References Revisited

CSE 333 Winter 2019

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Administrivia

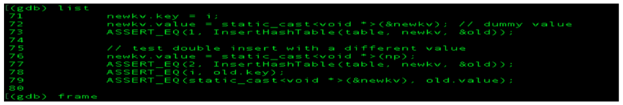
- No exercise due Friday. Next exercise out today after midterm, due Wednesday before class (STL map exercise)
- Midterm: Friday in class
  - Closed book, no notes
  - Old exams and topic list on the course web now
    - Everything up through C++ classes, dynamic memory, templates & STL (vectors only– not map and others)
  - Review in sections tomorrow
- Homework 3 – spec out now, files pushed by Friday
  - Spec overview & demo in class today
- Missed classes (especially smart pointers) – can we schedule a make-up lecture? When?

Discussion group and email hints

- *Please* send any necessary email to cse333-staff[at]cs, ***not*** to individual TAs/instructor

Please help your readers (both for cse333 and elsewhere):

- Use descriptive titles and provide enough context in the question so readers don't need to go on a treasure hunt
- Please don't post screenshots of text



```
[(gdb) list
71              newkv.key = i;
72              newkv.value = static_cast<void *>(&newkv); // dummy value
73              ASSERT_EQ(1, InsertHashTable(table, newkv, &old));
74
75              // test double insert with a different value
76              newkv.value = static_cast<void *>(np);
77              ASSERT_EQ(2, InsertHashTable(table, newkv, &old));
78              ASSERT_EQ(i, old.key);
79              ASSERT_EQ(static_cast<void *>(&newkv), old.value);
80
[(gdb) frame
```

  - Hard to read and/or require opening an extra window
  - If it's text, copy and paste the text(!) (drag to select in terminal or dialog boxes)
  - Images are fine if they actually are relevant to the posting
- Your readers thank you for your help 😃

∃ Confusion About References

- When should they be used?
  - Particularly with parameters and return values

- When can using them cause trouble?

The Plan…

- We'll go through a bunch of code examples
- For each example, we want to decide if it is appropriate to use references, and then chose one answer from this list:

A. **We must NOT use a reference**

B. **It's OK but *discouraged* to use a reference**

C. **It's OK and *encouraged* to use a reference**

D. **We must use a reference**

E. **We're lost…**

Parameters 1

param1.cc

```
#include <cstdlib>
#include <iostream>

using namespace std;

// SHOULD WE BE USING REFERENCES FOR PARAMETERS "a" AND "b"?
// (Answer: ?)
int LeastCommonMultiple(const int &a, const int &b) {
  for (int n=1; ; n++) {
    if ((n % a == 0) && (n % b == 0))
      return n;
  }
}

int main(int argc, char **argv) {
  int x = 12, y = 14;

  int lcm = LeastCommonMultiple(x, y);
  cout << "LCM(" << x << "," << y << ") is " << lcm << endl;
  return EXIT_SUCCESS;
}
```

`param1.cc`

- **B. It's OK but *discouraged* to use a reference**
  - A const reference to a small primitive type (*e.g.* `int`, `float`)
  - We aren't changing the argument values (`const`), so it doesn't matter if we use a copy or not – reference is *optional*
  - Correct behavior, but might have better performance with regular call-by-value

Parameters 2

param2.cc

```
#include <cmath>
#include <cstdlib>
#include <iostream>

#include "ThreeDPoint.h"

// SHOULD WE BE USING REFERENCES FOR PARAMETERS "a" AND "b"?
// (Answer: ?)
double Distance(const ThreeDPoint &a, const ThreeDPoint &b) {
  double dist = pow(a.x-b.x,2) + pow(a.y-b.y,2) + pow(a.z-b.z,2);
  return sqrt(dist);
}

int main(int argc, char **argv) {
  ThreeDPoint a(1,2,3), b(4,5,6);

  int dist = Distance(a, b);
  cout << "Distance(a,b) is " << dist << endl;
  return EXIT_SUCCESS;
}
```

`param2.cc`

- C. It's OK and *encouraged* to use a reference
  - A const reference to a complex type (*e.g.* struct, object instance)
  - We aren't changing the argument values (`const`), so it doesn't matter if we use a copy or not – reference is *optional*
  - Correct behavior and likely performance benefit from not having to copy

- Follow-up: Why not pass in a pointer instead?

