C/C++ File Operations

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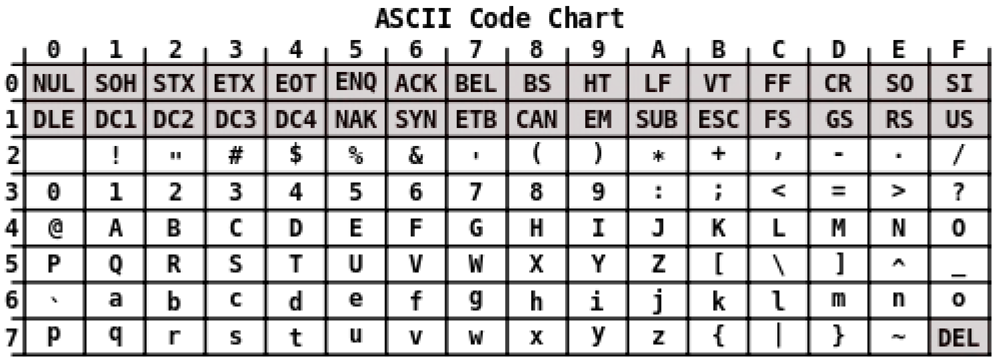
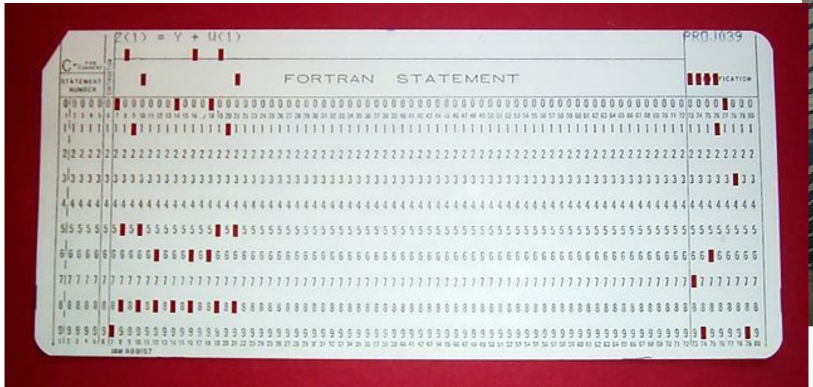
Files

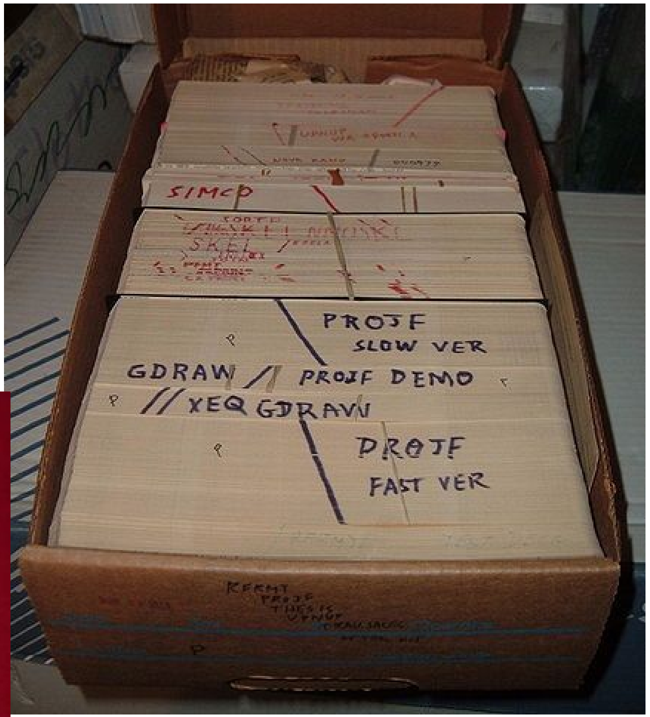
File : a block of arbitrary information, or resource for storing information, which is available to a computer program and is usually based on some kind of durable storage. [wikipedia]



