Class introduction

... done with support of

Agenda

- Class introduction, class vs struct
- Access specifiers
- Life cycle of class
- Inheritance, Encapsulation, Interface class
- Virtual table
- Keywords
- Possible problems, tips and tricks
- Demo, Lessons learned, Q&A, ...

Class introduction, class vs struct

- Class is elementary structure of C++ language
- Class uses by default `private` access specifier
- Class is intended to use encapsulation - limiting access to member variables in order to prevent i.e. unintended modifications
- Read more about encapsulation here

```
class Person
{
    std::string name;
    uint8_t age;
};
```

Class introduction, class vs struct

```
class Person
{
    std::string name; // Private by default

public:
    void setName(std::string newName) { name = newName; }
    std::string getName() { return name; }
};

int main() {
    Person john;
    john.setName("John Doe");
    std::cout << john.getName() << std::endl;
    return 0;
}
```

Class introduction, class vs struct

- `Struct` is the same as `class`, but used `public` specifier by default
  - Struct can be inherited, can contain methods, can contain virtual table, ...
- Due to historical reasons it is used mostly for data collection
- "POCO" - Plain Old C Object

Class introduction, class vs struct

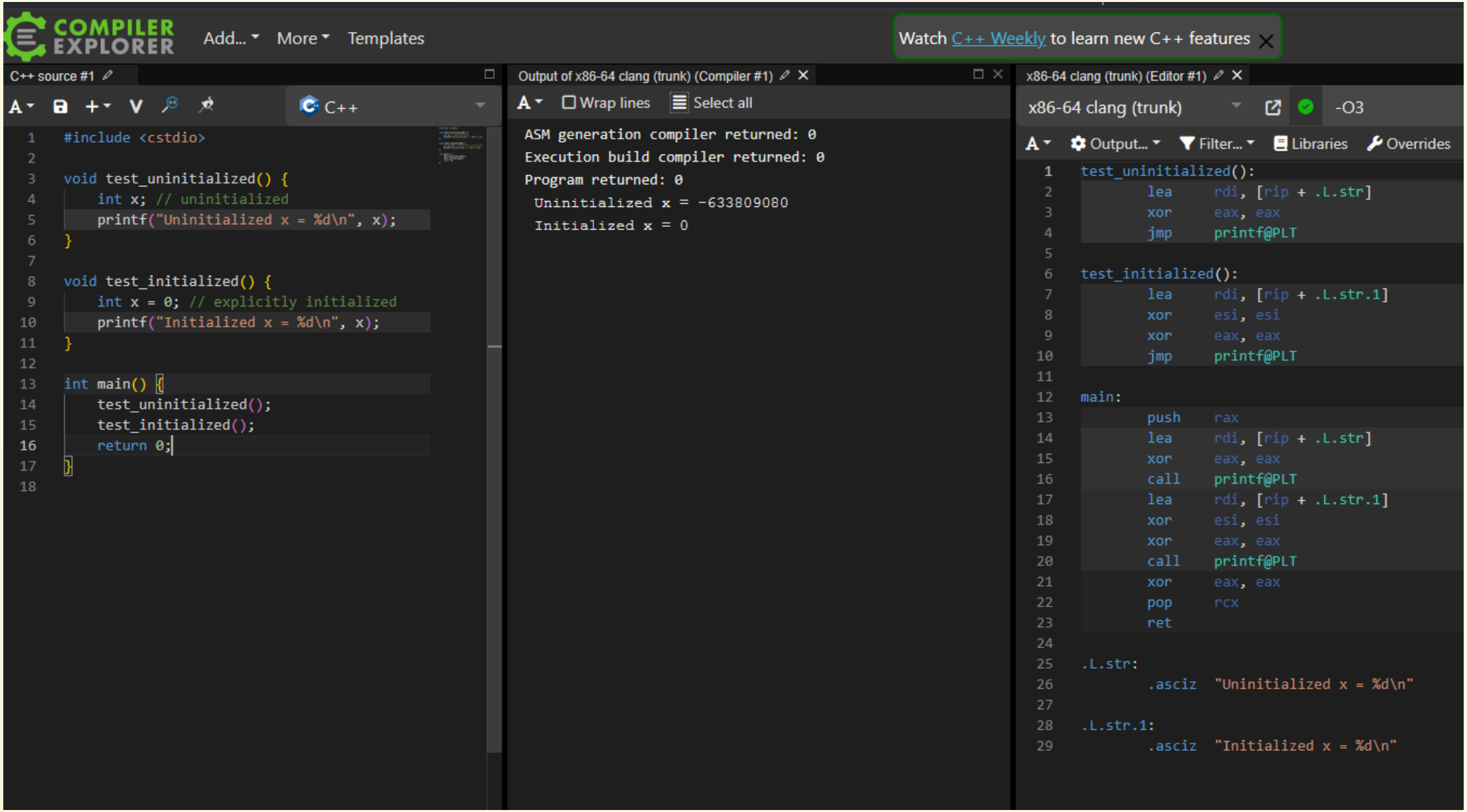
```
struct Person
{
	std::string name;
	uint8_t age;
};

int main()
{
	Person john;
	john.name = "John Doe"; //This is valid, because all members are public
	john.age = 42;

	return 0;
}
```

