# Computer Networks - *Xarxes de Computadors*

## Outline

- Course Syllabus
- Unit 1: Introduction
- Unit 2. IP Networks
- Unit 3. TCP
- Unit 4. LANs
- **Unit 5. Network applications**

# Unit 5. Network applications

## Outline

- **DNS**
- Email
- Web
- Charsets
- HTML

# Unit 2: IP Networks

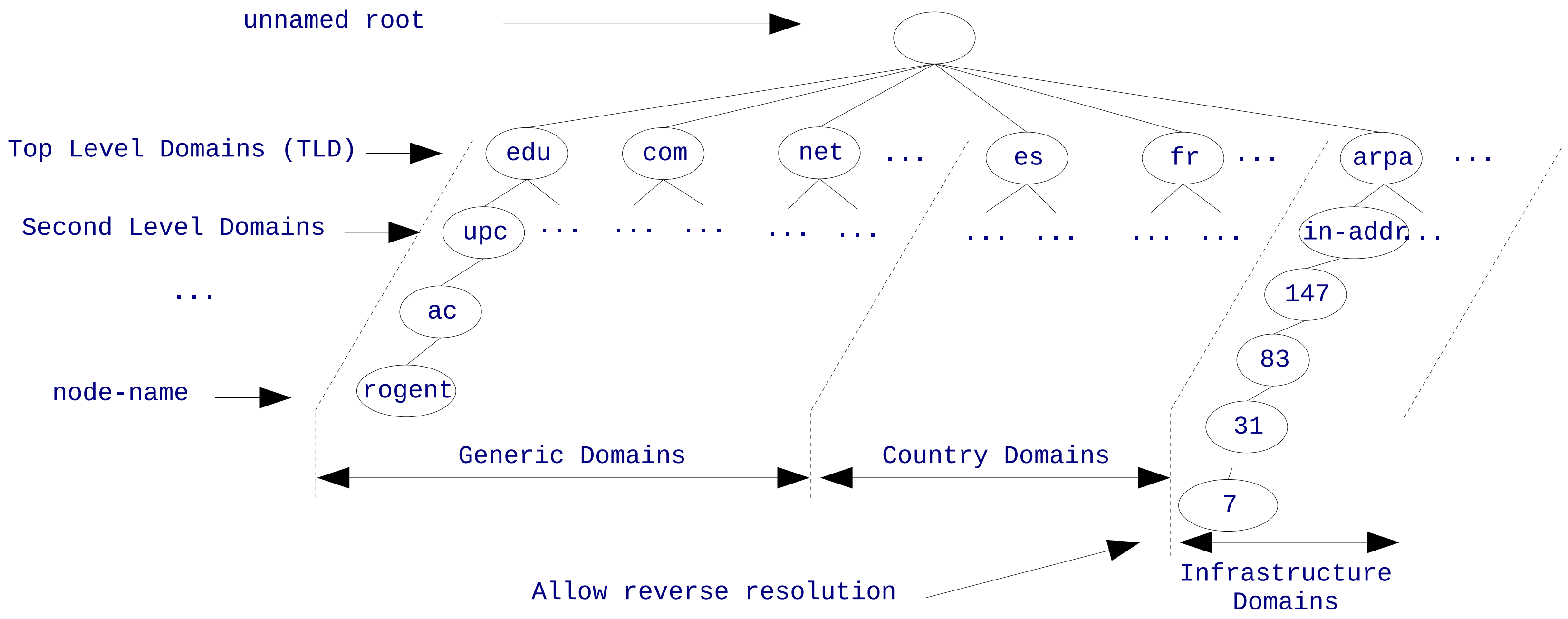
Domain Name System DNS (RFC 1034, 1035)

- Allows users to use names instead of IP addresses: e.g. rogent.ac.upc.edu instead of 147.83.31.7, www.upc.edu instead of 147.83.194.21, etc.
- Names consists of a node-name and a domain-mane: rogent.ac.upc.edu, www.upc.edu
- DNS consists of a worldwide distributed data base.
- DNS data base entries are referred to as Resource Records (RR).
- The information associated with a name is composed of 1 or more RRs.
- Names are case insensitive (e.g. www.upc.edu and WWW.UPC.EDU are equivalent).

# Unit 2: IP Networks

## DNS – Domain Hierarchy

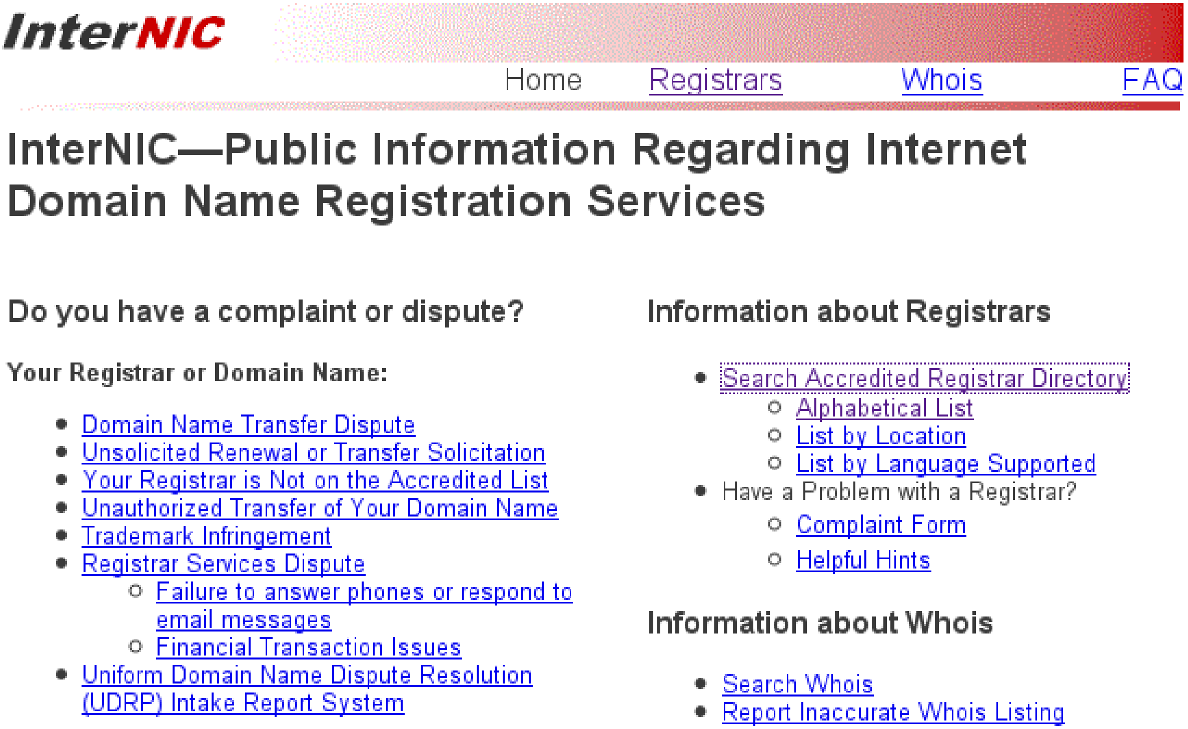
- DNS data base is organized in a tree:



# Unit 2: IP Networks

## DNS – Domain Hierarchy

- The *Internet Corporation for Assigned Names and Numbers* (ICANN) is responsible for managing and coordinating the DNS.
- ICANN delegates Top Level Domains (TLD) administration to registrars: http://www.internic.net
- Domains delegate the administration of subdomains.



InterNIC

Home Registrars Whois FAQ

### InterNIC—Public Information Regarding Internet Domain Name Registration Services

#### Do you have a complaint or dispute?

**Your Registrar or Domain Name:**

- Domain Name Transfer Dispute
- Unsolicited Renewal or Transfer Solicitation
- Your Registrar is Not on the Accredited List
- Unauthorized Transfer of Your Domain Name
- Trademark Infringement
- Registrar Services Dispute
  - Failure to answer phones or respond to email messages
  - Financial Transaction Issues
- Uniform Domain Name Dispute Resolution (UDRP) Intake Report System

#### Information about Registrars

- Search Accredited Registrar Directory
  - Alphabetical List
  - List by Location
  - List by Language Supported
- Have a Problem with a Registrar?
  - Complaint Form
  - Helpful Hints

