

CSE 333

Lecture 10 - references, const, classes

Hal Perkins

Department of Computer Science & Engineering
University of Washington



Administrivia

HW2 due a week from tomorrow

New exercise out today, due before class Friday

Sections tomorrow: C++. const / references / classes

Look at *C++ Primer* for details and explanations. We won't have time in class to cover everything useful.

Today's goals

Useful C++ features

- references, const

Introducing C++ classes

- defining, using them

Reminder: pointers

C: a pointer is a variable containing an address

- you can change its value to change what it is pointing to
- a pointer can contain the address of a different variable

→

```
int main(int argc, char **argv) {  
    int x = 5, y = 10;  
    int *z = &x;  
  
    *z += 1;    // sets x to 6  
    x += 1;    // sets x (and therefore *z) to 7  
  
    z = &y;    // sets z to the address of y  
    *z += 1;    // sets y (and therefore *z) to 11  
  
    return EXIT_SUCCESS;  
}
```

pointer.cc

x	5
----------	---

y	10
----------	----

z	?
----------	---

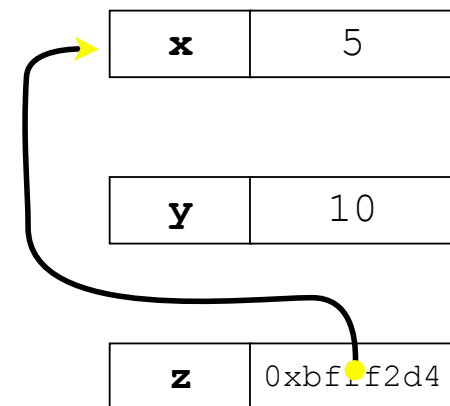
Reminder: pointers

C: a pointer is a variable containing an address

- you can change its value to change what it is pointing to
- a pointer can contain the address of a different variable

```
int main(int argc, char **argv) {  
    int x = 5, y = 10;  
    int *z = &x;  
  
    *z += 1; // sets x to 6  
    x += 1;  // sets x (and therefore *z) to 7  
  
    z = &y;  // sets z to the address of y  
    *z += 1; // sets y (and therefore *z) to 11  
  
    return EXIT_SUCCESS;  
}
```

pointer.cc



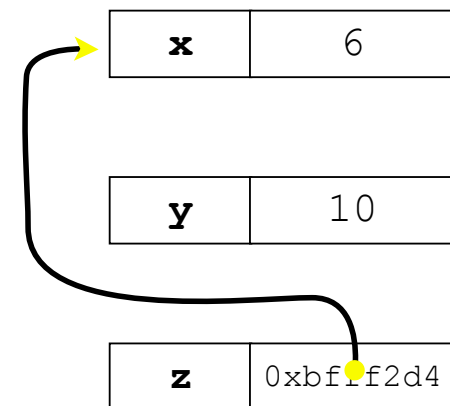
Reminder: pointers

C: a pointer is a variable containing an address

- you can change its value to change what it is pointing to
- a pointer can contain the address of a different variable

```
int main(int argc, char **argv) {  
    int x = 5, y = 10;  
    int *z = &x;  
  
    *z += 1; // sets x to 6  
    x += 1;  // sets x (and therefore *z) to 7  
  
    z = &y;  // sets z to the address of y  
    *z += 1; // sets y (and therefore *z) to 11  
  
    return EXIT_SUCCESS;  
}
```

pointer.cc



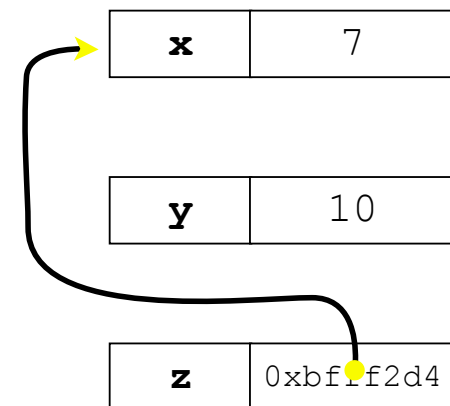
Reminder: pointers

C: a pointer is a variable containing an address

- you can change its value to change what it is pointing to
- a pointer can contain the address of a different variable

```
int main(int argc, char **argv) {  
    int x = 5, y = 10;  
    int *z = &x;  
  
    *z += 1; // sets x to 6  
    x += 1; // sets x (and therefore *z) to 7  
  
    z = &y; // sets z to the address of y  
    *z += 1; // sets y (and therefore *z) to 11  
  
    return EXIT_SUCCESS;  
}
```

