Hasso Plattner Institut
IT Systems Engineering | Universität Potsdam

WOCHE 2

BYOD

AGENDA

- Organization
- Templates
- RAII
- Smart Pointers

ORGANIZATION

- If you have not joined us at Piazza
  - piazza.com/hpi.uni-potsdam.de/fall2017/byod
- Any problems during setup?

TEMPLATES – FUNCTIONS

```
1 template <typename T> T multiply(T x, T y) {
2   return x * y;
3 }
4
5 double a = 4.0, b = 5.0;
6 multiply<double>(a, b);
7
8 int c = 7, d = 8;
9 multiply<int>(c, d);
```

What would need to change to allow multiplication of Ints and Doubles?

TEMPLATES – FUNCTIONS

```
1 template <typename T> T multiply(T x, T y) {
2   return x * y;
3 }
4
5 double a = 4.0, b = 5.0;
6 multiply<double>(a, b);
7
8 int c = 7, d = 8;
9 multiply<int>(c, d);
10
11 multiply(c, d);
```

TEMPLATES – CLASSES

```
1  template <typename T> class Calc {
2    public:
3      T multiply(T x, T y);
4      T add(T x, T y);
5  };
6
7  template <typename T> T Calc<T>::multiply(T x, T y) {
8    return x * y;
9  }
10
11 template <typename T> T Calc<T>::add(T x, T y) {
12   return x + y;
13 }
14
15 int main() {
16   double a = 4.0, b = 5.0;
17   Calc<double> c;
18   c.multiply(a, b);
19 }
```

Templates need to be defined in the same compilation unit

TEMPLATES IN OPOSSUM

```
1 chunk.add_column(std::make_shared<ValueColumn<int>>());
2 chunk.add_column(std::make_shared<ValueColumn<float>>());
3
4 std::vector<std::shared_ptr<ValueColumn>> _columns;
5
6 std::vector<std::shared_ptr<ValueColumn<int>>> _columns;
7
8 std::vector<std::shared_ptr<BaseColumn>> _columns;
```

TEMPLATES – SPECIALIZATION

```
1 template <>
2 class vector<bool> {
3   // Bitmap;
4 };
```

```
1 template <int rows, int columns>
2 class Matrix {
3   // Normal matrix implementation
4 };
5
6 template <int rows>
7 class Matrix<rows, 1> {
8   // Special matrix implementation
9 };
```

RAII – MOTIVATION

```
1 int main() {
2   ClassA* ca = new ClassA;
3
4   ca->someOperation();
5   ca->someOperationB();
6   ca->someOperationC();
7
8   delete ca;
9 }
```

```
1 int main() {
2   ClassA ca;
3
4   ca.someOperation();
5   ca.someOperationB();
6   ca.someOperationC();
7 }
```

RAII – MOTIVATION

```
1  void write_to_file (const std::string & message) {
2      static std::mutex mutex;
3
4      mutex.lock()
5
6      std::ofstream file("opossum.txt");
7      if (!file.is_open())
8          throw std::runtime_error("unable to open the
9                                    opossum");
10
11      file << message << std::endl;
12
13      mutex.unlock()
14 }
```


https://en.wikipedia.org/wiki/Resource_acquisition_is_initialization

RAII – MOTIVATION

```
1  void write_to_file (const std::string & message) {
2      static std::mutex mutex;
3
4      std::lock_guard<std::mutex> lock(mutex);
5
6      std::ofstream file("opossum.txt");
7      if (!file.is_open())
8          throw std::runtime_error("unable to open the
9                                    opossum");
10
11     file << message << std::endl;
12 }
```


https://en.wikipedia.org/wiki/Resource_acquisition_is_initialization

RAII – BENEFITS

- Encapsulation
  - Resource management is centralized in class definition
- Safety
  - You cannot forget to delete / free a resource
  - Destructors are called during exception handling
- Locality
  - Constructor and destructor side by side

