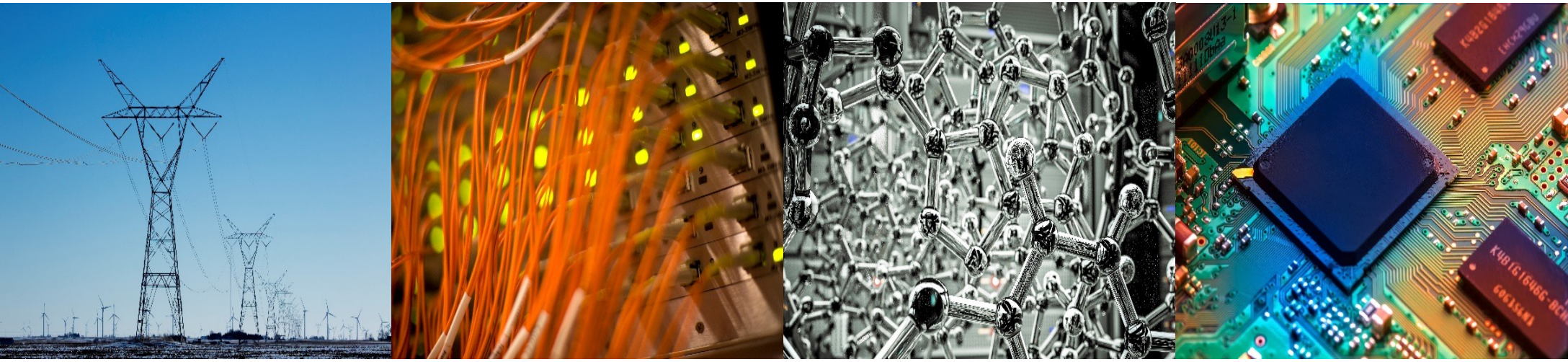
ECE 220 Computer Systems & Programming

Lecture 14 – File I/O

March 10, 2026



- Quiz3 should be completed @ CBTF this week
- MT1 regrade request is due on Wednesday

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Recursion with Backtracking Summary

You are presented with some options to solve a problem; you choose one and then a new set of options emerge. This procedure repeats. If you made a sequence of "good" choices, then eventually you will reach the goal state. If you didn't, then you need to backtrack to unmake previous choice(s) to reach the goal state.

Our goals:

1. Looking for a solution
2. Looking for all solutions
3. Looking for the best solution

Examples:

- Sudoku
- N-Queen
- Permutation
- Maze

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

Stream Abstraction for I/O

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

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**.

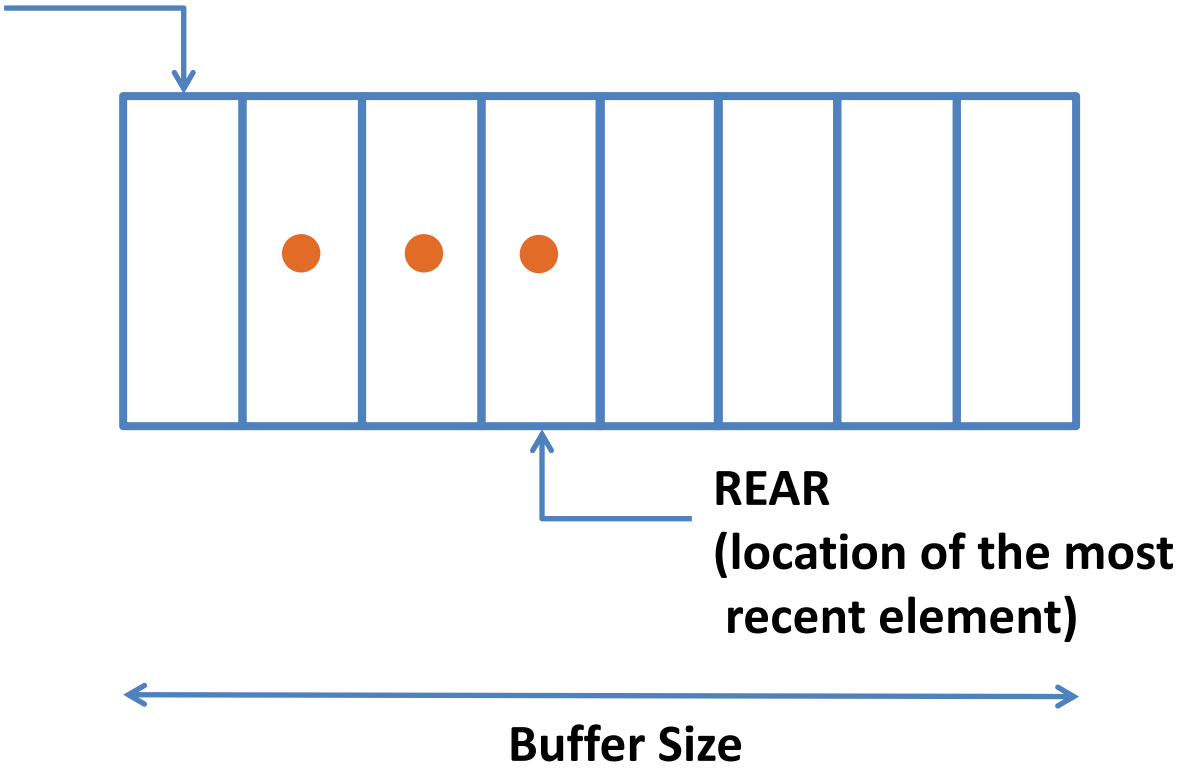
Error (monitor) is called **stderr**.

