CSCB09 Midterm Review

github.com/tabeebyeamin/AMACSS

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Agenda

- Unix Commands & File System
- C: Arrays, Pointers
- C: Dynamic Memory Allocation
- C: Makefiles

Unix commands

- **pwd**: print working directory
- **ls *[dir]***: show files in current directory or *dir* if specified
- **cd *dir***: change working directory to *dir*
    - special symbols: ∼, ., ..
- **cat or more *file***: show contents of *file*
- **cp, mv *[loc1] [loc2]***: copies or moves file/directoy from loc1 to loc2
- **rm *[-r] file***: remove file or directoy (-r lets your delete nonempty)
- **mkdir *[dir]***: create directory

More Useful Commands

- **grep *[regex]***: globally search regex and print
- **chmod**: change access permissions (r,w,x) *chmod 644 text*
- **who**: displays users logged in right now
- **sort**: sorts a collection of data *sort -k4 text*
- **wc**: word count *wc -l*

File

- Name, owner, size, perms,
- Ls -l or stat to get info on a file
- Implemented in a data structure called inode: has inode number, unix maintains inode to disk location

Directory

- Collection of files
- Every directory is a file itself
- Directory hierarchy is an acyclic graph, not a tree

Hard Links & SoftLinks

Hardlink

```
ln /Alice/ex1.c /Bob/ex1.c
```

- If ex1.c is removed, the directory entry gets removed, but the file itself is only removed if it no longer has any name/hard links

Softlink

```
Ln -s /Alice/ex1.c /Bob/ex1.c
```

- If /Alice/ex1.c is removed, the directory entry gets removed, and /Bob/ex1.c will be left with *dangling pointer*

Permissions

Each file has read write an execute permissions for owning user, group and others

`rwxrwxrwx`

- first 3 refer to User perms, second 3 to Group, last 3 refer to Others

By default

`rwxr-xr-x`

- chmod u+x fname: give user execute perms
- chmod g-r fname: remove read perms from users in group
- chmod a+rwx fname: all users all perms

C and stuff

Arrays

```c
int array[4] = {1,2,3,4};
char string[6] = "CSCB09";
```

- Contiguous chunk of memory, list of items with the same type
- Size of array not stored in the array
- Exceed array bounds causes undefined behaviour
- Allocates in the stack from top down

Pointers:

- Stores memory addresses of variables
- Is allocated in the **stack** just like any variable

```c
int *ptr;
```

Pointer Arithmetic

```c
x[i] == *(x + i);
```

- Respects the type of the pointer
  - if you had int pointer `ptr` and did `*(ptr + 1)`, you would increment 4 bytes in memory instead of one to get to the next int box

August 2017 Question 2a)

```
int a[4] = {0, 1, 2, 3};
int b = 1;
int *p = a;
p = p + b;
b++;
*p += b;
p = p + b;
*p += 2;
p--;
*p *= 4;
p = p - b;
*p = p - a;
```

What is a[0] a[1] a[2] and a[3]?

August 2017 Question 2a)

```c
int a[4] = {0, 1, 2, 3};
int b = 1;
int *p = a;
p = p + b;
b++;
*p += b;
p = p + b;
*p += 2;
p--;
*p *= 4;
p = p - b;
*p = p - a;
```

a[0] = 0, a[1] = 3 a[2] = 8 and a[3] = 5

Allocating memory on demand

```
malloc(# of items*size of each item in bytes)
```

- Finds available place in memory that has the request capacity, reserves it, and returns a pointer to the reserved chunk

```
Node *newNode = (Node *)malloc(sizeof(Node));
```

- dynamically allocated memory is allocated on the **heap**
- malloc returns pointer without any attached data type so you have to cast it
- always release (**free**) all the memory you allocated, or you could have memory leaks

Memory Allocation Question

August 2017 Question 2c) (too big to put on the slide)

Structs

```
typedef struct a_name_for_struct
{
    char *string_field;
    int *int_field;
}  new_type;
```

How to use them?

