Department I - C Plus Plus

Modern and Lucid C++ Advanced for Professional Programmers

Week 1 – C Plus Plus Recap

Prof. Peter Sommerlad / Thomas Corbat
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Basics Language Features

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- **Semantics of Values and (lvalue) References**

```
void foo(int p) {
  p = 23;
}
...
int i = 5;
foo(i);
```

```
void foo(int & p) {
  p = 23;
}
...
int i = 5;
foo(i);
```

- **What is the value of `i` after `foo(i)`?**

- **We will look at rvalue References too**

```
void foo(int && p) {
  ...
}
...

foo(5);
```

- **With the `const` keyword you have a powerful tool to improve your code**
- **Where can we place the `const` keyword?**
  - Types of Variables/Parameters/Return Types
  - Member Functions (`this` pointer)
  - Pointers

```
Spaceship vulture{};
vulture.load(Stuff{});

Spaceship const eagle{};
out << eagle.built();
```

```
struct Spaceship {
  void load(Stuff const &) {}
  Date built() const {}
};
```

- **`load()` modifies the Spaceship thus it must not be `const`**
- **`built()` only queries the date, does not modify Spaceship and therefore should be `const`**

- **Composite types (Classes)**

```
struct Telephone {
  void dial(PhoneNumber);
private:
  Log<Calls> call_log;
};
```

- **Enums**

```
enum class Gender {
  female, male, apache
  //50 more
};
```

- **Lambdas**

```
void catch_me_if_you_can() {
  Criminal abagnale{"Frank"s};
  auto hanratty = [abagnale] {
    offer_deal(abagnale);
  };
}
```

- **Functions**

```
Meal cookBreakfast(Kitchen & kitchen) {
  auto frying_pan = kitchen.getPan();
  kitchen.sink().wash(frying_pan);
  auto oven = kitchen.oven();
  oven.put(frying_pan);
  oven.turnOn(Oven::Temperature::hot);
  frying_pan.add(Egg{});
  frying_pan.add(Bacon{});
  return frying_pan.slightlyBurntFood();
}
```

- **Namespaces**
  - Named

```
namespace Labyrinth {
  Minotaur asterion{};
}
```

  - Global

```
//Global namespace
int main() {}
```

  - Anonymous

```
namespace {
}
```

  - Inline

```
namespace MyLib {
  inline namespace V1 {
    struct WillImprove {
    };
  }
}
```

- **Variables**
  - Local

```
void tour_de_rappi() {
  Restaurant baeren{};
}
```

  - Global

```
Climate warming{};
```

  - Member

```
class Ship {
  int number_of_leaks{};
};
```

  - Can all be `static`, what would each mean?

- **You can throw everying in C++**
- **`try/catch`**
  - but no `finally` – is that a problem?
- **Catch clauses tried from top to bottom**
- **Exception wildcard ellipsis (`...`)**
- **Good style to**
  - Throw by value
  - Catch by `const &`

```
void go_home_from_lecture() try {
  try {
    waitForBell();
  } catch (FellAsleepException const & e) {
    wakeUp();
    wonderWhyTheRoomIsDarkAndEverybodyIsGone();
  }
  packYourStuff();
  try {
    getUp();
  } catch (LegGotPinsAndNeedlesException const & e) {
    dieOfPain() || stayMotionless(TIME_TO_RECOVER);
  }
  leaveHSR();
  gotoTheStation();
  //...
} catch(...) {
  //Did not expect that. I don't know what it is.
  wonderAboutException();
  //Let somebody else care...
  throw;
}
```

- **Operators for primitive types are specified in the language (E.g +, -, /,...)**
  - Caveat: Only for expressions with operands of the same type

```
int intValue1 = 15;
int intValue2 = 24;
auto intIntSum = intValue1 + intValue2;

long longValue1 = 11l;
auto longIntSum = longValue1 + intValue1;

double doubleValue = 128.0;
auto doubleIntSum = doubleValue + intValue1;

unsigned unsignedValue = 99u;
auto unsignedIntSum = unsignedValue + intValue1;
```

- **Negative/positive overflow of unsigned integers is defined**
  - However, it might feature unexpected behavior

```
int zeroIndex = 0;
for (unsigned size = 5; size <= 10; size--) {
  if (zeroIndex <= size - 1) {
    std::cout << "access with 0 is ok for size " << size << '\n';
  } else {
    std::cout << "access with 0 is not ok for size " << size << '\n';
  }
}
```

