree.



Root Name Servers

- The root servers form the authoritative cluster for enquiry in the event of locally-unresolvable name queries
- There are 13 root servers globally
 - ▣ In some cases, a root server is a cluster of servers

Resource Records

- The **Resource Records** (RR) are the key objects in the Domain Name System
- A RR consists of a domain name, TTL, class, type, value
 - ❑ Domain Name: which domain this record applies to
 - ❑ TTL: indicates stability or temporal extent of the record
 - ❑ Class: IN for internet (others exist, but deprecated)
 - ❑ Type: a closed vocabulary of the following:
 - A : The Internet address of the host
 - CNAME : The canonical name for an alias
 - MX : The mail exchanger
 - NS : The name server
 - PTR : The host name if the query is in the form of an Internet address; otherwise the pointer to other information
 - SOA : The domain's start-of-authority information
 - ❑ Value: data (semantics depend on record type)

Asking for Domain Name: Example

User requests the URL

`www.someschool.edu/index.html`

1. User machine runs the client side of the DNS software
2. Browser extracts the hostname from the URL, and passes it to the client-side of the DNS application
3. DNS client sends a query containing the hostname to a DNS server
4. DNS client eventually receives a reply containing the IP address for the hostname
5. Browser initiates a TCP connection to the process located at port 80 at the IP address

A Typical DNS Query: dig

```
dig www.unimelb.edu.au
; <<>> DiG 9.3.0s20021217 <<>> www.unimelb.edu.au
;; global options: printcmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 19905
;; flags: qr rd ra; QUERY: 1, ANSWER: 1, AUTHORITY: 2, ADDITIONAL: 2
;; QUESTION SECTION:
;www.unimelb.edu.au.      IN      A
;; ANSWER SECTION:
www.unimelb.edu.au.      15589   IN      A      128.250.148.40
;; AUTHORITY SECTION:
unimelb.edu.au.          1217    IN      NS      ns2.unimelb.edu.au.
unimelb.edu.au.          1217    IN      NS      ns1.unimelb.edu.au.
;; ADDITIONAL SECTION:
ns1.unimelb.edu.au.      491     IN      A      128.250.20.2
ns2.unimelb.edu.au.      494     IN      A      128.250.144.180
;; Query time: 393 msec
;; SERVER: 128.250.66.5#53(128.250.66.5)
;; WHEN: Fri Apr 18 05:46:56 2014
;; MSG SIZE rcvd: 120
```

Domain Resource Records

; Authoritative data for cs.vu.nl

cs.vu.nl.	86400	IN	SOA	star boss (9527,7200,7200,241920,86400)
-----------	-------	----	-----	---