ASCII Code Chart

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





File Properties

- Files are organized into one-dimensional arrays of bytes.
  - The format of a file is defined by its content, since a file is solely a container for data.
  - A file might have a size (number of bytes).
  - File permissions - who may or may not read, modify, delete or create files and folders.
- Files are typically accessed using names, and they can be located in directories.

```
#include <stdio.h>
#include <string.h>
#include <iostream>

int main() {
  FILE* fp_read = stdin;
  FILE* fp_write = stdout;
  if (fp_read == NULL || fp_write == NULL) return -1;
 ...
```

```
hexdump file_op.cc
00000 23 69 6e 63 6c 75 64 65 20 3c 73 74 64 69 6f 2e
00010 68 3e 0a 23 69 6e 63 6c 75 64 65 20 3c 73 74 72
00020 69 6e 67 2e 68 3e 0a 23 69 6e 63 6c 75 64 65 20
00030 3c 69 6f 73 74 72 65 61 6d 3e 0a 0a 69 6e 74 20
00040 6d 61 69 6e 28 29 20 7b 0a 20 20 46 49 4c 45 2a
00050 20 66 70 5f 72 65 61 64 20 3d 20 73 74 64 69 6e
00060 3b 0a 20 20 46 49 4c 45 2a 20 66 70 5f 77 72 69
00070 74 65 20 3d 20 73 74 64 6f 75 74 3b 0a 20 20 69
00080 66 20 28 66 70 5f 72 65 61 64 20 3d 3d 20 4e 55
00090 4c 4c 20 7c 7c 20 66 70 5f 77 72 69 74 65 20 3d
 ...
```

File Operations

- Creating a file with a given name.
- Setting attributes that control operations on the file.
- Opening a file to use its contents.
- Reading or updating the contents.
- Committing updated contents to durable storage.
- Closing the file, thereby losing access until it is opened again.

Unix File Permissions

- Files have owners and groups.
- Read, Write, eXecute permissions for User, Group, Others.
  - Directories : read permission to `ls`, execution to `cd`.
  - `chmod, chown, chgrp`

```
$ ls -al
total 296
drwxr-xr-x   7 jwlim  staff     238 Nov 11 23:23 .
drwxr-xr-x  41 jwlim  staff    1394 Nov 10 16:16 ..
-rwxr-xr-x   1 jwlim  staff  127656 Nov 10 17:06 a.out
-rw-r--r--   1 jwlim  staff    3628 Nov 10 17:06 main.cc
-rw-r--r--   1 jwlim  staff    3593 Nov 10 16:41 main_tmp.cc
-rw-r--r--   1 jwlim  staff    3221 Nov 10 16:17 matrix.cc
-rw-r--r--   1 jwlim  staff    4604 Nov 10 16:47 matrix.h
|\_/\_/\_/      \___/  \___/  \____/ \__________/ \__________/
t u  g  o       owner  group   size    mod. time    file name
y s  r  t
p e  o  h
e r  u  e
     p  r
```

C stdio File Interface - open, close

```
#include <stdio.h>

int main() {
  // FILE* fopen(const char* filename, const char* mode);
  //   r : read only, r+ : read and write (beginning of the file)
  //   w : truncate and write, w+ : read and write (beginning of the file)
  //   a : write (always end of file), a+ : read and write (always end)
  //   b : binary, ignored.
  FILE* fp = fopen("test.txt", "r");
  if (fp == NULL) return -1;  // Error in opening the file.

  // size_t fread(void* ptr, size_t size, size_t nitems, FILE* stream);
  char buf[2560];
  size_t read = fread(buf, 256, 10, fp);

  fclose(fp);
  return 0;
}
```

C stdio File Interface - read, write

```
#include <stdio.h>

int main() {
  FILE* fp_read = fopen("source.txt", "r");
  FILE* fp_write = fopen("destination.txt", "w");
  if (fp_read == NULL || fp_write == NULL)  return -1;

  char buf[1024];
  size_t read = 0;
  // size_t fread(void* ptr, size_t size, size_t nitems, FILE* stream);
  while ((read = fread(buf, 1, 1024, fp_read)) > 0) {
    // size_t fwrite(const void* ptr, size_t size, size_t nitems,
    //                FILE* stream);
    size_t written = fwrite(buf, read, 1, fp_write);
  }
  fclose(fp_read);
  fclose(fp_write);
  return 0;
}
```

