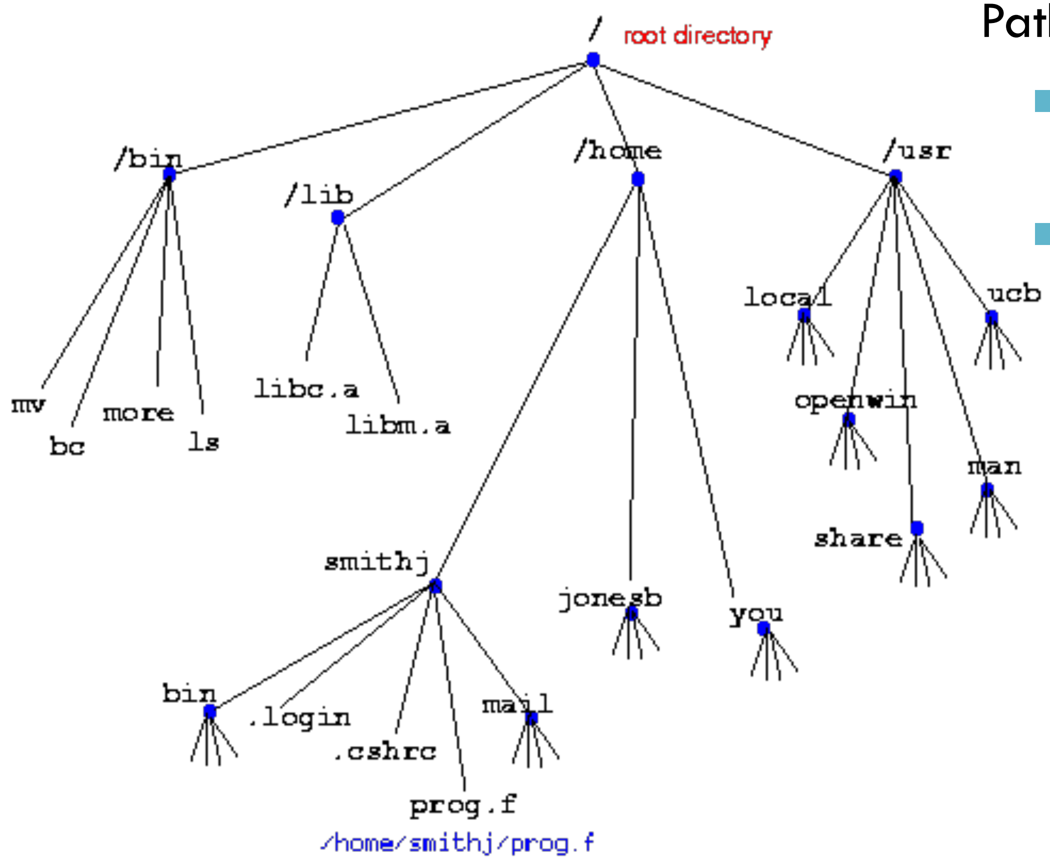
LABORATORY OF DATA SCIENCE

Data Access: Files

Two issues

- **Where** are my files?
  - Local file systems
  - Distributed file systems
  - Network protocols
- Which **format** is data in?
  - Text
    - CSV, ARFF
  - XML
  - Binary, Compressed, …

Local file system



Path of a **resource**

- Windows:
  - C:\Program Files\Office\sample.doc
- Linux:
  - /usr/home/r/ruggieri/sample.txt

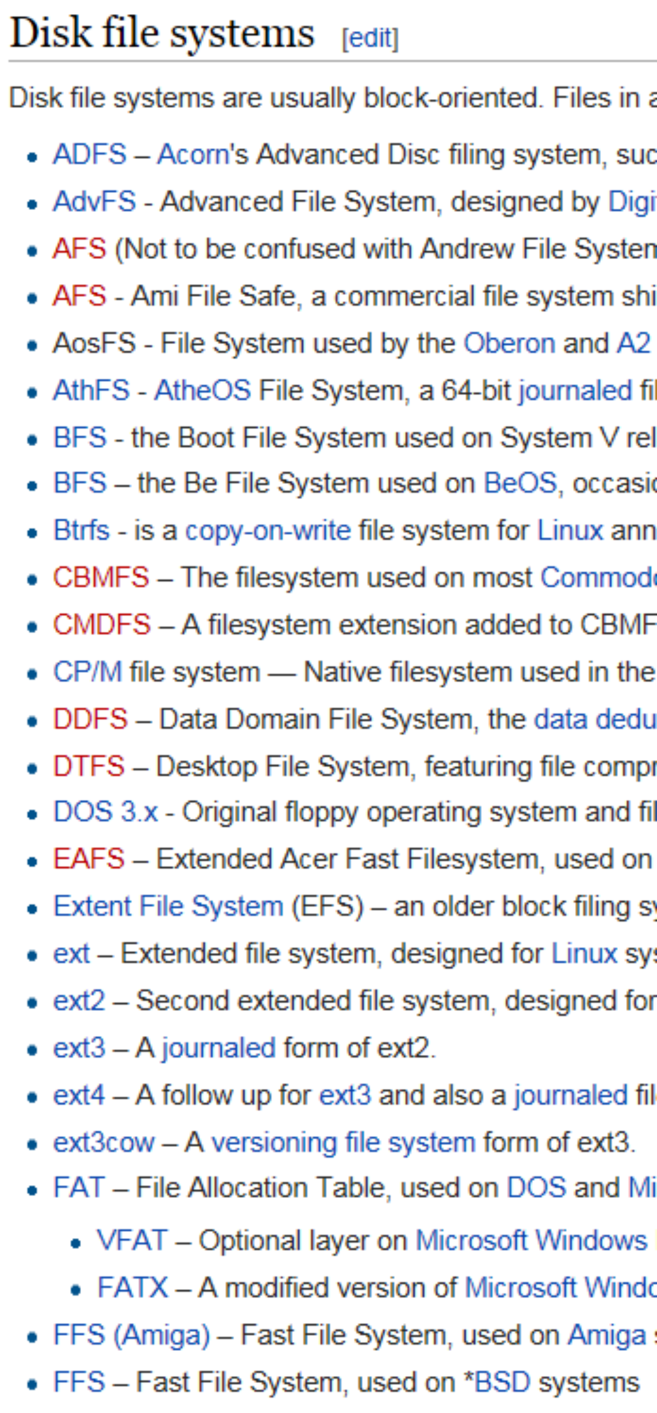
Local file system

A logical abstraction of persistent mass memory

- hierarchical view (tree of directories and files)
- types of resources (file, directory, pipe, link, special)
- resource attributes (owner, rights, hard links)
- services (indexing, journaling)

Sample file system:

- Windows
  - NTFS, FAT32
- Linux
  - EXT2, EXT3, JFS, XFS, REISERFS, FAT32



Disk file systems [edit]