- Declare a variable:

  ```
  new_type  v;
  ```

- Access a field:

  ```
  v.int_field = 10;
  ```

- Pass them or return them from a function:

  ```
  new_type update_values(new_type v, int value);
  ```

In the memory model

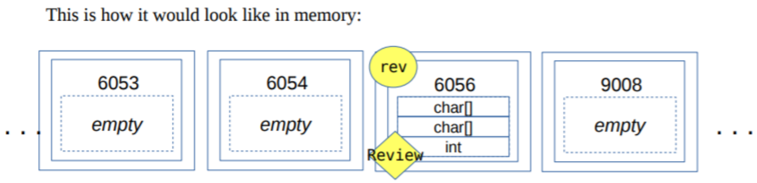


Figure 1: Structs in Memory

- ONE chubby box, inside that box are all the components of the struct
- It's NOT an array, but you can put an array inside a struct
- Passing a struct variable to a function makes a copy!
- Returning a struct variable from a function also makes a copy!
- Lots of data traffic this way, so we prefer using pointers

Using pointers for structs

```
typedef   struct  a_name_for_struct
{
   int field_name;
} new_type;
```

Using pointers means

- accessing fields with the -> operator

```
new_type  v;
new_type  *vp;
vp=&v;
vp->field_name=value;
```

- dynamically allocating in the heap

```
new_type v2 = (new_type *)malloc(sizeof(new_type));
```

August 2017 Question 4, (Also May 2017 Question 2c)

```c
struct student {
    int age;
    char *name;
}
// Increase the age of a student by amt.
void increase_age(struct student s, int amt) {
    s.age += amt;
}
int main() {
    struct student rob;
    rob.age = 10;
    increase_age(rob, 5);
    printf("%d should be 15\n", rob.age);
}
```

- Does this code do what it's supposed to?

August 2017 Question 4, (Also May 2017 Question 2c)

```c
struct student {
    int age;
    char *name;
}
// Increase the age of a student by amt.
void increase_age(struct student s, int amt) {
    s.age += amt;
}
int main() {
    struct student rob;
    rob.age = 10;
    increase_age(rob, 5);
    printf("%d should be 15\n", rob.age);
}
```

- We are changing a copy of rob, original stays the same

Memory Model Review

- Memory for a process is called its address space
- Memory is a sequence of bytes
- Memory location is identifiable by an address
- Variables, pointers, function frames go in the **stack**
    - bottom-up
- Dynamically allocated memory (malloc) goes in the **heap**
    - top-down
- String literals go in **read-only data** (cannot be changed!)
- Global variables outside of functions go in **static data**

Memory Model Worksheet Review

Write a program that declares 3 strings. The first named first should be set to the value “Monday”, and be stored on the stack frame for main. second should be a string literal with the value “Tuesday”. third should have value “Wednesday” and be on the heap. The pointers for second and third will be in stack frame for main.

Memory Model Worksheet Review

Write a program that declares 3 strings. The first named first should be set to the value “Monday”, and be stored on the stack frame for main. second should be a string literal with the value “Tuesday”. third should have value “Wednesday” and be on the heap. The pointers for second and third will be in stack frame for main.

```
char first[6] = "Monday";
char *second = "Tuesday";
char *third = malloc(9*sizeof(char));
strcpy(third, "Wednesday");
```

Memory Model Worksheet Review

Add to your program so that it declares an array string list of 3 pointers to char and point the elements to first, second, and third, respectively. So now you have an array of strings. Where is the memory allocated for this array?

```
char first[6] = "Monday";
char *second = "Tuesday";
char *third = malloc(9*sizeof(char));
strcpy(third, "Wednesday");
```

Memory Model Worksheet Review

Add to your program so that it declares an array string list of 3 pointers to char and point the elements to first, second, and third, respectively. So now you have an array of strings. Where is the memory allocated for this array?

```c
char first[6] = "Monday";
char *second = "Tuesday";
char *third = malloc(9*sizeof(char));
strcpy(third, "Wednesday");

char *string_list[3];
string_list[0] = first;
string_list[1] = second;
string_list[2] = third;
```

Memory for the array is located in the stack, in the frame for the function. **Note:** we can modify strings at index 0 and 2, but not 1.

