Computer Networks

Application Layer

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Objectives

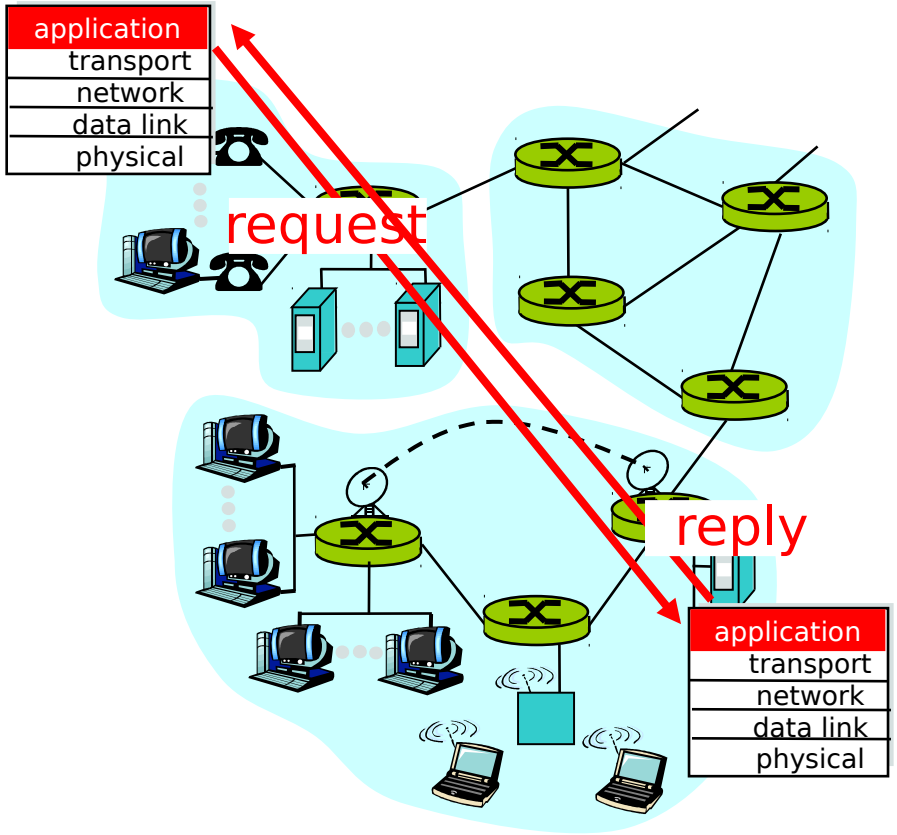
- Applications
- Domain Name System
- Email Service
- Web service
- File Transfer Protocol

Applications

- An application is a **program**, or **group of programs**, that is designed for the end user. Application software can be divided into two general classes: systems software and applications software
- A **computer program** is a list of instructions that tell a computer what to do. Everything a computer does is done by using a computer program. Some examples of computer programs: A web browser like Mozilla Firefox and Apple Safari can be used to view web pages on the Internet.

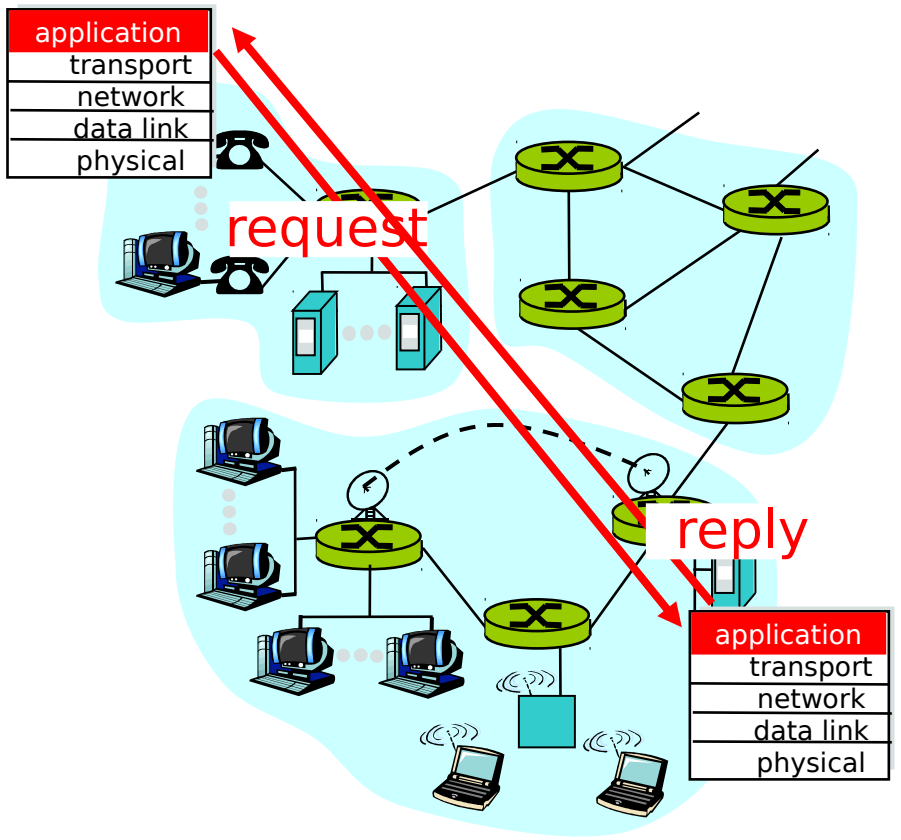
Applications on a network

- An application on a network is set of distributed and interactive processes
- Application – layer protocols:
  - Part of applications
  - Define message format and operations
  - Use transport layer services (TCP or UDP) to exchange messages



Client – server model

- Architecture of applications on networks
- Components of an application are designed to play role of client or server
- Client
  - Establish a communication to the server
  - Request services from the server
  - Web client: Browser
  - Email: Mail user agent
- Server
  - Provide services requested by a client
  - Web server: return web page to client
  - Mail server: exchange mails for client

