Memory Management and Pointers

CSC 340

February 17, 2016

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Pointer Basics

- Type of variable that stores a memory address (of a single object or an array of objects)
- Pointers "point" to a location in memory

```
int age = 37;
int * pointer = &age;
```

- Pointers must always point to a legal memory address before you attempt to use them
  - If they don't, you'll get segmentation (or other memory) faults

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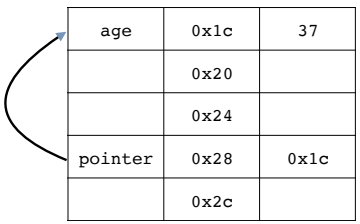
Visualizing Pointers

```
int age = 37;
int * pointer = &age;
```



age	0x1c	37
	0x20	
	0x24	
pointer	0x28	0x1c
	0x2c	

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Declaring and Initializing Pointers

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- Pointer variables must be declared to have a pointer type
- The * operator identifies the variable as a pointer variable

```
// NULL pointer
double *d_pointer = NULL;
Person *p_pointer = NULL;
// Multiple declarations (what are the types?)
int *p1 = NULL, *p2 = NULL, v1, v2;
```

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The & and * operators

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- & - The address of operator
  - Returns the address of a variable, which can be assigned to a pointer variable

```
Person john, *pointer = NULL;
pointer = &john;
```

- * - dereferencing operator (or the value of operator)

```
cout << *pointer;
(*pointer).first_name = "John";
```

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The -> operator

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- Used to access a data or function member in an object, through a pointer
- Is a short hand version of dereferencing * and the member-of . combination

```
// Equivalent:
(*person).first_name = "John";
person->first_name = "John";
```

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Pointer Assignment

- When two pointers are of the same data type, you can assign one pointer to the other:

```
Person john, *one_person, *other_person;
one_person = &john;
other_person = one_person;
```

- Both pointers now point to the same object
- What does this do?

```
*other_person = *one_person;
```

- https://gist.github.com/jrob8577/567eba3ffcfaec58c080

The new and delete operators

- Pointers can be used to point to memory space dynamically allocated by the new operator

```
Person * person_array = new Person[10];
```

  - The new operator may fail (we will learn about exception handling later)
  - Once created successfully, person_array can be treated as a fixed size array

- When dynamically allocated variables are no longer needed, delete them to return memory to the freestore

```
delete person_array;
```

- Undefined pointer variables are also called stale pointers. Dereferencing a stale pointer is usually disastrous.

Pointer arithmetic

- You can add and subtract with pointers
  - The ++ and — operators can be used
  - Two pointers of the same type can be subtracted to the obtain the number of indexed variables between them (the pointers should be in the same array!)

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Pointer arithmetic example

```
int * array = new int[10];

// Need to init
for( int i = 0; i < 10; i ++ )
{
    *(array + i) = i;
}

for( int i = 0; i < 10; i++ )
{
    // Same as array[i]
    cout << *(array + i) << " ";
}
```


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Pointers and Functions

- Pointers can be passed to functions
  - Similar to call by reference
- Pointers can be returned from functions
  - Create an array in the function, and return it
  - The caller is responsible for deleting the array
  - Should not return the address of a local object

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Reference Variables

- A reference variable is a pointer constant that always dereferences implicitly
  ```
  int longname = 10;
  int & count = longname;
  ```
- count can be treated as an alias of longname
- Must be initialized at declaration
- Often not necessary

Other uses for pointers

- Linked data structures
  - Linked Lists
  - Tree
  - Graphs
- Inheritance and Polymorphism