- **Program output:**

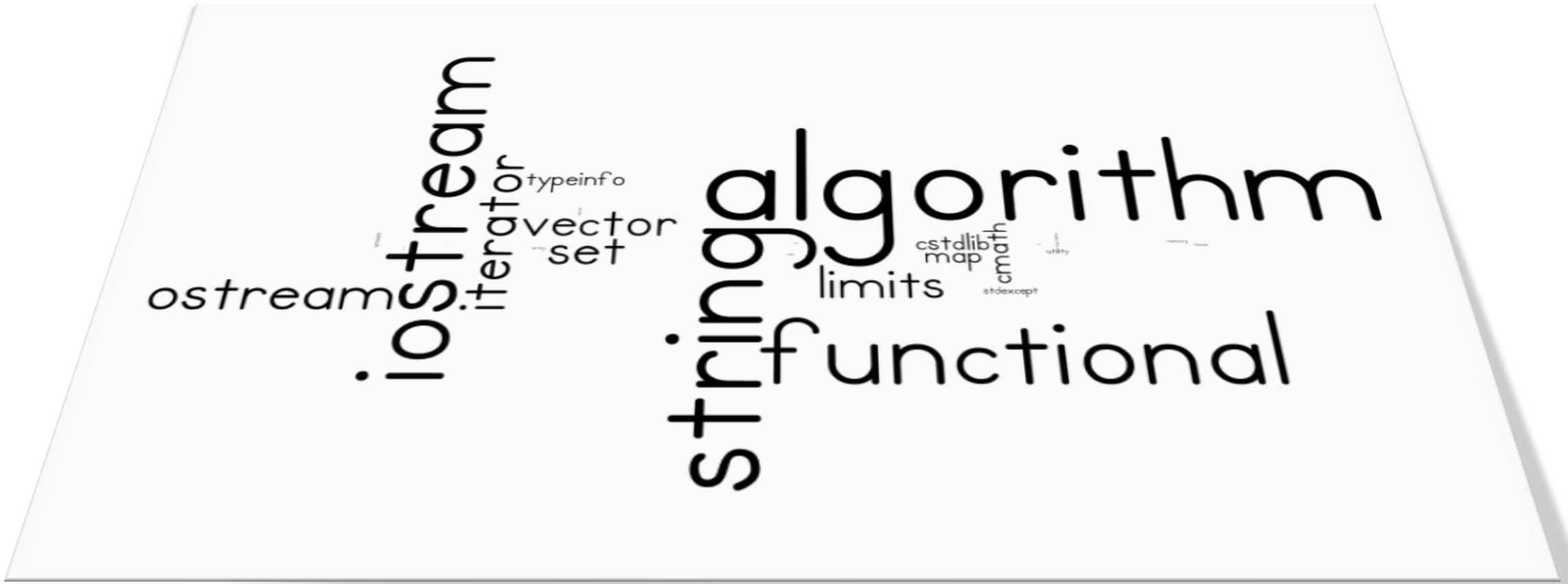
```
access with 0 is ok for size 5
access with 0 is ok for size 4
access with 0 is ok for size 3
access with 0 is ok for size 2
access with 0 is ok for size 1
access with 0 is ok for size 0
```

Discuss with your neighbor the keywords

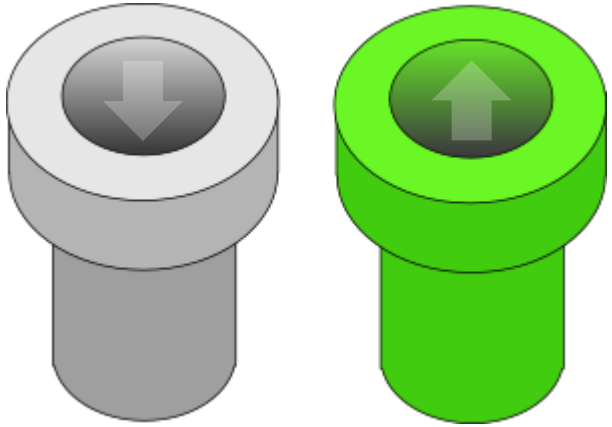
- `explicit`
- `inline`
- `using`
- `virtual`
- `mutable`
- `friend`
- `override`
- `final`

- **In which context can they be used?**
- **What do they mean?**
- **Do you know any other keywords?**

Standard Library


algorithm
functional
string
iostream
ostream
iterator
typeinfo
vector
set
limits
cstdlib
map
cmath
stdexcept

