

Files

Fundamentals of Computer and Programming
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What We Will Learn

- Introduction
 - Text vs. Binary files
- Text File Operations
 - Open/Close
 - Read/Write
- Binary File Operations
 - Open/Close
 - Read/Write
- Bugs and avoiding them



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Introduction

- Data storages of computers
 - 1- Main memory (RAM)
 - It is volatile
 - Read / Write data using variables
 - 2-Secondary storage (Hard Disk)
 - It is **not** volatile
 - Read / Write data using **files**



Text & Binary Files

- How does computer store data?
 - They are coded
- When data are stored in main memory
 - It is variable
 - Coding is specified by the type: int, char, ...
- When data are stored in secondary memory
 - It is file
 - Coding is specified by the file type: **Text** & **Binary**



Text Files

- ASCII encoding
- Each line is a string
- Each line is terminated by `\n`
- Human-readable files
 - Editable by text editor (e.g. Notepad)
- Examples
 - C source files
 - Every `.txt` files



Binary Files

➤ Binary encoding

- int, double, float, struct, ... are directly (as 0,1) stored in the file

➤ Human unreadable files

- Is not editable by text editor
 - Needs special editor which understands the file

➤ Examples

- .exe files
- Media files such as .mp3
- Picture files such as .bmp, .jpg



Working with Files

➤ Until now

- We read/write data from/to terminal (console)

➤ In C

- We can read data from file
- We can write data to file



Working with Files

- Main steps in working with files
- 1) Open file
 - Get a file handler from Operating System
- 2) Read/Write
 - Use the handler
- 3) Close file
 - Free the handler
- 4) Other operations
 - Check end of file, skip in file, ...



Opening Files

- Function **fopen** opens files

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

```
FILE * fopen(char *name, char *mode);
```

- **FILE** * is struct

- Saves information about file.
- We **don't need** to know about it.

- If cannot open file, fopen returns **NULL**.

- name is the name of file:

- Absolute name: **C:\prog\test.txt**
- Relative name: **Mytest.txt**



Opening Files: Modes

- **r**: open for read. We **cannot** write to the file.
- **w**: open for write. Create new file. We **cannot** read from the file. If file exist, its content will be destroyed.
- **a**: open for write. We **cannot** read from the file. If file exist, its content **won't** be destroyed. We write at end of file.
- **r+**, **w+**, **a+** : same to **r**, **w**, **a** but we **can** read and write.



Opening Files: Modes

- Files are
 - Text: Some strings
 - Binary: Image file, Video file, ...
- To open binary file, we should add **b** to the mode.
 - `rb` : open binary file for read
 - `w+b`: create new binary file for read and write



Opening Files: Example

```
FILE *fp;  
  
fp = fopen("c:\\test.txt", "r");  
  
if(fp == NULL) {  
    printf("Cannot open file\n");  
    return -1;  
}
```

➤ Open file c:\\test.txt for read



File-Position Pointer (FPP)

- File-Position Pointer
 - A pointer in file
 - Points to current location of read and write
- When file is open
 - File-Position Pointer is set to start of file
- When you read/write from/to file
 - The File-Position Pointer advance according to the size of data
 - If you read 2 bytes, it moves 2 bytes
 - If you write 50 bytes, it advances 50 bytes



Closing Files

- Each opened file should be closed.
- If we write to a file and don't close it, some of data will be **LOST**
- To close the file

```
fclose(FILE *fp) ;
```



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Reading/Writing Text File

- `fscanf` reads from file. `fscanf` is same to `scanf`. Return **EOF** if reached.
- `fprintf` writes to file. `fprintf` is same to `printf`.

```
int fscanf(FILE *fp, "format",  
parameters);
```

```
int fprintf(FILE *fp, "format",  
parameters);
```



Text File: Example

➤ We have file in this format

<Number of students>

<id of student 1> <grade of student 1>

<id of student 2> <grade of student 2>

...

