Computer Networks (CS F303)

BITS Pilani
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Module-2 Application Layer

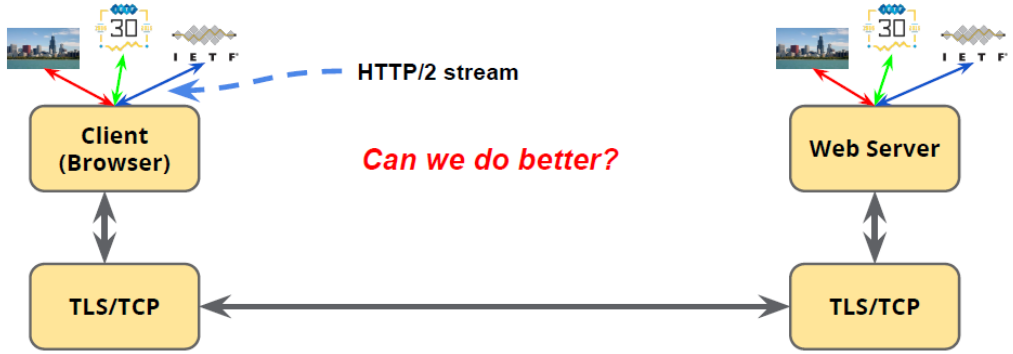
Today's Agenda

- HTTP/2 Protocol
  - Stream oriented protocol
- Domain Name System (DNS)
  - Hostname to IP address mapping system

HTTP/2Feature: Stream Multiplexing

- What is ***stream***?
  - Bi-directional sequence of text format frames sent over the HTTP/2 protocol exchanged between the server and client

- HTTP/1 is capable of transmitting only one stream at a time
  - Receiving large amount of media content via individual streams sent one by one is inefficient and resource consuming



- HTTP/2 allows transmission of parallel multiplexed requests and responses
  - A binary framing layer is created
  - This layer allows client and server to disintegrate the HTTP payload into small, independent and manageable interleaved sequence of frames
  - This information is then reassembled at the other end

HTTP/2 Feature: Server PUSH

- It allows the server to send additional cacheable information to the client that isn't requested but is anticipated in future requests.

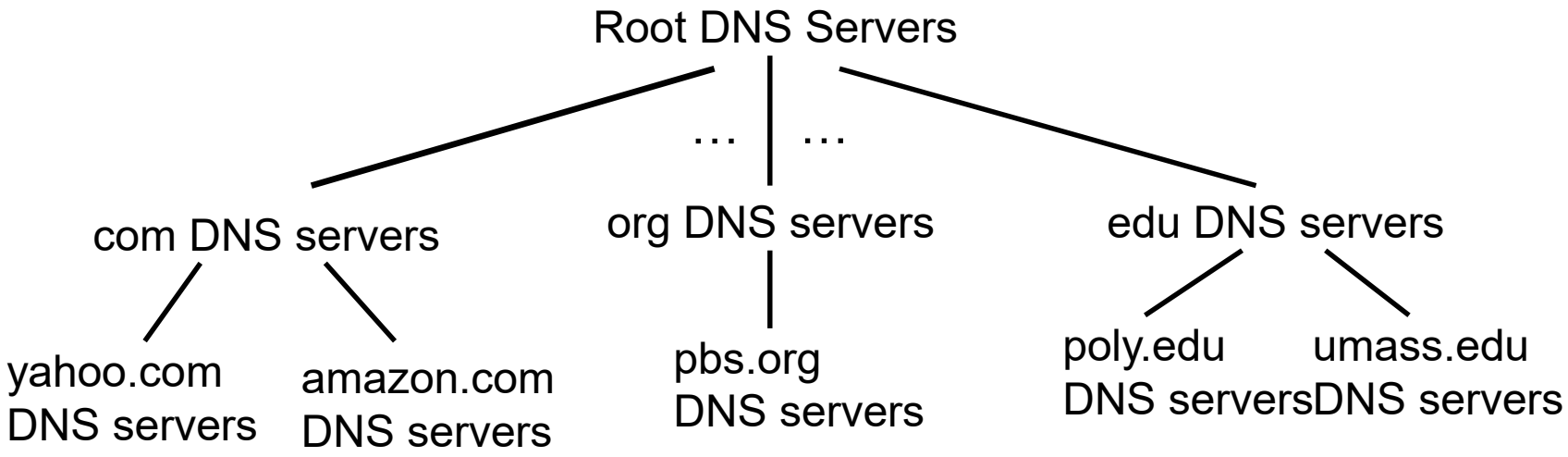
- This mechanism saves a request-respond round trip and reduces network latency.