Access specifier

- `public`
  - Variable/function can be modified/called from **outside** of instance
- `protected`
  - Variable/function can be modified/called only from **inside of instance or it's child**
- `private`
  - Variable/function can be modified/called only from **inside** of instance.

Class introduction, class vs struct

- Member variables
- Member functions
- ⚠️ Be careful about uninitialized variables
- https://en.wikipedia.org/wiki/Uninitialized_variable


COMPILER EXPLORER
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C++ source #1
C++
#include <cstdio>
void test_uninitialized() {
int x; // uninitialized
printf("Uninitialized x = %d\n", x);
}
void test_initialized() {
int x = 0; // explicitly initialized
printf("Initialized x = %d\n", x);
}
int main() {
test_uninitialized();
test_initialized();
return 0;
}
Output of x86-64 clang (trunk) (Compiler #1)
Wrap lines
Select all
ASM generation compiler returned: 0
Execution build compiler returned: 0
Program returned: 0
Uninitialized x = -633809080
Initialized x = 0
x86-64 clang (trunk) (Editor #1)
x86-64 clang (trunk)
-O3
Output...
Filter...
Libraries
Overrides
test_uninitialized():
lea rdi, [rip + .L.str]
xor eax, eax
jmp printf@PLT
test_initialized():
lea rdi, [rip + .L.str.1]
xor esi, esi
xor eax, eax
jmp printf@PLT
main:
push rax
lea rdi, [rip + .L.str]
xor eax, eax
call printf@PLT
lea rdi, [rip + .L.str.1]
xor esi, esi
xor eax, eax
call printf@PLT
xor eax, eax
pop rcx
ret
.L.str:
.asciz "Uninitialized x = %d\n"
.L.str.1:
.asciz "Initialized x = %d\n"

Class introduction

- Demo time

Life cycle of class

- Compiler creates several function for you
- Constructor
  - Function that is called upon instance creation
  - User can alter it in order to set initial values to variables or force user to set them
  - "Parametrized" vs "default" constructor

Life cycle of class

- Destructor
  - Called at the end of class lifetime (i.e. when object goes out of scope. Warning, this mechanism is not guaranteed!)
  - Can be used to cleanup resources (free allocated memory, end connection, close sockets, free handles, unsubscribe to messages, ...)
  - ⚠️ Always declare destructor as virtual!