#### Information about Whois

- Search Whois
- Report Inaccurate Whois Listing

# Unit 2: IP Networks

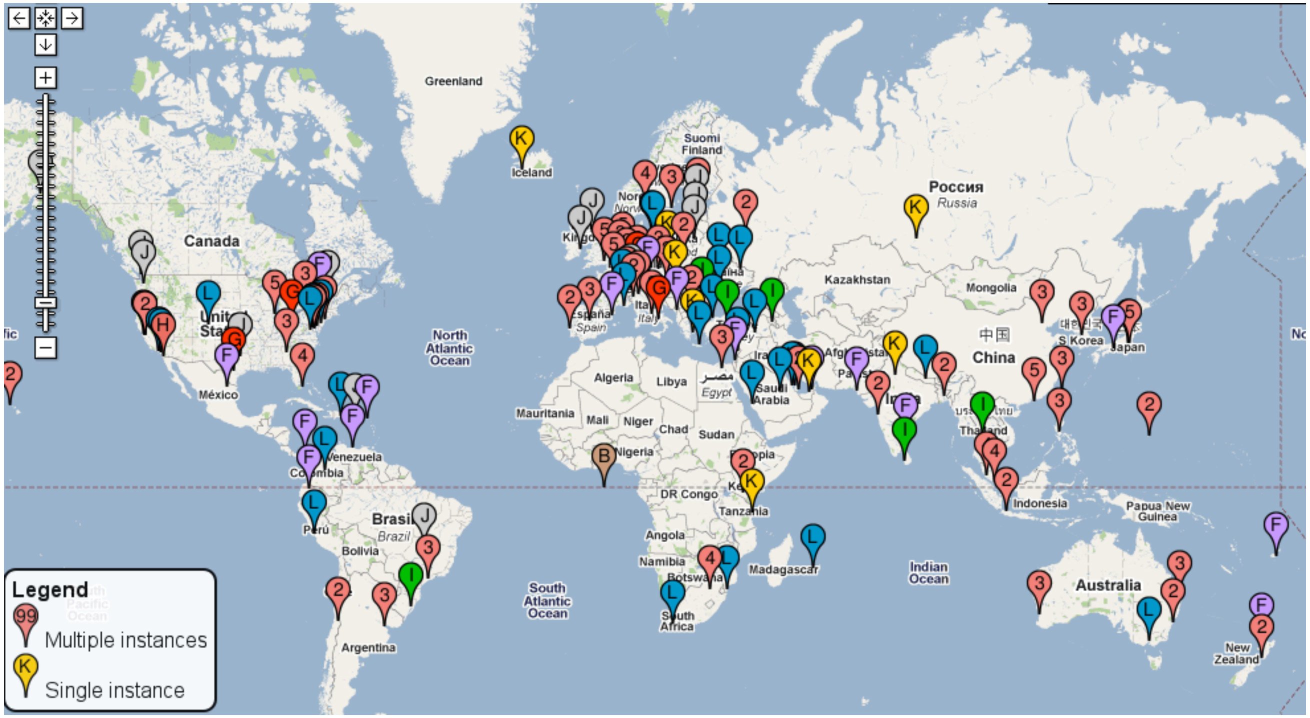
## DNS – Data Base Organization

- Access to DNS data base is done using *Name Servers* (NS).
- NSs may hold permanent and cached RRs. Cached RRs are removed after a timeout.
- Each subdomain has an *authority* which consists of a primary and backup NSs.
- In this context, subdomains are referred to as *zones*, and delegated subdomains *subzones*.
- An authority has the complete information of a zone:
  - Names and addresses of all nodes within the zone.
  - Names and addresses of all subzone authorities.

# Unit 2: IP Networks

## DNS – Data Base Organization

- Root Servers are the entry point to the domain hierarchy.
- Root Servers are distributed around the world and have the TLD addresses: http://www.root-servers.org
- Root server addresses are needed in a NS configuration.



Source: http://www.root-servers.org

# Unit 2: IP Networks

## DNS - Unix example: The resolver

- The applications use the calls (*resolver* library):

```
struct hostent *gethostbyname(const char *name) ;
struct hostent *gethostbyaddr(const void *addr, int len, int type);
```

- The resolver first looks the /etc/hosts file:

```
# hosts         This file describes a number of hostname-to-address
#               mappings for the TCP/IP subsystem.  It is mostly
#               used at boot time, when no name servers are running.
#               On small systems, this file can be used instead of a
#               "named" name server.
# Syntax:
# IP-Address  Full-Qualified-Hostname  Short-Hostname
127.0.0.1       localhost
10.0.1.1        massanella.ac.upc.edu massanella
```

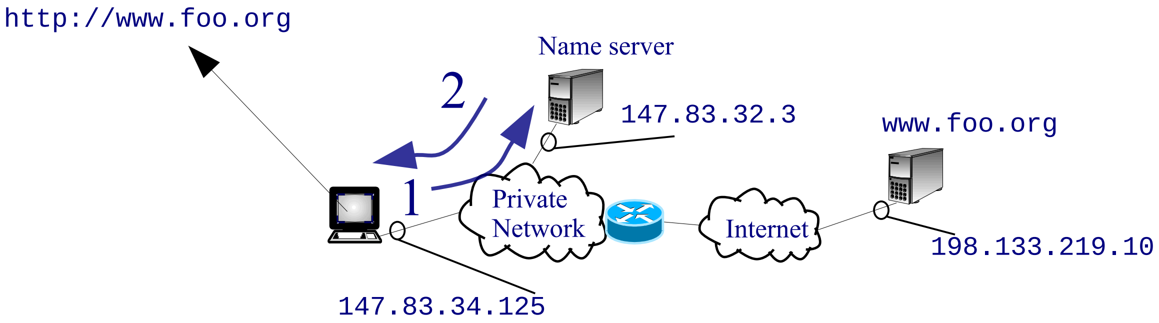
- Otherwise a *name server* is contacted using /etc/resolv.conf file:

```
search ac.upc.edu
nameserver 147.83.32.3
nameserver 147.83.33.4
```

# Unit 2: IP Networks

## DNS - Protocol

- Client-server paradigm
- UDP/TCP. Short messages uses UDP.
- well-known port: 53



```
1  18:36:00.322370 IP (proto: UDP) 147.83.34.125.1333 >
         147.83.32.3.53:  53040+ A? www.foo.org. (31)
2  18:36:00.323080 IP (proto: UDP) 147.83.32.3.53 > 147.83.34.125.1333:
         53040 1/2/2 www.foo.org. A 198.133.219.10 (115)
```

# Unit 2: IP Networks

## DNS – Unix example: Basic NS configuration

- Unix NS implementation is BIND (Berkeley Internet Name Domain), http://www.isc.org.
- named is the BIND NS daemon.
- BIND basic configuration files:
  - `/etc/named.conf` global configuration
  - `/var/lib/named/root.hint` root servers addresses
  - `/var/lib/named/*.db` zone files

# Unit 2: IP Networks

## DNS – Unix example: zone file

The domain name

The domain NS

The domain maintainer mail address (the @ is written as a '.')

```
linux # cat /var/lib/named/foo.db
; BIND data file for foo.org
; /var/lib/named/foo.db
;
foo.org. IN      SOA     dns.foo.org. root.foo.org. (
                     1998121401          ; Serial
                         604800          ; Refresh
                          86400          ; Retry
                        2419200          ; Expire
                         604800 )        ; Default TTL
        IN      NS      dns.foo.org.
        IN      MX      10      mail.foo.org.
server  IN      A       198.133.219.10
www     IN      CNAME   server
ftp     IN      CNAME   server
news    IN      A       198.133.219.20
mail    IN      A       198.133.219.30
dns     IN      A       198.133.219.40
dns2    IN      A       198.133.219.50
…
sub.foo.org. IN NS      dns3.sub.foo.org.
dns3    IN      A       10.10.0.24
…
```

comments

configuration

MX preference value (used if multiple servers are available)

NS name

domain mail server

IP addresses and alias names

Resource Records (RR)

delegated sub-domain

name (type A or CNAME), domain (type NS of MX). If the domain is missing, it is automatically added.

class:
IN: Internet System.

type:
SOA: Start Of Authority.
NS: NS name.
MX: the domain mail exchange.
A: A host address.
CNAME: Canonical Name Record. E.g. the real hostname of www.foo.org is server.foo.org.

address (type A), name (type NS or CNAME)...

# Unit 2: IP Networks

## DNS – Unix example: root servers addresses

```
linux # cat /var/lib/named/root.hint

;       This file holds the information on root name servers needed to
;       initialize cache of Internet domain name servers
;       (e.g. reference this file in the "cache  .  <file>"
;       configuration file of BIND domain name servers).
;
;       This file is made available by InterNIC
;       under anonymous FTP as
;           file                /domain/named.root
;           on server           FTP.INTERNIC.NET
;       -OR-                    RS.INTERNIC.NET
.                        3600000  IN  NS    A.ROOT-SERVERS.NET.
A.ROOT-SERVERS.NET.      3600000  IN  A     198.41.0.4
.                        3600000  IN  NS    B.ROOT-SERVERS.NET.
B.ROOT-SERVERS.NET.      3600000  IN  A     192.228.79.201
.                        3600000  IN  NS    C.ROOT-SERVERS.NET.
C.ROOT-SERVERS.NET.      3600000  IN  A     192.33.4.12

...
.                        3600000  IN  NS    M.ROOT-SERVERS.NET.
M.ROOT-SERVERS.NET.      3600000  IN  A     202.12.27.33
```

comments

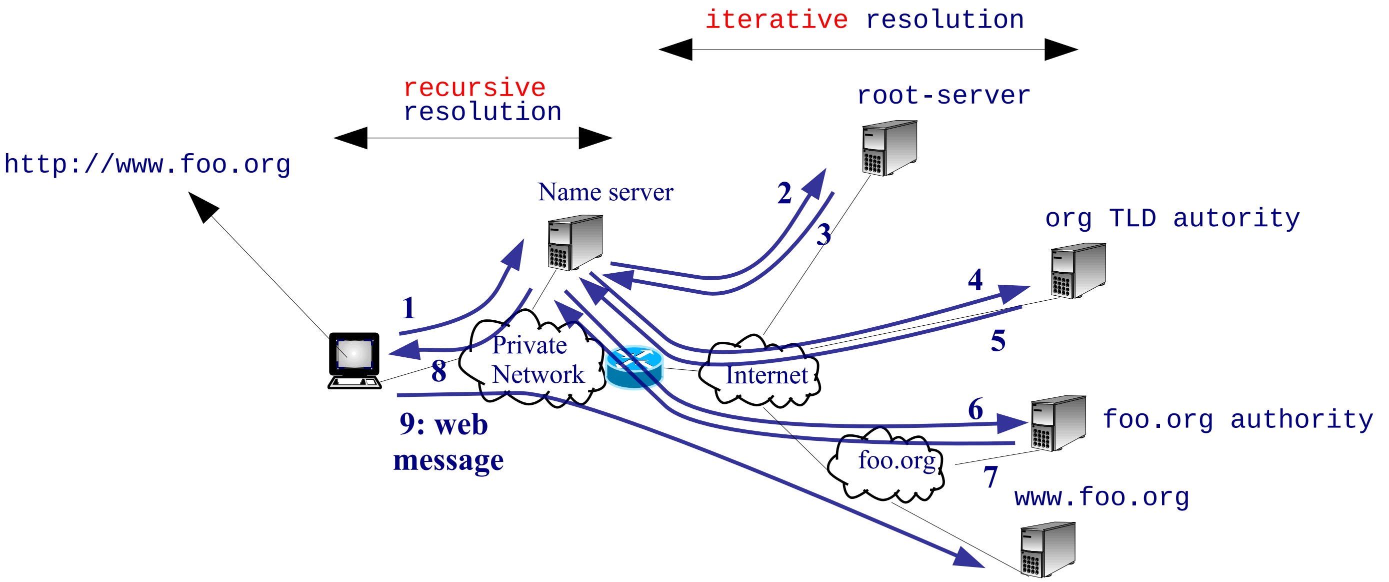
Resource Records (RR)
pointing to root-servers