POINTERS – HAVE FUN KEEPING TRACK

```
1 SomeClass* scp = new SomeClass;
2
3 OtherClass* ocp = new OtherClass(scp);
4 WeirdClass* wcp = new WeirdClass(scp);
5
6 scp = new SomeOtherClass;
7
8 delete scp;
```

SMART POINTERS – MOTIVATION

- Motivation: Lifetime management of objects
  - *new (malloc)* also includes declaration of ownership
  - Possibility to lose objects -> resource leaks
  - Copying of p -> observation of ownership necessary

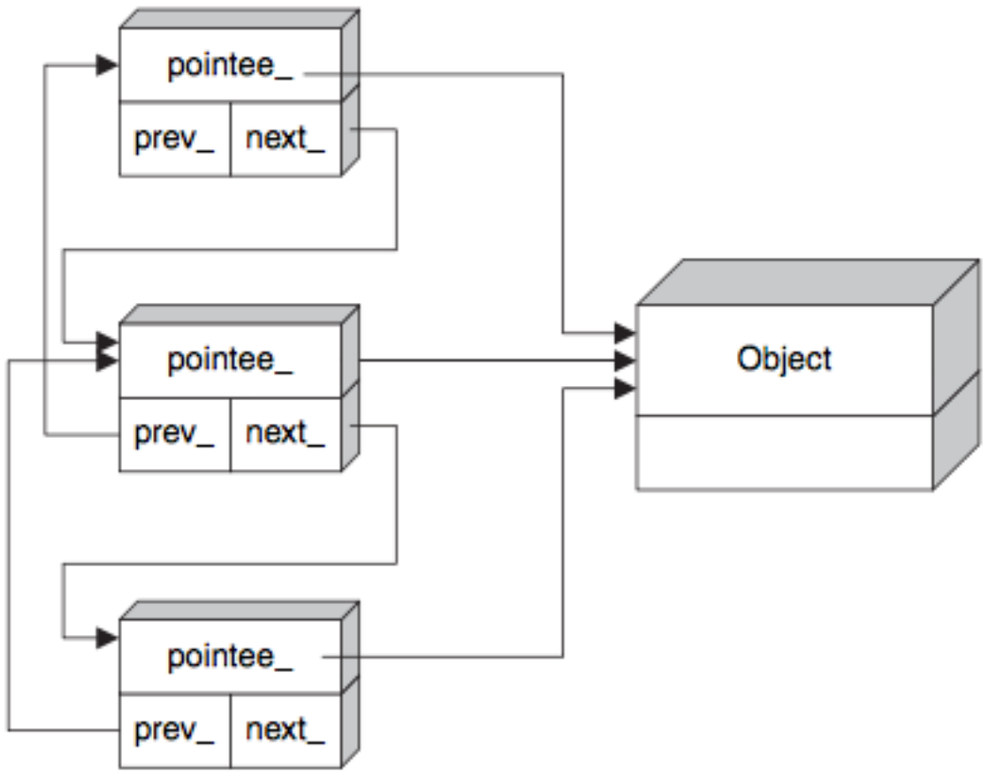
SMART POINTERS – WHAT IS A SMART POINTER?

- Exactly mimics *regular* pointers' syntax and some semantics
  - Pointer-like behavior (proxy)
  - Ownership management
    - Transfer of ownership
    - Releasing objects
- Transparent for the developer

SMART POINTERS – SHARED OWNERSHIP HANDLING

- Ideas? - Standard does not specify an implementation
  - Deep Copy (Copy on Write)
  - Reference Linking

