CSC 211: Object Oriented Programming
Pointers

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Fall 2019

Announcements

- Makeup exam (poll)
  - 10/31 (thursday)
  - 11/01 (friday)
  - 11/04 (monday)
- Solve 1 problem (assignment 3)

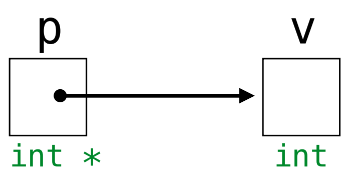
So far …

- Every variable/object (regardless of scope) exists at some memory location (**memory address**)
- Every memory address corresponds to a **unique location** in memory
- The compiler translates names into memory addresses when generating machine level code
- C++ allows programmers to manipulate variables/objects and their memory addresses directly

What is a pointer?

- A special type of variable whose value is the **memory address** of another variable
- Pointers must be **declared** before use
  - pointer type **must** be specified
  - pointers **must always** point to variables/objects of the same type

A pointer **p** that stores the memory address of another variable **v** is said to **point** to **v**



Declaration of pointer variables

```
type *ptr_name;
```

Declaration of pointer variables

```
// can declare a single
// pointer (preferred)
int *p;

// can declare multiple
// pointers of the same type
int *p1, *p2;

// can declare pointers
// and other variables too
double *p3, var, *p4;
```

Pointer Operators

- **Address-of** operator
  - used to get the memory address of another variable/object

&

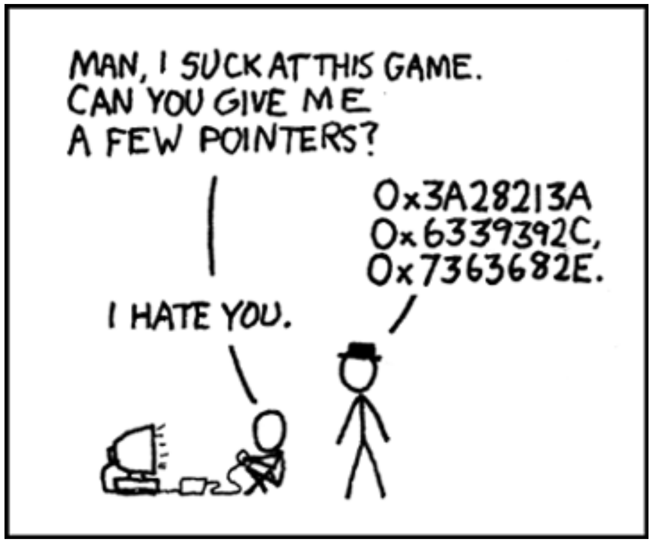
- **Dereference** Operator
  - used to get the actual value of a given memory address (dereferencing a pointer)

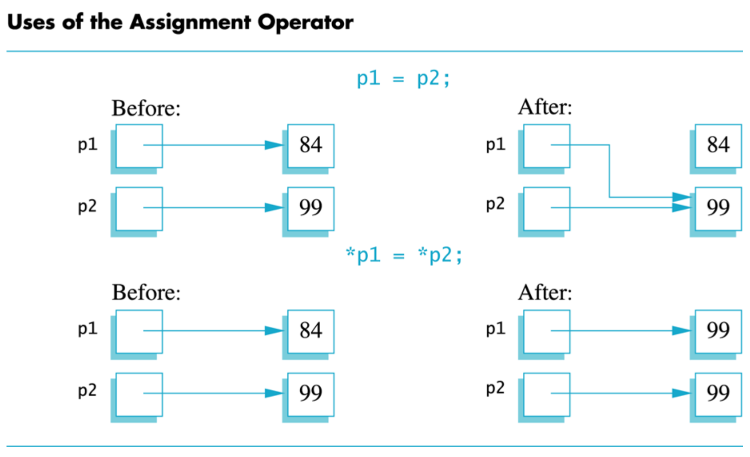
*

```
#include <iostream>

int main() {
    int var = 10;
    int *ptr;

    ptr = &var;
    *ptr = 20;

    // print both
    // using cout

    return 0;
}
```

Assuming 32-bit words

Address	Value	Variable
…		
0x91340A08		
0x91340A0C		
0x91340A10		
0x91340A14		
0x91340A18		
0x91340A1C		
0x91340A20		
0x91340A24		
0x91340A28		
0x91340A2C		
0x91340A30		
0x91340A34		
…		


MAN, I SUCK AT THIS GAME. CAN YOU GIVE ME A FEW POINTERS?
0x3A28213A 0x6339392C, 0x7363682E.
I HATE YOU.



```
int main() {
    int temp = 10;
    int value = 100;
    int *p1, *p2;

    p1 = &temp;
    *p1 += 10;

    p2 = &value;
    *p2 += 5;

    p2 = p1;
    *p2 += 5;

    return 0;
}
```

Address	Value	Variable
…		
0x91340A08		
0x91340A0C		
0x91340A10		
0x91340A14		
0x91340A18		
0x91340A1C		
0x91340A20		
0x91340A24		
0x91340A28		
0x91340A2C		
0x91340A30		
0x91340A34		
…		

Null pointers and functions

- Pointers can be initialized to an "empty" address (points to nothing) using the **nullptr** keyword
  - **nullptr** is just a pointer literal
- Pointers can be passed as parameters to functions
  - pointers are **treated as any other variable**
  - just remember they are holding **memory addresses**

```cpp
#include <iostream>

void increment(int *ptr) {
    (*ptr) ++;
}

int main() {
    int var = 10;

    increment(&var);
    increment(&var);

    // print using cout

    return 0;
}
```

Address	Value	Variable
…		
0x91340A08		
0x91340A0C		
0x91340A10		
0x91340A14		
0x91340A18		
0x91340A1C		
0x91340A20		
0x91340A24		
0x91340A28		
0x91340A2C		
0x91340A30		
0x91340A34		
…		

Pointers and references

- Not the same!
  - pointers are actual **variables**
  - references are *aliases* for existing variables
- **Careful** … both use the ampersand operator (&)
  - references are **declared** using the ampersand (&)
  - **address-of** operator (&) is used with pointers

Pointers and arrays

- When declaring an array, the array name is treated as a **constant pointer** (pointing to the **base address**)

Pointer arithmetic

- As pointers hold **memory addresses** (basically integers), we can add integers to it
- Must be careful !
  - `p+1` does not add 1 byte to the memory address, it adds the **size of the variable pointed by `p`**
- Can use pointer arithmetic to work with arrays

Example

- Implement `reverse a string` using pointer arithmetic