pointer.cc



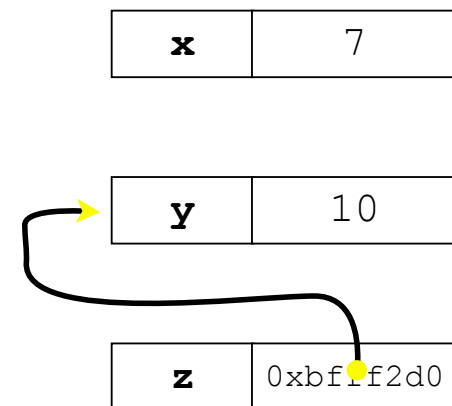
Reminder: pointers

C: a pointer is a variable containing an address

- you can change its value to change what it is pointing to
- a pointer can contain the address of a different variable

```
int main(int argc, char **argv) {  
    int x = 5, y = 10;  
    int *z = &x;  
  
    *z += 1;    // sets x to 6  
    x += 1;    // sets x (and therefore *z) to 7  
  
    z = &y;    // sets z to the address of y  
    *z += 1;    // sets y (and therefore *z) to 11  
  
    return EXIT_SUCCESS;  
}
```

pointer.cc



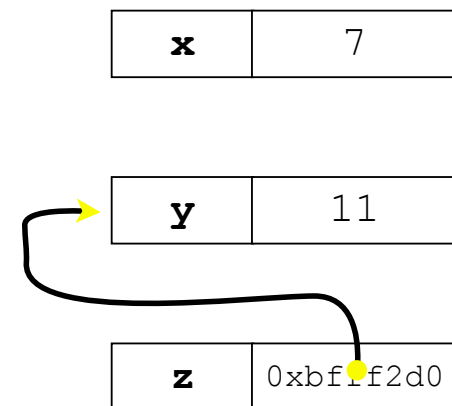
Reminder: pointers

C: a pointer is a variable containing an address

- you can change its value to change what it is pointing to
- a pointer can contain the address of a different variable

```
int main(int argc, char **argv) {  
    int x = 5, y = 10;  
    int *z = &x;  
  
    *z += 1; // sets *z (and therefore x) to 6  
    x += 1;  // sets x (and therefore *z) to 7  
  
    z = &y;  // sets z to the address of y  
    *z += 1; // sets *z (and therefore y) to 11  
  
    return EXIT_SUCCESS;  
}
```


pointer.cc



References

C++: introduces references *as part of the language*

- a reference acts like **an alias** for some other variable
 - **alias**: another name that is bound to the aliased variable
 - mutating a reference **is** mutating the referenced variable



```
int main(int argc, char **argv) {  
    int x = 5, y = 10;  
    int &z = x; // binds the name "z" to variable x  
  
    z += 1; // sets z (and thus x) to 6  
    x += 1; // sets x (and thus z) to 7  
  
    z = y; // sets z (and thus x) to the value of y  
    z += 1; // sets z (and thus x) to 11  
  
    return EXIT_SUCCESS;  
}
```

reference1.cc


x	5
----------	---

y	10
----------	----

References

C++: introduces references as part of the language

- a reference is **an alias** for some other variable
 - **alias**: another name that is bound to the aliased variable
 - mutating a reference **is** mutating the referenced variable



```
int main(int argc, char **argv) {  
    int x = 5, y = 10;  
    int &z = x; // binds the name "z" to variable x  
  
    z += 1; // sets z (and thus x) to 6  
    x += 1; // sets x (and thus z) to 7  
  
    z = y; // sets z (and thus x) to the value of y  
    z += 1; // sets z (and thus x) to 11  
  
    return EXIT_SUCCESS;  
}
```