SMART POINTERS – REFERENCE LINKING



Modern C++ Design, Andrei Alexandrescu

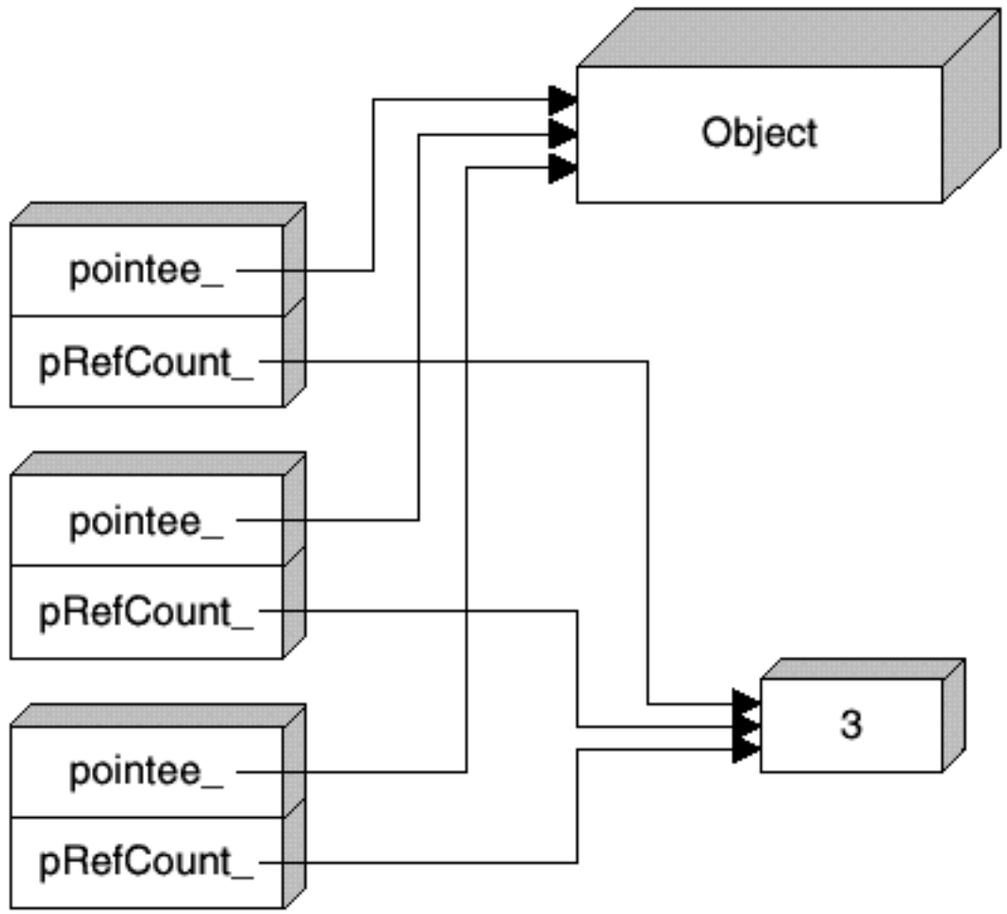
SMART POINTERS – OWNERSHIP HANDLING

- Ideas? - Standard does not specify an implementation
  - Deep Copy (Copy on Write)
  - Reference Linking
  - **Reference Counting**
  - …

SMART POINTERS – REFERENCE COUNTING

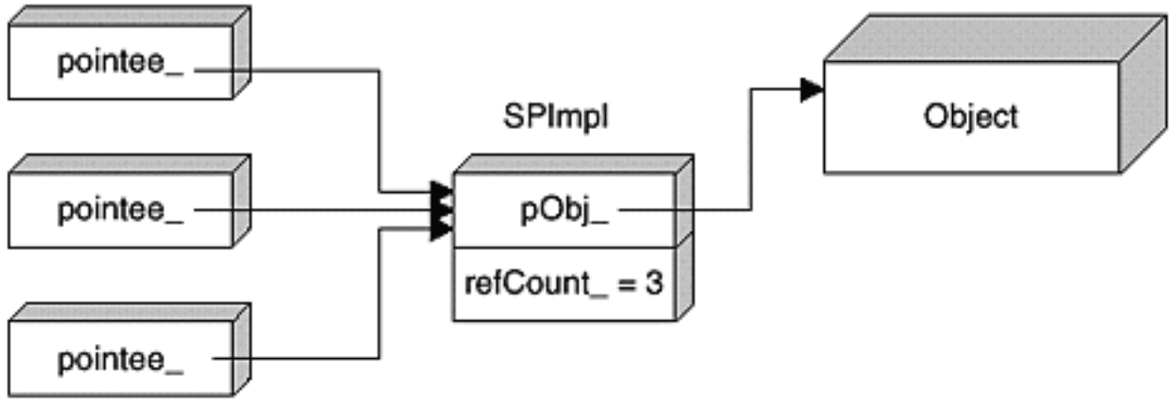
- Issue with reference counting?
  - Overhead
  - Synchronization issues
- How to implement reference counting?

