Programming with Java StructuredTaskScope

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Learning Objectives in this Part of the Lesson

- Understand Java's structured concurrency model
- Recognize the classes used to program Java's structure concurrency model, e.g.
  - ThreadPerTaskExecutor
  - StructuredTaskScope
    - Both ShutdownOnFailure & ShutdownOnSuccess

```
try (var scope = new
     StructuredTaskScope
     .ShutdownOnFailure()) {
  Future<String> user = scope
    .fork(() -> findUser());
  Future<Integer> order = scope
    .fork(() -> fetchOrder());

  scope.join();
  scope.throwIfFailed();

  return new Response
                  (user.resultNow(),
                   order.resultNow());
}
```

Programming with Java StructuredTaskScope

Programming with Java StructuredTaskScope

- StructuredTaskScope is the basic API for Java structured concurrency

Class StructuredTaskScope<T>

java.lang.Object
    jdk.incubator.concurrent.StructuredTaskScope<T>

Type Parameters:

T - the result type of tasks executed in the scope

All Implemented Interfaces:

`AutoCloseable`

Direct Known Subclasses:

`StructuredTaskScope.ShutdownOnFailure`, `StructuredTaskScope.ShutdownOnSuccess`

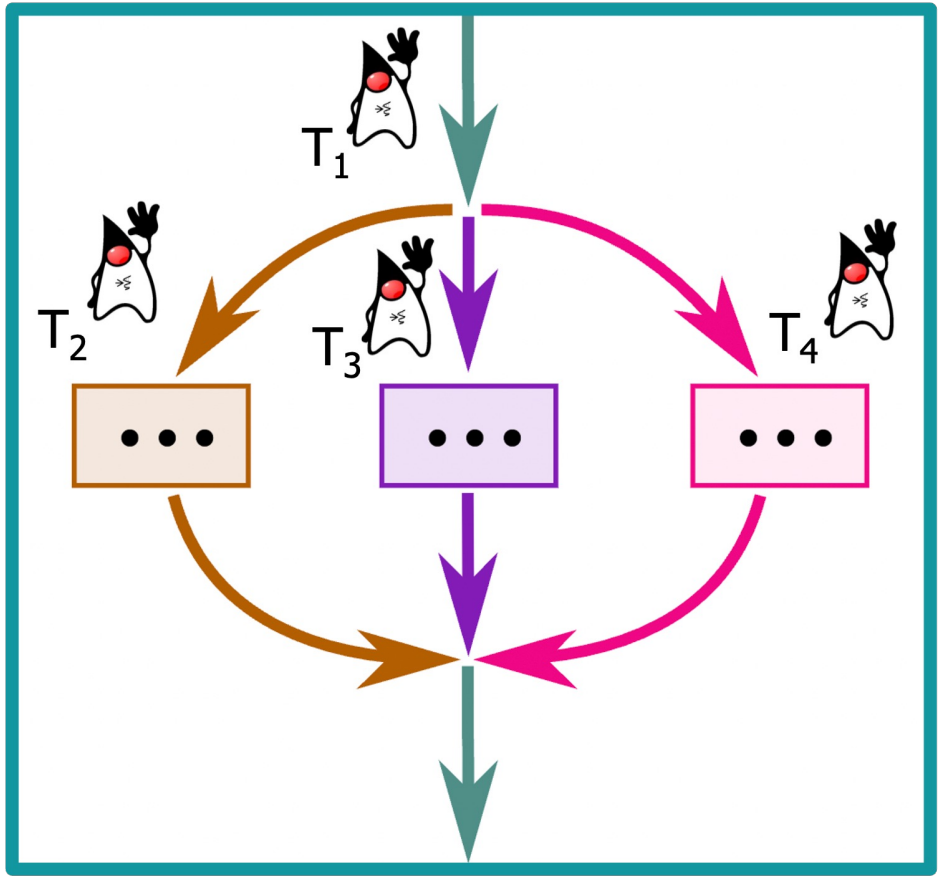
```
public class StructuredTaskScope<T>
extends Object
implements AutoCloseable
```

A basic API for *structured concurrency*. `StructuredTaskScope` supports cases where a task splits into several concurrent subtasks, to be executed in their own threads, and where the subtasks must complete before the main task continues. A `StructuredTaskScope` can be used to ensure that the lifetime of a concurrent operation is confined by a *syntax block*, just like that of a sequential operation in structured programming.