Domain Name System (DNS)

- When a browser (HTTP client) requests the URL www.bits-pilani.ac.in/index.html
- In order to send an HTTP request msg to the destination host the client's host must obtain the IP address of the destination host

- The **domain name system** maps the **name** people use to locate a website to the IP address that a computer uses to locate a website.
- Why do we need the mapping between host name and IP address?
- *Application-layer protocol:* hosts, name servers communicate to *resolve* names (address/name translation)

DNS Structure – Distributed Hierarchical Database



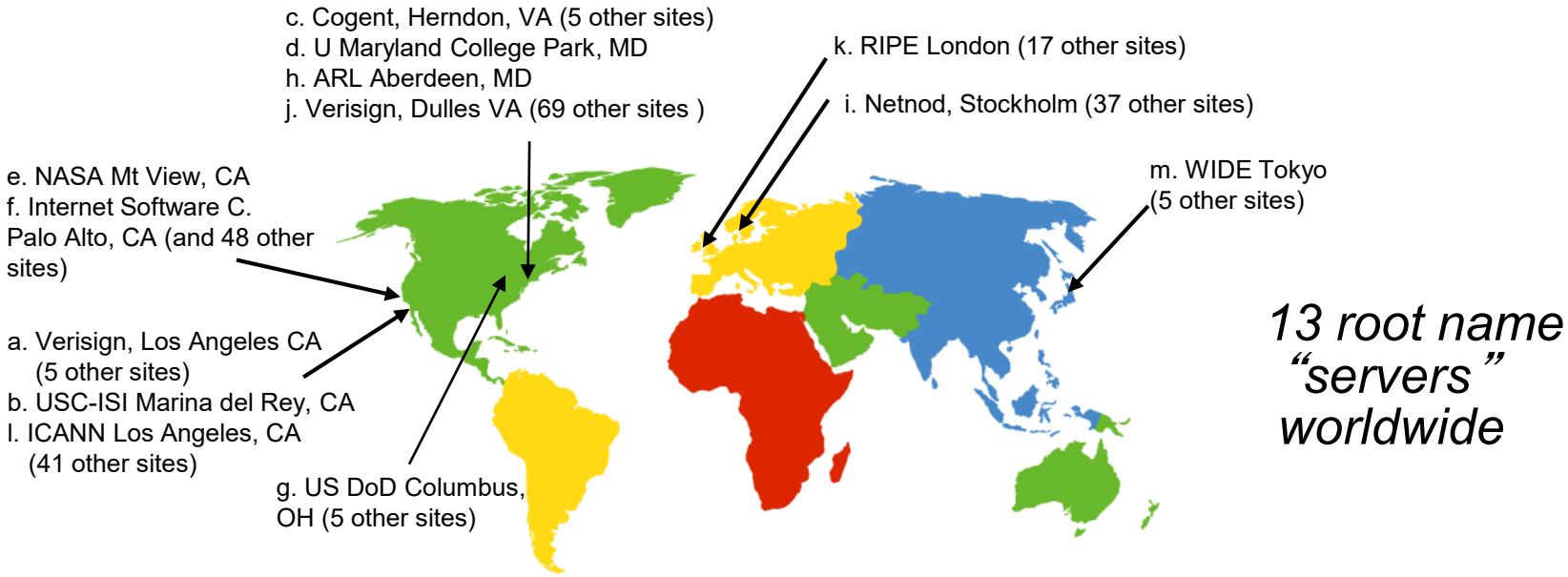
Client wants IP for www.amazon.com; 1st approx:

- 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

List of all top level domain servers is available at: ***https://www.icann.org/resources/pages/tlds-2012-02-25-en***

Root Name Servers

- Root name server:
  - Total 13 server, mostly located in North America.
  - Each server is actually a network of replicated servers

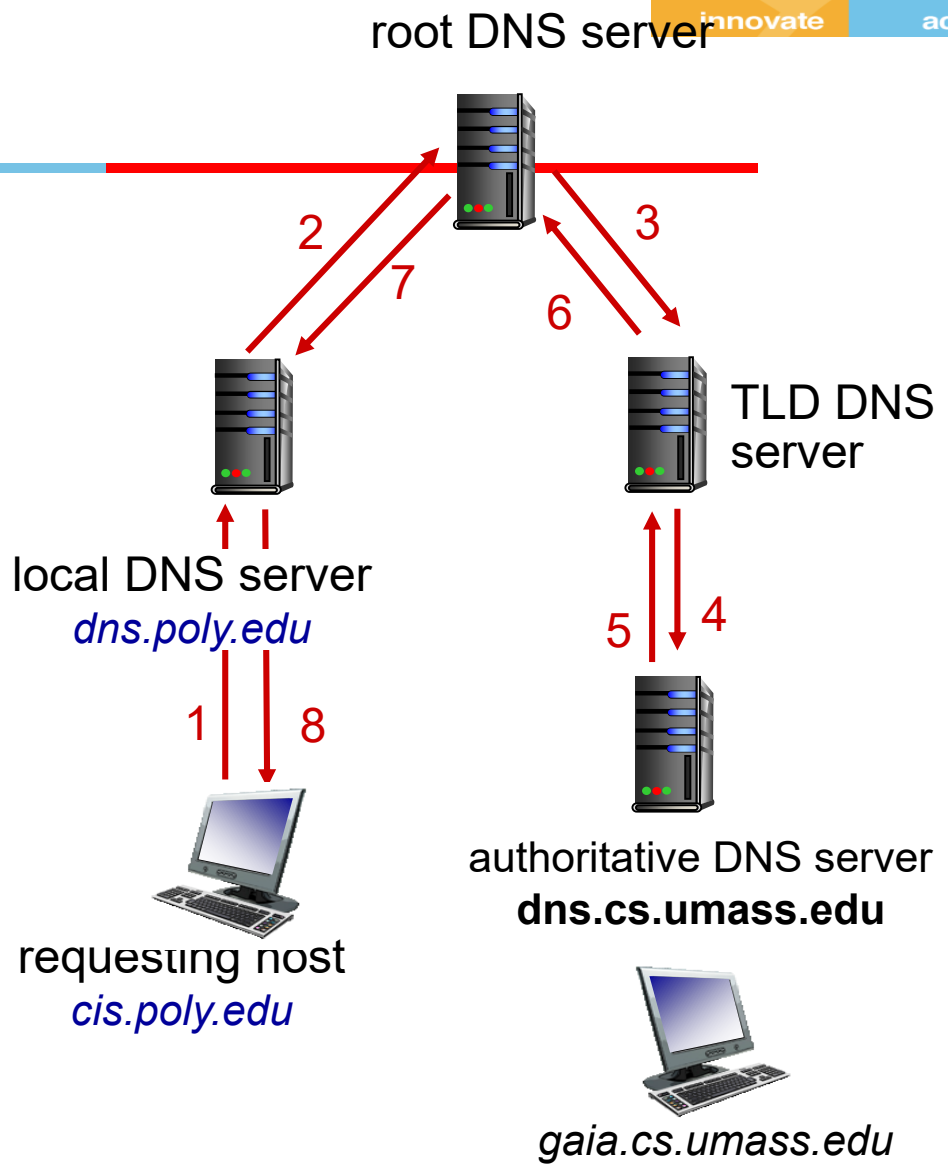


13 root name "servers" worldwide

DNS Services

- Hostname to IP address translation
  - Host name to IP address mapping
- Host aliasing
  - Canonical name to alias name(s) mapping
- Mail server aliasing
  - Host name to mail server mapping
- Load distribution
  - Replicated Web servers: many IP addresses correspond to one name

