Couche application

- FTP
- SMTP / POP3 / IMAP
- DNS

Computer Networks. Tanenbaum
Computer Networking. Kurose&Ross

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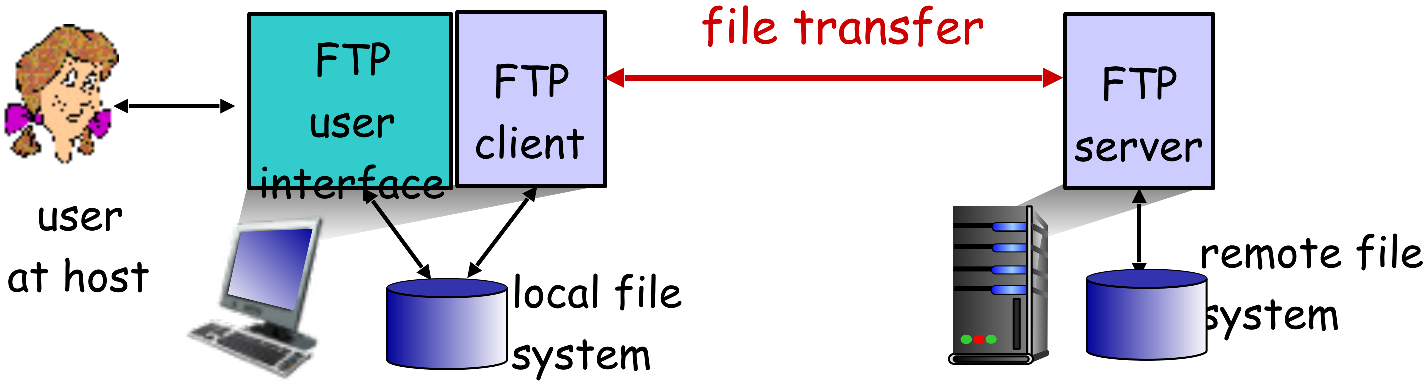
Couche application

FTP

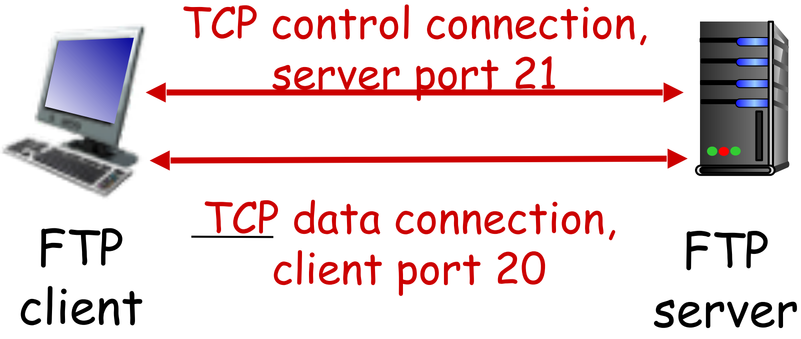
FTP: the file transfer protocol



- transfer file to/from remote host
- client/server model
  - *client:* side that initiates transfer (either to/from remote)
  - *server:* remote host
- ftp: RFC 959
- ftp server: port 21

FTP: separate control, data connections

- FTP client contacts FTP server at port 21, using TCP
- client authorized over control connection
- client browses remote directory, sends commands over control connection
- when server receives file transfer command, *server* opens *2nd* TCP data connection (for file) *to* client port 20
- after transferring one file, server closes data connection


TCP control connection, server port 21
TCP data connection, client port 20
FTP client
FTP server

- server opens another TCP data connection to transfer another file
- control connection: *"out of band"* (http is "in-band")
- FTP server maintains "state": current directory, earlier authentication

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FTP commands, responses

sample commands (client→ server):

- sent as ASCII text over control channel
- **USER *username***
- **PASS *password***
- **LIST** return list of file in current remote directory
- **RETR filename** retrieves (gets) file
- **STOR filename** stores (puts) file onto remote host

sample return codes (serveur→ client)

- status code and phrase (as in HTTP)
- **331 Username OK, password required**
- **125 data connection already open; transfer starting**
- **425 Can't open data connection**
- **452 Error writing file**

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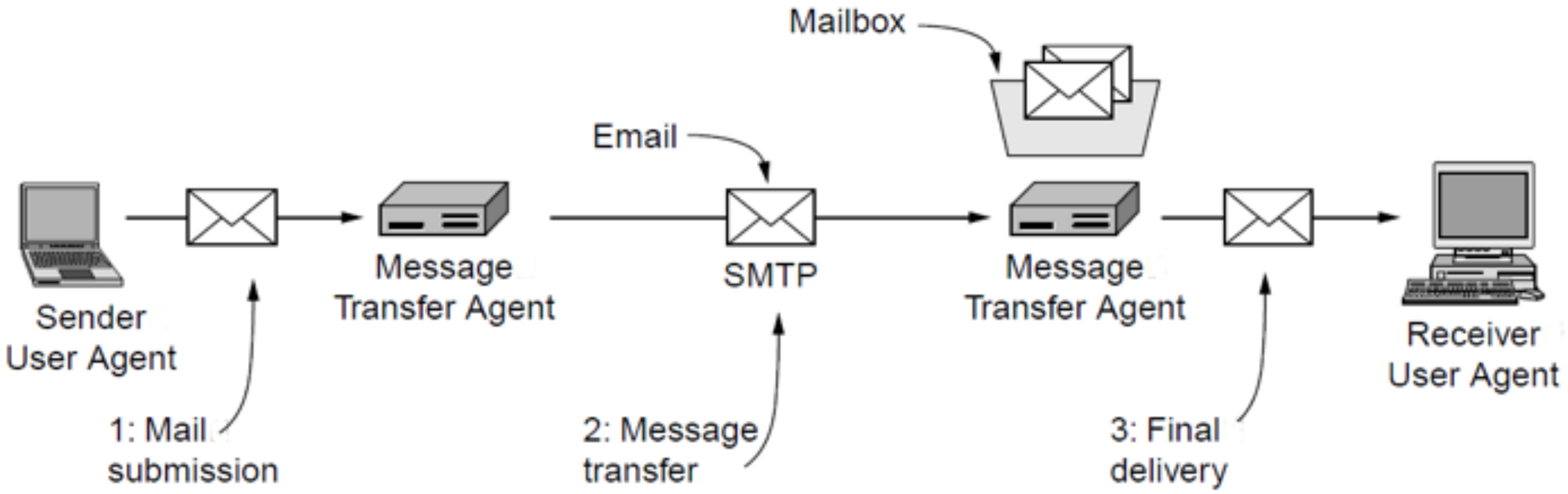
Couche application

electronic mail

- SMTP, POP3, IMAP

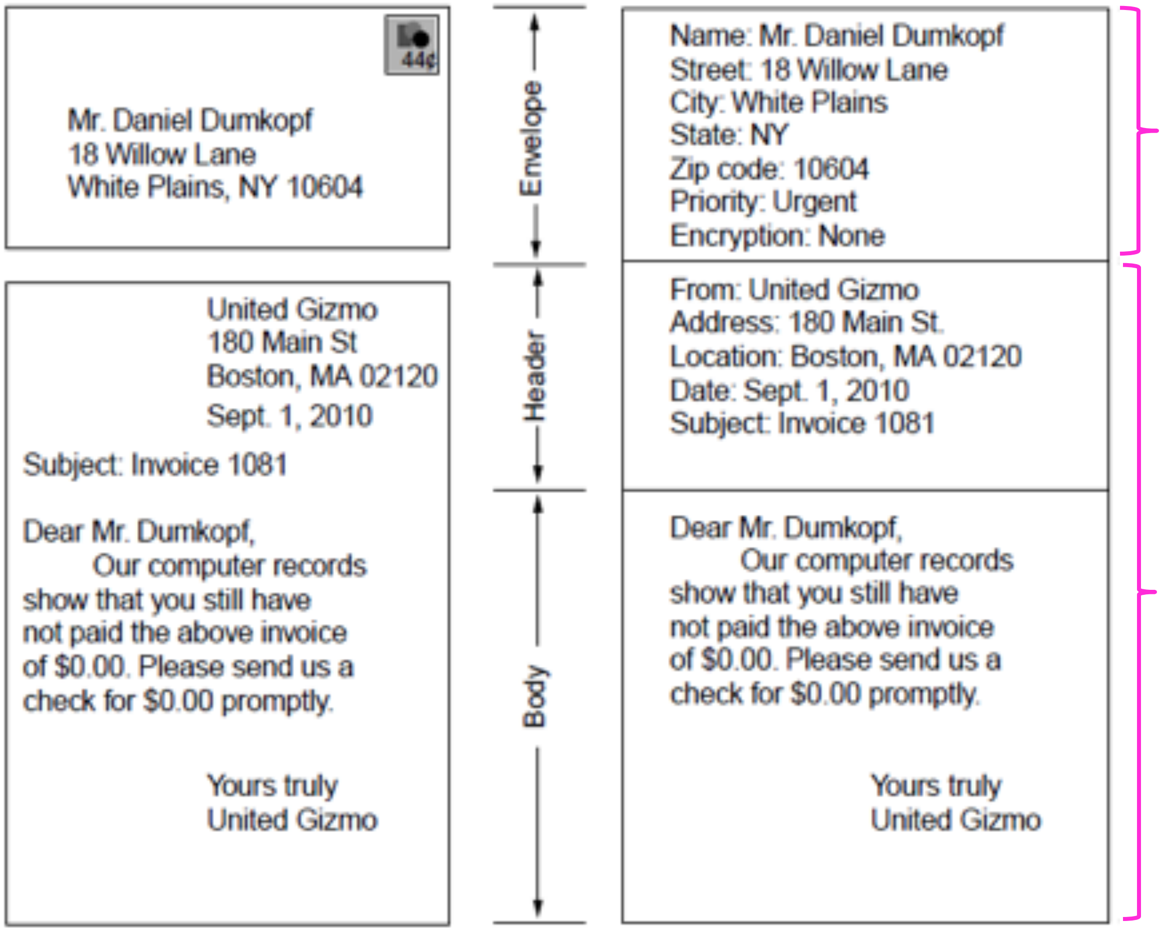
Architecture et Services

The key components and steps (numbered) to send email



Architecture of the email system

Architecture and Services (2)



44¢

Mr. Daniel Dumkopf
18 Willow Lane
White Plains, NY 10604

United Gizmo
180 Main St
Boston, MA 02120
Sept. 1, 2010

Subject: Invoice 1081

Dear Mr. Dumkopf,
Our computer records show that you still have not paid the above invoice of $0.00. Please send us a check for $0.00 promptly.