See jdk/incubator/concurrent/StructuredTaskScope.html

Programming with Java StructuredTaskScope

- StructuredTaskScope is the basic API for Java structured concurrency
  - It splits a task into several subtasks that run concurrently within a syntax block



See jdk/incubator/concurrent/StructuredTaskScope.html

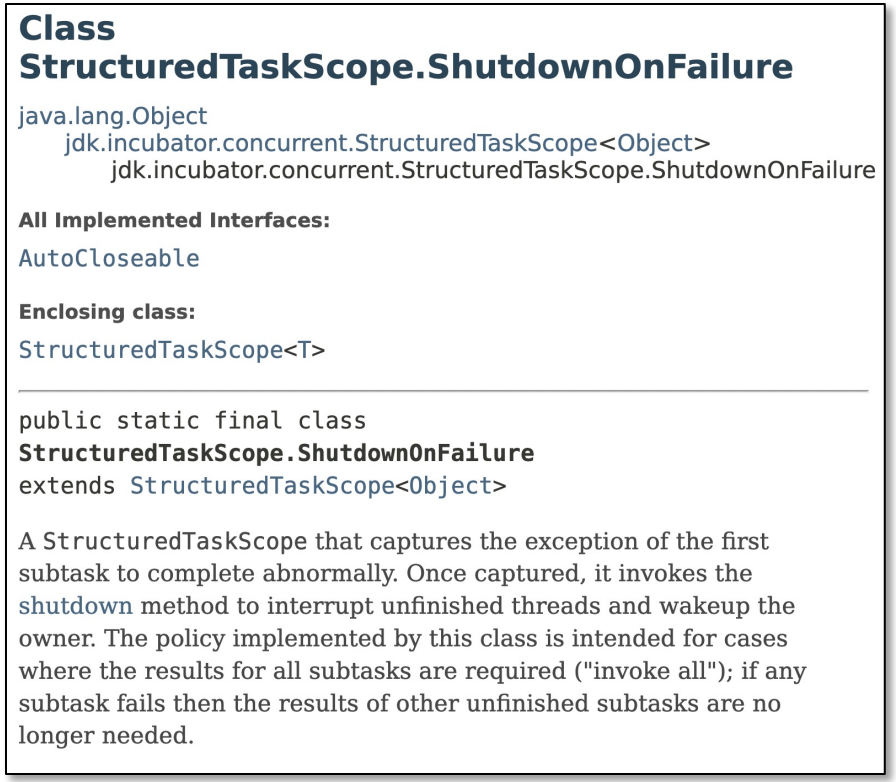
Programming with Java StructuredTaskScope

- StructuredTaskScope is the basic API for Java structured concurrency
  - It splits a task into several subtasks that run concurrently within a syntax block
  - It defines several nested subclasses

See openjdk.org/jeps/11

Programming with Java StructuredTaskScope

- StructuredTaskScope is the basic API for Java structured concurrency
  - It splits a task into several subtasks that run concurrently within a syntax block
  - It defines several nested subclasses
    - ShutdownOnFailure
      - Captures the exception of the first subtask to complete abnormally



Class StructuredTaskScope.ShutdownOnFailure

java.lang.Object
jdk.incubator.concurrent.StructuredTaskScope<Object>
jdk.incubator.concurrent.StructuredTaskScope.ShutdownOnFailure

All Implemented Interfaces:

AutoCloseable

Enclosing class:

StructuredTaskScope<T>

---

public static final class
StructuredTaskScope.ShutdownOnFailure
extends StructuredTaskScope<Object>

A StructuredTaskScope that captures the exception of the first subtask to complete abnormally. Once captured, it invokes the shutdown method to interrupt unfinished threads and wakeup the owner. The policy implemented by this class is intended for cases where the results for all subtasks are required ("invoke all"); if any subtask fails then the results of other unfinished subtasks are no longer needed.