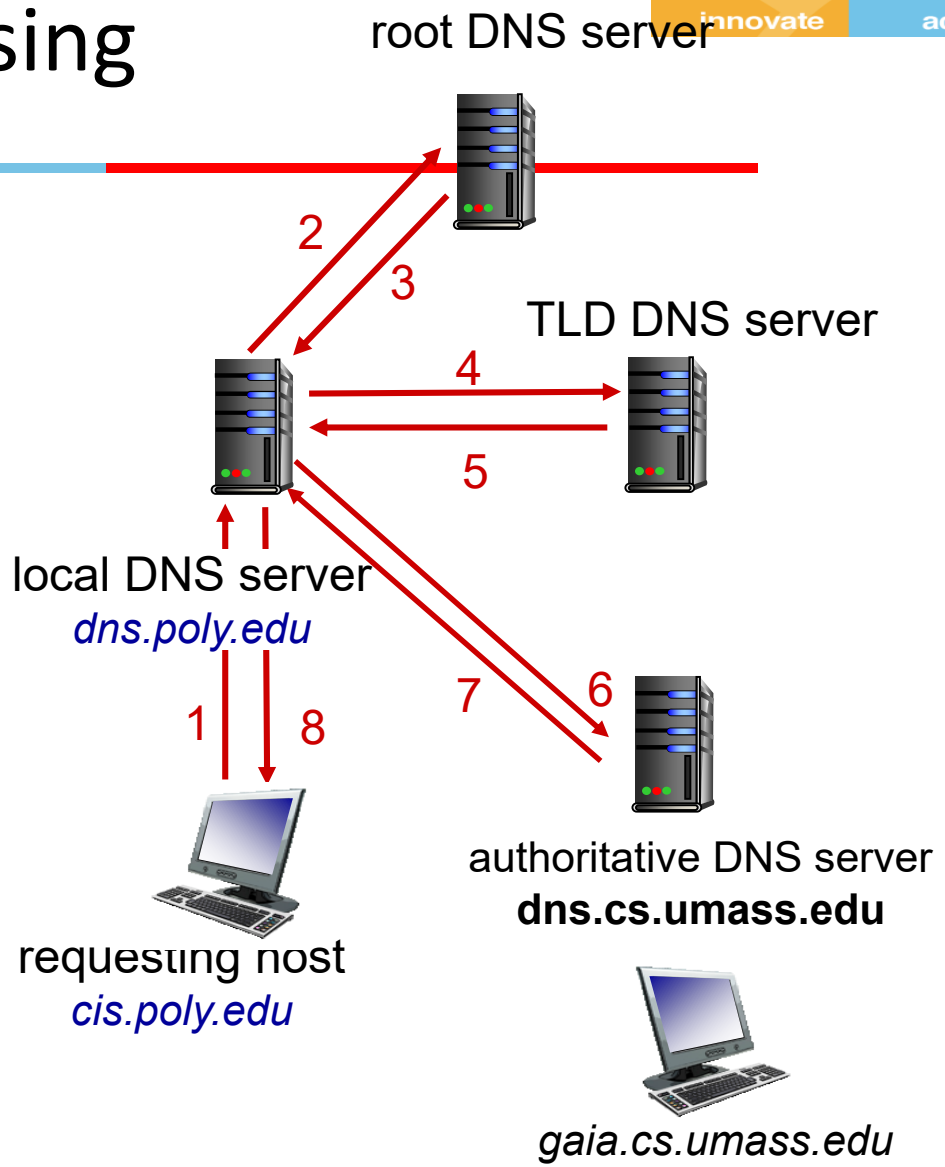
Recursive Query



Practical DNS Query Processing

- TLD server may know only of an intermediate DNS server for the hostname, which in turn knows the authoritative DNS server for the hostname.