<id of student n> <grade of student n>



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

برنامه‌ای که شماره و نمره
دانشجویان را از فایل بخواند و
میانگین را محاسبه کند.

```
int main(void) {
    FILE *fpin;
    char inname[20];
    int num, i, id;
    float sum, average, grade;

    printf("Enter the name of input file: ");
    scanf("%s", inname);

    fpin = fopen(inname, "r");
    if(fpin == NULL) {
        printf("Cannot open %s\n", inname);
        return -1;
    }
}
```

```
/* Read the number of students */  
fscanf(fpin, "%d", &num);  
  
/* Read the id and grade from file */  
sum = 0;  
for(i = 0; i < num; i++){  
    fscanf(fpin, "%d %f", &id, &grade);  
    sum += grade;  
}  
  
average = sum / num;  
printf("Average = %f\n", average);  
  
fclose(fpin);  
return 0;  
}
```

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

```
int main(void){
```

```
    FILE *fpin, *fpout;
```

```
    char inname[20], outname[20];
```

```
    int num, i, id;
```

```
    float sum, average, grade;
```

```
    printf("Enter the name of input file: ");
```

```
    scanf("%s", inname);
```

```
    printf("Enter the name of output file: ");
```

```
    scanf("%s", outname);
```

```
    fpin = fopen(inname, "r");
```

```
    if(fpin == NULL){
```

```
        printf("Cannot open %s\n", inname);
```

```
        return -1;
```

```
}
```

برنامه‌ای که شماره و نمره دانشجویان را
از فایل بخواند و لیست دانشجویانی که
نمره آنها بیشتر از میانگین است را در
فایل دیگری بنویسد.

```
fpout = fopen(outname, "w");  
if(fpout == NULL){  
    printf("Cannot open %s\n", outname);  
    return -1;  
}
```

```
/* Read the number of students */  
fscanf(fpin, "%d", &num);
```

```
/* Read the id and grade from file */  
sum = 0;  
for(i = 0; i < num; i++){  
    fscanf(fpin, "%d %f", &id, &grade);  
    sum += grade;  
}
```

```
average = sum / num;
```

```
fclose(fpin);

fpin = fopen(inname, "r");

fscanf(fpin, "%d", &num);

fprintf(fpout, "%f\n", average);

for(i = 0; i < num; i++){
    fscanf(fpin, "%d %f", &id, &grade);
    if(grade >= average)
        fprintf(fpout, "%d: %s\n", id, "passed");
    else
        fprintf(fpout, "%d: %s\n", id, "failed");
}

fclose(fpin);

fclose(fpout);

return 0;
```

Reading/Writing Characters (Text Files)

- To write a character to file

```
fputc(char c, FILE *fp)
```

- To read a char from file

```
char fgetc(FILE *fp) ;
```

- Returns **EOF** if reaches to End of File




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

برنامه‌ای که اسم یک فایل ورودی و خروجی را از کاربر بگیرد و فایل ورودی را در خروجی کپی کند.

```
int main(void) {

    FILE *fpin, *fpout;
    char inname[20], outname[20];
    char c;

    printf("Enter the name of input file: ");
    scanf("%s", inname);

    printf("Enter the name of output file: ");
    scanf("%s", outname);

    fpin = fopen(inname, "r");
    if(fpin == NULL) {
        printf("Cannot open %s\n", inname);
        return -1;
    }
```

```
fpout = fopen(outname, "w");  
if(fpout == NULL){  
    printf("Cannot open %s\n", outname);  
    return -1;  
}
```

```
while((c = fgetc(fpin)) != EOF)  
    fputc(c, fpout);
```

```
fclose(fpin);  
fclose(fpout);
```

```
return 0;
```

```
}
```

Checking End of File

- Each file has two indicators
 - End of file indicator
 - Error indicator
- These indicators are set when we **want to read** but there is not enough data or there is an error
- How to use
 - Try to read
 - If the number of read object is less than expected
 - Check end of file → **feof**
 - Check error of file → **ferror**
- **feof** tells that an attempt has been made to read past the end of the file, which is **not** the same as that we just read the last data item from a file. We have to read one past the last data item for feof to return nonzero.



Checking End of File

➤ Previous example with `fEOF`

```
while(1) {  
    c = fgetc(fpin) ;  
    if(fEOF(fpin))  
        break ;  
    fputc(c, fpout) ;  
}
```



Read/Write a Line (Text File)

- We can read a line of file
 - `fscanf` reads until the first free space

```
char * fgets(char *buff, int  
maxnumber , FILE *fp) ;
```

- Read at most `maxnumber-1` chars
- Reading stops after EOF or `\n`, if a `\n` is read it is stored in buffer
- Add `'\0'` to the end of string
- If reach to end of file without reading any character, return **NULL**



Read/Write a Line (Text File)

- We can write a line to file

```
int fputs(char *buff, FILE *fp) ;
```

- Write the string buff to file
- Does **NOT** add \n at the end



Example: Count the number of lines

```
char buf[500]; // 500 > every line

fpin = fopen(inname, "r");
if (fpin == NULL) {
    printf("Cannot open %s\n", inname);
    return -1;
}

while (fgets(buf, 500, fpin) != NULL)
    count++;

printf("Number of Lines = %d\n", count);
```