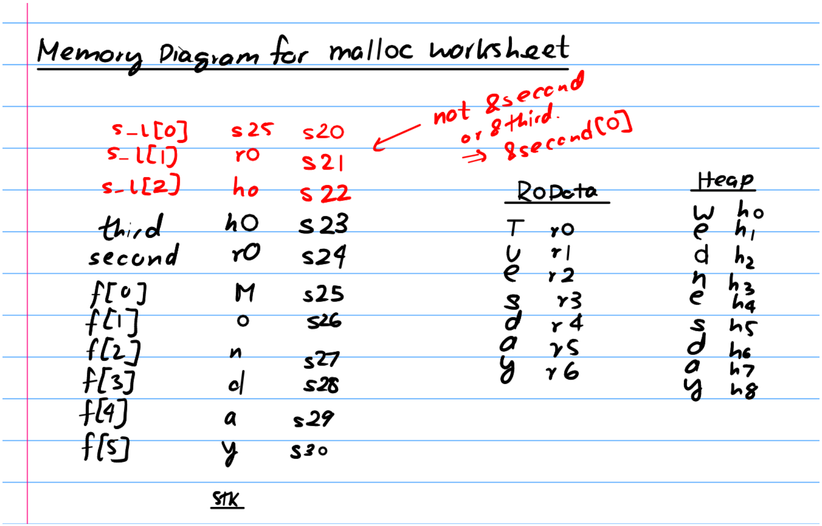
Memory Model Worksheet Review

Draw the memory model for the program

```
char first[6] = "Monday";
char *second = "Tuesday";
char *third = malloc(9*sizeof(char));
strcpy(third, "Wednesday");

char *string_list[3];
string_list[0] = first;
string_list[1] = second;
string_list[2] = third;
```

Memory Model Worksheet Review



Memory Diagram for malloc worksheet

s_l[0]	s25	s20
s_l[1]	r0	s21
s_l[2]	h0	s22
third	h0	s23
second	r0	s24
f[0]	M	s25
f[1]	o	s26
f[2]	n	s27
f[3]	d	s28
f[4]	a	s29
f[5]	y	s30

STK

not &second or &third. ⇒ &second[0]

RoData

T	r0
u	r1
e	r2
s	r3
d	r4
a	r5
y	r6

Heap

W	h0
e	h1
d	h2
n	h3
e	h4
s	h5
d	h6
a	h7
y	h8

Figure 2: Memory Model

Makefiles

- Manually calling gcc is not scalable for large number of files

```
myprogram: file1.c
    gcc -Wall -o myprogram file1.c
```

- have a file titled `make` and create rules inside it like above

Makefiles

- You can use the following patterns to represent target, all prereqs, first prereq and outdate prereqs

```
myprogram: file1.c file2.c
    gcc -Wall -o myprogram file1.c
```

- $@: myprogram
- $^: file1.c file2.c
- $<: file1.c
- $?: outdated prereqs

Makefile Worksheet Review

```
dinner: pizza salad
pizza: cheese topping.peppers
    echo making pizza
    cat cheese topping.peppers > pizza
cheese:
    echo gooey cheese > cheese
topping.%:
    echo yummy $@ > $@
salad:
    echo salad is healthy
```

- cheese is already created. Sequentially run the following and give **console output** and **files modified** for:
  - make salad
  - make pizza
  - make dinner

Makefile Worksheet Review

make salad outputs

- echo salad is healthy
- salad is healthy

make pizza modifies `topping.peppers` and `pizza` and outputs

- echo yummy topping.peppers > topping.peppers
- echo making pizza
- making pizza
- cat cheese topping.peppers > pizza

make dinner outputs

- echo salad is healthy
- salad is healthy

Additional Topics of Study

- Familiarize yourself with string libraries (str[n]cmp, str[n]cpy, str[n]cat)
- Familiarize yourself with input scanning functions (scanf, fgets etc.)
- Do Bianca's past papers in the exam repo:
    - August 2017 Questions 1f), 2, 3, 5, all of 4 except forks and signal questions
    - May 2017 Questions 1, 4 and maybe 2