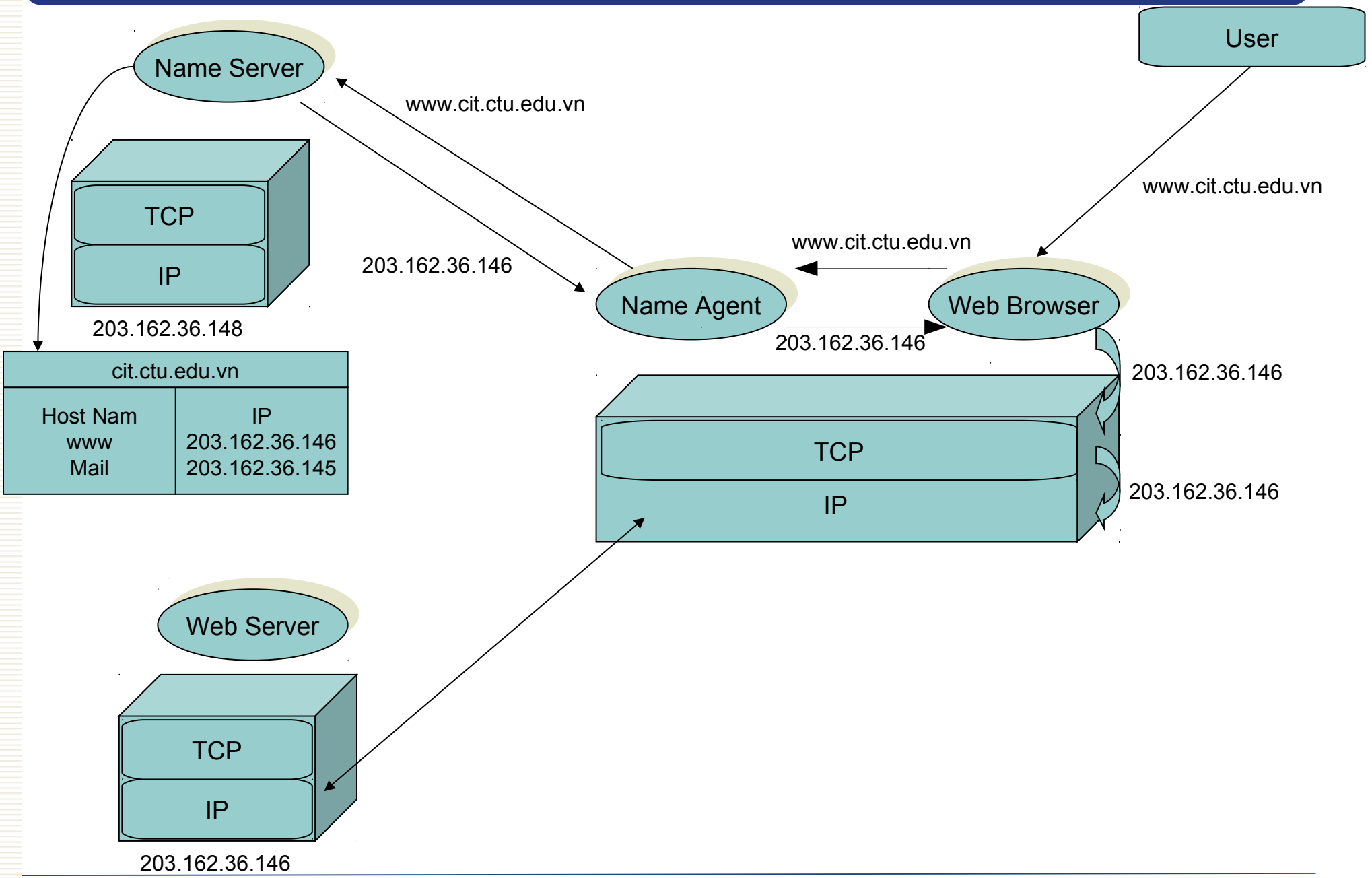


Domain Name System

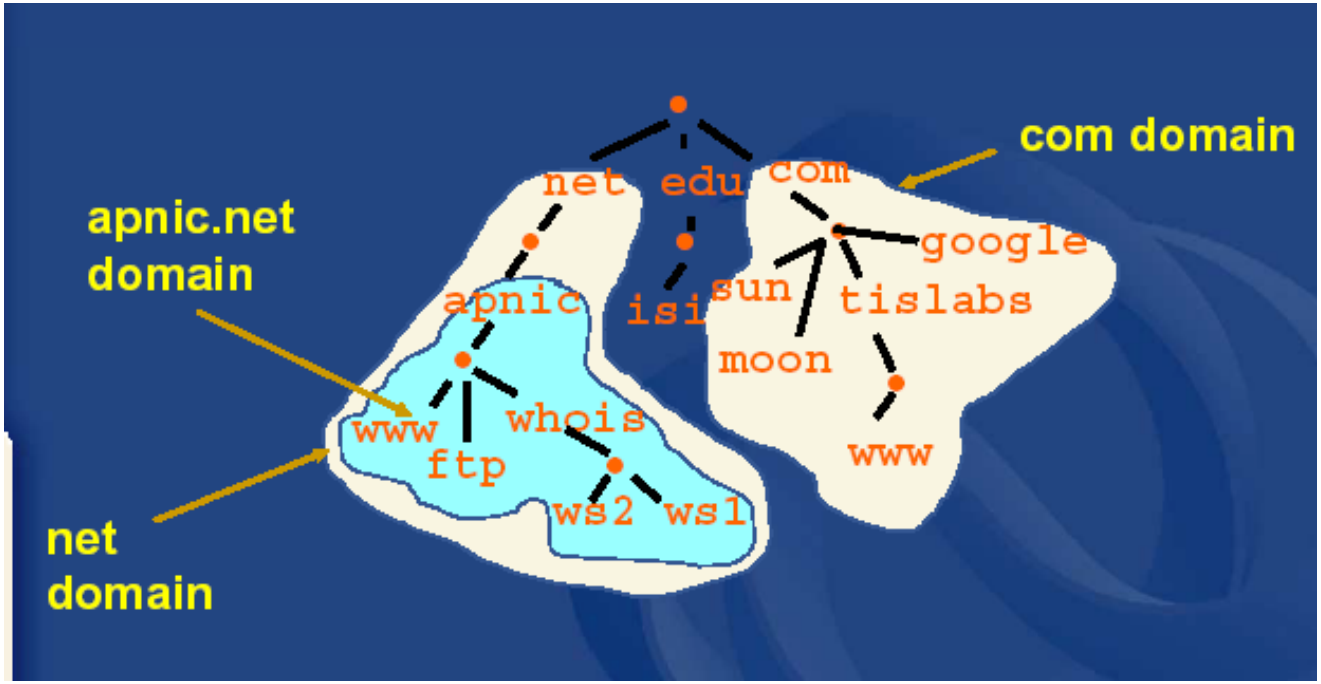
DNS - Domain Name System

- Internet protocol uses IP addresses to identify hosts, e.g 203.162.36.145
- Hard for users to use IP addresses to identify hosts → DNS is a solution for users to identify hosts by using semantic/logical names, such as www.cit.ctu.edu.vn instead of 203.162.36.146
- www.cit.ctu.edu.vn is a logical name
  - **vn** : Vietnam
  - **edu**: Educational domain
  - **ctu** : Cantho University
  - **cit** : College of IT
  - **www**: Web server

