ECE 220 Computer Systems & Programming

Lecture 16: File I/O in C

October 24th, 2017

ECE ILLINOIS

ILLINOIS

Input/Output Streams


```
scanf("%d", &x)
```

I/O Device operates using I/O protocol (such as memory mapped I/O)

In C, we abstract away the I/O details to an I/O function call

How formatted I/O works…

```
scanf("%d %d %f", &a, &b, &x);  // Reads three variables worth of data from stdin

int scanf(char format_string[], . . .)
{
    while (not end of format_string)
    {
        // get next format spec in format_string

        // read next set of ASCII chars from Stream based on format spec

        // convert ASCII string to int, or float, or keep as string, based on spec

        // assign to appropriate argument (treat argument as pointer)
    }

    return number of items successfully read;
}
```

The Stream Abstraction for I/O

All character-based I/O in C is performed on **text streams (or FILEs)**.

A stream is a **sequence of ASCII characters**, such as:

- the sequence of ASCII characters printed to the monitor by a single program
- the sequence of ASCII characters entered by the user during a single program
- the sequence of ASCII characters in a single file

Characters are processed in the order in which they were added to the stream.

- e.g., a program sees input characters in the same order as the user typed them.

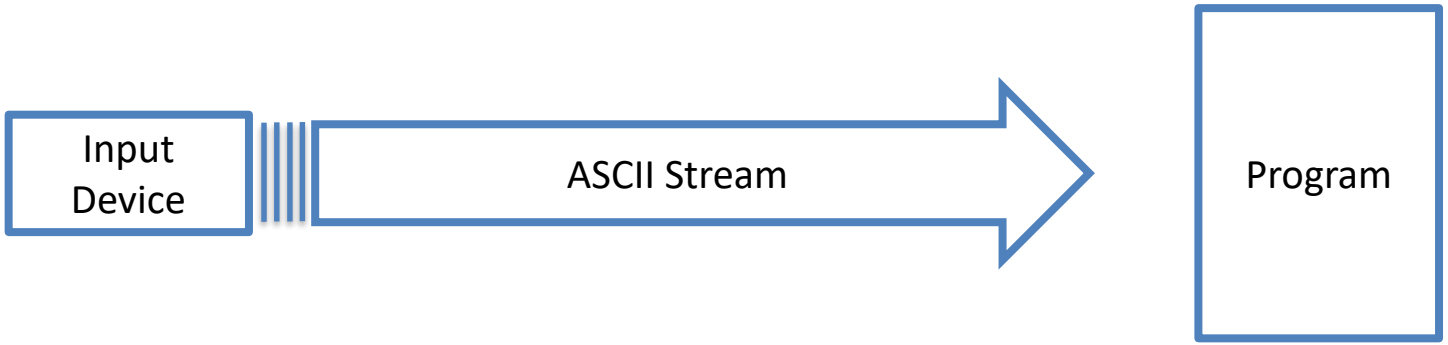
Standard Streams:

Input (keyboard) is called **stdin**.

Output (monitor) is called **stdout**.

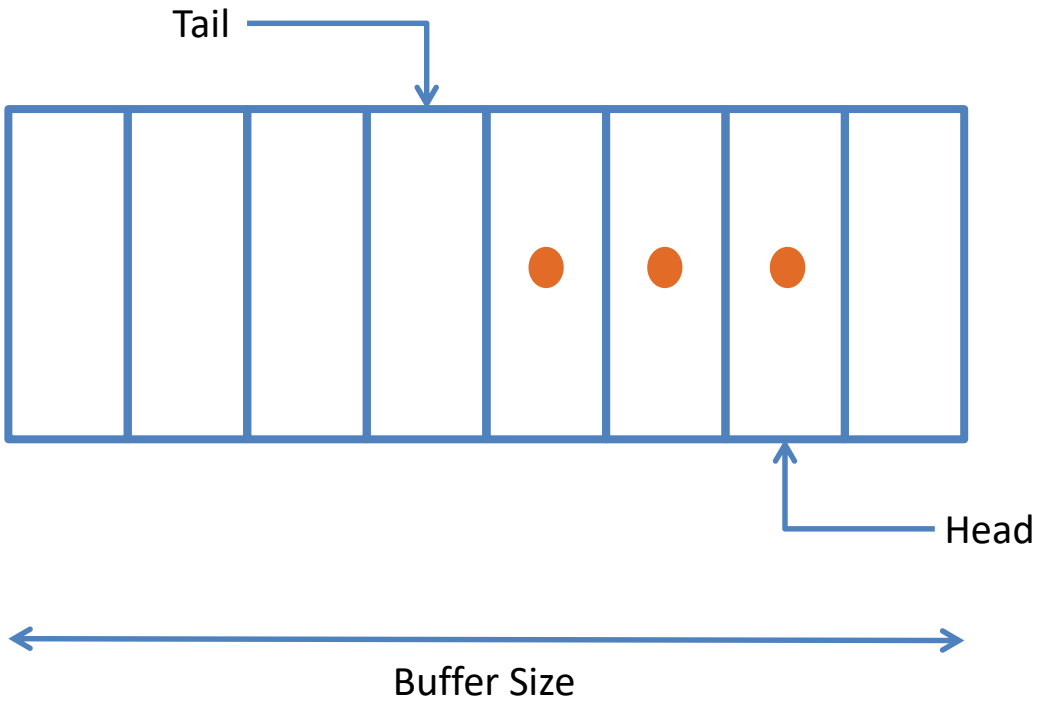
Error (monitor) is called **stderr**.