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

برنامه‌ای که اسم یک فایل ورودی و خروجی را از کاربر بگیرد و فایل ورودی را در خروجی کپی کند.

```
int main(void) {

    FILE *fpin, *fpout;
    char inname[20], outname[20];
    char buf[1000];

    printf("Enter the name of input file: ");
    scanf("%s", inname);

    printf("Enter the name of output file: ");
    scanf("%s", outname);

    fpin = fopen(inname, "r");
    if(fpin == NULL) {
        printf("Cannot open %s\n", inname);
        return -1;
    }
```



```
fpout = fopen(outname, "w");  
if(fpout == NULL) {  
    printf("Cannot open %s\n", outname);  
    return -1;  
}
```

```
while(fgets(buf, 1000, fpin) != NULL)  
    fputs(fpout, buf);
```

```
fclose(fpin);  
fclose(fpout);
```

```
return 0;
```

```
}
```

File 1:

3 30

1 2 3 4 5 6 7

12 34 56 78 90

123 456

File 2:

654 321

09 87 65 43 21

7 6 5 4 3 2 1

تابعی که اطلاعات دو فایل را بگیرد
و فایل اول را به صورت برعکس در
فایل دوم بنویسد.

تعداد خطها و حداکثر طول هر خط
فایل اول مشخص شده است.

```
void reverse_copy1(FILE *fpin, FILE *fpout){
    int lines, max_len, i = 0, j;
    fscanf(fpin, "%d %d\n", &lines, &max_len);
    char arr[lines * max_len];
    do{
        char c = fgetc(fpin);
        if(feof(fpin))
            break;
        arr[i++] = c;
    }while(1);

    for(j = i - 1; j > -1; j--){
        fputc(arr[j], fpout);
    }
```

**What happen if input file
is to large?!!
Huge memory allocation!
May not feasible**

```

void reverse_copy2(char *inname, char *outname){
    FILE * fpin = fopen(inname, "r"); FILE * fpout = fopen(outname, "w");
    if((fpin == NULL) || (fpout == NULL)){ printf("Error");  exit(-1); }

    int lines, max_len, i, j, k;
    fscanf(fpin, "%d %d\n", &lines, &max_len);
    fclose(fpin);
    char arr[max_len];
    for(i = 0; i < lines; i++){
        int tmp1, tmp2;
        FILE * fpin = fopen(inname, "r");
        fscanf(fpin, "%d %d\n", &tmp1, &tmp2);

        for(j = 0; j < lines - i; j++)
            fgetc(arr, max_len, fpin);

        fclose(fpin);

        for(k = strlen(arr) - 1; k >= 0; k--)
            fputc(arr[k], fpout);
    }
    fclose(fpout);
}

```

So many open/close
Lot of dummy read

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 - Read/Write
- **Binary File Operations**
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- Bugs and avoiding them



Binary Files: A Different File Format

- Data in binary files are
 - **Not** encoded in ASCII format
 - Encoded in binary format
- We must use different functions to read/write from/to binary files
 - Why?
 - Because, data should not be converted to/from ASCII encoding in writing/reading the files



No Conversion to ASCII

- In text files, everything is saved as ASCII codes
 - `fprintf(fp, "%d", 10)`
 - Saves 2 bytes in the file: ASCII '1' ASCII '0'
 - 00110001 00110000
 - `fscanf(fp, "%d", &i)`
 - Read 2 bytes from file (ASCII '1' ASCII '0') and convert it to base 2 which mean integer number 10
- In binary files, there is **not** any binary to text conversion, everything is read/write in binary format
 - `int i = 10; fwrite(&i, sizeof(int), 1, fp)`
 - Saves 4 bytes in the file: The code of 10 in base 2
 - 00000000 00000000 00000000 00001010
 - `fread(&i, sizeof(int), 1, fp)`
 - Reads 4 bytes from file into i (without any conversion)



Writing to Binary Files

```
int fwrite(void *buf, int size, int num,  
FILE *fp)
```

- Writes **num** objects from **buf** to **fp**. Size of each object is **size**. Returns the number of written objects.
- If (return val < num)
 - There is an error



Reading from Binary Files

```
int fread(void *buf, int size, int num,  
FILE *fp)
```

