Embedded Software

Resource Handling - Improving our programs

ENGINEERING COLLEGE OF AARHUS

Challenge - Resource Handling

- Brainstorm - What do you consider a Resource Handling challenge?
  - What is a resource?
  - In which situations do you foresee challenges?
- Team up 2 & 2 for 3 minutes

The Challenge

- Design and implement a system that
  - That garbage collects a resource when no one uses it (multi parties may share a resource)
  - It must be thread-safe
    - The resource itself is *NOT* protected, but its destruction must be

Usage example

- Following usage scenario must work
  - Allocate resource in Thread A
  - Pass it to Thread B while keeping it in A
  - Relinquish usage in Thread A followed by Thread B
  - Resource is hereafter relinquished
- Could be ported to our Message Queues

The exercises this lecture

- RAII and SmartPointer
- Counted Smart Pointer
- Templated Counted Smart Pointer (OPTIONAL)
- boost::shared_ptr<>

Resource Handling

RAII for short repetition

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- Managing memory is often a problem or challenge,
  - ensuring correctness - forgetting to deallocate (message etc.)
  - dealing with exceptions

RAII

- Managing memory is often a problem or challenge,
  - ensuring correctness - forgetting to deallocate (message etc.)
  - dealing with exceptions
- ***Idiom : Resource Acquisition Is Initialization***
  - Wrap up all resources in their own object that handles their lifetime and put object on stack

RAII Basic example

- Simple RAII class which also is a ***SmartPointer***

```
template<typename T>
class RAII
{
public:

    explicit RAII( T* p = 0 ) : p_(p) {}

    ~RAII() { delete p_; }

    T& operator*() const { return p_; }
    T* operator->() const { return p_; }
};
```

- Usage example

```
{
    RAII<std::vector<int> > r( new std::vector<int>() );
    std::cout << r->size() << std::endl;
} // The std::vector<int> is automatically deallocated
```


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RAII in effect

Resource is deallocated

Accessing handled resource

- Usage example

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boost::shared_ptr<T>

Classic problem

- What is the problem here?

```
void f()
{
    Client* c = new Client;
    Data* d = acquireData(c);
    if(...)
      return;

    delete d;
    delete c;
}
```

Classic problem

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void f()
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Exception what then?

Classic problem

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void f()
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    Data* d = acquireData(c);
    if(...)
      return;

    delete d;
    delete c;
}
```

Exception what then?

Bad, where is the deallocation?

Simple example

- std::string is automatically deallocated
  - Where exception is thrown
  - End of scope

```
void f()
{
    boost::shared_ptr<std::string> stringPtr(new std::string(”Hello”));

    if (...) throw std::some_error(“Bad number”);

    std::cout << *stringPtr << std::endl;

}
```

Exit points

Complex example

```
   Stdout readout:
   Pointer          Value  Use Count
1) 003756D0          42        1
2) 003756D0          43        2
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   boost::shared_ptr<int> ee;
   boost::shared_ptr<int> aa(new int(42));

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       boost::shared_ptr<int> bb(aa);
       ++(*bb);
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       ee = bb;
3)     std::cout << ee << "\t" << *ee << "\t" <<ee.use_count()<<std::endl;
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   ee.reset();
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Copy code and verify!

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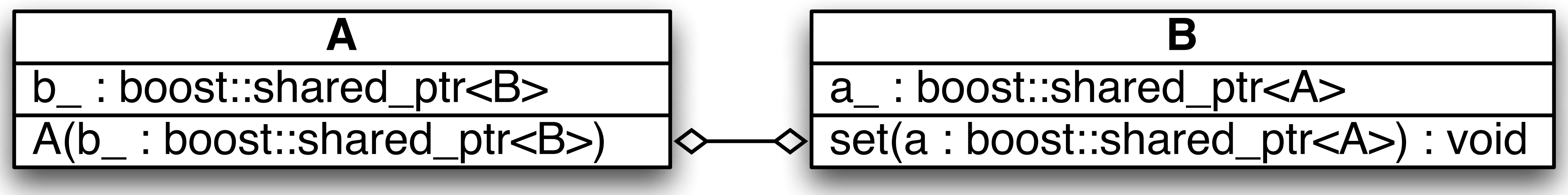
boost::shared_ptr<T> - Properties