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**

Simple Buffer

FRONT
(location just before the “first” element)



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

I/O Functions in C

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

/* Open/create a file for I/O */
FILE* fopen(char* filename, char* mode) **/* mode: "r", "w", "a", "r+", "w+", "a+" */**
success-> returns a pointer to FILE
failure-> returns NULL

/* Close a file for I/O */
int fclose(FILE* stream)
success-> returns 0
failure-> returns EOF (Note: EOF is a macro, commonly -1)

/* Writes a formatted string to a file */
int fprintf(FILE* stream, const char* format, …)
success-> returns the number of characters written
failure-> returns a negative number

/* Reads a formatted string from a file */
int fscanf(FILE* stream, consta char* format, …)
success-> returns the number of items read; 0, if pattern doesn't match
failure-> returns EOF

/* Reads next ASCII character from stream */
int fgetc(FILE* stream)

success-> returns the character read

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

/* Writes an ASCII character to stream */
int fputc(int char, FILE* stream)

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

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

/* Reads a string (line) from stream */
char* fgets(char* string, int num, FILE* stream)

success-> returns a pointer to string

failure-> returns NULL

/* Writes a string (line) to stream */
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

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

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

if not -> returns 0

```c
/* File I/O Example */
#include <stdio.h>
int main(){
   FILE *file;
   char buffer[100];

   /*                                                              */
   file = fopen("intro.txt", "w");

   /*                                                              */
   printf("Write a self introduction with less than 100 characters: ");
   fgets(buffer, 100, stdin);

   /*                                                              */
   fputs("Your self introduction: ", file);
   fputs(buffer, file);

   fclose(file);

   /*                                                              */
   fputs(buffer, stdout);

   return 0;
}
```

Exercise: Read an mxn matrix from file in_matrix.txt and write its transpose to file out_matrix.txt. **The first row of the file specifies the size of the matrix.**

Hint: use fscanf to read from a file and use fprintf to write to a file.

```
#include <stdlib.h>
#include <stdio.h>
int main(){
    FILE *in_file, ;
    FILE *out_file;

    /* open in_matrix.txt for read */
    in_file = fopen("in_matrix.txt", "r");
    if(in_file == NULL)
        return -1;

    /* read matrix dimensions from file */
    int m, n, r, c;
    fscanf(in_file, "%d %d", &m, &n);

    /* dynamically allocate memory to store in_matrix */
    int *in_matrix = (int *)malloc(m*n*sizeof(int));

    /* read in_matrix elements from file */
```

in_matrix.txt

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

out_matrix.txt

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

```
    /* close in_matrix.txt */


    /* open out_matrix.txt for write */
    out_file = fopen("out_matrix.txt", "w");
    if(out_file == NULL)
        return -1;

    /* write out_matrix dimensions to file */
    fprintf(out_file, "%d %d\n", n, m);

    /* write out_matrix elements to file */









    /* close out_matrix.txt */


    /* deallocate memory */
    free(in_matrix);
    return 0;
}
```