CMSC 216
Introduction to Computer Systems
Lecture 7
Command Line Arguments & Pointers

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Notes

- Project 2 posted
  - public tests posted and submit server open soon
  - questions?
  - due week from Monday, 8PM
- Read Reek, Chapter 6: Pointers

Chapter 6, Reek

POINTERS

Pointers

- Pointers are variables whose value is an address
- Every variable is stored at an address in memory
- We use pointers to perform manipulation of memory, by accessing items at the address stored in the pointer

Declaration of pointers

- A pointer to an **`int`** value would be declared like this: **`int *ip;`**
- Creates a variable called **`ip`**, whose type is "pointer to **`int`**"
- We can assign the address of an **`int`** variable to be the value of this new pointer

Pointer operators

- Obtaining the address of an object (**`&`**)
  - Placed before a variable (or an object in memory)
- Accessing the value at an address (**`*`**)
  - Placed before an expression which is either a pointer or otherwise evaluates to an address
- Example:

```
int i = 6;
int *p;
p = &i;
printf("%d %d\n", *p, *(&i));
```

	Memory	Address
i	6	1084
p	1084	1088

Using a dereferenced pointer

- The **`*`** operator can be used on both the left and right sides of an assignment

```
int i = 6;
int j;
int *p;
p = &i;
j = *p;
printf("%d %d\n", i, j);
*p = 4;
printf("%d %d\n", i, j);
```

	Memory	Address
i	4	1084
j	6	1088
p	1084	1092

Garbage pointers

- When a pointer is declared, it points to whatever address was in the memory location allocated for the pointer (no initialization)
- Trying to dereference this random address will generally result in one of three Bad Things:
  - accessing a memory location you don't have permission to access (a "segmentation fault")
  - violating the computer's alignment policies (a "bus error")
  - silent failure: everything appears to work right... for now

`NULL` pointer

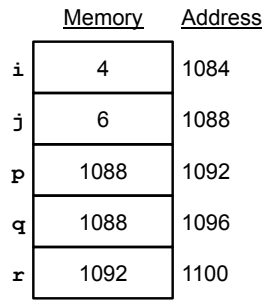
- This is a pointer that points to the address 0, where nothing is allowed to be accessed
- Defined in `stddef.h`, which is included by many other header files
- Analogue to Java's `null`
  - What happens when you try to call a method of an object which is `null`?
  - Very similar thing happens in C when trying to dereference a `NULL` pointer; it's usually a segfault
- Just like in Java, you have to check pointers to see if they're `NULL` **before** dereferencing them:

```
void f(int *p) {
  if (p != NULL)
    *p = 55;
}
```


Pointers to Pointers

- You can also obtain the address of a pointer variable:

```
int i = 4;
int j = 6;
int *p = &i;
int *q = &j;
int **r = &p;
printf("%d\n", **r);
*r = &j;
printf("%d\n", *p);
```



- This technique will be useful later when working with pointers as parameters

Pointers as parameters

- You can also pass addresses into a function:

```
void swap(int *a, int *b) {
  int tmp = *a;
  *a = *b;
  *b = tmp;
}
...
int x = 2;
int y = 3;
swap(&x, &y);
printf("%d %d\n", x, y);
```

- Why do we need to use pointers here?

Section 13.4, Reek

Command Line Arguments

Command line arguments

- When executing a command like "**`ls -l`**", or "**`emacs puzzles.c`**", the various parts of the command line are called arguments to the program
- We can access these through parameters to the **`main()`** function
- The parameters are represented as strings (similar to the **`String[] args`** you use in Java's **`main()`** method).

Accessing command line arguments

- This program (named **`prog`**) will print out each argument, one per line
  - Note: the type "**`char *`**" is also used to represent strings in C

```
#include <stdio.h>

int main(int argc, char *argv[]) {
  int i;
  for (i = 0; i < argc; i++)
    printf("Arg #%d: %s\n", i, argv[i]);
  return 0;
}
```

- What if we execute "**`./prog -l 53 -c -d`**"?

Accessing command line args, cont.

- If we execute "**`./prog -l 53 -c -d`**"?
  - Output is:

```
Arg #0: ./prog
Arg #1: -l
Arg #2: 53
Arg #3: -c
Arg #4: -d
```


Chapter 6, Reek

POINTERS

Structures and pointers

- We can also have pointers to structures:

```
typedef struct {
  int number, num_students, start_time;
} Section;

void add_students(Section *sec,
                  int students_to_add)
{
  (*sec).num_students += students_to_add;
}
...
Section s = {101, 25, 1300};
add_to_students(&s, 5);
printf("%d\n", s.num_students);
```


The -> operator

- Dereferencing of a pointer to a structure must occur before accessing a field of the structure; due to precedence, parentheses are needed

```
Section s = {101, 25, 1300};
Section *sp = &s;
*sp.num_students += 5;   /* WRONG */
(*sp).num_students += 5; /* RIGHT */
```

- C has a special operator to make this easier:
  - "`(*sp).num_students`" is equivalent to "`sp->num_students`"

Don't forget to check for `NULL`

- A common error is to do something like this: assume `abs_val()` is supposed to return the absolute value of the number pointed to by `cp`, or return -1 if `cp` is `NULL`

```
typedef struct {
  double real;
  double imag;
} Complex;
...
double abs_val(Complex *cp) {
  double r = cp->real * cp->real;
  double i = cp->imag * cp->imag;
  if (cp == NULL)
    return -1;
  return r + i;
}
```

- Remember that the `->` is doing dereferencing; you must perform the `NULL` check before the pointer is dereferenced!

Generic pointers

- Pointers to `void` (`void *`) can point to any type:

```
void *vp;
int a, *ip;
double b, *dp;
vp = &a;
ip = vp;
vp = &b;
dp = vp;
vp = ip;
```

- No casts needed with `void *` pointers

Generic pointers, cont.

- You can't dereference a **`void *`** - you first need to cast or assign it to a real pointer type
  - the value obtained from a dereference depends on the type of pointer
- **`NULL`** is really defined as **`(void *) 0`**
- These allow use of generic code, but misuse can lead to the kinds of errors we've seen before:

```
void *vp;
int *ip;
double a = 3.14159;
vp = &a;
ip = vp;
printf("%d\n", *ip);  /* -266631570 */
```