- **Input and output for programs**
  - `std::cin` and `std::cout` (only in `main` function)
- **Using and overloading input and output operators**
  - `operator >>`
  - `operator <<`

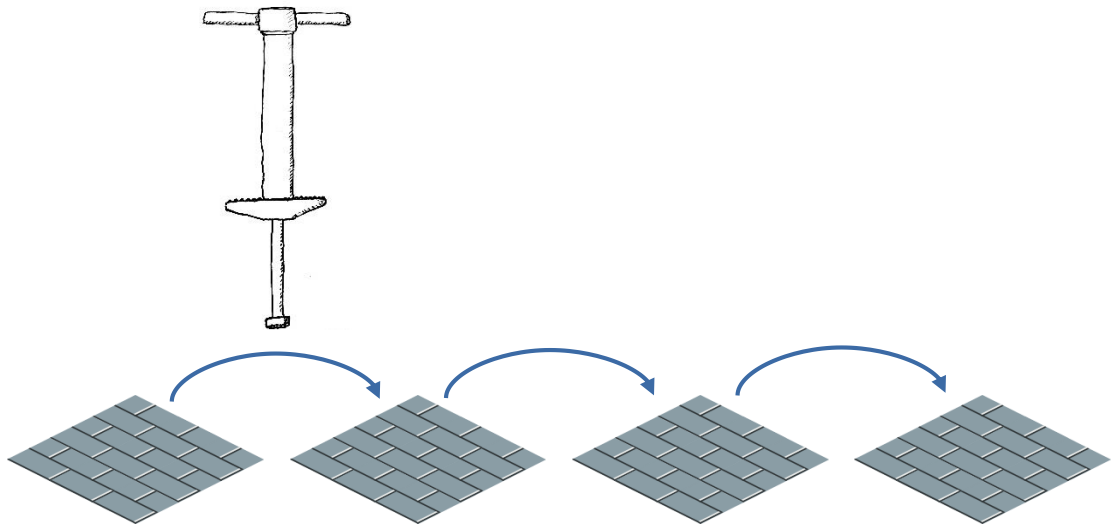


```
struct Order {
  unsigned amount;
  Product product;
};

std::ostream & operator<<(std::ostream & out, Order const & o) {
  out << o.amount << "x" << o.product;
  return out;
}
```

- **Iterators specify ranges**
- **Jump from element to element**

```
void iteration() {
  std::vector<Tile> tiles{...};
  auto pogo_stick = std::begin(tiles);
  pogo_stick++;
  auto tile = *pogo_stick;
}
```



- **Capabilities depend on the specific iterator type**
- **Categories:** Input iterator, Bidirectional iterator, Output iterator, Forward iterator, Random access iterator
- **We will implement our own iterators in this module**

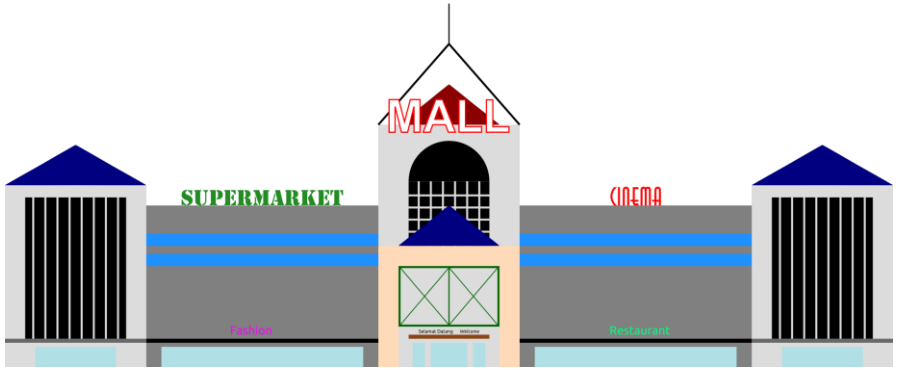
- **Benefits of using standard algorithms over hand-written loops**
  - Correctness
  - Easier to read and understand
  - Performance

```
bool find_with_loop(std::vector<int> const & values, int const v) {
  auto const end = std::end(values);
  for(auto it = std::begin(values); it != end; ++it) {
    if (*it == v) {
      return true;
    }
  }
  return false;
}
```

```
bool find_with_algorithm(std::vector<int> const & values, int const v) {
  auto const pos = std::find(std::begin(values), std::end(values), v);
  return pos != std::end(values);
}
```