address of a name
NS name

# Unit 2: IP Networks

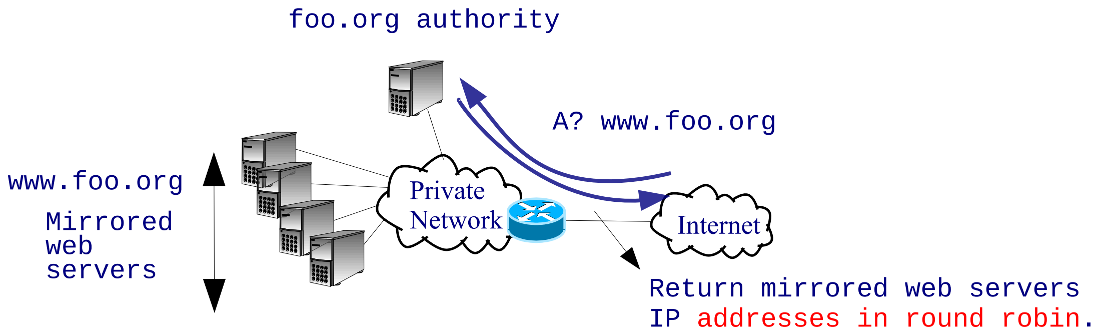
## DNS – Resolution

- NSs cache name resolutions.
- A cached RR is returned without looking for in the NS authority.
- The same name may be associated with several IP addresses (e.g. load balancing).
- The addresses of a common domain may not belong to the same IP network (e.g. Content Distribution Networks).



# Unit 2: IP Networks

## DNS – Load balancing, example



Return mirrored web servers IP addresses in round robin.

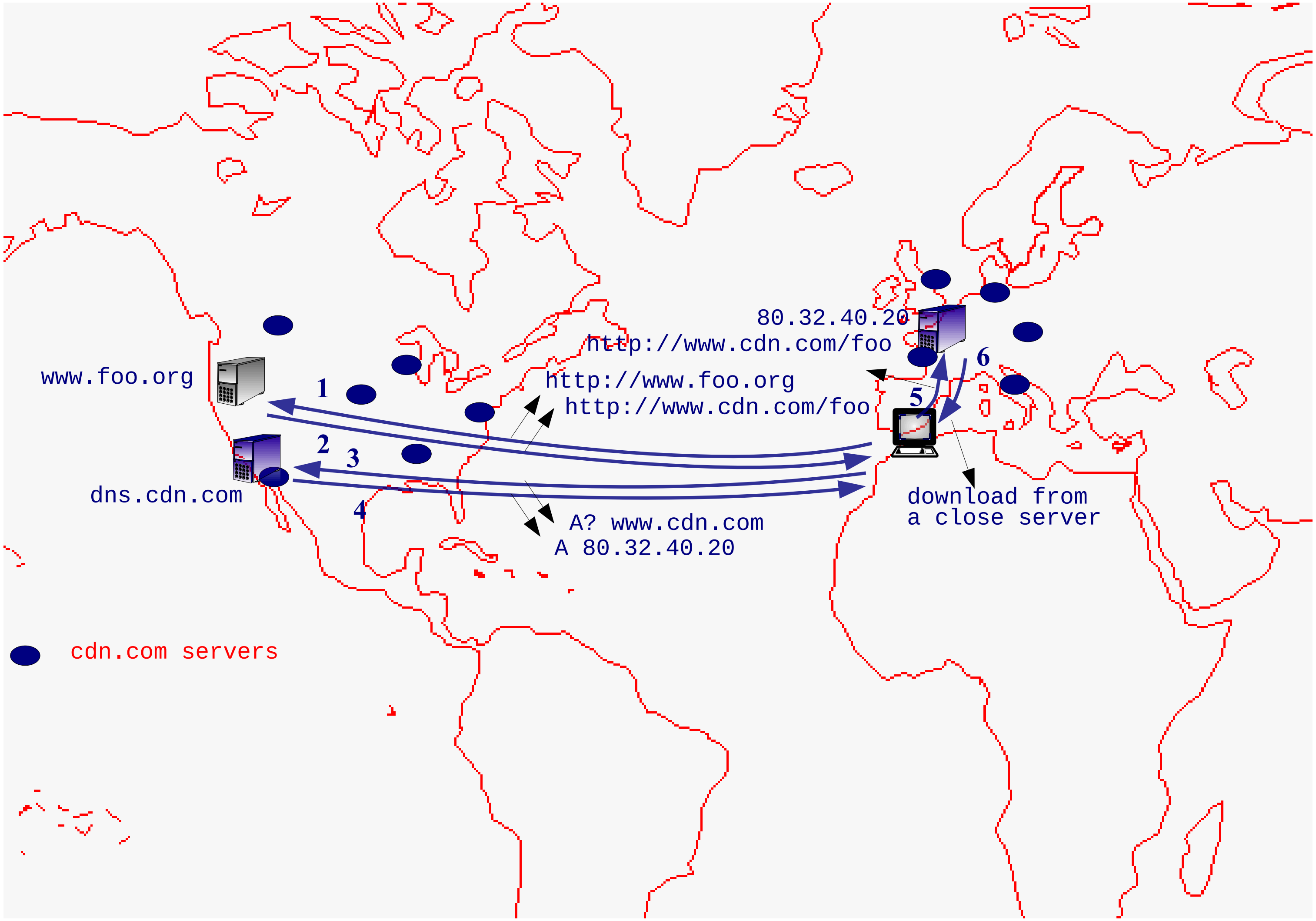
- Example using dig:

```
linux ~> dig www.microsoft.com

; <<>> DiG 9.3.2 <<>> www.microsoft.com
;; global options:  printcmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 31808
;; flags: qr rd ra; QUERY: 1, ANSWER: 9, AUTHORITY: 0, ADDITIONAL: 0

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

;; ANSWER SECTION:
www.microsoft.com.      3135    IN      CNAME   toggle.www.ms.akadns.net.
toggle.www.ms.akadns.net. 181   IN      CNAME   g.www.ms.akadns.net.
g.www.ms.akadns.net.    181     IN      CNAME   lb1.www.ms.akadns.net.
lb1.www.ms.akadns.net.  181     IN      A       207.46.19.60
lb1.www.ms.akadns.net.  181     IN      A       207.46.18.30
lb1.www.ms.akadns.net.  181     IN      A       207.46.20.60
lb1.www.ms.akadns.net.  181     IN      A       207.46.19.30
lb1.www.ms.akadns.net.  181     IN      A       207.46.198.30
lb1.www.ms.akadns.net.  181     IN      A       207.46.225.60

;; Query time: 42 msec
;; SERVER: 192.168.1.1#53(192.168.1.1)
;; WHEN: Sun Mar 11 10:48:11 2007
;; MSG SIZE  rcvd: 203
```

```
linux ~> dig www.microsoft.com

; <<>> DiG 9.3.2 <<>> www.microsoft.com
;; global options:  printcmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 17923
;; flags: qr rd ra; QUERY: 1, ANSWER: 9, AUTHORITY: 0, ADDITIONAL: 0

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

;; ANSWER SECTION:
www.microsoft.com.      3469    IN      CNAME   toggle.www.ms.akadns.net.
toggle.www.ms.akadns.net. 215   IN      CNAME   g.www.ms.akadns.net.
g.www.ms.akadns.net.    215     IN      CNAME   lb1.www.ms.akadns.net.
lb1.www.ms.akadns.net.  215     IN      A       207.46.198.30
lb1.www.ms.akadns.net.  215     IN      A       207.46.199.30
lb1.www.ms.akadns.net.  215     IN      A       207.46.18.30
lb1.www.ms.akadns.net.  215     IN      A       207.46.19.60
lb1.www.ms.akadns.net.  215     IN      A       207.46.198.60
lb1.www.ms.akadns.net.  215     IN      A       207.46.20.60

;; Query time: 43 msec
;; SERVER: 192.168.1.1#53(192.168.1.1)
;; WHEN: Sun Mar 11 10:42:38 2007
;; MSG SIZE  rcvd: 203
```

# Unit 2: IP Networks

## DNS - Content Distribution Networks, example



# Unit 2: IP Networks

## DNS – Messages: Message Format

- All DNS messages have the same format:
  - Header: type of message.
  - Question: What is to be resolved.
  - Answer: Answer to question.
  - Authority: Domain authority names.
  - Additional: Typically, the authority name's addresses.

```
-------------------------------------------------
|             Header (12 bytes)                 |
-------------------------------------------------
/             Question (variable)               /
-------------------------------------------------
/             Answer (variable)                 /
-------------------------------------------------
/             Authority (variable)              /
-------------------------------------------------
/             Additional (variable)             /
-------------------------------------------------
```

# Unit 2: IP Networks

## DNS – Messages: Header

- Identification: 16 random bits used to match query/response
- Flags. Some of them:
  - Query-Response, QR: 0 for query, 1 for response.
  - Authoritative Answer, AA: When set, indicates an authoritative answer.
  - Recursion Desired, RD: When set, indicates that recursion is desired.
- The other fields indicate the number of Questions, Answer, Authority and Additional fields of the message.

```
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 bits
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|          Identification        |      Flags                    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|         #Questions            |      #Answers                 |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|         #Authorities          |      #Additional              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

# Unit 2: IP Networks

## DNS – Messages: Question

- QName: Indicates the name to be resolved.
- QType: Indicates the question type:
  - Address, A.
  - Name Server, NS.
  - Pointer, PTR: For an inverse resolution.
  - Mail Exchange, MX: Domain Mail Server address.
- Qclass: For Internet addresses is 1.

