Programming for Engineers

File Handling

ICEN 200 – Spring 2018

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Files in C

- Storage of data in variables and arrays is temporary—such data is lost when a program terminates.
- Files are used for *permanent* retention of data.
- Computers store files on secondary storage devices, such as hard drives, CDs, DVDs and flash drives.
- Objective: how data files are created, updated and processed by C programs.
- We both consider sequential-access and random-access file processing.

Files and Streams

- C views each file simply as a sequential stream of bytes.
- Each file ends either with an end-of-file marker or at a specific byte number recorded in a system-maintained, administrative data structure.
- When a file is opened, a stream is associated with it.
- Three files and their associated streams are automatically opened when program execution begins—the standard input, the standard output and the standard error.
- Streams provide communication channels between files and programs.

Text file vs Binary files

- Text file is a term used for a file that is essentially a sequence of character codes.

- Binary file is a term used for a file in which most bytes are not intended to be interpreted as character codes. Here are a few common binary file formats:
  - PDF, for documents
  - JPEG, GIF, and PNG, for images
  - MP3, for audio tracks

Steps in processing a file

- Create the stream via a pointer variable using the **`FILE`** structure:

  ```
  FILE *p;
  ```

- Open the file, associating the stream name with the file name.
- Read or write the data.
- Close the file.

Open the file: fopen()

- `FILE *fopen(const char *filename, const char *mode);`

Mode	Purpose	Stream Position
r	Read File exists	Beginning of file
r+	Read and write File exists	Beginning of file
w	Write If file exists, it is truncated to NULL, otherwise new created.	Beginning of file
w+	Write and read If file exists, it is truncated to NULL, otherwise new created.	Beginning of file
a	Append (write at end) File exists	End of file
a+	Read and append File exists	End of file

Opening Binary Files

Mode	Description
`rb`	Open an existing file for reading in binary mode.
`wb`	Create a file for writing in binary mode. If the file already exists, discard the current contents.
`ab`	Append: open or create a file for writing at the end of the file in binary mode.
`rb+`	Open an existing file for update (reading and writing) in binary mode.
`wb+`	Create a file for update in binary mode. If the file already exists, discard the current contents.
`ab+`	Append: open or create a file for update in binary mode; writing is done at the end of the file.

Functions to read and write data to file

- Function `fgetc`
  - like `getchar`, reads one character from a file.
  - receives as an argument a `FILE` pointer for the file from which a character will be read.
  - The call `fgetc(stdin)` reads one character from stdin –the standard input.

- Function `fputc`,
  - like `putchar`, writes one character to a file.
  - receives as arguments a character to be written and a pointer for the file to which the character will be written.

Functions to read and write data to file

- Function `fgets`
  - Reads one line from a file.
  - `char *fgets(char *str, int n, FILE *stream)`

- Function `fputs`
  - Writes one line to a file.
  - `int fputs(const char *str, FILE *stream)`

Functions to read and write data to file

- Function `fprintf`
  - Like printf
  - Takes first argument as file pointer

- Function `fscanf`
  - Like scanf
  - Takes first argument as file pointer

Close the File: `fclose()`

- `int fclose(FILE * stream)`
- Returns 0 if successfully closed
- *If function `fclose` is not called explicitly, the operating system normally will close the file when program execution terminates.*

Create a sequential file ... (1)

```
1  // Fig. 11.2: fig11_02.c
2  // Creating a sequential file
3  #include <stdio.h>
4
5  int main(void)
6  {
7     FILE *cfPtr; // cfPtr = clients.txt file pointer
8
9     // fopen opens file. Exit program if unable to create file
10    if ((cfPtr = fopen("clients.txt", "w")) == NULL) {
11       puts("File could not be opened");
12    }
13    else {
14       puts("Enter the account, name, and balance.");
15       puts("Enter EOF to end input.");
16       printf("%s", "? ");
17
18       unsigned int account; // account number
19       char name[30]; // account name
20       double balance; // account balance
21
22       scanf("%d%29s%lf", &account, name, &balance);
```

Create a sequential file ... (2)

```
23
24          // write account, name and balance into file with fprintf
25          while (!feof(stdin)  ) {
26             fprintf(cfPtr, "%d %s %.2f\n", account, name, balance);
27             printf("%s", "? ");
28             scanf("%d%29s%lf", &account, name, &balance);
29          }
30
31          fclose(cfPtr); // fclose closes file
32       }
33    }
```

```
Enter the account, name, and balance.
Enter EOF to end input.
? 100 Jones 24.98
? 200 Doe 345.67
? 300 White 0.00
? 400 Stone -42.16
? 500 Rich 224.62
? ^Z
```

