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**

These slides are based on the set of slides provided by Llorenç Cerdà, Leandro Navarro and Jaime Delgado for this course.
They include some modifications and some new slides.

Outline

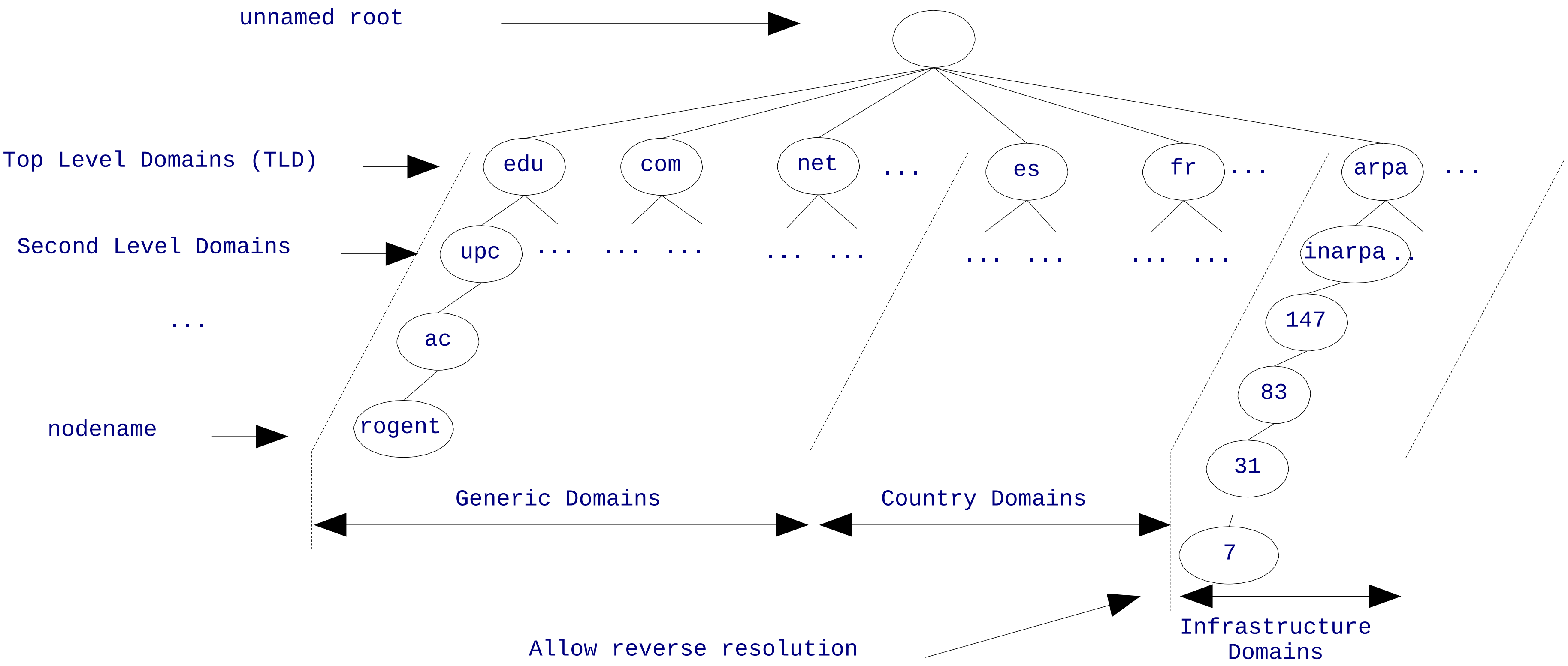
- **DNS**
- Charsets
- Email
- Web
- HTML & XML

Domain Name System DNS (RFC 1034, 1035, Y1987)

- 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).

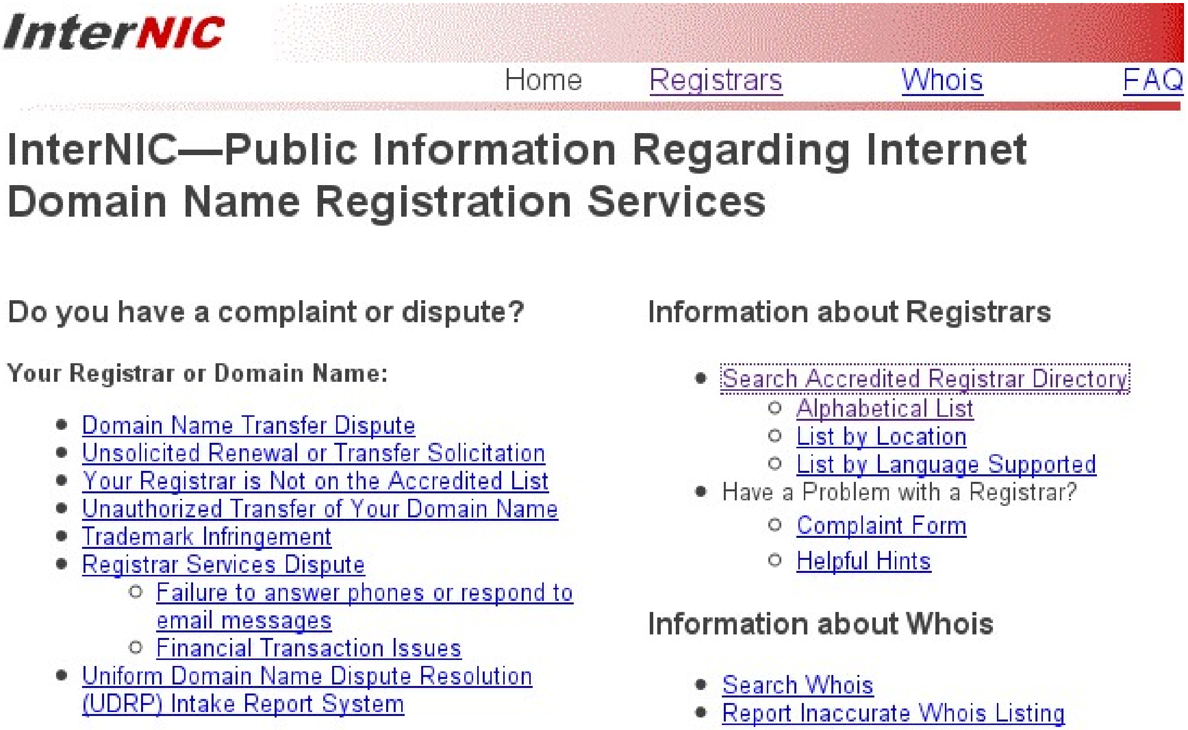
DNS – Domain Hierarchy

- DNS data base is organized in a tree:



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—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

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.

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:

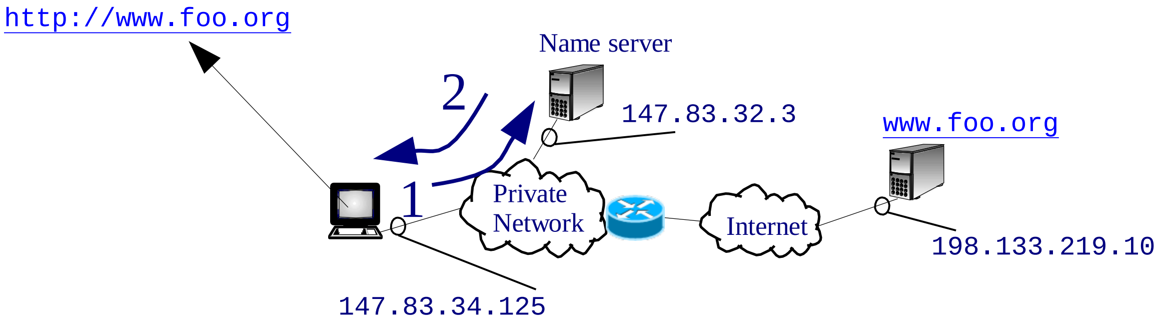
```
# hosts         This file describes a number of hostnametoaddress
#               mappings for the TCP/IP subsystem.  It is mostly
#               used at boot time, when no name servers are running.
#               On small systems, this file can be used instead of a
#               "named" name server.
# Syntax:
# IPAddress   FullQualifiedHostname    ShortHostname
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
```

DNS - Protocol

- Client-server paradigm
- UDP/TCP. Short messages use 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)
```

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

DNS – Unix example: zone file

```
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
…
```

The domain name

The domain NS

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

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)...

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
```

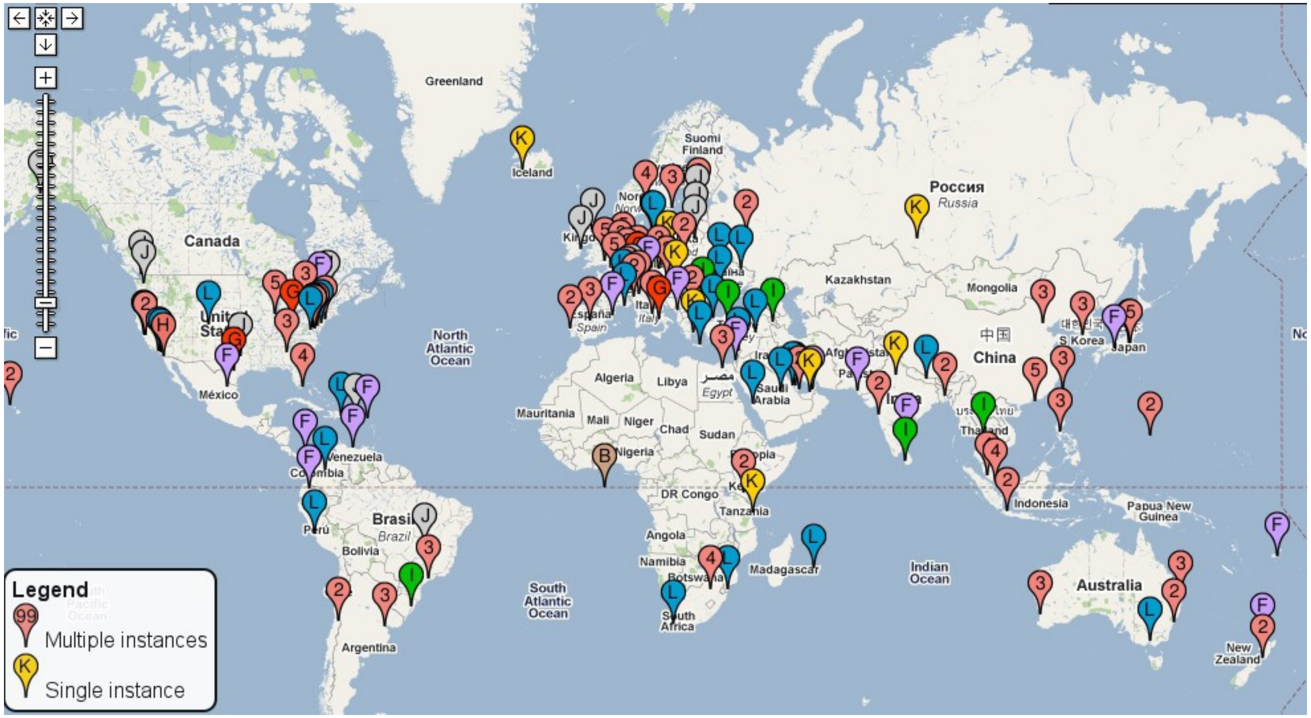
comments

Resource Records (RR)
pointing to root-servers

address of a name
NS name

DNS – Data Base Organization

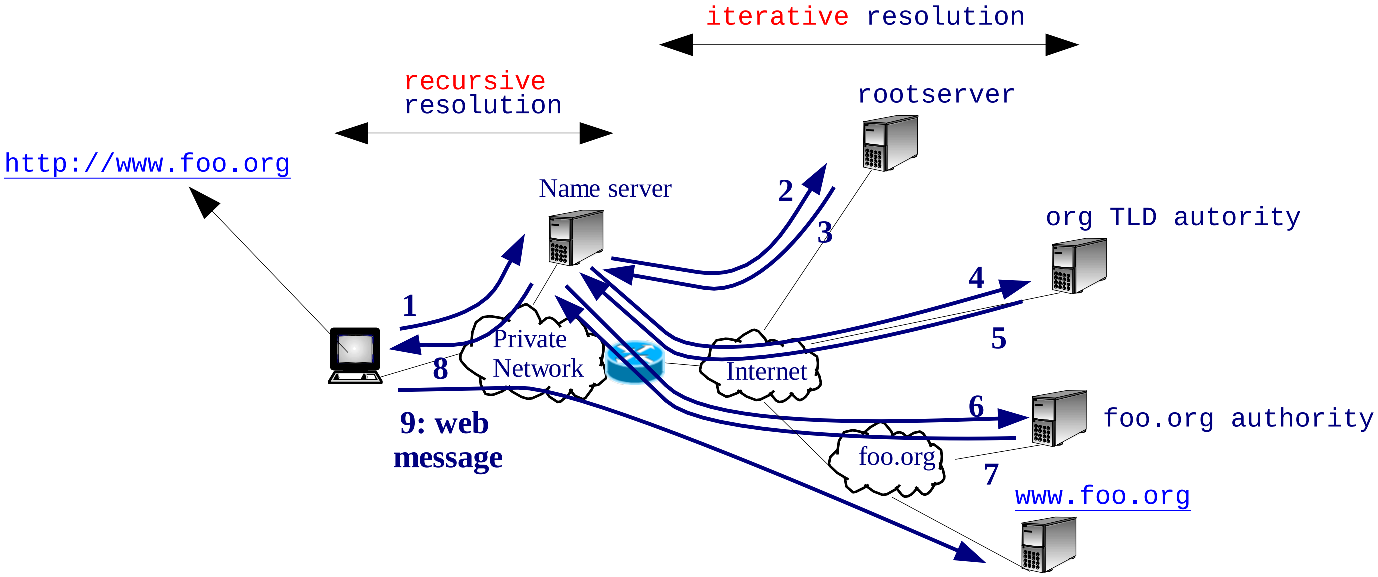
- Root Servers are the entry point to the domain hierarchy.
- Root Servers are distributed around the world and have the TLD addresses: http://www.root-servers.org
- Root server addresses are needed in a NS configuration.