- **Heap memory management in C++ should be handled with `std::shared_ptr` and `std::unique_ptr`**

```
void mall() {
  auto main_door = std::make_shared<Mall>();
  auto side_door = main_door;
  auto more_door = side_door;
  auto hodor = main_door;
}
```




```
void toolbox() {
  auto handle = std::make_unique<Hammer>();
  //You cannot have a hammer with two handles
  auto handle_too = handle;
}
```

- **We will look at legacy alternatives using `new` and `delete` in this module though**

Advanced Topics

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- **The most capable means of introducing coupling into your software**

```
class Parent {
  //Members of Parent
};

class Child : public Parent {
  //Members of Child
};
```

- **Can be used to "mix-in" functionality into your classes**
  - E.g. boost::operators
- **Multiple inheritance will be discussed in more detail**
  - Especially diamond hierarchies

- **To write compile-time polymorphic classes and functions**
  - With template argument deduction for template functions

```
template<typename T>
class Box {
  T content;
public:
  T const & peek() const {
    return content;
  }
  T & open() {
    return content;
  }
};
```

```
template<typename T>
Box<T> wrap(T const & t) {
  return Box<T>{t};
}


...
Present doll{};
Box<Present> gift = wrap(doll);
```

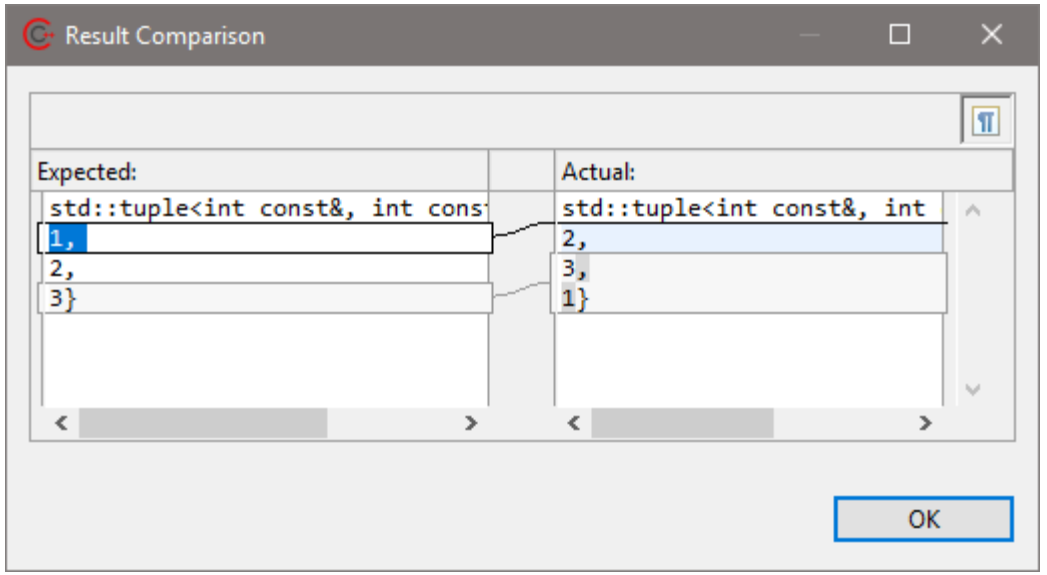
- **Variable templates will be introduced**
- **SFINAE**

- **Creating unit tests using CUTE**

```
void thisIsATest() {
  ASSERTM("start writing tests", false);
}
```

- **The CUTE plug-in has a simplified wizard, regarding libraries**
- **Also new the visualization of tuples**

```
void testTuplesAreDifferent() {
  int const a { 1 };
  int const b { 2 };
  int const c { 3 };
  ASSERT_EQUAL(std::tie(a, b, c), std::tie(b, c, a));
}
```



- **We might have a look at a different test approach later in this course for our container example**

- **Signed overflow (Unit C++20)**

```
void evil_inside() {
  int i = 0;
  while (i++ > 0);
}
```

- **Dangling references**

```
int & evil_outside() {
  int i = 0;
  return i;
}
```

- **Multiple side effects**

```
void whats_that() {
  int i{};
  i = i++ + ++i;
}
```

- **Accessing (possibly) unallocated memory**

```
void wish_me_luck() {
  std::vector<int> values{1, 2};
  int second = values[2];
  ...
}
```

- **Not UB but the emojis of programming**

```
bool statement = ...;
if (statement == true) {
  return false;
} else if (false == statement) {
  return true;
} else {
  return true;
}
```