Yours truly
United Gizmo

Name: Mr. Daniel Dumkopf
Street: 18 Willow Lane
City: White Plains
State: NY
Zip code: 10604
Priority: Urgent
Encryption: None

From: United Gizmo
Address: 180 Main St.
Location: Boston, MA 02120
Date: Sept. 1, 2010
Subject: Invoice 1081

Dear Mr. Dumkopf,
Our computer records show that you still have not paid the above invoice of $0.00. Please send us a check for $0.00 promptly.

Yours truly
United Gizmo

Envelope

Message (= header and body)

Paper mail

Electronic mail

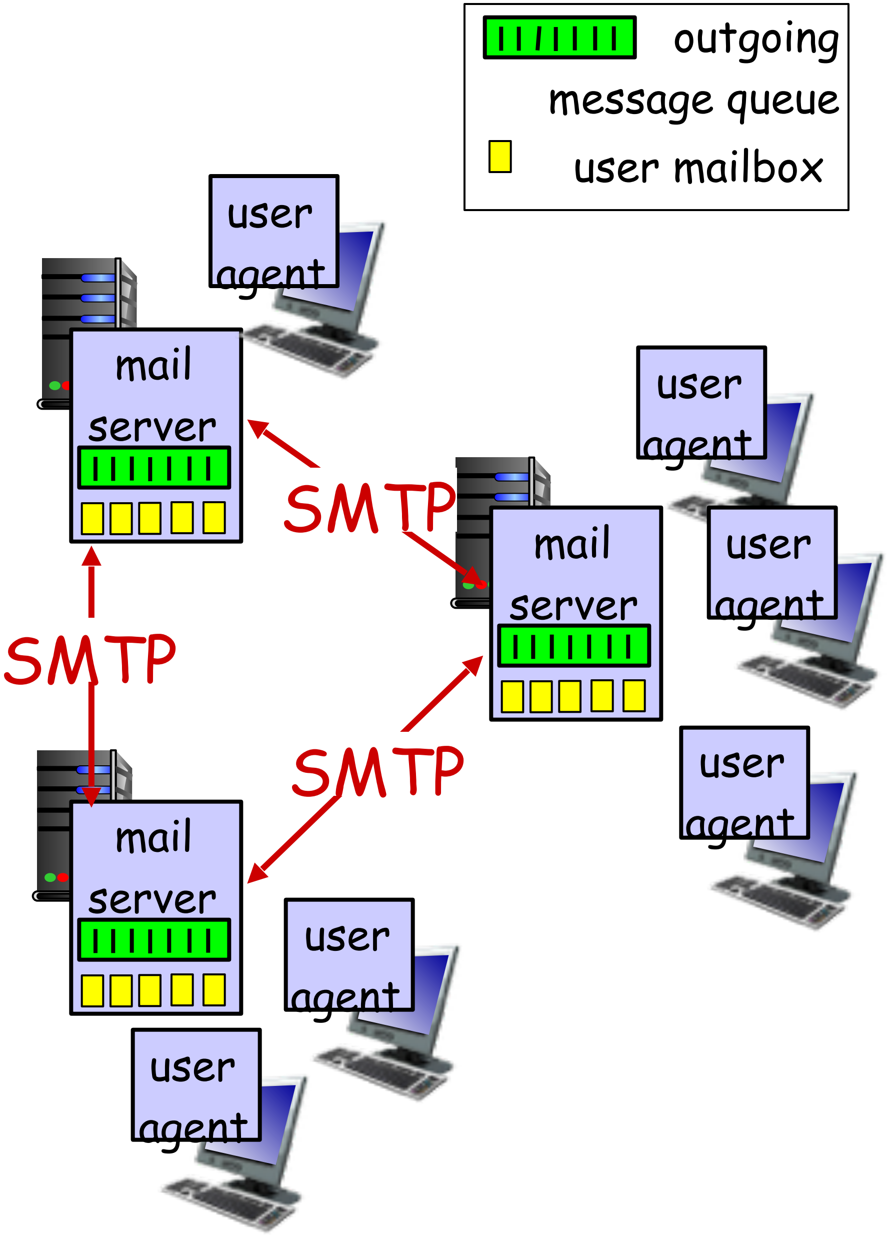
Electronic mail

Three major components:

- user agents
- mail servers
- simple mail transfer protocol: SMTP

User Agent

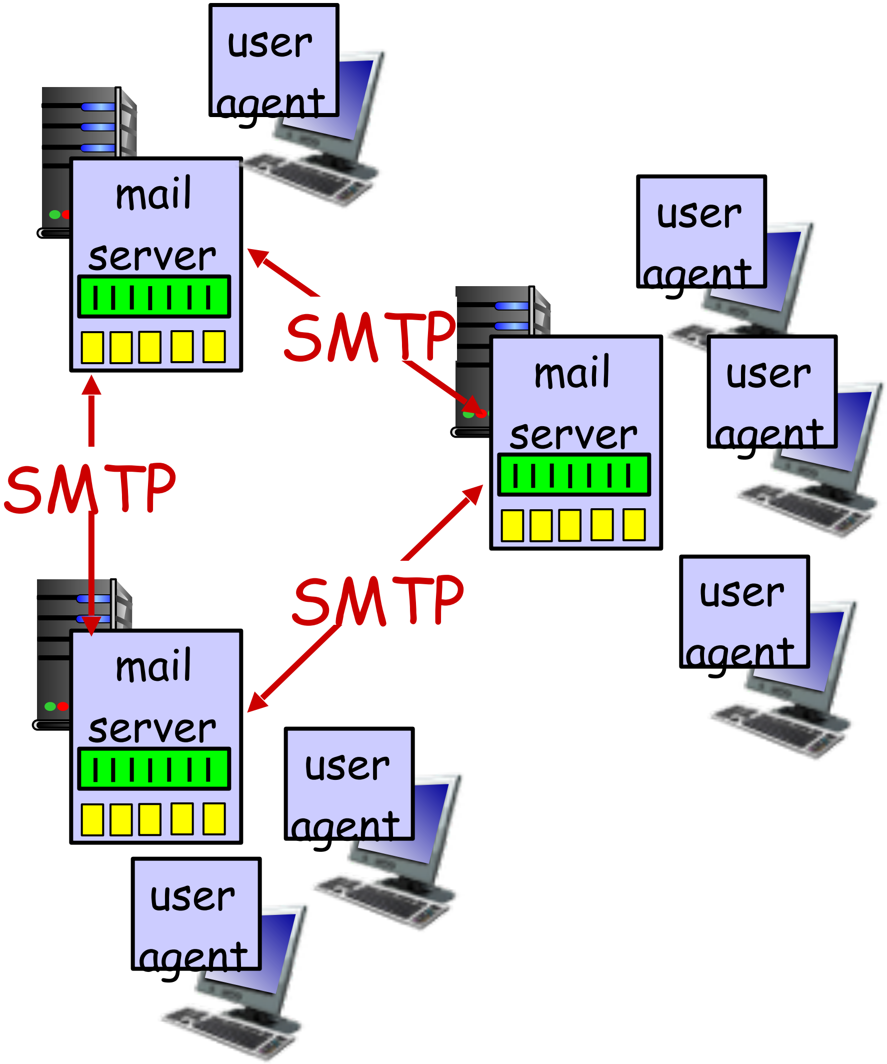
- a.k.a. “mail reader”
- composing, editing, reading mail messages
- e.g., Outlook, Thunderbird, iPhone mail client
- outgoing, incoming messages stored on server



Electronic mail: mail servers

mail servers:

- *mailbox* contains incoming messages for user
- *message queue* of outgoing (to be sent) mail messages
- *SMTP protocol* between mail servers to send email messages
  - client: sending mail server
  - "server": receiving mail server



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Electronic Mail: SMTP [RFC 2821]

- uses TCP to reliably transfer email message from client to server, port 25
- direct transfer: sending server to receiving server
- three phases of transfer
  - handshaking (greeting)
  - transfer of messages
  - closure
- command/response interaction (like HTTP, FTP)
  - commands: ASCII text
  - response: status code and phrase
- messages must be in 7-bit ASCI