DNS - Domain Name System

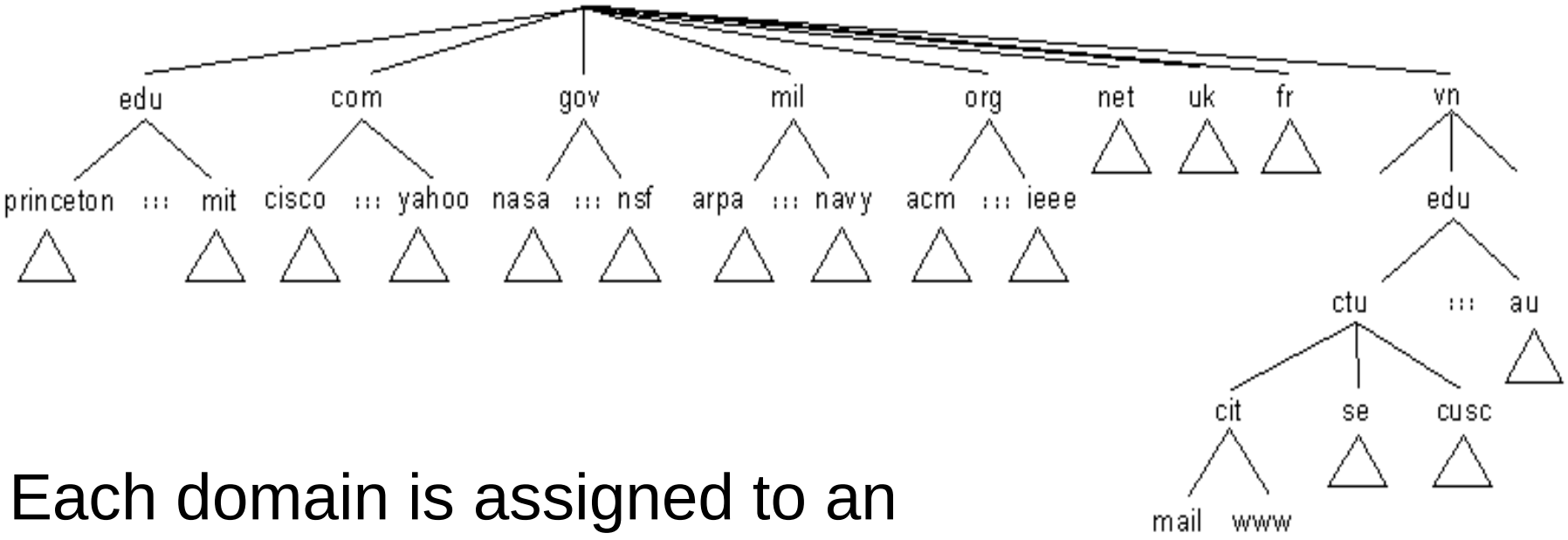


Hierarchical Name Space



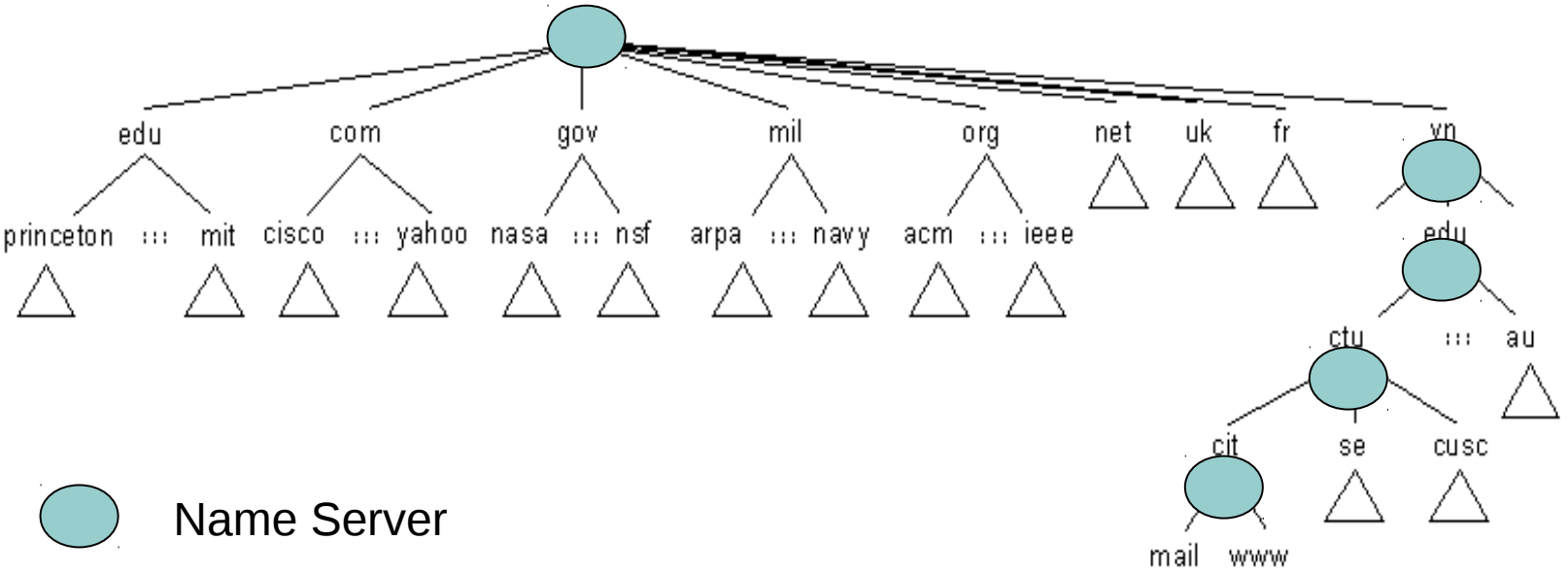
- Each domain has a name , so called Domain Name
- Parent - children relationship between domains,
- Com domain is parent of Sun, Google domains

Internet Name Space



- Each domain is assigned to an organization.
- Each domain maintains information about hosts of an organization, such as logical name and IP of hosts

Internet Name Server



- Name Server is a host that runs name resolving service. A name server maintains a database mapping between host names and IP addresses.

Internet Name Server

- Resolving Names
  - Process of mapping a domain name into an IP address (forward lookup)
- Resolving IP addresses
  - Process of mapping an IP address (~~forward~~ lookup) into a domain name
- A name server is responsible for both operations of resolving names and resolving IP addresses
- Zones of Authority (ZOA) is a part of name space that a name server is responsible for resolving names and resolving IP addresses
- A name server can be responsible for many ZOAs

Types of name servers

- Primary name server
  - Maintain a database for its ZOAs
- Secondary name server
  - Backup database for primary name server
- Caching domain name server
  - Cache results of resolving names or IP addresses to speed up processes of resolving names or IP addresses

DNS Database

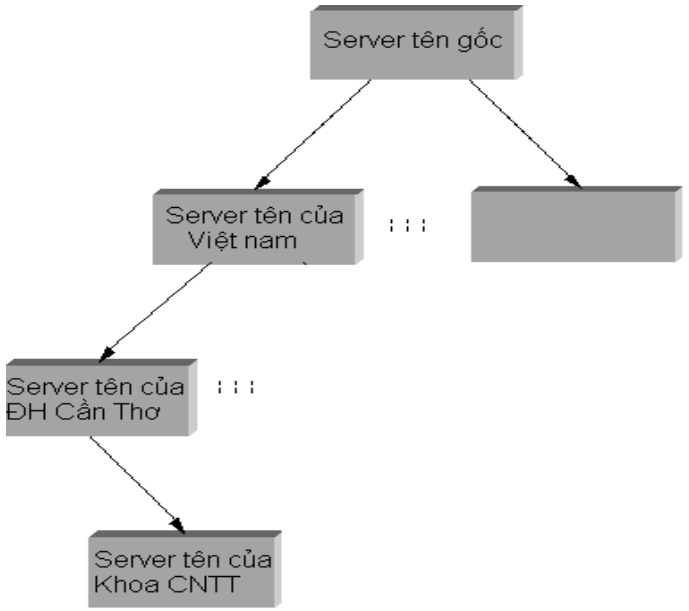
- (Name, Value, Type, Class, TTL)
  - Mapping Name → Value
    - www.cit.ctu.edu.vn → 203.162.36.146
  - Type: Type or meaning of the value
  - Class: A classification of names
  - TTL: Time To Live of the record

DNS Database

- (Name, Value, Type, Class, TTL)
  - Type A: Mapping a domain name to an IP address
    - (ns.ctu.edu.vn, 203.162.41.166, **A**, IN)
  - Type NS: A domain and its Name server
    - (ctu.edu.vn, ns.ctu.edu.vn, **NS**, IN)
  - Type CNAME: The value is a canonic name of the name
    - (dns.ctu.edu.vn, ns.ctu.edu.vn, **CNAME**, IN)
  - Type MX: A domain and its Mail server
    - (ctu.edu.vn, mail.ctu.edu.vn, MX, IN)

