DYNAMIC MEMORY ALLOCATION IN C

CSSE 120—Rose Hulman Institute of Technology

Final Exam Facts

- Date: Thursday, February 25, 2010
- Time: 8:00 AM to 12:00 noon
- Venue: **O259 – O257 – O267 (see schedule page)**
- Chapters: Zelle chapters 1 12.1
  Assigned C readings from Kochan plus Web resources linked from ANGEL Resources page
- On-computer part: will be only in C
- You may bring two double-sided sheets of paper this time.

Final Exam Facts

- Organization: A paper part and a computer part, similar to the first 2 exams.
- The paper part will emphasize both C and Python.
- There will be a portion in which we will ask you to compare and contrast C and Python language features and properties.
- The computer part will be in C.
- The computer part will be worth approximately 50% of the total.

Memory Requirements

- Any variable requires a certain amount of memory.
- Primitives, such an `int`, `double`, and `char`, typically may require between 1 and 8 bytes, depending on the desired precision, architecture, and Operating System's support.
- Complex variables such as ***structs***, ***arrays***, and ***strings*** typically require as many bytes as their components.

How large is this?

- `sizeof` operator gives the number bytes needed to store a value
- sizeof(char)
- sizeof(int)
- sizeof(double)
- sizeof(char *)
- sizeof(student)
- sizeof(jose)
- printf("size of char is %d bytes.\n", sizeof(char));

```
typedef struct {
        char *name;
        int year;
        double gpa;
} student;
```

```
char *firstName;
int terms;
double scores;
student jose;
```

Q3

How large is this?

- 32 bits = 4 bytes
- int : 4 bytes
- double : 8 bytes
- char : 1 byte
- pointer : 4 bytes

Memory Allocation

- In many programming languages, memory gets dynamically allocated as the need arises.
- Example: Lists in Python grow and shrink as we add or remove items from them.
- In Python, memory gets allocated as the need arises.
- Memory gets freed up when it is no longer needed.

Static Memory Allocation

- In C, we have the ability to manually allocate memory.
- We typically do this when we know ahead of time the storage needs of a complex data-structure.
- We have seen this last time, when we did this:

```
char string[10];
```

- We allocated ten bytes to store a string.
- In some of the examples, we used all of the allocated bytes, in some, we did not.

Dynamic Memory allocation in C

- We use the `malloc` command to dynamically allocate memory on the heap.
- The syntax is:

```
malloc(<size>);
```

- The command returns a pointer to a memory location.
- We typically want to store that pointer.

Example: Dynamic Memory allocation in C

- Suppose we want to reserve space for 10 doubles.
- We would do:

```
double *samples;
samples = (double *) malloc(count *sizeof(double));
```

- The memory returned to you can store objects of any type (void pointer).
- We give it the desired type by typecasting.

Deallocation of Dynamic Memory

- When we allocate memory, we also need to free it up when we are done with it.
- This is only necessary when we dynamically allocate memory (using constructs like **malloc()**).
- Otherwise, we may well run out of the memory space allocated to us.

Memory Deallocation in C

- In order to deallocate memory, we use the `free` command
- The syntax is:

```
free(<pointer>);
```

- To continue our example, we would do:

```
free(result);
```

Sample Project for Today

- Check out ***MallocSample*** from your SVN Repository
- Verify that it runs, get help if it doesn't

Returning Arrays from Functions

- In *maf-main*.c, remove the **exit()** call near the beginning.
- Run the program:
  - What happens?
  - Why?
- Original version of **getSamples()** just creates local storage that is recycled when function is done!
- If we want samples to ***persist beyond the function's lifetime***, we need to allocate memory using "malloc".
  - Also need to **#include <stdlib.h>**

Dynamically allocating an array

```
double *getSamples(int count) {
        double *samples;
        samples = (double *)malloc(count * sizeof(double));
        if (samples == NULL) {
                exit(EXIT_FAILURE);
        }
        int i;


        for (i=0; i<count; i++) {
                samples [i] = gaussian(82.5, 7.1);
        }
        return samples;
}
```

Typecast to desired pointer type

returns a void pointer (void *) to memory of specified size or NULL if request fails. Memory is uninitialized

Exit program if out of memory or cannot allocate for another reason

Q5, 6

Using Dynamically Allocated Array

```
double *sampleA;
double *sampleB;
int sampleCount = 5;

sampleA = getSamples(sampleCount);
sampleB = getSamples(sampleCount);

for (i=0; i<sampleCount; i++) {
      printf%0.1lf\n", sampleA[i] + sampleB[i]);
}

free(sampleA);
free(sampleB);
```

Don't forget to free the memory that was previously "malloc-ed".

Recap: sizeof, malloc and free

- sizeof operator: gives the number of bytes needed to store a value
- *malloc(<amount>): returns a pointer to space for an object of size *amount*, or NULL if the request cannot be satisfied. The space is uninitialized.
- void free(void *p): deallocates the space pointed to by p; does nothing if p is NULL. p must point to memory that was previously dynamically allocated.

Descriptions from K&R, p. 252

Dynamically Allocating Structs

- Can use **malloc** to dynamically allocate **struct**s
- We'll use this to create an Array data type soon that's "smarter" than the basic C version
- Will need to use pointers to structs
  - student *zeb;
- Accessing elements of structs is different with pointers…

Pointers to Structs

- Direct reference

```
student debby = {"Deb", 2011, 2.9};
debby.gpa = 3.2;
printf("%s, Class of %d\n",
    debby.name, debby.year);
```

- Use dot when you have the struct directly

- Pointer reference

```
student *aaron;
aaron = (student *)
    malloc(sizeof(student));
aaron->name = "Aaron";
aaron->year = 2009;
aaron->gpa = 3.1;
printf("%s, Class of %d\n",
    aaron->name,aaron->year);
```

- Use "arrow" when you have a pointer to it

aaron->gpa is shorthand for (*aaron).gpa

Overcoming some array limitations

- **`malloc`** reserves space for variables or arrays in a separate location in memory called the heap
  - It allows the return type of a function to be an array
  - It allows arrays to be resized
- Keywords:
  - **`ptr = malloc(number_of_bytes_needed)`**
  - **`sizeof()`**
  - **`free(ptr)`**
  - **`ptr = realloc(ptr, number_of_bytes_needed)`**
- What does realloc do()

Q9, 10

Your C Capstone Project

- A mini-project to be done individually
- Due Friday at 5:00 PM
- Demo
- 10 min to read the spec
- Questions and Answers
- Turn in your in-class quiz
- Work on the project