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

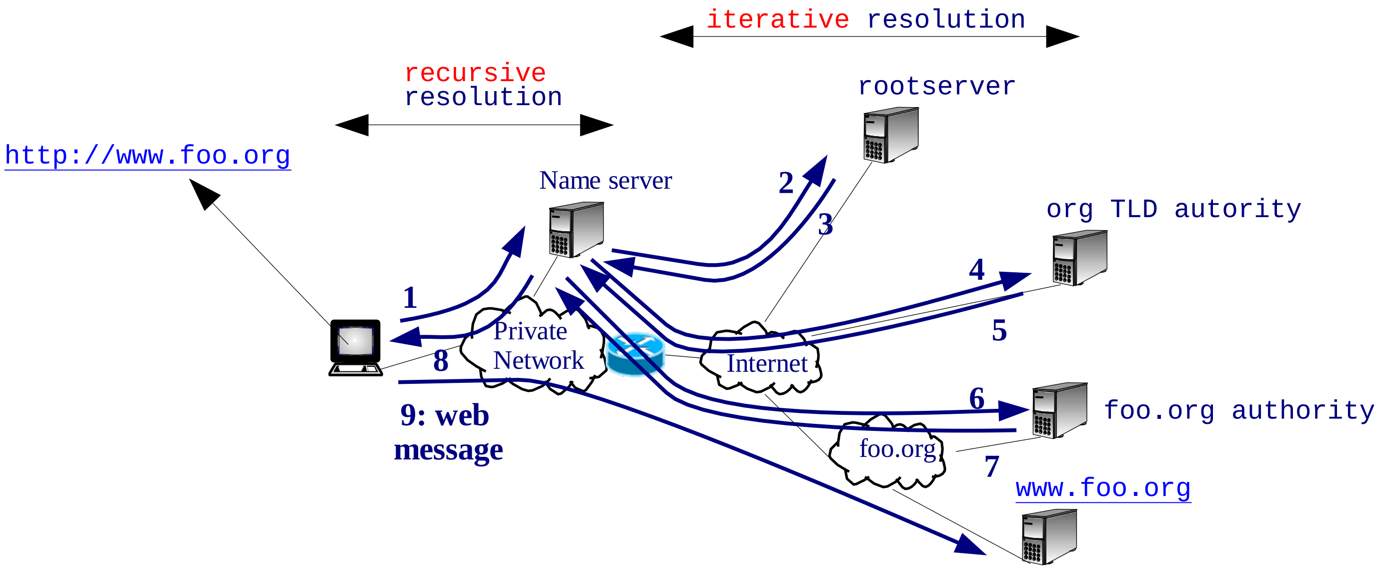
DNS – Resolution

- NSs cache name resolutions.
- A cached RR is returned without looking for in the NS authority.



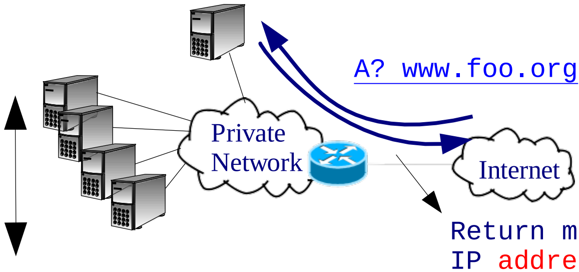
DNS – Resolution

- 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).



DNS – Load balancing, example

foo.org authority



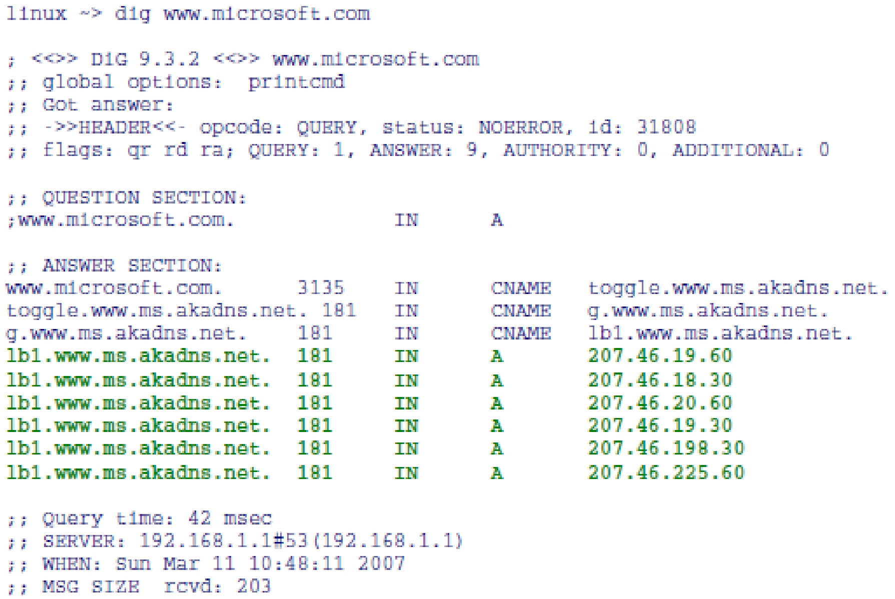
A? www.foo.org

www.foo.org

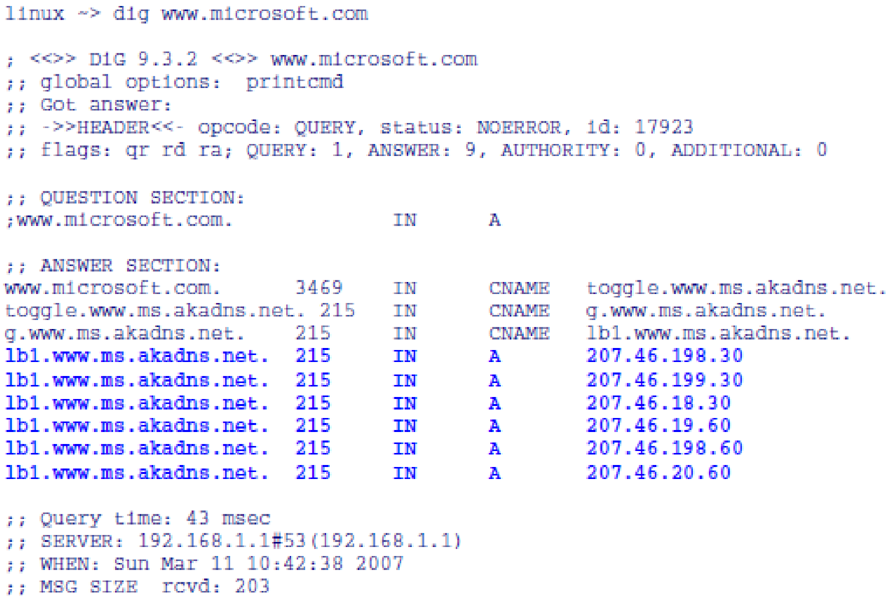
Mirrored
web
servers

Return mirrored web servers
IP addresses in round robin.

- Example using dig:

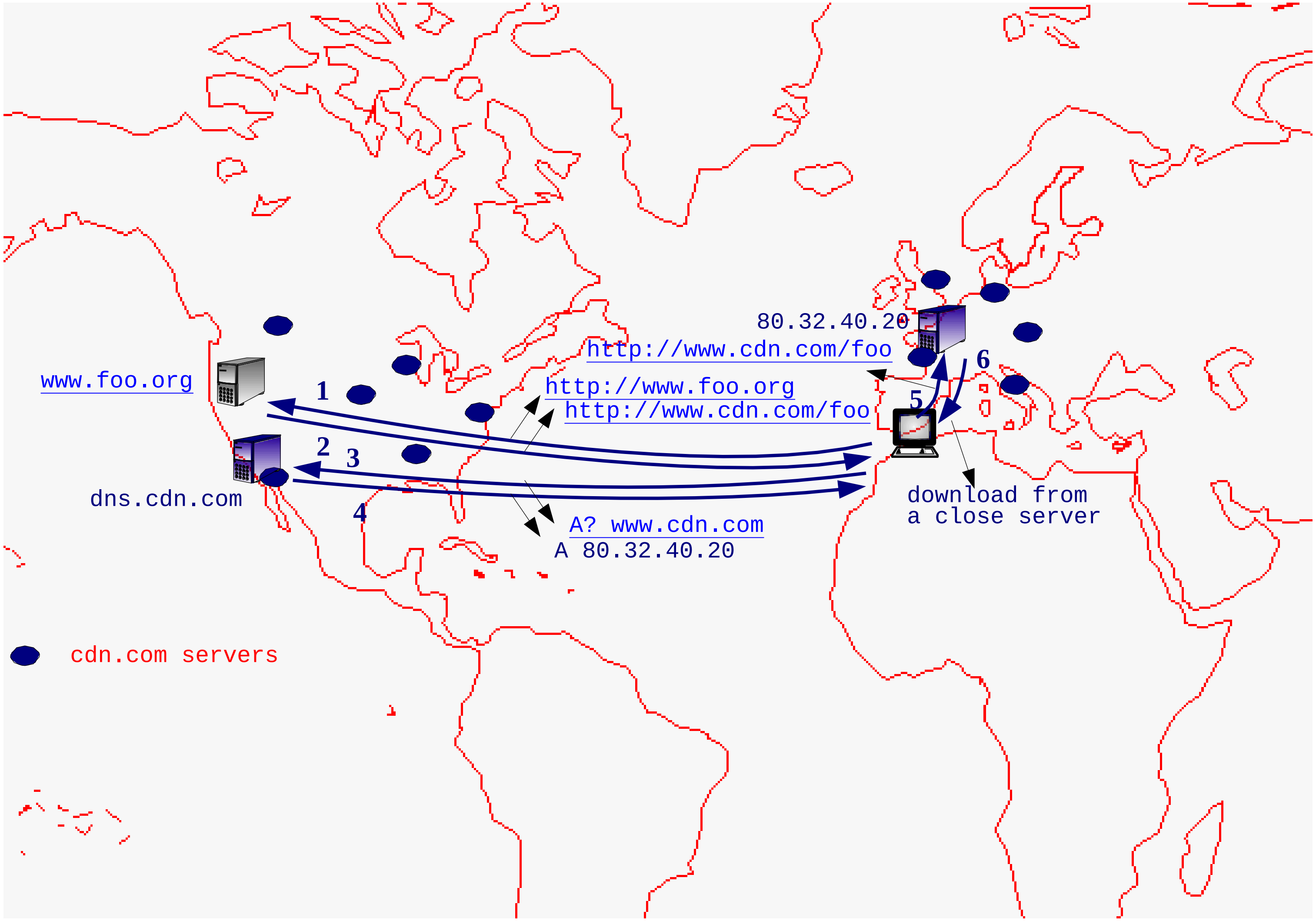


```
linux ~> dig www.microsoft.com

; <<>> 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
```

DNS - Content Distribution Networks, example



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)             /
-------------------------------------------------
```

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              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

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`

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)         /
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

DNS – Messages: Example

```
# tcpdump s1500 vvpni eth0 port 53
tcpdump: listening on eth0, linktype 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.**
- **+: RecursionDesired 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).**

Outline

- DNS
- **Charsets**
- Email
- Web
- HTML & XML

Languages, cultures, alphabets

7400 million people (2016)

22% speak Chinese, 11% English, 7% 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)

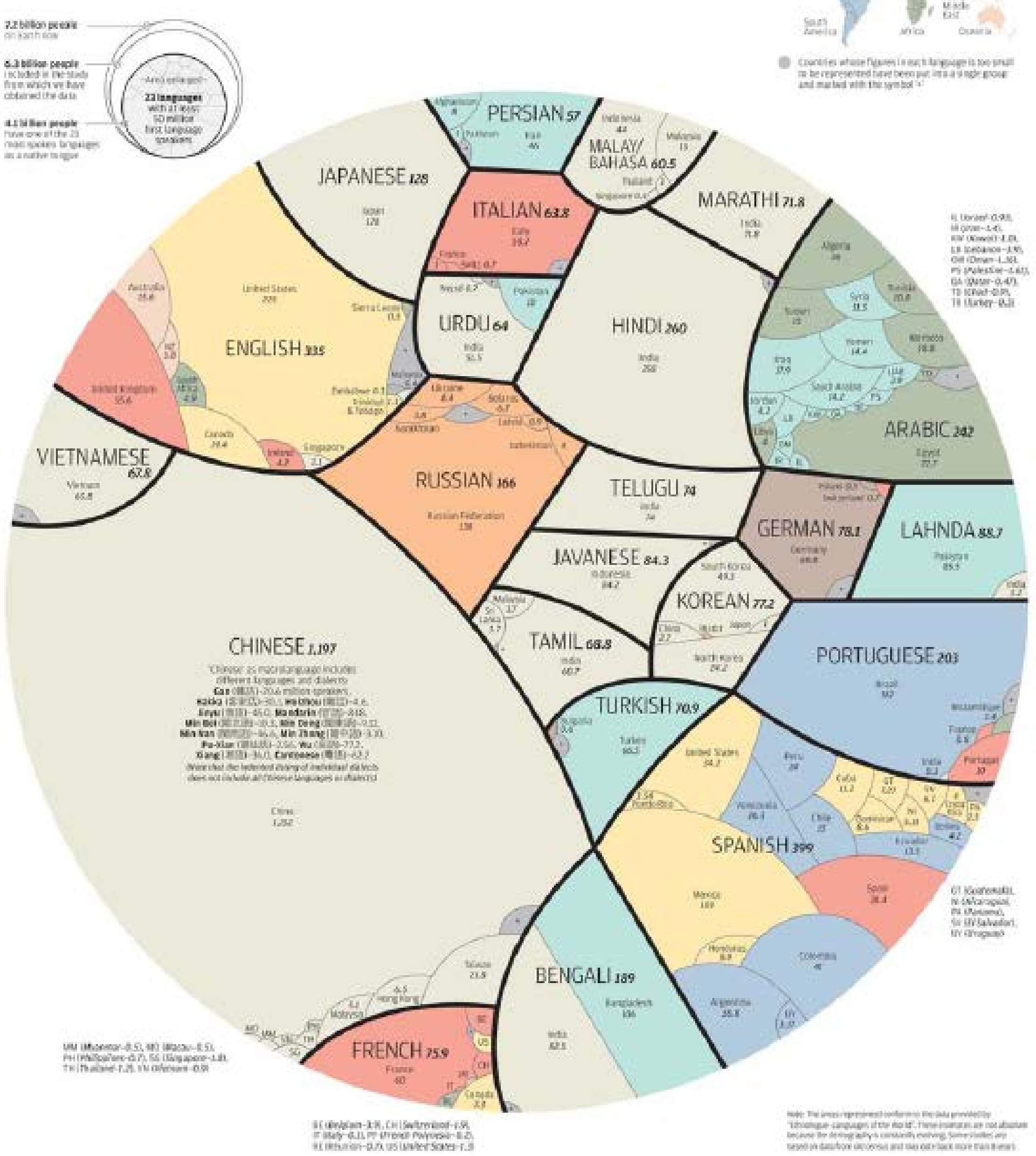
Culture:

- 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

A world of languages

There are at least 7,102 known languages alive in the world today. Twenty-three of these languages are a mother tongue for more than 50 million people. The 23 languages make up the native tongue of 4.1 billion people. We represent each language within black borders and then provide the numbers of native speakers (in millions) by country. The colour of these countries shows how languages have taken root in many different regions.



Languages, cultures, alphabets

Internacionalization (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-8859-15, unicode-9-0
. . .

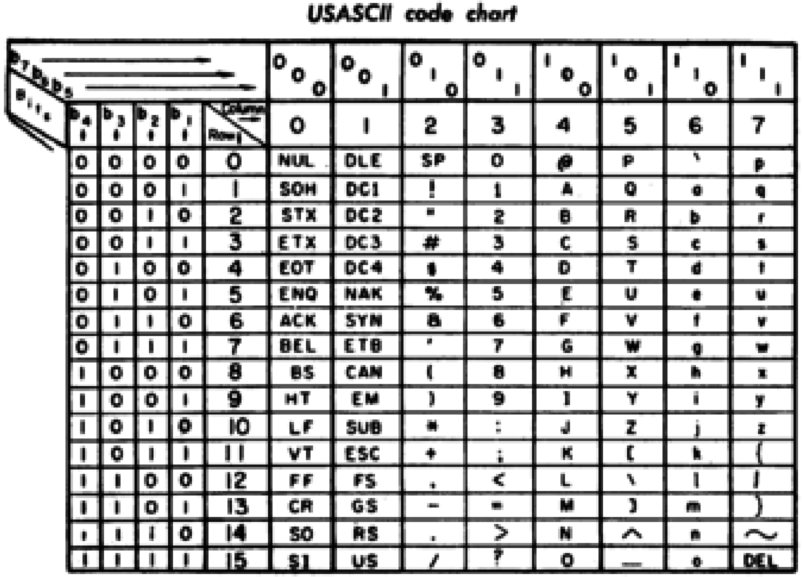
Content-Language: ca
Content-Type: text/html; charset=utf-8
. . .

