16CSCN01I: Introduction to Computer Networks

Lecture 3: Application Layer

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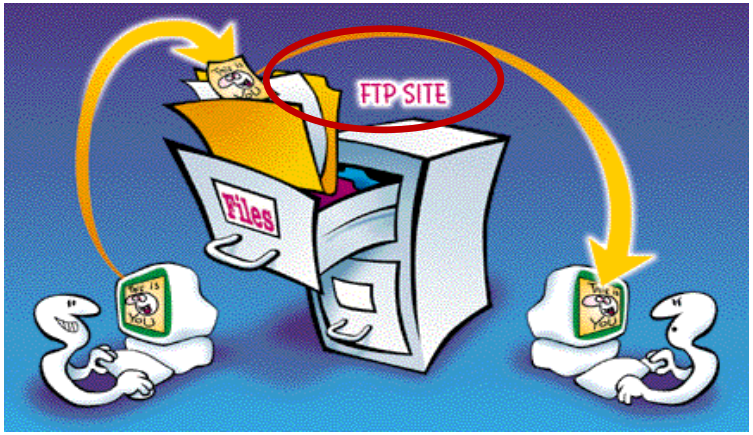
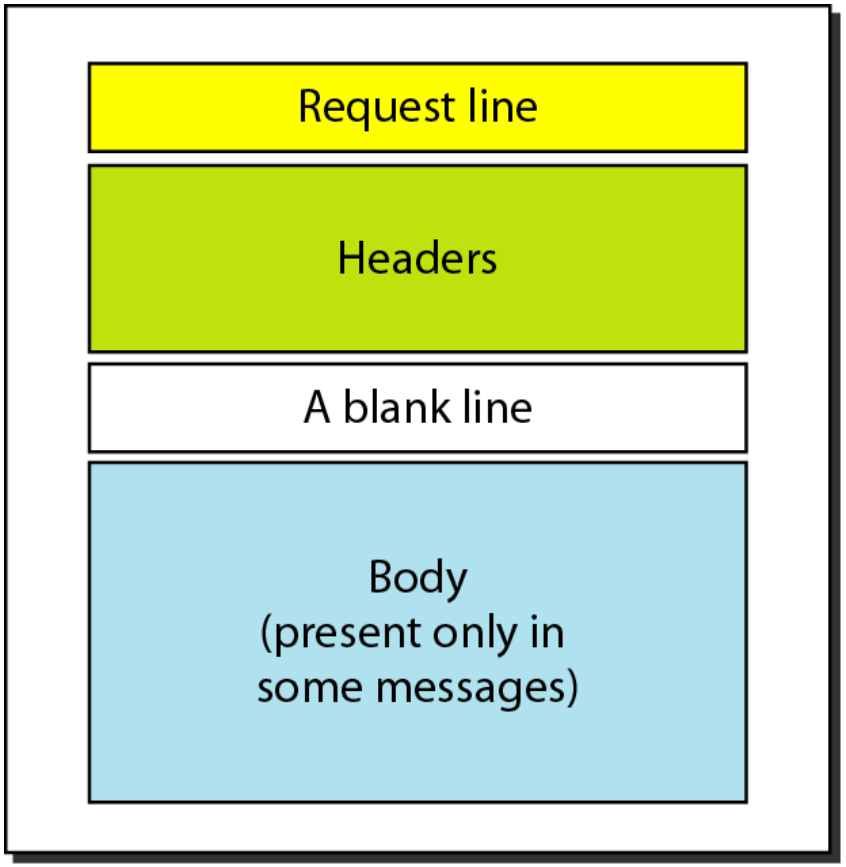
Application Layer
What Will We Study?



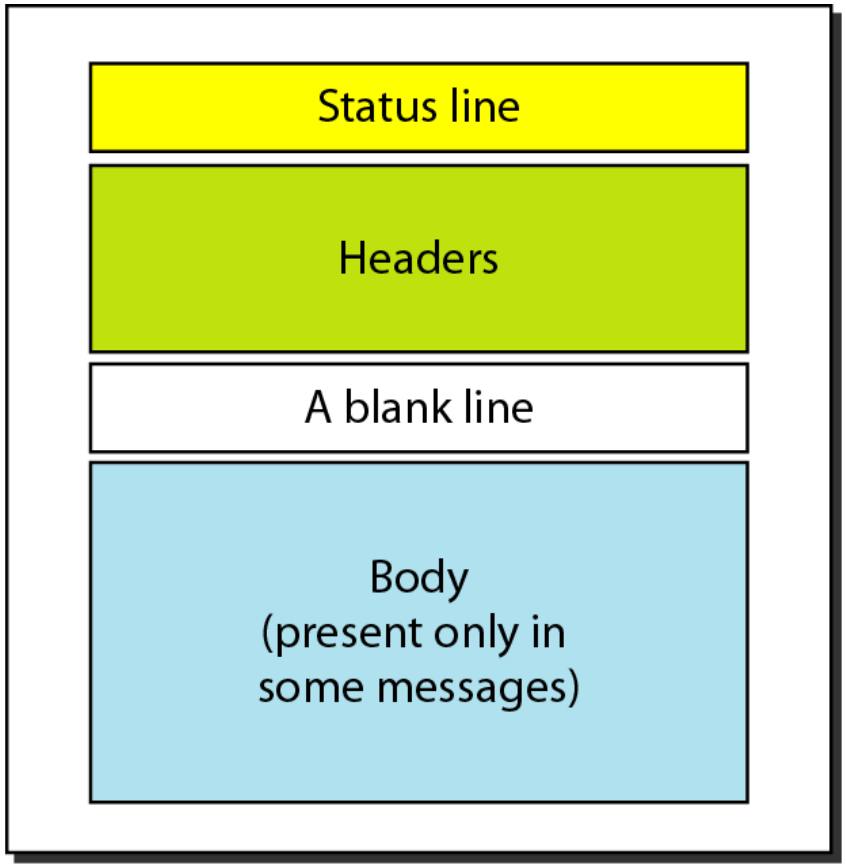
SMTP GMail

HTTP Messages

- Two types: Request, Response
- Written in ASCII

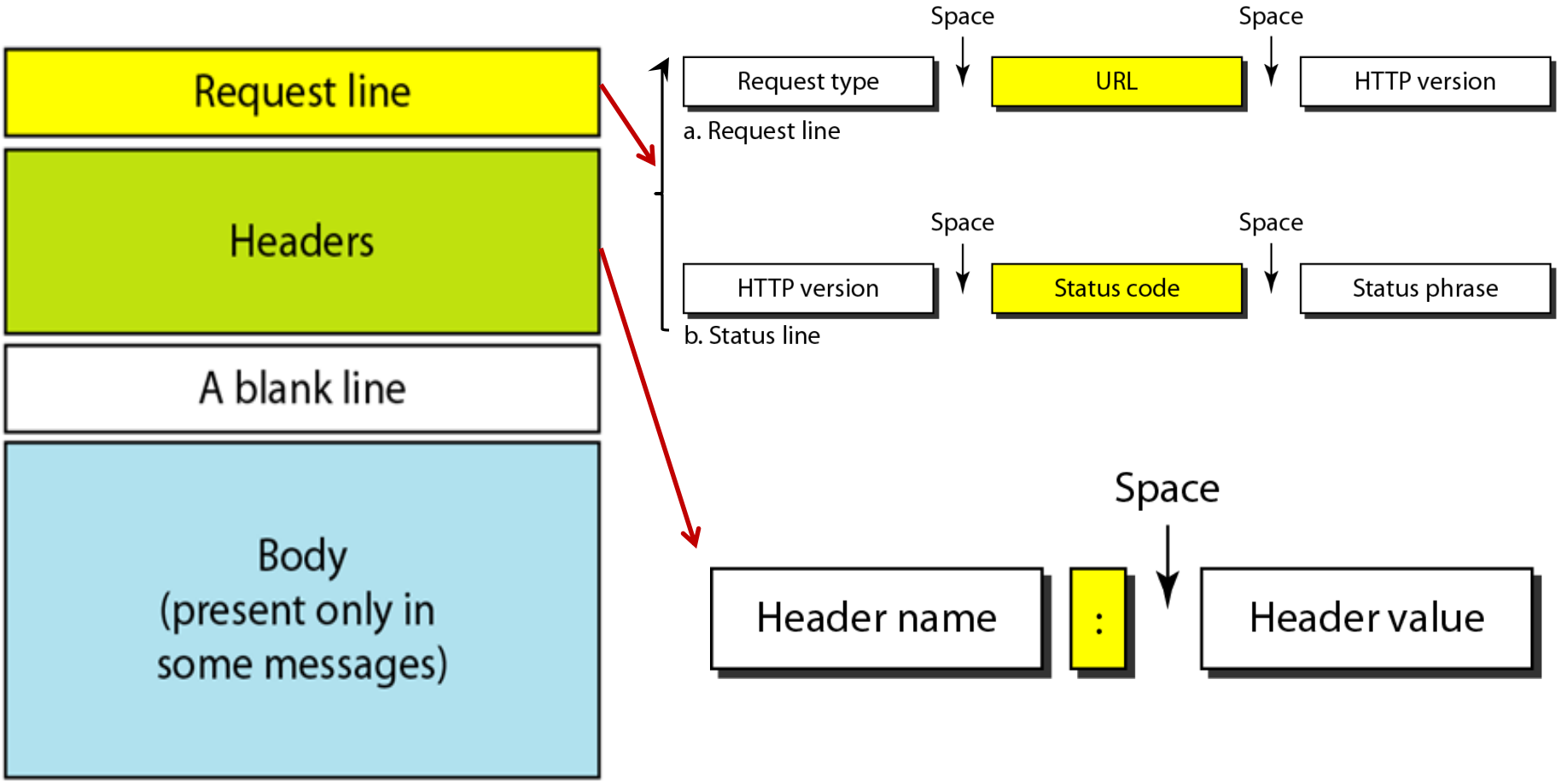


Request message



Response message

HTTP Messages



HTTP Request Messages

request line (GET, POST, HEAD commands)

```
GET /somedir/page.html HTTP/1.0
User-agent: Mozilla/4.0
Accept: text/html, image/gif,image/jpeg
Accept-language:fr
```