Stream Buffering



- Input device is the producer; Program is the consumer
- We want producer and consumer to be operating independently
- Why??? Think Netflix over spotty internet connection
- We can accomplish that via **buffering**
- Added advantage: we can look ahead in the I/O stream

Simple Buffer



- Producer adds data at Tail
- Consumer removes data from Head
- Buffer Full?
- Buffer Empty?
- Concept of circular buffer
- Also called First in, First Out (FIFO) or Queue

Basic I/O Functions

The standard I/O functions are declared in the <stdio.h> header file.

Function	*Description*
putchar	Displays an ASCII character to the screen.
getchar	Reads an ASCII character from the keyboard.
printf	Displays a formatted string.
scanf	Reads a formatted string.
fopen	Open/create a file for I/O.
fclose	Close a file for I/O.
fprintf	Writes a formatted string to a file.
fscanf	Reads a formatted string from a file.
fgetc	Reads next ASCII character from stream.
fputc	Writes an ASCII character to stream.
fgets	Reads a string (line) from stream.
fputs	Writes a string (line) to stream.
EOF & feof	End of file

How to use these I/O functions

FILE* fopen(char* filename, char* mode) //mode: “r”, “w”, “a”, …

success-> returns a pointer to FILE

failure-> returns NULL

int fclose(FILE* stream)

success-> returns 0

failure-> returns EOF (Note: EOF is a macro, commonly -1)

int fgetc(FILE* stream)

success-> returns the next character

failure-> returns EOF and sets end-of-file indicator

int fputc(FILE* stream)

success-> write the character to file and returns the character written

failure-> returns EOF and sets end-of-file indicator

char* fgets(char* string, int, num, FILE* stream)

success-> returns a pointer to string

failure-> returns NULL

int fputs(const char* string, FILE* stream)

success-> writes string to file and returns a non-negative value

failure-> returns EOF and sets the end-of-file indicator

int feof(FILE* stream) //checks end-of-file indicator

if at the end of file-> returns a non-zero value

if not -> returns 0

int fprintf(FILE* stream, const char* format, …)

success-> returns the number of characters written

failure-> returns a negative number

int fscanf(FILE* stream, const char* format, …)

success-> returns the number of items read; 0, if pattern doesn't match

failure-> returns EOF

File I/O – fprintf and fscanf

```
//read an mxn matrix from a file – in_matrix.txt
FILE *in_file;
int matrix[10][10];
int m, n, i, j;
in_file = fopen("in_matrix.txt", "r");
if(in_file == NULL)
        return -1;

fscanf(in_file, "%d %d", &m, &n);
if ((n > 10) || (m > 10) || (n < 0) || (m <0)) return -1

for(i=0;i<m;i++)
{
     for(j=0;j<n;j++)
     {
          fscanf(in_file, "%d", &matrix[i][j]);
     }
}
fclose(in_file);
```

in_matrix.txt

```
2 3
1 2 3
4 5 6
```

```
//transpose the mxn matrix given in in_matrix.txt
//and write the new nxm matrix to out_matrix.txt
File *out_file;

out_file = fopen("out_matrix.txt", "w");

if(out_file == NULL)
        return -1;
fprintf(out_file, "%d %d\n", n, m);
for(i=0;i<n;i++)
{
     for(j=0;j<m;j++)
     {
          fprintf(out_file, "%d", &matrix[j][i]);
     }
     fprintf(out_file, "\n");
}
fclose(out_file);
```

in_matrix.txt

```
2 3
1 2 3
4 5 6
```

out_matrix.txt

```
3 2
1 4
2 5
3 6
```