The Java ExecutorService Interface (Part 2)

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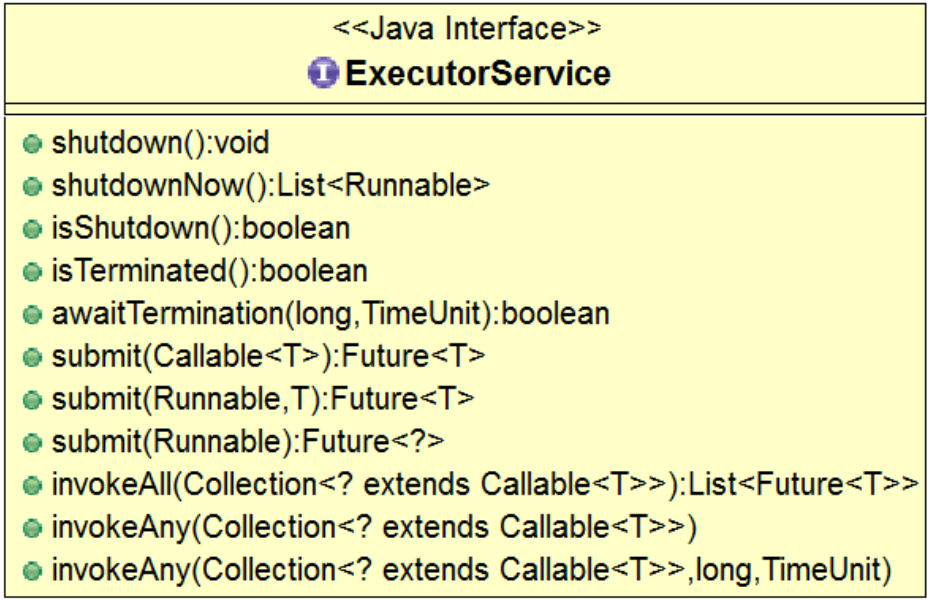
Learning Objectives in this Part of the Lesson

- Recognize the powerful features defined in the Java ExecutorService interface & related interfaces/classes
- Know key methods provided by the Java ExecutorService



Key Methods in the ExecutorService Interface (Part 1)

Key Methods in the ExecutorService Interface

- ExecutorService can execute individual tasks

```
public interface ExecutorService
                    extends Executor {
  // Inherited from Executor
  void execute(Runnable command);

  <T> Future<T> submit
          (Callable<T> task);
  ...
```

Key Methods in the ExecutorService Interface

- ExecutorService can execute individual tasks
  - execute() runs one-way tasks that return void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public interface ExecutorService
                    extends Executor {
  // Inherited from Executor
  void execute(Runnable command);

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  ...
```

However, this method isn't very useful/common in practice

Key Methods in the ExecutorService Interface

- ExecutorService can execute individual tasks
  - execute() runs one-way tasks that return void
  - submit() runs two-way async tasks that return a value via a future


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  ...
```

This method is the most useful/common in practice

Key Methods in the ExecutorService Interface

- ExecutorService can execute individual tasks
  - execute() runs one-way tasks that return void
  - submit() runs two-way async tasks that return a value via a future
    - Supports "synchronous future" processing model

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public interface ExecutorService
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- ExecutorService can execute individual tasks
  - execute() runs one-way tasks that return void
  - submit() runs two-way async tasks that return a value via a future
    - Supports "synchronous future" processing model
    - Future.get() can block until task completes successfully

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public interface ExecutorService
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Key Methods in the ExecutorService Interface

- ExecutorService can execute individual tasks
  - execute() runs one-way tasks that return void
  - submit() runs two-way async tasks that return a value via a future
    - Supports "synchronous future" processing model
    - Future.get() can block until task completes successfully
      - After which point get() returns the task's result

```
public interface ExecutorService
                    extends Executor {
  // Inherited from Executor
  void execute(Runnable command);

  <T> Future<T> submit
          (Callable<T> task);
  ...
```