- A wrapping created with new T
- **Reference counted**
- **delete is guaranteed called when the last reference to the object dies or when the member function reset() is called**
- **The same thread safety as build-in types**
- **It is possible to supply an alternative functor that handles the “deallocation”**
- May be used in a container
- Implements the comparison operators
- Allows conversion from shared_ptr<T> to shared_ptr<U> if T* implicit can be converted to U* or if T is a specialization of U or U is void

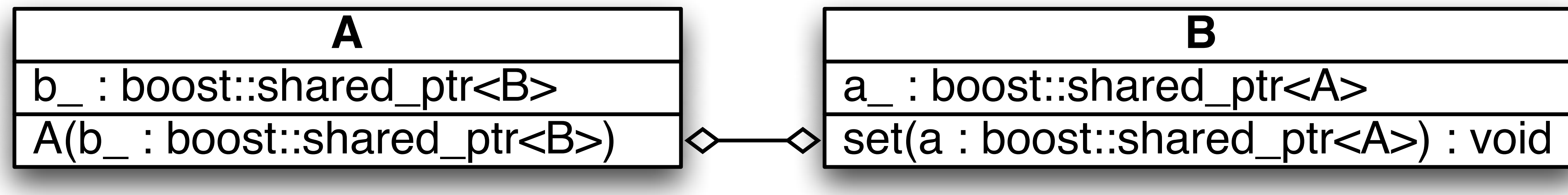
boost::weak_ptr<T> - Cyclic dependencies

Cyclic dependency - What?



Cyclic dependency - What?

- Problem simple



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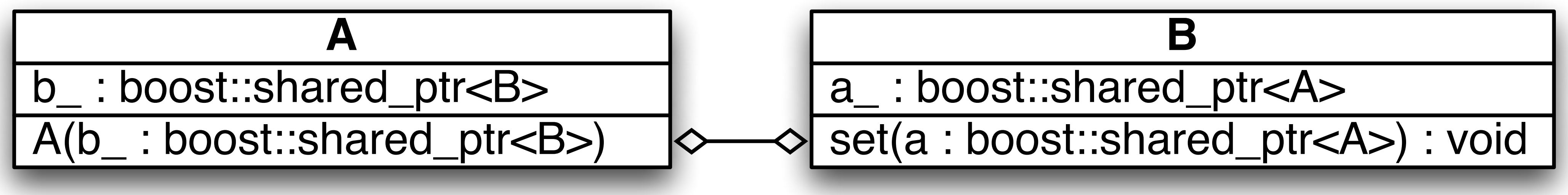
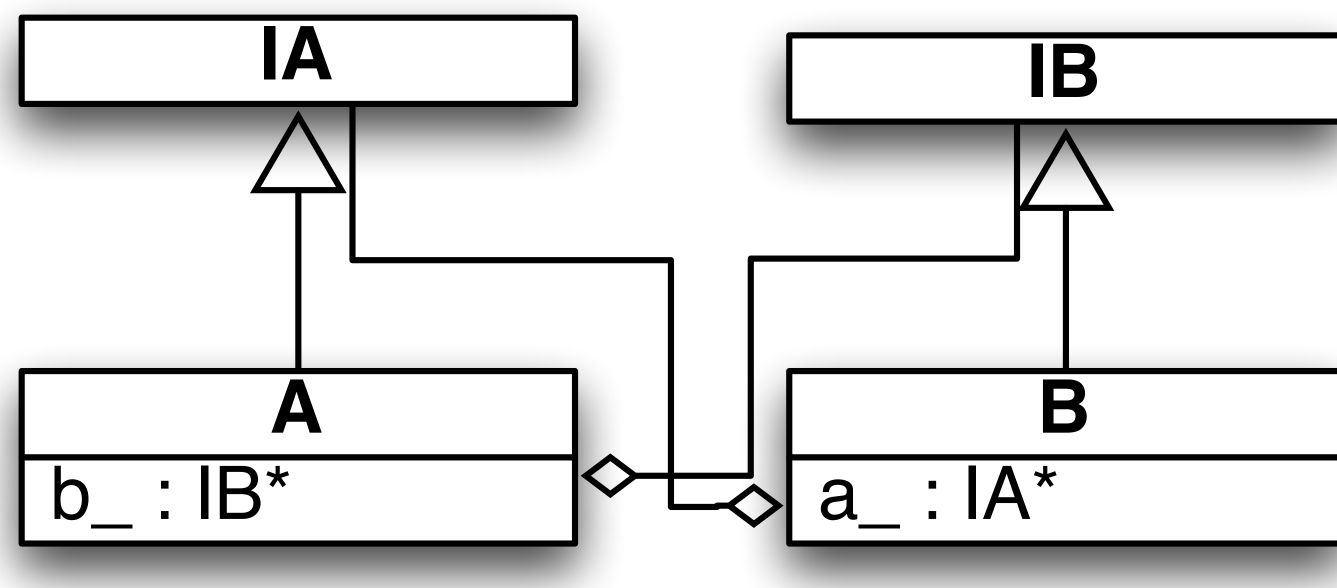