Scenario: Alice sends message to Bob

1) Alice uses UA to compose message “to” `bob@someschool.edu`

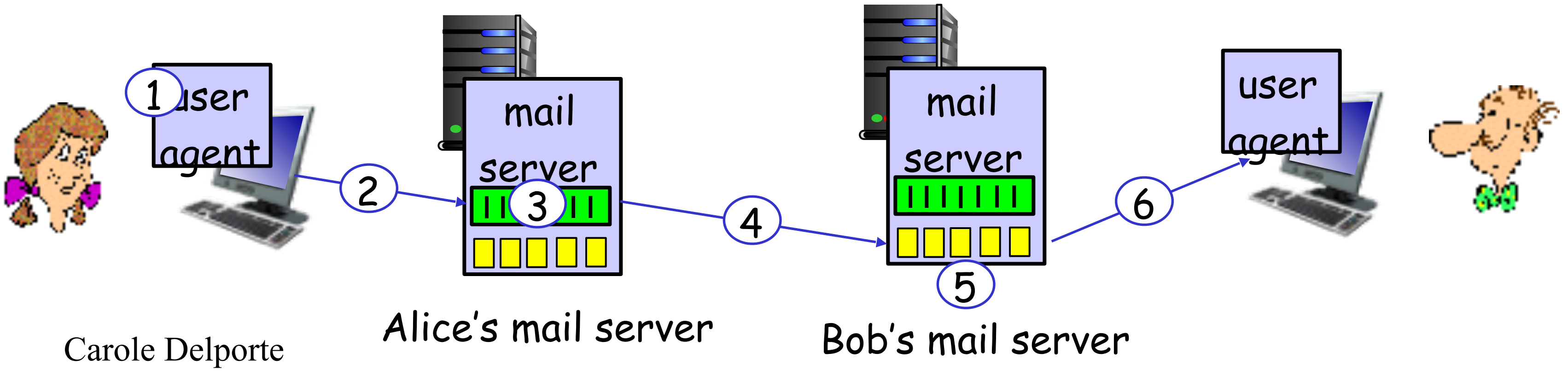
2) Alice’s UA sends message to her mail server; message placed in message queue

3) client side of SMTP opens TCP connection with Bob’s mail server

4) SMTP client sends Alice’s message over the TCP connection

5) Bob’s mail server places the message in Bob’s mailbox

6) Bob invokes his user agent to read message



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Try SMTP interaction for yourself:

- **`telnet servername 25`**
- see 220 reply from server
- enter HELO, MAIL FROM, RCPT TO, DATA, QUIT commands

above lets you send email without using email client (reader)

- **`security:`**
- port 465 SSL/TLS
- port 587 (STARTTLS)

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Sample SMTP interaction

```
$ telnet smtp-auth.sfr.fr 587
Trying 93.17.128.23...
Connected to smtp-auth.sfr.fr.
Escape character is '^]'.
220 msfrf2308.sfr.fr ESMTP ABO **************************
HELO sfr.fr
250 msfrf2308.sfr.fr
MAIL FROM:<noel@sfr.fr>
250 2.1.0 Ok
RCPT TO: <cd@liafa.univ-paris-diderot.fr>
250 2.1.5 Ok
DATA
354 End data with <CR><LF>.<CR><LF>
BLABLA blabla
Et encore
.
250 2.0.0 Ok: queued as C25897000079
QUIT
221 2.0.0 Bye
Connection closed by foreign host.
```

```
host-129-142:~ caroledelporte1$ telnet smtp.irif.fr 587
Trying 81.194.30.253...
Connected to mailhub.math.univ-paris-diderot.fr.
Escape character is '^]'.
220 mailhub.math.univ-paris-diderot.fr ESMTP Postfix
HELO irif.fr
250 mailhub.math.univ-paris-diderot.fr
EHLO irif.fr
250-mailhub.math.univ-paris-diderot.fr
250-PIPELINING
250-SIZE 31457280
250-ETRN
250-STARTTLS
250-ENHANCEDSTATUSCODES
250-8BITMIME
250 DSN
STARTTLS
220 2.0.0 Ready to start TLS
xxxxxxxxx
```

SMTP: final words

- SMTP uses persistent connections
- SMTP requires message (header & body) to be in 7-bit ASCII
- SMTP server uses `CRLF.CRLF` to determine end of message

comparison with HTTP:

- HTTP: pull
- SMTP: push
- both have ASCII command/response interaction, status codes
- HTTP: each object encapsulated in its own response msg
- SMTP: multiple objects sent in multipart msg

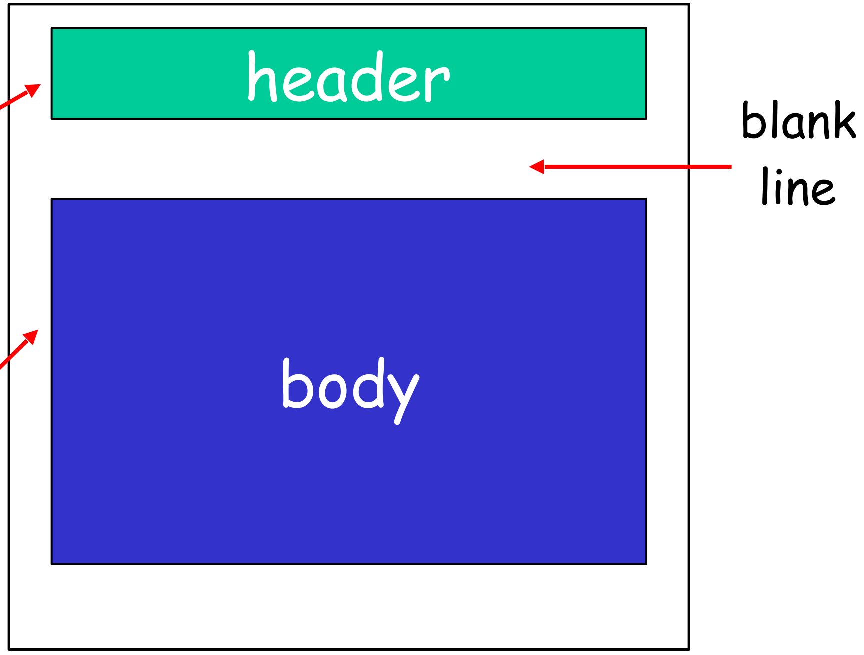
Mail message format

SMTP: protocol for exchanging email msgs

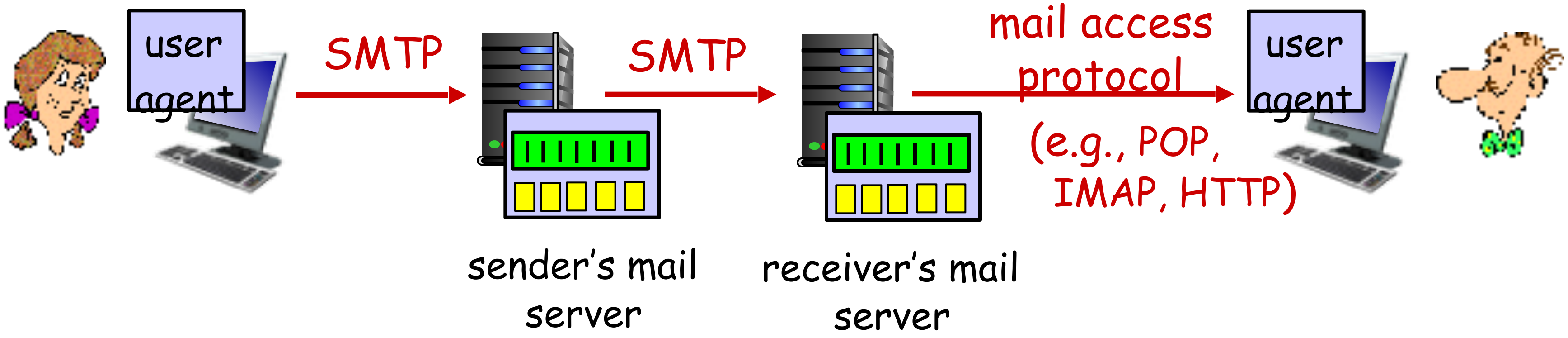
RFC 822: standard for text message format:

- header lines, e.g.,
  - To:
  - From:
  - Subject:

  different from SMTP MAIL FROM, RCPT TO: commands!
- Body: the "message"
  - ASCII characters only



Mail access protocols



- SMTP: delivery/storage to receiver's server
- mail access protocol: retrieval from server
  - POP: Post Office Protocol [RFC 1939]: authorization, download
  - IMAP: Internet Mail Access Protocol [RFC 1730]: more features, including manipulation of stored msgs on server
  - HTTP: gmail, Hotmail, Yahoo! Mail, etc.