See jdk.incubator.concurrent/jdk/incubator/concurrent/StructuredTaskScope.ShutdownOnFailure.html

Programming with Java StructuredTaskScope

- StructuredTaskScope is the basic API for Java structured concurrency
  - It splits a task into several subtasks that run concurrently within a syntax block
  - It defines several nested subclasses
    - ShutdownOnFailure
    - ShutdownOnSuccess
      - Captures the result of the first subtask to complete successfully

Class StructuredTaskScope.ShutdownOnSuccess<T>

java.lang.Object
  jdk.incubator.concurrent.StructuredTaskScope<T>
    jdk.incubator.concurrent.StructuredTaskScope.ShutdownOnSuccess<T>

Type Parameters:

T - the result type

All Implemented Interfaces:

AutoCloseable

Enclosing class:

StructuredTaskScope<T>

```
public static final class StructuredTaskScope.ShutdownOnSuccess<T>
extends StructuredTaskScope<T>
```

A StructuredTaskScope that captures the result of the first subtask to complete successfully. Once captured, it invokes the shutdown method to interrupt unfinished threads and wakeup the owner. The policy implemented by this class is intended for cases where the result of any subtask will do ("invoke any") and where the results of other unfinished subtask are no longer needed.

Unless otherwise specified, passing a null argument to a method in this class will cause a NullPointerException to be thrown.

See jdk/incubator/concurrent/StructuredTaskScope.ShutdownOnSuccess.html

Programming with Java StructuredTaskScope

- StructuredTaskScope is the basic API for Java structured concurrency
  - It splits a task into several subtasks that run concurrently within a syntax block
  - It defines several nested subclasses
    - ShutdownOnFailure
    - ShutdownOnSuccess
      - Captures the result of the first subtask to complete successfully
        - Essentially like "invokeAny()"

Programming with Java ShutdownOnFailure

Programming with Java ShutdownOnFailure

- ShutdownOnFailure is used with the try-with-resources feature, like the Executors .ThreadPerTaskExecutor

```
try (var scope = new StructuredTaskScope
    .ShutdownOnFailure()) {
  Future<String> user = scope
    .fork(() -> findUser());
  Future<Integer> order = scope
    .fork(() -> fetchOrder());

  scope.join();
  scope.throwIfFailed();

  return new Response
    (user.resultNow(),
     order.resultNow());
}
```

See howtodoinjava.com/java/multi-threading/structured-concurrency

Programming with Java ShutdownOnFailure

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   scope.join();
   scope.throwIfFailed();

   return new Response
      (user.resultNow(),
       order.resultNow());
}
```

Creates a new virtual Thread every time fork() is called

See jdk/incubator/concurrent/StructuredTaskScope.html#fork

Programming with Java ShutdownOnFailure

- ShutdownOnFailure is used with the try-with-resources feature, like the Executors .ThreadPerTaskExecutor
  - However, it's more flexible due to its join() method

```
try (var scope = new StructuredTaskScope
      .ShutdownOnFailure()) {
   Future<String> user = scope
      .fork(() -> findUser());
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   scope.join();
   scope.throwIfFailed();

   return new Response
      (user.resultNow(),
       order.resultNow());
}
```

This barrier synchronizer waits for all threads to finish or for the task scope to shut down if an exception should occur

See jdk/incubator/concurrent/StructuredTaskScope.ShutdownOnFailure.html#join

Programming with Java ShutdownOnFailure

- ShutdownOnFailure is used with the try-with-resources feature, like the Executors .ThreadPerTaskExecutor
  - However, it's more flexible due to its join() method
  - It can also handle any exceptions that arise