- DNS responses are usually cached to improve the delay performance and to reduce the number of DNS messages
  - e.g., Local DNS server caches the TLD server information



DNS Records

DNS: distributed database for 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

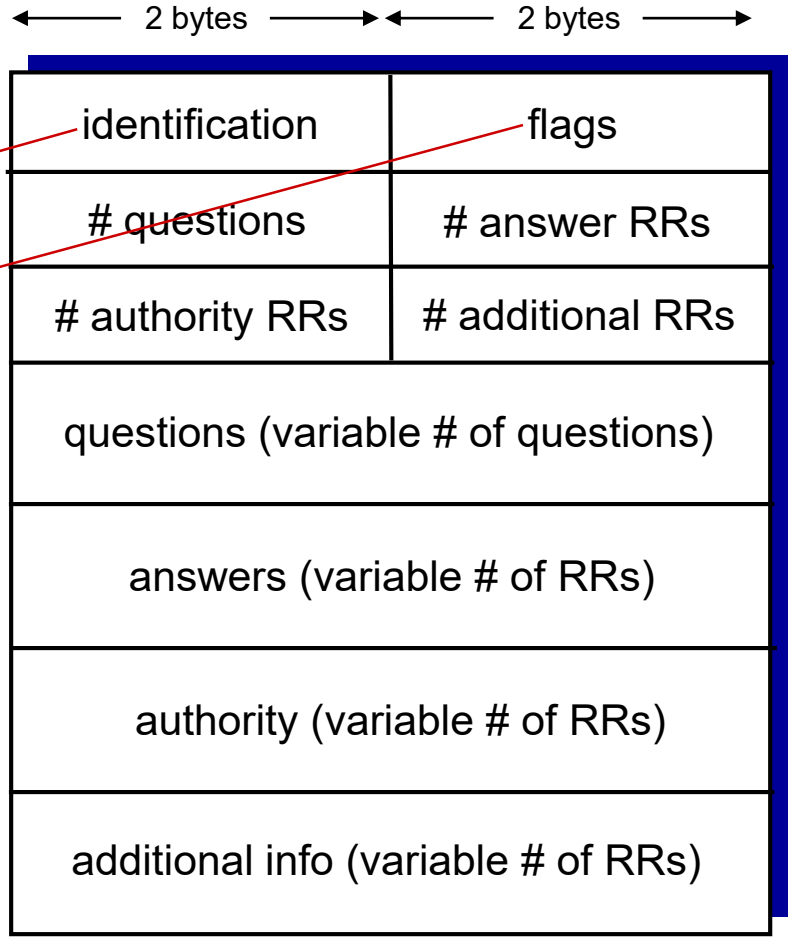
- **`value`** is name of mailserver associated with **`name (host name, i.e., mailserver alias)`**

DNS Messages

- *Query* and *reply* messages, both with same *message format*
- *Explore DNS protocol in Lab Session #2*

msg header

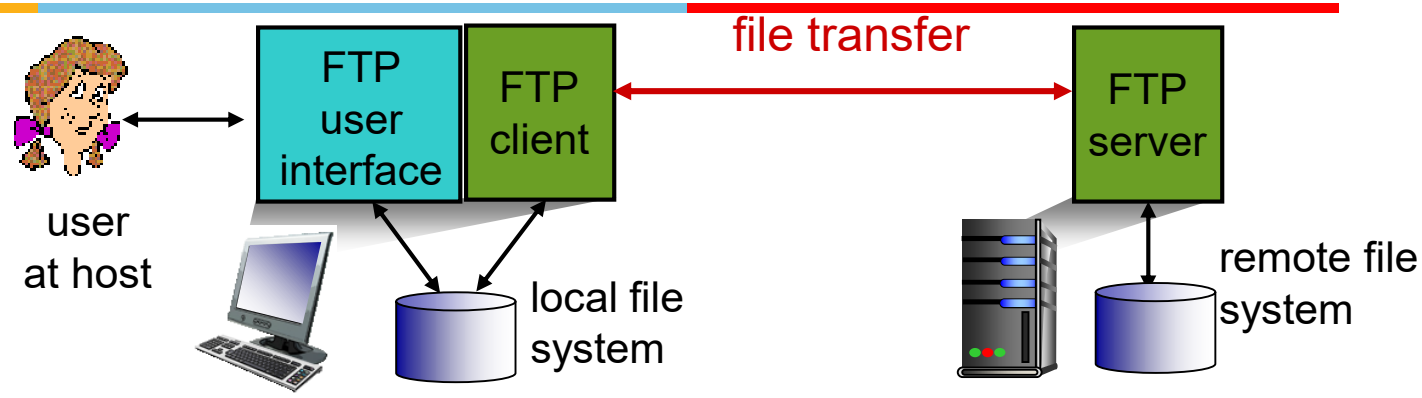
- identification: 16 bit # for query, reply to query uses same #
- flags:
  - query or reply
  - recursion desired
  - recursion available
  - reply is authoritative