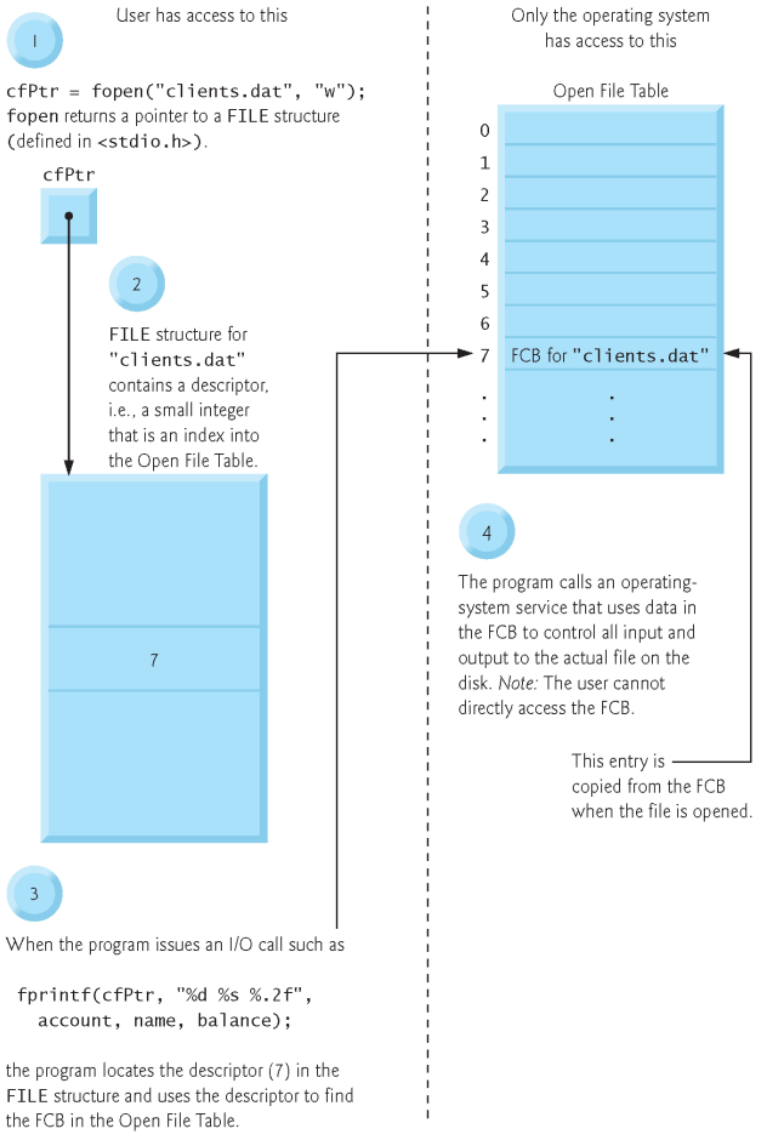
Read a record from File

```
1  // Fig. 11.6: fig11_06.c
2  // Reading and printing a sequential file
3  #include <stdio.h>
4
5  int main(void)
6  {
7     FILE *cfPtr; // cfPtr = clients.txt file pointer
8
9     // fopen opens file; exits program if file cannot be opened
10    if ((cfPtr = fopen("clients.txt", "r")) == NULL) {
11       puts("File could not be opened");
12    }
13    else { // read account, name and balance from file
14       unsigned int account; // account number
15       char name[30]; // account name
16       double balance; // account balance
17
18       printf("%-10s%-13s%s\n", "Account", "Name", "Balance");
19       fscanf(cfPtr, "%d%29s%lf", &account, name, &balance);
20
```

```
21          // while not end of file
22          while (!feof(cfPtr)  ) {
23             printf("%-10d%-13s%7.2f\n", account, name, balance);
24             fscanf(cfPtr, "%d%29s%lf", &account, name, &balance);
25          }
26
27          fclose(cfPtr); // fclose closes the file
28       }
29    }
```

```
Account    Name           Balance
100        Jones            24.98
200        Doe             345.67
300        White             0.00
400        Stone           -42.16
500        Rich            224.62
```

