CSE 333

Lecture 10 - references, const, classes

Hal Perkins

Department of Computer Science & Engineering

University of Washington

Administrivia

HW2 due a week from tomorrow

<panic>if not started yet</panic>

Midterm exam a week from next Monday(!!!)

New exercise out today, due before class Friday

Section 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

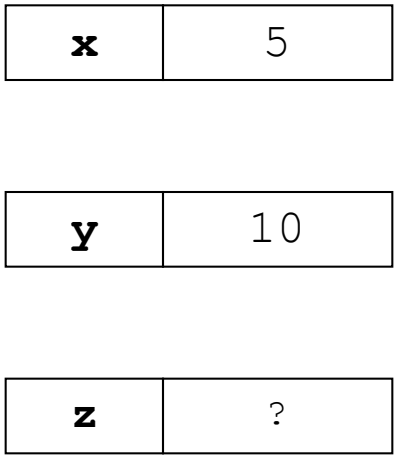
```
int main(int argc, char **argv) {
  int x = 5, y = 10;
  int *z = &x;

  *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



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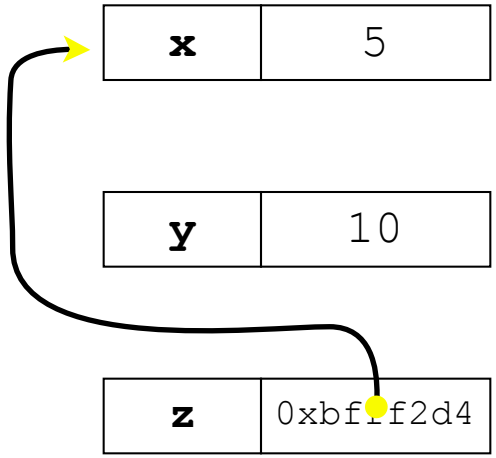

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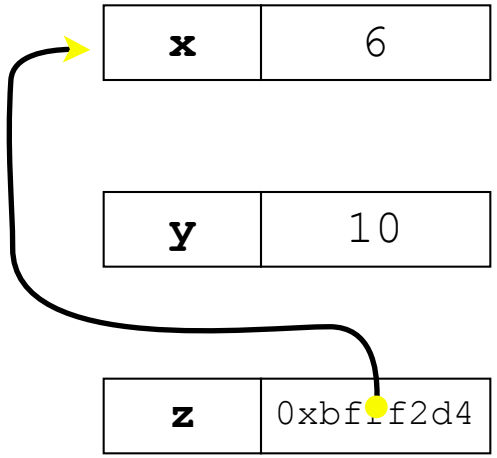

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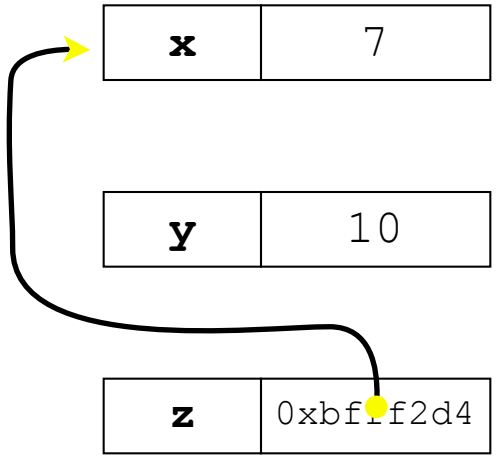

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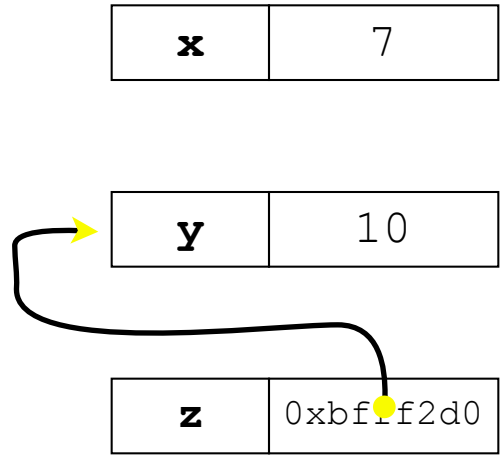

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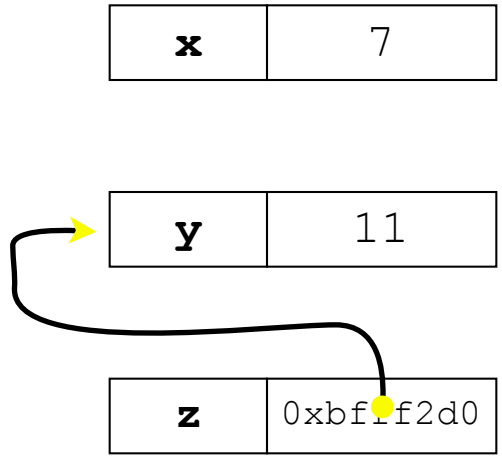

References

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
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  z = y;   // sets z (and thus x) to the value of y
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reference1.cc

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reference1.cc

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  z = y;   // sets z (and thus x) to the value of y
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  return EXIT_SUCCESS;
}
```

reference1.cc

x,z	6

y	10

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```

reference1.cc

x,z	7

y	10

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  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

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  cout << "a: " << a << "; b: " << b << endl;
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}
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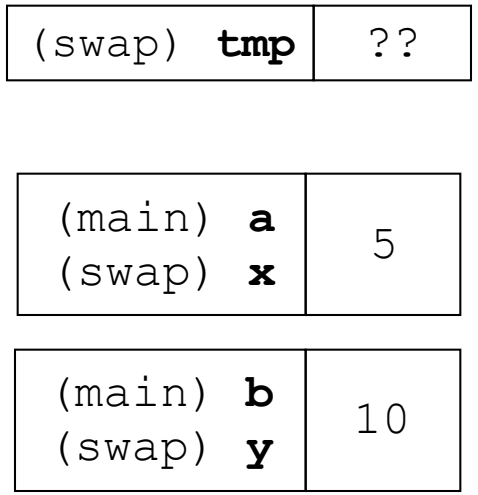
passbyreference.cc



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  int tmp = x;
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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** (swap) **x**	5

(main) **b** (swap) **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;
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}

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

  swap(a, b);
  cout << "a: " << a << "; b: " << b << endl;
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passbyreference.cc

(swap) **tmp**	5

(main) **a** (swap) **x**	10

(main) **b** (swap) **y**	10

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  int tmp = x;
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}

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** (swap) **x**	10

(main) **b** (swap) **y**	5

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
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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 for input values

particularly for large values

use pointers for 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 the C++ 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 (i.e., unchangeable pointers referencing changeable data – see previous slide)

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 {
 public:
   members;
 private:
   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
- common style convention: structs for simple bundles of data (maybe with convenience constructors); classes for abstractions with data + functions

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 verticies 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

Reading Assignment

Before next class: read sections in *C++ Primer* covering constructors, copy constructors, assignment (operator=), and destructors

- Ignore “move semantics” for now
- The table of contents and index are your friends…

See you on Friday!