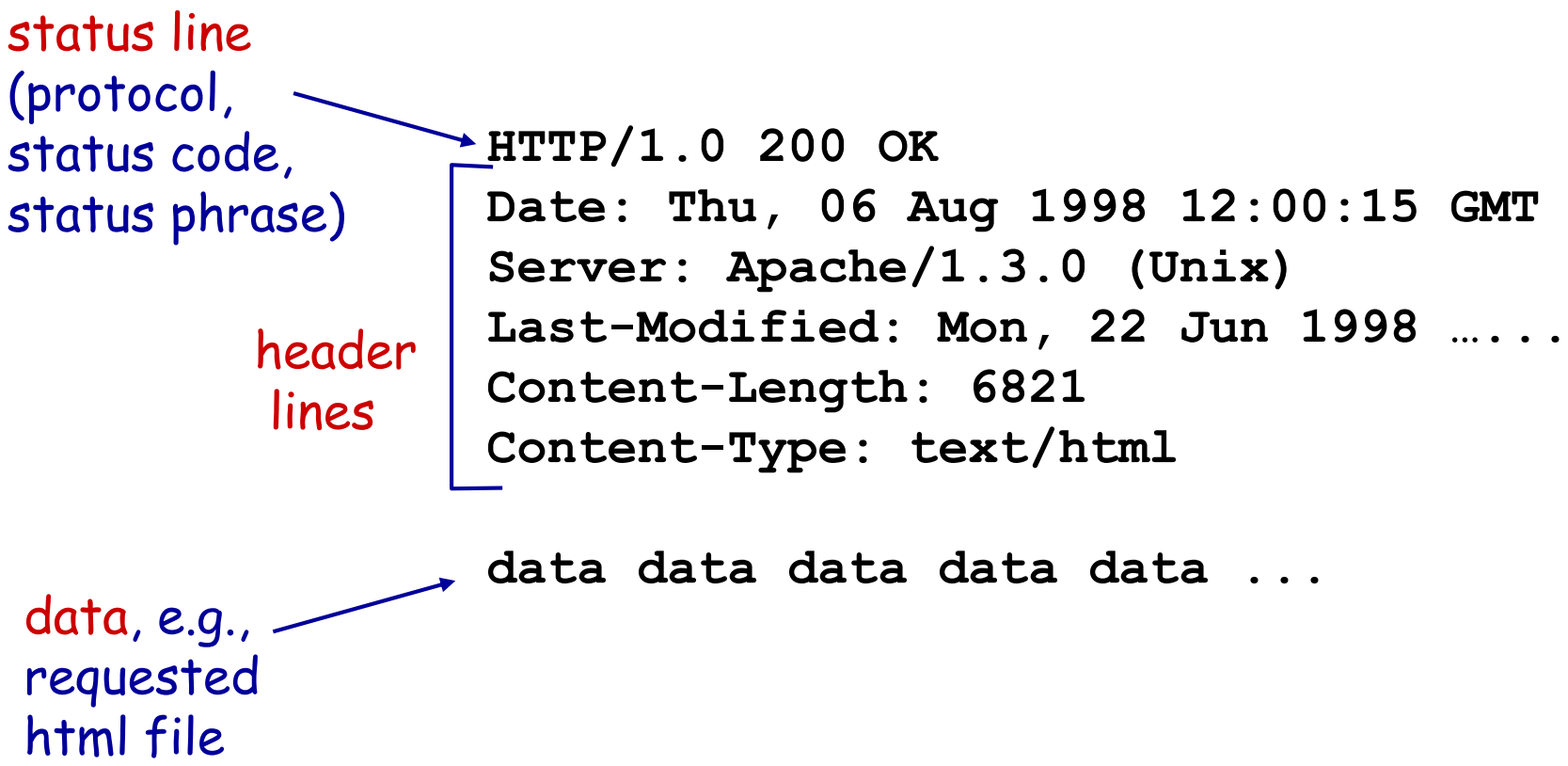
header lines

Indicates end of message

(extra carriage return, line feed)

body

Response Message



Status Code: examples

2XX Success

- Ex: 200 OK: request succeeded, requested object later in this msg

3XX Redirection

- Ex: 301 moved permanently: requested object moved, new location specified later in this message (Location)

4XX Client error

- Ex: 400 bad request: request message not understood by server; 404 not found: requested document not found on this server

5XX Server error

- Ex: 505 HTTP Version Not Supported

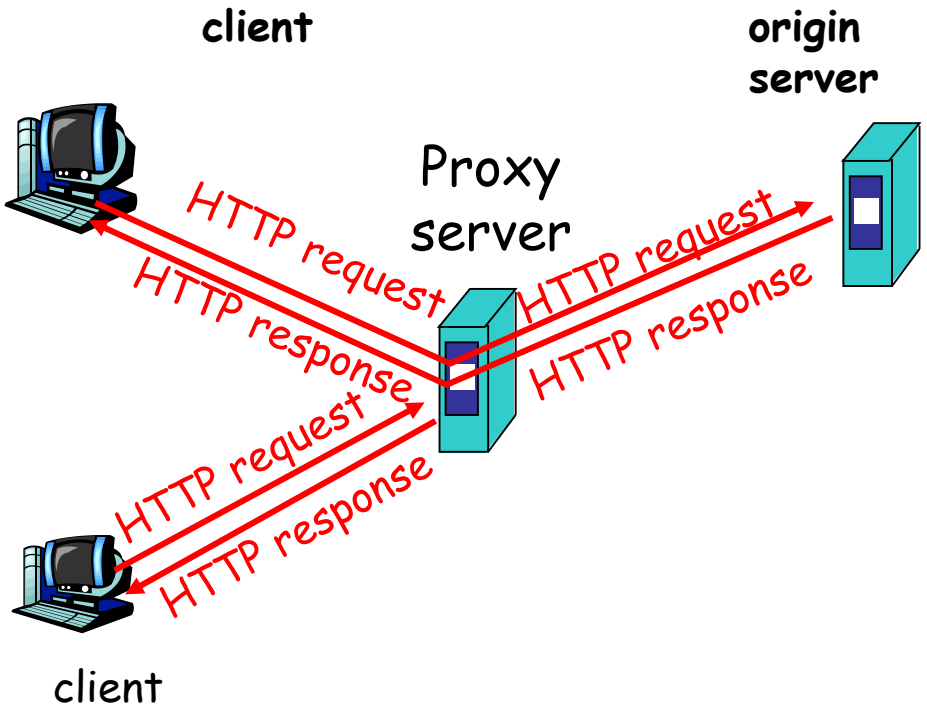
Web Caches (proxy server)

- Instead of direct connection to web server, the browser may connect with the **proxy** server.

- What for?
  - Limiting the traffic to the remote web pages. Web content is stored in proxy cache (reduce traffic on institution's access link)
  - Controlling access to web resources
  - Reduce response time for client request

Web Caches (proxy server): How it Works?

- User sets browser: Web accesses via cache
- Browser sends all HTTP requests to the proxy server
- Proxy server (listening usually to port 8080) check:
  - If its cache does not contain the requested page or if it is outdated, then
    - proxy connects to a given page
    - stores the reply in the cache.
    - Proxy returns the answer to the client.
  - object in cache: cache returns object

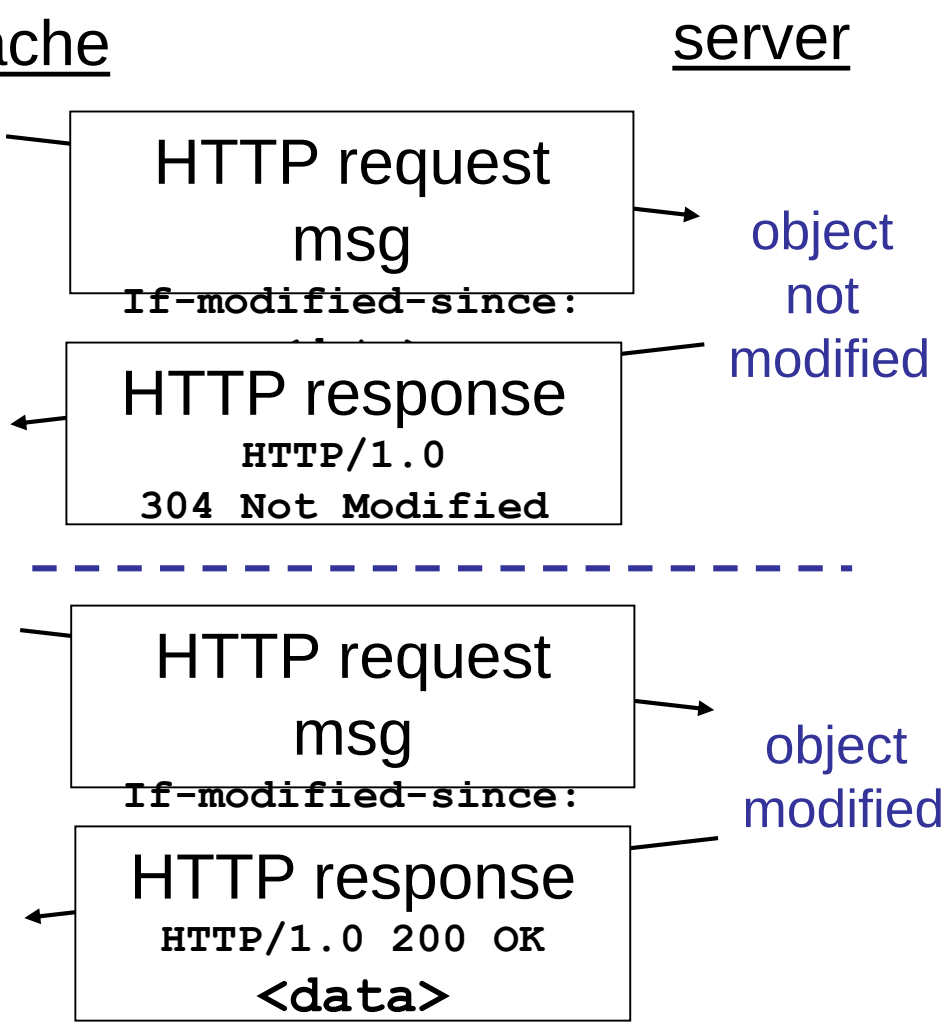


Proxies and Conditional GET

- **How the proxy checks whether the page in cache is up to date?**
- WWW server sets a field Expires: in the reply header. After this date, proxy removes the page from the cache.
- WWW server may set the “no-cache” field. This page will not be stored in proxy cache at all.
- Client may set these fields in the HTTP request. Proxy will neglect the contents of its cache.
- In the remaining cases: heuristic based on the “Last-modified” field.