SMART POINTERS – REFERENCE COUNTING



Modern C++ Design, Andrei Alexandrescu

SMART POINTERS – REFERENCE COUNTING



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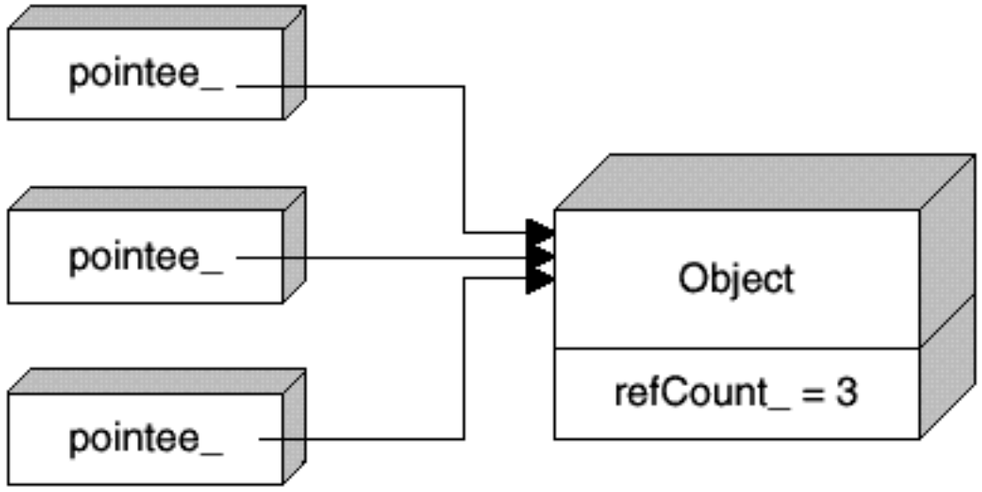
SMART POINTERS – REFERENCE COUNTING



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SMART POINTERS – REFERENCE COUNTING

