C++ MEMORY MODEL, DYNAMIC MEMORY MANAGEMENT

Problem Solving with Computers-I

Review: Pointers (good bad and ugly)

The good:

The bad:

The ugly:

Pointer pitfalls and memory errors

- **Segmentation faults**: Program crashes because it attempted to access a memory location that either doesn't exist or doesn't have permission to access
- Examples
  - Out of bound array access
  - Dereferencing a pointer that does not point to anything results in undefined behavior.

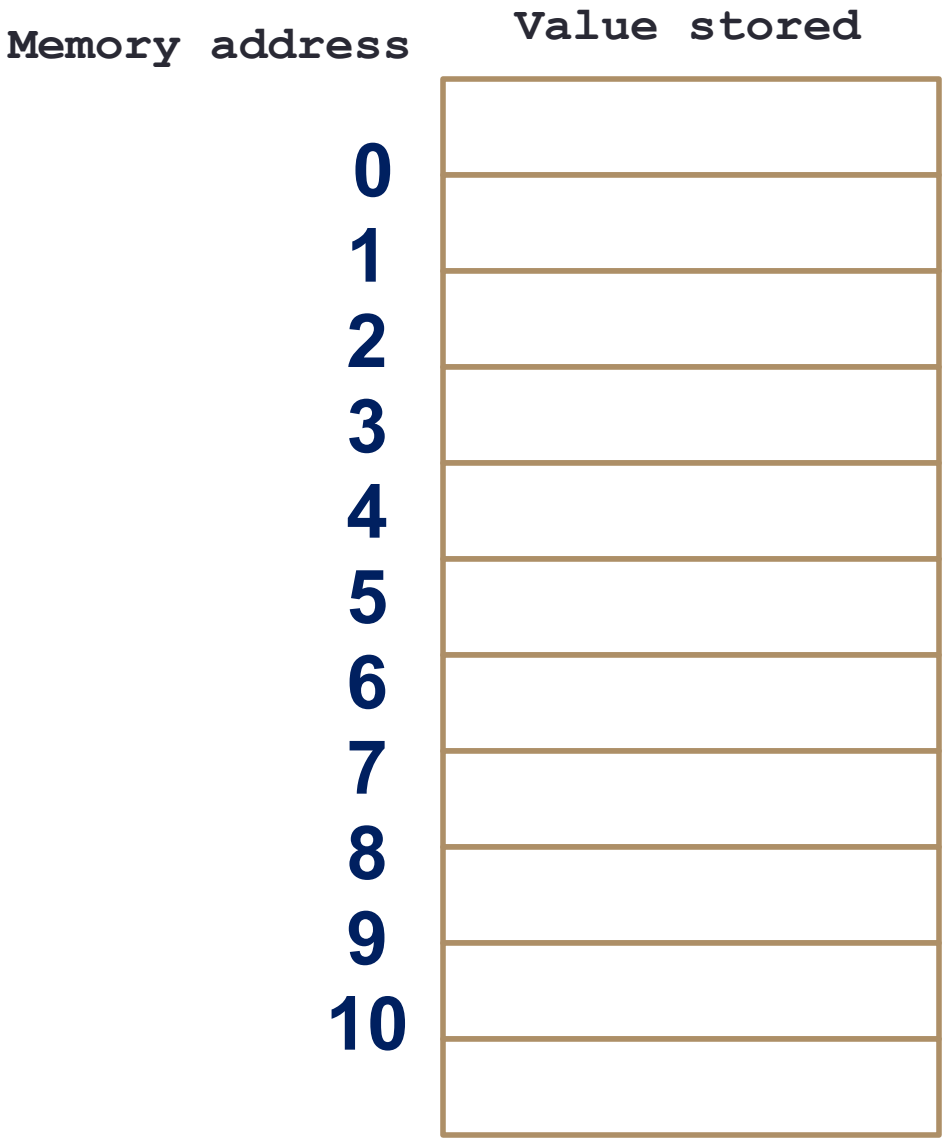

```
int arr[] = {50, 60, 70};

for(int i=0; i<=3; i++){
   cout<<arr[i]<<endl;
}
```