reference1.cc


x, z	5
-------------	---

y	10
----------	----

References

C++: introduces references as part of the language

- a reference is **an alias** for some other variable
 - **alias:** another name that is bound to the aliased variable
 - mutating a reference **is** mutating the referenced variable



```
int main(int argc, char **argv) {  
    int x = 5, y = 10;  
    int &z = x; // binds the name "z" to variable x  
  
    z += 1; // sets z (and thus x) to 6  
    x += 1; // sets x (and thus z) to 7  
  
    z = y; // sets z (and thus x) to the value of y  
    z += 1; // sets z (and thus x) to 11  
  
    return EXIT_SUCCESS;  
}
```

reference1.cc


x, z	6
-------------	---

y	10
----------	----

References

C++: introduces references as part of the language

- a reference is **an alias** for some other variable
 - **alias**: another name that is bound to the aliased variable
 - mutating a reference **is** mutating the referenced variable



```
int main(int argc, char **argv) {  
    int x = 5, y = 10;  
    int &z = x; // binds the name "z" to variable x  
  
    z += 1; // sets z (and thus x) to 6  
    x += 1; // sets x (and thus z) to 7  
  
    z = y; // sets z (and thus x) to the value of y  
    z += 1; // sets z (and thus x) to 11  
  
    return EXIT_SUCCESS;  
}
```

reference1.cc

x, z	7
-------------	---

y	10
----------	----

References

C++: introduces references as part of the language

- a reference is **an alias** for some other variable
 - **alias:** another name that is bound to the aliased variable
 - mutating a reference **is** mutating the referenced variable

```
int main(int argc, char **argv) {  
    int x = 5, y = 10;  
    int &z = x; // binds the name "z" to variable x  
  
    z += 1; // sets z (and thus x) to 6  
    x += 1; // sets x (and thus z) to 7  
  
    z = y; // sets z (and thus x) to the value of y  
    z += 1; // sets z (and thus x) to 11  
  
    return EXIT_SUCCESS;  
}
```

reference1.cc

x, z	10
-------------	----

y	10
----------	----

References

C++: introduces references as part of the language

- a reference is **an alias** for some other variable
 - **alias:** another name that is bound to the aliased variable
 - mutating a reference **is** mutating the referenced variable

```
int main(int argc, char **argv) {  
    int x = 5, y = 10;  
    int &z = x; // binds the name "z" to variable x  
  
    z += 1; // sets z (and thus x) to 6  
    x += 1; // sets x (and thus z) to 7  
  
    z = y; // sets z (and thus x) to the value of y  
    z += 1; // sets z (and thus x) to 11  
  
    return EXIT_SUCCESS;  
}
```

reference1.cc

x, z	11
-------------	----

y	10
----------	----

Pass by reference

C++ allows you to truly pass-by-reference

- client passes in an argument with normal syntax
 - function uses reference parameters with normal syntax
 - modifying a reference parameter modifies the caller's argument

```
void swap(int &x, int &y) {  
    int tmp = x;  
    x = y;  
    y = tmp;  
}
```

→

```
int main(int argc, char **argv) {  
    int a = 5, b = 10;  
  
    swap(a, b);  
    cout << "a: " << a << "; b: " << b << endl;  
    return EXIT_SUCCESS;  
}
```

passbyreference.cc

(main)	a	5
--------	----------	---

(main)	b	10
--------	----------	----

Pass by reference

C++ allows you to truly pass-by-reference

- client passes in an argument with normal syntax
 - function uses reference parameters with normal syntax
 - modifying a reference parameter modifies the caller's argument

```
void swap(int &x, int &y) {  
    int tmp = x;  
    x = y;  
    y = tmp;  
}
```

```
int main(int argc, char **argv) {  
    int a = 5, b = 10;
```

```
    swap(a, b);  
    cout << "a: " << a << "; b: " << b << endl;  
    return EXIT_SUCCESS;  
}
```

