Advanced C++ Topics

Alexander Warg, 2017
WHAT IS BEHIND C++

• Language Magics
• Object Life Time
• Object Memory Layout

INTRODUCTION TO TEMPLATES

• Template Function
• Template Class

WHAT I DO NOT EXPLAIN

• Standard C++ Library
Some more keywords
  - new, delete, class, virtual, mutable, explicit...

Stricter type system
  - e.g. no automatic conversion from void *
  - custom class types
  - strictly typed enums (C++11)

Function overloading / Operator overloading
  - multiple functions with the same name but different arguments

Extensible hierarchical type system
  - classes and inheritance

Generic programming via templates
**Constructors:** Special Member Functions for object initialization

- Same name as the class
- No return type
Constructors: Special Member Functions for object initialization
- Same name as the class
- No return type

Destructors: Special Member Functions for object destruction
- Name: ~Classname()
- No return type
- No arguments
CONSTRUCTORS (CLASS FOO)
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**Foo()** -> Default Constructor  
No arguments  
Generated by Compiler if no other Constructors
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**Foo(Type x)** -> Conversion Constructor  
Is used to cast type Type to Foo (implicitly)  
(see keyword **explicit**)
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   (see keyword `explicit`)

**Foo(Foo const &o)** -> Copy Constructor
   *Always* generated by Compiler if not provided
   (related to `operator = (Foo const &o)`, see later)
**CONSTRUCTORS (CLASS FOO)**

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No arguments  
Generated by Compiler if no other Constructors

**Foo(Type x)** -> Conversion Constructor  
Is used to cast type Type to Foo (implicitly)  
(see keyword `explicit`)

**Foo(Foo const &o)** -> Copy Constructor  
Always generated by Compiler if not provided  
(related to `operator = (Foo const &o)`, see later)

**Foo(Type a, Type b, Type c)** -> Normal Constructor
Foo(Foo &&o) -> Move Constructor
(related to `operator = (Foo &&o)`, see later)
**Foo(Foo &&o)** -> Move Constructor
(related to **operator = (Foo &&o)**, see later)

**Type &&x** -> RValue reference
Fast optimized move operations
Support for **perfect forwarding**
Implicit type conversion
- among integer types (incl. enum)
- conversion ctor ?
- conversion operator ?
- from pointers/references of derived classes to pointers/references to base classes

Explicit type conversion (casts)
C++ has three (actually four) types of casts
- static_cast<type>(...)
- reinterpret_cast<type>(...)
- dynamic_cast<type>(...)
- const_cast<type>(...)

**Virtual Functions**
Support for Overriding functions in C++

**Pure Virtual Functions** (Abstract Function)
class A { void func() = 0; };
<A> cannot be instantiated (is abstract)

**Multiple Inheritance**
class A : public B, public C {...};
Virtual deletion ...
MULTIPLE INHERITANCE
MULTIPLE INHERITANCE

- Car
- name()
MULTIPLE INHERITANCE

<table>
<thead>
<tr>
<th>Car</th>
<th>Boat</th>
</tr>
</thead>
<tbody>
<tr>
<td>name()</td>
<td>name()</td>
</tr>
</tbody>
</table>
MULTIPLE INHERITANCE

Object
  cnt

Car
  name()

Boat
  name()
MULTIPLE INHERITANCE

Object
  cnt

Car
  name()

Boat
  name()

Amphi
MULTIPLE INHERITANCE

Amphi

Car
  Object

Boat
  Object
MULTIPLE INHERITANCE
Functions that operate on a *Generic Type* (e.g. $T$)
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```c
int max(int a, int b)
{
    return a>b?a:b;
}
```
Functions that operate on a *Generic Type* (e.g. $T$)

```c
int max(int a, int b) {
    return a > b ? a : b;
}

int a, b;
int x = max(a, b);
```
Functions that operate on a *Generic Type* (e.g. *T*)

```c
int max(int a, int b) {
    return a>b?a:b; }

int a, b;
int x = max(a, b);

double a, b;
double x = max(a, b);
```
Functions that operate on a *Generic Type* (e.g. \( T \))

```cpp
template< typename T >
T max(T a, T b)
{
  return a>b?a:b;
}

int a, b;
int x = max<int>(a, b);

double a, b;
double x = max<double>(a, b);
```
Functions that operate on a \textit{Generic Type} (e.g. \textit{T})

\begin{verbatim}
#include <algorithm>

template< typename T >
T max(T a, T b)
{ return a>b?a:b; }

int a, b;
int x = max(a, b);

double a, b;
double x = max(a, b);
\end{verbatim}
Classes with members of *Generic Types* (e.g. $T$)
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class List_item
{
    List_item *next, *prev;
    void *data;
};
Classes with members of *Generic Types* (e.g. *T*)

```cpp
template< typename T >
class List_item
{
    List_item *next, *prev;
    T *data;
};
```
DON'T DO THIS...

**Too Much operator overloading**
- Keep usual semantics
- Avoid implicit conversion operators

```c
using namespace <X> in Header Files
```

```c
#define ...
```
- Use enum's for constant values
- Use templates for functions