C++20 Coroutines

What's next?

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Introduction

Agenda

Introduction

Quick refresh about the coroutines.

Missing coroutines parts

RVO or the co_await

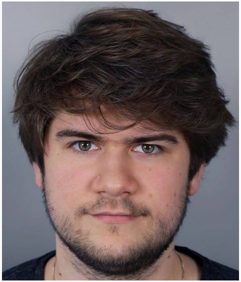
Questions...

Time is rather tight.
Please hold your questions till the end.

Who am I?

Dawid Pilarski

- Senior Software Developer in TomTom
- Member of the ISO/JTC1/SC22/WG21
- Member of the PKN KT (programming languages)
- C++ blog writer



Quick refresh about the coroutines.

What are the coroutines?

Subroutine Is a sequence of program instructions that performs a specific task, packaged as a unit.

Function Is a subroutine

Coroutine Is generalization of the function.

What are the coroutines?

Function can be:

- called
- returned from

What are the coroutines?

Coroutine can be:

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- returned from
- suspended

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Coroutine can be:

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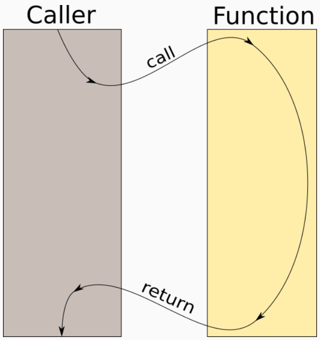
- suspended
- resumed from
- created
- destroyed

Coroutine flowchart

Function's flow:



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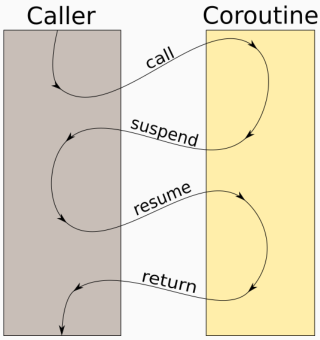

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- Implementation of the co_await keyword (~3 functions)

You need to remember to implement on average 9 functions.

Coroutine declaration

```
// returned-type   name      arguments
//|-------------| |-------| |---------------|
  generator<int> fibonacci (int from_value);
```

- Whether the function is a coroutine depends on it's definition.

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- Whether the function is a coroutine depends on it’s definition.
- If function is a coroutine it’s return type must support coroutines.

Promise_type

Type supports coroutines if it has promise_type.

promise_type can be:

- member of the class
- member of the specialization of the coroutine_traits<returned_type>

Promise_type

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- `awaitable final_suspend();`
- `return_type get_return_object();`
- `void unhandled_exception();`

- suspension at the beginning
- suspension at the end
- how to create return_type
- handling unhandled exception

Keywords and promise_type

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Keywords and promise_type

Promise_type is also responsible for keyword's actions:

- `co_return V;`
- `co_return;`
- `co_yield V;`

- `p.return_value(V);`
- `p.return_void();`
- `co_await p.yield_value();`

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    - void
    - bool
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  - `T await_resume()`

Missing coroutines parts

Type erasure

asynchronous RAII

RVO or the co_await

What is RVO?

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Allows to avoid unnecessary copy or move construction of the values returned from the function.

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Allows to avoid unnecessary copy or move construction of the values returned from the function.
For example:

```
std::vector<int> foo(){
  return {1,2,3,4,5};
}

// ...

// no copy or move construction
// invoked
auto _ = foo();
```

RVO on regular functions

regular function

```
std::vector<int> foo(){
  return {1,2,3,4,5};
}
```

transformed by compiler into:

```
void foo(std::vector<int>* ptr){
  new(ptr) std::vector<int>
           {1,2,3,4,5};
}
```

Why RVO is not possible with co_await

expression

```
co_await event;
```

transformed by compiler into:

```
{
  auto&& awaiter = transform(event);
  if(!awaiter.await_ready()){
    <coroutine suspend>
    awaiter.await_suspend();
  }
  <coroutine resume>;
  awaiter.await_resume();
}
```

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How to resolve the issue [P1663R0]

1. Remove await_resume function.

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Extensions to the coroutine_handle

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On coroutine resumption the compiler will generate code to check whether the exception was saved with set_exception and will rethrow it when needed.

Example of the yield_value

```
template <typename T> class task<T>::promise_type{
// ....

  template <typename U> requires ConvertibleTo<U, T>
  void return_value(U&& value){
    handle.set_value<T>(std::forward<U>(value));
  }

  template <typename... Args>
            requires Constructible<T, Args...>
  void return_value(std::in_place_construct<Args&&...>
                    ctor_args){
    handle.set_value_from<T>(ctor_args);
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How do compiler know the result of the co_await?

With removal of the await_ready the compiler no longer knows about the co_await returned type.

We will need to guide the compiler. The proposal P1663R0 proposes to add member await_result_type to the Awaiter.

RVO summary

pros	cons
• very simplified awaiter concept	

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- removing await_ready makes co_await always suspend the coroutine (even if not needed)
- a need to support RVO manually (with the help of construct_in_place)
- proposed RVO does not consider synchronous coroutines - only co_await keyword.

return value [and|or] return void

Thank you for your attention!

Special thank you! goes to:

- Gor Nishanov
- Lewiss Baker

for making coroutines

Bibliography and further reading

- Lewiss Baker's Assymetric transfer blog
- newest C++ draft
- My blog - blog.panicsoftware.com
- James McNellis - "Introduction to the C++ Coroutines"
- Gor Nishanov - any video about the coroutines
- Toby Allsopp - "Coroutines: what can't they do?"

Questions?

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