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

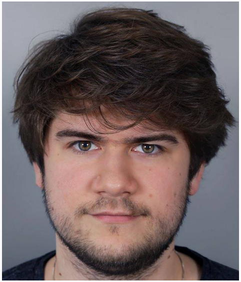
Questions...

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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- suspended

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Coroutine can be:

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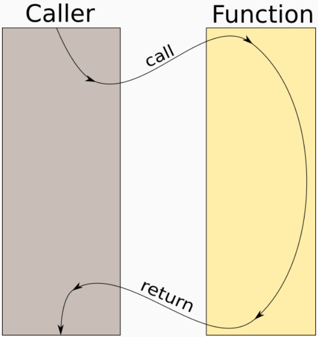
- resumed from
- created
- destroyed

Coroutine flowchart

Function's flow:



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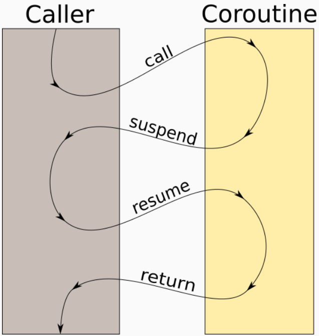

How to implement custom coroutine types.

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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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//|-------------/ |-------/ |--------------/
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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 initial_suspend();`	suspension at the beginning
`awaitable final_suspend();`	suspension at the end
`return_type get_return_object();`	how to create return_type
`void unhandled_exception();`	handling unhandled exception

Keywords and promise_type

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`co_return V;`	`p.return_value(V);`
`co_return;`	`p.return_void();`
`co_yield V;`	`co_await p.yield_value();`

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  - `await_suspend(coroutine_handle<P>)` returning
    - void
    - bool
    - another `coroutine_handle`
  - `T await_resume()`

Missing coroutines parts

Type erasure

asynchronous RAII

RVO or the co_await

What is RVO?

RVO - Return Value Optimization.

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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_ready();
}
```

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Why RVO is not possible with co_await

expression

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co_await event;
```

1. On await_suspend coroutine gets executed
2. On await_ready result is returned
3. Result needs to be preserved since await_suspend till await_ready

transformed by compiler into:

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

How to resolve the issue [P1663R0]

1. Remove await_resume function.

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  ~~awaiter.await_ready();~~
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How to resolve the issue [P1663R0]

1. Remove await_resume function.
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  auto&& awaiter = transform(event);
  ~~if(!awaiter.await_ready()){~~
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    awaiter.await_suspend();
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How to resolve the issue [P1663R0]

1. Remove await_resume function.
2. await_suspend will will create return result
3. Remove await_ready function.

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

Extensions to the coroutine_handle

Two additional functions in the coroutine_handle are needed.

- set_value

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

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Two additional functions in the coroutine_handle are needed.

- set_value
- set_exception

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 await_suspend

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.

return value [and|or] return void

Thank you for 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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