C stdio File Interface - scanf, printf

```c
#include <stdio.h>

int main() {
  FILE* fp_read = fopen("source.txt", "r");
  FILE* fp_write = fopen("destination.txt", "w");
  if (fp_read == NULL || fp_write == NULL)  return -1;

  // int fscanf(FILE* stream, const char* format, ...);
  int data;
  while (fscanf(fp_read, "%d", &data) > 0) {
    // int fprintf(FILE* stream, const char* format, ...);
    fprintf(fp_write, "%d\n", data);
  }
  fclose(fp_read);
  fclose(fp_write);
  return 0;
}
```

C stdio File Interface - gets, puts

```
#include <stdio.h>
#include <string.h>   // memset

int main() {
  FILE* fp_read = fopen("source.txt", "r");
  FILE* fp_write = fopen("destination.txt", "w");
  if (fp_read == NULL || fp_write == NULL)  return -1;

  // char* fgets(char* str, int size, FILE* stream);
  char buf[1024];
  memset(buf, 0, 1024);
  while (fgets(buf, 1023, fp_read) > 0) {
    // int fputs(const char* str, FILE* stream);
    fputs(buf, fp_write);
  }
  fclose(fp_read);
  fclose(fp_write);
  return 0;
}
```

C stdio File Interface - end of file

```
#include <stdio.h>
#include <string.h>   // memset
#include <iostream>

int main() {
  FILE* fp = fopen("test.txt", "r");
  if (fp == NULL) return -1;   // Error in opening the file.

  char buf[1024];
  memset(buf, 0, 1024);
  // int feof(FILE* stream); - non-zero if end-of-file flag is set.
  while (!feof(fp)) {
    fgets(buf, 1023, fp);
    std::cout << buf;
  }

  fclose(fp);
  return 0;
}
```

C stdio File Interface - seek

```
#include <stdio.h>
#include <iostream>

int main() {
  FILE* fp = fopen("data.bin", "r");
  if (fp == NULL) return -1;  // Error in opening the file.

  // int fseek(FILE* stream, long offset, int whence);
  //   SEEK_SET, SEEK_CUR, SEEK_END; returns 0 if successful.
  // void rewind(FILE* stream);  = fseek(stream, 0L, SEEK_SET);
  // long ftell(FILE* stream);
  fseek(fp, 0L, SEEK_END);
  std::cout << ftell(fp) << std::endl;   // Prints the size of the file.

  char buf[256];
  fseek(fp, 1024L, SEEK_SET);
  size_t read = fread(buf, 256, 10, fp);

  fclose(fp);
  return 0;
}
```

C stdio File Interface - stdin, stdout

```
#include <stdio.h>
#include <string.h>   // memset

int main() {
  FILE* fp_read = stdin;
  FILE* fp_write = stdout;
  if (fp_read == NULL || fp_write == NULL)  return -1;

  char buf[1024];
  memset(buf, 0, 1024);
  // char* fgets(char* str, int size, FILE* stream);
  while (fgets(buf, 1023, fp_read) > 0) {
    // int fputs(const char* str, FILE* stream);
    fputs(buf, fp_write);
  }
  fclose(fp_read);
  fclose(fp_write);
  return 0;
}
```

C++ File Stream Interface

- ifstream, ofstream : similar to cin, cout, but for files.

```
// print the content of a text file.
#include <iostream>
#include <fstream>

using namespace std;

int main () {
  ifstream infile;
  infile.open("test.txt", ifstream::in);

  int ch = infile.get();
  while (infile.good()) {
    cout << (char) ch;
    ch = infile.get();
  }
  infile.close();
  return 0;
}
```

C unistd File Interface

Used when low-level control on files is needed.
  e.g. change permission, network socket communication, file locking, etc.

- Headers : `unistd.h`, `fcntl.h`
- `FILE* fp : int file_descriptor`
- `fopen`, `fclose`, `fread`, `fwrite` , … :
  `open`, `close`, `read`, `write`, …