Return Value 1

ret1.cc

```
#include <cstdlib>
#include <iostream>

typedef struct Point_st {
  double x, y, z;
} Point;

// SHOULD WE BE USING A REFERENCE FOR THE RETURN VALUE?
// (Answer: ?)
Point &MakePoint(const int x, const int y, const int z) {
  Point retval = {x, y, z};
  return retval;
}

int main(int argc, char **argv) {
  Point p = MakePoint(1, 2, 3);
  std::cout << p.x << "," << p.y << "," << p.z << std::endl;
  return EXIT_SUCCESS;
}
```

ret1.cc

- A. **We must NOT use a reference**
  - A reference to a stack-allocated complex type
  - Never return a reference (or pointer to) a local variable
    - Also, destructor is called on object when returning

Copy Constructor

Complex1.h

```
#ifndef _COMPLEX_H_
#define _COMPLEX_H_

#include <iostream>

namespace complex {

class Complex {
 public:
  // Copy constructor -- should we pass a reference or not?
  // (Answer: ?)
  Complex(const Complex &copyme) {
    real_ = copyme.real_;
    imag_ = copyme.image_;
  }

 private:
  double real_, imag_;
};  // class Complex

}  // namespace complex

#endif  // _COMPLEX_H_
```

`Complex1.h`

- **D. We must use a reference**
  - A const reference to a complex type
  - We aren’t changing the argument’s values so it doesn’t matter if we use a copy or not, in theory
  - A copy constructor *must* take a reference, otherwise it would need to call itself to make a (call-by-value) copy of the argument…

operator+

Complex2.h

```
#include <iostream>

namespace complex {

class Complex {
 public:
  // Should operator+ return a reference or not?
  // (Answer: ?)
  Complex &operator+(const Complex &a) const {
    Complex tmp(0,0);
    tmp.real_ = this->real_ + a.real_;
    tmp.imag_ = this->imag_ + a.imag_;
    return tmp;
  }

 private:
  double real_, imag_;
};  // class Complex

}  // namespace complex
```

`Complex2.h`

- A. **We must NOT use a reference**
  - A reference to a stack-allocated variable
  - Never return a reference (or pointer to) a local variable
    - Destructor is also called on object when returning

- Follow-up: If we fix the code, does chaining work?

Assignment Operator

Complex3.h

```
#include <iostream>

namespace complex {

class Complex {
 public:
  // Should the assignment operator return a reference?
  // (Answer: ?)
  Complex &operator=(const Complex &a) {
    if (this != &a) {
      this->real_ = a.real_;
      this->imag_ = a.imag_;
    }
    return *this;
  }

 private:
  double real_, imag_;
};  // class Complex

}  // namespace complex
```

`Complex3.h`

- D. **We must use a reference**
  - A reference to `*this`, the object this method was called on
  - All of the "work" is done in the method body; the return value is only there for chaining (but *required* for chaining to work correctly)

- Follow-up: What happens in `(a = b) = c;` if we don't use a reference?
  - Does it compile?
  - Does it "work"?
  - Does it do the "right thing"?

operator+=

Complex4.h

```
#include <iostream>

namespace complex {

class Complex {
 public:
  // Should += return a reference?
  // (Answer: ?)
  Complex &operator+=(const Complex &a) {
    this->real_ += a.real_;
    this->imag_ += a.imag_;
    return *this;
  }

 private:
  double real_, imag_;
};  // class Complex

}  // namespace complex
```

Complex4.h

- D. **We must use a reference**
  - A reference to `*this`, the object this method was called on
  - All of the "work" is done in the method body; the return value is only there for chaining (but *required* for chaining to work correctly)
  - You hardly see people chain `+=`, but it is allowed by the primitive data types, so we follow suit
    - Style/code quality: overloaded operators should have similar semantics to basic definitions to avoid programmer surprises

operator<<

Complex5.h

```
#include <iostream>

namespace complex {

class Complex {
 public:
  double real() const { return real_; };
  double imag() const { return imag_; };

 private:
  double real_, imag_;
};  // class Complex

}  // namespace complex

// Should operator<< return a reference?
// (Answer: ?)
std::ostream &operator<<(std::ostream &out,
                         const complex::Complex &a) {
  out << "(" << a.real() << " + " << a.imag() << "i)";
  return out;
}
```

`Complex5.h`

- **D. We must use a reference**
  - A reference to `out`, the ostream object provided as an reference argument
  - The return value is only there for chaining (but *required* for chaining to work correctly)
  - Copying of streams is disallowed (and doesn't make sense)