- Reads **num** objects from file **fp** to **buf**. Size of each object is **size**. Returns the number of read objects.
- If (return val < num)
 - There is an error
 - Or EOF → Check with **fEOF**



fread: Examples

- Reading 1 int from binary file fp

```
int i;
```

```
fread(&i, sizeof(int), 1, fp);
```

- This means

- Read 1 object from file fp. Save result in &i.
The size of the object is sizeof(int)

- It reads 4 bytes from file and saves in &i
 - We read an integer from file and save it in i



fread: Examples

- Read five floats

```
float farr[5];
```

```
fread(farr, sizeof(float), 5, fp);
```

- This means

- Read **5** objects from file **fp**. Save result in **farr**.
The size of each object is **sizeof(float)**

- It reads 20 bytes from file and saves in **farr**

- We read 5 floats from file and save them in **farr**



fwrite: Examples

- Writing 1 char to binary file **fp**

```
char c = 'A' ;
```

```
fwrite(&c, sizeof(char), 1, fp) ;
```

- This means

- Write **1** object from **&c** into file **fp**. Size of the object is **sizeof(char)**

- It writes 1 byte from address **&c** and saves result in file

- We write char **c** to the file



`fwrite`: Examples

- Writing 4 doubles to binary file `fp`

```
double darr[4];
```

```
fwrite(darr, sizeof(double), 4, fp);
```

- This means

- Write 4 object from **darr** into file **fp**. Size of the object is **sizeof(double)**
- It writes 32 bytes from address **darr** and saves result in file
 - We write the array of double to the file



```

#include <stdio.h>

struct point{
    int x, y;
};

int main(void){
    FILE *fp;
    struct point p;
    int i;
    fp = fopen("c:\\point.bin", "wb");
    if(fp == NULL){
        printf("Cannot create file\n");
        return -1;
    }
    for(i = 0; i < 5; i++){
        printf("Enter X and Y: ");
        scanf("%d %d", &p.x, &p.y);
        fwrite(&p, sizeof(p), 1, fp);
    }
    fclose(fp);
    return 0;
}

```

برنامه‌ای که X و Y ۵ نقطه را از کاربر می‌گیرد و آنها را در یک فایل باینری ذخیره می‌کند.

برنامه‌ای که اطلاعات نقطه‌های که با
مثال قبلی در فایل ذخیره شده است
را خوانده و نمایش می‌دهد.

```
#include <stdio.h>

struct point{
    int x, y;
};

int main(void){
    FILE *fp;
    struct point p;
    int i;
    fp = fopen("c:\\point.bin", "rb");
    if(fp == NULL){
        printf("Cannot read from file\n");
        return -1;
    }
    while(1){
        if(fread(&p, sizeof(p), 1, fp) < 1)
            break;
        printf("X = %d, and Y = %d\n", p.x, p.y);
    }
    fclose(fp);
    return 0;
}
```

Sequential and Random Accesses

- The access to file is sequential if
 - If we **don't move** the FPP manually
 - FPP advances through read and write
- Text file processing usually uses sequential access (why?)
- The access to file is Random
 - FPP advances through read and write
 - ***We can also move the FPP manually***
- File processing can use *Random* access



Moving FPP, Why?

- To access randomly
- Consider very large file (information about all students in the university)
- Change the name of 5000th student
 - If it is saved in text file
 - Read 4999 lines, skip them and change the 5000th
 - If it is saved in binary file and each object has the **same size**
 - Jump to the 5000th object by **fseek**



Moving FPP

```
int fseek(FILE *fp, long offset, int  
org)
```

➤ Set FPP in the **offset** respect to **org**

➤ org:

➤ **SEEK_SET**: start of file

➤ **SEEK_CUR**: current FPP

➤ **SEEK_END**: End of file

➤ Returns nonzero if it is unsuccessful



```
fp = fopen("point.bin", "rb");  
  
fread(&p, sizeof(p), 1, fp);  
printf("%d %d\n", p.x, p.y); 1 1
```

فرض کنید در یک فایل
باینری اطلاعات نقاط زیر به
ترتیب نوشته شده است .
(1,1)(2,2)(3,3)(4,4)(5,5)

```
fseek(fp, 2 * sizeof(p), SEEK_SET);  
  
fread(&p, sizeof(p), 1, fp);  
printf("%d %d\n", p.x, p.y); 3 3
```

```
fseek(fp, -3 * sizeof(p), SEEK_END);  
  
fread(&p, sizeof(p), 1, fp);  
printf("%d %d\n", p.x, p.y); 3 3
```

```
fseek(fp, 1 * sizeof(p), SEEK_CUR);  
  
fread(&p, sizeof(p), 1, fp);  
printf("%d %d\n", p.x, p.y); 5 5
```