Disk file systems are usually block-oriented. Files in a

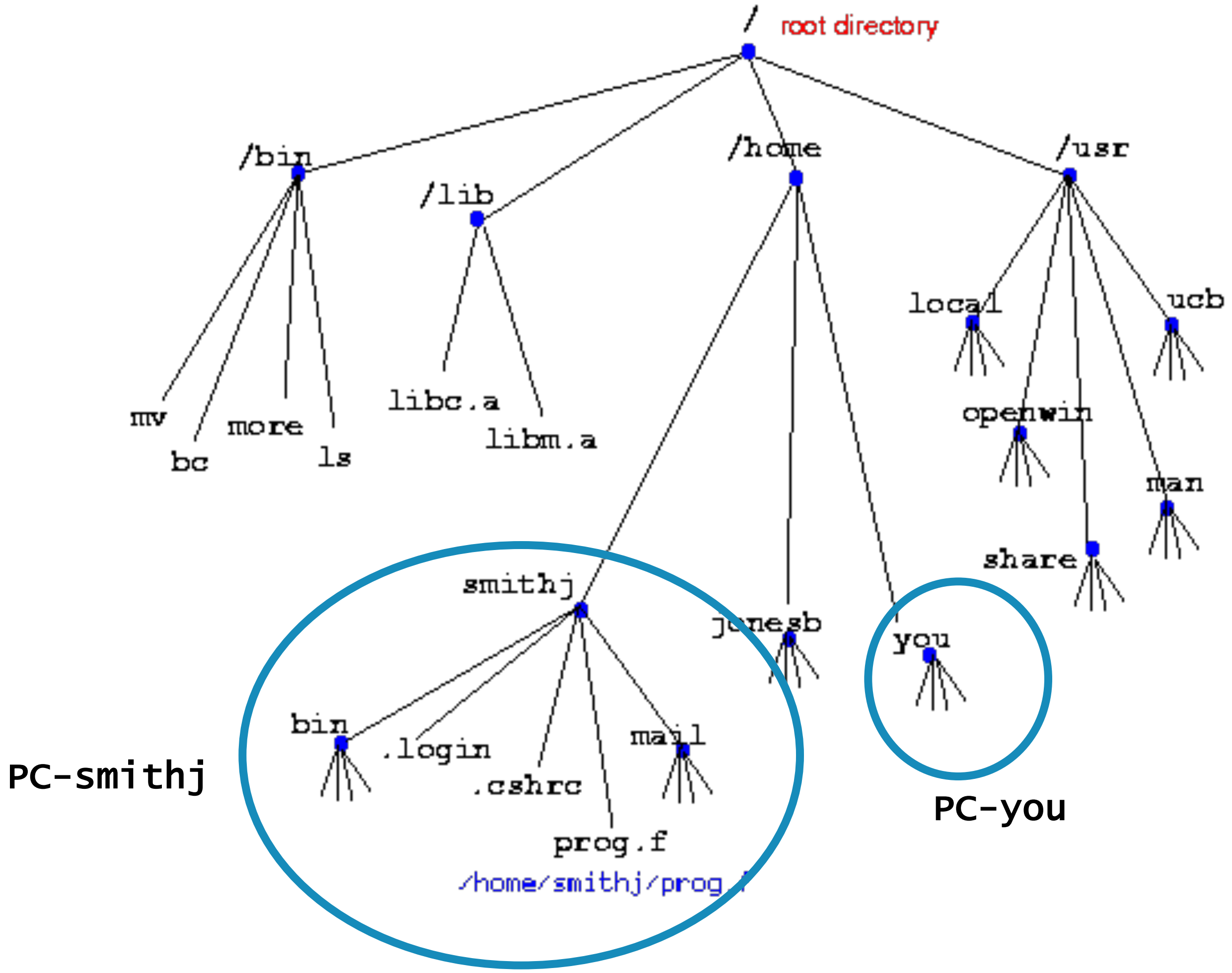
- ADFS – Acorn's Advanced Disc filing system, suc
- AdvFS - Advanced File System, designed by Digi
- AFS (Not to be confused with Andrew File Systen
- AFS - Ami File Safe, a commercial file system shi
- AosFS - File System used by the Oberon and A2
- AthFS - AtheOS File System, a 64-bit journaled fi
- BFS - the Boot File System used on System V rel
- BFS – the Be File System used on BeOS, occasi
- Btrfs - is a copy-on-write file system for Linux ann
- CBMFS – The filesystem used on most Commod
- CMDFS – A filesystem extension added to CBMF
- CP/M file system — Native filesystem used in the
- DDFS – Data Domain File System, the data dedu
- DTFS – Desktop File System, featuring file compr
- DOS 3.x - Original floppy operating system and fi
- EAFS – Extended Acer Fast Filesystem, used on
- Extent File System (EFS) – an older block filing sy
- ext – Extended file system, designed for Linux sys
- ext2 – Second extended file system, designed for
- ext3 – A journaled form of ext2.
- ext4 – A follow up for ext3 and also a journaled fil
- ext3cow – A versioning file system form of ext3.
- FAT – File Allocation Table, used on DOS and Mi
  - VFAT – Optional layer on Microsoft Windows
  - FATX – A modified version of Microsoft Windo
- FFS (Amiga) – Fast File System, used on Amiga s
- FFS – Fast File System, used on *BSD systems

Local file system

Physical view

- Disk partition
  - collection of contiguous blocks on a disk
- File system driver
  - software abstracting a file system on a partition
  - Maps a file system to each partition
- Mount
  - starting a file system driver on a partition
  - Windows (start up typically is automatic):
    - at startup for NTFS and FAT partitions
    - names of partitions: A: … Z:
  - Linux
    - at startup for partitions in **/etc/fstab**
    - **> mount –t ext3 /dev/hda2 /mtn/mydisk**

Distributed file system



Distributed file system

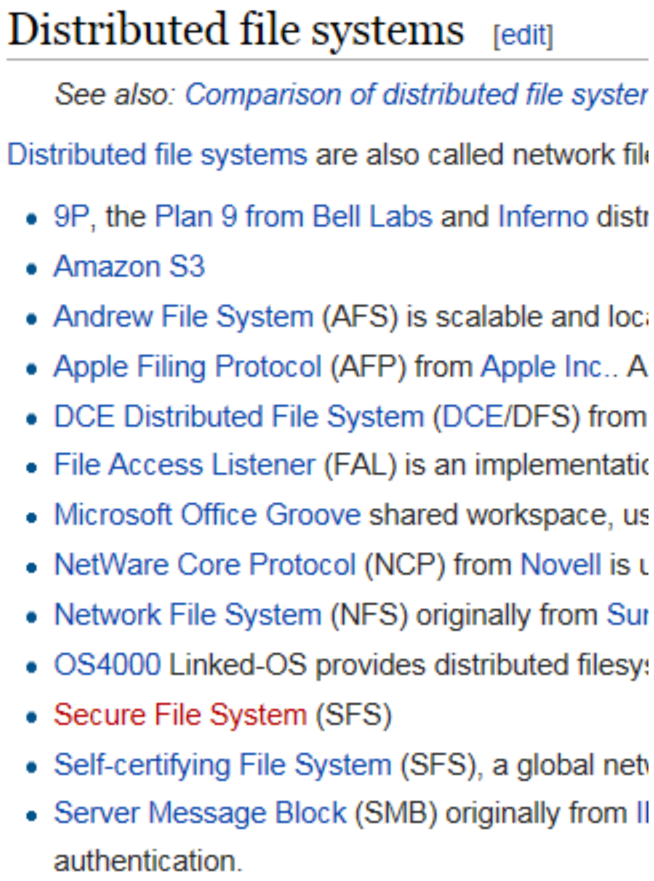
Acts as a client for a remote file access protocol

- logical abstraction of remote persistent mass memory

Sample file system:

- Samba (SMB)

  or Common Internet File System (CIFS)
- Network File System (NFS)



Distributed file systems [edit]

See also: Comparison of distributed file syster

Distributed file systems are also called network fil

- 9P, the Plan 9 from Bell Labs and Inferno distr
- Amazon S3
- Andrew File System (AFS) is scalable and loc
- Apple Filing Protocol (AFP) from Apple Inc.. A
- DCE Distributed File System (DCE/DFS) from
- File Access Listener (FAL) is an implementatic
- Microsoft Office Groove shared workspace, us
- NetWare Core Protocol (NCP) from Novell is u
- Network File System (NFS) originally from Su
- OS4000 Linked-OS provides distributed filesy
- Secure File System (SFS)
- Self-certifying File System (SFS), a global net
- Server Message Block (SMB) originally from I

  authentication.