POP3 protocol

Port 110

authorization phase

- client commands:
  - **user**: declare username
  - **pass**: password
- server responses
  - **+OK**
  - **-ERR**

```
S:  +OK POP3 server ready
C:  user bob
S:  +OK
C:  pass hungry
S:  +OK user successfully logged on
```

transaction phase, client:

- **list**: list message numbers
- **retr**: retrieve message by number
- **dele**: delete
- **quit**

```
C:  list
S:  1 498
S:  2 912
S:  .
C:  retr 1
S:  <message 1 contents>
S:  .
C:  dele 1
C:  retr 2
S:  <message 1 contents>
S:  .
C:  dele 2
C:  quit
S:  +OK POP3 server signing off
```

```
$ telnet ouindose.informatique.univ-paris-diderot.fr 110
Trying 194.254.199.73...
Connected to nivose.informatique.univ-paris-diderot.fr.
Escape character is '^]'.
+OK Qpopper (version 4.1b18) at nivose starting.
user cd
+OK Password required for cd.
Pass ENCLAIR
+OK cd has 41 visible messages (0 hidden) in 397421 octets.
list
+OK 41 visible messages (397421 octets)
1 33935
.....
41 13037
.
quit
+OK Pop server at ouindose signing off.
Connection closed by foreign host.
$
```

POP3 (more) and IMAP

more about POP3

- previous example uses POP3 "download and delete" mode
  - Bob cannot re-read e-mail if he changes client
- POP3 "download-and-keep": copies of messages on different clients
- POP3 is stateless across sessions

IMAP

- keeps all messages in one place: at server
- allows user to organize messages in folders
- keeps user state across sessions:
  - names of folders and mappings between message IDs and folder name

envoiMailSimple.java

```
import java.util.*;
import javax.mail.Address;
import javax.mail.Message;
import javax.mail.Session;
import javax.mail.Transport;
// les 2 classes suivantes sont  utiles pour  le courrier electronique
Internet
import javax.mail.internet.InternetAddress;
import javax.mail.internet.MimeMessage;

public class envoiMailSimple {
 public static void main(String[] args) {
  try {
  // emetteur du message (MAIL FROM:)
    Address emetteur = new InternetAddress("papi@dugrandnord.com",
    "Pere Noel");
```

```
// recepteur du message (RCPT TO:)
     Address receveur = new
InternetAddress("etudiant@informatique.univ-paris-diderot.fr");

   // positionnement de la propriete mail.host au serveur local
     Properties props = new Properties();
     props.put("mail.host", "ouindose.informatique.univ-paris-
diderot.fr");

    // demarrage d'une session de courrier
     Session mailConnection = Session.getInstance(props, null);

    // Construction du message envoyé par Internet
     Message msg = new MimeMessage(mailConnection);
     msg.setFrom(emetteur);
     msg.setRecipient(Message.RecipientType.TO, receveur);
     msg.setSubject("Bientot Noel");
     msg.setContent(" M'as tu envoye ta commande?\n j'attends",
      "text/plain");
```

```
 //Emission du message
  Transport.send(msg);
}
catch (Exception ex) {
  ex.printStackTrace();
}    }}
```

pop3Client.java

```
import javax.mail.*;
import javax.mail.internet.*;
import java.util.*;
import java.io.*;

public class pop3Client {
  public static void main(String[] args) {
    Properties props = new Properties();

    String host = "ouindose.informatique.univ-paris-diderot.fr";
    String username= "cd";
    String password ="enclair";
    String protocol = "pop3";
```

pop3Client.java

```
try {
 Session session = Session.getDefaultInstance(props,null);
  Store store = session.getStore(protocol);
   store.connect(host, username, password);
  System.out.println("connection reussi");
```

pop3Client.java

```
// Open the folder
    Folder inbox = store.getFolder("INBOX");
    if (inbox == null) {
     System.out.println("No INBOX");
     System.out.exit(1);
    }
    inbox.open(Folder.READ_ONLY);

 //lecture des messages
Message[] messages = inbox.getMessages();
    for (int i = 0; i < messages.length; i++) {
     System.out.println("------------ Message " + (i+1)
      + " ------------");
     messages[i].writeTo(System.out);
          }
    inbox.close(false);
```

pop3Client.java

```
catch (Exception ex) {
  ex.printStackTrace();
}
System.exit(0);     }}
```

Saisir le mot de passe:

```
Session session = Session.getDefaultInstance(props,new
MailAuthenticator("cd"));
```

Avec class MailAuthenticator qui étend la classe Authenticator

MailAuthenticator.java

```
import javax.mail.*;
import javax.swing.*;
import java.awt.*;
import java.awt.event.*;

public class MailAuthenticator extends Authenticator {

  private JDialog passwordDialog = new JDialog(new JFrame(), true);
  private JLabel passwordLabel = new JLabel("Password: ");
  private String username;
  private JPasswordField passwordField = new JPasswordField(20);
  private JButton okButton = new JButton("OK");
```

MailAuthenticator.java

```
public MailAuthenticator(String u) {
   username = new String(u);
   Container pane = passwordDialog.getContentPane();
   pane.setLayout(new GridLayout(2, 1));
   JPanel p = new JPanel();
   p.add(passwordLabel);
   p.add(passwordField);
    p.add(okButton);
   pane.add(p);
   passwordDialog.pack();
   ActionListener al = new HideDialog();
   okButton.addActionListener(al);
   passwordField.addActionListener(al);
 }
 class HideDialog implements ActionListener {
  public void actionPerformed(ActionEvent e) {
   passwordDialog.hide();
  }
 }
 public PasswordAuthentication getPasswordAuthentication() {
  passwordDialog.show();
  String password = new String(passwordField.getPassword());
  passwordField.setText("");
  return new PasswordAuthentication(username, password);
 }
}
```

Récuperation des champs du message

```
Message[] messages = inbox.getMessages();
    for (int i = 0; i < messages.length; i++) {
      String from = InternetAddress.toString(messages[i].getFrom());
      if (from != null) System.out.println("From: " + from);
      String replyTo = InternetAddress.toString(
       messages[i].getReplyTo());
      if (replyTo != null) System.out.println("Reply-to: "
       + replyTo);
      String to = InternetAddress.toString(
       messages[i].getRecipients(Message.RecipientType.TO));
      if (to != null) System.out.println("To: " + to);
      String cc = InternetAddress.toString(
      messages[i].getRecipients(Message.RecipientType.CC));
      if (cc != null) System.out.println("Cc: " + cc);
```

```
 String subject = messages[i].getSubject();
  if (subject != null) System.out.println("Subject: " + subject);

  Date sent = messages[i].getSentDate();
  if (sent != null) System.out.println("Sent: " + sent);

  Date received = messages[i].getReceivedDate();
  if (received != null) System.out.println("Received: " + received);

  System.out.println();
}
```

Couche application

DNS

DNS: domain name system

people: many identifiers:

- SSN, name, passport #

Internet hosts, routers:

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

Domain Name System:

- *distributed database* implemented in hierarchy of many *name servers*
- *application-layer protocol:* hosts, name servers communicate to *resolve* names (address/name translation)
  - note: core Internet function, implemented as application-layer protocol
  - complexity at network's "edge"

DNS: services, structure

DNS services

- hostname to IP address translation
- host aliasing
- mail server aliasing
- load distribution
  - replicated Web servers: many IP addresses correspond to one name

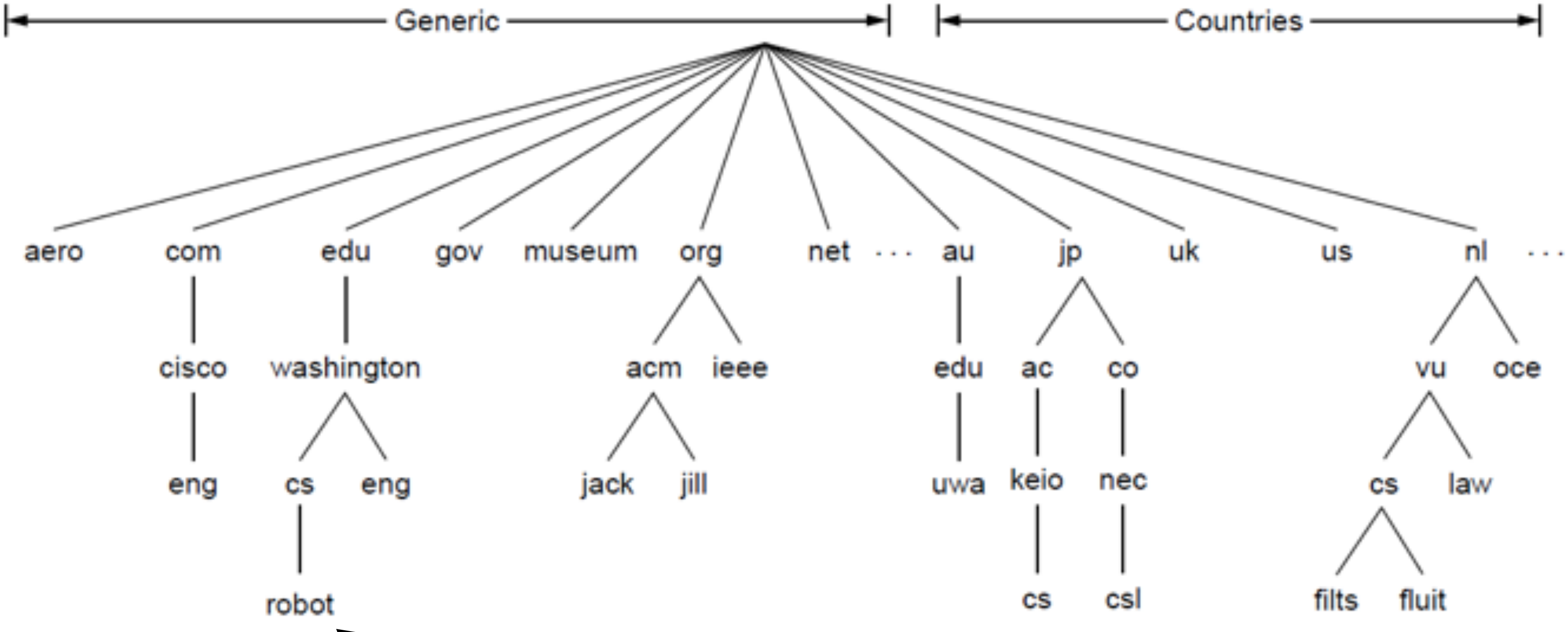
why not centralize DNS?