passbyreference.cc

(main) a	5
-----------------	---

(main) b	10
-----------------	----

Pass by reference

C++ allows you to truly pass-by-reference

- client passes in an argument with normal syntax
 - function uses reference parameters with normal syntax
 - modifying a reference parameter modifies the caller's argument



```
void swap(int &x, int &y) {  
    int tmp = x;  
    x = y;  
    y = tmp;  
}
```

```
int main(int argc, char **argv) {  
    int a = 5, b = 10;  
  
    swap(a, b);  
    cout << "a: " << a << "; b: " << b << endl;  
    return EXIT_SUCCESS;  
}
```

passbyreference.cc

(swap) tmp	??
-------------------	----


(main) a	5
(swap) x	

(main) b	10
(swap) y	

Pass by reference

C++ allows you to truly pass-by-reference

- client passes in an argument with normal syntax
 - function uses reference parameters with normal syntax
 - modifying a reference parameter modifies the caller's argument



```
void swap(int &x, int &y) {  
    int tmp = x;  
    x = y;  
    y = tmp;  
}  
  
int main(int argc, char **argv) {  
    int a = 5, b = 10;  
  
    swap(a, b);  
    cout << "a: " << a << "; b: " << b << endl;  
    return EXIT_SUCCESS;  
}
```

passbyreference.cc

(swap) tmp	5
-------------------	---


(main) a	5
(swap) x	

(main) b	10
(swap) y	

Pass by reference

C++ allows you to truly pass-by-reference

- client passes in an argument with normal syntax
 - function uses reference parameters with normal syntax
 - modifying a reference parameter modifies the caller's argument



```
void swap(int &x, int &y) {  
    int tmp = x;  
    x = y;  
    y = tmp;  
}  
  
int main(int argc, char **argv) {  
    int a = 5, b = 10;  
  
    swap(a, b);  
    cout << "a: " << a << "; b: " << b << endl;  
    return EXIT_SUCCESS;  
}
```

passbyreference.cc

(swap) tmp	5
-------------------	---


(main) a	10
(swap) x	

(main) b	10
(swap) y	

Pass by reference

C++ allows you to truly pass-by-reference

- client passes in an argument with normal syntax
 - function uses reference parameters with normal syntax
 - modifying a reference parameter modifies the caller's argument



```
void swap(int &x, int &y) {  
    int tmp = x;  
    x = y;  
    y = tmp;  
}  
  
int main(int argc, char **argv) {  
    int a = 5, b = 10;  
  
    swap(a, b);  
    cout << "a: " << a << "; b: " << b << endl;  
    return EXIT_SUCCESS;  
}
```

passbyreference.cc

(swap) tmp	5
-------------------	---

(main) a	10
(swap) x	

(main) b	5
(swap) y	

Pass by reference

C++ allows you to truly pass-by-reference

- client passes in an argument with normal syntax
 - function uses reference parameters with normal syntax
 - modifying a reference parameter modifies the caller's argument

```
void swap(int &x, int &y) {  
    int tmp = x;  
    x = y;  
    y = tmp;  
}
```

```
int main(int argc, char **argv) {  
    int a = 5, b = 10;  
  
    swap(a, b);  
    cout << "a: " << a << "; b: " << b << endl;  
    return EXIT_SUCCESS;  
}
```

passbyreference.cc

(main) a	10
-----------------	----

(main) b	5
-----------------	---

const

const: cannot be changed

- used much more in C++ than in C

```
void BrokenPrintSquare(const int &i) {  
    i = i*i;  // Compiler error here!  
    std::cout << i << std::endl;  
}  
  
int main(int argc, char **argv) {  
    int j = 2;  
    BrokenPrintSquare(j);  
    return EXIT_SUCCESS;  
}  
  
brokenpassbyrefconst.cc
```

const

const's syntax is confusing

```
int main(int argc, char **argv) {
    int x = 5;          // x is an int
    const int y = 6;    // y is a (const int)
    y++;               // compiler error

    const int *z = &y;  // z is a (variable pointer) to a (const int)
    *z += 1;           // compiler error
    z++;               // ok

    int *const w = &x;  // w is a (const pointer) to a (variable int)
    *w += 1;           // ok
    w++;               // compiler error

    const int *const v = &x; // v is a (const pointer) to a (const int)
    *v += 1;           // compiler error
    v++;               // compiler error

    return EXIT_SUCCESS;
}
```

constmadness.cc

style guide tip

use const reference parameters to pass input values

- particularly for large values

use pointers to pass output parameters

- input parameters first, then output parameters last

```
#include <cstdlib>

void CalcArea(const int &width, const int &height,
              int *const area) {
    *area = width * height;
}

int main(int argc, char **argv) {
    int w = 10, h = 20, a;

    CalcArea(w, h, &a);
    return EXIT_SUCCESS;
}
```

styleguide.cc

When to use references?