FILE Pointer



Operating System's File Control Block

Binary Files

- A **binary file** is created by executing a program that stores directly in the file the computer's internal representation of each file component.

```
1.  FILE *binaryp;
2.  int   i;
3.
4.  binaryp = fopen("nums.bin", "wb");
5.
6.  for  (i = 2; i <= 500; i += 2)
7.      fwrite(&i, sizeof (int), 1, binaryp);
8.
9.  fclose(binaryp);
```

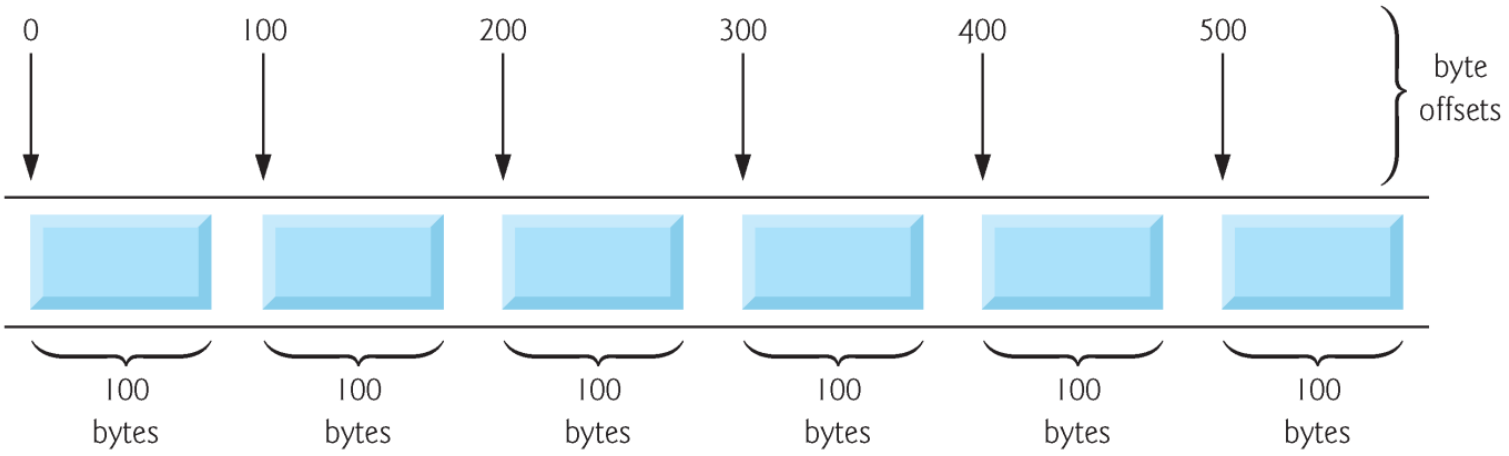
Reset a file position pointer

- The statement
  - `rewind(cfPtr);`

  causes a program's file position pointer—which indicates the number of the next byte in the file to be read or written—to be repositioned to the *beginning* of the file (i.e., byte 0) pointed to by cfPtr.
- The file position pointer is not really a pointer.
- Rather it's an integer value that specifies the byte in the file at which the next read or write is to occur.
- This is sometimes referred to as the file offset.
- The file position pointer is a member of the FILE structure associated with each file.

Random Access File

- Individual records of a random-access file are normally fixed in length and may be accessed directly (and thus quickly) without searching through other records.
- Random-access files are appropriate for
  - airline reservation systems, banking systems, point-of-sale systems, and other kinds of transaction-processing systems that require rapid access to specific data.



Random Access File

- Fixed-length records enable data to be inserted in a random-access file *without destroying other data in the file*.
- Data stored previously can also be updated or deleted without rewriting the entire file.

fwrite()

- Example use
  - `fprintf(fPtr, "%d", number);`

  could print a single digit or as many as 11 digits (10 digits plus a sign, each of which requires 1 byte of storage)
- For a four-byte integer, we can use
  - `fwrite(&number, sizeof(int), 1, fPtr);`