Other FPP related functions

- Find out where is the FPP

```
int ftell(FILE *fp)
```

- **ftell** returns the current FPP

- With respect to SEEK_SET

- Reset the FPP to the start of file

```
void rewind(FILE *fp)
```



```
#include <stdio.h>

struct point{
    int x, y;
};

int main(void) {
    FILE *fp;
    struct point p;
    int num;
    fp = fopen("point.bin", "rb+");
    if(fp == NULL){
        printf("Cannot read from file\n");
        return -1;
    }
    printf("Enter the number of points: ");
    scanf("%d", &num);
    printf("Enter new X and Y: ");
    scanf("%d %d", &(p.x), &(p.y));
    fseek(fp, (num - 1) * sizeof(p), SEEK_SET);
    fwrite(&p, sizeof(p), 1, fp);
    fclose(fp);
    return 0;
}
```

برنامه‌ای که شماره یک نقطه و X و Y جدید را از کاربر می‌گیرد و مختصات نقطه تعیین شده را در فایل عوض می‌کند

fseek in Text files

- Not very useful
- Offset counts the number of characters including '\n'
- Typical useful versions
 - `fseek(fp, 0, SEEK_SET)`
 - Go to the start of file
 - `fseek(fp, 0, SEEK_END)`
 - Go to the end of file



File 1:

3 30

1 2 3 4 5 6 7

12 34 56 78 90

123 456

File 2:

654 321

09 87 65 43 21

7 6 5 4 3 2 1

تابعی که دو File Handler را بگیرد
و فایل اول را به صورت برعکس در
فایل دوم بنویسد.

تعداد خطها و حداکثر طول هر خط
فایل اول مشخص شده است.

```
void reverse_copy3(FILE *fpin, FILE *fpout){
    int lines, max_len;
    fscanf(fpin, "%d %d\n", &lines, &max_len);
    do{
        char c = fgetc(fpin);
        rewind(fpout);
        fputc(c, fpout);
    }while(!feof(fpin));
}
```

This is a wrong version!!!


```

void reverse_copy4(FILE *fpin, FILE *fpout){
    int lines, max_len, i, j, k;
    fscanf(fpin, "%d %d\n", &lines, &max_len);
    char arr[max_len];

    for(i = 0; i < lines; i++){
        fseek(fpin, 0, SEEK_SET);
        fscanf(fpin, "%d %d\n", &lines, &max_len);
        for(j = 0; j < lines - i; j++)
            fgets(arr, max_len, fpin);
        for(k = strlen(arr) - 1; k >= 0; k--)
            fputc(arr[k], fpout);
    }
}

```

High overhead, a lot of reading to seek!!

```

void reverse_copy5(FILE *fpin, FILE *fpout){
    int lines, max_len, i, j;
    fscanf(fpin, "%d %d\n", &lines, &max_len);
    i = 1;  j = 1;
    while(1){
        fseek(fpin, -1 * i, SEEK_END);
        char c = fgetc(fpin);
        i++;
        fputc(c, fpout);
        if(c == '\n'){
            i++; //this is due to Windows, \n is saved as "\n\r" !!!
            j++;
        }
        if(j > lines)
            break;
    }
}

```

Good, but we have to seek from end for each read → High overhead

```
void reverse_copy6(FILE *fpin, FILE *fpout){
    int lines, max_len, i, j;
    fscanf(fpin, "%d %d\n", &lines, &max_len);
    j = 1;
    fseek(fpin, -1, SEEK_END);
    while(1){
        char c = fgetc(fpin);
        fputc(c, fpout);
        i = 2;
        if(c == '\\n'){
            i++; // This is due to Windows
            j++;
        }
        fseek(fpin, -1 * i, SEEK_CUR);
        if(j > lines)
            break;
    }
}
```

Good enough 😊

Common Bugs and Avoiding Them

- Take care about mode in **fopen**
 - w & w+: all data in file will be lost
 - r: you cannot write. **fprintf** does **not** do any thing
- Take care about text or binary
 - fscanf/fprintf don't do meaningful job in binary files
- Check the successful open: **fp != NULL**
- Check EOF as much as possible.
- Close the open files.



Reference

- **Reading Assignment:** Chapter 11 of “C How to Program”