```
try (var scope = new StructuredTaskScope
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   Future<String> user = scope
      .fork(() -> findUser());
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   scope.throwIfFailed();

   return new Response
      (user.resultNow(),
       order.resultNow());
}
```

Throws an Exception if a sub-task completed abnormally

See jdk/incubator/concurrent/StructuredTaskScope.ShutdownOnFailure.html#throwIfFailed

Programming with Java ShutdownOnFailure

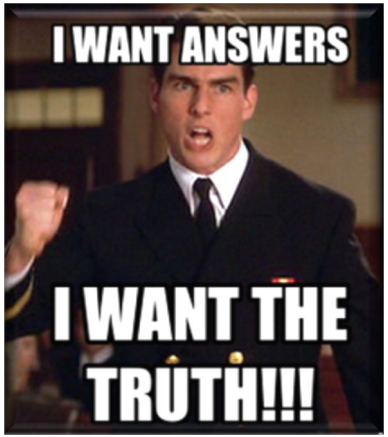
- ShutdownOnFailure is used with the try-with-resources feature, like the Executors .ThreadPerTaskExecutor
  - However, it's more flexible due to its join() method
  - It can also handle any exceptions that arise
  - Users can access Future results without blocking

```
try (var scope = new StructuredTaskScope
      .ShutdownOnFailure()) {
   Future<String> user = scope
      .fork(() -> findUser());
   Future<Integer> order = scope
      .fork(() -> fetchOrder());

   scope.join();
   scope.throwIfFailed();

   return new Response
        (user.resultNow(),
         order.resultNow());
}
```

Return a result using new Future methods



See java/util/concurrent/Future.html#resultNow

Programming with Java
ShutdownOnSuccess

Programming with Java ShutdownOnSuccess

- ShutdownOnSuccess also uses try-with-resources

```
try (var scope = new StructuredTaskScope
    .ShutdownOnSuccess
       <List<BigFraction>>()) {
  var quickSortF = scope
    .fork(() -> quickSort(list));

  var heapSortF = scope
    .fork(() -> heapSort(list));

  scope.join();

  return scope.result();
}
```

See howtodoinjava.com/java/multi-threading/structured-concurrency

Programming with Java ShutdownOnSuccess

- ShutdownOnSuccess also uses try-with-resources
  - It provides "invoke-any" semantics that take only the fastest result


```
try (var scope = new StructuredTaskScope
    .ShutdownOnSuccess
        <List<BigFraction>>()) {
  var quickSortF = scope
    .fork(() -> quickSort(list));

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    .fork(() -> heapSort(list));

  scope.join();

  return scope.result();
}
```

See howtodoinjava.com/java/multi-threading/executorservice-invokeany

Programming with Java ShutdownOnSuccess

- ShutdownOnSuccess also uses try-with-resources
  - It provides "invoke-any" semantics that take only the fastest result

Run quicksort & heapsort in parallel!

```
try (var scope = new StructuredTaskScope
    .ShutdownOnSuccess
        <List<BigFraction>>()) {
  var quickSortF = scope
    .fork(() -> quickSort(list));

  var heapSortF = scope
    .fork(() -> heapSort(list));

  scope.join();

  return scope.result();
}
```

See jdk/incubator/concurrent/StructuredTaskScope.html#fork

Programming with Java ShutdownOnSuccess

- ShutdownOnSuccess also uses try-with-resources
  - It provides "invoke-any" semantics that take only the fastest result

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try (var scope = new StructuredTaskScope
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        <List<BigFraction>>()) {
  var quickSortF = scope
    .fork(() -> quickSort(list));

  var heapSortF = scope
    .fork(() -> heapSort(list));

  scope.join();

  return scope.result();
}
```

Wait for the first result to complete

See jdk/incubator/concurrent/StructuredTaskScope.ShutdownOnFailure.html#join

Programming with Java ShutdownOnSuccess

- ShutdownOnSuccess also uses try-with-resources
  - It provides "invoke-any" semantics that take only the fastest result


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try (var scope = new StructuredTaskScope
    .ShutdownOnSuccess
        <List<BigFraction>>()) {
  var quickSortF = scope
    .fork(() -> quickSort(list));

  var heapSortF = scope
    .fork(() -> heapSort(list));

  scope.join();

  return scope.result();
}
```

Return the first result

See jdk/incubator/concurrent/StructuredTaskScope.ShutdownOnSuccess.html#result

End of Programming with Java StructuredTaskScope