cs.vu.nl.	86400	IN	MX	1 zephyr
-----------	-------	----	----	----------

cs.vu.nl.	86400	IN	MX	2 top
-----------	-------	----	----	-------

cs.vu.nl.	86400	IN	NS	star
-----------	-------	----	----	------

Name
server
←

star	86400	IN	A	130.37.56.205
------	-------	----	---	---------------

zephyr	86400	IN	A	130.37.20.10
--------	-------	----	---	--------------

top	86400	IN	A	130.37.20.11
-----	-------	----	---	--------------

www	86400	IN	CNAME	star.cs.vu.nl
-----	-------	----	-------	---------------

ftp	86400	IN	CNAME	zephyr.cs.vu.nl
-----	-------	----	-------	-----------------

← IP addresses of
computers

flits	86400	IN	A	130.37.16.112
-------	-------	----	---	---------------

flits	86400	IN	A	192.31.231.165
-------	-------	----	---	----------------

flits	86400	IN	MX	1 flits
-------	-------	----	----	---------

flits	86400	IN	MX	2 zephyr
-------	-------	----	----	----------

flits	86400	IN	MX	3 top
-------	-------	----	----	-------

rowboat		IN	A	130.37.56.201
---------	--	----	---	---------------

		IN	MX	1 rowboat
--	--	----	----	-----------

		IN	MX	2 zephyr
--	--	----	----	----------

← Mail
gateways

little-sister		IN	A	130.37.62.23
---------------	--	----	---	--------------

laserjet		IN	A	192.31.231.216
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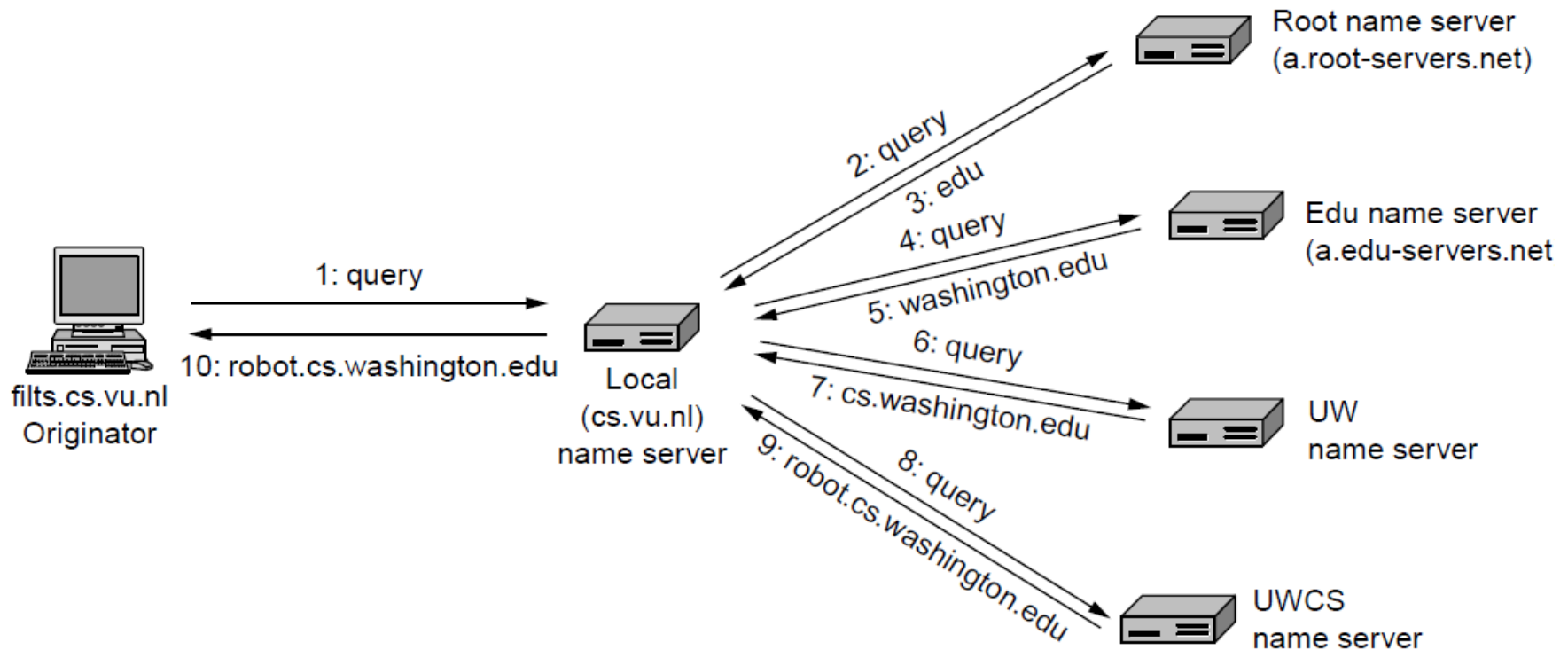
- A portion of a possible DNS database for cs.vu.nl.