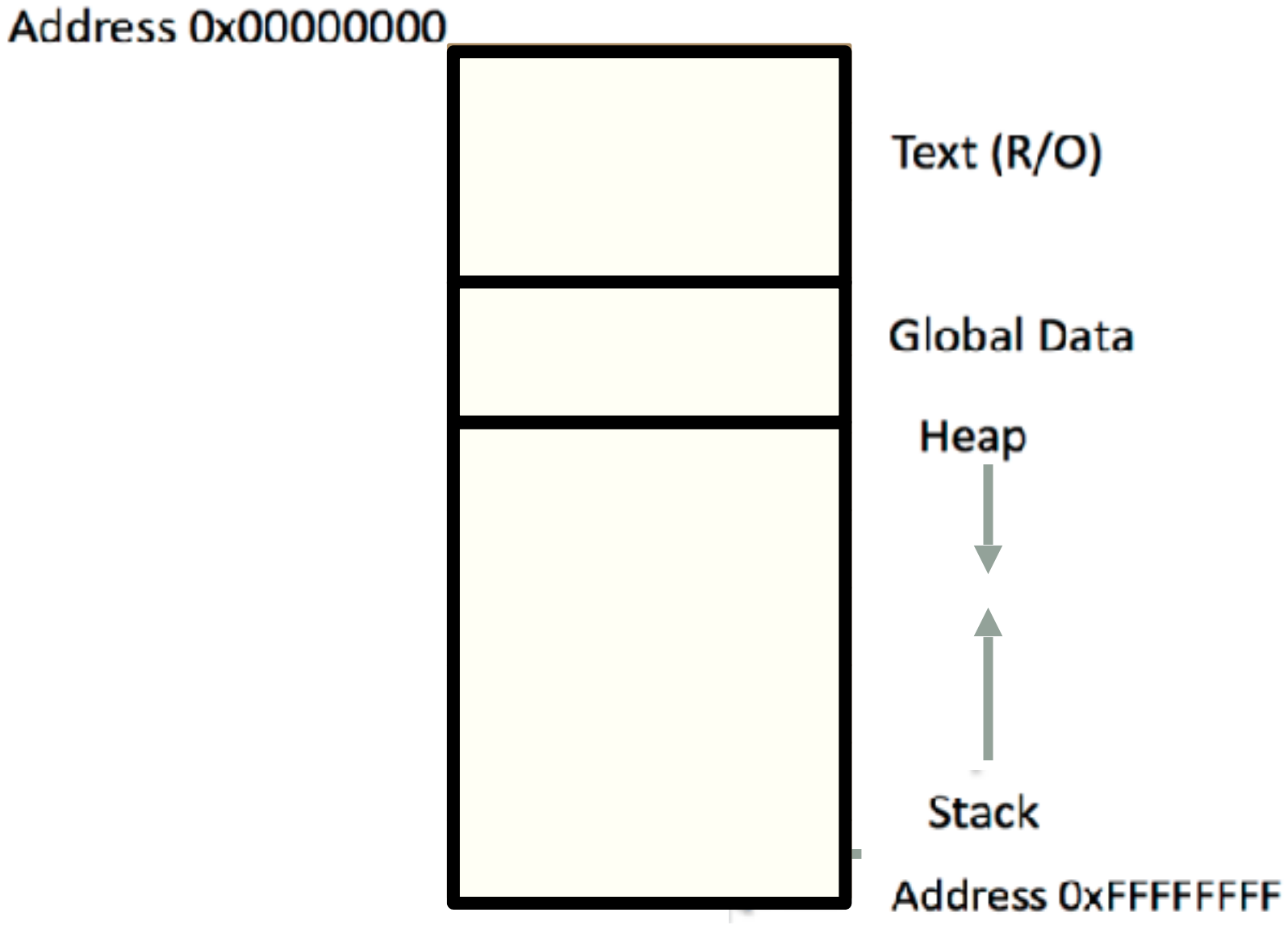
```
int x = 10;
int* p;
cout<<*p<<endl;
```

General model of memory

- Sequence of adjacent cells
- Each cell has 1-byte stored in it
- Each cell has an address (memory location)



C++ Memory Model



C++ data/variables: the not so obvious facts

The not so obvious facts about data/variables in C++ are that there are:

- two scopes: local and global
- three different regions of memory: global data, heap, stack
- four variable types: local variable, global variables, dynamically allocated variables, and function parameters

Variable: scope: Local vs global

```
 1 #include <iostream>
 2 using namespace std;
 3
 4 int B;
 5
 6 int* foo(){
 7     int A;
 8     A = 15;
 9     return &A;
10 }
11 int bar(){
12
13     B = 20;
14     return B;
15
16 }
```

Which of the functions on the left has a memory related bug?

A. foo()

B. bar()

C. Both

D. Neither

Dynamically managed memory: Heap

```
 1 #include <iostream>
 2 using namespace std;
 3
 4 int* createAnInt(){
 5
 6
 8
 9
10 }
```

Write a function to create an integer in memory

- Need to create the object on heap memory
- To create an object on the heap use the new keyword

Heap vs. stack

```
1 #include <iostream>
2 using namespace std;
3
4 int* createAnIntArray(int len){
5
6     int arr[len];
7     return arr;
8
9 }
```

Does the code correctly create an array of integers?

A. Yes

B. No

Dynamic memory management

- To allocate memory on the heap use the ‘new’ operator
- To free the memory use delete

```
int *p= new int;
delete p;
```

Dangling pointers and memory leaks

- Dangling pointer: Pointer points to a memory location that no longer exists
- Memory leaks (tardy free):
  - Heap memory not deallocated before the end of program
  - Heap memory that can no longer be accessed

Dynamic memory pitfalls

- Does calling foo() result in a memory leak? A. Yes B. No

```
void foo(){
      int * p = new int;

}
```

Q: Which of the following functions returns a dangling pointer?

```
int* f1(int num){
     int *mem1 =new int[num];
     return(mem1);
}
```

```
int* f2(int num){
      int mem2[num];
      return(mem2);
}
```

A. f1

B. f2

C. Both

Review of homework 7, problem 4

```
void printRecords(UndergradStudents records [], int numRecords);
int main(){
    UndergradStudents ug[3];
    ug[0] = {"Joe", "Shmoe", "EE", {3.8, 3.3, 3.4, 3.9} };
    ug[1] = {"Macy", "Chen", "CS", {3.9, 3.9, 4.0, 4.0} };
    ug[2] = {"Peter", "Patrick", "ME", {3.8, 3.0, 2.4, 1.9} };
    printRecords(ug, 3);
}
```

Expected output

These are the student records:
ID# 1, Shmoe, Joe, Major: EE, Average GPA: 3.60
ID# 2, Chen, Macy, Major: CS, Average GPA: 3.95
ID# 3, Peter, Patrick, Major: ME, Average GPA: 2.77

Next time

- C++ Memory Model
- Dynamic memory allocation