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 sent)

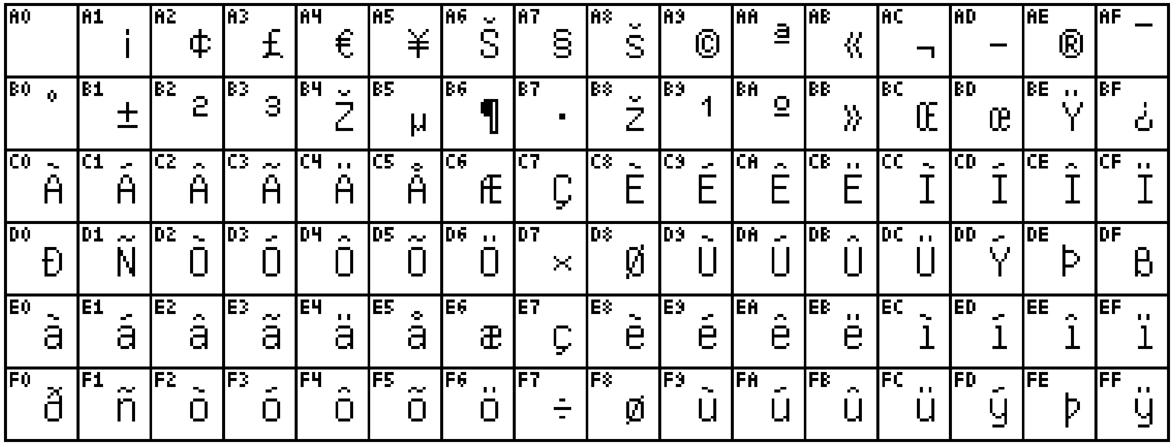


USASCII code chart

Bits				b_7 b_6 b_5	0 0 0	0 0 1	0 1 0	0 1 1	1 0 0	1 0 1	1 1 0	1 1 1
b_4	b_3	b_2	b_1	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



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

- More variants

ISO 8859-15 extends -1 + Ÿ, €

ISO 8859-2 (Central European)

ISO 8859-4 (North European)

ISO 8859-5 (Cyrillic)

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 + emoticons
= Universal Character Set (UCS)

Encoding: UCS-4 bytes (fixed length)

Proportional spacing, language independent

Unicode consortium: synchronized with ISO,

- Unicode 9.0.0 (7/2016): 128,172 symbols
- U+hex code: U+0020 = ' '

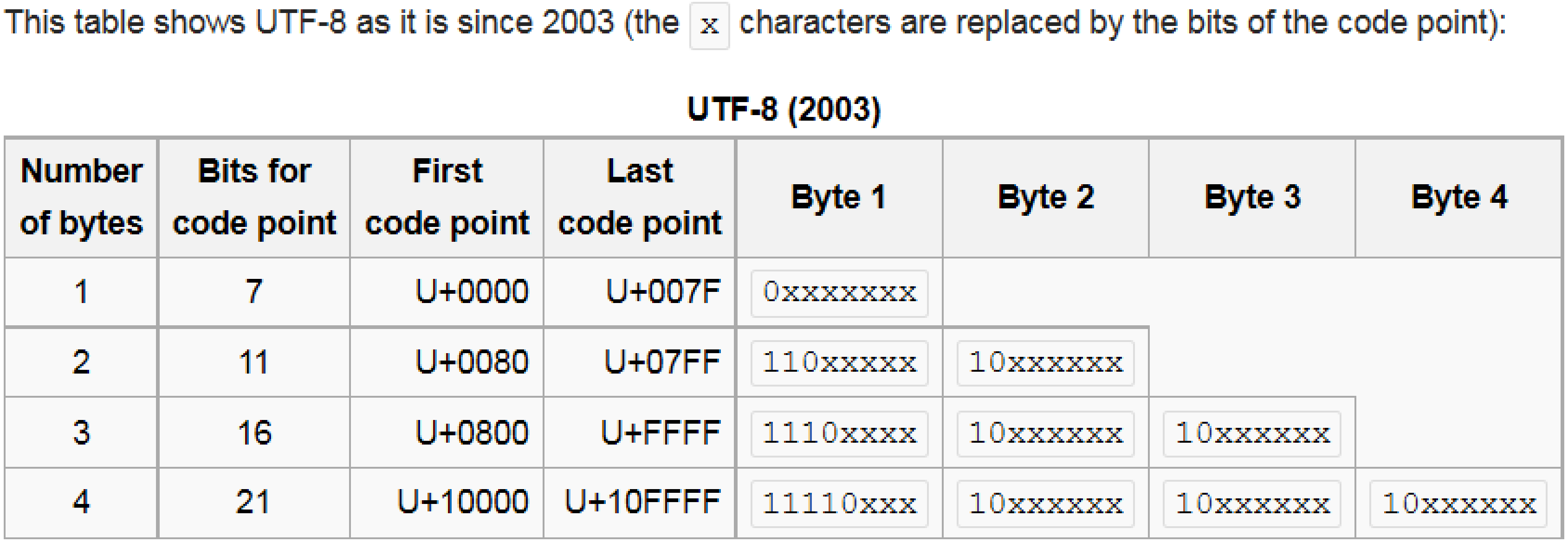
Character Encodings: Universal Transformation Format (UTF)

- Difficulty or impossibility to transport 8 o 16 bits data in Internet protocols:
- UTF-7, **UTF-8**, UTF-16, UTF-32 (variable length)

http://www.unicode.org   http://unicode-table.com

UTF-8

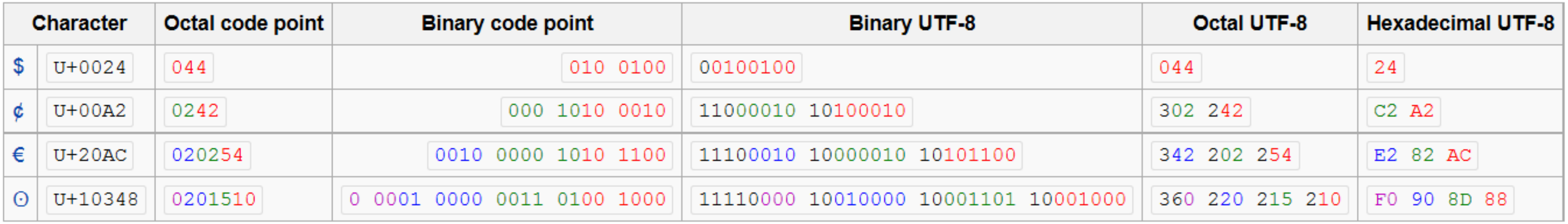
Unicode (or Universal Coded Character Set) Transformation Format – 8-bit



This table shows UTF-8 as it is since 2003 (the `x` characters are replaced by the bits of the code point):

UTF-8 (2003)

Number of bytes	Bits for code point	First code point	Last code point	Byte 1	Byte 2	Byte 3	Byte 4
1	7	U+0000	U+007F	0xxxxxxx			
2	11	U+0080	U+07FF	110xxxxx	10xxxxxx		
3	16	U+0800	U+FFFF	1110xxxx	10xxxxxx	10xxxxxx	
4	21	U+10000	U+10FFFF	11110xxx	10xxxxxx	10xxxxxx	10xxxxxx



Character		Octal code point	Binary code point	Binary UTF-8	Octal UTF-8	Hexadecimal UTF-8
$	U+0024	044	010 0100	00100100	044	24
¢	U+00A2	0242	000 1010 0010	11000010 10100010	302 242	C2 A2
€	U+20AC	020254	0010 0000 1010 1100	11100010 10000010 10101100	342 202 254	E2 82 AC
𐍈	U+10348	0201510	0 0001 0000 0011 0100 1000	11110000 10010000 10001101 10001000	360 220 215 210	F0 90 8D 88

Source: Wiquipedia

Variable length encodings

- UTF-8 (8 bits) (rfc2044)

```
ContentType:  text/plain; charset=UTF8
ContentTransferEncoding:  8bit
CatalÃ , FranÃ§ais, TÃ¤mÃ¤ on testi.
```

- UTF-7 (7 bits) (smtp …)

```
ContentType:  text/plain; charset=UTF7
ContentTransferEncoding:  7bit
Catal+AOA,   Fran+AOcais,   T+AOQm+AOQ on testi.
```

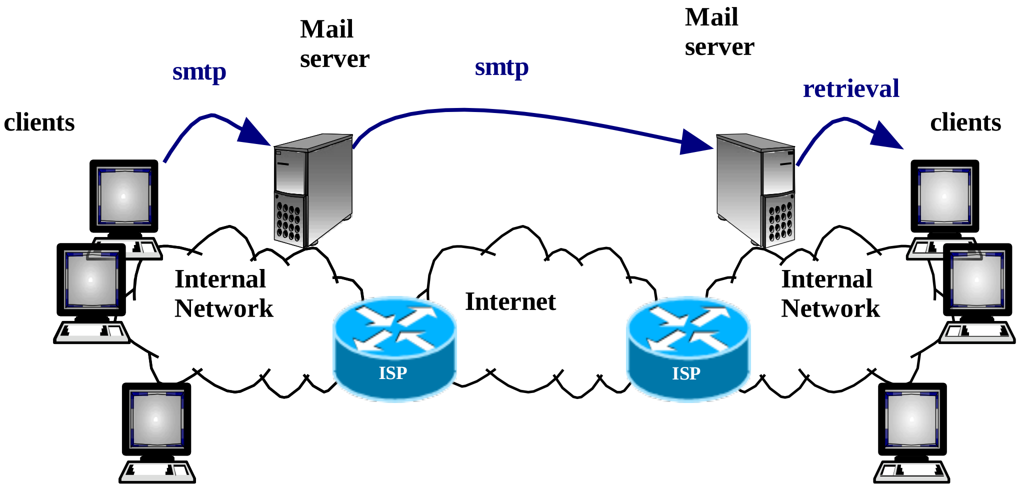
https://www.charset.org/utf8-to-latin-converter

Outline

- DNS
- Charsets
- **Email**
- Web
- HTML & XML

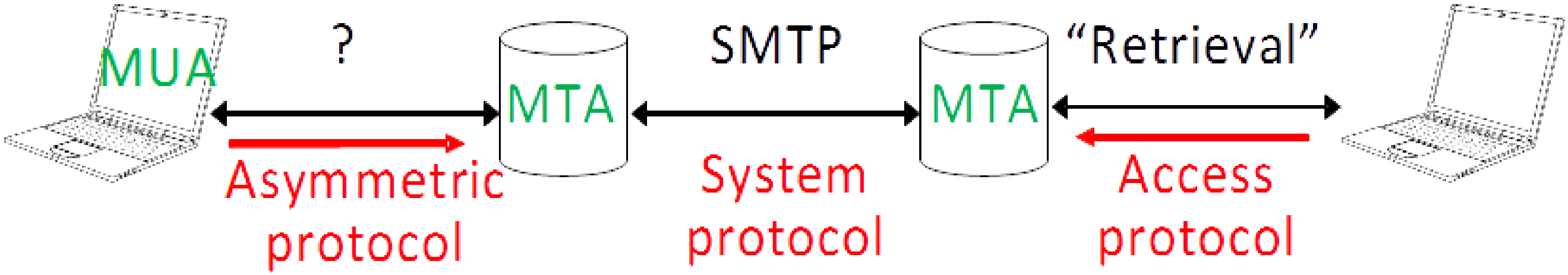
Email

- 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 (Y 1982)and last updated by RFC-5321 (Y 2008).
  - Retrieval protocols (IMAP, POP, HTTP).



Unit 5. Network applications

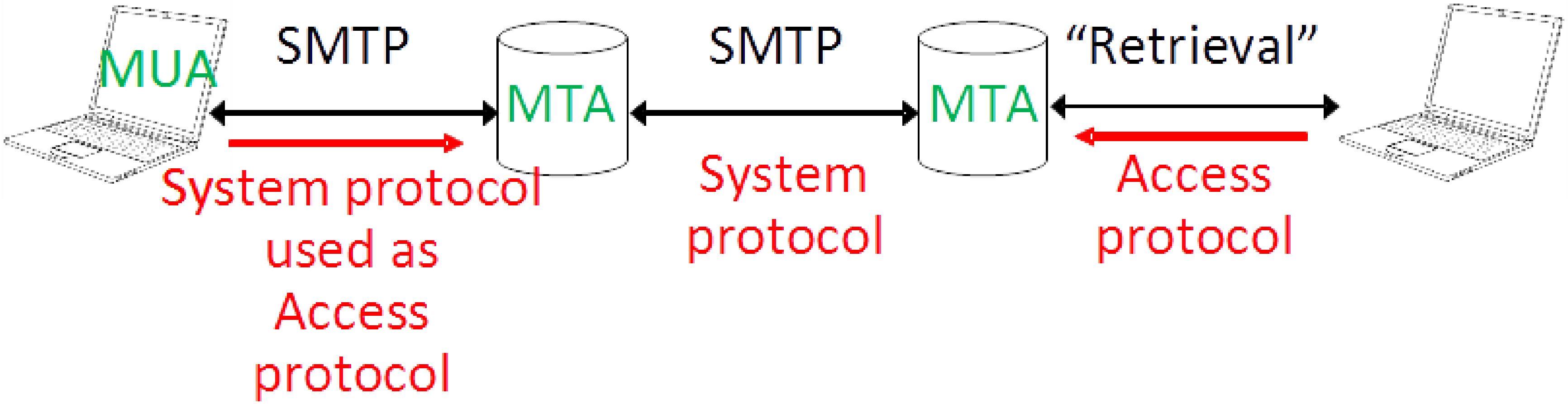
Email - Architecture



- MUA: Mail User Agent
- MTA: Mail Transfer Agent
- *SMTP: Simple Mail Transfer Protocol*