```
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 bits
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
/                       QName (variable)                        /
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|         QType                 |      QClass                   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

```
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 bytes
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|6|r|o|g|e|n|t|2|a|c|3|u|p|c|3|e|d|u|0|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Codification example of `rogent.ac.upc.edu`

# Unit 2: IP Networks

## DNS – Messages: Resource Records (RRs)

- The fields Answer, Authority and Additional are composed of RRs:
  - Name, Type, Class: The same as in the Question field.
  - TTL (Time To Live): Number of seconds the RR can be cached.
  - RDLenth: RR size in bytes.
  - Rdata: E.g. An IP address if the Type is 'A', or a name if the Type is 'NS', 'MX' or 'CNAME'.

```
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 bits
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
/                        Name (variable)                        /
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|          Type                 |       Class                   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                             TTL                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|         RDLenth               |      RData (variable)         /
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

# Unit 2: IP Networks

## DNS – Messages: Example

```
# tcpdump -s1500 -vvpni eth0 port 53
tcpdump: listening on eth0, link-type EN10MB (Ethernet), capture size 200 bytes
11:17:30.769328 IP (UDP, length: 55) 147.83.30.137.1042 > 147.83.30.70.53: 36388+ A? ns.uu.net. (27)
11:17:30.771324 IP (UDP, length: 145) 147.83.30.70.53 > 147.83.30.137.1042: 36388
                 q: A? ns.uu.net. 1/2/2 ns.uu.net. A 137.39.1.3
                 ns: ns.uu.net. NS auth00.ns.uu.net., ns.uu.net. NS auth60.ns.uu.net.
                 ar: auth00.ns.uu.net. A 198.6.1.65, auth60.ns.uu.net. A 198.6.1.181 (117)
```

**Query message:**

- 36388: Identifier.
- +: Recursion-Desired is set.
- A?: Qtype = A.
- ns.uu.net.: Name to resolve.

**Response message:**

- 36388: Identifier.
- q: A? ns.uu.net.: Repeat the Question field.
- 1/2/2: 1 Answers, 2 Authorities, 2 Additional follows.
- ns.uu.net. A 137.39.1.3: The answer (RR of type A, address: 137.39.1.3).
- ns: ns.uu.net. NS auth00.ns.uu.net., ns.uu.net. NS auth60.ns.uu.net.: 2 Authorities (RRs of type NS: the domain ns.uu.net. authorities are auth00.ns.uu.net. and auth60.ns.uu.net).
- ar: auth00.ns.uu.net. A 198.6.1.65, auth60.ns.uu.net. A 198.6.1.181: 2 Additional (RRs of type A: authorities IP addresses).

# Unit 5. Network applications

## Outline

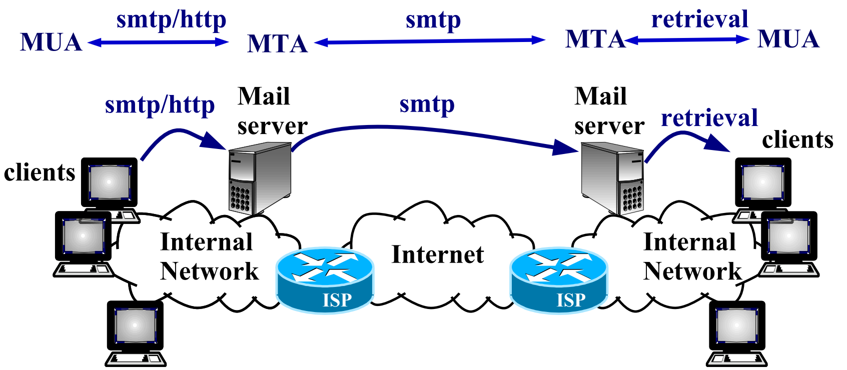
- DNS
- **Email**
- Web
- Charsets
- HTML

# Unit 5. Network applications

## Email

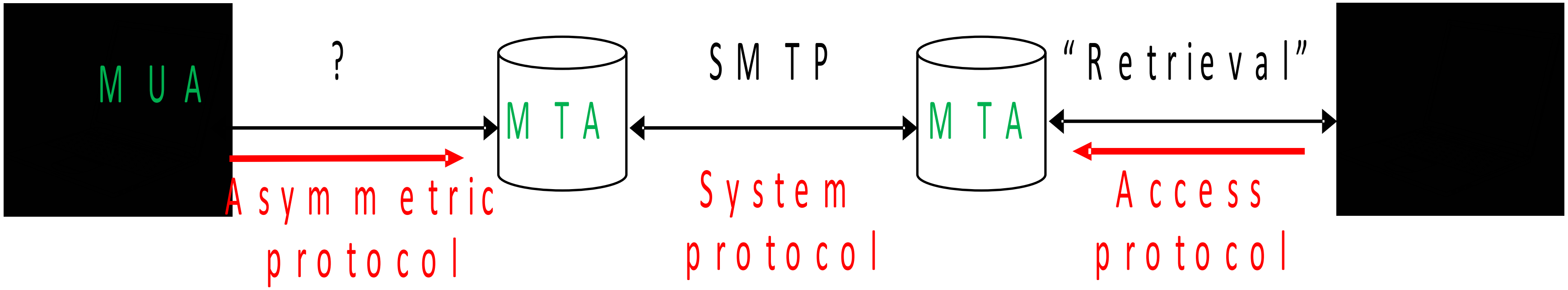
- Electronic mail (email): One of the first applications used in the Internet to electronic messaging.
- Components:
  - Transport layer: TCP, well-known port: 25.
  - Application layer protocol: Simple Mail Transfer Protocol (SMTP). First defined by RFC-821 and last updated by RFC-5321.
  - Retrieval protocols (IMAP, POP, HTTP).