Inserting Records into DNS

- A newly created domain name should be first registered at a registrar
  - Internet Cooperation of Assigned Names and Numbers (ICANN) accredits the registrars
  - Accredited registrar list is available at www.internic.net

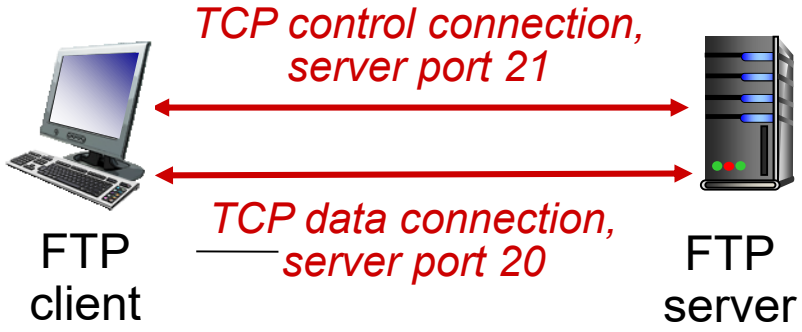
FTP: File Transfer Protocol



- 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: Connections

- Control connection
  - Authorization, directory listing etc.
- When server receives file transfer command,
  - *Server* opens *2nd* TCP data connection (for file) *to* client
- After transferring one file, server closes data connection



FTP Commands and Responses

Sample commands:

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

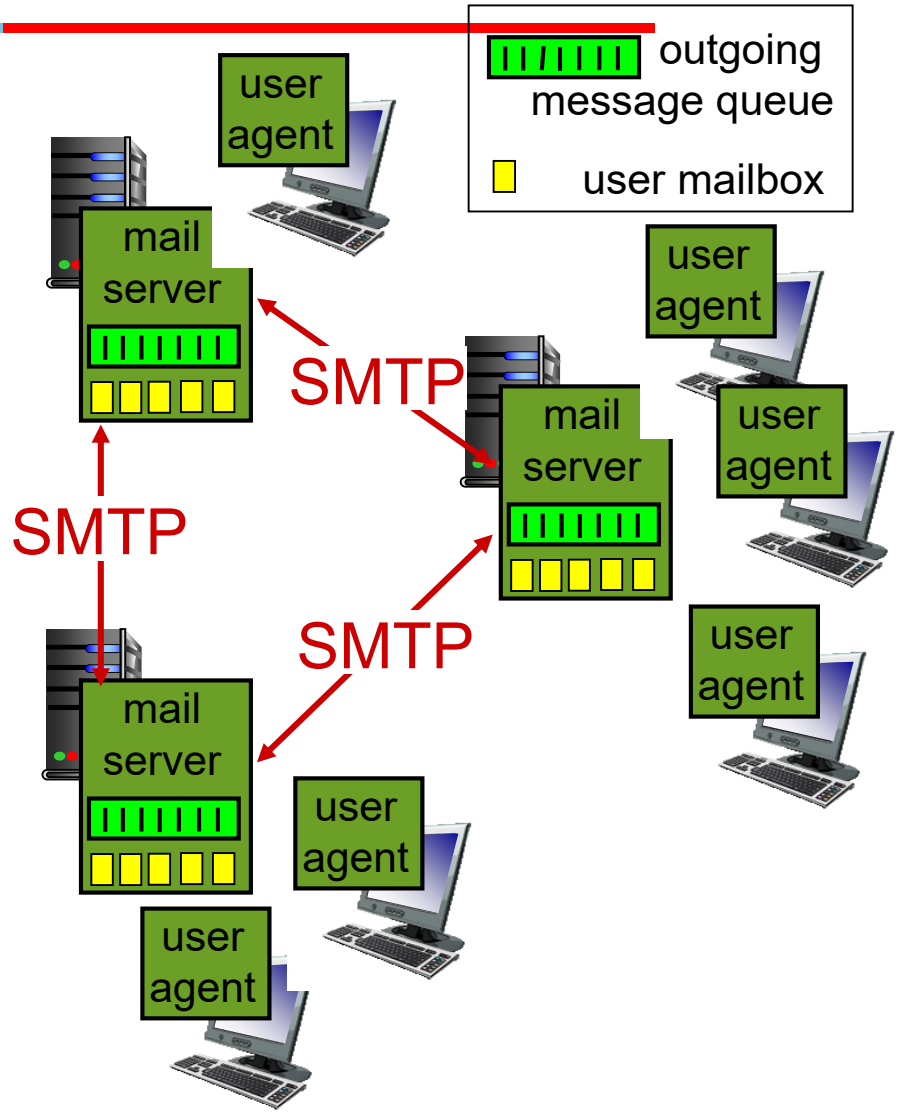
Sample return codes

- **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**

eMail

Three major components:

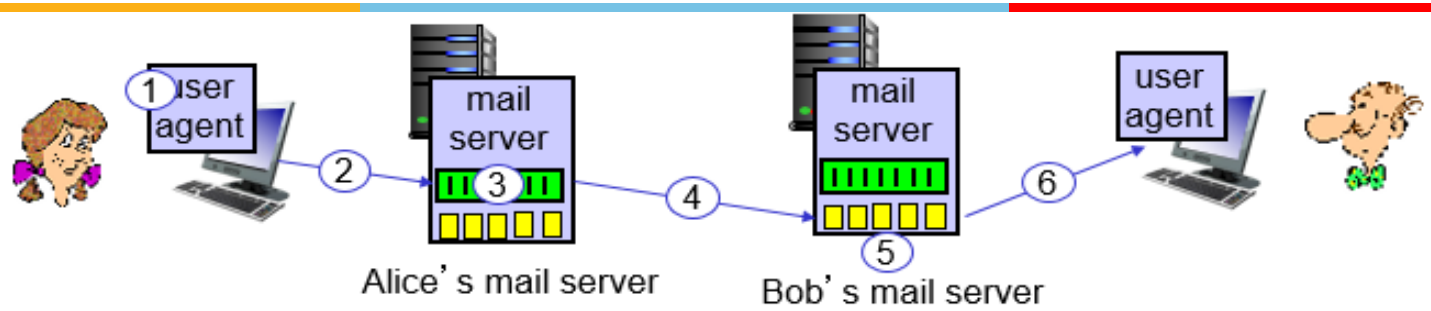
- User agents
  - e.g., Outlook, Thunderbird
- Mail servers
  - Contains incoming messages for user
- Simple mail transfer protocol:
  - SMTP



SMTP [RFC 5321, Original RFC 821]