- single point of failure
- traffic volume
- distant centralized database
- maintenance

DNS Name space

DNS namespace is hierarchical from the root down

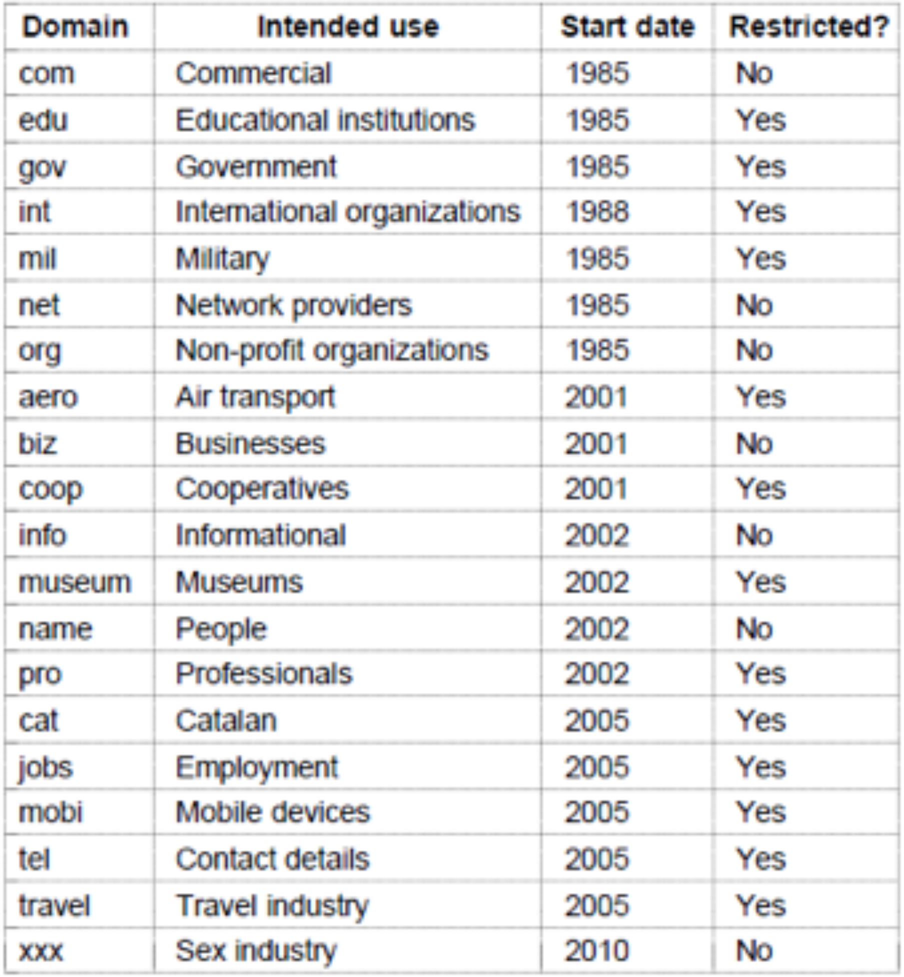
- Different parts delegated to different organizations



The computer robot.cs.washington.edu

DNS Name Space

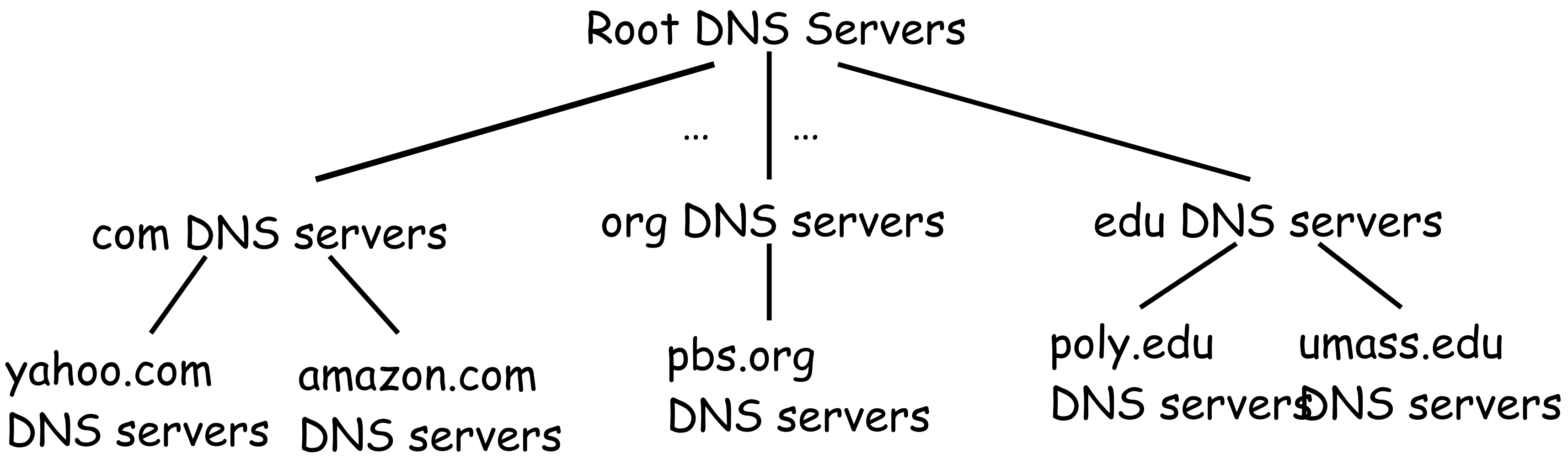
Generic top-level domains are controlled by ICANN who appoints registrars to run them



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

This one was controversial →

DNS: a distributed, hierarchical database

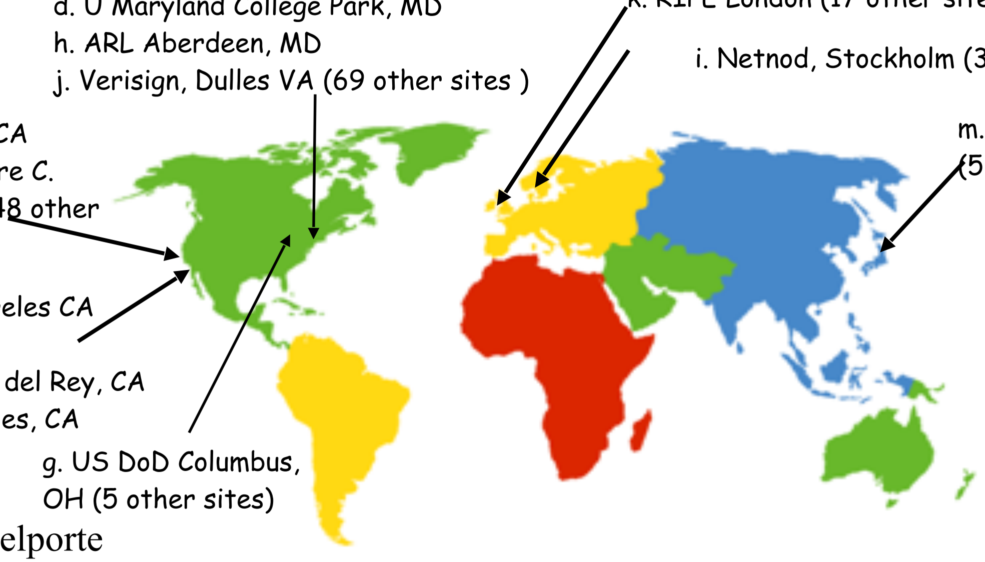


client wants IP for www.amazon.com; 1st approx:

- 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:
  - contacts authoritative name server if name mapping not known
  - gets mapping
  - 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

TLD, authoritative servers

top-level domain (TLD) servers:

- responsible for com, org, net, edu, aero, jobs, museums, and all top-level country domains, e.g.: uk, fr, ca, jp
- Network Solutions maintains servers for .com TLD
  - NTIA cooperative agreement with Educause for the managment.edu TLD
- .fr Association Française pour le Nommage Internet en Coopération (A.F.N.I.C.)

authoritative DNS servers:

- organization's own DNS server(s), providing authoritative hostname to IP mappings for organization's named hosts
- can be maintained by organization or service provider