Proxies and Conditional GET

- cache: specify date of cached copy in HTTP request
- If-modified-since: <date>
- server: response contains no object if cached copy is up-to-date:
- HTTP/1.0 304 Not Modified



Cookies: Keeping “state”

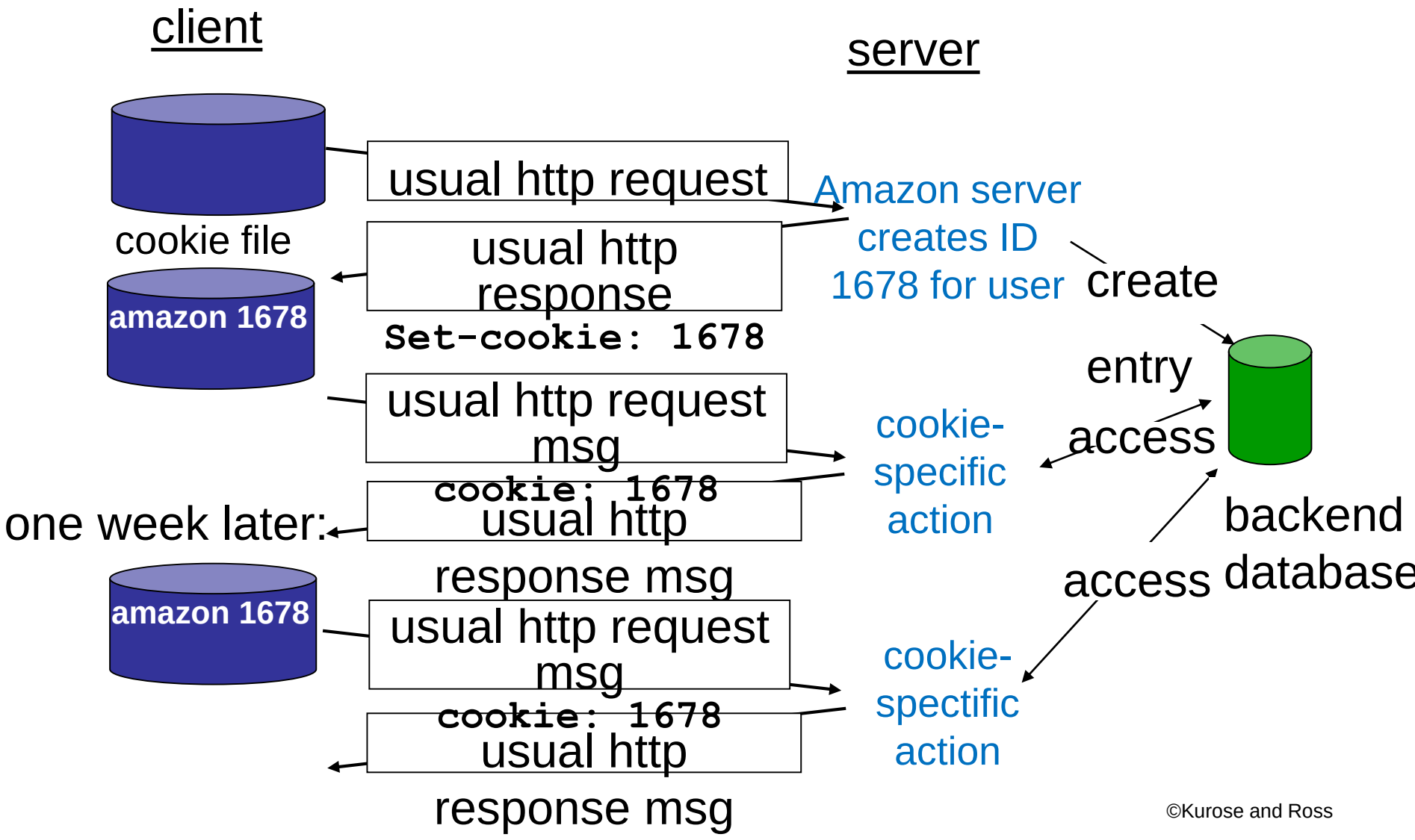
Many major Web sites use cookies

Why cookies:

Allow sites to keep state information

How?

Cookies: keeping "state"



Application Layer
What Will We Study?

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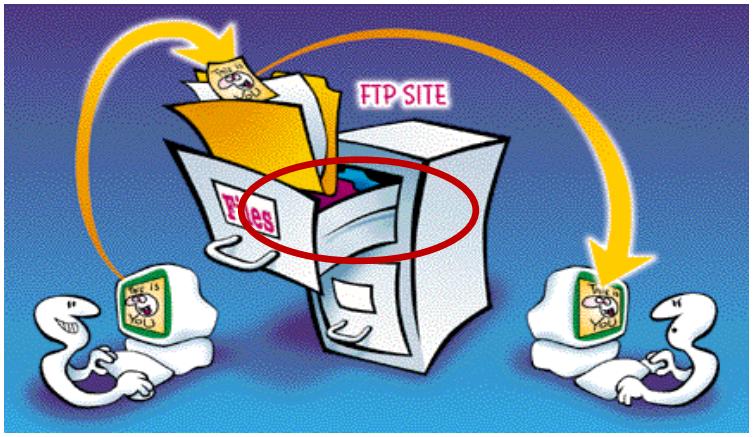
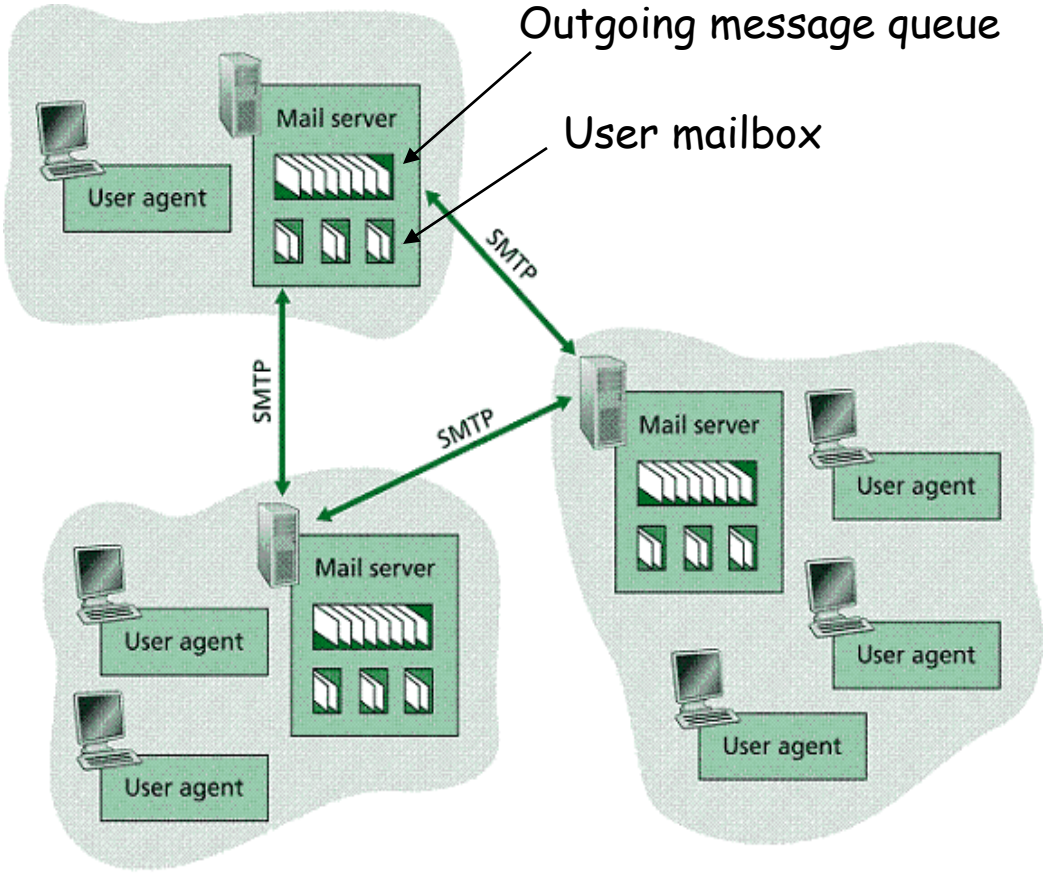