MUA: Mail User Agent
MTA: Mail Transfer Agent



# Unit 5. Network applications

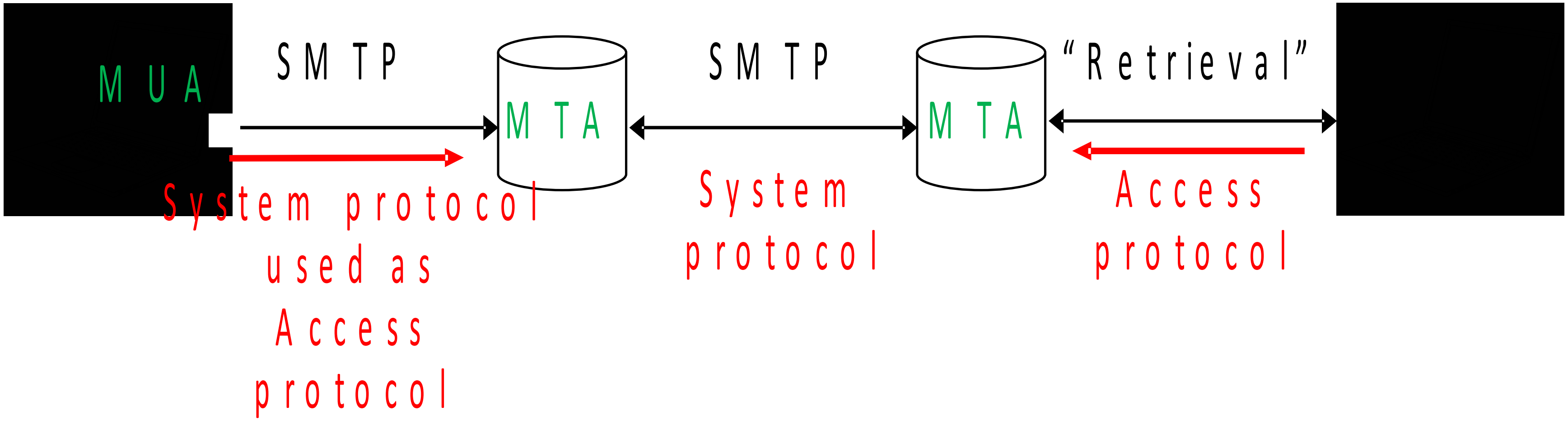
## Email – Architecture



- **MUA: Mail User Agent**
- **MTA: Mail Transfer Agent**

# Unit 5. Network applications

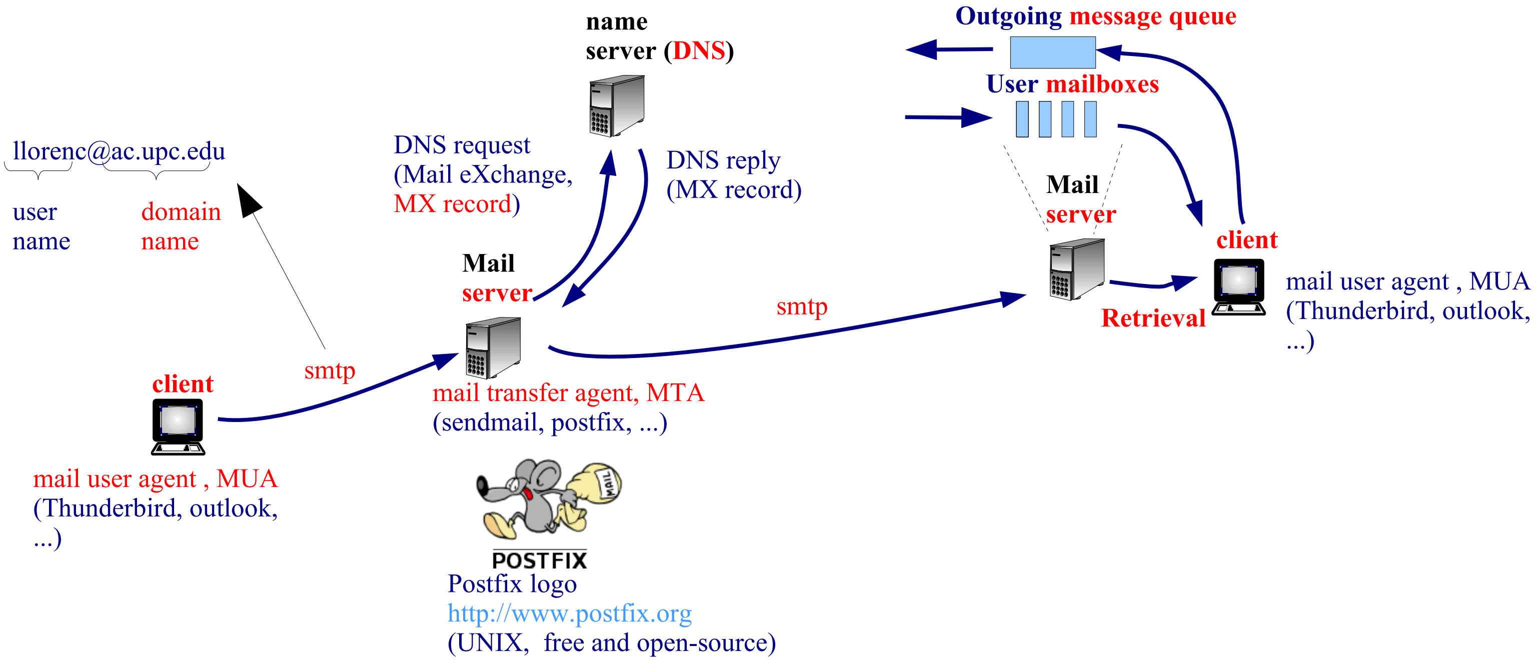
## Email – Protocols



- **“Retrieval” protocols (mailbox access):**
  - Post Office Protocol (POP3)
  - Internet Message Access Protocol (IMAP)
  - Hypertext Transfer Protocol (HTTP): Webmail
- **Simple Mail Transfer Protocol (SMTP)**

# Unit 5. Network applications

## Email - SMTP processing model


name server (DNS)
Outgoing message queue
User mailboxes
llorenc@ac.upc.edu
user name
domain name
DNS request (Mail eXchange, MX record)
DNS reply (MX record)
Mail server
Mail server
client
mail user agent , MUA (Thunderbird, outlook, ...)
smtp
smtp
Retrieval
client
mail transfer agent, MTA (sendmail, postfix, ...)
mail user agent , MUA (Thunderbird, outlook, ...)
MAIL
POSTFIX
Postfix logo
http://www.postfix.org
(UNIX, free and open-source)

# Unit 5. Network applications

## Email - SMTP protocol (RFC-821, last update RFC-5321)

- Designed as a simple (few commands) and text-based protocol (ASCII).
  - Client basic commands: HELO (identify SMTP client), MAIL FROM: (identify sender mailbox), RCPT TO: (identify recipient mailbox), DATA (mail message), QUIT (close transaction).
  - Server replies: Three digit number (identify what state the client to enter next), and a human understandable message.
- Example: Manually send an email using telnet to port 25.

**CLIENT**

**SERVER**

**COMMANDS**

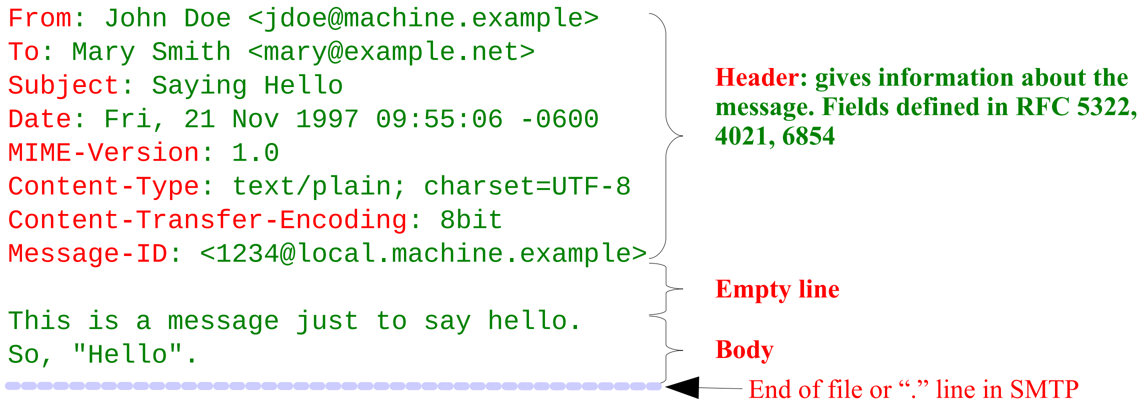
**SMTP transaction**

```
linux ~> telnet relay.upc.edu 25
Trying 147.83.2.12...
Connected to relay.upc.edu.
Escape character is '^]'.
220 dash.upc.es ESMTP MTA ready and waiting; Fri, 10 Nov 2023 13:25:47 +0100
HELO linux.ac.upc.edu
250 dash.upc.es Hello linux.ac.upc.edu [147.83.34.125], pleased to meet you
MAIL FROM: <llorenc@ac.upc.edu>
250 2.1.0 <llorenc@ac.upc.edu>... Sender ok
RCPT TO: <albert@ac.upc.edu>
250 2.1.5 <albert@ac.upc.edu>... Recipient ok
DATA
354 Enter mail, end with "." on a line by itself

Hello world
.
250 2.0.0 p14DvFOQ008320 Message accepted for delivery
QUIT
221 2.0.0 dash.upc.es closing connection
Connection closed by foreign host.
```

# Unit 5. Network applications

## Email – message formats

- Format described in RFC 822 (updates: RFC 5322, 6854) Internet Message Format
- Example:



```
From: John Doe <jdoe@machine.example>
To: Mary Smith <mary@example.net>
Subject: Saying Hello
Date: Fri, 21 Nov 1997 09:55:06 -0600
MIME-Version: 1.0
Content-Type: text/plain; charset=UTF-8
Content-Transfer-Encoding: 8bit
Message-ID: <1234@local.machine.example>

This is a message just to say hello.
So, "Hello".
```

**Header: gives information about the message. Fields defined in RFC 5322, 4021, 6854**

**Empty line**

**Body**

End of file or "." line in SMTP

# Multipurpose Internet Mail Extensions (MIME)

- RFC 2045, 2046, 2049
- Examples:

```
From: Nathaniel Borenstein <nsb@thumper.bellcore.com>
To: Ned Freed <ned@innosoft.com>
Subject: Plain text mail
Content-type: text/plain; charset=us-ascii

This is plain text mail.
```

---

```
...Subject: French mail
Content-type: text/plain; charset=iso-8859-1
Content-transfer-encoding: quoted-printable

Le courrier =E9lectronique =E0 la fran=E7aise ...
```

---

```
...Content-type: image/gif
Content-Transfer-Encoding: base64

R0lGODdhSgGgAfUAAENDQ01NTTw8PEVF...
```

# MIME: example multipart

```
  From: Nathaniel Borenstein <nsb@bellcore.com>
  To: Ned Freed <ned@innosoft.com>
  Subject: A multipart example
  Content-Type: multipart/mixed; boundary=CUT_HERE

--CUT_HERE
  Content-type: text/plain

  Hey, Ned, look at this neat picture:
--CUT_HERE
  Content-type: image/gif
  Content-Transfer-Encoding: base64

  5WVlZ6enqqqr....
--CUT_HERE
  Content-type: text/plain

  Wasn’t that neat?
--CUT_HERE--
```

End of multipart

# MIME: content type

- Text: …
  - Attribute: charset=iso-8859-1
  - text/plain (simple text), text/html ...
- Image: image/gif, image/jpeg, image/png ...
- Audio: sound, voice, music …
- Application: application specific content
  - application/octet-stream: data without any associated application
  - application/organization-product
- Multipart: a set of objects
  - multipart/mixed: a combination of several objects
  - multipart/alternative: an object in several formats to select one (text/html/rtf)
  - multipart/digest: collection of messages
  - multipart/related: set of objects part of a single object (web page)
- Message:
  - RFC822: a complete message (eg. resent message)
  - Partial: a fragment …

Registration scheme
Type/subtype:
mantained by IANA.org

# MIME: transfer encoding

Ways to encode content: (to “get through” a 7 bit transport)

- Quoted-Printable:
  - The majority of text is 7 bits, transform some characters €→ =E4
  - The result “almost" legible without decoding. Depends on table (charset)
- Base64:
  - 3 bytes (24 bits) <=> 4 ASCII (32 bits)
  - A-Za-z0-9+/=
  - '=' as padding, other are ignored (\r, \n, …)
- Binary: No encoding: any character and lines of any length
- 7bit: No character encoding (all 7 bits)
- 8bit: No character encoding (8 bits)
- In the heading:

```
MIME-Version: 1.0
Subject: =?iso-8859-1?Q?acentuaci=F3n=20t=EDpica?=
```

# Unit 5. Network applications

## Email - retrieval protocols

- Post Office Protocol (POP), RFC-1939:
  - POP server listens on well-known port 110
  - User normally deletes messages upon retrieval.
- Internet Message Access Protocol (IMAP) RFC-3501:
  - IMAP server listens on well-known port 143
  - Messages remain on the server until the user explicitly deletes them.
  - Provide commands to create folders, move messages, download only parts of the messages (e.g. only the headers)
- Web based Email (HTTP)
  - A web server handles users mailboxes. User agent is a web browser, thus, using HTTP to send and retrieve email messages.

