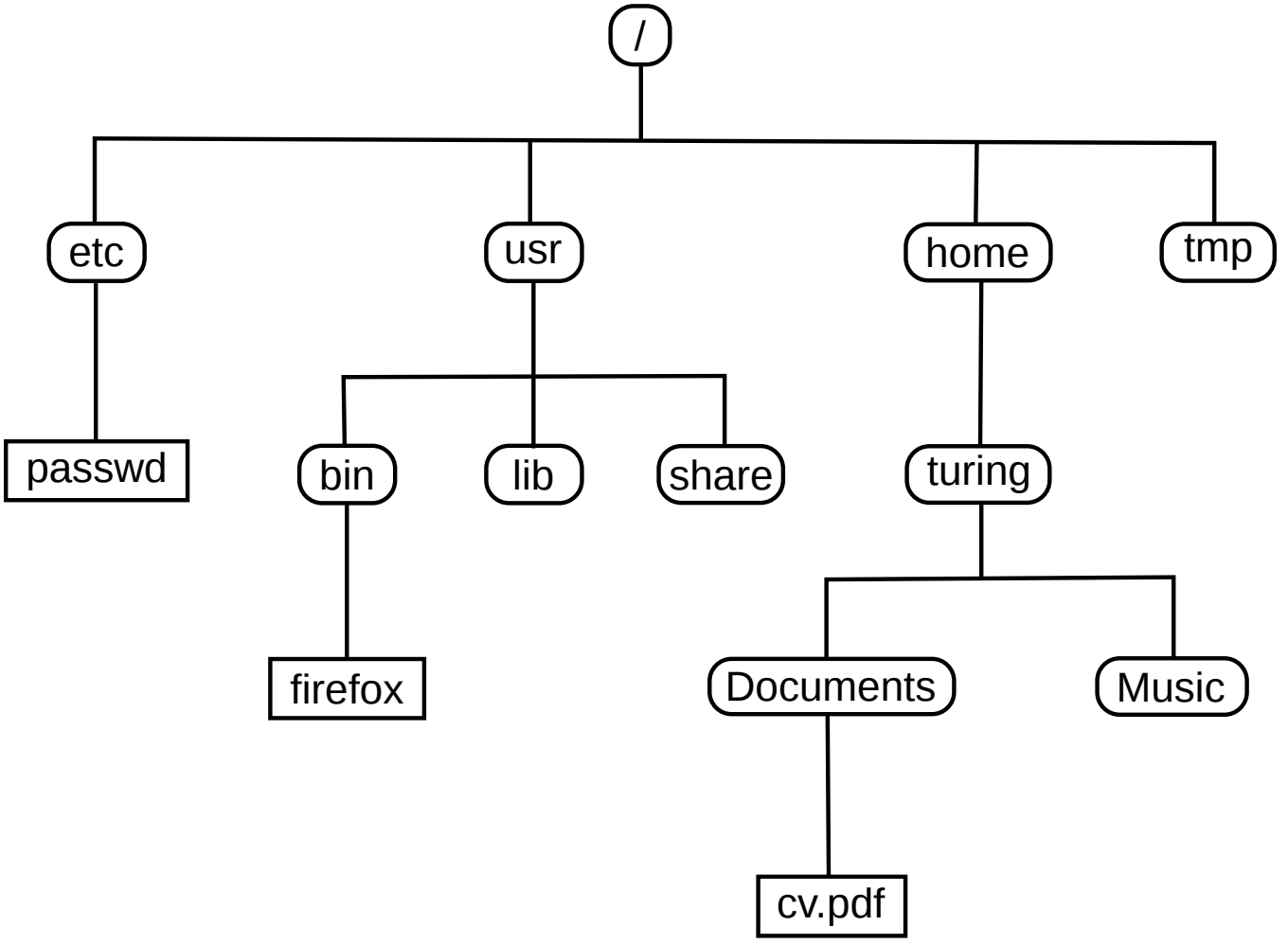
File System

- data and programs are kept on secondary storage
- conceptual unit: file

- a container of files: folder
- also called: directory

- folders can be nested inside other folders
- top level folder: root

Unix File System



Paths

- how to refer to a file?
- path: sequence of folders, followed by the file

- absolute path: start from the root
- relative path: start from the “current” folder

- current folder: .
- parent folder (immediately above the current): ..