DNS Database

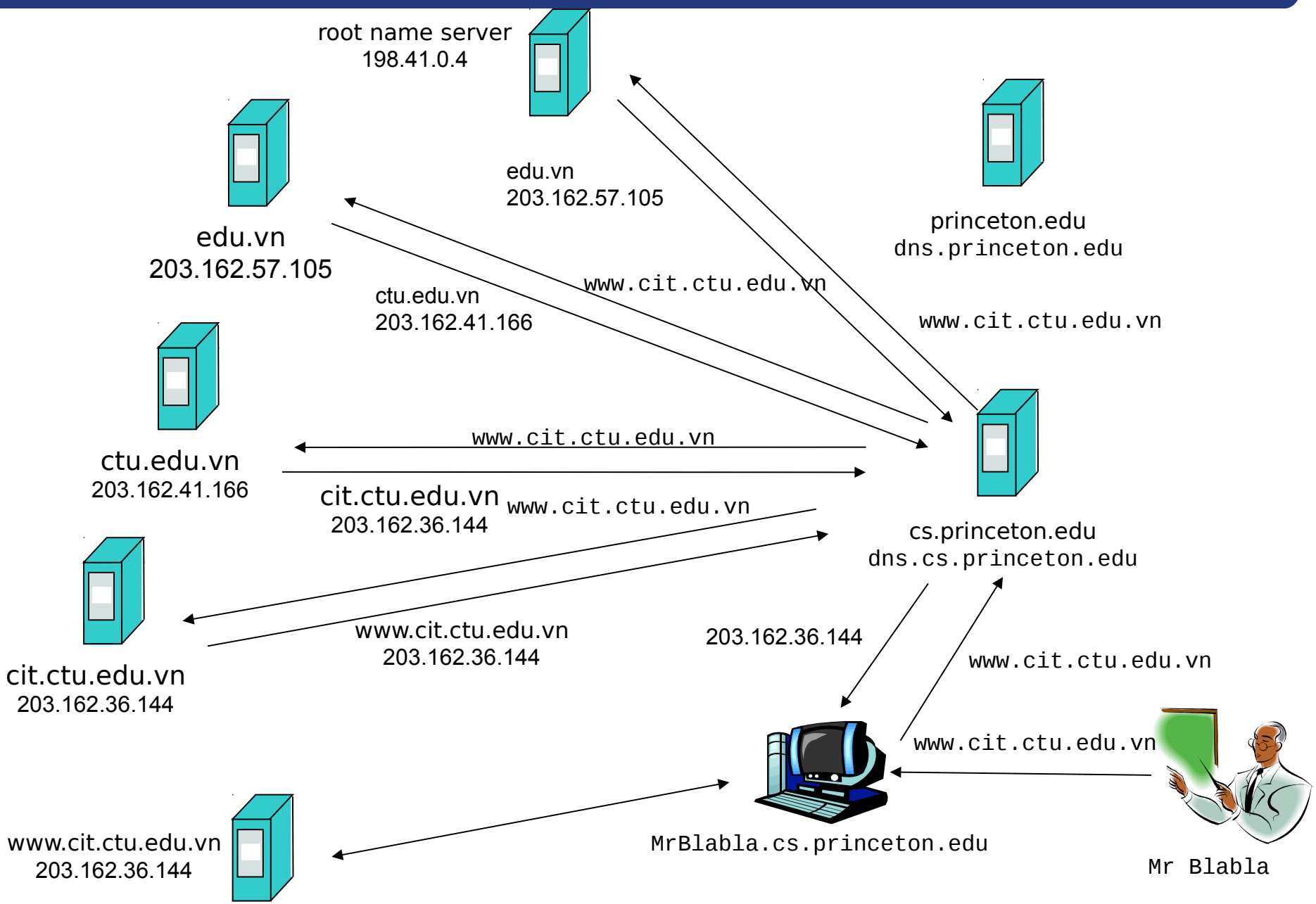
- A Root name server must contain
  - A record of type **NS** for each child domain
  - A record of type **A** to mapping name server to IP address
  - (edu.vn, dns1.vnnic.net.vn, NS, IN);
  - (dns1.vnnic.net.vn, **203.162.57.105**, A, IN)
- Similar for other name servers
  - dns1.vnnic.net.vn:
    - (ctu.edu.vn, ns.ctu.edu.vn, NS, IN)
    - (ns.ctu.edu.vn, **203.162.41.166**, A, IN)
  - ns.ctu.edu.vn:
    - (cit.ctu.edu.vn, ns.cit.ctu.edu.vn, NS, IN)
    - (**ns**.cit.ctu.edu.vn, **203.162.36.144**, A, IN)
    - (ctu.edu.vn, mail.ctu.edu.vn, MX, IN)
    - (mail.ctu.edu.vn, 203.162.139.21, A, IN)
    - (www.ctu.edu.vn, mail.ctu.edu.vn, CNAME, IN)



DNS Database

- Each name server must contain at least one Root Name server
  - (**.** , a.root-servers.net, NS, IN)
    (a.root-server.net, 198.41.0.4, A, IN)

Process of resolving name



http://www.simpledns.com/lookup-dg.aspx

Tracing DNS delegation for "www.ctu.edu.vn":

Loading root server list (static data):
-> a.root-servers.net (198.41.0.4)
-> b.root-servers.net (192.228.79.201)
-> c.root-servers.net (192.33.4.12)
-> d.root-servers.net (128.8.10.90)
-> e.root-servers.net (192.203.230.10)
-> f.root-servers.net (192.5.5.241)
-> g.root-servers.net (192.112.36.4)
-> h.root-servers.net (128.63.2.53)
-> i.root-servers.net (192.36.148.17)
-> j.root-servers.net (192.58.128.30)
-> k.root-servers.net (193.0.14.129)
-> l.root-servers.net (199.7.83.42)
-> m.root-servers.net (202.12.27.33)

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-> l.root-servers.net (199.7.83.42)
-> m.root-servers.net (202.12.27.33)

http://www.simpledns.com/lookup-dg.aspx

Tracing DNS delegation for "www.ctu.edu.vn":

Sending request to "g.root-servers.net" (192.112.36.4)

Timeout waiting for response

Sending request to "h.root-servers.net" (128.63.2.53)

Received referral response - DNS servers for "vn":
-> a.dns-servers.vn (194.0.1.18)
-> b.dns-servers.vn (203.119.10.105)
-> c.dns-servers.vn (203.119.38.105)
-> d.dns-servers.vn (203.119.44.105)
-> e.dns-servers.vn (203.119.60.105)
-> f.dns-servers.vn (203.119.68.105)
-> vn.cctld.authdns.ripe.net (193.0.9.126)

http://www.simpledns.com/lookup-dg.aspx

Tracing DNS delegation for "www.ctu.edu.vn":

Sending request to "b.dns-servers.vn" (203.119.10.105)

Received referral response - DNS servers for "ctu.edu.vn":
-> ns.ctu.edu.vn (123.30.143.222)
-> ns-sd.ctu.edu.vn (123.30.143.254)