Life cycle of class

- Rule of three
  - Copy constructor
  - Copy assignment operator
  - Move semantics was introduced in C++11 standard
- Rule of five
  - Move constructor
  - Move assignment operator
- Read more here

Life cycle of class

- Demo time

Encapsulation, Inheritance, Interface class

Encapsulation

- Limiting access to member variables
- Creating "read-only" variables
- Validating input/output of variables

Encapsulation

```
class Person
{
     int age;
public:
     void setAge(int newAge)
     {
          if ((newAge > 0) && (newAge < 100))
          {
               age = newAge;
          } else
          throw std::exception("Invalid age");
     }
};
```

Inheritance

```
class Animal
{
protected:
     unsigned int legs;

public:
     virtual void setLegs(unsigned int newLegs) {
          legs = newLegs;
     }

     virtual unsigned int getLegs() const {
          return legs;
     }

}
```

Inheritance

```
class Dog : public Animal
{
}

int main()
{
     Dog lassie;
     lassie.setLegs(4);

     return 0;
}
```

Inheritance

```
class Dog : public Animal
{
}

int main()
{
      Animal lassie = new Dog;
      lassie->setLegs(4);

      return 0;
}
```

Interface class (Abstract class)

- Defining interface, forcing user to fulfill requirements
- You can't instantiate it

```
class NoisyAnimal{
     virtual void makeNoise() = 0; //this enforce us to implement makeNoise function
}

class NoisyDog : public NoisyAnimal
{
     void makeNoise() {
          std::cout << "HAF HAF!" << std::endl;
     }
}
```

```
int main()
{
     NoisyAnimal animal; //This will throw compilation error
     NoisyDog dog;       //This is fine
     dog.makeNoise();
     return 0;
}
```

Encapsulation, Inheritance, Interface class

- Demo time

Virtual table

- Table that is containing relationship between parents/children and calls proper functions
- Created by using keyword `virtual` somewhere in class (or eventually others that imply `virtual`, i.e. `final`, `override`)
- Used for runtime polymorphism
  - Polymorphism -> instance of class behaving like other type
  - Remember `Animal lassie = new Dog;`
- Read more here

Virtual table

- Demo time

Keywords

- `this`
  - Returns address of current instance. Useful when I am registering myself to some publisher.
- `override` (vs overload)
  - Overrides method in parent
  - Checks whether method I am trying to override truly exists in parent
  - Prevents unintended overloading (functions of same name but with different parameters)

Keywords

- `final`
  - If used on class, prevents further inheritance
  - If used on method, prevents overriding this method
- `const`
  - Prevents modification of given variable
  - If used on function, prevents any member variable modification
- `explicit`
  - Prevents unintended conversion of input parameters

Keywords

Possible problems, tips and tricks

- Always initialize your member variables (at least with `{}`);
  - Otherwise in `Release` or `-O3` build these values will obtain random values!
- Size of empty class is not zero. It is at least 1 byte in order to allocate some memory (to be capable of using `this` keyword)
  - Read more here

Possible problems, tips and tricks

- Diamond inheritance problem

```
class Parent {
     void foo() = 0;
}

class ChildA : public Parent{
     void foo() {
          std::cout << "Foo from A"; }
}

class ChildB : public Parent{
     void foo() {
          std::cout << "Foo from B"; }
}
```

```
class Grandchild : public ChildA, ChildB
{
}

int main()
{
     Grandchild joe;
     joe.foo();      //Which "foo" override is called? From ChildA or ChildB?
                     //This results in compilation error
     return 0;
}
```

Demo time

- C uninitialized variables
- Simple class, encapsulation
- Abstract class
- Examining default constructor, , parametrized constructor, destructor
- Virtual destructor issue
- final, const, override

Lessons learned

- Initialize your variables, otherwise they **WILL** get random values (at least with `{}`)
  - Otherwise in `Release` or `-O3` they they are not implicitly zeroed
- Declare your destructor as **virtual**
- If possible, use as many keywords as possible (`const`, `override`, `final`, `explicit`, ...)
  - Compilers are very smart and thus performance optimization is not goal of using i.e. `const` keyword. Readability and maintainability is your goal.

Q&A