Network protocols

- Files accessed through **explicit** request/reply
- A **local copy** has to be made before accessing data
- Resource naming:
  - Uniform Resource Locator (URL)
    - scheme://user:password@host:port/path
    - http://bob:bye@www.host.it:80/home/idx.html
    - scheme = protocol name (http, https, ftp, file, jdbc, …)
    - port = TCP/IP port number

HTTP Protocol

- HyperText Transfer Protocol
  - URL: http://user:pwd@www.di.unipi.it
  - State-less connections
  - Crypted variant: Secure HTTP (HTTPs)
- Windows clients
  - Any browser
  - > wget
    - GNU http://www.gnu.org/software/wget/
    - W3C http://www.w3.org/Library
- Linux clients
  - Any browser
  - > wget

FTP Protocol

- File Transfer Protocol
  - URL: ftp://user:pwd@ftp.apa.unip.it/myfile
  - State-less connections
  - Commands: get / put / mget
  - Crypted variant: Secure FTP (SFTP)
- Windows clients
  - FTP: > ftp or any browser
  - SFTP:
    - PuTTY ttp://www.chiark.greenend.org.uk/~sgtatham/putty
    - SSH Secure Shell http://www.ssh.com
- Linux clients
  - FTP: > ftp > sftp > gftp (GUI)

SCP Protocol

- Secure Copy
  - > scp data.zip user@alice.cli.di.unip.it:datacopy.zip
  - File copy from/to a remote account
  - File paths must be known in advance

- Client
  - command line:
    - **> scp/pscp   > scp2**
  - Windows GUI
    - WinSCP http://winscp.sourceforge.net
    - SSH Secure Shell
  - Linux GUI
    - SCP: default

Two issues

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  - Distributed file systems
  - Network protocols
- Which **format** is data in?
  - Text
    - CSV, ARFF
  - XML
  - Binary, Compressed, …

What is a file?

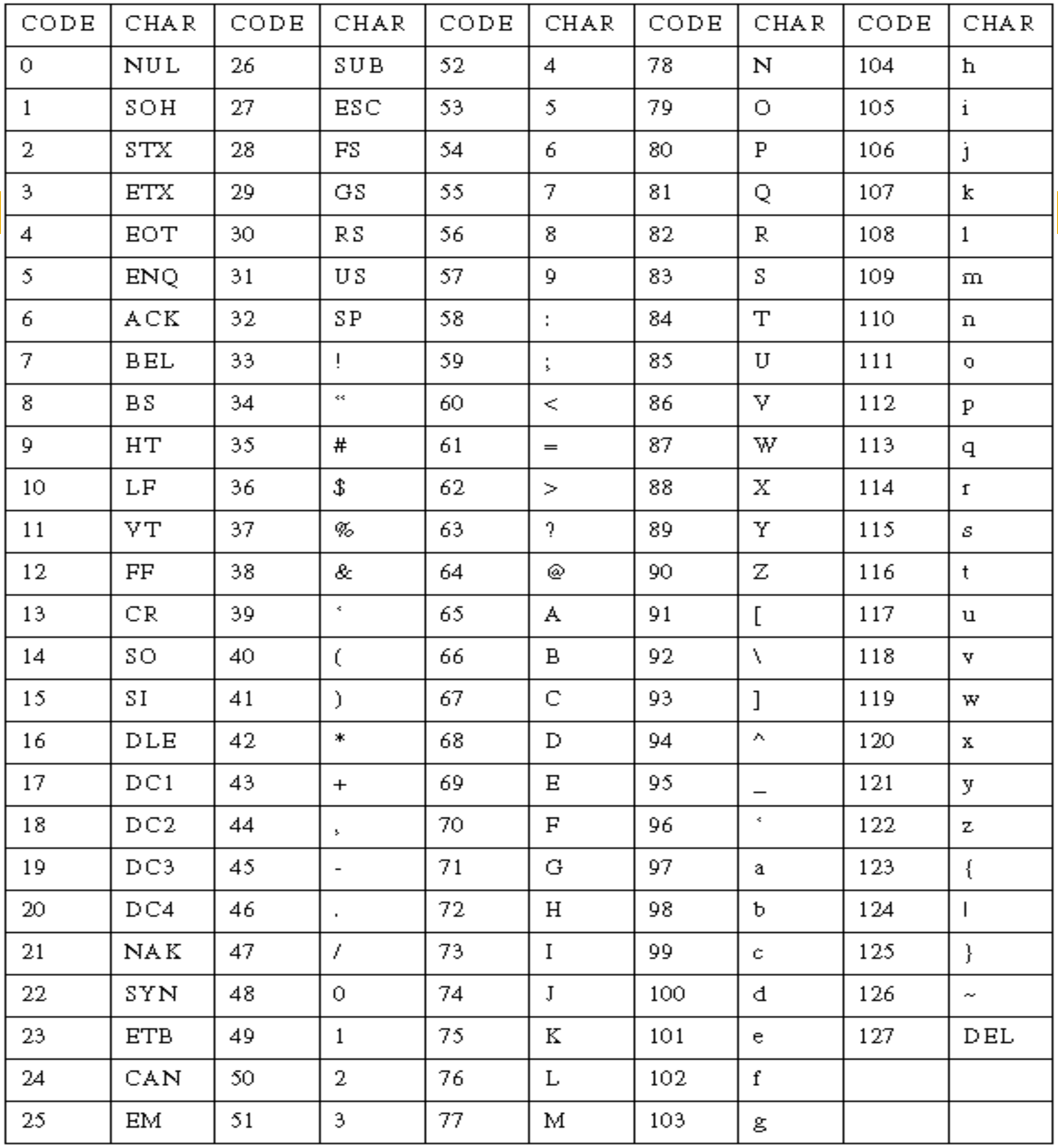
- File = sequence of bytes

67	73	65	79	10	83	10	…	

How bytes are mapped to chars?

- Character set = alphabet of characters
- Coding bytes by means of a character set
  - ASCII, EBCDIC (1 byte per char)
  - UNICODE (1/2/4 bytes per char)

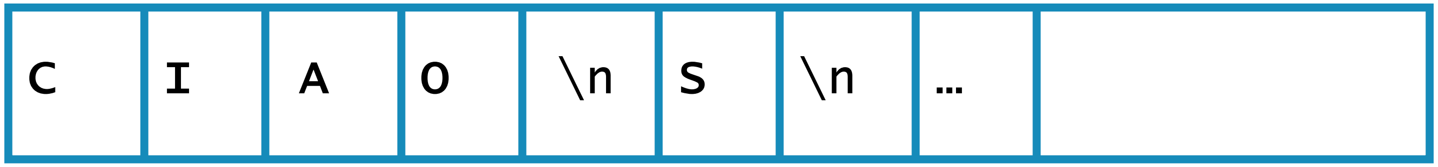
American Standard Code for Information Interchange



CODE	CHAR	CODE	CHAR	CODE	CHAR	CODE	CHAR	CODE	CHAR
0	NUL	26	SUB	52	4	78	N	104	h
1	SOH	27	ESC	53	5	79	O	105	i
2	STX	28	FS	54	6	80	P	106	j
3	ETX	29	GS	55	7	81	Q	107	k
4	EOT	30	RS	56	8	82	R	108	l
5	ENQ	31	US	57	9	83	S	109	m
6	ACK	32	SP	58	:	84	T	110	n
7	BEL	33	!	59	;	85	U	111	o
8	BS	34	"	60	<	86	V	112	p
9	HT	35	#	61	=	87	W	113	q
10	LF	36	$	62	>	88	X	114	r
11	VT	37	%	63	?	89	Y	115	s
12	FF	38	&	64	@	90	Z	116	t
13	CR	39	'	65	A	91	[	117	u
14	SO	40	(	66	B	92	\	118	v
15	SI	41	)	67	C	93	]	119	w
16	DLE	42	*	68	D	94	^	120	x
17	DC1	43	+	69	E	95	_	121	y
18	DC2	44	,	70	F	96	`	122	z
19	DC3	45	-	71	G	97	a	123	{
20	DC4	46	.	72	H	98	b	124	|
21	NAK	47	/	73	I	99	c	125	}
22	SYN	48	0	74	J	100	d	126	~
23	ETB	49	1	75	K	101	e	127	DEL
24	CAN	50	2	76	L	102	f		
25	EM	51	3	77	M	103	g		

