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# Boost.ScopeExit

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## Table of Contents

Introduction .....	1
Tutorial .....	1
Alternatives .....	3
Supported Compilers .....	6
Configuration .....	7
Reference .....	7
Acknowledge .....	8

## Introduction

Nowadays, every C++ developer is familiar with [RAII](#) technique. It binds resource acquisition and release to initialization and destruction of a variable that holds the resource. But there are times when writing a special class for such variable is not worth the effort.

This is when [ScopeExit](#) macro comes into play. You put resource acquisition directly in your code and next to it you write a code that releases the resource.

Read [Tutorial](#) to find out how to write programs with [ScopeExit](#) or jump straight to the [Reference](#) section.

## Tutorial

Imagine that you want to make many modifications to data members of the `World` class in the `World::addPerson` function. You start with adding a new `Person` object to a vector of persons:

```
void World::addPerson(Person const& person) {  
    bool commit = false;  
    m_persons.push_back(person); // (1) direct action
```

Some operation down the road may throw an exception and all changes to involved objects should be rolled back. This all-or-nothing semantic is also known as [strong guarantee](#).

In particular, last added person must be deleted from `m_persons` when the function throws. All you need is to define a delayed action (release of a resource) right after the direct action (resource acquisition):

```
void World::addPerson(Person const& aPerson) {
    bool commit = false;
    m_persons.push_back(aPerson); // (1) direct action
    BOOST_SCOPE_EXIT( (&commit)(&m_persons) )
    {
        if(!commit)
            m_persons.pop_back(); // (2) rollback action
    } BOOST_SCOPE_EXIT_END

    // ... // (3) other operations

    commit = true; // (4) turn all rollback actions into no-op
}
```

The block below point (1) is a [ScopeExit](#) declaration. Unlike point (1), an execution of the [ScopeExit](#) body will be delayed until the end of the current scope. In this case it will be executed either after point (4) or on any exception.

The [ScopeExit](#) declaration starts with `BOOST_SCOPE_EXIT` macro invocation which accepts [Boost.Preprocessor sequence](#) of captured variables. If a capture starts with the ampersand sign `&`, a reference to the captured variable will be available inside the [ScopeExit](#) body; otherwise, a copy of the variable will be made after the point (1) and only the copy will be available inside the body.

In the example above, variables `commit` and `m_persons` are passed by reference because the final value of the `commit` variable should be used to determine whether to execute rollback action or not and the action should modify the `m_persons` object, not its copy. This is a most common case but passing a variable by value is sometimes useful as well.

Consider a more complex case where `World::addPerson` can save intermediate states at some points and roll back to the last saved state. You can use `Person::m_evolution` to store a version of changes and increment it to cancel all rollback actions associated with those changes.

If you pass a current value of `m_evolution` stored in the `checkpoint` variable by value, it will remain unchanged until the end of the scope and you can compare it with the final value of the `m_evolution`. If the latter wasn't incremented since you saved it, the rollback action inside the block should be executed:

```
void World::addPerson(Person const& aPerson) {
    m_persons.push_back(aPerson);

    // This block must be no-throw
    Person& person = m_persons.back();
    Person::evolution_t checkpoint = person.m_evolution;

    BOOST_SCOPE_EXIT( (checkpoint)(&person)(&m_persons) )
    {
        if(checkpoint == person.m_evolution)
            m_persons.pop_back();
    } BOOST_SCOPE_EXIT_END

    // ...

    checkpoint = ++person.m_evolution;

    // Assign new id to the person
    World::id_t const prev_id = person.m_id;
    person.m_id = m_next_id++;
    BOOST_SCOPE_EXIT( (checkpoint)(&person)(&m_next_id)(prev_id) )
    {
        if(checkpoint == person.m_evolution) {
            m_next_id = person.m_id;
            person.m_id = prev_id;
        }
    } BOOST_SCOPE_EXIT_END

    // ...

    checkpoint = ++person.m_evolution;
}
```

Full code listing can be found in [world.cpp](#).