# Unit 5. Network applications

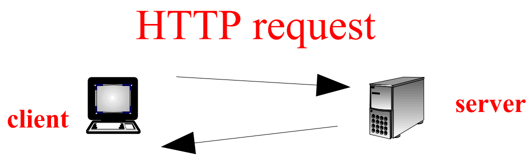
## Outline

- DNS
- Email
- **Web**
- Charsets
- HTML

# Unit 5. Network applications

## Web

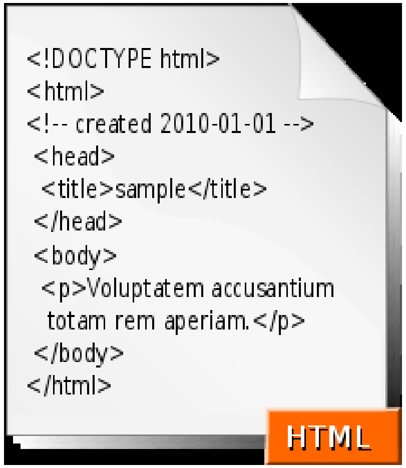
- World Wide Web (WWW): was started by Tim John Berners-Lee in 1989 and developed in the 90s to provide an easy access to information in the Internet.
- Components:
  - Transport: TCP, well-known port 80, most use port 443 secure transport (TLS)
  - Application layer protocol: HyperText Transfer Protocol (HTTP). HTTP 1.1: RFC9110 (Semantics) and RFC9112 (9112).
  - HyperText Markup Language (HTML): Language used to format web documents (Hypertext, with hyper links).



Web browser:
- Firefox
- Chrome
- ...

HTTP response (HTML page)

Web server:
- Apache
- ...

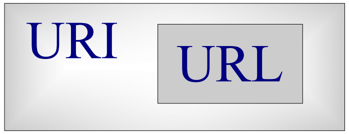


```
<!DOCTYPE html>
<html>
<!-- created 2010-01-01 -->
 <head>
  <title>sample</title>
 </head>
 <body>
  <p>Voluptatem accusantium
   totam rem aperiam.</p>
 </body>
</html>
```

Source: wikipedia

# Unit 5. Network applications

## Web – links



- Uniform Resource Identifier (URI) RFC3986
  - Generic syntax to identify a resource.
- Uniform Resource Locator (URL) RFC1738
  - Subset of URIs identifying the locating a resource in the Internet.
- The URL general syntax is

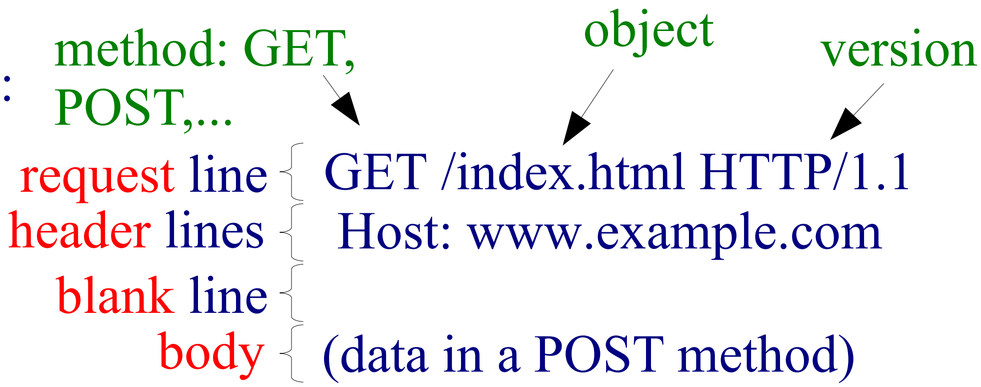
  **scheme://username:password@domain:port/path?query_string#fragment_id**

  - scheme: Purpose, and the syntax of the remaining part. http, gopher, file, ftp...
  - domain name or IP address gives the destination location. The port is optional.
  - query_string: contains data to be passed to the server.
  - fragment_id: specifies a position in the html page.
  - Examples:
    - http://tools.ietf.org/html/rfc1738
    - http://147.83.2.135
    - http://studies.ac.upc.edu/FIB/grau/XC/#Practs
    - file:///home/llorenc/gestio/2010/cd/autors.html
    - http://www.amazon.com/product/03879/refs9?pf_ra=ATVPD&pf_rd=07HR2

# Unit 5. Network applications

## Web – HTTP Messages, RFC2616

- Client (HTTP request):



method: GET, POST,...

object

version

request line

header lines

blank line

body

```
GET /index.html HTTP/1.1
Host: www.example.com

(data in a POST method)
```

- Header: Allows the client to give additional information about the request and the client itself.
  - Host:
    - host of the resource being requested
    - mandatory in HTTP/1.1

# Unit 5. Network applications

## Web – HTTP Messages, RFC2616

- **Methods:**
  - GET Typical command. Requests an object.
  - POST Request that the origin server accept the entity enclosed in the request. The enclosed data is typically the contents of the HTML form fields, provided by the client.
  - HEAD the server returns only the header
  - OPTIONS request communication options
  - PUT store entity
  - PATCH modify an existing resource
  - DELETE delete entity
  - TRACE final recipient echoes the received message back
  - CONNECT used with a proxy
- NOTES
  - Most used: GET, POST
  - Safe and mandatory: GET, HEAD

# Unit 5. Network applications

## Web – HTTP Messages, RFC2616

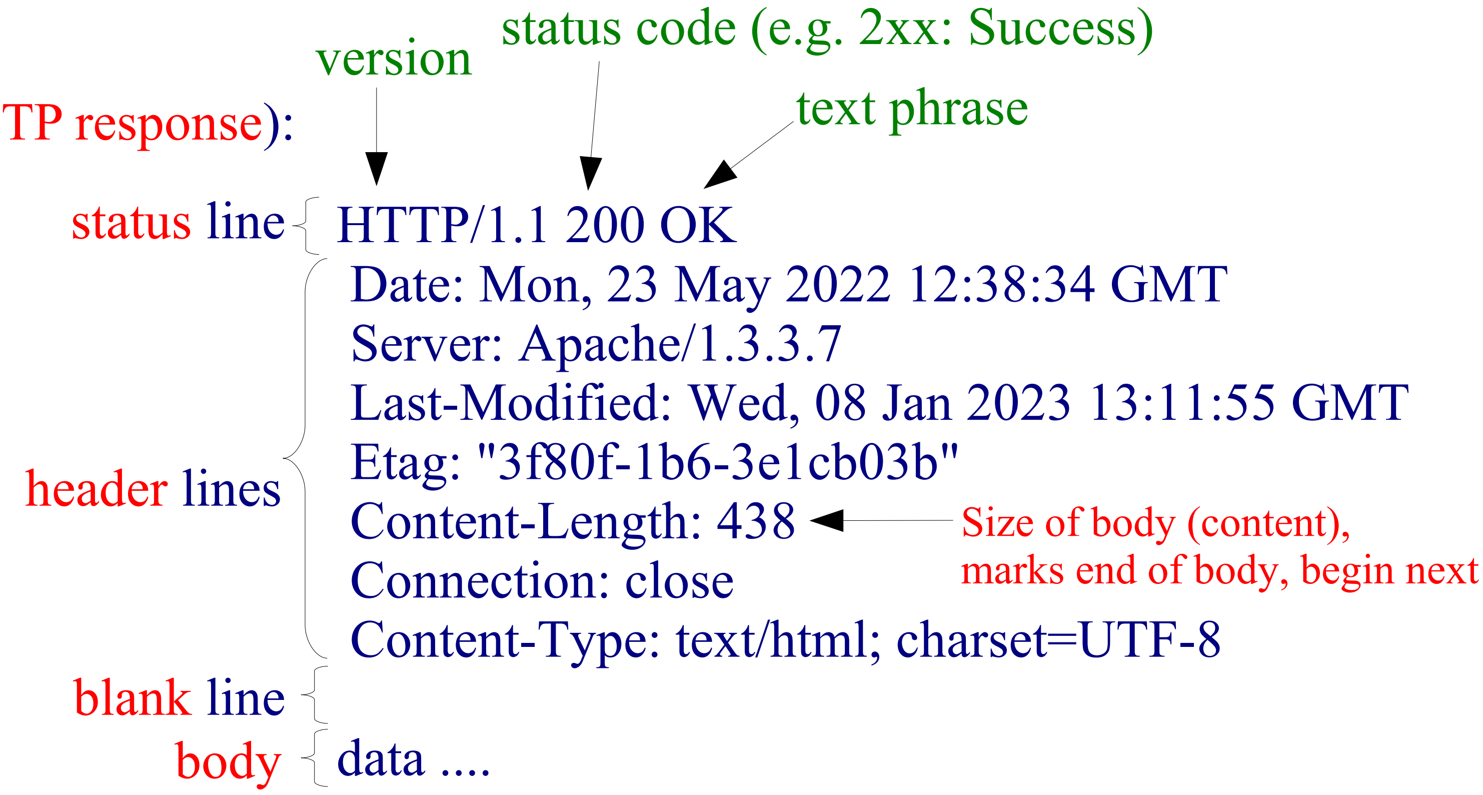
- POST uses MIME types: application/octet-stream, to send raw binary data, and application/x-www-form-urlencoded, to send name-value pairs. Example:

| | |
|---|---|
| request line | POST /login.jsp HTTP/1.1 |
| header lines | Host: www.mysite.com<br>User-Agent: Mozilla/4.0<br>Content-Length: 27 ← Size of body (content), marks end of the body<br>Content-Type: application/x-www-form-urlencoded |
| blank line | |
| body | userid=llorenc&password=mypassword |

# Unit 5. Network applications

## Web – HTTP Messages, RFC2616

- Server (HTTP response):



version

status code (e.g. 2xx: Success)

text phrase

status line

```
HTTP/1.1 200 OK
```

header lines

```
Date: Mon, 23 May 2022 12:38:34 GMT
Server: Apache/1.3.3.7
Last-Modified: Wed, 08 Jan 2023 13:11:55 GMT
Etag: "3f80f-1b6-3e1cb03b"
Content-Length: 438
Connection: close
Content-Type: text/html; charset=UTF-8
```