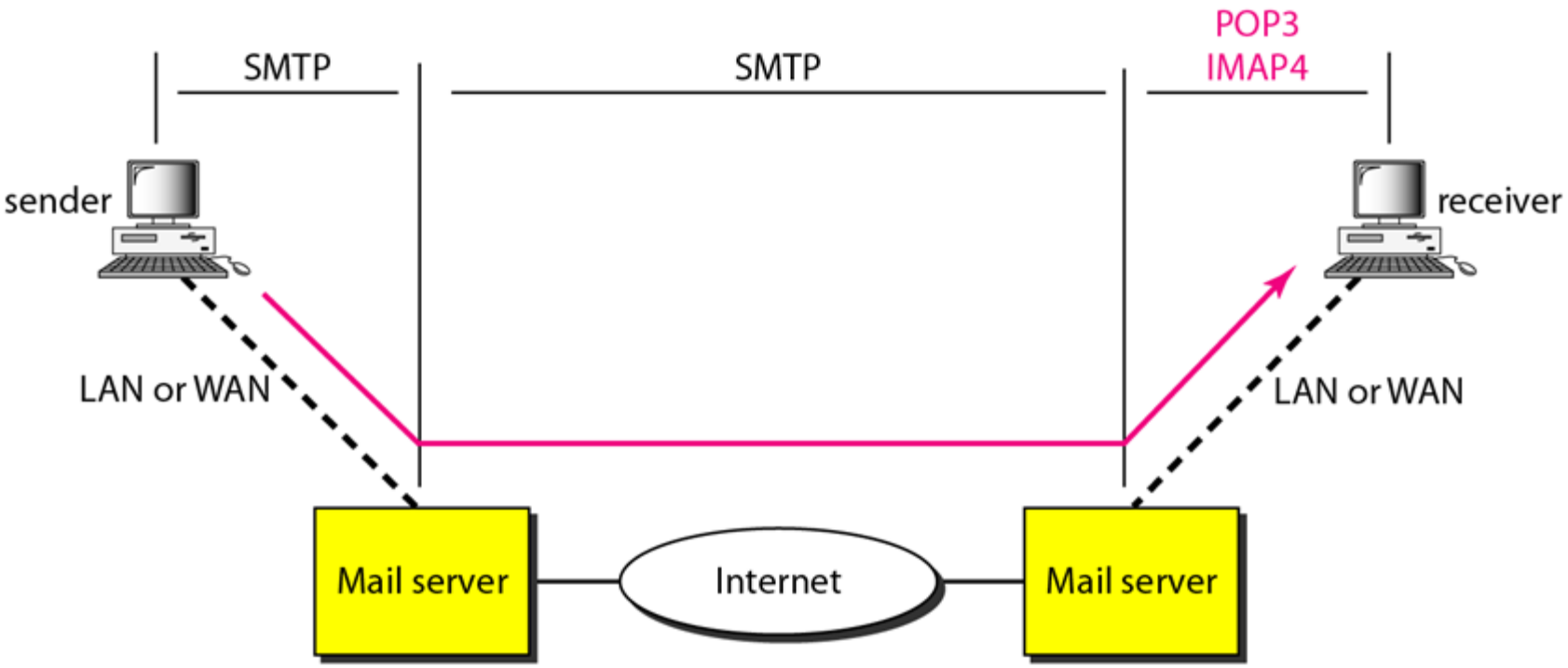
SMTP: Email in the Internet

3 major components:

- **User agent** (mail reader):
  - compose, read, reply to, and forward messages. Ex: outlook
- **Mail server** (port 25):
  - stores incoming and outgoing messages for each of its users in mailbox and message queue.
- **SMTP protocol:**
  - Application layer protocol for sending messages between mail servers



SMTP: Email in the Internet

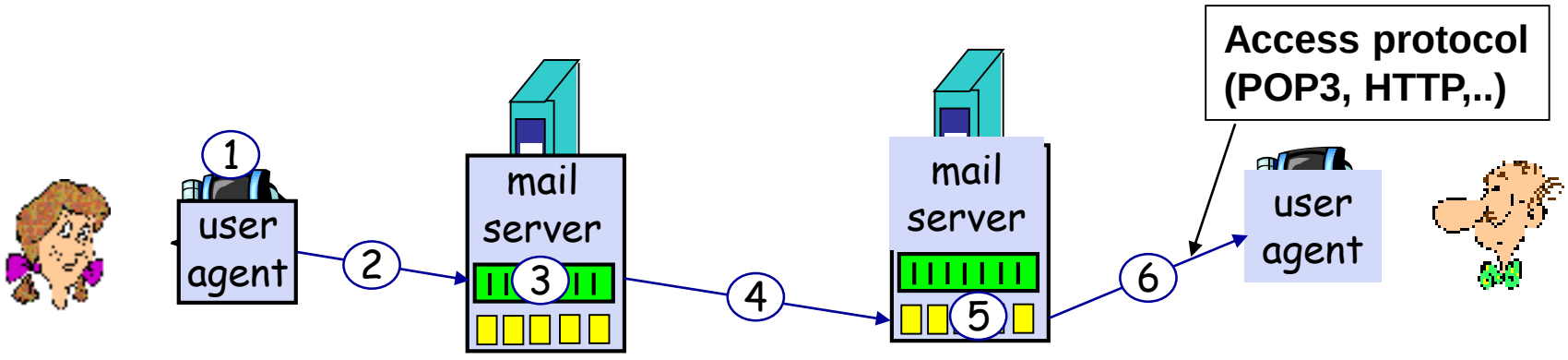


SMTP: Simple Mail Transport Protocol

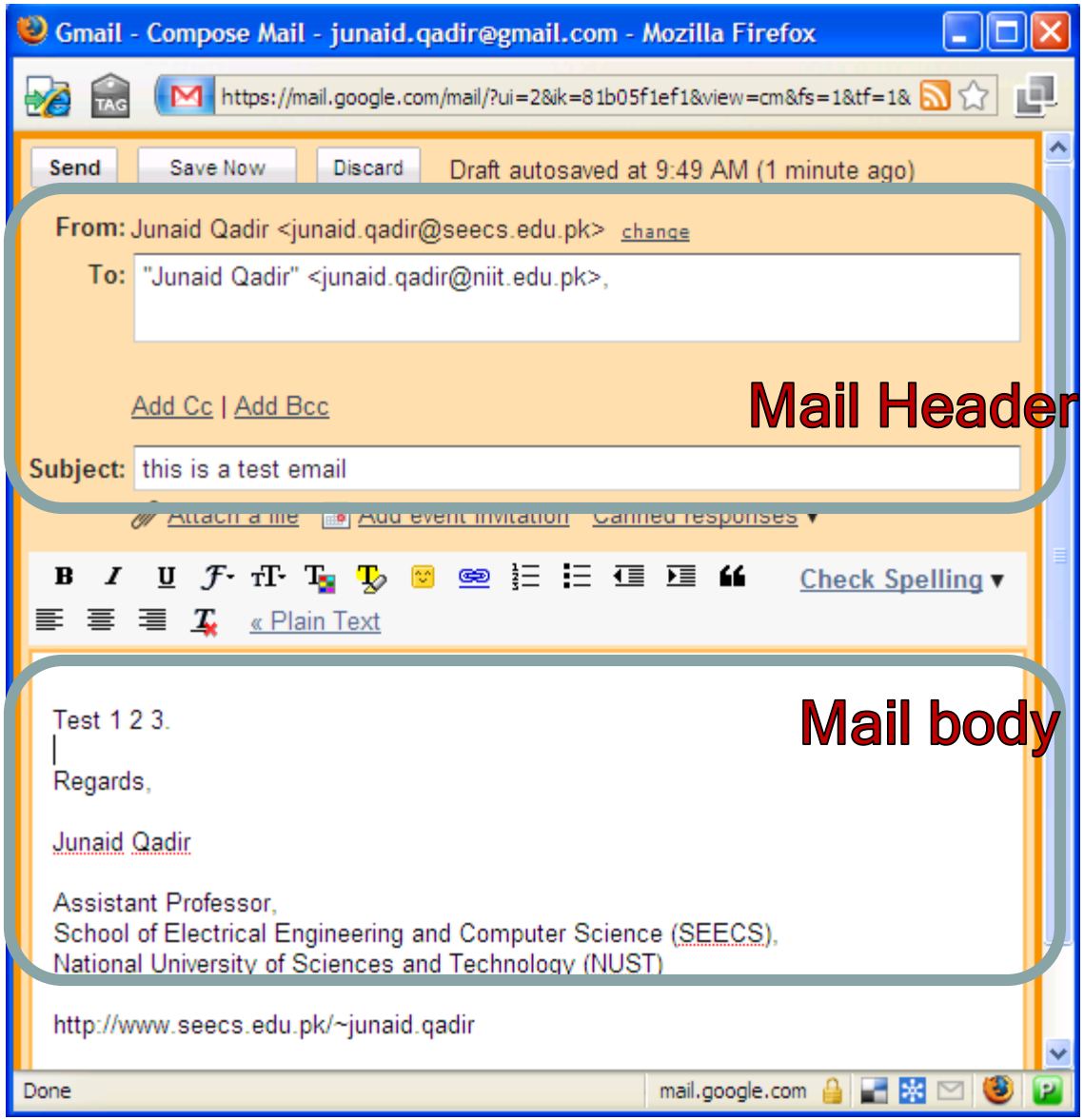
- Application layer protocol for sending messages between mail servers
- Uses TCP connection (between sender and receiver servers, no intermediate servers)
- Has 2 sides: client and server. Both sides run on every mail server
- Command/response interaction
  - Commands: ASCII text (e.g.: HELO, MAIL FROM, RCPT TO, DATA)
  - Response: status code and phrase (e.g.: 220 server name, 250 hello client name,…)
- Messages must be in 7-bit ASCII (problems when attachment is multimedia data)
- SMTP uses persistent connections

Example: Atteyat and Ali

- Atteyat composes an email to Ali.
- When done, her user agent sends the message to her mail server
- Message is placed in the server's outgoing message queue (in green)
- SMTP on Atteyat's server opens a TCP connection with the SMTP on Ali's server, then sends the message, closes connection
- Ali's server places message in Ali's mailbox (in yellow)
- Ali invokes his user agent to read his mailbox