Text file = file+character set

- Text file = sequence di characters

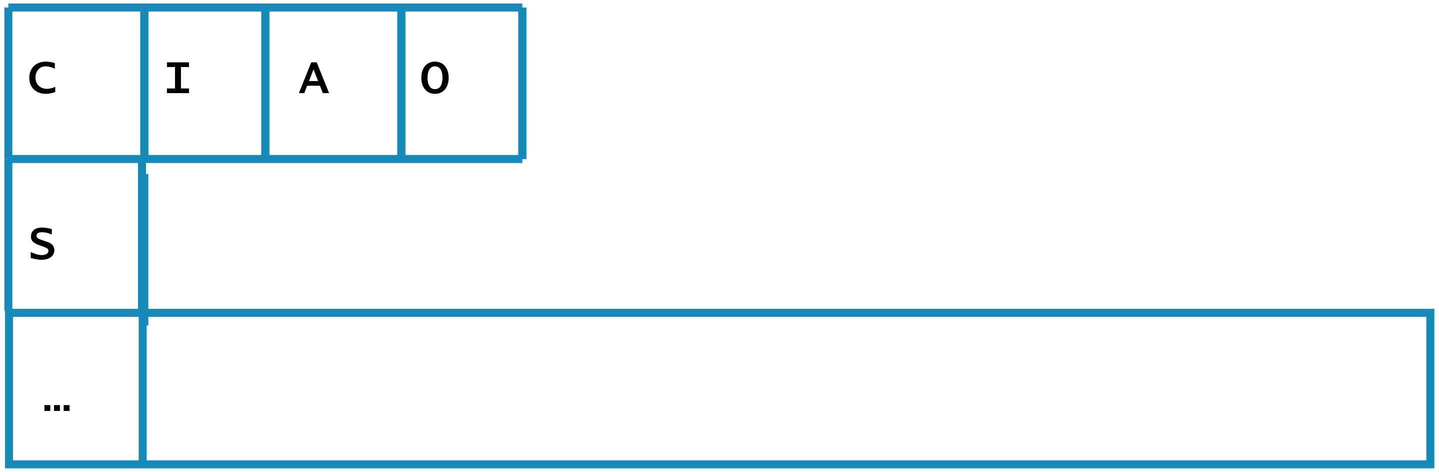


Viewing text files

- By a text editor
  - Emacs, Nodepad++,TextPad, UltraEdit, Vi, etc.
- "Carriage return" character
  - Start a new line
  - Coding
    - Unix: 1 char ASCII(0A) ('\n' in Java)
    - Windows: 2 chars ASCII(0D 0A) ("\r\n" in Java)
    - Mac: 1 char ASCII(0D) ('\r' in Java)
  - Conversions
    - > **dos2unix**
    - > **unix2dos**

Text file = file+character set

- Text file = sequence of **lines**



Tabular data format

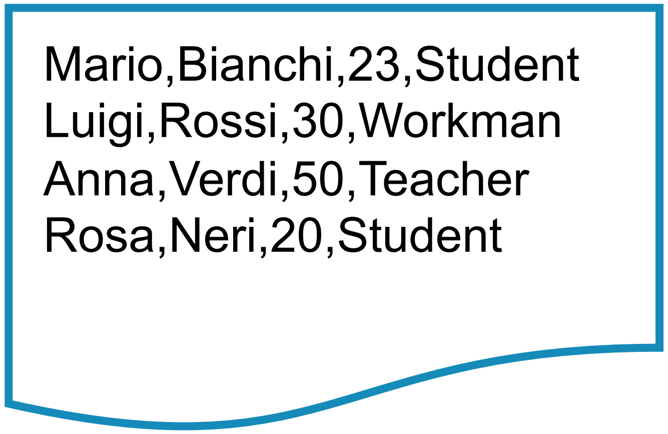
Column

Row

Mario	Bianchi	23	Student
Luigi	Rossi	30	Workman
Anna	Verdi	50	Teacher
Rosa	Neri	20	Student

Representing tabular data in text files

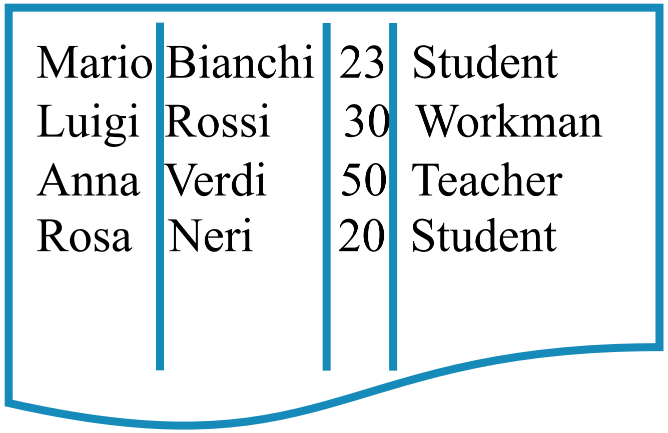
- **Comma Separated Values (CSV)**
  - A row per line
  - Column values in a line separated by a special character
  - Delimiters: comma, tab, space



```
Mario,Bianchi,23,Student
Luigi,Rossi,30,Workman
Anna,Verdi,50,Teacher
Rosa,Neri,20,Student
```

Representing tabular data in text files

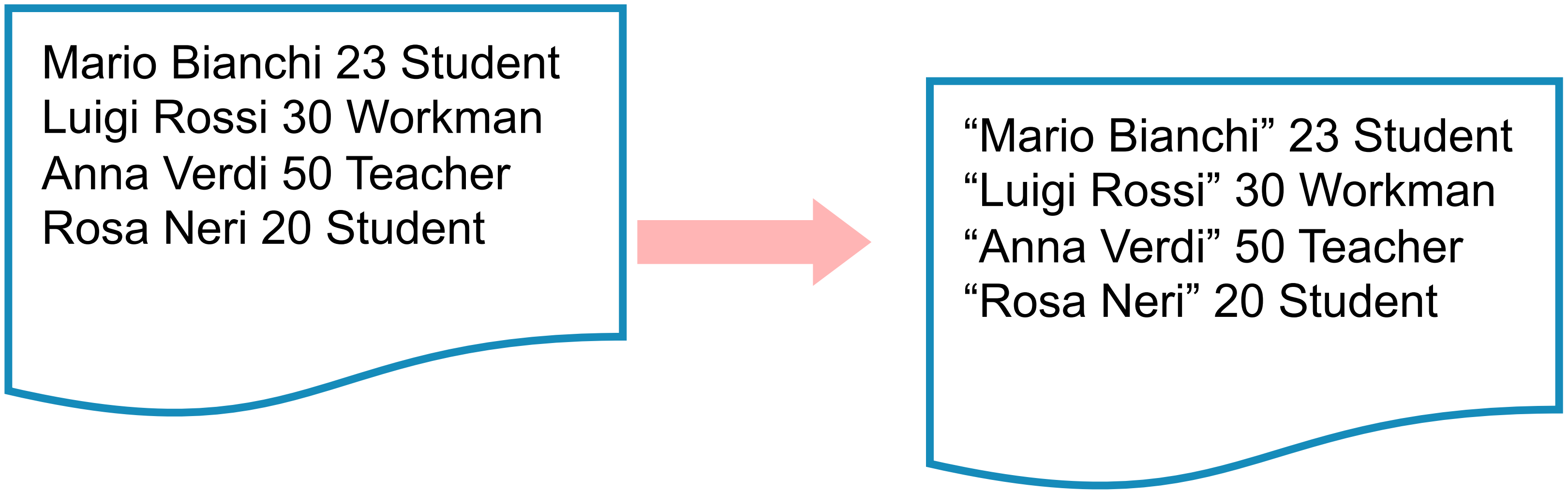
- **Fixed Length Values (FLV)**
  - A row per line
  - Column values occupy a fixed number of chars
    - Allow for random access to elements
    - Higher disk space requirements



Mario	Bianchi	23	Student
Luigi	Rossi	30	Workman
Anna	Verdi	50	Teacher
Rosa	Neri	20	Student

Quoting

- What happens in CSV if a delimiter is part of a value?
  - Format error
- Solution: **quoting**
  - Special delimiters for start and end of a value (ex. " … ")

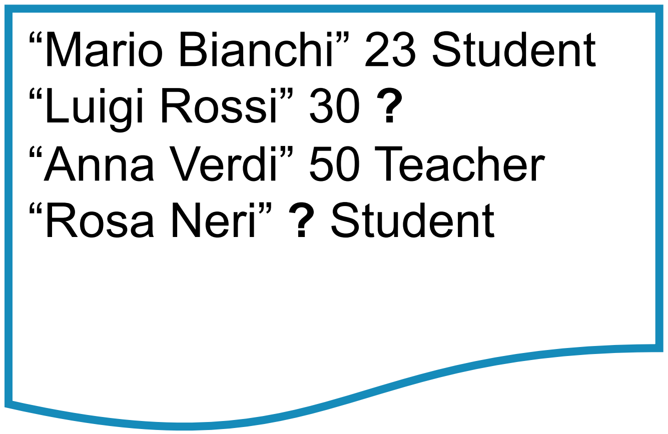


```
Mario Bianchi 23 Student
Luigi Rossi 30 Workman
Anna Verdi 50 Teacher
Rosa Neri 20 Student
```

```
"Mario Bianchi" 23 Student
"Luigi Rossi" 30 Workman
"Anna Verdi" 50 Teacher
"Rosa Neri" 20 Student
```