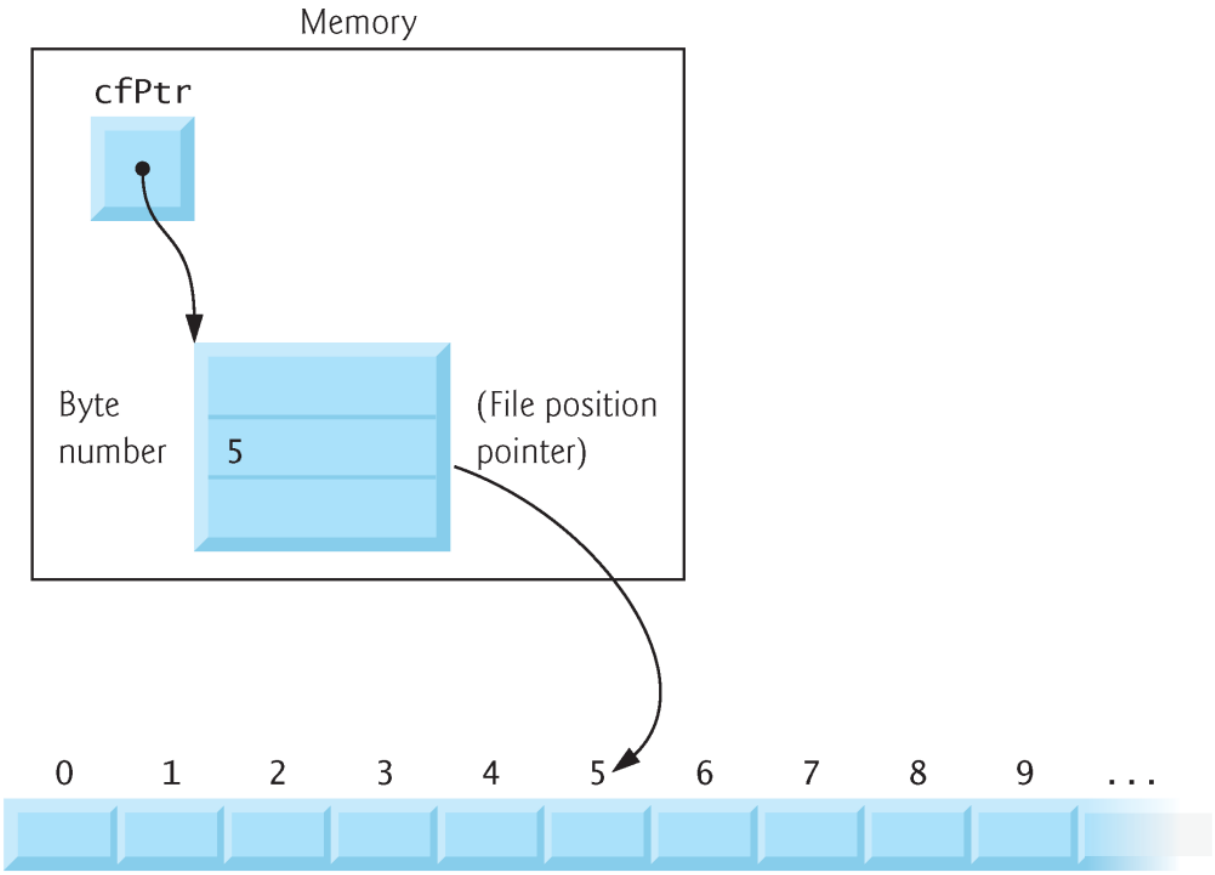
  which *always* writes four bytes on a system with four-byte integers from a variable number to the file represented by `fPtr`. 1 denotes one integer will be written.

fread()

- Function `fread` reads a specified number of bytes from a file into memory.
- For example,
  - `fread(&client, sizeof(struct clientData), 1, cfPtr);`

  reads the number of bytes determined by `sizeof(struct clientData)` from the file referenced by `cfPtr`, stores the data in client and returns the number of bytes read.
- The bytes are read from the location specified by the file position pointer.

Random Access View



Moving to a location

- `fseek`
  - `int fseek(FILE *stream, long int offset, int whence);`
  - `offset` is the number of bytes to seek from
  - `whence` in the file pointed to by stream—a positive `offset` seeks forward and a negative one seeks backward.
- Argument whence is one of the values
  - `SEEK_SET`: Value 0, beginning of file.
  - `SEEK_CUR`: Value 1, current position.
  - `SEEK_END`: Value 2, end of file.