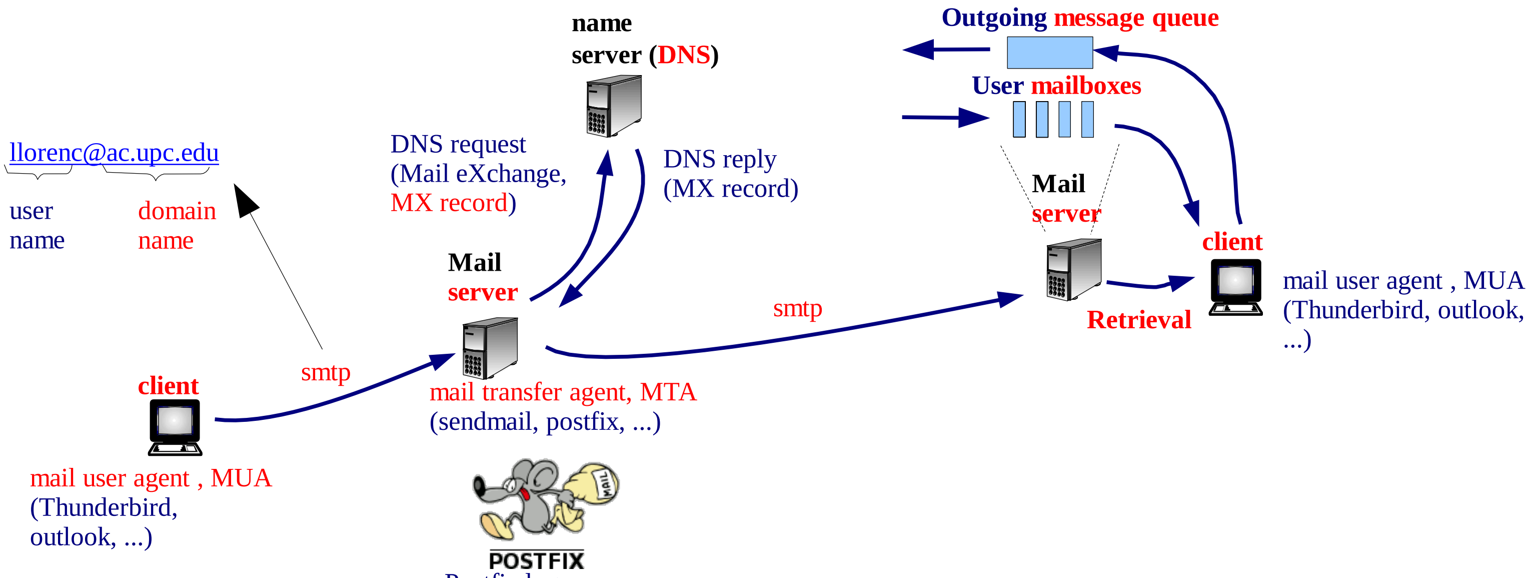
Unit 5. Network applications

Email - Protocols



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

Email - SMTP processing model



llorenc@ac.upc.edu

user name

domain name

name server (DNS)

DNS request (Mail eXchange, MX record)

DNS reply (MX record)

Outgoing message queue

User mailboxes

Mail server

client

mail user agent , MUA (Thunderbird, outlook, ...)

Retrieval

smtp

Mail server

mail transfer agent, MTA (sendmail, postfix, ...)

smtp

client

mail user agent , MUA (Thunderbird, outlook, ...)

POSTFIX

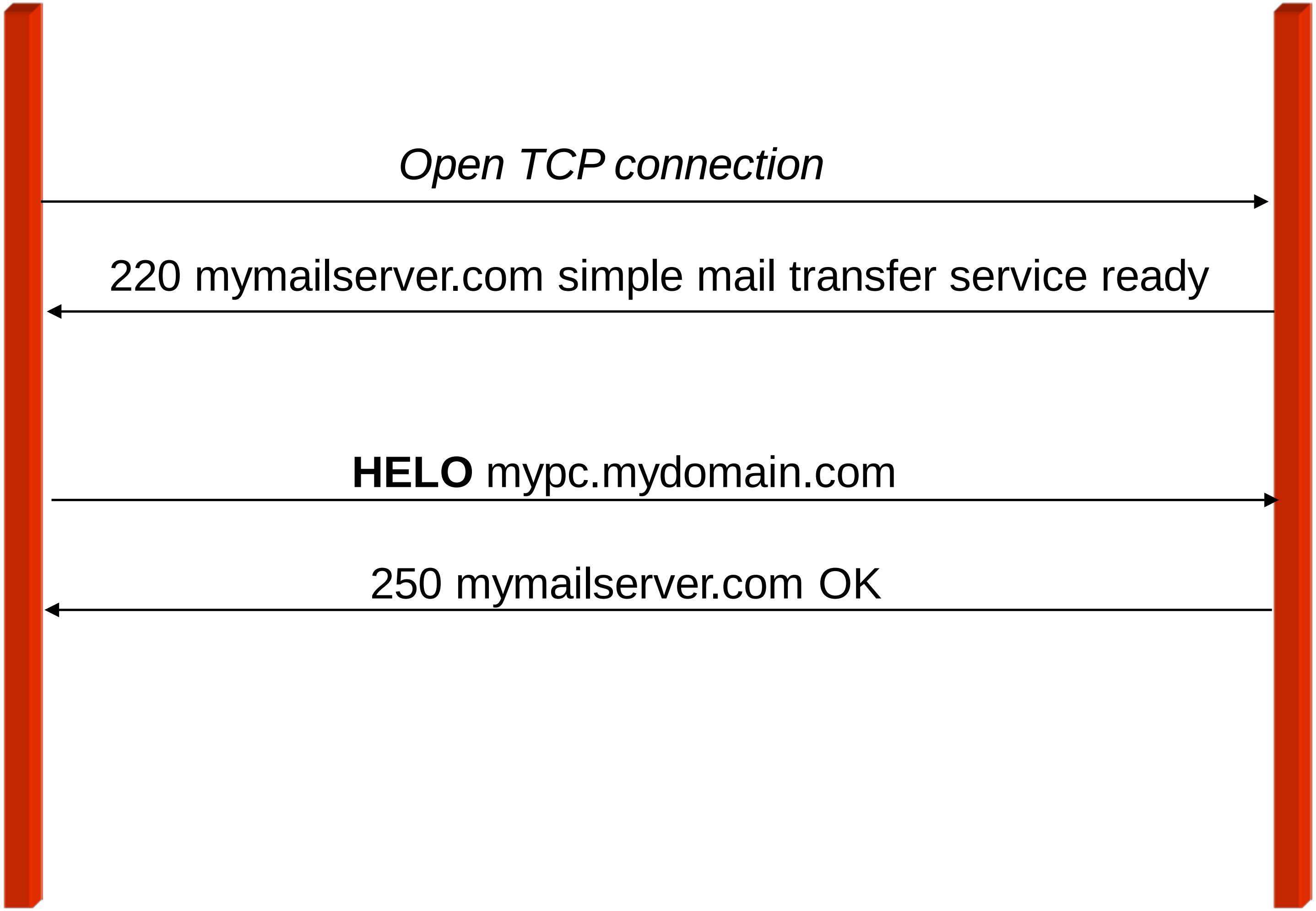
Postfix logo
http://www.postfix.org
(UNIX, free and open-source)

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.

SMTP protocol

“Connection” establishment



Sender

Receiver

Open TCP connection

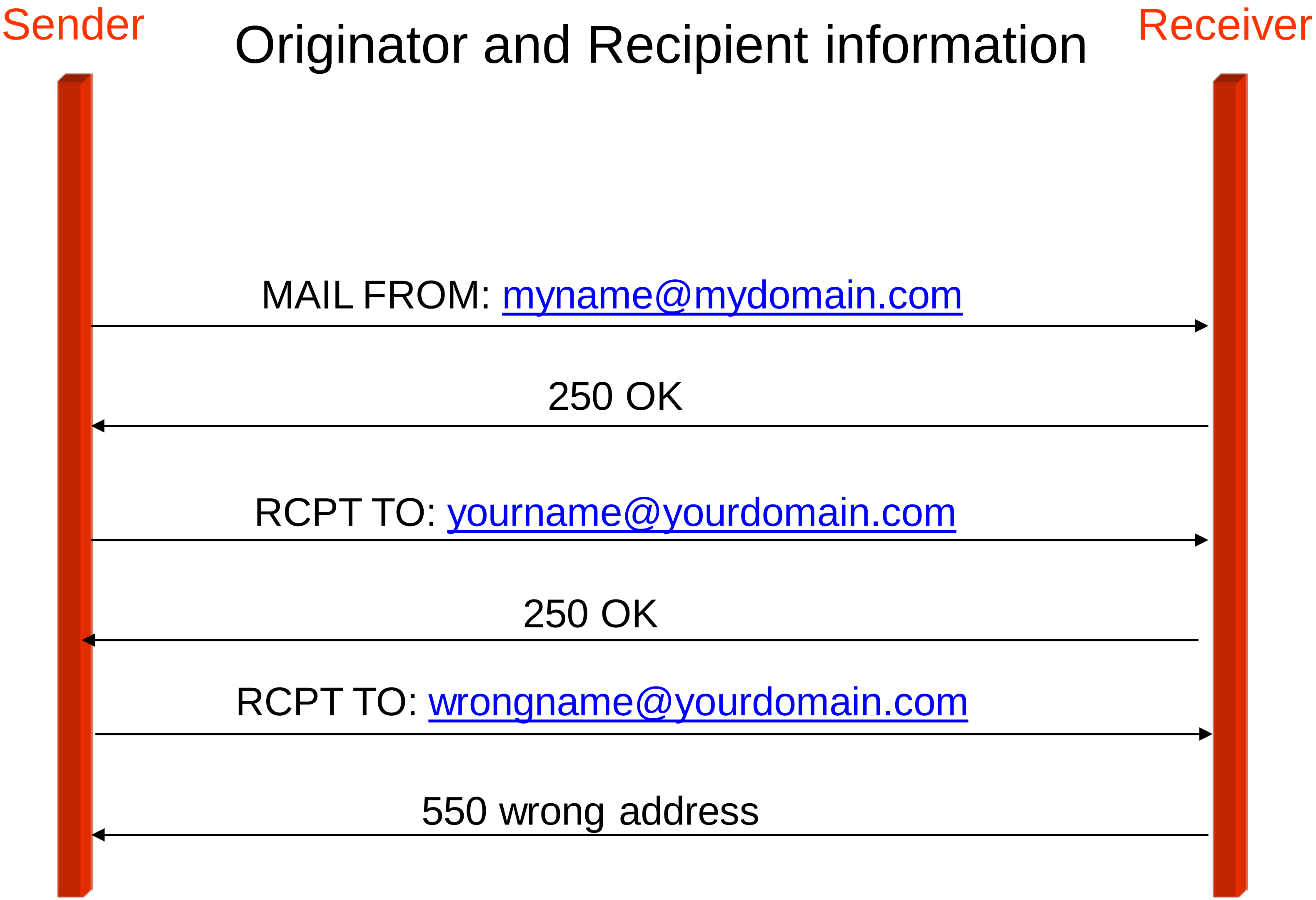
220 mymailserver.com simple mail transfer service ready

HELO mypc.mydomain.com

250 mymailserver.com OK

SMTP protocol

Originator and Recipient information



MAIL FROM: myname@mydomain.com

250 OK

RCPT TO: yourname@yourdomain.com

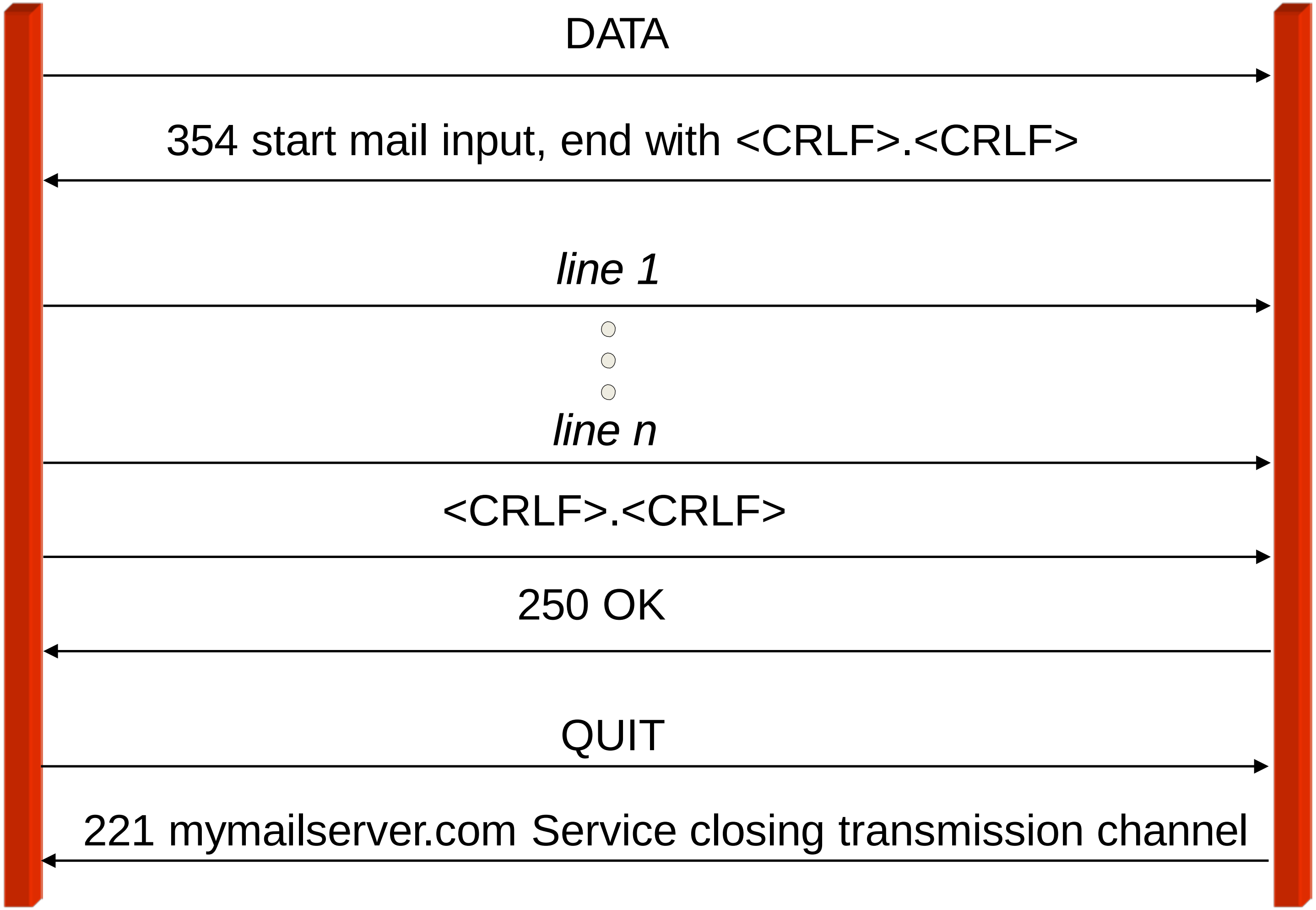
250 OK

RCPT TO: wrongname@yourdomain.com

550 wrong address

SMTP protocol

Message transmission and Close



Sender

Receiver

DATA

354 start mail input, end with <CRLF>.<CRLF>

line 1

line n

<CRLF>.<CRLF>

250 OK

QUIT

221 mymailserver.com Service closing transmission channel

Email – message formats

- Format described in RFC-822 (update RFC-5322) Internet Message Format
- Example (extracted from the RFC):

```
From: John Doe <jdoe@machine.example>
To: Mary Smith <mary@example.net>
Subject: Saying Hello
Date: Fri, 21 Nov 1997 09:55:06 0600
MessageID: <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

Empty line

Body

Email - SMTP protocol (RFC-5321, originally RFC-821)

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 Sendmail 8.14.1/8.13.1; Fri, 4 Feb 2011 14:57:15 +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.
linux ~>
```

Encrypted SMTP: port 465

Multipurpose Internet Mail Extensions: MIME

- Used in mail, web, etc.
- Specification for “Transport” of composite multimedia objects
  - Transport type information (receiver can automatically present)
  - Encoding to enable/facilitate the transfer
- The internal format becomes invisible to users
- Include one or more objects, text in diverse alphabets, large objects (fragments, refs), alternatives, etc.