Local DNS name server

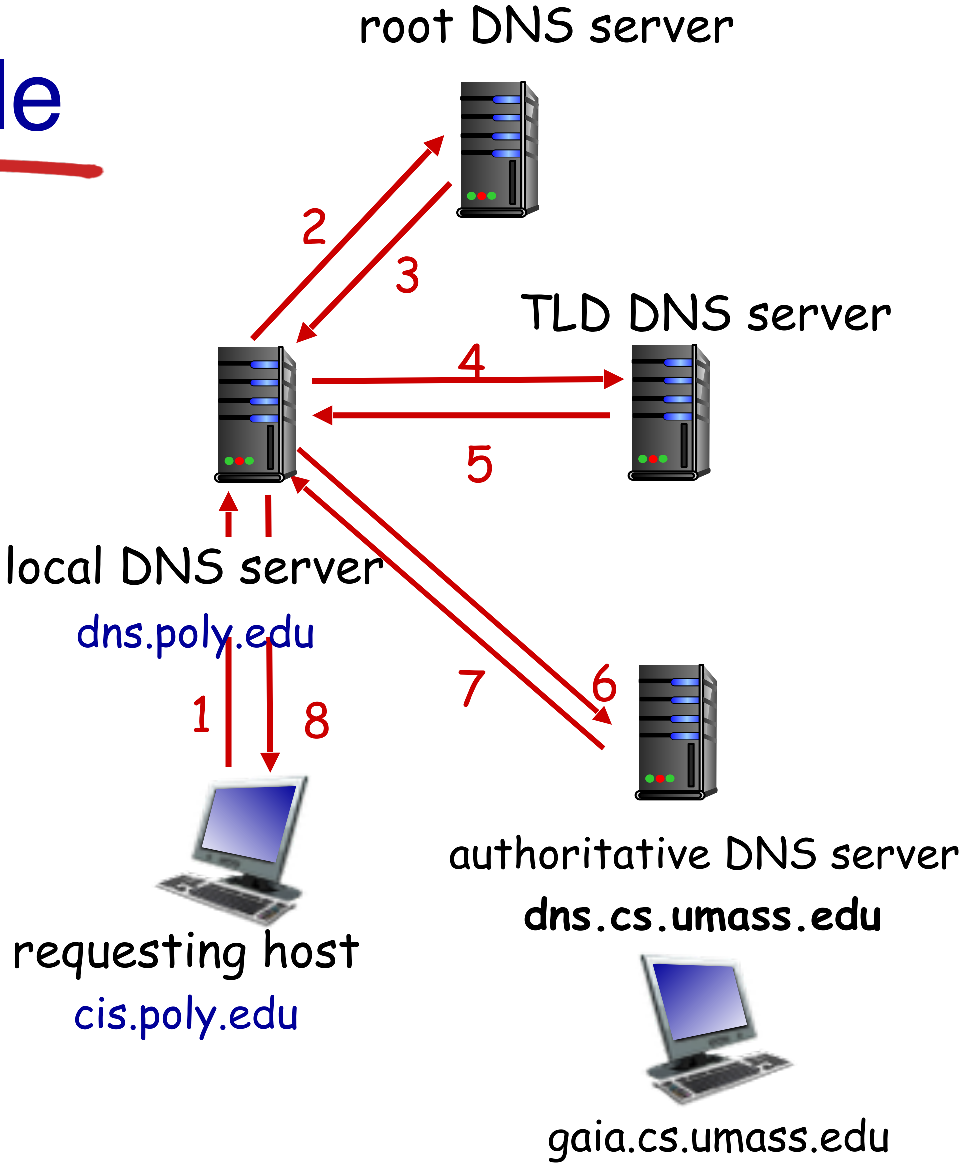
- does not strictly belong to hierarchy
- each ISP (residential ISP, company, university) has one
  - also called "default name server"
- when host makes DNS query, query is sent to its local DNS server
  - has local cache of recent name-to-address translation pairs (but may be out of date!)
  - acts as proxy, forwards query into hierarchy

DNS name resolution example

- 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"



root DNS server

TLD DNS server

local DNS server
dns.poly.edu

requesting host
cis.poly.edu

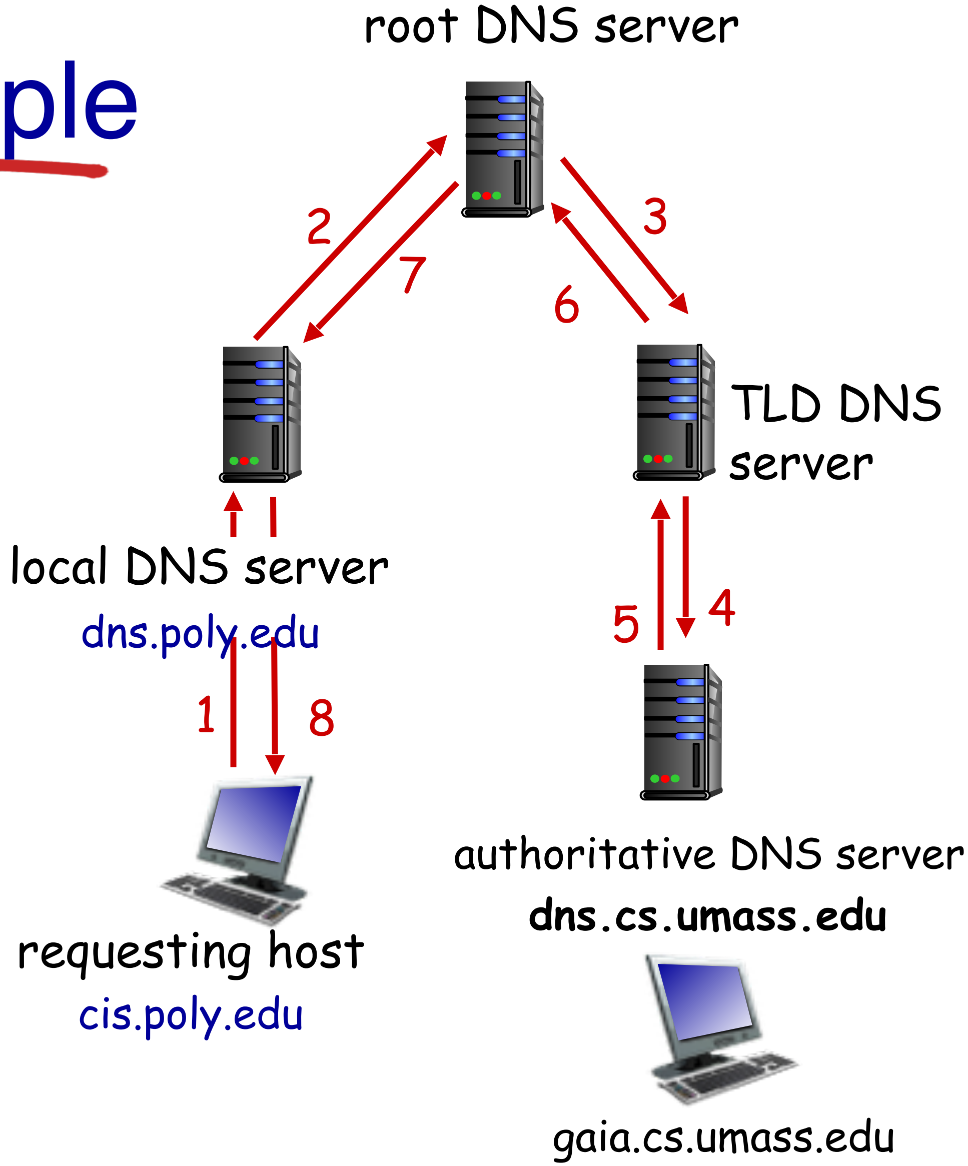
authoritative DNS server
dns.cs.umass.edu

gaia.cs.umass.edu

DNS name resolution example

recursive query:

- puts burden of name resolution on contacted name server
- heavy load at upper levels of hierarchy?



DNS: caching, updating records

- once (any) name server learns mapping, it *caches* mapping
  - cache entries timeout (disappear) after some time (TTL)
  - TLD servers typically cached in local name servers
    - thus root name servers not often visited
- cached entries may be *out-of-date* (best effort name-to-address translation!)
  - if name host changes IP address, may not be known Internet-wide until all TTLs expire
- update/notify mechanisms proposed IETF standard
  - RFC 2136

DNS records

DNS: distributed db 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 the canonical name of mail server that has an alias hostname **`name`**

Enregistrements DNS

- nslookup
- dig

```
dig www.google.com

; <<>> DiG 9.8.3-P1 <<>> www.google.com
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 30123
;; flags: qr rd ra; QUERY: 1, ANSWER: 6, AUTHORITY: 0, ADDITIONAL: 0

;; QUESTION SECTION:
;www.google.com.                    IN      A

;; ANSWER SECTION:
www.google.com.          181        IN      A         173.194.65.103
www.google.com.          181        IN      A         173.194.65.147
www.google.com.          181        IN      A         173.194.65.104
www.google.com.          181        IN      A         173.194.65.105
www.google.com.          181        IN      A         173.194.65.106
www.google.com.          181        IN      A         173.194.65.99

;; Query time: 5 msec
;; SERVER: 192.168.1.1#53(192.168.1.1)
;; WHEN: Thu Nov  6 22:24:54 2014
;; MSG SIZE  rcvd: 128
```

```
; <<>> DiG 9.8.3-P1 <<>> MX gmail.com
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 4224
;; flags: qr rd ra; QUERY: 1, ANSWER: 5, AUTHORITY: 0, ADDITIONAL: 0

;; QUESTION SECTION:
;gmail.com.                     IN      MX

;; ANSWER SECTION:
gmail.com.              2614    IN      MX      20 alt2.gmail-smtp-in.l.google.com.
gmail.com.              2614    IN      MX      40 alt4.gmail-smtp-in.l.google.com.
gmail.com.              2614    IN      MX      30 alt3.gmail-smtp-in.l.google.com.
gmail.com.              2614    IN      MX      10 alt1.gmail-smtp-in.l.google.com.
gmail.com.              2614    IN      MX      5 gmail-smtp-in.l.google.com.

;; Query time: 17 msec
;; SERVER: 192.168.1.1#53(192.168.1.1)
;; WHEN: Thu Nov  6 22:26:22 2014
;; MSG SIZE  rcvd: 150
```