Size of body (content), marks end of body, begin next

blank line

body

```
data ....
```

# Unit 5. Network applications

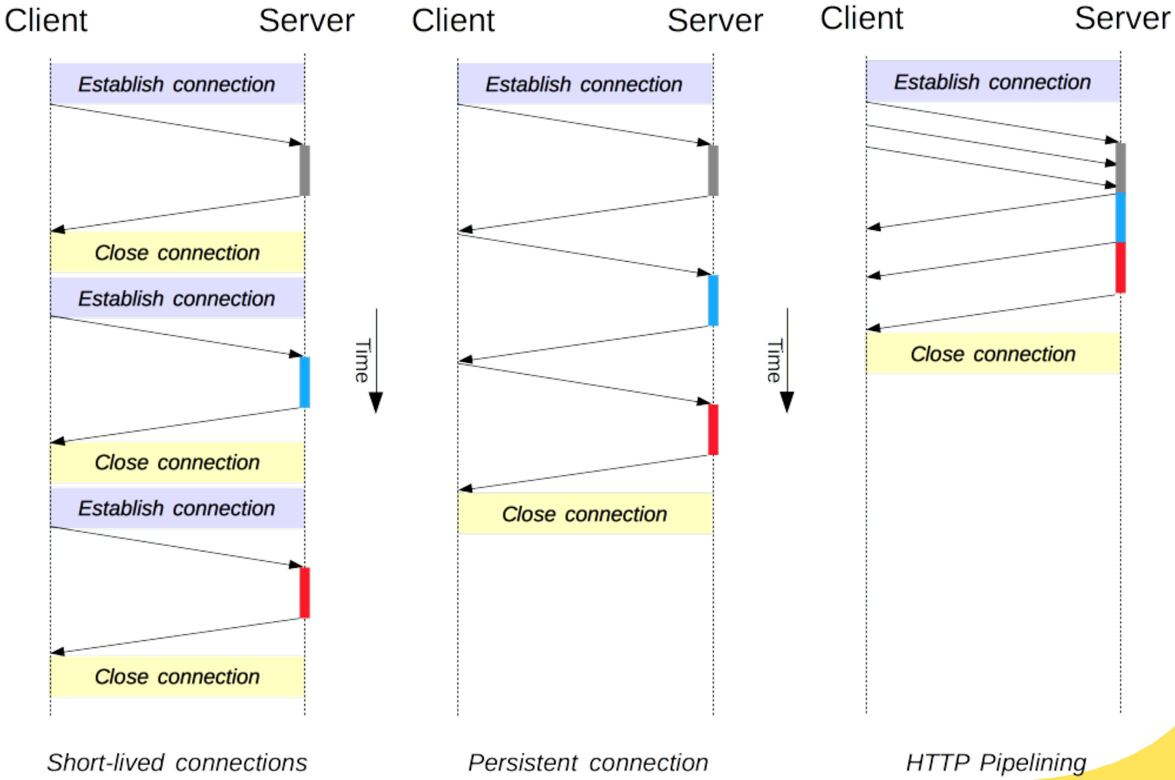
## Web – HTTP Messages, RFC 9110

- Header
  - Last-Modified: date, a timestamp indicating the date and time at which the origin server believes the selected representation was last modified, useful in conditional GET requests.
  - Etag: unique id, used in conditional retrieval.
  - Connection: keep-alive/close, controls whether or not the network connection stays open after the current transaction.
  - Accept: <MIME_type>/<MIME_subtype>, acceptable MIME types.
  - Date: date when message originated.
  - Expires: Date when the page content expires
  - Max-age: maximum seconds to keep in cache
  - Content-Language: list of preferred languages for the user. Allows content negotiation: the server sends best language when choice.
  - Connection: close (when client or server want to close)
  - ...

# Unit 5. Network applications

## Web – Persistent connections with pipelining

- Non persistent (default in HTTP/1.0): The server closes the TCP connection after every object.
- HTTP 1.1:
  - Persistent: The server maintains the TCP connection open until an inactivity time. All page objects will be sent over the same TCP connection.
  - Pipelining: The client can issue new requests as it finds new object references, even if previous objects not fully downloaded.



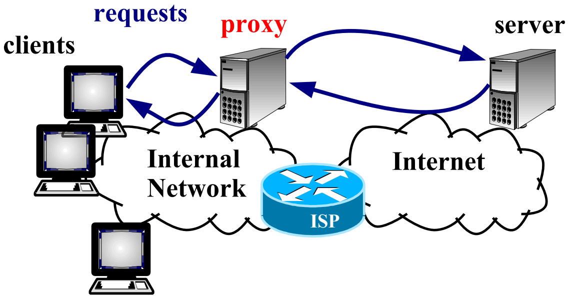
# Unit 5. Network applications

## Web – Caching and Intermediaries RFC 9111

- Caching: The client stores downloaded pages in a local (browser) cache. Conditional GET requests are used to download pages if necessary. It can use the Date and/or Etag:

```
GET /index.html HTTP/1.1
Host: www.example.com
If-Modified-Since: October 21, 2022 4:57 PM
If-None-Match: "686897696a7c876b7e"
```

- Intermediaries: Proxy: near & selected by client. Gateway (reverse proxy): near server to shed load.
- Advantages**:**
    - Security filtering (the proxy may reject access to unauthorized servers)
    - Logging
    - Caching
    - Save public IP addresses (only the proxy needs Internet access)
- Disadvantages**:**
    - “Man in the middle”
    - Not useful for HTTPS (end-to-end encrypted) content



# Unit 5. Network applications

## Web – web based applications

- Components:
  - Presentation: A web browser (client side).
  - Engine generating “on the fly” HTML pages (server side).
  - Storage: a database (e.g. mysql).

- Benefits:
  - Fast to deploy and upgrade (only server side).
  - Only a compatible browser is required at the client side.
  - Provide cross-platform compatibility (i.e., Windows, Mac, Linux, etc.)

# Unit 5. Network applications

## Outline

- DNS
- Email
- Web
- **Charsets**
- HTML

# Languages, cultures, alphabets

- >8 billion people (2023)

  19% English, 14% Mandarin chinese … 6% Spanish, 0,1% Catalan
- Apart from languages, there are cultures and alphabets
  - Language with several cultures: es_ES, es_CO ("locale")
  - Alphabet shared by several languages (e.g. català, français)
- Culture:
  - Messages, character sets, transliteration, ordering, search in strings, hours and dates, numbers and currency, pronunciation, …
- Interaction between agents in different languages and cultures: alphabets and character sets

# Languages, cultures, alphabets

Internationalization (i18n), Localization (l10n)

Alphabets

- "base": ascii
- National: e.g.: latin-1 (includes ascii), kanji
- International: e.g.: Unicode (includes latin-1 and “all” languages)

Expression or language negotiation (in HTTP):

**Accept-Language**: es, ca, en-gb, en
**Accept-Charset**: iso-8859-1, unicode-15-0
. . .

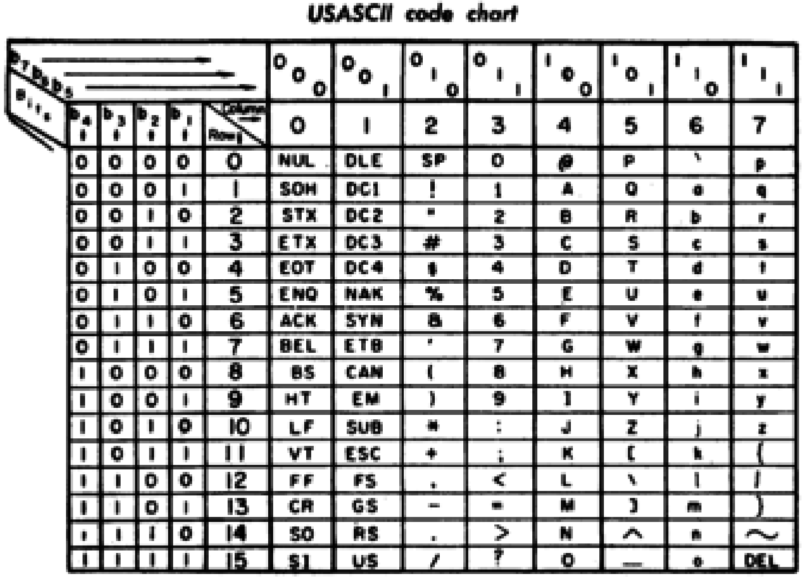
**Content-Language**: ca
**Content-Type**: text/html; charset=utf-8
. . .

English is the default …

# Character sets

Characters are encoded following several conventions:

- **repertoire**: a set of characters (name and representation (glyph))
- **code**: correspondence between repertoire and natural numbers.
- **encoding**: method (algorithm) to convert code numbers into a sequence of octets (> 256 characters)
- US-ASCII: 95 characters + control=128: 7 bits (1 octet/byte sent)



USASCII code chart

| b7 b6 b5 |  |  |  |  | 0 0 0 | 0 0 1 | 0 1 0 | 0 1 1 | 1 0 0 | 1 0 1 | 1 1 0 | 1 1 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| b4 | b3 | b2 | b1 | Row / Column | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 0 | 0 | 0 | 0 | 0 | NUL | DLE | SP | 0 | @ | P | ` | p |
| 0 | 0 | 0 | 1 | 1 | SOH | DC1 | ! | 1 | A | Q | a | q |
| 0 | 0 | 1 | 0 | 2 | STX | DC2 | " | 2 | B | R | b | r |
| 0 | 0 | 1 | 1 | 3 | ETX | DC3 | # | 3 | C | S | c | s |
| 0 | 1 | 0 | 0 | 4 | EOT | DC4 | $ | 4 | D | T | d | t |
| 0 | 1 | 0 | 1 | 5 | ENQ | NAK | % | 5 | E | U | e | u |
| 0 | 1 | 1 | 0 | 6 | ACK | SYN | & | 6 | F | V | f | v |
| 0 | 1 | 1 | 1 | 7 | BEL | ETB | ' | 7 | G | W | g | w |
| 1 | 0 | 0 | 0 | 8 | BS | CAN | ( | 8 | H | X | h | x |
| 1 | 0 | 0 | 1 | 9 | HT | EM | ) | 9 | I | Y | i | y |
| 1 | 0 | 1 | 0 | 10 | LF | SUB | * | : | J | Z | j | z |
| 1 | 0 | 1 | 1 | 11 | VT | ESC | + | ; | K | [ | k | { |
| 1 | 1 | 0 | 0 | 12 | FF | FS | , | < | L | \ | l | \| |
| 1 | 1 | 0 | 1 | 13 | CR | GS | - | = | M | ] | m | } |
| 1 | 1 | 1 | 0 | 14 | SO | RS | . | > | N | ^ | n | ~ |
| 1 | 1 | 1 | 1 | 15 | SI | US | / | ? | O | _ | o | DEL |