MIME: examples

```
From: Nathaniel Borenstein <nsb@thumper.bellcore.com>
To: Ned Freed <ned@innosoft.com>
Subject: Plain old email

This is a plain old email message.
It contains ASCII text, nothing more.
```

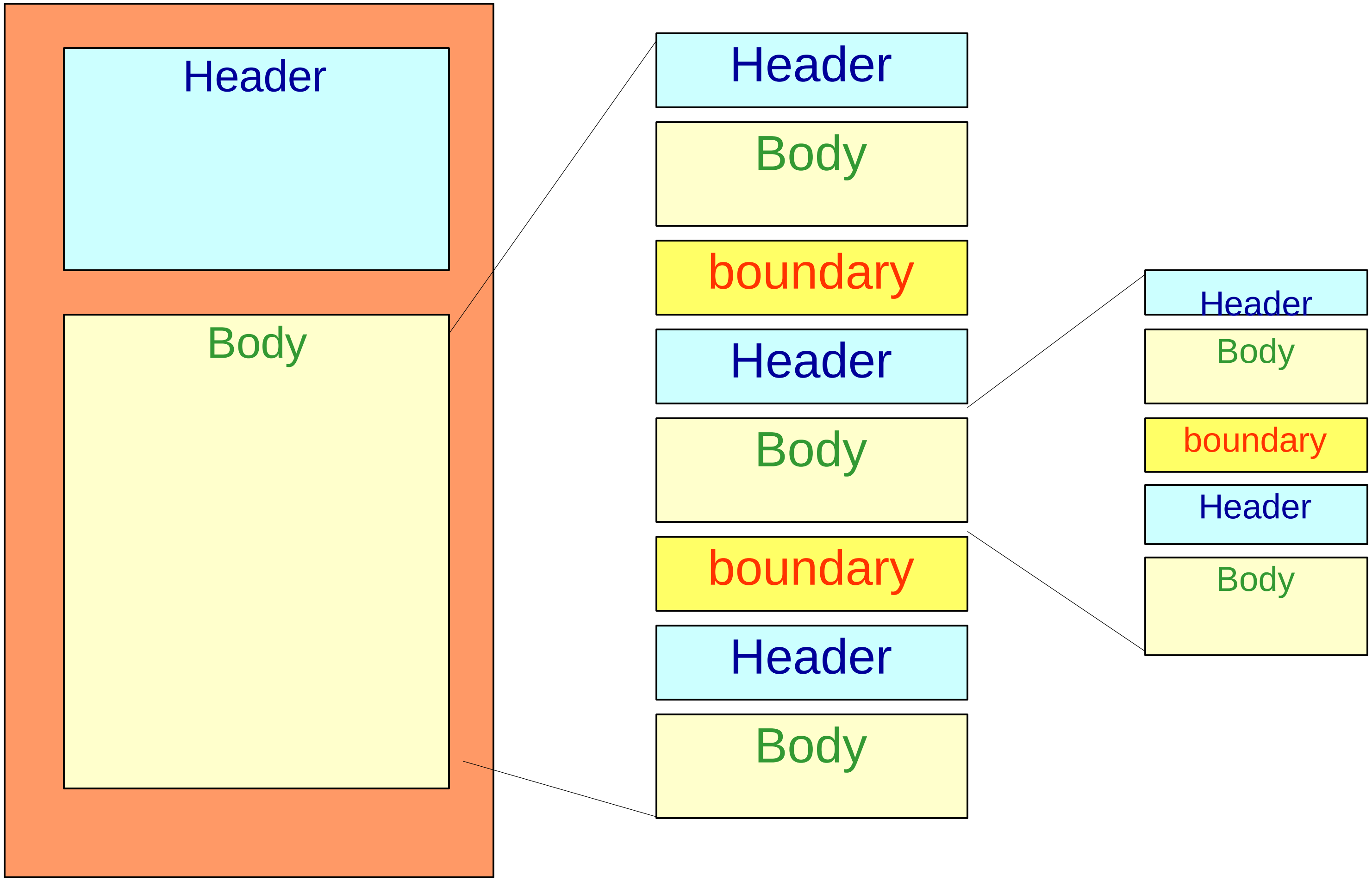
```
From: Nathaniel Borenstein <nsb@thumper.bellcore.com>
To: Ned Freed <ned@innosoft.com>
Subject: Plain text mail
Content-type: text/plain; charset=us-ascii

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 base64
Content-Transfer-Encoding:


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--
```

MIME multipart message



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
  - Mixed: a combination of several objects
  - Alternative: an object in several formats to select one (text/html/rtf)
  - Parallel: several objects for simultaneous presentation (e.g. audio+video)
  - Digest: collection of messages
  - Related: set of objects part of a single object (web page)
- Message:
  - RFC822: a complete message (eg. resent message) Partial:
  - a fragment …
  - External-Body: a reference to an external object

Registration scheme
Type/subtype:
mantained by IANA

MIME content types

- `Content-Type` element structure:
  - **`type/subtype`**

- Examples of type/subtype:
  - application/pdf, application/msword, application/soap+xml, application/vnd.ms-powerpoint, application/vnd.nokia.radio-preset, ...
  - audio/GSM, audio/mpeg, audio/vnd.dolby.mps, …
  - image/gif, image/jpeg, image/png, image/vnd.adobe.photoshop, ...
  - text/plain, text/html, text/vnd.dvb.subtitle, …
  - message/rfc822, message/http, ...
  - model/iges, …
  - multipart/mixed, multipart/alternative, …
  - video/H264, video/mp4, video/vnd.nokia.videovoip, …

MIME: transfer encoding

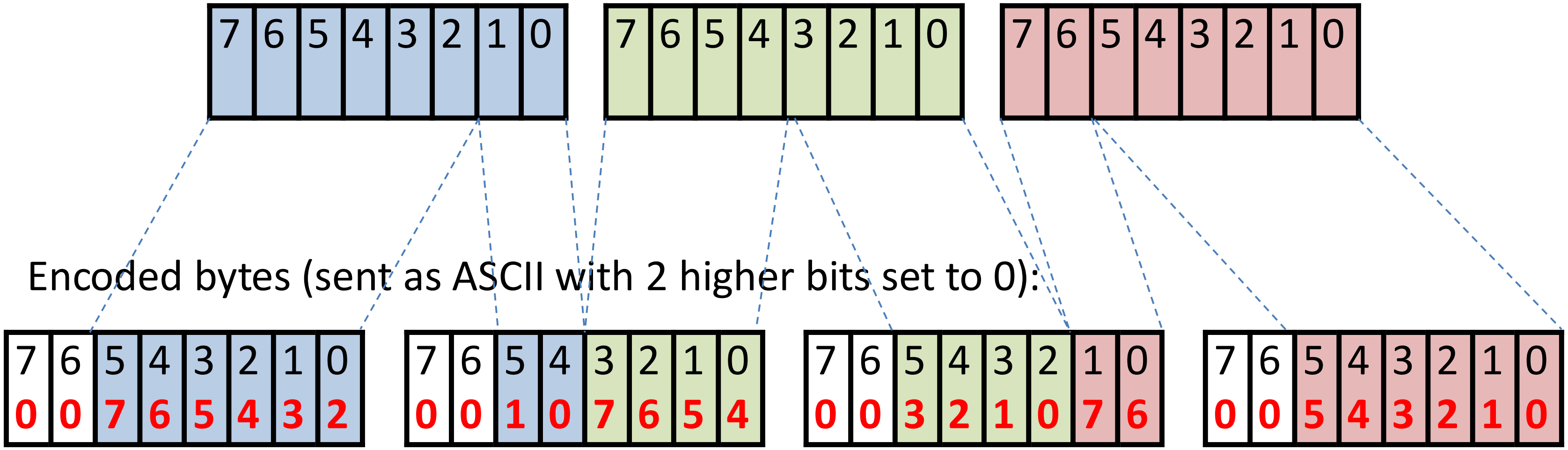
Ways to encode content: (to “get through” a 7 bit transport)

- 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) and lines of appropriate length
- 8Bit: No character encoding (8 bits) and lines of appropriate length
- In the heading:

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

Base64 encoding

Bytes to transmit (8 bits either 0 or 1):



Encoded bytes (sent as ASCII with 2 higher bits set to 0):

Only ASCII values from 0 to 63
(**64** posible values)

Inefficiency: 4 bytes transmitted for every 3 bytes!

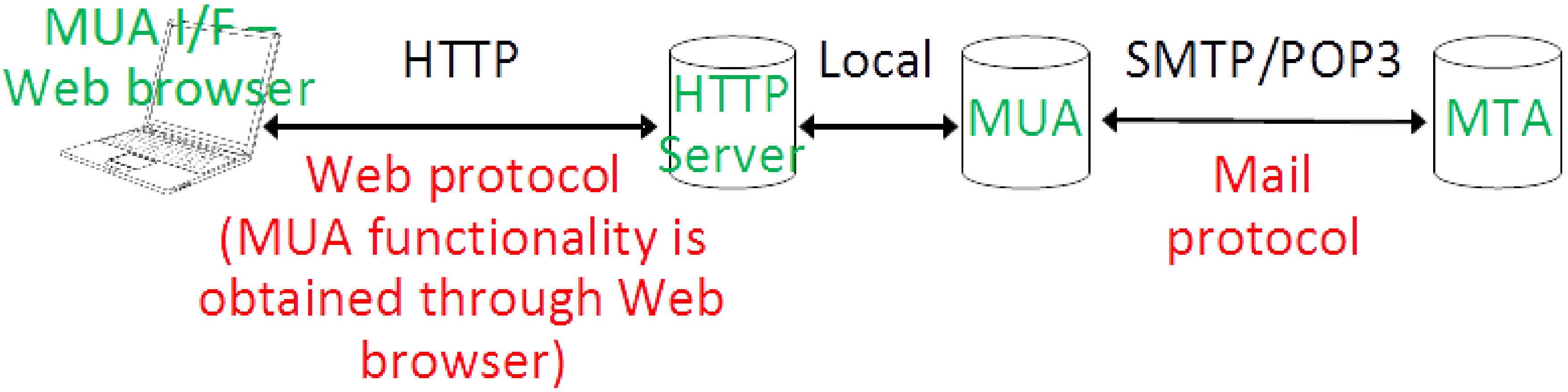
Mailbox Access protocols

- Post Office Protocol (POP) version 3 (POP3)
  - RFC 1939 (1996)
  - Client-server protocol (Asymmetric)
  - Messages retrieved from the mail server (copied locally).

- Internet Message Access Protocol (IMAP)
  - RFC 3501 (2003). 1st version 4 in RFC 1730 (1994). 1st RFC (version 2) in 1988 (RFC 1064).
  - Client-server protocol (Asymmetric)
  - Messages accessed and managed (folders, …) at the server

Unit 5. Network applications

Email - Webmail



- Web front-end for mail services. The MUA is a web browser.
- Real protocol to access the services: HTTP (web).
- The HTTP server machine uses SMTP or POP3, as required.

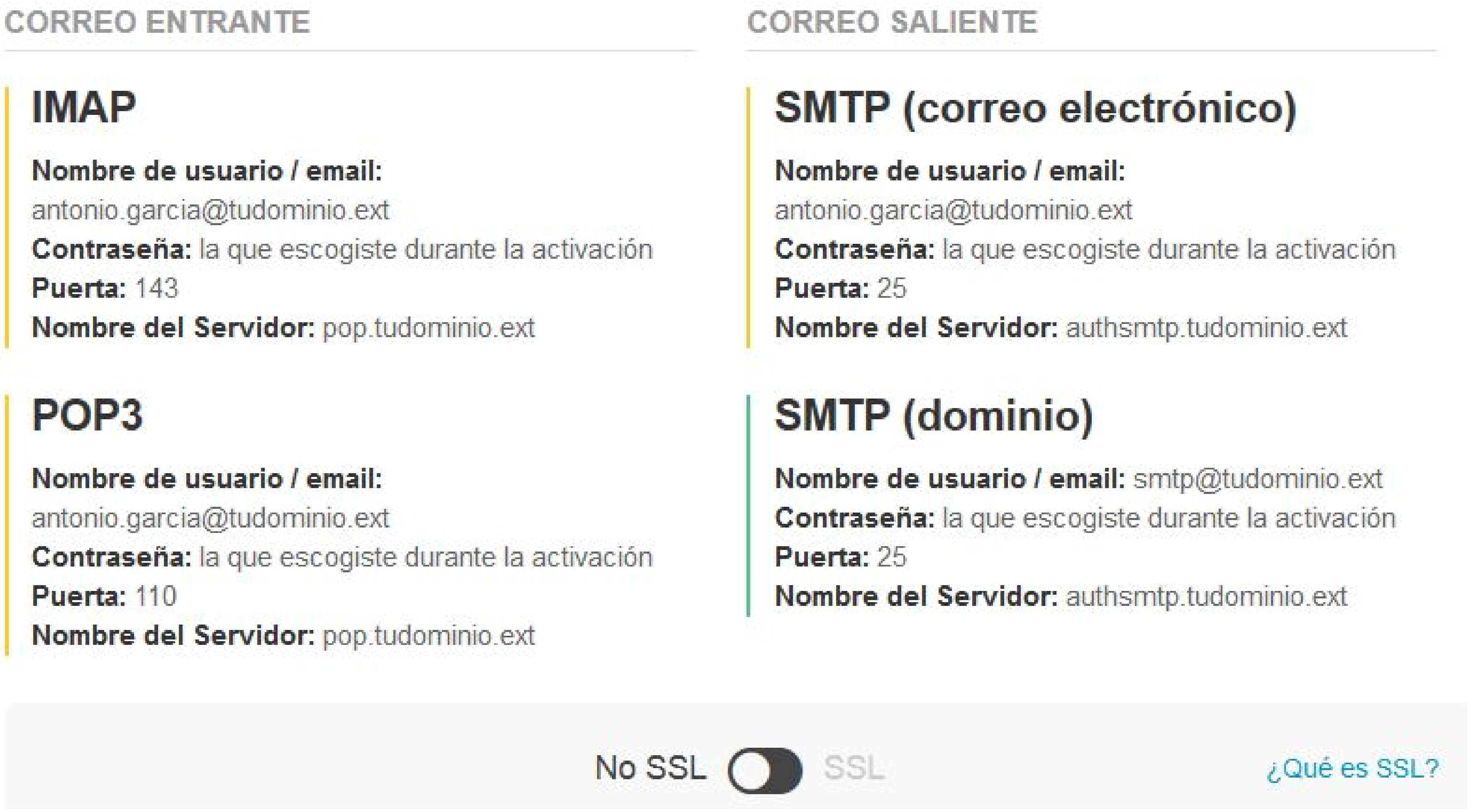
Unit 5. Network applications

Email - retrieval protocols

- Post Office Protocol (POP), RFC-1939:
  - POP server listens on well-known port 110
  - POPS port 995
  - User normally deletes messages upon retrieval

- Internet Message Access Protocol (IMAP) RFC-3501:
  - IMAP server listens on well-known port 143 (IMAPS port 993)
  - 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.