DNS In Action

- Finding the IP address for a given hostname is called **name resolution** and is done with the DNS protocol.
- Resolution:
 - ❑ Computer requests local name server to resolve
 - ❑ Local name server asks the root name server
 - ❑ Root returns the name server for a lower zone
 - ❑ Continue down zones until name server can answer
- DNS protocol:
 - ❑ Runs on UDP port 53, retransmits when lost messages
 - ❑ Caches name server answers for better performance

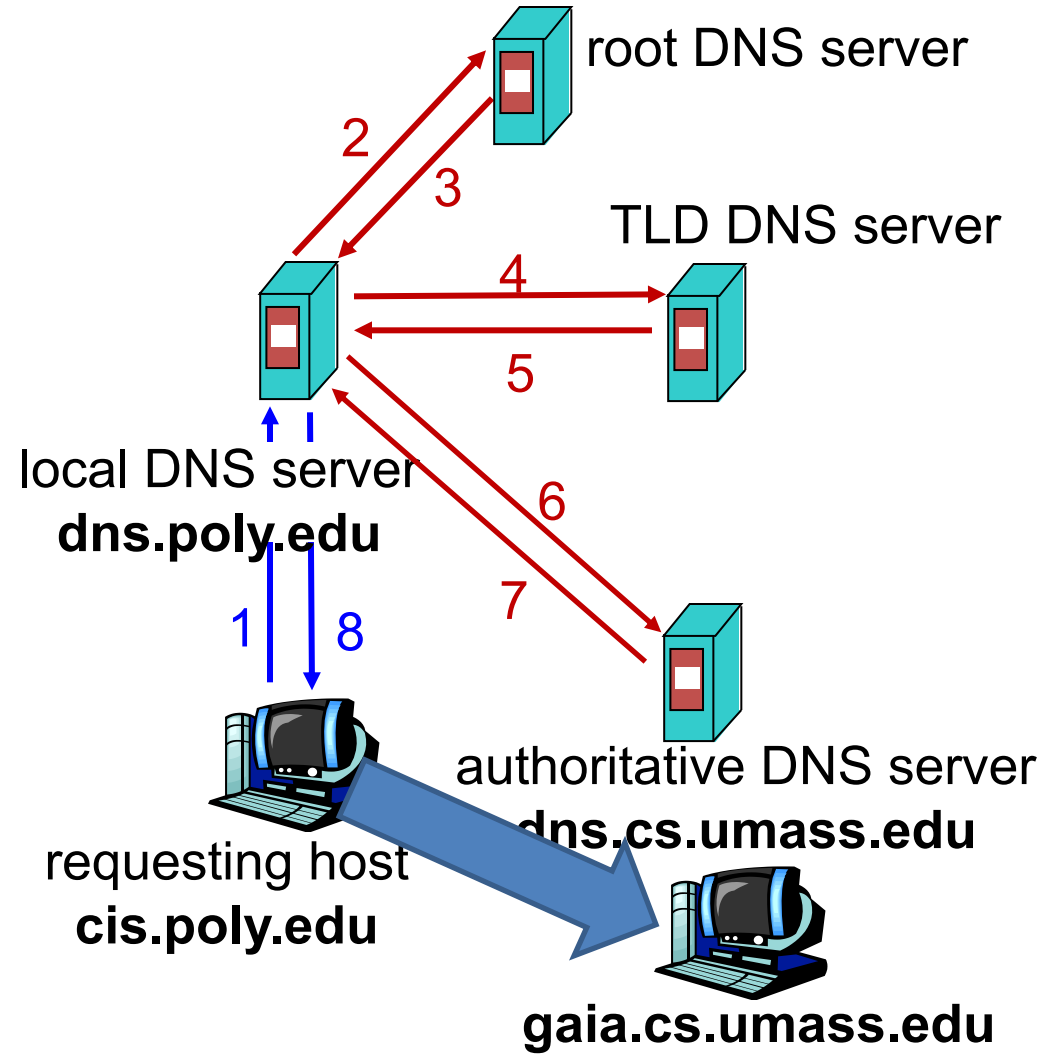
Example

- Example of a computer looking up the IP for a name



DNS Name Resolution Contd

- host at cis.poly.edu wants IP address for gaia.cs.umass.edu
- iterated query:
 - contacted server replies with name of server to contact
 - “I don’t know this name, but ask this server”
- recursive query:
 - server obtains mapping on client’s behalf



DNS: Caching & Updating Records

- Once (any) name server learns a mapping, it *caches* the mapping
 - IP addresses of TLD servers typically cached in local name servers
 - ➔ root name servers not often visited
 - Cache entries timeout (disappear) after some time