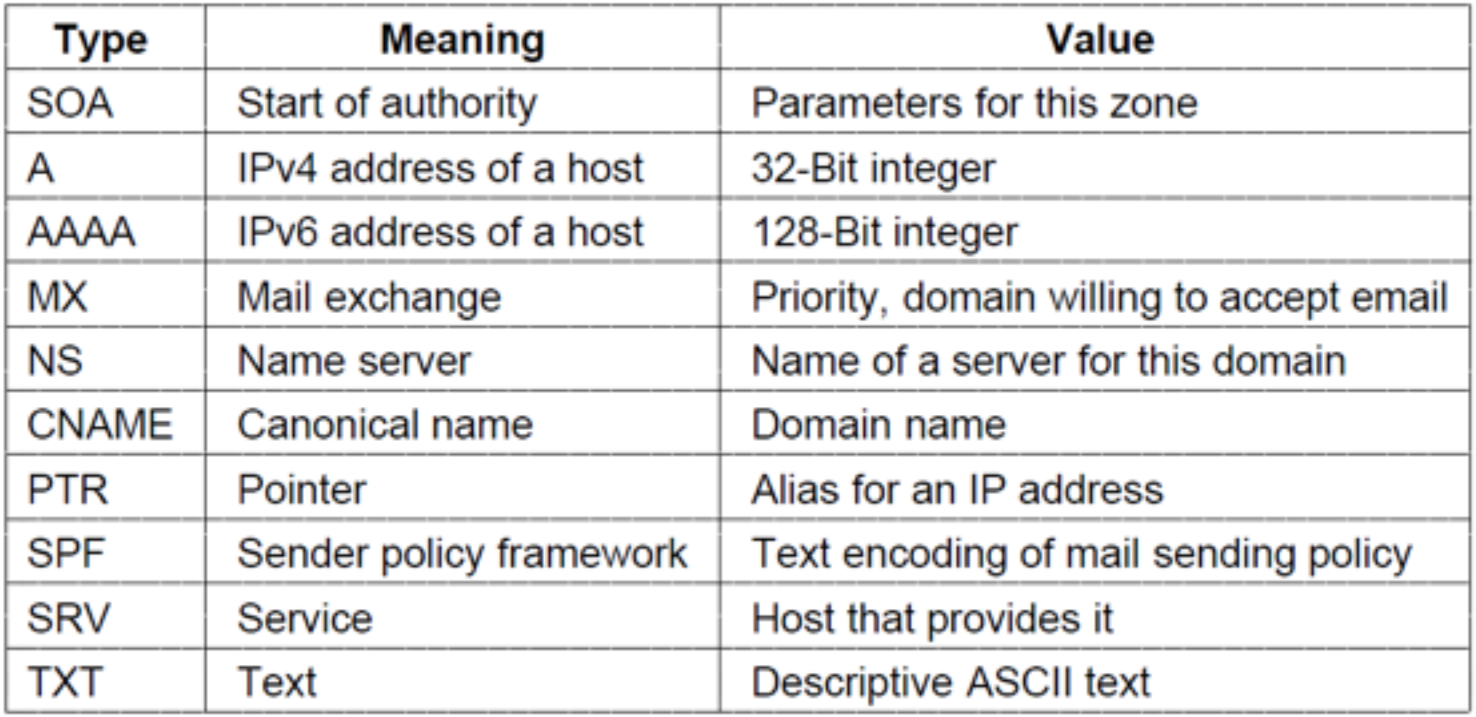
```
$dig au.edu
; <<>> DiG 9.7.2-P2 <<>> au.edu
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 36394
;; flags: qr rd ra; QUERY: 1, ANSWER: 1, AUTHORITY: 2, ADDITIONAL: 0

;; QUESTION SECTION:
;au.edu.                        IN      A

;; ANSWER SECTION:
au.edu.             10800   IN      A       168.120.16.231

;; AUTHORITY SECTION:
au.edu.             10800   IN      NS       abac.au.ac.th.
au.edu.             10800   IN      NS       ksc.au.ac.th.

.....
```

```
$dig www.ibm.com

; <<>> DiG 9.7.2-P2 <<>> www.ibm.com
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 21972
;; flags: qr rd ra; QUERY: 1, ANSWER: 4, AUTHORITY: 8, ADDITIONAL: 8

;; QUESTION SECTION:
;www.ibm.com.                IN      A

;; ANSWER SECTION:
www.ibm.com.            3600    IN      CNAME   www.ibm.com.cs186.net.
www.ibm.com.cs186.net.  60      IN      CNAME   www.ibm.com.edgekey.net.
www.ibm.com.edgekey.net. 300    IN      CNAME   e3062.x.akamaiedge.net.
e3062.x.akamaiedge.net. 19      IN      A       23.223.231.66
```

```
;; AUTHORITY SECTION:
x.akamaiedge.net.      2696   IN     NS     n3x.akamaiedge.net.
x.akamaiedge.net.      2696   IN     NS     n5x.akamaiedge.net.
x.akamaiedge.net.      2696   IN     NS     a0x.akamaiedge.net.
x.akamaiedge.net.      2696   IN     NS     n1x.akamaiedge.net.
x.akamaiedge.net.      2696   IN     NS     n4x.akamaiedge.net.
x.akamaiedge.net.      2696   IN     NS     n0x.akamaiedge.net.
x.akamaiedge.net.      2696   IN     NS     a1x.akamaiedge.net.
x.akamaiedge.net.      2696   IN     NS     n2x.akamaiedge.net.

;; ADDITIONAL SECTION:
a0x.akamaiedge.net.    648    IN     AAAA   2a02:26f0:32:f000:f508:905:cbfb:
348f
a1x.akamaiedge.net.    192    IN     AAAA
2a02:26f0:32:f000:f508:4b39:89c7:76b4
n0x.akamaiedge.net.    1221   IN     A      217.212.239.56
.....
```

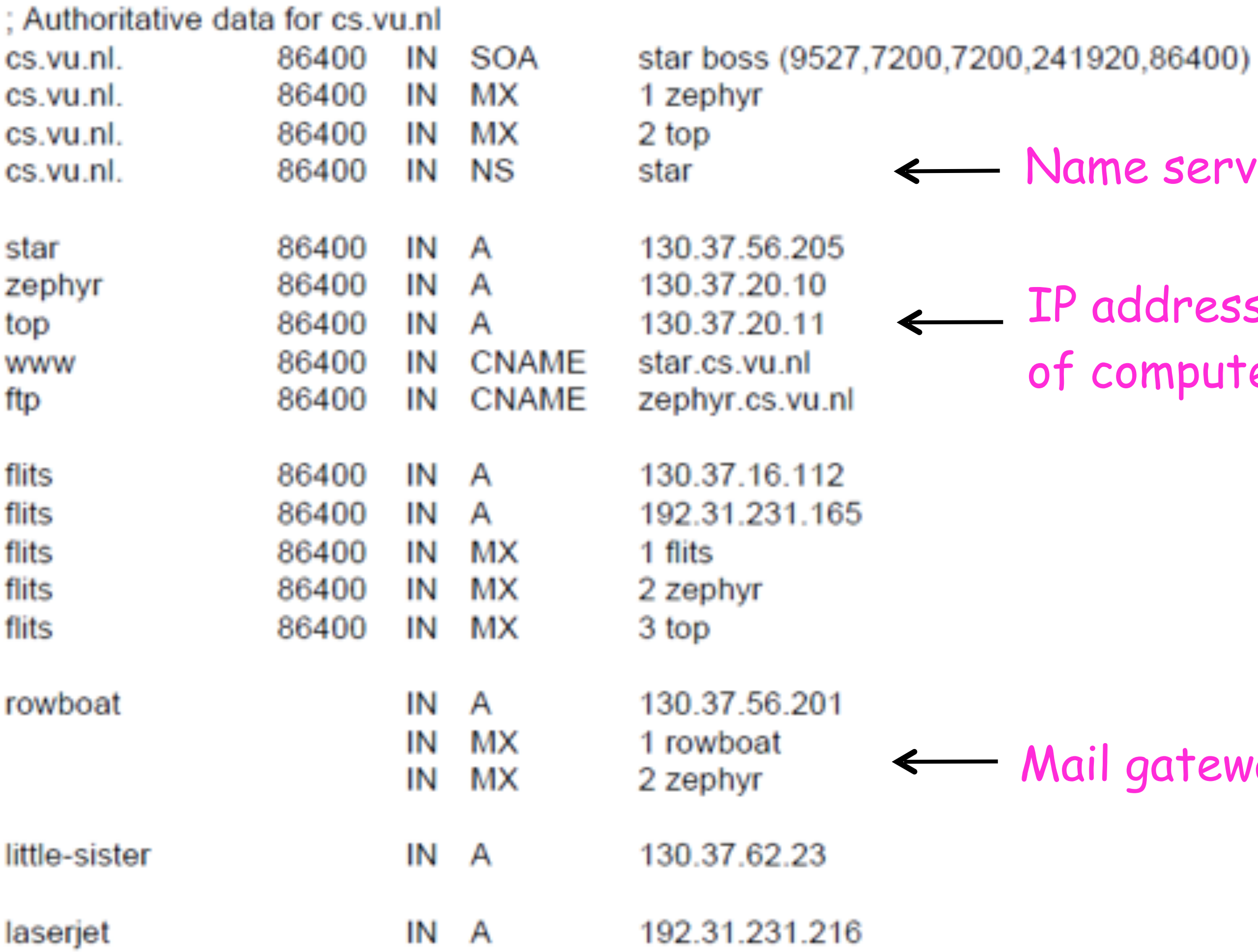
Domain Resource Records

The key resource records in the namespace are IP addresses (A/AAAA) and name servers (NS), but there are others too (e.g., MX)



Type	Meaning	Value
SOA	Start of authority	Parameters for this zone
A	IPv4 address of a host	32-Bit integer
AAAA	IPv6 address of a host	128-Bit integer
MX	Mail exchange	Priority, domain willing to accept email
NS	Name server	Name of a server for this domain
CNAME	Canonical name	Domain name
PTR	Pointer	Alias for an IP address
SPF	Sender policy framework	Text encoding of mail sending policy
SRV	Service	Host that provides it
TXT	Text	Descriptive ASCII text