CORREO ENTRANTE

IMAP

Nombre de usuario / email:
antonio.garcia@tudominio.ext
Contraseña: la que escogiste durante la activación
Puerta: 143
Nombre del Servidor: pop.tudominio.ext

POP3

Nombre de usuario / email:
antonio.garcia@tudominio.ext
Contraseña: la que escogiste durante la activación
Puerta: 110
Nombre del Servidor: pop.tudominio.ext

CORREO SALIENTE

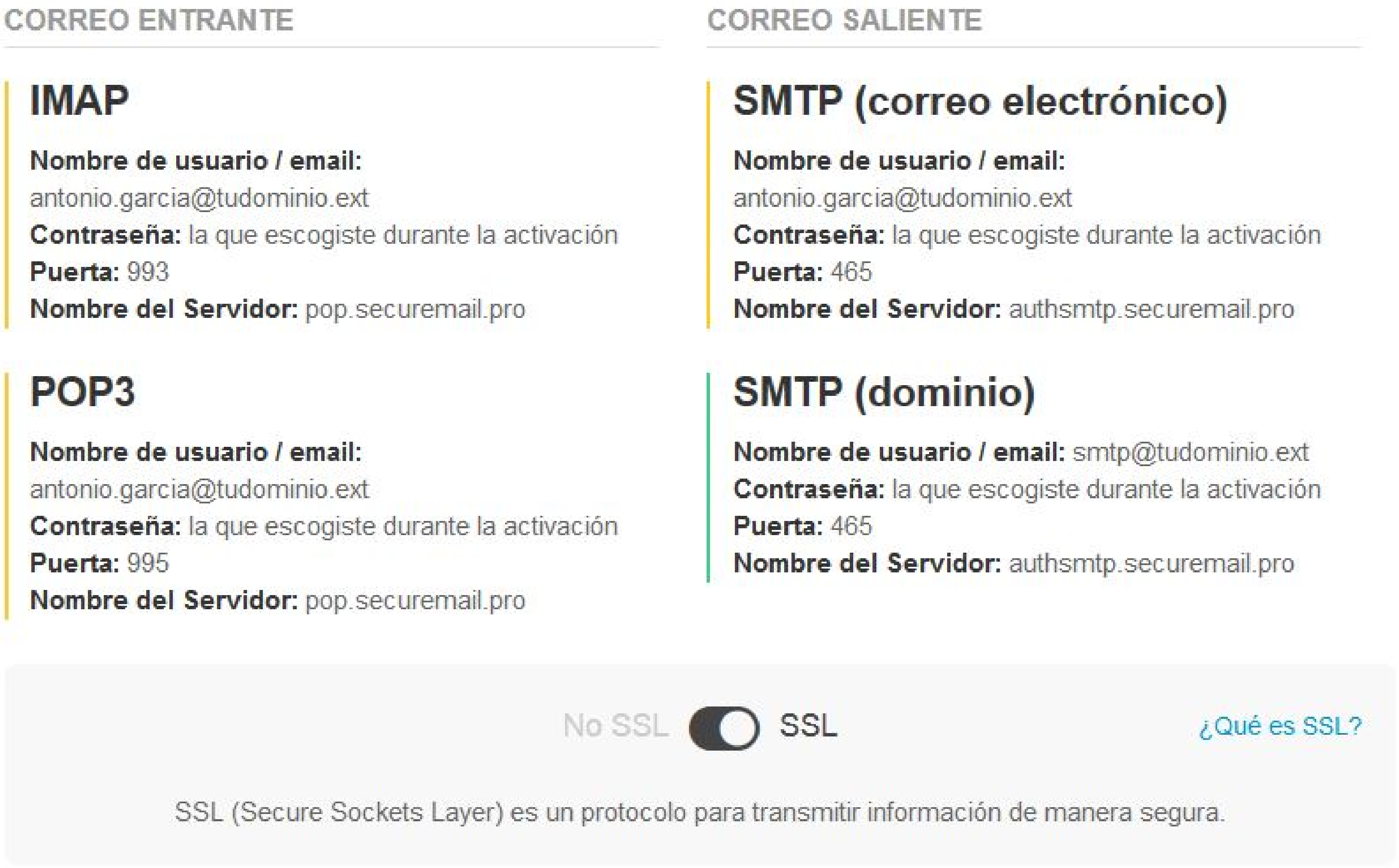
SMTP (correo electrónico)

Nombre de usuario / email:
antonio.garcia@tudominio.ext
Contraseña: la que escogiste durante la activación
Puerta: 25
Nombre del Servidor: authsmtp.tudominio.ext

SMTP (dominio)

Nombre de usuario / email: smtp@tudominio.ext
Contraseña: la que escogiste durante la activación
Puerta: 25
Nombre del Servidor: authsmtp.tudominio.ext

No SSL ● SSL



CORREO ENTRANTE

IMAP

Nombre de usuario / email: antonio.garcia@tudominio.ext
Contraseña: la que escogiste durante la activación
Puerta: 993
Nombre del Servidor: pop.securemail.pro

POP3

Nombre de usuario / email: antonio.garcia@tudominio.ext
Contraseña: la que escogiste durante la activación
Puerta: 995
Nombre del Servidor: pop.securemail.pro

CORREO SALIENTE

SMTP (correo electrónico)

Nombre de usuario / email: antonio.garcia@tudominio.ext
Contraseña: la que escogiste durante la activación
Puerta: 465
Nombre del Servidor: authsmtp.securemail.pro

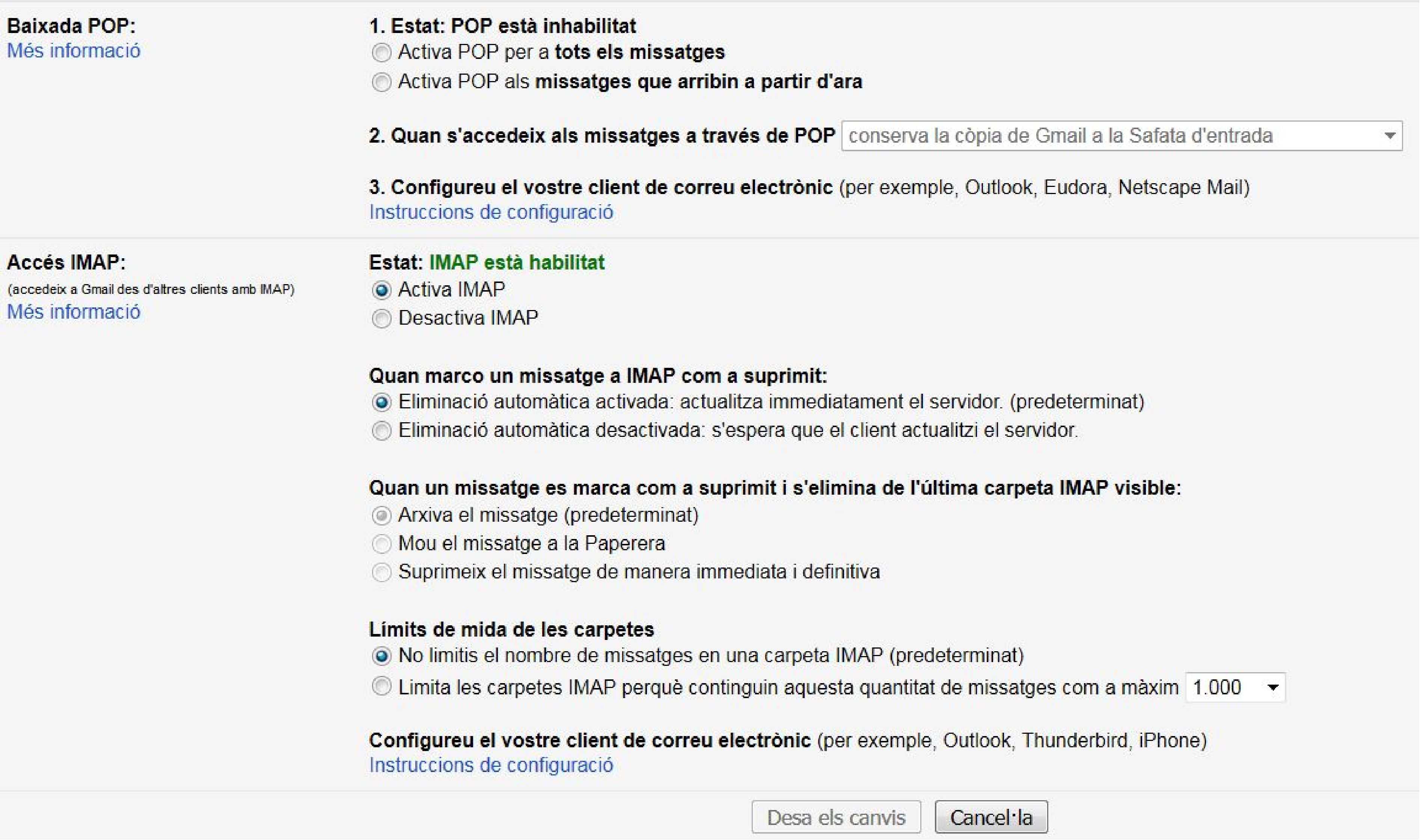
SMTP (dominio)

Nombre de usuario / email: smtp@tudominio.ext
Contraseña: la que escogiste durante la activación
Puerta: 465
Nombre del Servidor: authsmtp.securemail.pro

No SSL ● SSL

¿Qué es SSL?

SSL (Secure Sockets Layer) es un protocolo para transmitir información de manera segura.



Baixada POP:
Més informació

1. Estat: POP està inhabilitat
○ Activa POP per a **tots els missatges**
○ Activa POP als **missatges que arribin a partir d'ara**

2. Quan s'accedeix als missatges a través de POP conserva la còpia de Gmail a la Safata d'entrada ▾

3. Configureu el vostre client de correu electrònic (per exemple, Outlook, Eudora, Netscape Mail)
Instruccions de configuració

Accés IMAP:
(accedeix a Gmail des d'altres clients amb IMAP)
Més informació

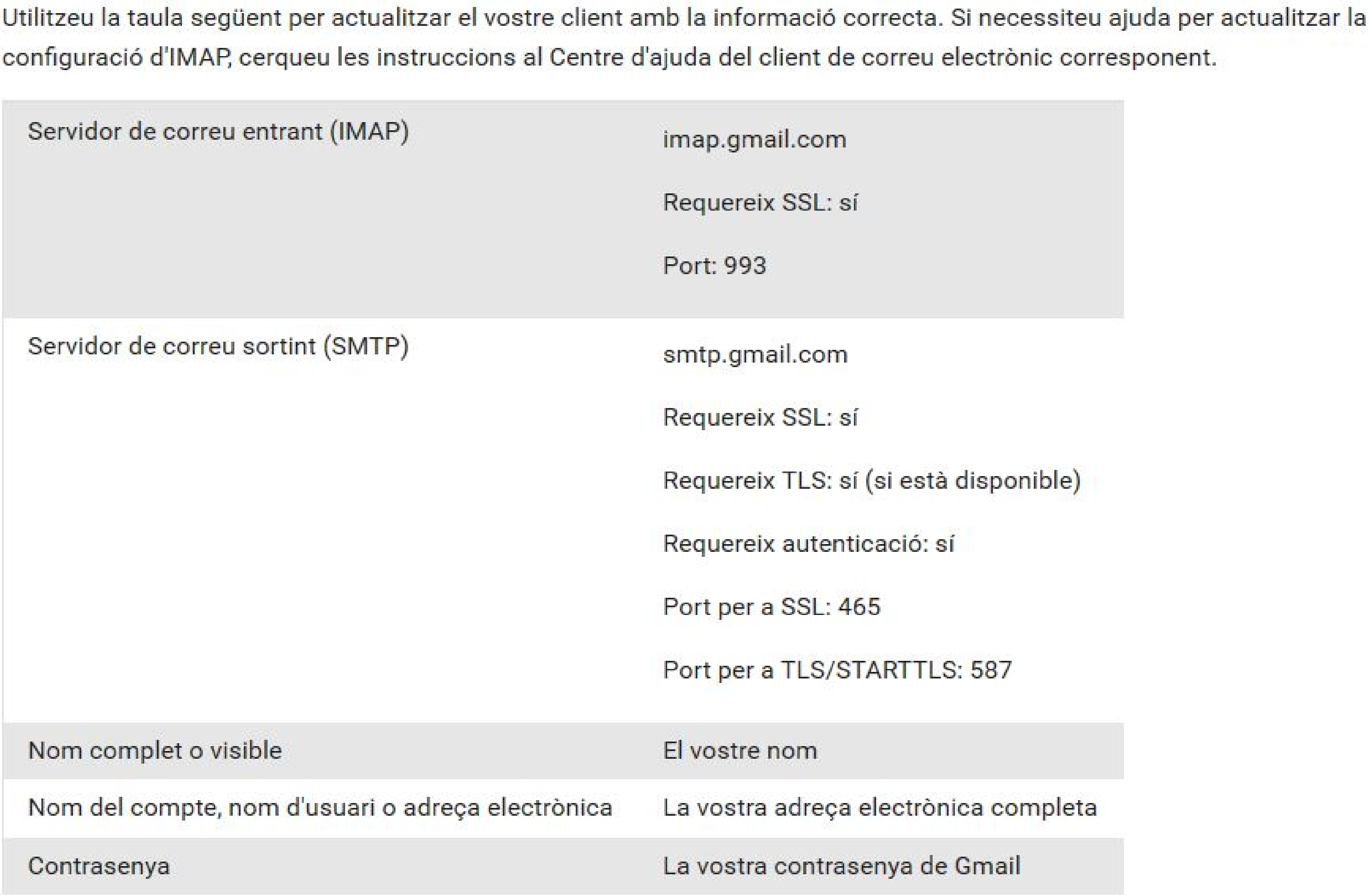
Estat: IMAP està habilitat
● Activa IMAP
○ Desactiva IMAP

Quan marco un missatge a IMAP com a suprimit:
● Eliminació automàtica activada: actualitza immediatament el servidor. (predeterminat)
○ Eliminació automàtica desactivada: s'espera que el client actualitzi el servidor.

Quan un missatge es marca com a suprimit i s'elimina de l'última carpeta IMAP visible:
● Arxiva el missatge (predeterminat)
○ Mou el missatge a la Paperera
○ Suprimeix el missatge de manera immediata i definitiva

Límits de mida de les carpetes
● No limitis el nombre de missatges en una carpeta IMAP (predeterminat)
○ Limita les carpetes IMAP perquè continguin aquesta quantitat de missatges com a màxim 1.000 ▾

Configureu el vostre client de correu electrònic (per exemple, Outlook, Thunderbird, iPhone)
Instruccions de configuració



Utilitzeu la taula següent per actualitzar el vostre client amb la informació correcta. Si necessiteu ajuda per actualitzar la configuració d'IMAP, cerqueu les instruccions al Centre d'ajuda del client de correu electrònic corresponent.