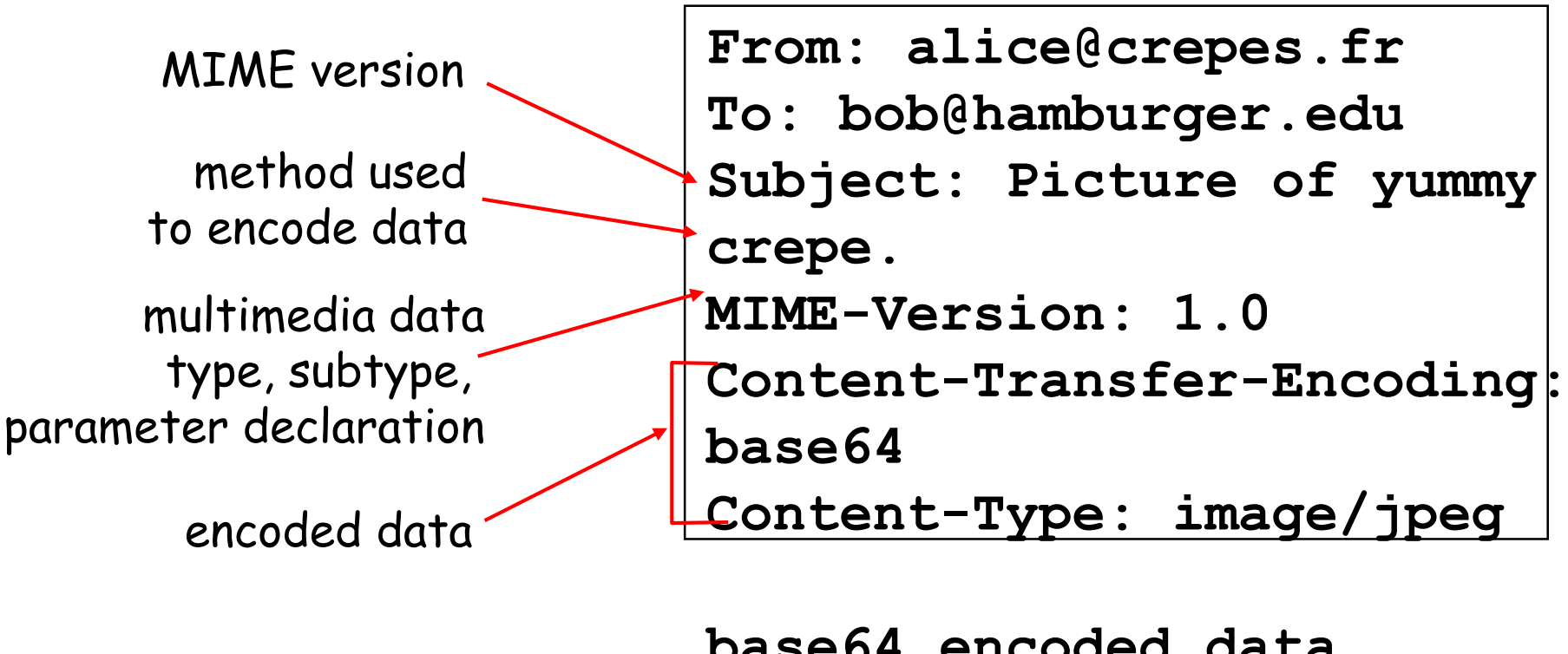
Mail Message Format



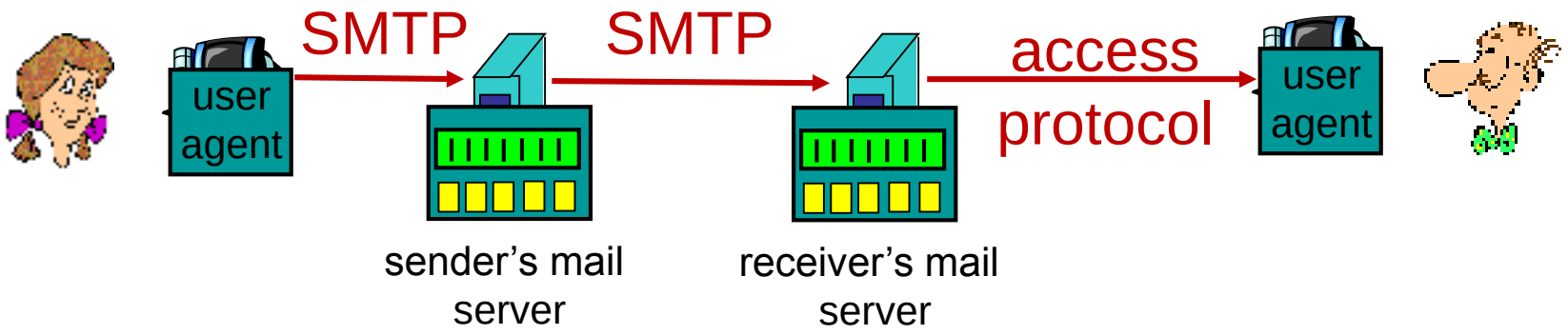
Data in ASCII only

MIME: Multipurpose Internet Mail Extensions

- For sending non-ASCII content (images, video, arabic characters,..), converts it first to ASCII (encoding method to be used)
- Additional headers declare MIME content type
- Two key MIME headers: Content-type, Content-transfer-encoding



Mail access protocols



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

Application Layer
What Will We Study?

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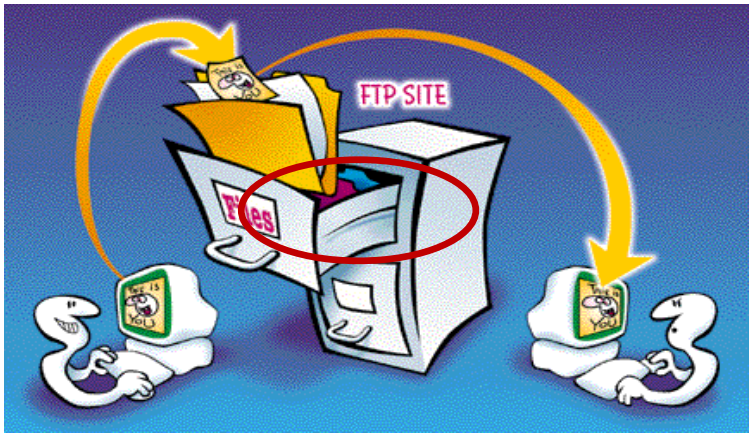

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DNS: Domain Name System

People: many identifiers:

- SSN, name, passport #,…

Internet hosts, routers:

- IP address (32 bit) - used in the network
- “name”, e.g.: ww.yahoo.com - used by humans

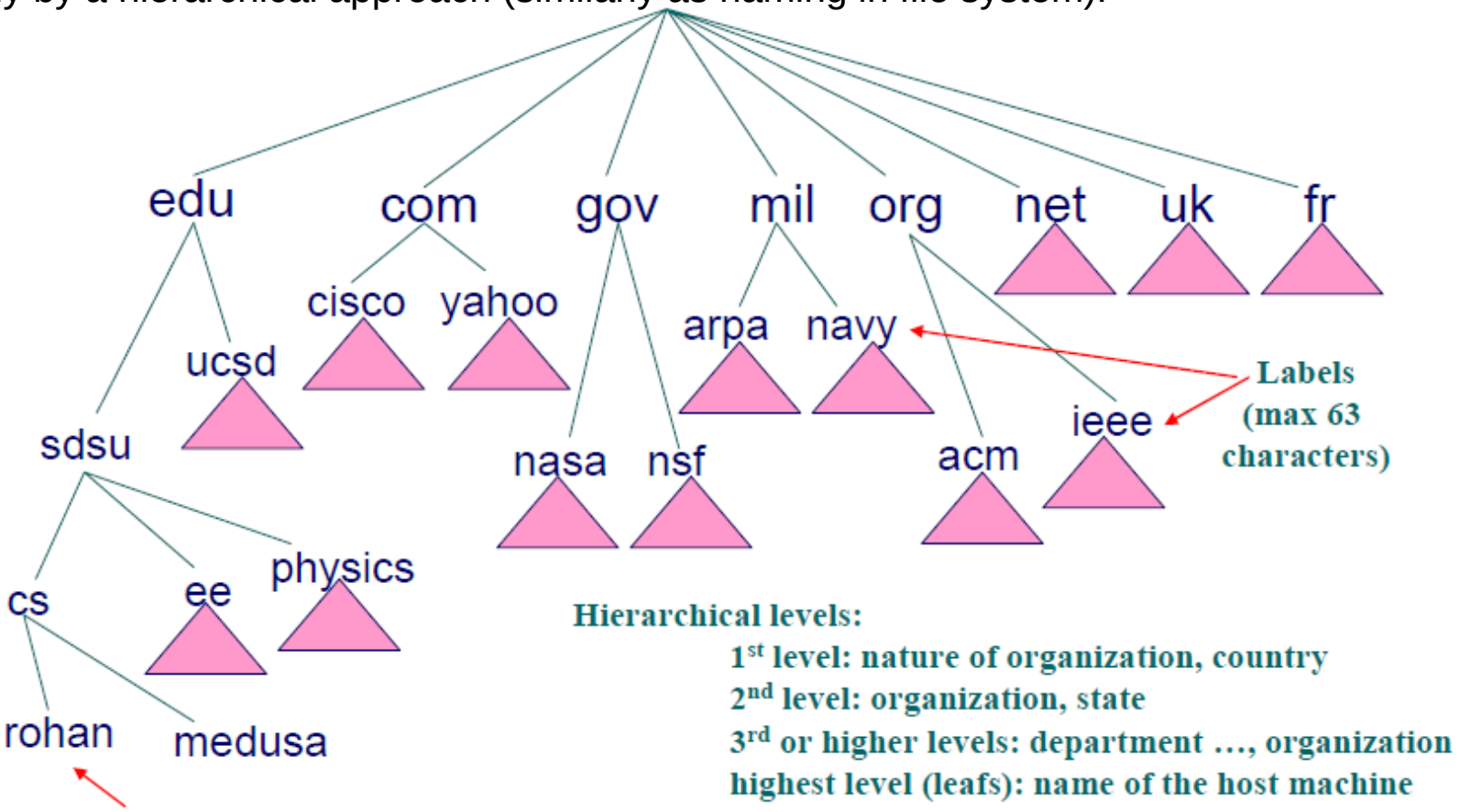
Q: map between IP addresses and name ?