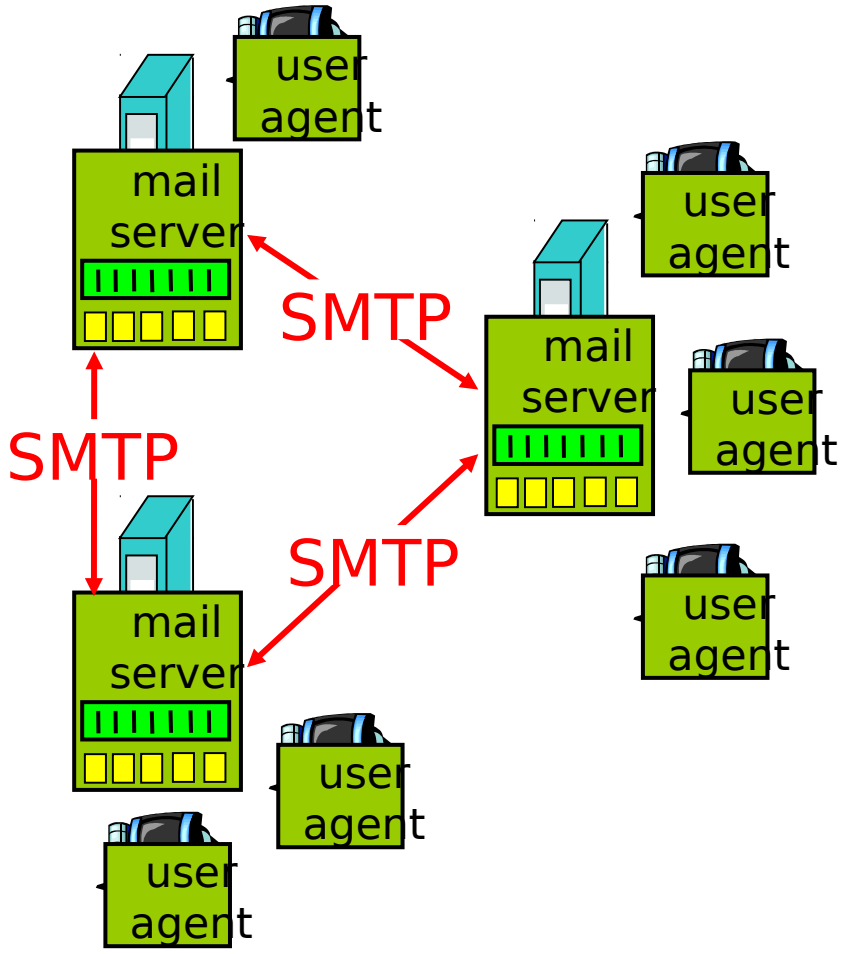
Sending request to "ns.ctu.edu.vn" (123.30.143.222)

Received authoritative (AA) response:
-> Answer: A-record for www.ctu.edu.vn = 123.30.143.225
-> Authority: NS-record for ctu.edu.vn = ns-sd.ctu.edu.vn
-> Authority: NS-record for ctu.edu.vn = ns.ctu.edu.vn
-> Additional: A-record for ns.ctu.edu.vn = 123.30.143.222
-> Additional: A-record for ns-sd.ctu.edu.vn = 123.30.143.254

Email Service

Electric mail system

- Exchange (send/receive) mails between users over communication networks
- Composes of 3 components
  - User Agent
  - Mail Server
  - Mail Protocols



- User Agent
  - “mail reader”
  - composing, editing, reading mail messages
  - Ex: Eudora, Outlook, elm, Netscape Messenger
  - outgoing, incoming messages stored on server
- Mail Servers
  - mailbox contains incoming messages (yet to be read) for user
  - message queue of outgoing (to be sent) mail messages
  - Communication between Mail Servers:
    - client: sending mail server
    - “server”: receiving mail server
- Mail Protocols
  - SMTP (Simple Mail Transfer Protocol) , RFC81
  - POP3 (Post Office Protocol version 3), RFC 1939
  - IMAP: (Internet Mail Access Protocol), RFC 1730

SMTP – Simple Mail Transfer Protocol

- Use TCP protocol to transfer mail from client to server, port 25
- Transfer message directly from sending server to receiving server
- Transaction in 3 phases
  - handshaking (greeting)
  - transfer of messages
  - closure
- Command/Response communication mode
  - commands: ASCII text
  - response: status code and phrase
- Messages are encoded in 7-bit ASCII

SMTP – Simple Mail Transfer Protocol

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

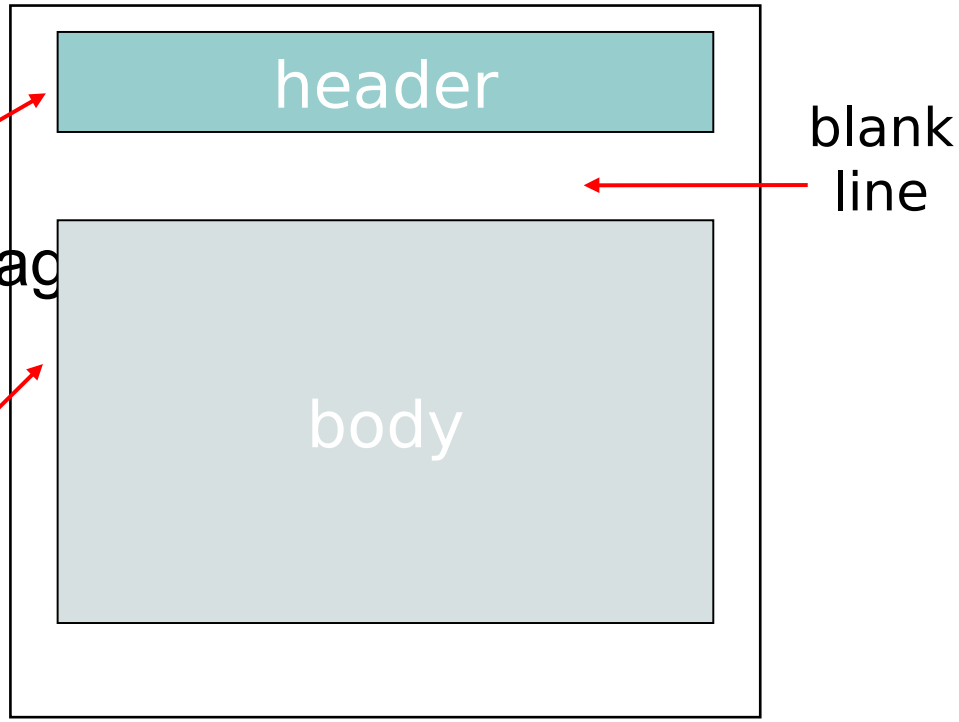
Mail message format

RFC 822: standard for text messag

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

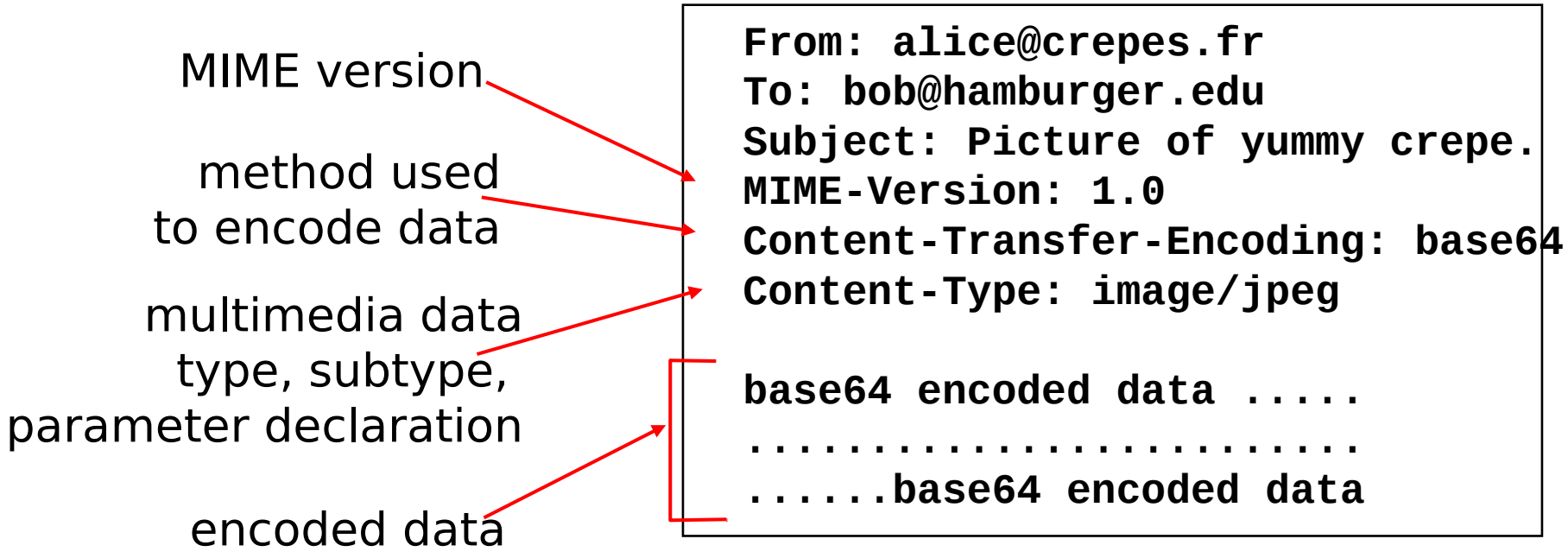
  <CRLF>

  <CRLF>
- body
  - the “message”, ASCII characters only



MIME (Multipurpose Internet Mail Extensions)