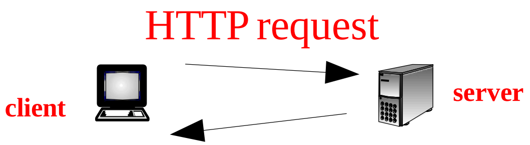
Servidor de correu entrant (IMAP)	imap.gmail.com Requereix SSL: sí Port: 993
Servidor de correu sortint (SMTP)	smtp.gmail.com Requereix SSL: sí Requereix TLS: sí (si està disponible) Requereix autenticació: sí Port per a SSL: 465 Port per a TLS/STARTTLS: 587
Nom complet o visible	El vostre nom
Nom del compte, nom d'usuari o adreça electrònica	La vostra adreça electrònica completa
Contrasenya	La vostra contrasenya de Gmail

Outline

- DNS
- Charsets
- Email
- **Web**
- HTML & XML

Web

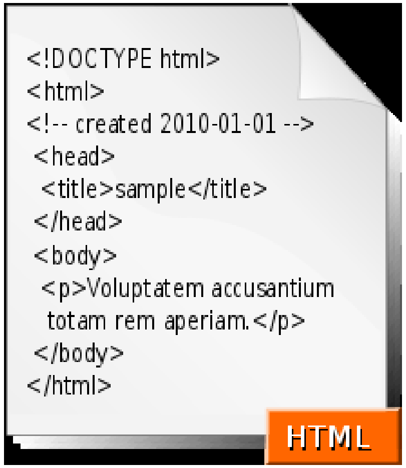
- World Wide Web, www: was started by Tim John Berners-Lee in 1989 and developed in the 90s to provide an easy access to information in the Internet.
- Components:
  - Transport layer: TCP, well-known port: 80.
  - Application layer protocol: HyperText Transfer Protocol (HTTP). RFC1945 (HTTP-1.0 Y1996), RFC2616 (HTTP-1.1 Y1999).
  - HyperText Markup Language (HTML): Language used to format web documents.



Web browser:
•firefox
•explorer
•...

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>
```

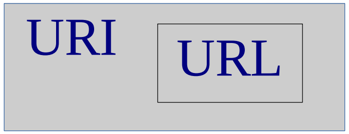
Source: wikipedia

Web elements

- Protocol
  - **HTTP** (HyperText Transfer Protocol)
- Information (format)
  - **HTML** (HyperText Markup Language)
- LINK to information
  - **URI** (Uniform Resource Identifier):

    URN (Name), **URL** (Locator)

Web – links



URI

URL

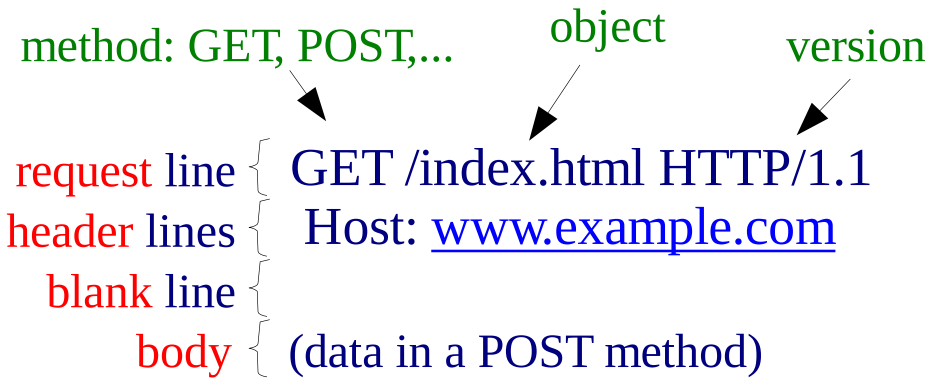
- Uniform Resource Identifier (URI) RFC3986
  - Generic syntax to identify a resource.
- Uniform Resource Locator (URL) RFC1738
  - Subset of URIs identifying the locating a resource in the Internet.
- The URL general syntax is

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

Web – HTTP Messages, RFC2616

- Client (HTTP request):



method: GET, POST,...

object

version

request line

GET /index.html HTTP/1.1

header lines

Host: www.example.com

blank line

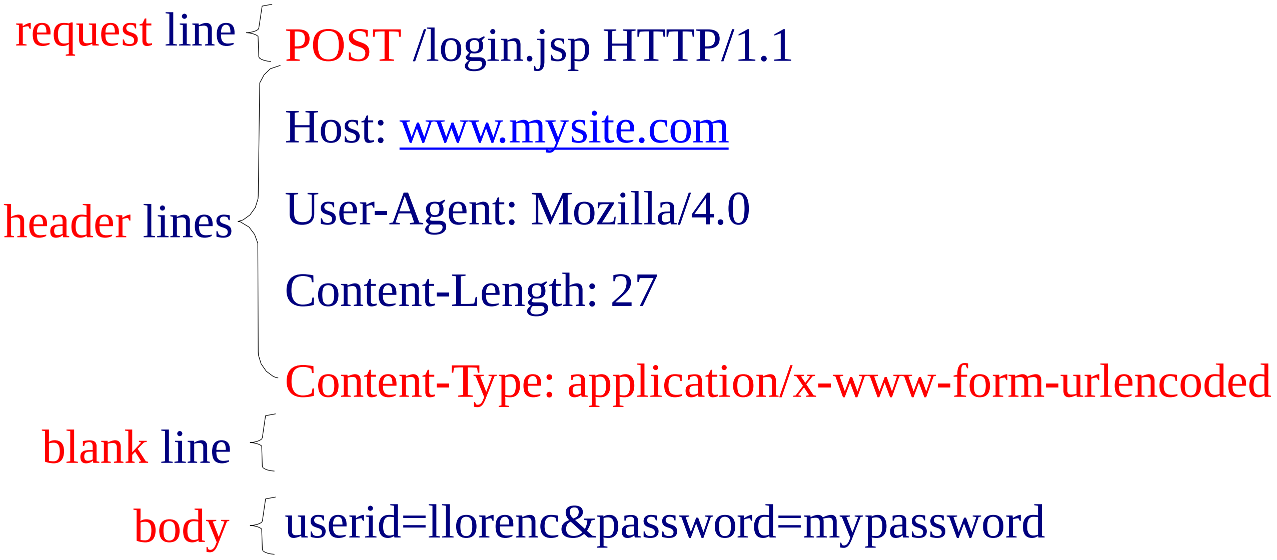
body

(data in a POST method)

- Methods:
  - GET: Typical command. Requests an object.
  - POST: Requests an object qualified by the data in the body. This data is the contents of the HTML form fields, provided by the client.
  - ...
- Header: Allows the client to give additional information about the request and the client itself.

Web – HTTP Messages, RFC2616

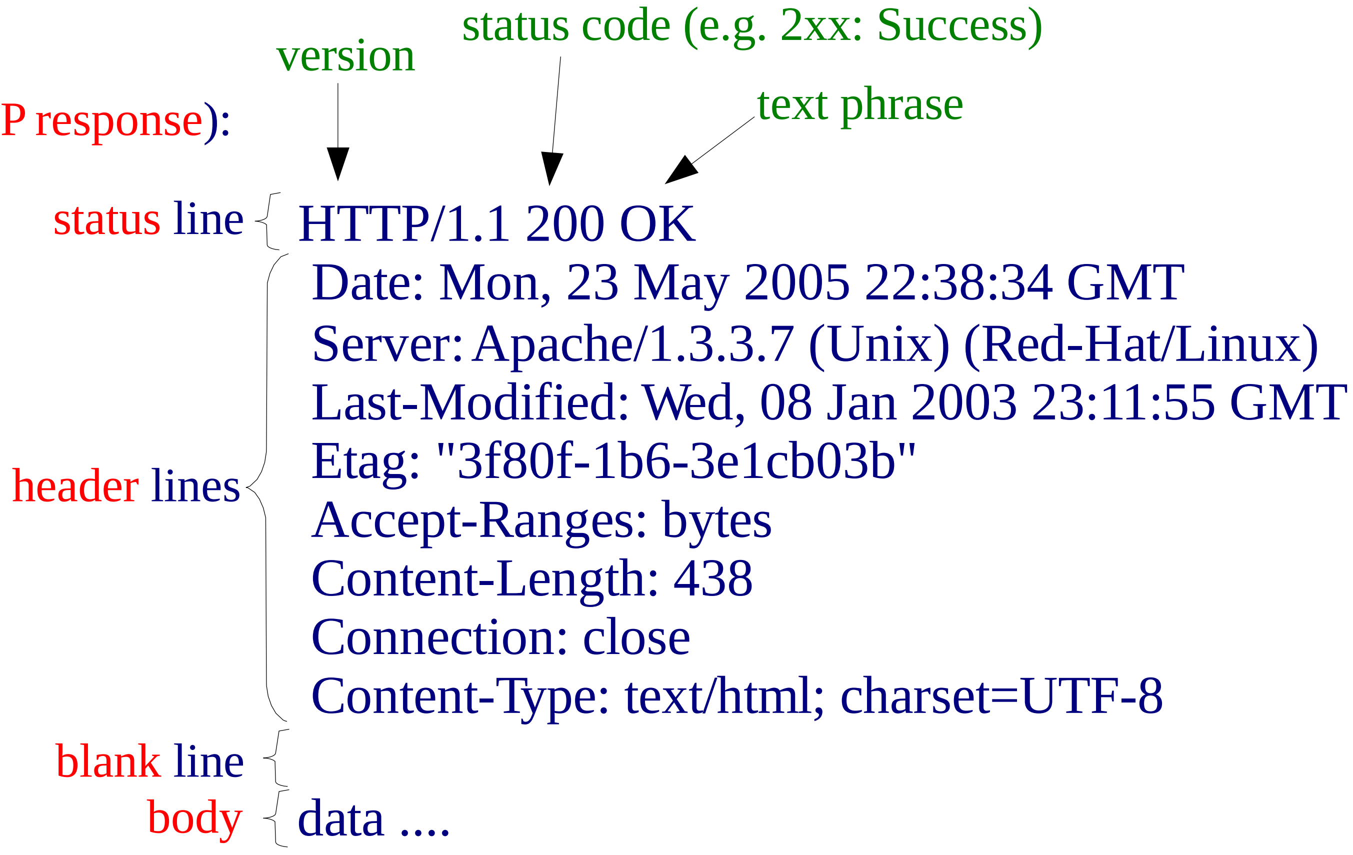
- POST uses MIME types: application/octet-stream, to send raw binary data, and application/x-www-form-urlencoded, to send name-value pairs. Example:



```
POST /login.jsp HTTP/1.1
Host: www.mysite.com
User-Agent: Mozilla/4.0
Content-Length: 27
Content-Type: application/x-www-form-urlencoded

userid=llorenc&password=mypassword
```

Web – HTTP Messages, RFC2616

- Server (HTTP response):



version

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

text phrase

status line

header lines

blank line

body

```
HTTP/1.1 200 OK
 Date: Mon, 23 May 2005 22:38:34 GMT
 Server: Apache/1.3.3.7 (Unix) (Red-Hat/Linux)
 Last-Modified: Wed, 08 Jan 2003 23:11:55 GMT
 Etag: "3f80f-1b6-3e1cb03b"
 Accept-Ranges: bytes
 Content-Length: 438
 Connection: close
 Content-Type: text/html; charset=UTF-8

data ....
```

Web – Persistent/non Persistent connections

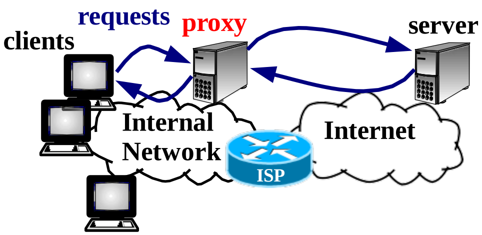
- Non persistent (default in HTTP/1.0): The server closes the TCP connection after every object. E.g, for an html page with 10 jpeg images, 11 TCP connections are sequentially opened.
- Persistent (default in HTTP/1.1) : The server maintains the TCP connection open until an inactivity time. All 11 objects would be sent over the same TCP connection.
- Persistent connections with pipelining (supported only in HTTP/1.1): The client issues new requests as soon as it encounters new references, even if the objects have been not completely downloaded.

Web – Caching and Proxies

- Caching: The client stores downloaded pages in a local 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, 2002 4:57 PM
If-None-Match: "686897696a7c876b7e"
```

- Proxy server: Acts as an intermediary for requests from clients.
  - Advantages:
    - Security (the proxy may reject the access to unauthorized servers)
    - Logs
    - Caching
    - Save public IP addresses (only the proxy may have access to the Internet)
    - ...



Web – web based applications

- Components:
  - Presentation: A web browser (client side).
  - Engine generating “on the fly” HTML pages (server side).
    - Languages:
      - Java.
      - Hypertext Preprocessor (PHP): Embedded program language and HTML code (http://www.php.net).
      - Other: ASP, CGI, ColdFusion, Perl, Python...
  - 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.)

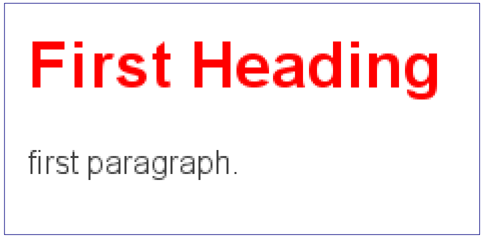
Outline

- DNS
- Charsets
- Email
- Web
- **HTML & XML**

HTML – Hyper-Text Markup Language, HTML

- In 1986 ISO standardized the Standard Generalized Markup Language (SGML). SGML introduced the <> syntax, and has been used in large documentation projects.
- Tim Berners-Lee defined HTML in 1989 inspired in SGML. HTML design mail goal was displaying formated 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:

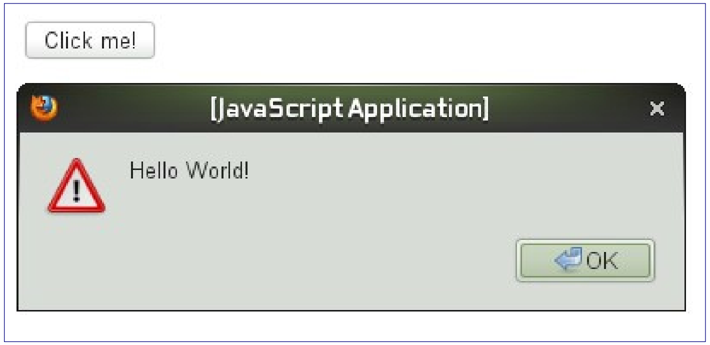
- element
- attribute
- text

HTML – Hyper-Text Markup Language, HTML

- HTML features (1):
  - 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.

  - javascript example:

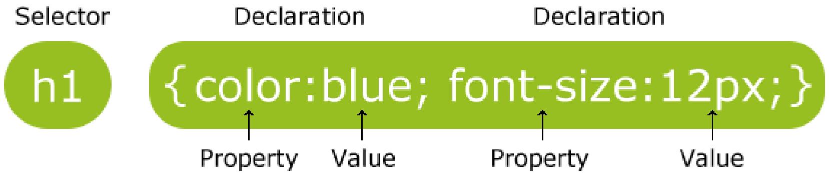
```
<html>
<head>
<script type="text/javascript">
 function displaymessage() {
   alert("Hello World!");
 }
</script>
</head>
<body>
 <form>
  <input type="button"
   value="Click me!" onclick="displaymessage()" />
 </form>
</body>
</html>
```



Hello World!