## Alternatives

### try-catch

This is an example of using a badly designed `File` class. An instance of `File` doesn't close a file in a destructor, a programmer is expected to call the `close` member function explicitly.

```
File passwd;
try {
    passwd.open("/etc/passwd");
    // ...
    passwd.close();
}
catch(...) {
    log("could not get user info");
    if(passwd.is_open())
        passwd.close();
    throw;
}
```

Note the following:

- the `passwd` object is defined outside of the `try` block because this object is required inside the `catch` block to close the file,
- the `passwd` object is not fully constructed until after the `open` member function returns, and

- if opening throws, the `passwd.close()` should not be called, hence the call to `passwd.is_open()`.

[ScopeExit](#) doesn't have any of these problems:

```
try {
    File passwd("/etc/passwd");
    BOOST_SCOPE_EXIT( (&passwd) ) {
        passwd.close();
    } BOOST_SCOPE_EXIT_END
    // ...
}
catch(...) {
    log("could not get user info");
    throw;
}
```

## RAII

[RAII](#) is absolutely perfect for the `File` class introduced above. Use of a properly designed `File` class would look like:

```
try {
    File passwd("/etc/passwd");
    // ...
}
catch(...) {
    log("could not get user info");
    throw;
}
```

However, using [RAII](#) to build up a [strong guarantee](#) could introduce a lot of non-reusable [RAII](#) types. For example:

```
m_persons.push_back(person);
pop_back_if_not_commit pop_back_if_not_commit_guard(commit, m_persons);
```

The `pop_back_if_not_commit` class is either defined out of the scope or as a local class:

```
class pop_back_if_not_commit {
    bool m_commit;
    std::vector<Person>& m_vec;
    // ...
    ~pop_back_if_not_commit() {
        if (!m_commit)
            m_vec.pop_back();
    }
};
```

In some cases [strong guarantee](#) can be accomplished with standard utilities:

```
std::auto_ptr<Person> spSuperMan(new Superman);
m_persons.push_back(spSuperMan.get());
spSuperMan.release(); // m_persons successfully took ownership.
```

or with specialized containers such as [Boost Pointer Container Library](#) or [Boost Multi-Index Containers Library](#).

## ScopeGuard

Imagine that you add a new currency rate:

```
bool commit = false;
std::string currency("EUR");
double rate = 1.3326;
std::map<std::string, double> rates;
bool currency_rate_inserted =
    rates.insert(std::make_pair(currency, rate)).second;
```

and then continue a transaction. If it cannot be completed, you erase the currency from rates. This is how you can do this with [ScopeGuard](#) and [Boost.Lambda](#):

```
using namespace boost::lambda;

ON_BLOCK_EXIT(
    if_(currency_rate_inserted && !_1) [
        bind(
            static_cast<
                ↵
            std::map<std::string, double>::size_type (std::map<std::string, double>::*)(std::string const&)
                >(&std::map<std::string, double>::erase)
            , &rates
            , currency
            )
        ]
    , boost::cref(commit)
    );

// ...

commit = true;
```

Note that

- Boost.lambda expressions are hard to write correctly, for example, overloaded function must be explicitly casted, as demonstrated in this example,
- condition in `if_` expression refers to `commit` variable indirectly through the `_1` placeholder,
- setting a breakpoint inside `if_[ ... ]` requires in-depth knowledge of [Boost.Lambda](#) and debugging techniques.

This code will look much better with native lambda expressions proposed for C++0x:

```
ON_BLOCK_EXIT(
    [currency_rate_inserted, &commit, &rates, &currency]() -> void
    {
        if(currency_rate_inserted && !commit)
            rates.erase(currency);
    }
);
```

With [ScopeExit](#) you can simply do

```
BOOST_SCOPE_EXIT( (currency_rate_inserted)(&commit)(&rates)(&currency) )
{
    if(currency_rate_inserted && !commit)
        rates.erase(currency);
} BOOST_SCOPE_EXIT_END

// ...

commit = true;
```

## C++0x

In future releases [ScopeExit](#) will take advantages of C++0x features.

- Passing capture list as [Boost.Preprocessor sequence](#) will be replaced with a traditional macro invocation style:

```
BOOST_SCOPE_EXIT(currency_rate_inserted, &commit, &rates, &currency)
{
    if(currency_rate_inserted && !commit)
        rates.erase(currency);
} BOOST_SCOPE_EXIT_END
```

- BOOST\_SCOPE\_EXIT\_END will be replaced with a semicolon:

```
BOOST_SCOPE_EXIT(currency_rate_inserted, &commit, &rates, &currency)
{
    if(currency_rate_inserted && !commit)
        rates.erase(currency);
};
```

- Users will be able to capture local variables implicitly with lambda capture defaults & and =:

```
BOOST_SCOPE_EXIT(&, currency_rate_inserted)
{
    if(currency_rate_inserted && !commit)
        rates.erase(currency);
};
```

- It will be possible to capture this pointer.