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

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

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

little-sister          IN  A      130.37.62.23

laserjet               IN  A      192.31.231.216
```

← Name server

← IP addresses of computers

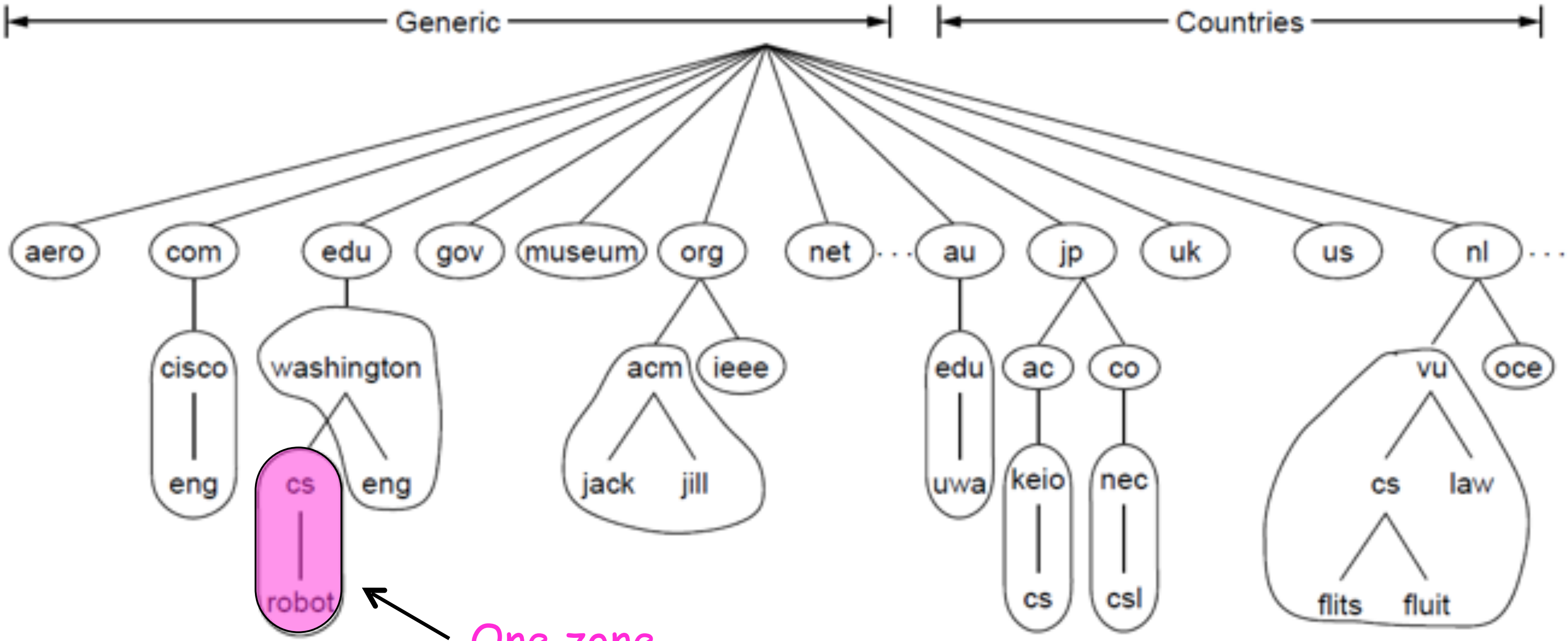
← Mail gateways

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

Carole Delporte

Name Servers

Name servers contain data for portions of the name space called zones (circled).



One zone

DNS protocol, messages

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

msg header

v identification: 16 bit # for query, reply to query uses same #

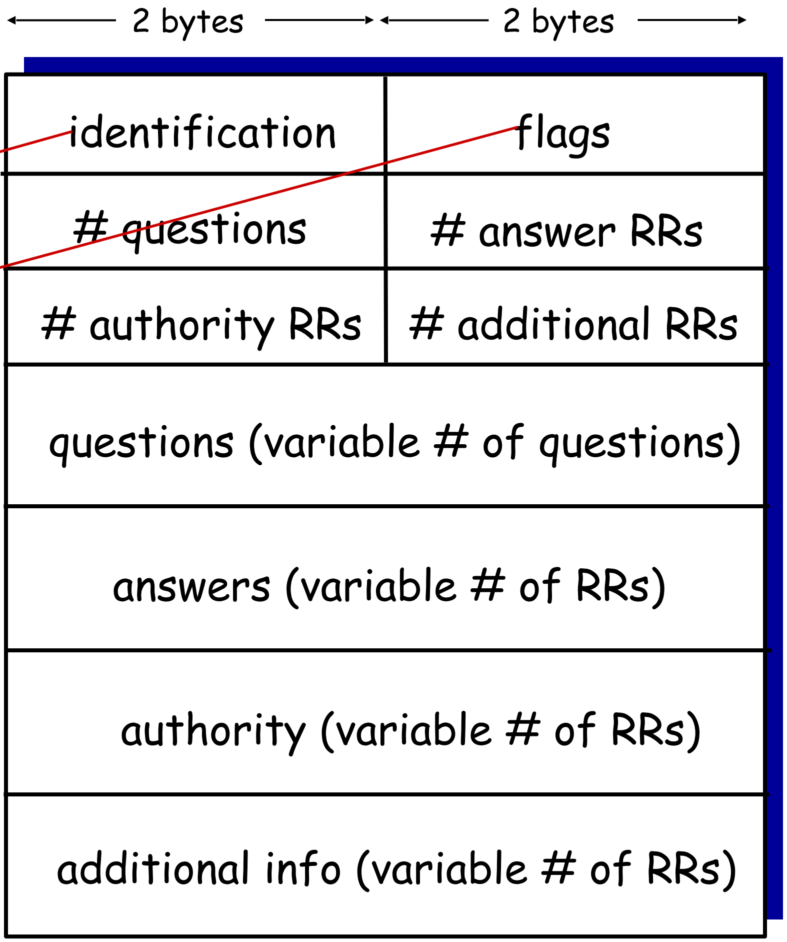
v flags:

  § query or reply

  § recursion desired

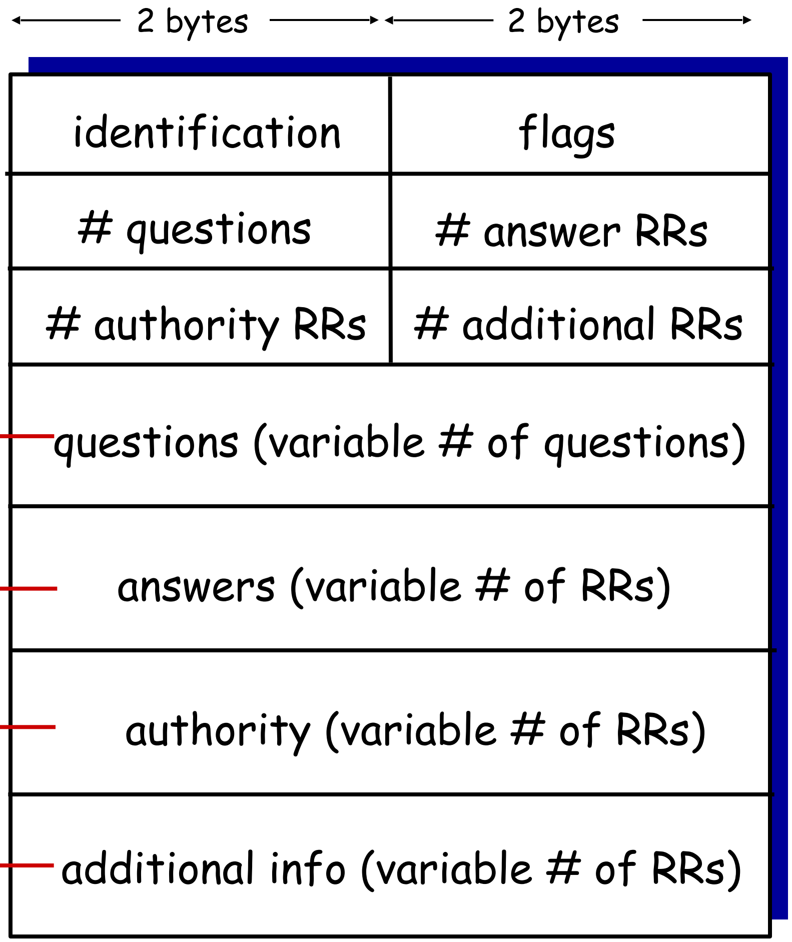
  § recursion available

  § 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)	

DNS protocol, messages



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)	

name, type fields for a query

RRs in response to query

records for authoritative servers

additional "helpful" info that may be used

Inserting records into DNS

- example: new startup “Network Utopia”
- register name networkuptopia.com at *DNS registrar* (e.g., Network Solutions)
  - provide names, IP addresses of authoritative name server (primary and secondary)
  - registrar inserts two RRs into .com TLD server:

    ```
    (networkutopia.com, dns1.networkutopia.com, NS)
    (dns1.networkutopia.com, 212.212.212.1, A)
    ```
- create authoritative server type A record for www.networkuptopia.com; type MX record for networkutopia.com

Attacking DNS

DDoS attacks

- Bombard root servers with traffic
  - Not successful to date
  - Traffic Filtering
  - Local DNS servers cache IPs of TLD servers, allowing root server bypass
- Bombard TLD servers
  - Potentially more dangerous

Redirect attacks

- Man-in-middle
  - Intercept queries, return bogus replies
- DNS poisoning
  - Send bogus replies to DNS server —> accepting bogus records into its cache

Exploit DNS for DDoS

- Send queries with spoofed source address: target IP
- Requires amplification