File Manager

- utility for file operations

- move around the file system
- create, delete
- copy, move, rename, …

File Types

- two types of files

- text: human-readable, easier to work with
- binary: only machine-readable, more efficient

File Extensions

- file names have an extension part
- for example: `.pdf`

MIME

- standard categorization of file types
- format: `type/subtype`
- types: image, audio, video, text, …

- image/jpeg, image/png
- audio/mpeg
- video/mp4, video/x-matroska
- application/pdf, application/zip
- text/html, text/plain

Text Editor

- application for creating and modifying text files

Archiving and Compression

- combine files and folders into one archive file
- compress a file for smaller file size

- extract archive file to get the original structure

- `tar` (archiving)
- `gzip`, `bzip2` (compression)
- `zip` (both)

User Interfaces

- how users interact with applications

- graphical environment: windows, mouse, …
- GUI: graphical user interface

- terminal: type command, see result
- CLI: command line interface

Bistate Objects

- some objects are always in one of two states

- coins: heads/tails
- switches: on/off
- transistors: on/off

Binary Numbers

- computers represent information using binary numbers

- bit: binary digit
- one of two values: `0`, `1`

Representing Numbers

- digits correspond to powers of 2

2^4	2^3	2^2	2^1	2^0
16	8	4	2	1

Binary Value Examples

decimal	binary
2	10
3	11
4	100
5	101
13	1101
22	10110

Bytes

- 8 bits: byte
- smallest unit of information
- values: [0..255]

Byte Value Examples

decimal	binary
0	00000000
1	00000001
13	00001101
22	00010110
65	01000001
128	10000000
255	11111111

Binary Value Notation

- is a value written in decimal or in binary?
- 101: is it 101 or 5?

- notation: binary values start with `0b`
- 0b101

Larger Units

- 1KB (kilobyte) = 1024 bytes
- 1MB (megabyte) = 1024 KB
- 1GB (gigabyte) = 1024 MB
- 1TB (terabyte) = 1024 GB

Hexadecimal Numbers

- reading binary numbers is difficult

- hexadecimal: base 16
- digits correspond to powers of 16

16^3	16^2	16^1	16^0
4096	256	16	1

Hexadecimal Digits

dec	bin	hex
8	1000	8
9	1001	9
10	1010	A
11	1011	B

dec	bin	hex
12	1100	C
13	1101	D
14	1110	E
15	1111	F

Hexadecimal Notation

- 1 hex digit: 4 bits
- 1 byte: 8 bits, 2 hex digits

- notation: hex values start with `0x`

Hexadecimal Value Examples

dec	bin	hex
16	00010000	10
30	00011110	1E
255	11111111	FF

Hex-Binary Conversion

- match hexadecimal digits and groups of 4-bits

```
   F     3     C     0
1111 0011 1100 0000

1111001111000000
```

```
  1100111100000

0011 0011 1100 0000
   3    3     C    0
```

Character Sets

- how to represent letters, punctuation signs, …?
- assign a number to each character

- a set of all such assignments: character set
- also called an “encoding”

ASCII Character Set

- 128 characters

- English letters
- digits
- punctuation signs
- special characters

ASCII Table

char	#
!	0x21
#	0x23
7	0x37
?	0x3F
@	0x40

char	#
A	0x41
B	0x42
Z	0x5A
a	0x61
z	0x7A

Case Sensitivity

- ‘A’ and ‘a’ have different numbers
- most programs consider these as different letters

ISO8859 Sets

- ASCII only for English
- use 8 bits per character: 256 characters

- ISO8859-1: Western European
- first 128 same as ASCII

- ISO8859-9: Turkish
- Turkish instead of Icelandic

ISO8859-1 and ISO8859-9

#	ISO8859-1	ISO8859-9
0x3F	?	?
0x41	A	A
0xC7	Ç	Ç
0xE7	ç	ç
0xD0	Ý	Ğ
0xF0	ð	ğ

Unicode

- a way of encoding all characters in all writing systems

- UTF-32: 32 bits per character
- UTF-16: 16/24/32 bits per character
- UTF-8: 8/16/24/32 bits per character

UTF Examples

char	#
!	0x0021
A	0x0041
Ç	0x00C7
∞	0x221E
举	0x4E3E

Metadata

- two types of data associated with a file

- actual data: content of the file
- metadata: data describing the content

Metadata Examples

- photo file:
- actual data: photograph
- metadata: who, where, when, image format, …

- song file
- actual data: song
- metadata: title, artist, lyrics, audio format, …

Text File Metadata

- actual data: text in the file
- metadata: copyright, author, …
- character set

Providing Metadata

- in some file formats, metadata is stored in the file along with the actual data
- cameras store technical metadata in photograph file
- music files can contain title, artist, …

- in some file formats, metadata has to be provided externally
- character set of a text file