- Allow an e-mail to contain any types of document such as audio, video, image, binary file, … RFC 2045, 2056



POP3 – Post Office Protocol Version 3 / 110

Client	Server	Description
	+OK POP3 server ready	
USER ptphi		
	+OK	
PASS godblessus		
	+OK login successfully	
LIST		List email in mail box
	+OK 1 1024 2 2550	Having two unread mails
RETR 1		Request to get the first mail
	+OK	
DELE 1		Request to delete the first mail
	+OK	
QUIT		Request to disconnect
	+OK Bye-Bye	

IMAP – Internet Mail Access Protocol / 143

- Not require to download mail to local computer

POP3 & IMAP

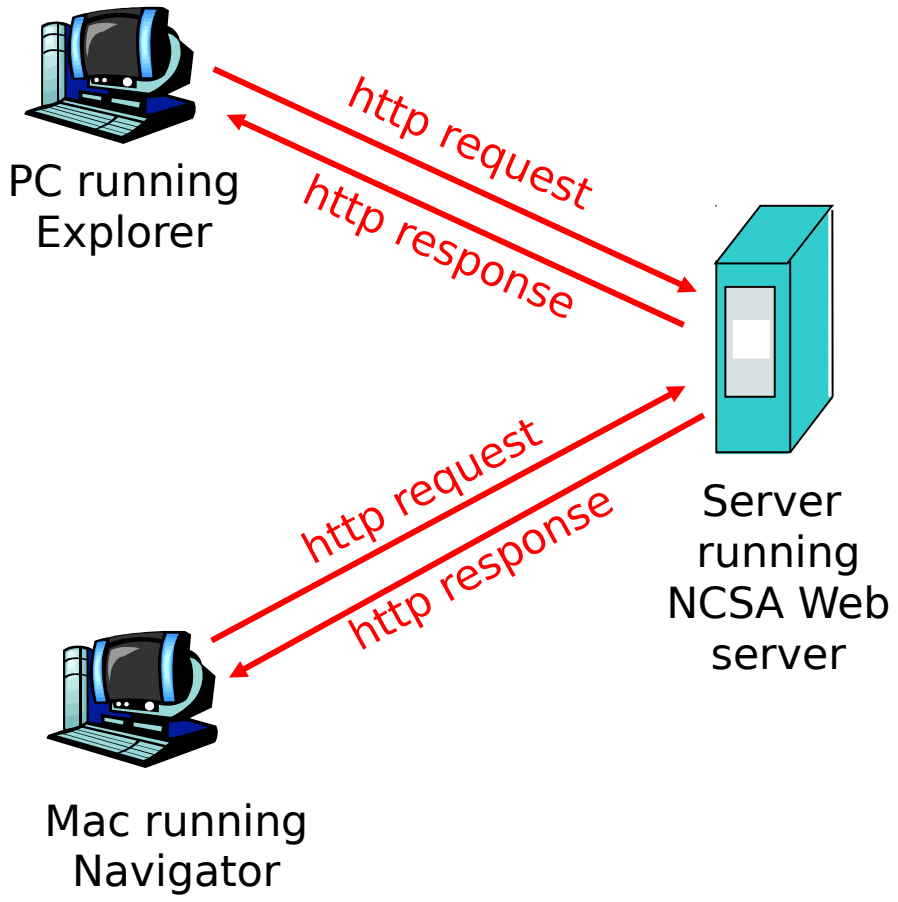
Characteristics	POP3	IMAP
RFC	RFC 1939	RFC 2060
Default Port	110	143
Place to store emails for user	PC	Server
How to read mail	Off-line	On-line
Connection Duration	short	Long
Server load	Small	More
Many mail inbox	No	Yes
Who does backup	User	ISP
Good for mobile users	No	Yes
Control user download	Less	More
Get a part of email	No	Yes
Quota disk issue ?	No	Sometimes
Easy to install	Yes	No
Widely supported	Yes	In developing

World Wide Web Service

World Wide Web Service

HTTP: HyperText Transfer Protocol

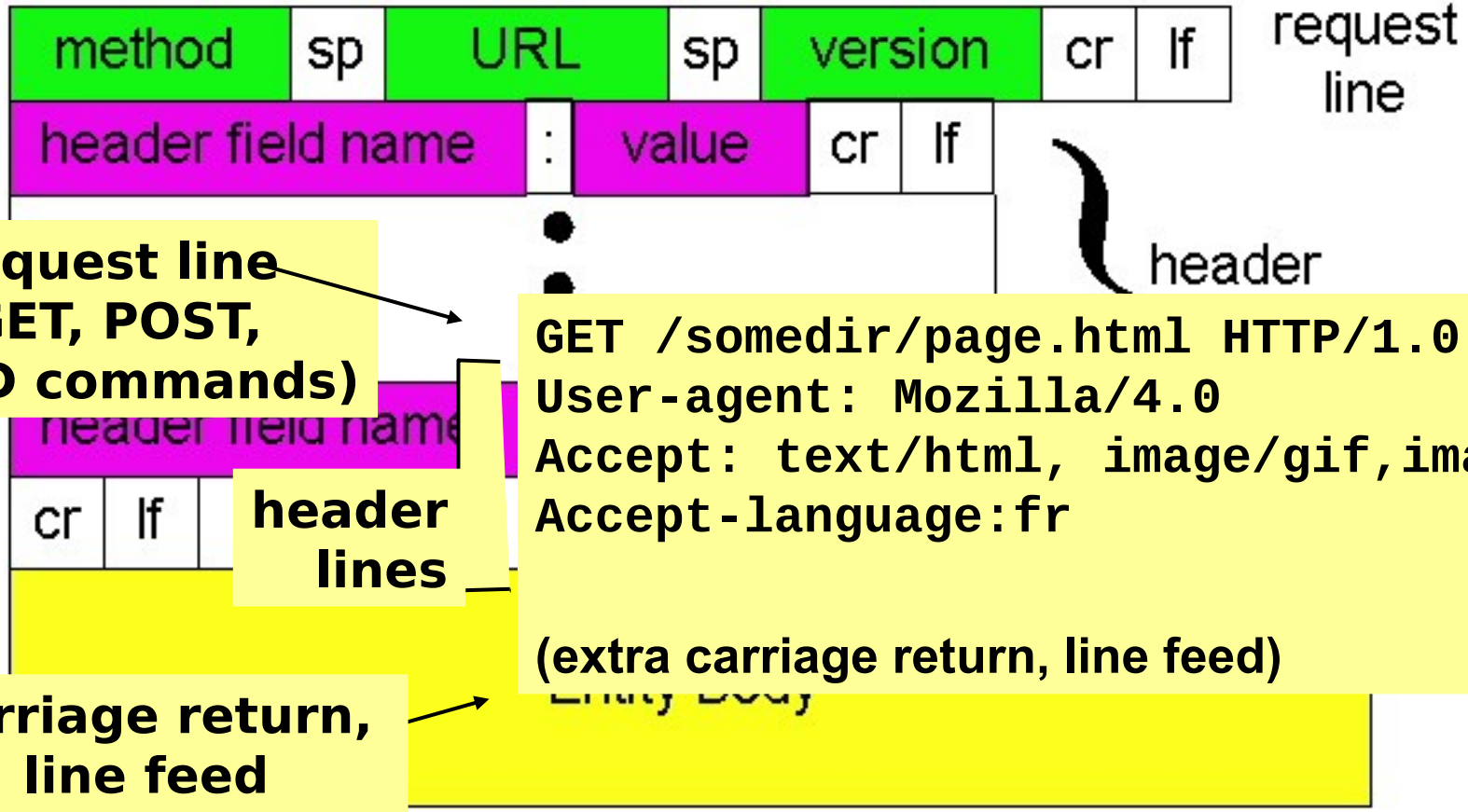
- client/server model
  - *client:* browser that requests, receives, “displays” Web objects
  - *server:* Web server sends objects in response to requests
- http1.0: RFC 1945
- http1.1: RFC 2068