Missing values

- How to represent missing values in CSV or FLV?
  - A reserved string: "?", "null", ""



```
"Mario Bianchi" 23 Student
"Luigi Rossi" 30 ?
"Anna Verdi" 50 Teacher
"Rosa Neri" ? Student
```

Meta-data

- Describe properties of data
  - Table name, column name, column type

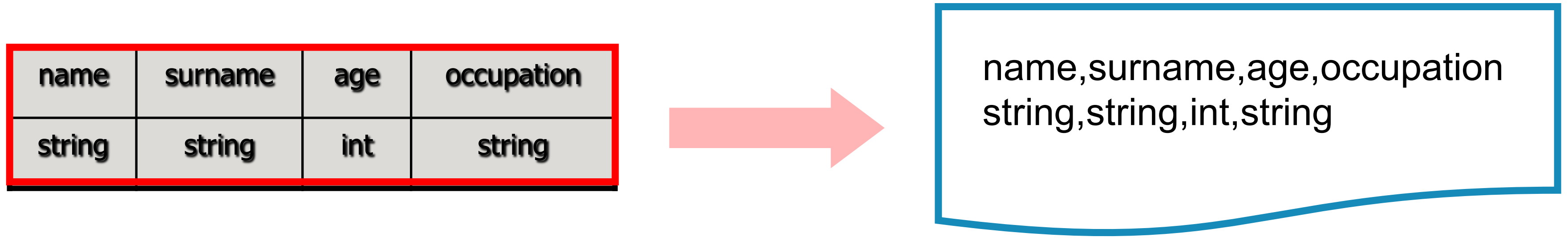
name	surname	age	occupation
string	string	int	string
Mario	Bianchi	23	Student
Luigi	Rossi	30	Workman
Anna	Verdi	50	Teacher
Rosa	Neri	20	Student

Meta-data: ARFF data types

- ARFF (Attribute-Relation File Format)
  - real / integer/ numeric
    - they are synonyms and cover numeric types
  - String
    - covers strings of any length
  - { name-1, …, name-n }
    - enumerated type
    - covers an enumeration of values
    - Ex., {high, medium, low} {Play, Don’t Play}
  - date "yyyy-MM-dd HH:mm:ss"
    - date and time
    - Ex., "2001-04-03 12:12:12"

How to represent meta-data in text files?

- Two rows: names and types

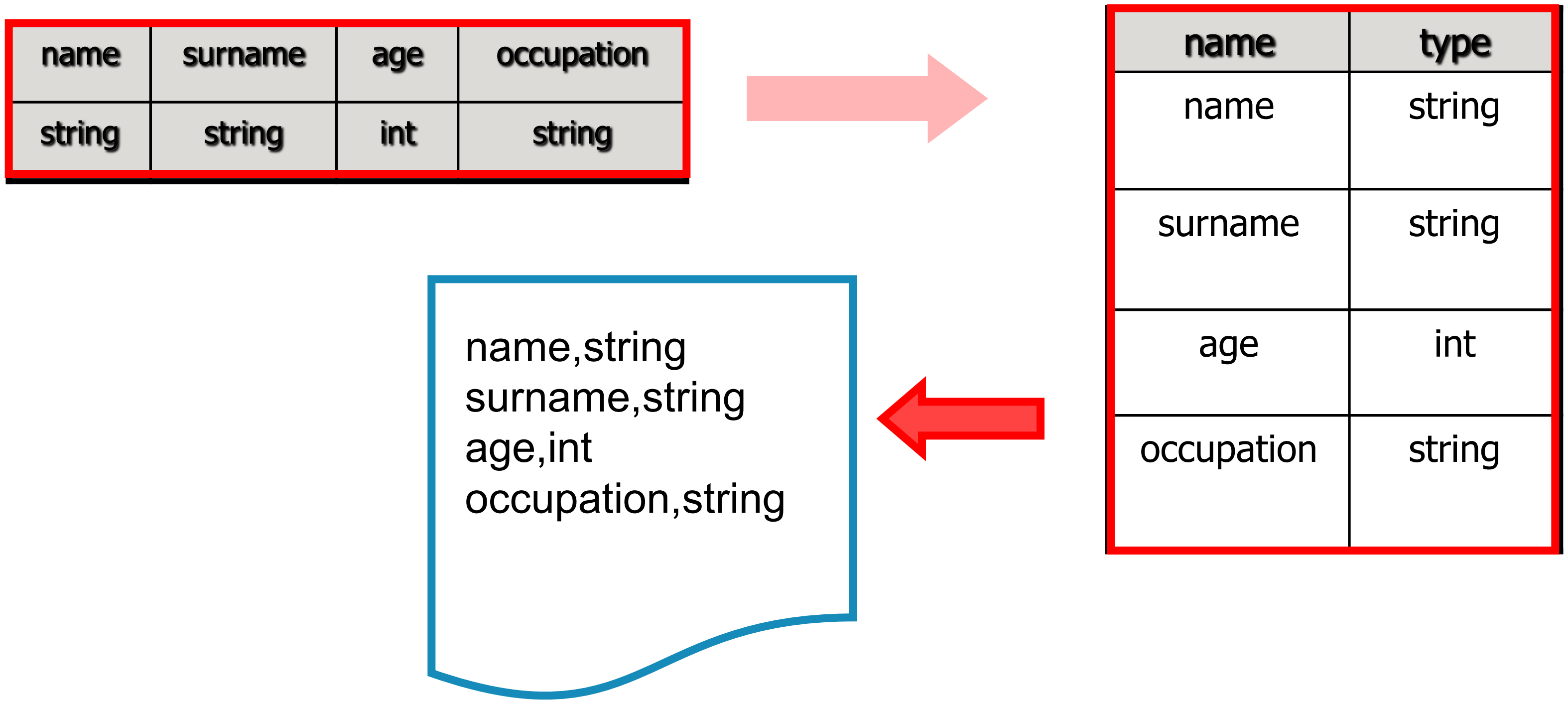


name	surname	age	occupation
string	string	int	string

```
name,surname,age,occupation
string,string,int,string
```

How to represent meta-data in text files?