Random Access File Code

```
1  // Fig. 11.10: fig11_10.c
2  // Creating a random-access file sequentially
3  #include <stdio.h>
4
5  // clientData structure definition
6  struct clientData {
7     unsigned int acctNum; // account number
8     char lastName[15]; // account last name
9     char firstName[10]; // account first name
10    double balance; // account balance
11 };
12
13 int main(void)
14 {
15    FILE *cfPtr; // accounts.dat file pointer
16
17    // fopen opens the file; exits if file cannot be opened
18    if ((cfPtr = fopen("accounts.dat", "wb")) == NULL) {
19       puts("File could not be opened.");
20    }
```

Random Access File Code

```
21       else {
22          // create clientData with default information
23          struct clientData blankClient = {0, "", "", 0.0};
24
25          // output 100 blank records to file
26          for (unsigned int i = 1; i <= 100; ++i) {
27             fwrite(&blankClient, sizeof(struct clientData), 1, cfPtr);
28          }
29
30          fclose (cfPtr); // fclose closes the file
31       }
32    }
```

Write randomly in a File (1)

```
1  // Fig. 11.11: fig11_11.c
2  // Writing data randomly to a random-access file
3  #include <stdio.h>
4
5  // clientData structure definition
6  struct clientData {
7     unsigned int acctNum; // account number
8     char lastName[15]; // account last name
9     char firstName[10]; // account first name
10    double balance; // account balance
11 }; // end structure clientData
12
13 int main(void)
14 {
15    FILE *cfPtr; // accounts.dat file pointer
16
17    // fopen opens the file; exits if file cannot be opened
18    if ((cfPtr = fopen("accounts.dat", "rb+")) == NULL) {
19       puts("File could not be opened.");
20    }
21    else {
22       // create clientData with default information
23       struct clientData client = {0, "", "", 0.0};
24
```

Write randomly in a File (2)

```
25          // require user to specify account number
26          printf("%s", "Enter account number"
27             " (1 to 100, 0 to end input): ");
28          scanf("%d", &client.acctNum);
29
30          // user enters information, which is copied into file
31          while (client.acctNum != 0) {
32             // user enters last name, first name and balance
33             printf("%s", "\nEnter lastname, firstname, balance: ");
34
35             // set record lastName, firstName and balance value
36             fscanf(stdin, "%14s%9s%lf", client.lastName,
37                client.firstName, &client.balance);
38
39             // seek position in file to user-specified record
40             fseek(cfPtr, (client.acctNum - 1) *
41                sizeof(struct clientData), SEEK_SET);
42
43             // write user-specified information in file
44             fwrite(&client, sizeof(struct clientData), 1, cfPtr);
45
```

Write randomly in a File (3)

```
46              // enable user to input another account number
47              printf("%s", "\nEnter account number: ");
48              scanf("%d", &client.acctNum);
49           }
50
51           fclose(cfPtr); // fclose closes the file
52        }
53     }
```

Sample Execution

```
Enter account number (1 to 100, 0 to end input): 37
Enter lastname, firstname, balance: Barker Doug 0.00
Enter account number: 29
Enter lastname, firstname, balance: Brown Nancy -24.54
Enter account number: 96
Enter lastname, firstname, balance: Stone Sam 34.98
Enter account number: 88
Enter lastname, firstname, balance: Smith Dave 258.34
Enter account number: 33
Enter lastname, firstname, balance: Dunn Stacey 314.33
Enter account number: 0
```

Reading Random Access File Sequentially (1)

```
1  // Fig. 11.14: fig11_14.c
2  // Reading a random-access file sequentially
3  #include <stdio.h>
4
5  // clientData structure definition
6  struct clientData {
7     unsigned int acctNum; // account number
8     char lastName[15]; // account last name
9     char firstName[10]; // account first name
10    double balance; // account balance
11 };
12
13 int main(void)
14 {
15    FILE *cfPtr; // accounts.dat file pointer
16
17    // fopen opens the file; exits if file cannot be opened
18    if ((cfPtr = fopen("credit.txt", "rb")) == NULL) {
19       puts("File could not be opened.");
20    }
```

Reading Random Access File Sequentially (2)

```
21      else {
22         printf("%-6s%-16s%-11s%10s\n", "Acct", "Last Name",
23            "First Name", "Balance");
24
25         // read all records from file (until eof)
26         while (!feof(cfPtr)) {
27            // create clientData with default information
28            struct clientData client = {0, "", "", 0.0};
29
30            int result = fread(&client, sizeof(struct clientData), 1, cfPtr);
31
32            // display record
33            if (result != 0 && client.acctNum != 0) {
34               printf("%-6d%-16s%-11s%10.2f\n",
35                  client.acctNum, client.lastName,
36                  client.firstName, client.balance);
37            }
38         }
39
40         fclose(cfPtr); // fclose closes the file
41      }
42   }
```

Reading Random Access File Sequentially Output

```
Acct  Last Name       First Name    Balance
29    Brown           Nancy          -24.54
33    Dunn            Stacey         314.33
37    Barker          Doug             0.00
88    Smith           Dave           258.34
96    Stone           Sam             34.98
```