DNS: Domain Name System

- At the beginning, when Internet was small, there were host files which contained name to IP address mappings. The file was maintained centrally and downloaded to each host.
- Today this is impossible, the host files would be too large. In addition it would be too difficult to update the host files in a large, constantly changing network.
- Possible solution: create a single large host file which can be used by all users.
  - This would create huge traffic, due to usage and to maintenance (adding, removing, modification of name-address mappings).
- Alternative: distribute large host file into many smaller ones stored on different computers and different location

DNS: Domain Name System

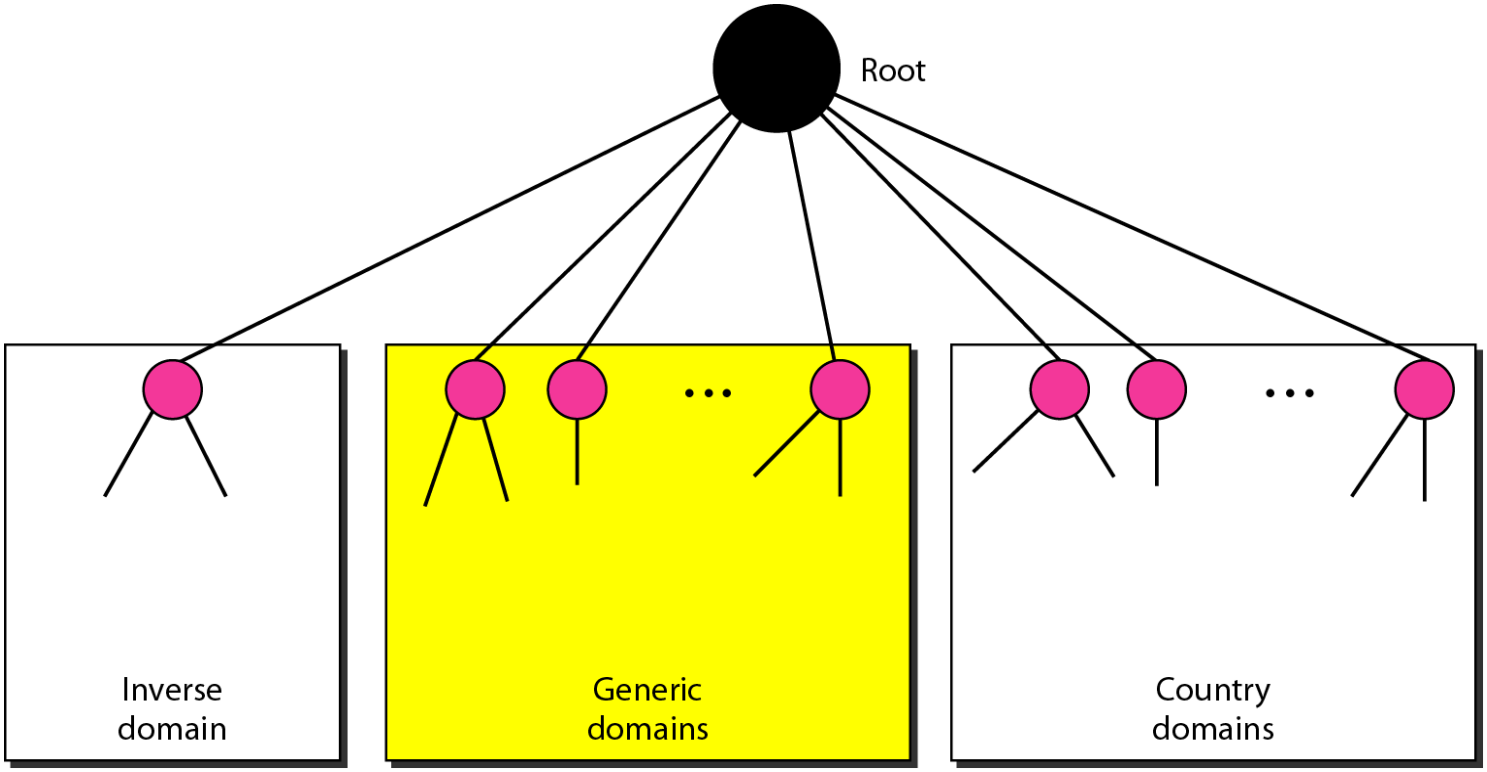
The host names must be unique. Handling of millions of unique names can be solved only by a hierarchical approach (similarly as naming in file system).



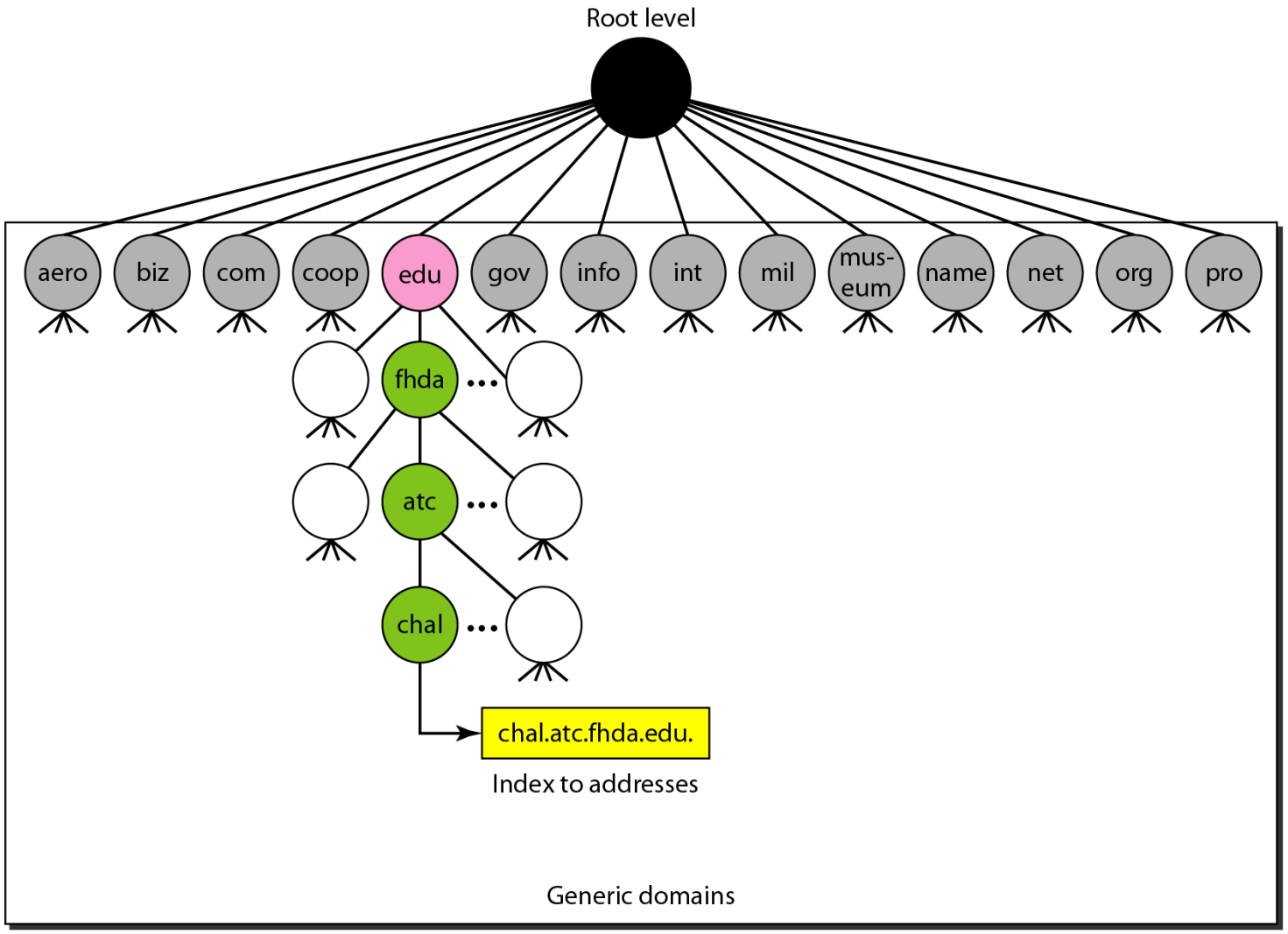
Domain name of this host is: `rohan.cs.sdsu.edu`. Notice the reverse order of labels: the top-level label is written at the rightmost end.