A stylistic choice

- not something mandated by language

Google C++ style guide suggests:

- input parameters:
 - either use values (for primitive types like int)
 - or use const references (for complex structs / object instances)
- output parameters
 - use const pointers

virality of const

- **OK to pass**

- a pointer to non-const
- to a function that expects
 - a pointer to const

- **not OK to pass**

- a pointer to a const
- to a function that expects
 - a pointer to a non-const

```
#include <iostream>

void foo(const int *y) {
    std::cout << *y << std::endl;
}

void bar(int *y) {
    std::cout << *y << std::endl;
}

int main(int argc, char **argv) {
    const int a = 10;
    int b = 20;

    foo(&b);    // OK
    bar(&a);    // not OK

    return 0;
}
```

Classes

class declaration syntax (in a .h file)

```
class Name {  
    private:  
        members;  
    public:  
        members;  
};
```

class member definition syntax (in a .cc file)

```
returntype classname::methodname(parameters) {  
    statements;  
}
```

You can name your .cc, .h file anything (unlike Java)

- ▶ typically name them Classname.cc, Classname.h

.h file

```
#ifndef _POINT_H_
#define _POINT_H_

class Point {
public:
    Point(const int x, const int y); // constructor
    int get_x() const { return x_; } // inline member function
    int get_y() const { return y_; } // inline member function
    double Distance(const Point &p) const; // member function
    void SetLocation(const int x, const int y); // member functn

private:
    int x_; // data member
    int y_; // data member
}; // class Point

#endif // _POINT_H_
```

Point.h

.cc file

```
#include <cmath>
#include "Point.h"

Point::Point(const int x, const int y) {
    x_ = x;
    this->y_ = y; // "this->" is optional, unless names conflict
}

double Point::Distance(const Point &p) const {
    // We can access p's x_ and y_ variables either through the
    // get_x(), get_y() accessor functions, or the x_, y_ private
    // member variables directly, since we're in a member
    // function of the same class.
    double distance = (x_ - p.get_x()) * (x_ - p.get_x());
    distance += (y_ - p.y_) * (y_ - p.y_);
    return sqrt(distance);
}

void Point::SetLocation(const int x, const int y) {
    x_ = x;
    y_ = y;
}
```

Point.cc

.cc file with main()

```
#include <iostream>
#include "Point.h"

using namespace std;

int main(int argc, char **argv){
    Point p1(1, 2); // stack allocate a new Point
    Point p2(4, 6); // stack allocate a new Point

    cout << "p1 is: (" << p1.get_x() << ", ";
    cout << p1.get_y() << ")" << endl;

    cout << "p2 is: (" << p2.get_x() << ", ";
    cout << p2.get_y() << ")" << endl;

    cout << "dist : " << p1.Distance(p2) << endl;
    return 0;
}
```

usepoint.cc

struct vs. class

in C

- a struct contains only fields
 - cannot contain methods
 - does not have public vs. private vs. protected

in C++

- struct and class are (nearly) the same
 - both can contain methods
 - both can have public vs. private vs. protected
- **struct**: default public, **class**: default private

Exercise 1

Write a C++ program that:

- has a class representing a 3-dimensional point
- has the following methods:
 - return the inner product of two 3d points
 - return the distance between two 3d points
 - accessors and mutators for the x, y, z coordinates

Exercise 2

Write a C++ program that:

- has a class representing a 3-dimensional box
 - use your exercise 1 class representing 3d points to store the coordinates of the vertices that define it
 - assume the box has right-angles only and its faces are parallel to the axes, so you only need two vertices to define it
- has the following methods:
 - test if one box is inside another box
 - return the volume of a box
 - handles “<<”, “=”, and a copy constructor
 - uses const in all the right places

See you on Friday!