- n rows, with two columns: name and type



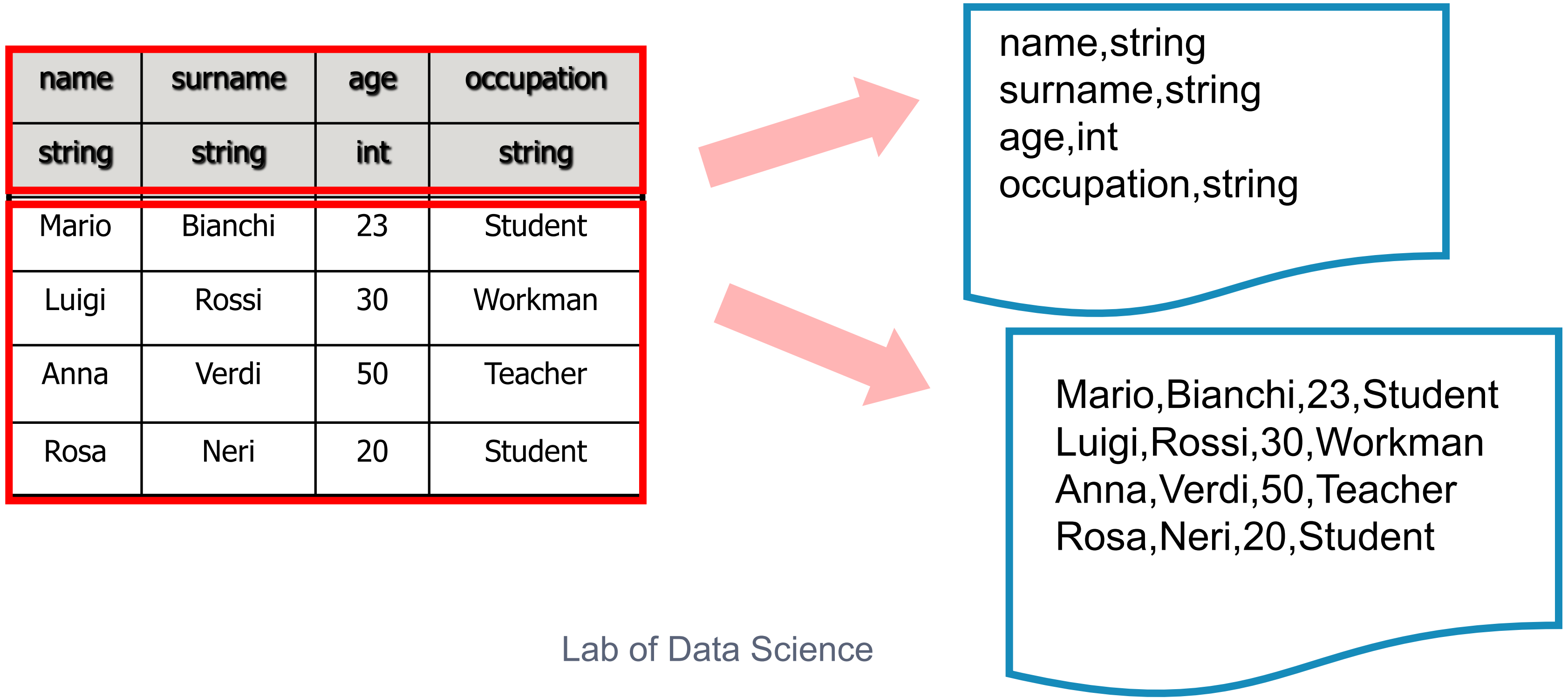
name	surname	age	occupation
string	string	int	string

name	type
name	string
surname	string
age	int
occupation	string

```
name,string
surname,string
age,int
occupation,string
```

Meta-data and data in text files

- Two distinct files
  - Eg., C4.5 format with .names and .data



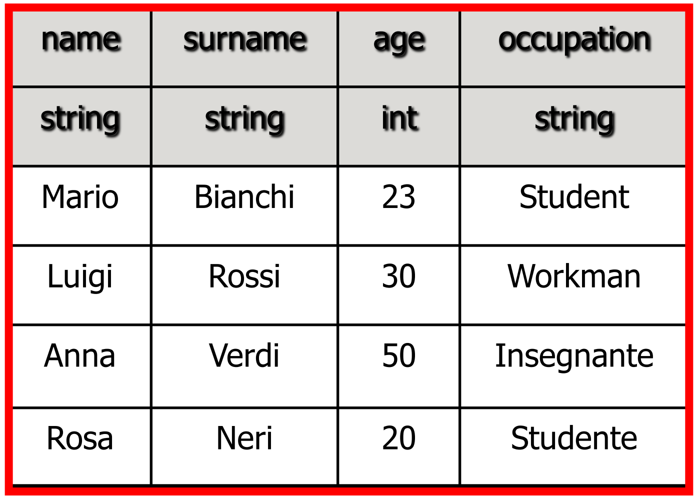
name	surname	age	occupation
string	string	int	string
Mario	Bianchi	23	Student
Luigi	Rossi	30	Workman
Anna	Verdi	50	Teacher
Rosa	Neri	20	Student

```
name,string
surname,string
age,int
occupation,string
```

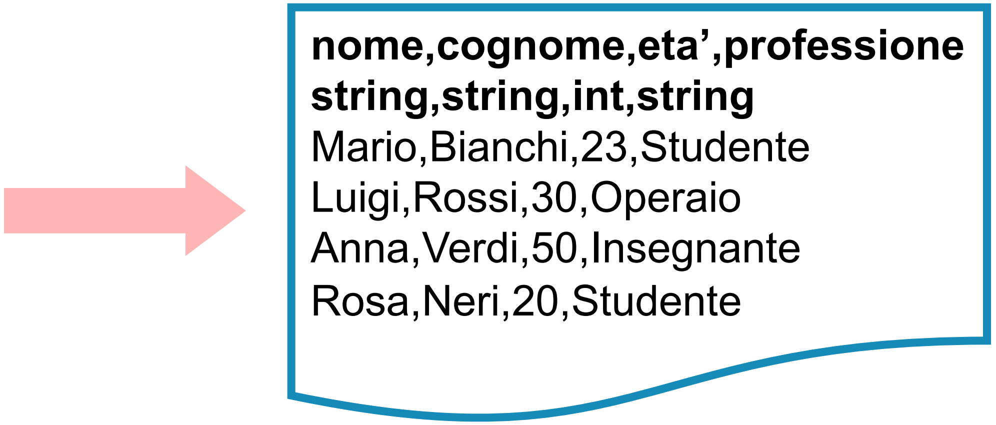
```
Mario,Bianchi,23,Student
Luigi,Rossi,30,Workman
Anna,Verdi,50,Teacher
Rosa,Neri,20,Student
```

Meta-data and data in text files

- In the same file
  - Meta-data first, then data



name	surname	age	occupation
string	string	int	string
Mario	Bianchi	23	Student
Luigi	Rossi	30	Workman
Anna	Verdi	50	Insegnante
Rosa	Neri	20	Studente



nome,cognome,eta',professione
string,string,int,string
Mario,Bianchi,23,Studente
Luigi,Rossi,30,Operaio
Anna,Verdi,50,Insegnante
Rosa,Neri,20,Studente

Meta-data and data in text files

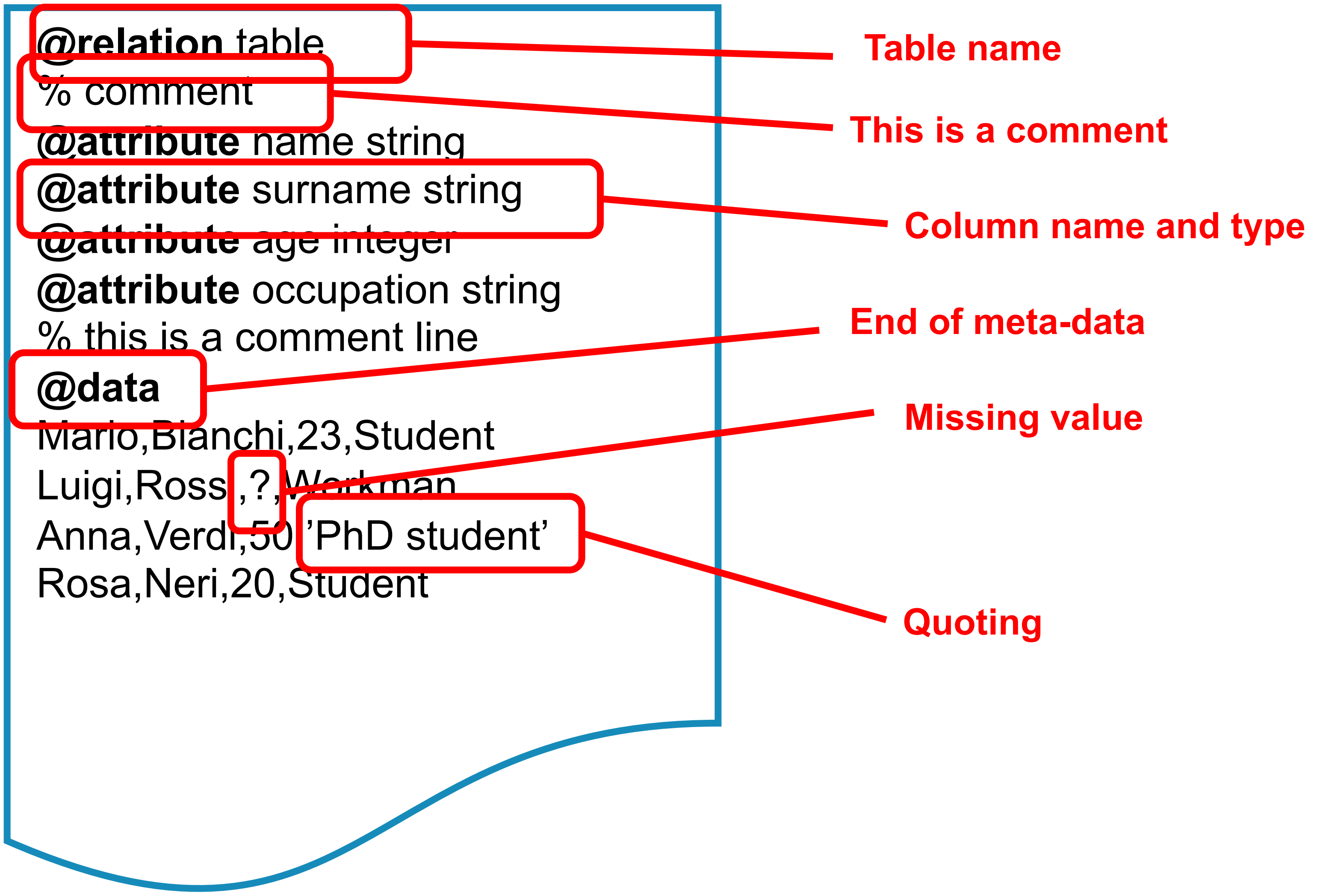
- In the same file
  - Meta-data first, then data
  - A delimiter line may be required