DNS IN THE INTERNET

In the Internet the domain name space is divided into three sections



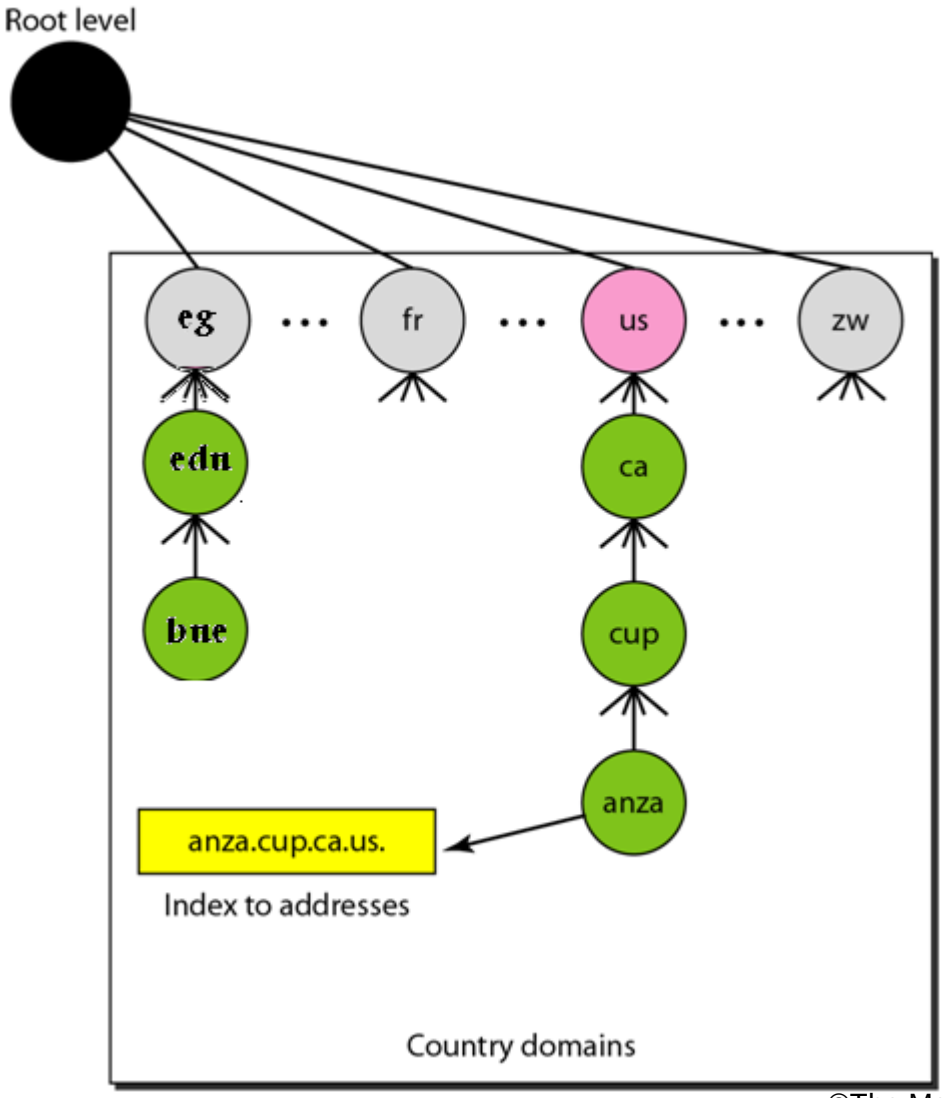
Generic domains



3-letters code (mostly)

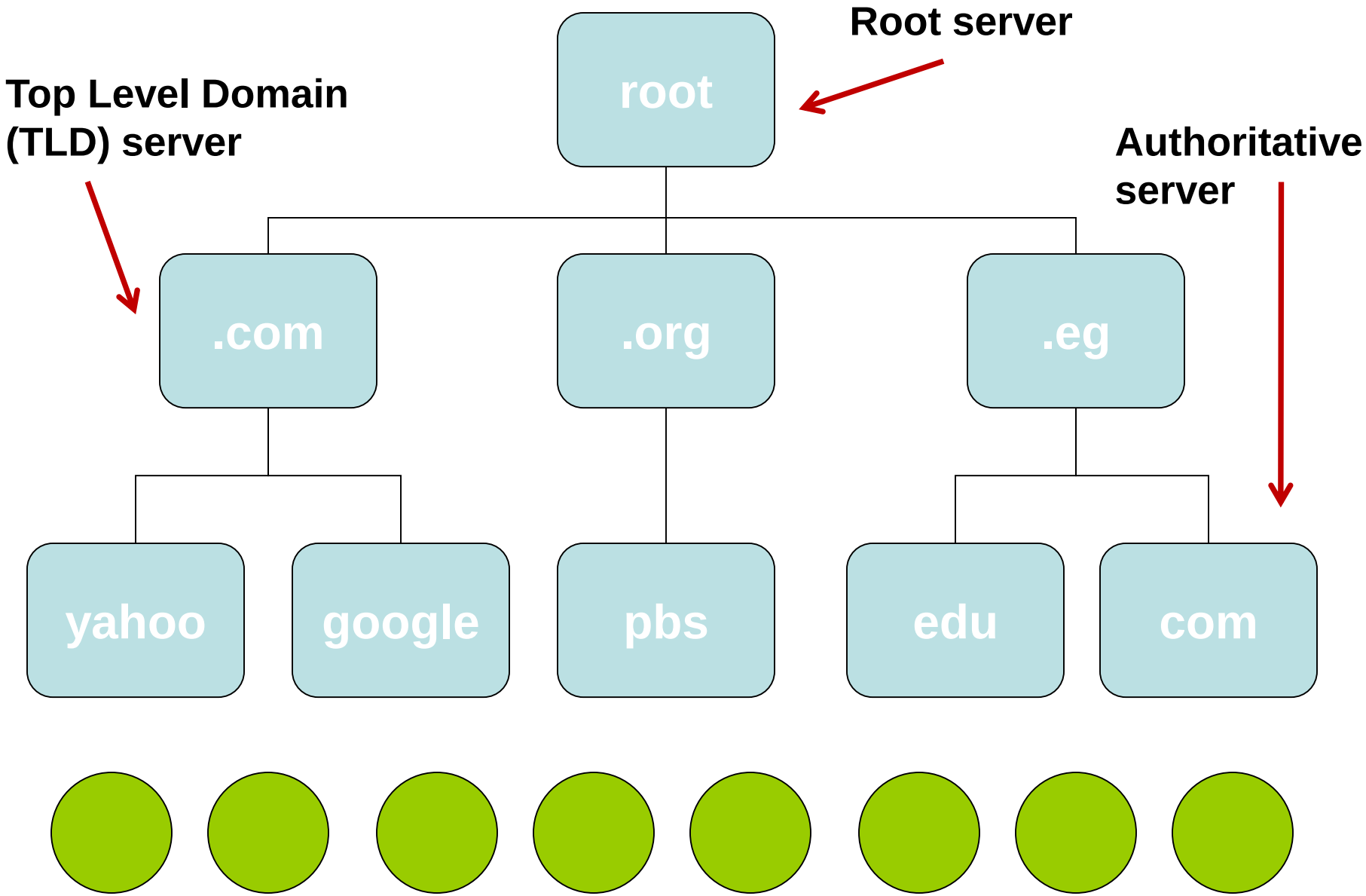
Country domains

2-letters code



DNS Servers

- **Root DNS server:**
  - There are 13 root DNS servers worldwide
  - When local name server fails, it contacts the root name server
  - Root either knows the mapping (reply directly) or knows IP of an “authoritative” name server that has the mapping
- **Top-Level Domain DNS server:**
  - Responsible for each of the TLD, e.g .com, .edu,.eg,…
- **Authoritative DNS server:**
  - Holds the mapping (names-IP) of all hosts within same organization
- Local DNS server:
  - Doesn’t belong to the DNS hierarchy
  - Acts as a default DNS server (contacted first)

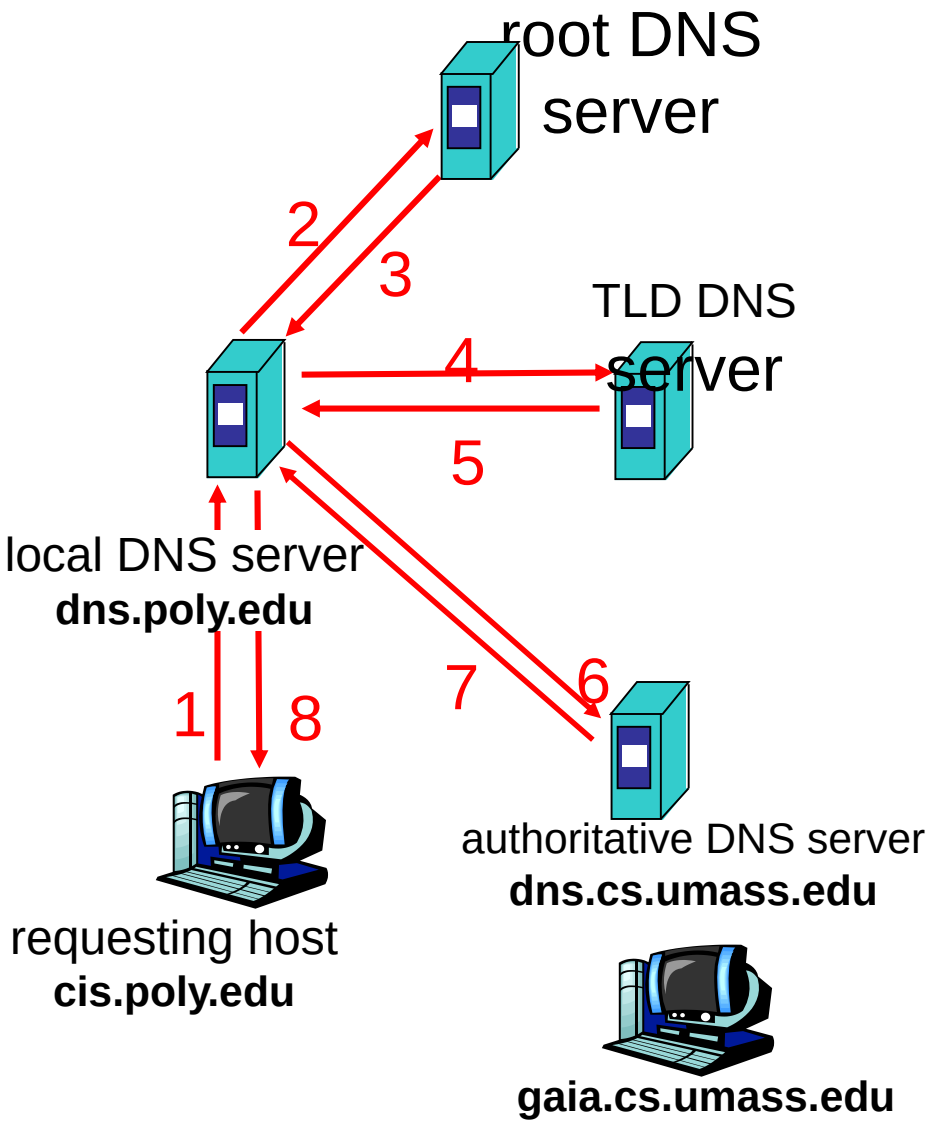

Root server
Top Level Domain (TLD) server
Authoritative server
root
.com
.org
.eg
yahoo
google
pbs
edu
com