- More complex



Usage – boost::weak_ptr

- Breaking cyclic dependencies

```
struct A {
    A(boost::shared_ptr<B> b)
    : b_(b) {}

    boost::shared_ptr<B>  b_;
};
```

```
struct B {
    void set(boost::shared_ptr<A> a)
    { a_ = a; }

    boost::shared_ptr<A>  a_;
};
```

Test harnish

```
boost::shared_ptr<B>    tmpB(new B);
boost::shared_ptr<A>    tmpA(new A(tmpB));
tmpB->set(tmpA);   // Cyclic dependency introduced
```

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```

```
struct B {
    void set(boost::shared_ptr<A> a)
    { a_ = a; }

    boost::weak_ptr<A>  a_;

    void doStuff() {
        boost::shared_ptr<A> a = a_.lock();
        if(a) {
            // Do stuff
        }
    };
};
```

Test harnish

```
boost::shared_ptr<B>    tmpB(new B);
boost::shared_ptr<A>    tmpA(new A(tmpB));
tmpB->set(tmpA);   // Cyclic dependency introduced
```

Properties – boost::weak_ptr

- **Typical usage is breaking cyclic dependencies**
- **Must call .lock() to determine whether the object pointed to still lives before trying to access it**
- **Must be converted to a shared_ptr when access the object again**
- Implements a ”a less important” shared_ptr
- A shared_ptr without reference counting.
- Can be used in containers

scoped_ptr<T>

Usage
boost::scoped_ptr

- Simpel usage
  - std::string is automatically deallocated
    - Where exception is thrown
    - End of scope

```
void f()
{
    boost::scoped_ptr<std::string>
    stringPtr(new std::string(”Hello”));

    if (...) throw std::some_error(“Bad number”);

    std::cout << *stringPtr << std::endl;

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Exit points

Properties
boost::scoped_ptr

- **Holds a pointer to an element allocated with new**
- **Guarantees that delete is called at destruction time**
- Calls delete via a call to the member function reset()
- Cannot be used in a container, not copyable
- Alternative
  - std::auto_ptr const but it cannot be reset

Boost::SmartPointer - Summary

Boost SmartPointer summary

- ***boost::scoped_ptr*** *& boost::scoped_array*
  - Objects with short lifespan – confined to function/object
  - Single object or an array of objects
  - Non-copyable (whole point)
- ***boost::shared_ptr*** *& boost::shared_array*
  - A more general wrapping used in containers
  - Single object or an array of objects
  - You want it *all* and you are willing to pay for it
- ***boost::weak_ptr***
  - Typically used to break circular references
- ***boost::intrusive_ptr***
  - Where OS or framework implement reference counting

Understandable or NOT

- Team up 2 and 2 for 2 mins
- Write down 1 thing that you
  - understood
  - did not quite get
- It will then be brought up on friday!