## The D Programming Language

[ScopeExit](#) is similar to [scope\(exit\)](#) feature built into the [D](#) programming language.

A curious reader may notice that the library doesn't implement `scope(success)` and `scope(failure)` of the [D](#) language. Unfortunately, it's not possible in C++ because failure or success condition cannot be determined by calling `std::uncaught_exception`. It's not a big problem, though. These two constructs can be expressed in terms of [scope\(exit\)](#) and a `bool commit` variable as explained in [Tutorial](#). Refer to [Guru of the Week #47](#) for more details about `std::uncaught_exception` and if it has any good use at all.

## Supported Compilers

The library should be usable on any compiler that supports [Boost.Typeof](#) except

- MSVC 7.1 and 8.0 fail to link if a function with [ScopeExit](#) is included by multiple translation units.
- GCC 3.3 can't compile [ScopeExit](#) inside a template. See [this thread](#) for more details.

The author tested the library on GCC 3.3, 3.4, 4.1, 4.2 and Intel 10.1.

## Configuration

Normally, no configuration is required for the library but note that the library depends on [Boost.Typeof](#) and you may want to configure or enforce [typeof emulation](#).

## Reference

### BOOST\_SCOPE\_EXIT

A [ScopeExit](#) declaration has the following synopsis:

```
#include <boost/scope_exit.hpp>

BOOST_SCOPE_EXIT ( scope-exit-capture-list )
    function-body
BOOST_SCOPE_EXIT_END
```

where

```
scope-exit-capture-list:
    ( scope-exit-capture )
    scope-exit-capture-list ( scope-exit-capture )

scope-exit-capture:
    identifier
    &identifier
```

The [ScopeExit](#) declaration schedules an execution of `scope-exit-body` at the end of the current scope. The `scope-exit-body` statements are executed in the reverse order of [ScopeExit](#) declarations in the given scope. The scope must be local.

Each identifier in `scope-exit-capture-list` must be a valid name in enclosing scope and it must appear exactly once in the list. If a `scope-exit-capture` starts with the ampersand sign `&`, the corresponding identifier will be available inside `scope-exit-body`; otherwise, a copy of it will be made at the point of [ScopeExit](#) declaration and that copy will be available inside `scope-exit-body`. In the latter case, the identifier must be CopyConstructible.

Only identifiers listed in `scope-exit-capture-list`, static variables, extern variables and functions, and enumerations from the enclosing scope can be used inside the `scope-exit-body`.



#### Note

this pointer is not an identifier and cannot be passed to `scope-exit-capture-list`.

The [ScopeExit](#) uses [Boost.Typeof](#) to determine types of `scope-exit-capture-list` elements. In order to compile code in [typeof emulation](#) mode, all types should be registered with `BOOST_TYPEOF_REGISTER_TYPE` or `BOOST_TYPEOF_REGISTER_TEMPLATE` macros, or appropriate [Boost.Typeof](#) headers should be included.

### BOOST\_SCOPE\_EXIT\_TPL

This macro is a workaround for various versions of gcc. These compilers don't compile [ScopeExit](#) declaration inside function templates. As a workaround, the `_TPL` suffix should be appended to `BOOST_SCOPE_EXIT`.

The problem boils down to the following code:

```
template<class T> void foo(T const& t) {  
    int i = 0;  
    struct Local {  
        typedef __typeof__(i)  typeof_i;  
        typedef __typeof__(t)  typeof_t;  
    };  
    typedef Local::typeof_i i_type;  
    typedef Local::typeof_t t_type;  
}  
  
int main() { foo(0); }
```

This can be fixed by adding `typename` in front of `Local::typeof_i` and `Local::typeof_t`.

See also [GCC bug 37920](#).



### Note

Although `BOOST_SCOPE_EXIT_TPL` has the same suffix as the `BOOST_TYPEOF_TPL`, it doesn't follow a convention of the [Boost.Typeof](#).

## Acknowledge

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