# ISO 8859

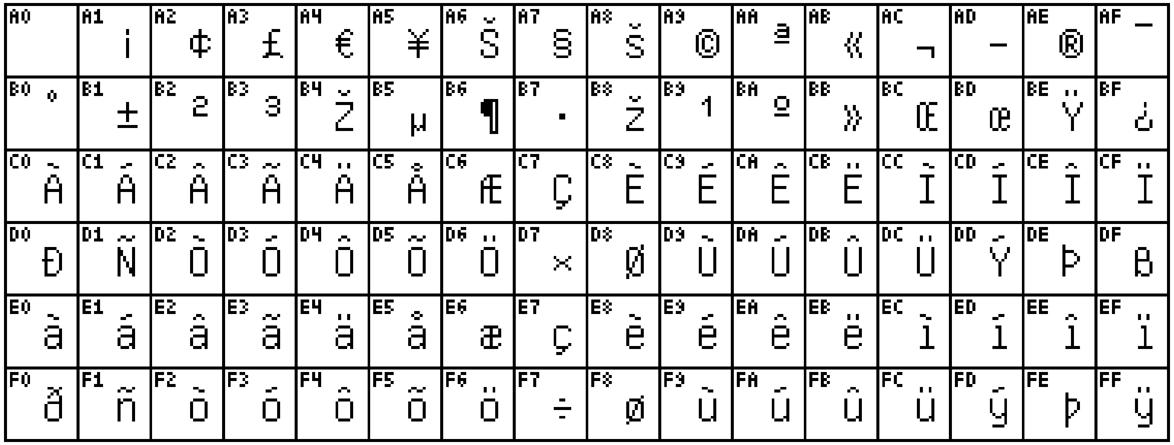
- ISO 8859-1 (ISO Latin 1): 190 + control = 256: 1 octet Western European, default for HTTP
- More variants

ISO 8859-15 extends -1 + Ÿ, €

ISO 8859-2 (Central European)

ISO 8859-4 (North European)

ISO 8859-5 (Cyrillic)



| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A0 | A1 ¡ | A2 ¢ | A3 £ | A4 € | A5 ¥ | A6 Š | A7 § | A8 š | A9 © | AA ª | AB « | AC ¬ | AD - | AE ® | AF ¯ |
| B0 ° | B1 ± | B2 ² | B3 ³ | B4 Ž | B5 µ | B6 ¶ | B7 · | B8 ž | B9 ¹ | BA º | BB » | BC Œ | BD œ | BE Ÿ | BF ¿ |
| C0 À | C1 Á | C2 Â | C3 Ã | C4 Ä | C5 Å | C6 Æ | C7 Ç | C8 È | C9 É | CA Ê | CB Ë | CC Ì | CD Í | CE Î | CF Ï |
| D0 Ð | D1 Ñ | D2 Ò | D3 Ó | D4 Ô | D5 Õ | D6 Ö | D7 × | D8 Ø | D9 Ù | DA Ú | DB Û | DC Ü | DD Ý | DE Þ | DF ß |
| E0 à | E1 á | E2 â | E3 ã | E4 ä | E5 å | E6 æ | E7 ç | E8 è | E9 é | EA ê | EB ë | EC ì | ED í | EE î | EF ï |
| F0 ð | F1 ñ | F2 ò | F3 ó | F4 ô | F5 õ | F6 ö | F7 ÷ | F8 ø | F9 ù | FA ú | FB û | FC ü | FD ý | FE þ | FF ÿ |

ISO 8859-6 (Arabic) — Most common Arabic glyphs

ISO 8859-7 (Greek)

ISO 8859-8 (Hebrew) — modern Hebrew.

ISO 8859-9 (Turkish, Kurdish)

ISO 8859-11 (Thai) — Contains most glyphs needed

# Universal Coded Character Set
# Unicode

All characters from all written languages + math + emoji + +=Universal Character set (UCS)

Encoding: UCS-4 bytes (fixed length)

Proportional spacing, language independent

Unicode consortium: synchronized with ISO,

- Unicode 15.1.0 (9/2023): 149,813 symbols 🤣 🥘
- U+hex code: U+0020 = ' '

Character Encodings: Universal Transformation Format (UTF)

- Difficulty or impossibility to transport 8 o 16 bits data in protocols:
- **UTF-8**, UTF-16, UTF-32 (variable length)

http://www.unicode.org

# Variable length encodings

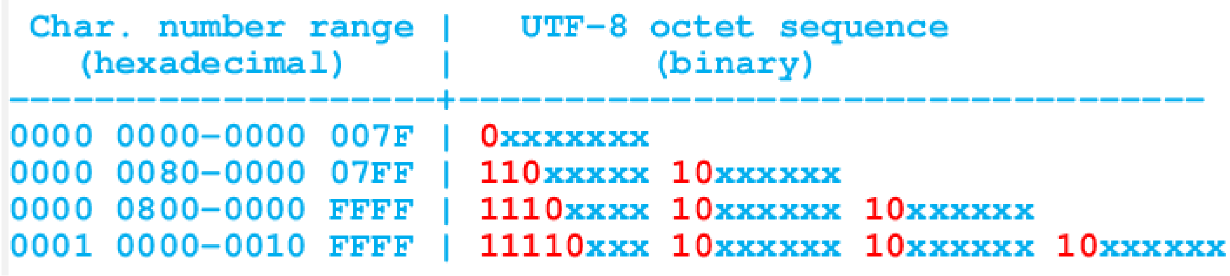
- UTF-8 (8 bits) (RFC 2044): variable length (1-4 bytes per character)
  - One to four 8-bit code units
  - Most common in the Internet

```
Content-Type: text/plain; charset=UTF-8

Content-Transfer-Encoding: 8bit

CatalÃ , FranÃ§ais.
```

- UTF-16 (16 bits)
  - One or two 16-bit code units
- UTF-32 (32 bits)
  - Fixed-length 32-bit code units

# Universal Coded Character Set
# Unicode

- **UTF-8 Encoding**
  - Determine high-order bits from the number of bytes
  - Fill in the bits marked x



```
 Char. number range  |    UTF-8 octet sequence
    (hexadecimal)    |          (binary)
---------------------+---------------------------------------------
0000 0000-0000 007F | 0xxxxxxx
0000 0080-0000 07FF | 110xxxxx 10xxxxxx
0000 0800-0000 FFFF | 1110xxxx 10xxxxxx 10xxxxxx
0001 0000-0010 FFFF | 11110xxx 10xxxxxx 10xxxxxx 10xxxxxx
```

- Example
  - character: €
  - code point: U+20AC
  - code point in binary (14 bits): 10 0000 1010 1100
  - 3 code units required:
  - UTF-8: 11100010 10000010 10101100
  - UTF-8 in hex: E282AC

# Unit 5. Network applications

## Outline

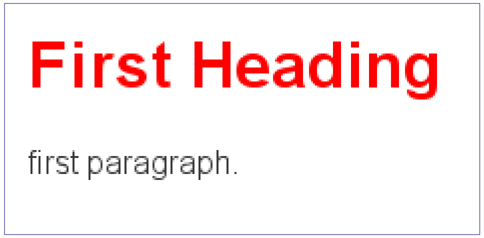
- DNS
- Email
- Web
- Charsets
- **HTML**

# Unit 5. Network applications

## HTML – Hyper-Text Markup Language

- Tim Berners-Lee defined HTML in 1989.
- HTML design mail goal was displaying formatted text documents with hyperlinks (including links to other documents) in web browsers.
- Based on tags e.g. <head> data </head>
- Example:

```
<html>
<head>
 <title>Basic html document</title>
</head>
<body>
  <h1><font color="red">First Heading</font></h1>
  <p>first paragraph.</p>
</body>
</html>
```



First Heading

first paragraph.

Terminology:

- element
- attribute
- text

# Unit 5. Network applications

## HTML – HyperText Markup Language, HTML

- HTML features (1):
  - Hyperlinks: Click on a link and jump to another document
  - Forms: The document accept user inputs that are sent to the server
  - Scripting: Allow adding programs. The program executes on the client's machine when the document loads, or at some other time such as when a link is activated.

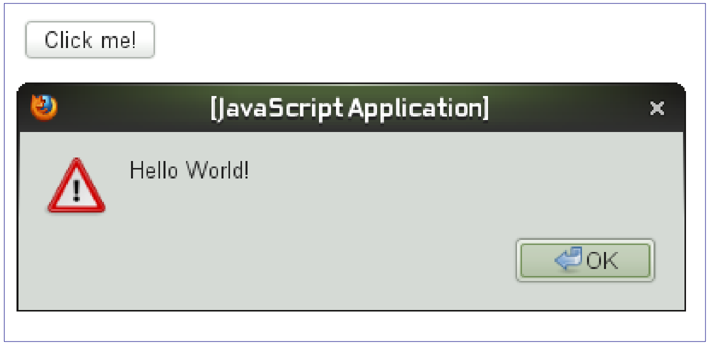
  - Hyperlinks
    - <a> tag defines an hyperlink
    - Syntax: <a href="url">link text</a>
    - Example: <a href="https://studies.ac.upc.edu/FIB/grau/XC/">XC</a>
  - Embedded images:
    - <img> tag links to an image to be included by value on the page
    - Syntax: <img src="url">

# Unit 5. Network applications

## HTML – Hyper-Text Markup Language, HTML

- HTML features (2):
  - javascript example:

```
<html>
<head>
<script type="text/javascript">
 function displaymessage() {
   alert("Hello World!");
 }
</script>
</head>
<body>
 <form>
  <input type="button"
   value="Click me!" onclick="displaymessage()" />
 </form>
</body>
</html>
```



Hello World!