World Wide Web Service

- Use TCP protocol, port 80
  - A client sends a TCP connection request to the server that is listening on port 80
  - The server accepts the connect request from the client
  - Messages are exchanged between the client and the server following HTTP protocol
  - The connection is terminated
- HTTP is a stateless protocol
  - Server doesn't maintain any information about the requests sent from clients in the pass

HTTP request format



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

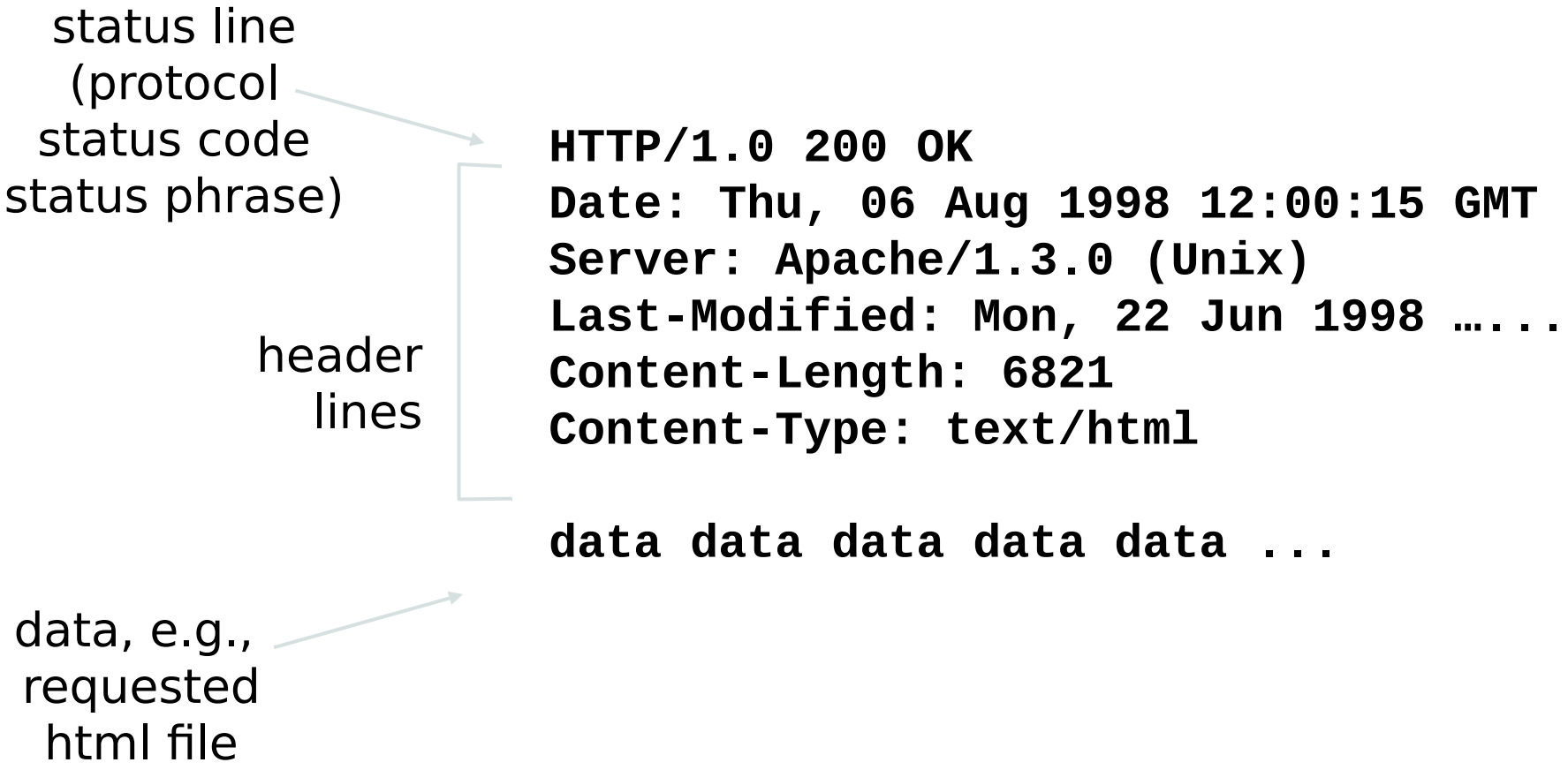
(extra carriage return, line feed)

Carriage return, line feed indicates end of message

HTTP request methods

Method	Description
OPTIONS	Request for current options
GET	Get a resource located at the address URL
HEAD	Get information about the resource located at address URL
POST	Send date to server
PUT	Upload a resource to the server at address URL
DELETE	Delete a resource at address URL
TRACE	Feedback of request massage
CONNECT	Used by proxies

