CMSC 216
Introduction to Computer Systems
Lecture 9
Pointers, cont.

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Administrivia

- Project 2 due next Friday
  - public tests posted
- Exam #1 next Thursday
  - practice exam posted by Friday, with answers later

Chapter 6, Reek

POINTERS

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?

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 */
```


Type conversion with pointers

- Converting from one type to a pointer has some uses:

```
unsigned int i;
unsigned char *ch;
i = 0x543210ab;
ch = (unsigned char *) &i;
printf("%d\n", *ch);
printf("%d\n",
        * (unsigned char *) &i);
```

- Prints out either MSB or LSB of **`i`**, depending on architecture

Type conversion, cont.

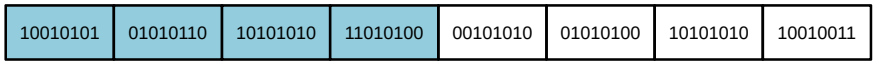
- Type conversion is very similar to what happens when we access an inactive union field

```
union {
  int i;
  double dbl;
} a;
double fp_val = 3.14159;
a.dbl = 3.14159;

printf("%d\n", a.i);  /* -266631570 */
printf("%d\n", * (int *) &fp_val);
```


Type conversion, cont.

- The two lines are the same!
- Although we stored a double-precision floating-point number at an address in memory, interpreting that address as a 4-byte integer results in a wildly different value from the floating-point number



The **const** modifier

- Indicates that a variable can't be changed, and enforced by compiler

```
int const i = 4;
const int j = 5;
i++;  /* ERROR */
j++;  /* ERROR */
```

- Order of type specifier and **const** modifier does matter when dealing with pointers:

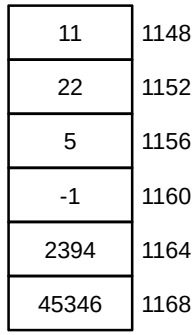
```
int i = 4, j = 5;
const int *p = &i;  /* pointer to constant int */
int * const q = &j; /* constant pointer to int */
p = &j;    /* OK */
*p += 5;   /* ERROR */
q = &i;    /* ERROR */
*q += 23;  /* OK */
```

- The program **cdecl** can be useful for decoding some more complex declarations

Incrementing pointers

- Pointers can be incremented/decremented just like integer type variables, "moving" one element at a time
  - how much is added to the address depends on the size of the type to which the pointer points (as declared)
- Recall arrays are contiguous memory
- What does this function do?

```
int mystery(int array[]) {
  int *p = &(array[0]);
  int sum = 0;
  while (*p != -1) {
    sum += *p;
    p++;
  }
  return sum;
}
```



Incrementing pointers, cont.

```
size_t strlen(const char *str) {
  size_t len = 0;
  while (*str) {
    len++;
    str++;
  }
  return len;
}
```

- Why can we move the **str** parameter?
- Why does this return the string's length?

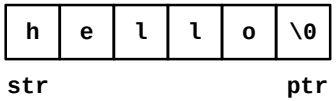
Incrementing pointers, cont.

- The postfix operators take precedence over the dereference operator and prefix operators
- ***** and prefix ops are at the same precedence level, and associate right to left
- **++*p** increments the value at the location to which **p** points, and evaluates to the incremented value
- ***p++** evaluates to the value at the location to which **p** points, and then advances **p**
- **(*p)++** evaluates to the value at the location to which **p** points, and then increments that value

Pointer arithmetic

- With two pointers in the same array, we can determine how far apart they are

```
size_t strlen(const char *str) {
  const char *ptr;
  for (ptr = str; *ptr; ptr++)
    ;
  return (size_t) (ptr – str);
}
```



Pointer arithmetic, cont.

- By adding an integer *n* to a pointer, we can get the address of the n^{th} element past the element to which the pointer currently points

```
int arr[] = {2, 3, 5, 7, 11};
int *p = &(arr[0]);
int *q = p + 4;
printf("%d\n", *q);
```

Output: 11

- Only valid forms of pointer arithmetic:
  - pointer - pointer
  - pointer ± integer