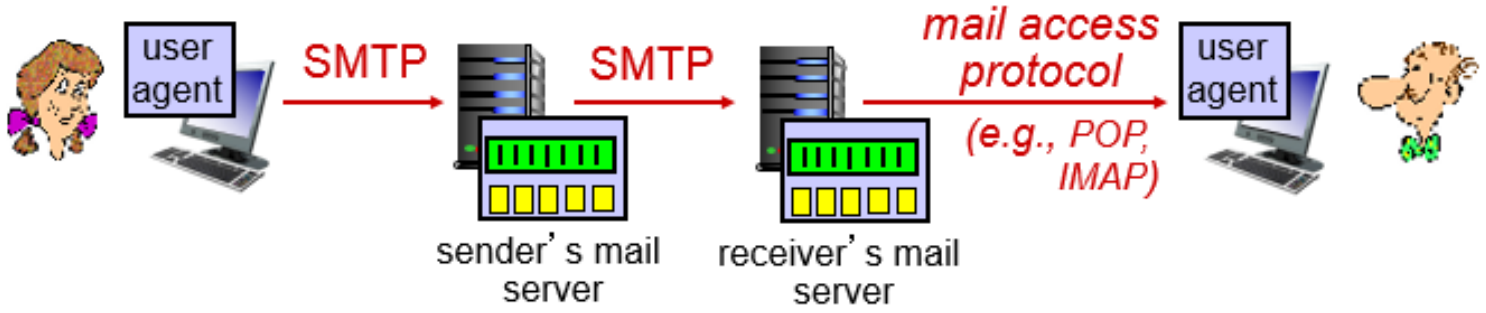
- Uses TCP to reliably transfer email message from client to server, port 25
- Direct transfer: sender's mail server to receiver's mail server
- Three phases of transfer
  - Handshaking (greeting)→Transfer of messages→Connection Closure
- Command/response interaction (like HTTP, FTP)
  - Commands: ASCII text
  - Response: status code and phrase
- Messages must be in 7-bit ASCII
  - Painful for multimedia data

Mail Transfer Process




```
S: 220 hamburger.edu
C: HELO crepes.fr
S: 250  Hello crepes.fr, pleased to meet you
C: MAIL FROM: <alice@crepes.fr>
S: 250 alice@crepes.fr... Sender ok
C: RCPT TO: <bob@hamburger.edu>
S: 250 bob@hamburger.edu ... Recipient ok
C: DATA
S: 354 Enter mail, end with "." on a line by itself
C: Do you like ketchup?
C: How about pickles?
C: .
S: 250 Message accepted for delivery
C: QUIT
S: 221 hamburger.edu closing connection
```

Mail Access Protocols



- Mail access protocol: retrieval from server
  - POP3 [Port:110]: Post Office Protocol [RFC 1939]: authorization, download and keep, download and delete
    - User can create folders and move the messages into them locally.
    - Stateless across the sessions
  - IMAP: Internet Mail Access Protocol [RFC 1730]: more features, including manipulation of stored msgs on server
    - Allows to create remote folders and maintains user state information across IMAP sessions
    - Permit a user agent to obtain components of messages. Good for low bandwidth connections.

POP3 Protocol

Authorization phase

- Client commands:
  - **`user:`** declare username
  - **`pass:`** password
- Server responses
  - **`+OK`**
  - **`-ERR`**

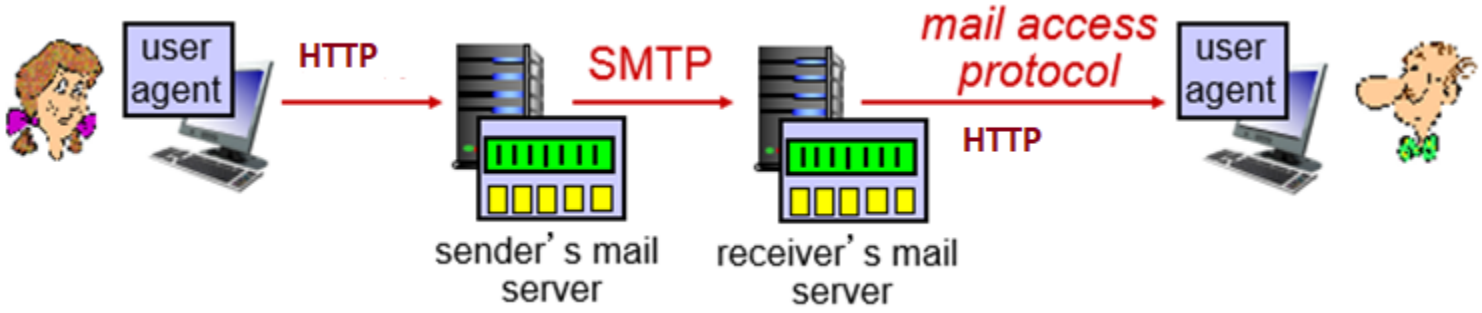
Transaction phase, client:

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

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

Web based E-Mail

- Hotmail introduced Web-based access in the 1990s



Thank You!