nome	cognome	eta'	professione
string	string	int	string
Mario	Bianchi	23	Studente
Luigi	Rossi	30	Operaio
Anna	Verdi	50	Teacher
Rosa	Neri	20	Student

$\rightarrow$

```
name,string
surname,string
age,int
occupation,string
@data
Mario,Bianchi,23,Student
Luigi,Rossi,30,Workman
Anna,Verdi,50,Teacher
Rosa,Neri,20,Student
```

Weka ARFF format



```
@relation table
% comment
@attribute name string
@attribute surname string
@attribute age integer
@attribute occupation string
% this is a comment line
@data
Mario,Bianchi,23,Student
Luigi,Rossi,?,Workman
Anna,Verdi,50,'PhD student'
Rosa,Neri,20,Student
```

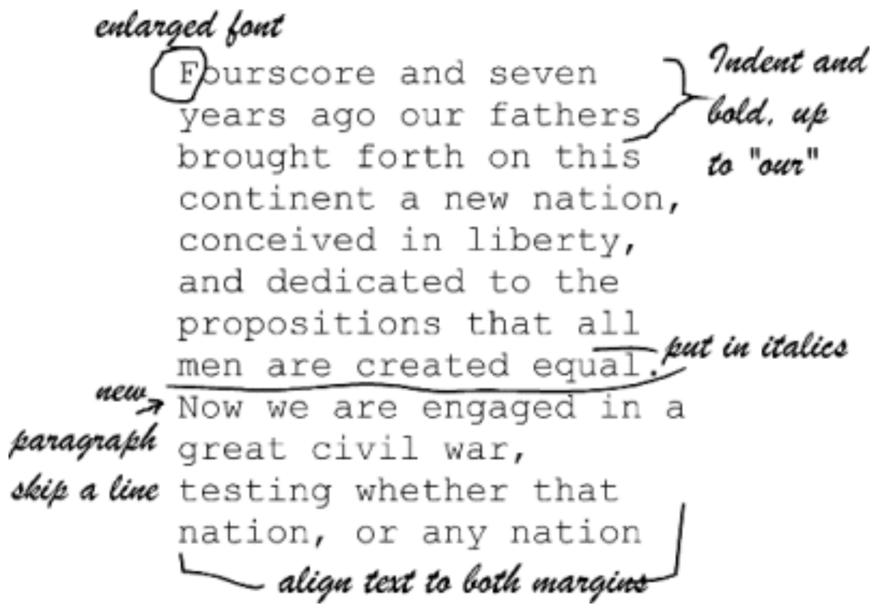
Two issues

- **Where** are my files?
  - Local file systems
  - Distributed file systems
  - Network protocols

- Which **format** is data in?
  - Text
    - CSV, ARFF
  - XML
  - Binary, Compressed, …

Data representation in XML

- XML = **eXtensible Markup Language**
- **XML** allows for the definition of markup languages that represent structured data
  - Markup: marking, tagging, highlighting the meaning of a data element



Fourscore and seven years ago our fathers brought forth on this continent a new nation, conceived in liberty, and dedicated to the propositions that all men are created equal.
Now we are engaged in a great civil war, testing whether that nation, or any nation

enlarged font
Indent and bold, up to "our"
put in italics
new paragraph
skip a line
align text to both margins

Why using markup languages?

- Problem: **data interchange** between applications
  - Proprietary data format do not allow for easy interchange
    - CSV with different delimiters, or column orders
    - Similar limitations of FLV, ARFF, binary data, etc.

- Solution:
  - definition of an interchange format…
  - … marking data elements with their meaning …
  - … so that any other party can easily interpret them.

XML by example

```
<?xml version="1.0" encoding="UTF-8"?>
<Music>
     <CD number="1" >
      <song track="1">
            <artist>Iron Maiden</artist>
            <album>Killers</album>
            <year>1980</year>
            <title>The Ides of March</title>
            <length>1:55</length>
      </song>
      <!– this is a comment -->
      <song track="4">
            <artist>Iron Maiden</artist>
            <album>Powerslave</album>
            <title>Another Life</title>
            <length>3:12</length>
      </song>
     </CD>
     …
</Music>
```

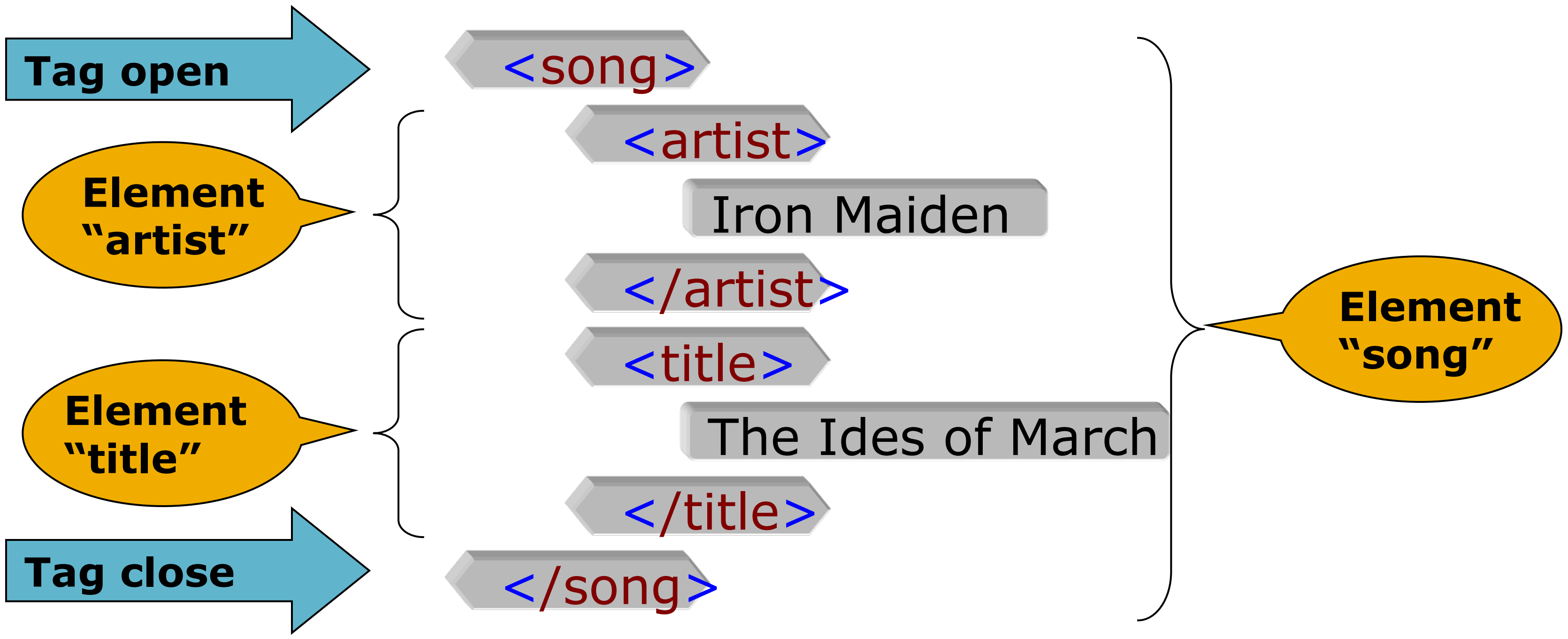
Prologue: XML declaration

```
<?xml version="1.0" encoding="UTF-8"?>
```