DNS Queries

Recursive vs Iterative

DNS Query: Iterative

Host at cis.poly.edu wants IP address for gaia.cs.umass.edu



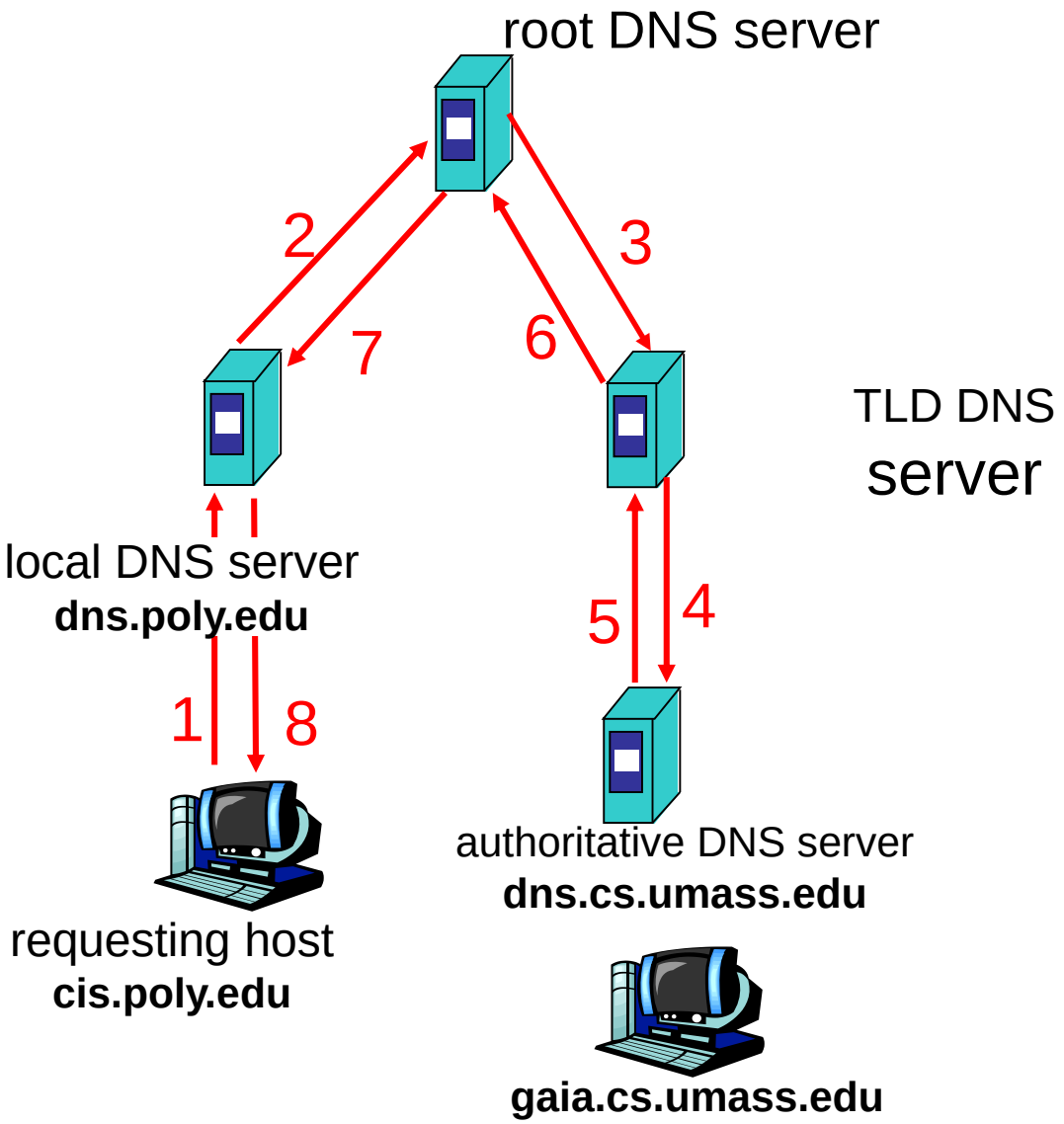
iterated query:

- contacted server replies with name of server to contact
- "I don't know this name, but ask this server"

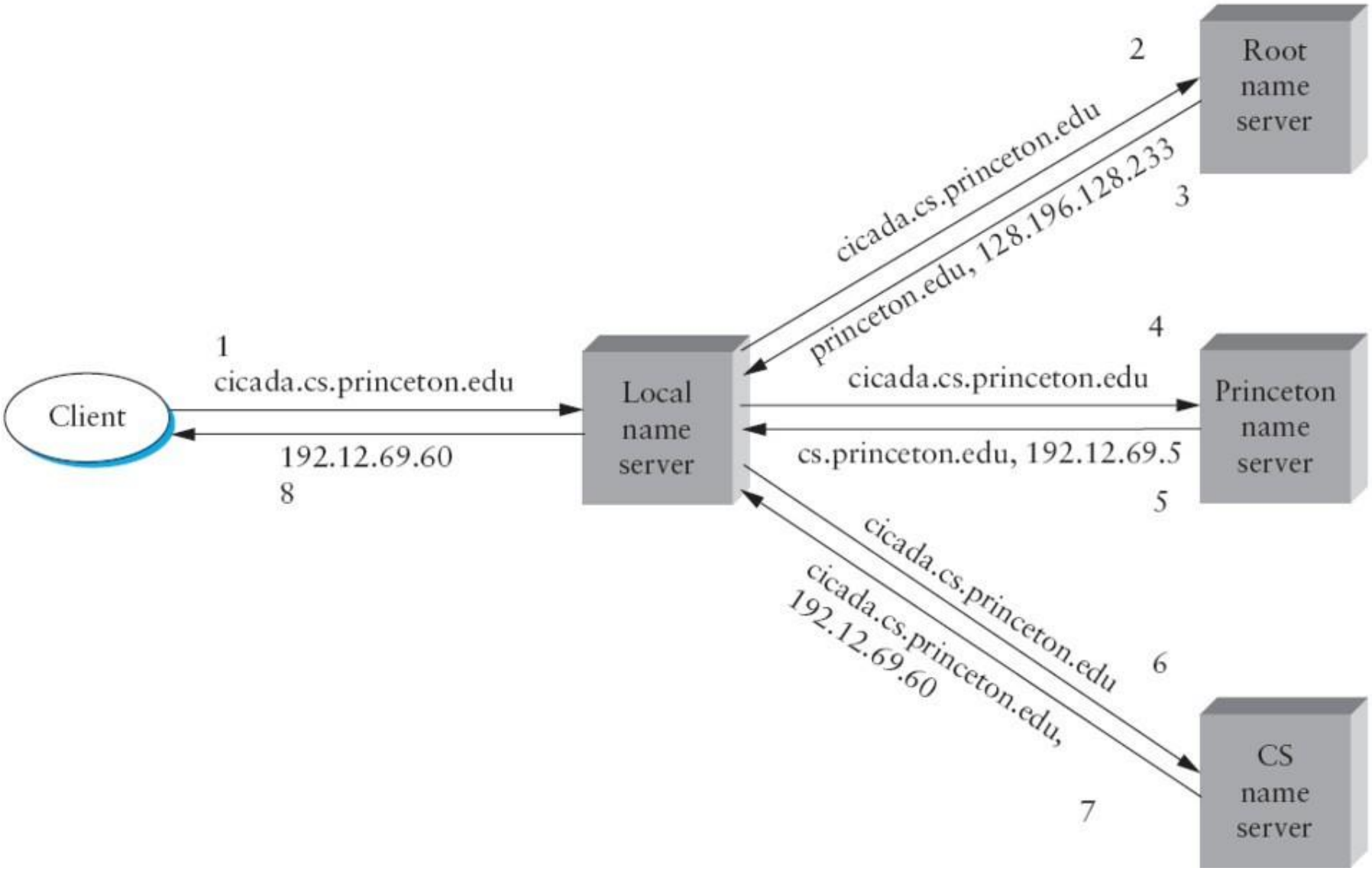
DNS Query: Recursive

recursive query:

- puts burden of name resolution on contacted name server
- heavy load?



How DNS works?



DNS Records

- **Format:**

  (name, value, type, ttl)

- **Types:**

  A, MX, CNAME, NS

DNS Records

- **Type A**

name is hostname, **value** is IP address.

(machine1.foo.com, 145.37.2.126, A)

- **Type=MX**

value is name of mailserver associated with alias name **name**

(foo.com, mail.foo.com, MX)

Country-code Top level domains (cc-TLDs)

Courtesy: wikimedia.org

ENCAPSULATION

DNS can use either UDP or TCP. In both cases the well-known port used by the server is port 53. UDP is used when the size of the response message is less than 512 bytes because most UDP packages have a 512-byte packet size limit. If the size of the response message is more than 512 bytes, a TCP connection is used.