HTML – Hyper-Text Markup Language, HTML

- HTML features (2):
  - Cascading Style Sheets, CSS: Allows describing the *physical layout* in a separate document. E.g. thousand of HTML pages can use the same CSS. If the style must be changed, only the CSS need to be updated.
  - CSS Syntax

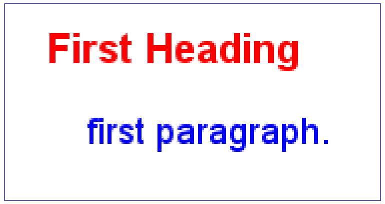


Source: http://www.w3schools.com/xml/

- CSS example
  - Content of the file “mystyle.css”:

```
h1 {color:red; font-size:20px;}
p {margin-left:20px; color:blue; font-size:18px;}
```

```
<html>
<head>
<link rel="stylesheet" type="text/css" href="mystyle.css" />
</head>
<body>
  <h1>First Heading</h1>
  <p>first paragraph.</p>
</body>
</html>
```



First Heading

first paragraph.

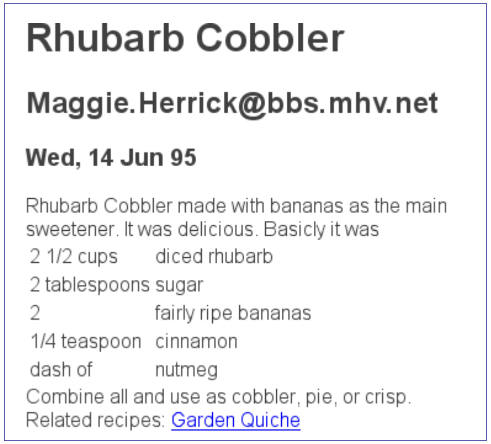
HTML & XML – Extensible Markup Language, XML

- History and Motivation
  - Due to tremendous success of web, World Wide Web Consortium (W3C) was created in 1994 to produce web standards.
  - Web evolution has increasingly involved towards the exchange of structured information, making HTML inadequate for many web projects.
  - XML is being developed in W3C to cope with transport and store of structured information. In 1998 XML 1.0 was the first W3C recommendation.
  - XML is not a replacement of HTML, but a framework for defining markup languages.
  - XML does not do anything: Someone must write an application (possibly a web application) to send, receive or display it.

HTML & XML – Extensible Markup Language, XML

- Limitations of HTML
  - Consider a web site publishing recipes. A recipe could be as:

```
<h1>Rhubarb Cobbler</h1>
<h2>Maggie.Herrick@bbs.mhv.net</h2>
<h3>Wed, 14 Jun 95</h3>
Rhubarb Cobbler made with bananas as the main sweetener.
It was delicious.  Basicly it was
  <table>
  <tr><td> 2 1/2 cups <td> diced rhubarb
  <tr><td> 2 tablespoons <td> sugar
  <tr><td> 2 <td> fairly ripe bananas
  <tr><td> 1/4 teaspoon <td> cinnamon
  <tr><td> dash of <td> nutmeg
  </table>
Combine all and use as cobbler, pie, or crisp.
Related recipes: <a href="#GardenQuiche">Garden Quiche</a>
```



Rhubarb Cobbler

Maggie.Herrick@bbs.mhv.net

Wed, 14 Jun 95

Rhubarb Cobbler made with bananas as the main sweetener. It was delicious. Basicly it was

2 1/2 cups	diced rhubarb
2 tablespoons	sugar
2	fairly ripe bananas
1/4 teaspoon	cinnamon
dash of	nutmeg

Combine all and use as cobbler, pie, or crisp.
Related recipes: Garden Quiche

Source: http://www.brics.dk/~amoeller/XML/xml/htmlvsxml.html

- Problems:
  - How to check that a recipe is introduced correctly? (ingredients amounts...)
  - How to identify the fields of the recipe? (author, ingredients...)
  - What if we want to display the fields in a different order?
  - …
- We need to define the semantics (meaning) of tags, and the syntax (what tags, and how can they be used).

HTML & XML – Extensible Markup Language, XML

- Solution: XMLization

```
<recipe id="117" category="dessert">
  <title>Rhubarb Cobbler</title>
  <author><email>Maggie.Herrick@bbs.mhv.net</email></author>
  <date>Wed, 14 Jun 95</date>
  <description>
    Rhubarb Cobbler made with bananas as the main sweetener.
    It was delicious.
  </description>
  <ingredients>
    <item><amount>2 1/2 cups</amount><type>diced rhubarb</type></item>
    <item><amount>2 tablespoons</amount><type>sugar</type></item>
    <item><amount>2</amount><type>fairly ripe bananas</type></item>
    <item><amount>1/4 teaspoon</amount><type>cinnamon</type></item>
    <item><amount>dash of</amount><type>nutmeg</type></item>
  </ingredients>
  <preparation>
    Combine all and use as cobbler, pie, or crisp.
  </preparation>
  <related url="#GardenQuiche">Garden Quiche</related>
</recipe>
```

Source: http://www.brics.dk/~amoeller/XML/xml/htmlvsxml.html

Terminology:
•element
•attribute
•text

- XML is designed to tailor-made markup languages.
- Examples:
  - Community Network Markup Language (CNML) to describe guifi.net: http://guifi.net/es/guifi/cnml/3671
  - gnome GConf configuration system: http://projects.gnome.org/gconf

HTML & XML – Extensible Markup Language, XML

- A well-formed XML document satisfies a list of syntax rules provided in the specification. It is more rigid than HTML (e.g. all tags must be closed: <tag> </tag> or <tag attribute1=.. />).
- XML namespaces
  - Allow differentiating elements names defined by different developers.
  - The namespace is defined by the xmlns attribute in the start tag of an element.
  - URL are often used as an easy way to define "unique" namespaces.

```
<widget xmlns="http://www.widget.org"
        xmlns:xhtml="http://www.w3.org/TR/xhtml1"
        type="gadget">
  <head size="medium"/>
  <big><subwidget ref="gizmo"/></big>
  <info>
    <xhtml:head>
      <xhtml:title>Description of gadget</xhtml:title>
    </xhtml:head>
    <xhtml:body>
      <xhtml:h1>Gadget</xhtml:h1> A
      gadget contains a big gizmo
    </xhtml:body>
  </info>
</widget>
```

Source: http://www.brics.dk/~amoeller/XML/xml/htmlvsxml.html

default namespace.

namespace with prefix xhtml. The prefix acts as a shortname for the namespace.

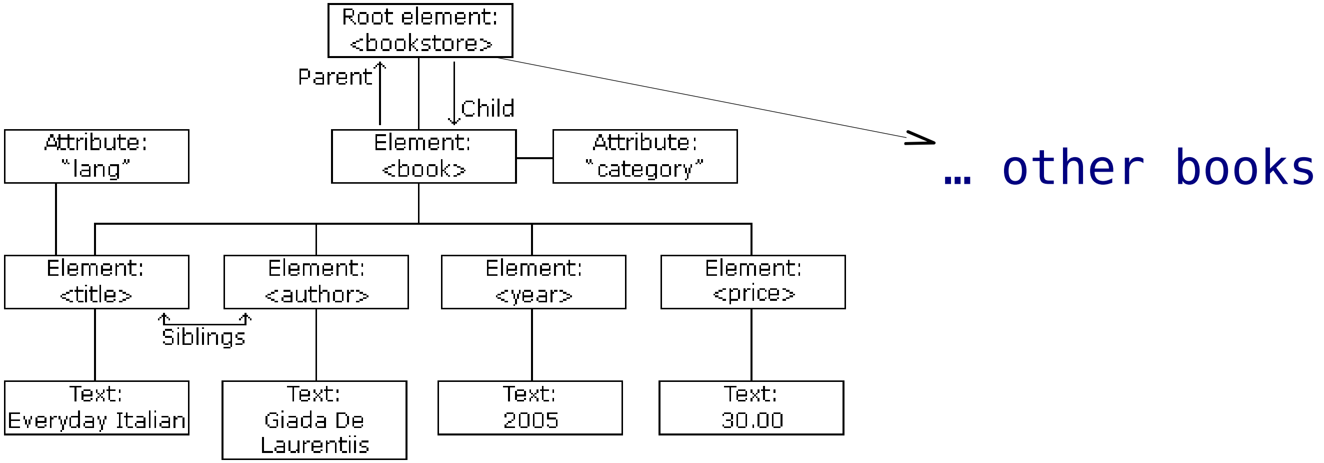
HTML & XML – Extensible Markup Language, XML

- XML documents have a tree structure

```
<bookstore>
  <book category="COOKING">
    <title lang="en">Everyday Italian</title>
    <author>Giada De Laurentiis</author>
    <year>2005</year>
    <price>30.00</price>
  </book>
  <book category="CHILDREN">
    <title lang="en">Harry Potter</title>
    <author>J K. Rowling</author>
    <year>2005</year>
    <price>29.99</price>
  </book>
...
</bookstore>
```

Terminology:

- element
- attribute
- text



Source: http://www.w3schools.com/xml/

HTML & XML – Extensible Markup Language, XML

- XPath: Navigating XML documents
  - Syntax for selecting parts of an XML document.
  - Used e.g. by the XML transformation language XSLT (explained later).
  - Example

```
<bookstore>
  <book category="COOKING">
    <title lang="en">Everyday Italian</title>
    <author>Giada De Laurentiis</author>
    <year>2005</year>
    <price>30.00</price>
  </book>
  <book category="CHILDREN">
    <title lang="en">Harry Potter</title>
    <author>J K. Rowling</author>
    <year>2005</year>
    <price>29.99</price>
  </book>
...
</bookstore>
```

Example of a XPath expression: title of the first book of the bookstore: /bookstore/book[1]/title

Source: http://www.w3schools.com/xml/

HTML & XML – Extensible Markup Language, XML

- Validation of XML documents
- A "Valid" XML document conforms to the syntax of an XML schema.
- The syntax defines what tags and how can be used.

- Most used schema languages:
  - Document Type Definition, DTD:
    - First XML schema language.
    - Does not follow XML syntax.
  - XML Schema Definition, XSD:
    - Follows XML syntax (allows namespaces).
    - Can express more complex rules than DTD.

HTML & XML – Extensible Markup Language, XML

- Document Type Definition, DTD
  - Content of the file “note.dtd”:

```
<!ELEMENT note (to,from,heading,body)>
<!ATTLIST note date CDATA #IMPLIED>
<!ELEMENT to (#PCDATA)>
<!ELEMENT from (#PCDATA)>
<!ELEMENT heading (#PCDATA)>
<!ELEMENT body (#PCDATA)>
```

Source: http://www.w3schools.com/xml/

element “note” contains the elements to,from,heading,body.

element “note” has attribute “date” (#IMPLIED means “not required”).

element “to” contains character data (#PCDATA).

  - Reference to the DTD defined in “note.dtd”:

```
<?xml version="1.0" encoding="ISO-8859-1"?>
<!DOCTYPE note SYSTEM "note.dtd">
<note date="10/01/2008">
  <to>Tove</to>
  <from>Jani</from>
  <heading>Reminder</heading>
  <body>Don't forget me this weekend!</body>
</note>
```

Declaration starting an XML document.

DTD schema defined in location “note.dtd”.

  - Validation example with xmllint (http://xmlsoft.org/):

```
linux ~/> xmllint --dtdvalid note.dtd exemple-dtd.xml
exemple-dtd.xml validates
```

HTML & XML – Extensible Markup Language, XML

- XML Schema Definition, XSD
  - Content of the file “note.xsd”:

```
<?xml version="1.0"?>
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema">
  <xs:element name="note">
    <xs:complexType>
      <xs:sequence>
            <xs:element name="to" type="xs:string"/>
            <xs:element name="from" type="xs:string"/>
            <xs:element name="heading" type="xs:string"/>
            <xs:element name="body" type="xs:string"/>
      </xs:sequence>
    </xs:complexType>
  </xs:element>
</xs:schema>
```

namespace where the schema is defined, the namespace should be prefixed xs.

root element

complexType: contains other elements

sequence: child elements must appear in the same order

http://www.w3schools.com/xml/

- Reference to the XSD defined in “note.xsd”:

```
<?xml version="1.0"?>
<note xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
      xsi:schemaLocation="note.xsd">
  <to>Tove</to>
  <from>Jani</from>
  <heading>Reminder</heading>
  <body>Don't forget me this weekend!</body>
</note>
```

XSD schema defined in location “note.xsd”

- An XML file using XSD can also be validated with xmllint.

HTML & XML – Extensible Markup Language, XML

- Extensible Stylesheet Language, XSL
  - Extend the CSS idea of HTML.
  - The main component is the XSL Transformations, XSLT. XSLT
  - is a programming language for specifying transformations between XML and a particular target language (e.g. HTML).
  - All major browsers support XML/XSLT: mozilla, explorer, google chrome...

  - An XSL style sheet consists of one or more rules called templates.
  - Templates are applied when a specified node is matched.

HTML & XML – Extensible Markup Language, XML

- XSL Transformations, XSLT

```
<?xml version="1.0" encoding="ISO-8859-1"?>
<?xml-stylesheet type="text/xsl" href="cdcatalog.xsl"?>
<catalog>
  <cd>
    <title>Empire Burlesque</title>
    <artist>Bob Dylan</artist>
  </cd>
…
</catalog>
```

reference an XSLT “cdcatalog.xsl” in an XML document

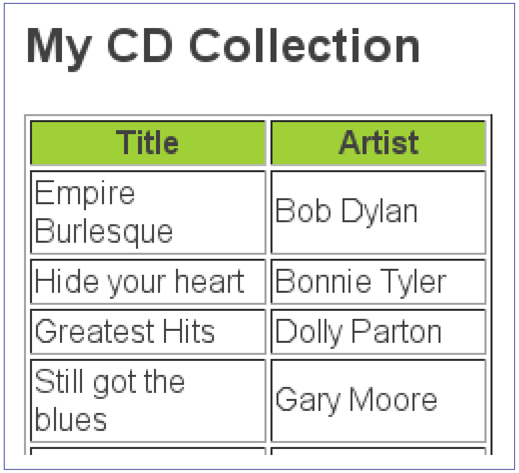
- Content of the file “cdcatalog.xsl”:

```
<?xml version="1.0" encoding="ISO-8859-1"?>
<xsl:stylesheet version="1.0"
xmlns:xsl="http://www.w3.org/1999/XSL/Transform">
<xsl:template match="/">
  <html><body>
  <h2>My CD Collection</h2>
  <table border="1">
    <tr bgcolor="#9acd32">
      <th>Title</th>
      <th>Artist</th>
    </tr>
    <xsl:for-each select="catalog/cd">
    <tr>
      <td><xsl:value-of select="title"/></td>
      <td><xsl:value-of select="artist"/></td>
    </tr>
    </xsl:for-each>
  </table>
  </body></html>
</xsl:template>
</xsl:stylesheet>
```

defines a template. Attibute match specifies the nodes using XPath

select every element of a node-set

extract the value of an XML element



My CD Collection

Title	Artist
Empire Burlesque	Bob Dylan
Hide your heart	Bonnie Tyler
Greatest Hits	Dolly Parton
Still got the blues	Gary Moore

Source: http://www.w3schools.com/xml/