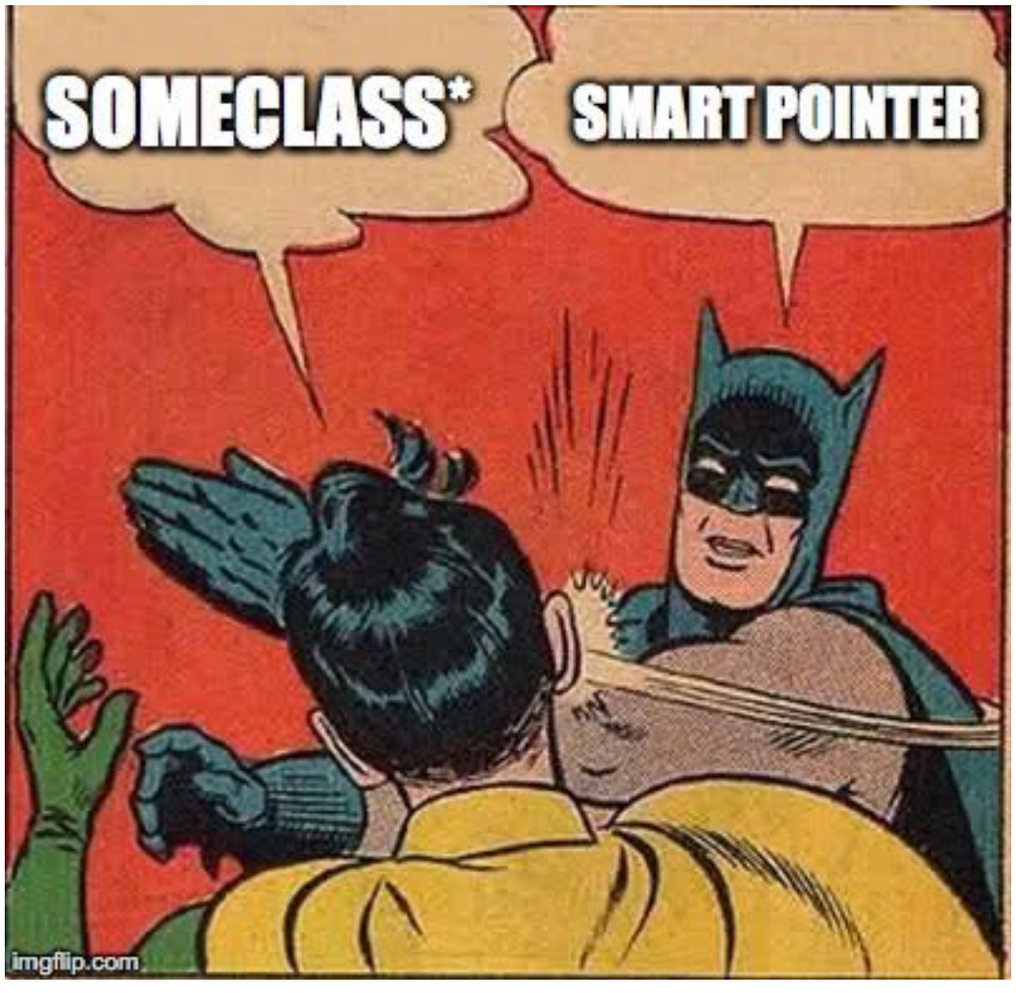
A shared_ptr<T> contains a pointer of type T and an object of type __shared_count. The shared_count contains a pointer of type _Sp_counted_base* which points to the object that maintains the reference-counts and destroys the managed resource.*

gcc libstdc++ memory manual

SMART POINTERS – C++

- Defined in <memory>
- std::unique_ptr<T>
  - Implicitly deleted copy constructor & copy assignment
- std::shared_ptr<T>
  - Reference counting
  - Thread safety?
- std::weak_ptr<T>
  - Does not affect ownership

SMART POINTERS



There is some variation to this rule. We will get into this later.

SMART POINTERS – STD HELPERS

- std::make_shared - why?
  - Single memory allocation
    - std::shared_ptr<T>(new T(args...))
  - ~~Exception safety:~~
    - ~~f(std::shared_ptr<int>(new int(42)), g())~~
- std::make_unique
  - Exception safety, convenience and consistency

SMART POINTERS – CONSTNESS

```
1        auto p1 = std::make_shared<const SomeClass>();
2  const auto p2 = std::make_shared<       SomeClass>();
3  const auto p3 = std::make_shared<const SomeClass>();
4
5  p1->ConstMemberFunction();
6  p1->NonConstMemberFunction();
7
8  p2->NonConstMemberFunction();
9  p2 = std::make_shared<SomeClass>();
10
11 p3->ConstMemberFunction();
12 p3->NonConstMemberFunction();
13 p3 = std::make_shared<const SomeClass>();
```

SMART POINTERS – CONSTNESS

```
1         auto p1 = std::make_shared<const SomeClass>();
2 const   auto p2 = std::make_shared<      SomeClass>();
3 const   auto p3 = std::make_shared<const SomeClass>();
4
5 p1->ConstMemberFunction();
6 p1->NonConstMemberFunction();
7
8 p2->NonConstMemberFunction();
9 p2 = std::make_shared<SomeClass>();
10
11 p3->ConstMemberFunction();
12 p3->NonConstMemberFunction();
13 p3 = std::make_shared<const SomeClass>();
```

- Code review information
- Compression and encoding
- Presentation of sprint 2