HTTP response format



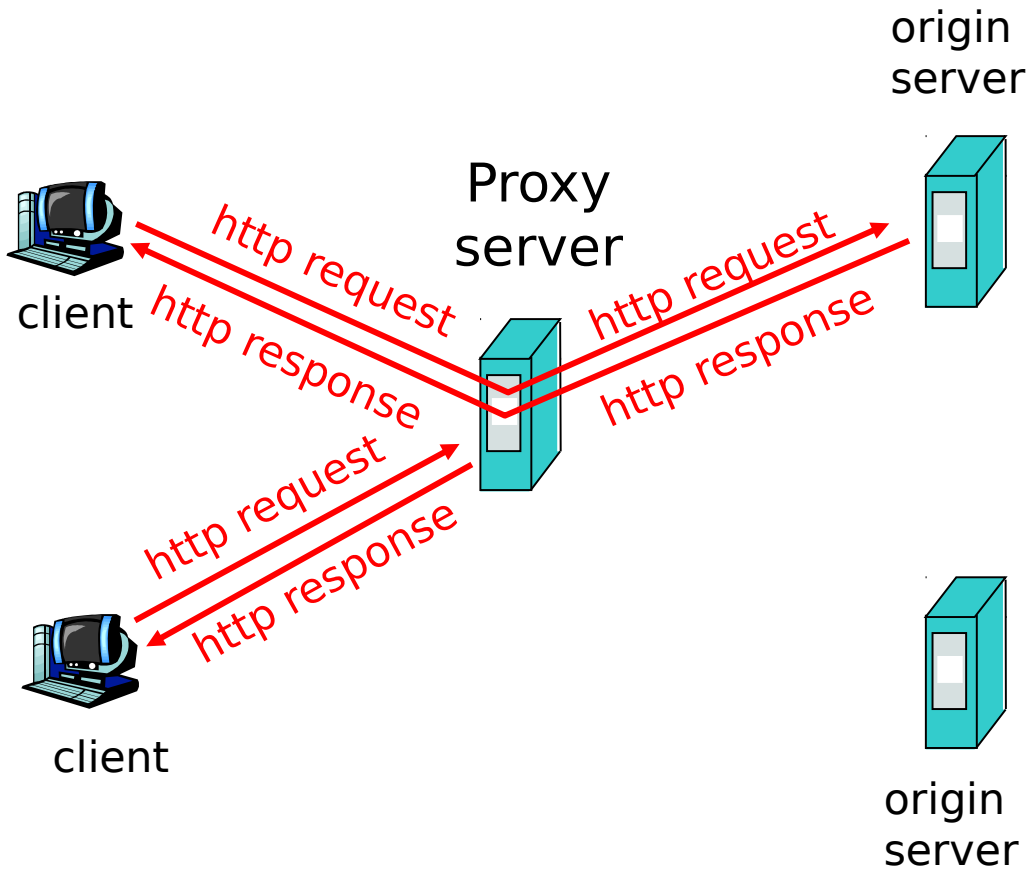
HTTP response format

Code	Type	Comment
1xx	Information	Request was received and is being processed
2xx	Successful	Request was processed successfully
3xx	Redirection	Need another request to accomplish the request
4xx	Client error	Request format is incorrect
5xx	Server error	Server can't accomplish a correct request

Web Caches (proxy server)

Respond to client request without connecting to the original web server

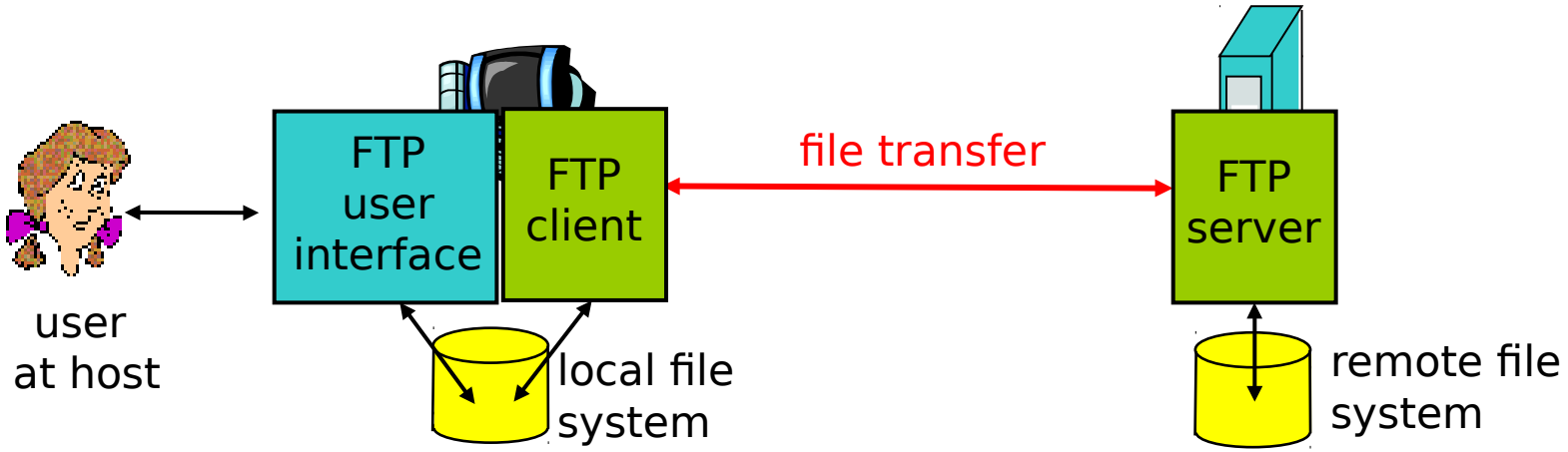
- Cache at browser or proxy server
- When a client sends a request to the Web proxy
  - If the requested resource is in the cache: proxy server will return the resource
  - If not, proxy server requests for the resource from the original server and forwards the resource to the client



Bài tập

- Download phan mềm puttytel cho windows
  - http://192.168.2.71/softs hoặc www.putty.org
- Nối kết đến web server mà bạn muốn lấy trang web về bằng lệnh sau
  - telnet server-name/IP 80
  - Ví dụ: telnet www.google.com.vn 80
  - puttytel www.google.com.vn 80
  - puttytel 192.168.2.71 80
- Gởi yêu cầu lấy trang web mà bạn muốn
  - GET http://www.google.com.vn HTTP/1.1
- Lưu lại thành tập tin và mở tập tin bằng một browser

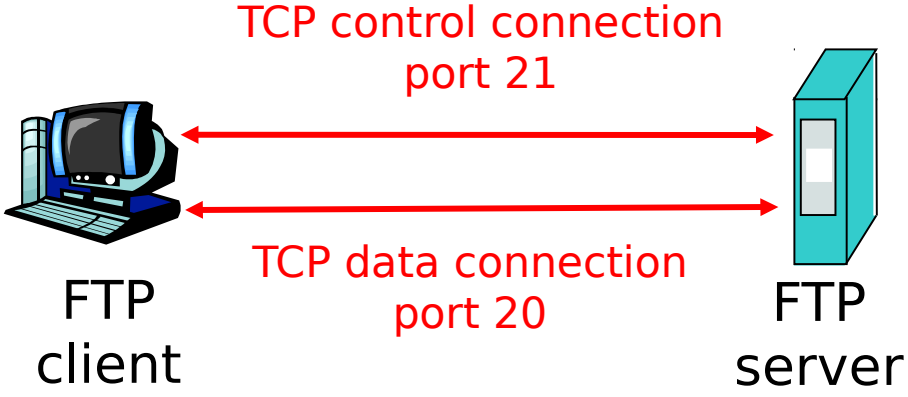
FTP - File Transfer Protocol



- 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: separate control, data connections

- ftp client connects to ftp server at port 21/TCP
- Two TCP channels are used:
  - control: is used to exchange requests and responses between client and server
  - data: is used to upload and download data files
- ftp server maintains the state of the current directory and user sessions



FTP client commands

Lệnh	Tham số	Ý nghĩa
ftp	host-name	Request to connect to a FTP server host-name
user	user-name	User authentication
ascii		Set data exchange in text mode
binary		Set data exchange in binary mode
ls		Display remote directory
cd	remote-dir	Change current directory on the server
get	remote-file local-file	Download remote-file from FTP server and store it with the name local-file
put	local-file remote-file	Upload local-file into the server with the name remote-file
mkdir	dir-name	Create a new directory dir-name on the server
rmdir	dir-name	Delete the directory dir-name on the server
quit		Terminate the connection

http://www.cyberciti.biz/faq/linux-unix-ftp-commands/

Bài tập / Hệ điều hành Linux

- Nối kết đến ftp server
  - ftp 192.168.2.74
  - Username: user1, password: user1
- Xem nội dung thư mục trên server bằng lệnh ls
- Down load tập tin readme.txt bằng lệnh
  - get readme.txt
- Cắt nối kết bằng lệnh quit
- Kiểm tra sự hiện diện của tập tin readme.txt trong thư mục hiện hành của máy tính cục bộ
- Làm theo các bước trong tập tin readme.txt

Remote access services

- Telnet
- SSH