- Mandatory at the beginning of the document
- Attributes:
  - *version*: (mandatory) XML version of the document.
  - *encoding*: (optional) character encoding (default: UTF-8)
  - *standalone*: (optional) if set to yes then the document does not refer to external documents (default: no)

Elements

- An **element** is a piece of data, delimited by and identified by a **tag name**.



```
<song>
    <artist>
        Iron Maiden
    </artist>
    <title>
        The Ides of March
    </title>
</song>
```

Elements

- **Tag open** syntax :

  <*name attributes*>

  - ***name*** is the name of the element.
  - ***attributes*** is an *optional* list of attribute-values

- **Tag close** syntax:

  </*name*>

  - ***name*** is the name of the element

- Elements with no content:

  <*name attributes* />

- There exists one and only one **root element**

Attributes

- They allow for specifying properties of elements using the syntax **attribute = “value”**

  <name attribute=“value”>

  - `<CD number="1" >`

- Attributes appear in the tag open
  - Order is not relevant
  - The “attribute or inner element?” dilemma

Text

- Reserved chars: ‘>’, ‘<’ and ‘&’
  - Meta-characters for reserved chars
    - &gt (greater-than sign: >);
    - &lt (less-than sign: <);
    - & amp (ampersand);
  - Character entities: ‘à’
    - **&agrave;**

- CDATA sections
  - Bunch of textual data
    - <!CDATA[here any text with no XML meaning]]>

Tabular data, again

name	surname	age	occupation
string	string	int	string
Mario	Bianchi	23	Student
Luigi	Rossi	30	Workman
Anna	Verdi	?	Teacher
Rosa	Neri	20	Student

How to represent tabular data in XML?

- Format “**Row**”
  - an element <row> for every row, with an attribute for every non-missing column value

```
<?xml version="1.0" encoding="UTF-8"?>
<root>
   <row name=“Mario” surname=“Bianchi” age=“23” ocpt=“Student” />
   <row name=“Luigi” surname=“Rossi” age=“30” ocpt=“Workman” />
   <row name=“Anna” surname=“Verdi” ocpt=“Teacher” />
   <row name=“Mario” surname=“Bianchi” age=“23” ocpt=“Student” />
</root>
```

How to represent tabular data in XML?

- Format "**Elements**"
  - an element <row> with an inner element for every non-missing column value

```
<?xml version="1.0" encoding="UTF-8"?>
<root>
    <row>
        <name>Mario</name>
        <surname>Bianchi</surname>
        <age>23</age>
        <ocpt>Studente</ocpt>
    </row>
    <row>
        <name>Luigi</name>
        <surname> Rossi </surname>
        <age>30</age>
        <ocpt> Operaio </ocpt>
    </row>
</root>
```

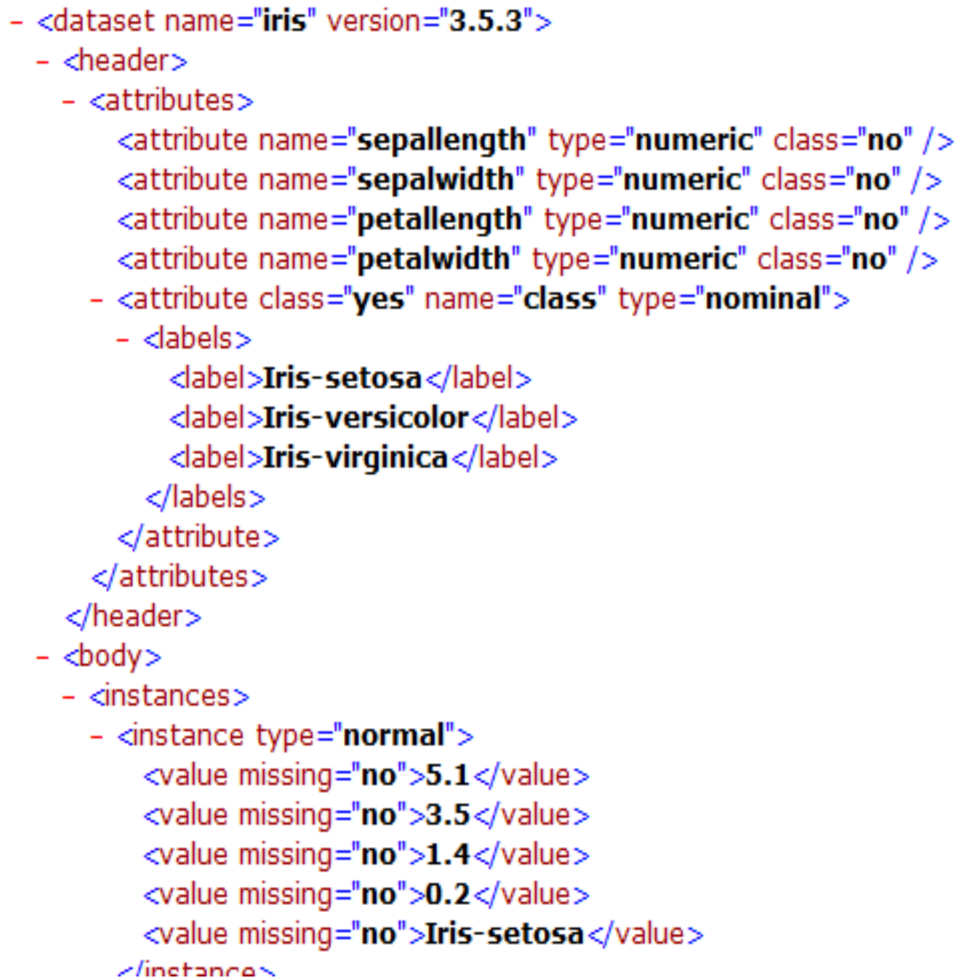
How to represent meta-data in XML?

- An element <schema> with an inner element <attribute> for every column

```
<?xml version="1.0" encoding="UTF-8"?>
<root>
    <schema>
          <attribute name=“name” type=“string”/>
          <attribute name=“surname” type=“string”/>
          <attribute name=“age” type=“int”/>
          <attribute name=“ocpt” type=“string”/>
     </schema>
   <row name=“Mario” surname=“Bianchi” age=“23” ocpt=“Student” />
   <row name=“Luigi” surname=“Rossi” age=“30” ocpt=“Workman” />
   <row name=“Anna” surname=“Verdi” ocpt=“Teacher” />
   <row name=“Mario” surname=“Bianchi” age=“23” ocpt=“Student” />
</root>
```

ARFF+XML = XRFF

- eXtensible attribute-Relation File Format
- XML version of ARFF
  - with additional column data types



```
- <dataset name="iris" version="3.5.3">
  - <header>
    - <attributes>
        <attribute name="sepallength" type="numeric" class="no" />
        <attribute name="sepalwidth" type="numeric" class="no" />
        <attribute name="petallength" type="numeric" class="no" />
        <attribute name="petalwidth" type="numeric" class="no" />
      - <attribute class="yes" name="class" type="nominal">
        - <labels>
            <label>Iris-setosa</label>
            <label>Iris-versicolor</label>
            <label>Iris-virginica</label>
          </labels>
        </attribute>
      </attributes>
    </header>
  - <body>
    - <instances>
      - <instance type="normal">
          <value missing="no">5.1</value>
          <value missing="no">3.5</value>
          <value missing="no">1.4</value>
          <value missing="no">0.2</value>
          <value missing="no">Iris-setosa</value>
        </instance>
```