Key Methods in the ExecutorService Interface

- ExecutorService can execute individual tasks
  - execute() runs one-way tasks that return void
  - submit() runs two-way async tasks that return a value via a future
  - submit() can also run one-way async tasks that return no value

```
public interface ExecutorService
                    extends Executor {
  // Inherited from Executor
  void execute(Runnable command);

  <T> Future<T> submit
          (Callable<T> task);

  <T> Future<T> submit
          (Runnable task);
  ...
```

Key Methods in the ExecutorService Interface

- ExecutorService can execute individual tasks
  - execute() runs one-way tasks that return void
  - submit() runs two-way async tasks that return a value via a future
  - submit() can also run one-way async tasks that return no value
    - It is possible to cancel this computation, however

```
public interface ExecutorService
                    extends Executor {
  // Inherited from Executor
  void execute(Runnable command);

  <T> Future<T> submit
          (Callable<T> task);

  <T> Future<T> submit
          (Runnable task);
  ...
```

Key Methods in the ExecutorService Interface

- ExecutorService can also execute groups of tasks

```
public interface ExecutorService
                    extends Executor {
  ...
  <T> List<Future<T>> invokeAll
     (Collection<? extends
      Callable<T>> tasks) ...;

  <T> T invokeAny
     (Collection<? extends
      Callable<T>> tasks) ...;

  <T> T invokeAny(Collection<?
      extends Callable<T>> tasks,
      long timeout, TimeUnit unit)
      ...; ...
```

Key Methods in the ExecutorService Interface

- ExecutorService can also execute groups of tasks
  - Returns a list of futures when all tasks complete

```
public interface ExecutorService
                    extends Executor {
  ...
 <T> List<Future<T>> invokeAll
     (Collection<? extends
      Callable<T>> tasks) ...;

 <T> T invokeAny
     (Collection<? extends
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 <T> T invokeAny(Collection<?
     extends Callable<T>> tasks,
     long timeout, TimeUnit unit)
     ...; ...
```

All futures returned in this list are "done"!

See docs.oracle.com/javase/8/docs/api/java/util/concurrent/ExecutorService.html#invokeAll

Key Methods in the ExecutorService Interface

- ExecutorService can also execute groups of tasks
  - Returns a list of futures when all tasks complete
  - Return the result of *one* successful completion

```
public interface ExecutorService
                    extends Executor {
  ...
  <T> List<Future<T>> invokeAll
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      (Collection<? extends
       Callable<T>> tasks) ...;

  <T> T invokeAny(Collection<?
       extends Callable<T>> tasks,
       long timeout, TimeUnit unit)
       ...; ...
```

Useful for concurrent algorithms that just want the result that completes first

Key Methods in the ExecutorService Interface

- ExecutorService can also execute groups of tasks
  - Returns a list of futures when all tasks complete
  - Return the result of *one* successful completion
    - Cancel uncompleted tasks

```
public interface ExecutorService
                    extends Executor {
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```

Key Methods in the ExecutorService Interface

- ExecutorService can also execute groups of tasks
  - Returns a list of futures when all tasks complete
  - Return the result of *one* successful completion
    - Cancel uncompleted tasks
    - Ignore other completed task results

```
public interface ExecutorService
                    extends Executor {
  ...
  <T> List<Future<T>> invokeAll
      (Collection<? extends
       Callable<T>> tasks) ...;

  <T> T invokeAny
      (Collection<? extends
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  <T> T invokeAny(Collection<?
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      extends Callable<T>> tasks,
      long timeout, TimeUnit unit)
      ...; ...
```

Don't modify the collection param while invokeAll() or invokeAny() are running!!!

Key Methods in the ExecutorService Interface

- ExecutorService can also execute groups of tasks
  - Returns a list of futures when all tasks complete
  - Return the result of *one* successful completion

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public interface ExecutorService
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  <T> T invokeAny(Collection<?
      extends Callable<T>> tasks,
      long timeout, TimeUnit unit)
      ...; ...
```

These methods block the calling thread until they are finished, which may be non-intuitive..

Key Methods in the ExecutorService Interface (Part 2)

Key Methods in the ExecutorService Interface

- An ExecutorService client can initiate shutdown operations to manage its lifecycle

```
public interface ExecutorService
                    extends Executor {
  ...
  void shutdown();

  List<Runnable> shutdownNow();
  ...
```

Key Methods in the ExecutorService Interface

- An ExecutorService client can initiate shutdown operations to manage its lifecycle
  - Perform "orderly shutdown" that completes active tasks


```
public interface ExecutorService
                 extends Executor {
  ...
  void shutdown();

  List<Runnable> shutdownNow();
  ...
```

Key Methods in the ExecutorService Interface

- An ExecutorService client can initiate shutdown operations to manage its lifecycle
  - Perform "orderly shutdown" that completes active tasks
    - But ignores new tasks

```
public interface ExecutorService
                    extends Executor {
  ...
  void shutdown();

  List<Runnable> shutdownNow();
  ...
```

Key Methods in the ExecutorService Interface

- An ExecutorService client can initiate shutdown operations to manage its lifecycle
  - Perform "orderly shutdown" that completes active tasks
  - Attempt to cancel active tasks & don't process waiting tasks

```
public interface ExecutorService
                 extends Executor {
  ...
  void shutdown();

  List<Runnable> shutdownNow();
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```

Key Methods in the ExecutorService Interface

- An ExecutorService client can initiate shutdown operations to manage its lifecycle
  - Perform "orderly shutdown" that completes active tasks
  - Attempt to cancel active tasks & don't process waiting tasks
    - Activate tasks are cancelled by posting an interrupt request to executor thread(s)

```
public interface ExecutorService
                 extends Executor {
  ...
  void shutdown();

  List<Runnable> shutdownNow();
  ...
```

Remember that all these Java interrupt requests are "voluntary"!!

See docs.oracle.com/javase/tutorial/essential/concurrency/interrupt.html

Key Methods in the ExecutorService Interface

- An ExecutorService client can initiate shutdown operations to manage its lifecycle
  - Perform "orderly shutdown" that completes active tasks
  - Attempt to cancel active tasks & don't process waiting tasks
    - Activate tasks are cancelled by posting an interrupt request to executor thread(s)
    - Returns waiting tasks

```
public interface ExecutorService
                 extends Executor {
  ...
  void shutdown();

  List<Runnable> shutdownNow();
  ...
```

Key Methods in the ExecutorService Interface

- ExecutorService can query status of a shutdown, as well as wait for termination to finish

```
public interface ExecutorService
                 extends Executor {
  ...
  boolean isShutdown();

  boolean isTerminated();

  boolean awaitTermination
              (long timeout,
               TimeUnit unit)  ...;
```

Key Methods in the ExecutorService Interface

- ExecutorService can query status of a shutdown, as well as wait for termination to finish
  - True if Executor shut down

```
public interface ExecutorService
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Key Methods in the ExecutorService Interface

- ExecutorService can query status of a shutdown, as well as wait for termination to finish
  - True if Executor shut down
  - True if all tasks completed after shut down

```
public interface ExecutorService
                    extends Executor {
  ...
  boolean isShutdown();

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  boolean awaitTermination
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```

Key Methods in the ExecutorService Interface

- ExecutorService can query status of a shutdown, as well as wait for termination to finish
  - True if Executor shut down
  - True if all tasks completed after shut down
  - Blocks until all tasks complete

```
public interface ExecutorService
                 extends Executor {
  ...
  boolean isShutdown();

  boolean isTerminated();

  boolean awaitTermination
                (long timeout,
                 TimeUnit unit) ...;
```

shutdownNow() *may* reduce blocking time for awaitTermination()

Key Methods in the ExecutorService Interface

- ExecutorService can query status of a shutdown, as well as wait for termination to finish
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- Blocks until all tasks complete

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public interface ExecutorService
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  boolean isShutdown();

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  boolean awaitTermination
              (long timeout,
               TimeUnit unit)  ...;
```

shutdown() & awaitTermination() provide barrier synchronization*

See en.wikipedia.org/wiki/Barrier_(computer_science)

End of Overview of Java ExecutorService (Part 2)