Interfaces Related to the
Java ExecutorService

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Learning Objectives in this Part of the Lesson

- Recognize the powerful features defined in the Java ExecutorService interface
- Understand other interfaces related to ExecutorService

### Interface ExecutorService

- **All Superinterfaces:** Executor
- **All Known Subinterfaces:** ScheduledExecutorService
- **All Known Implementing Classes:** AbstractExecutorService, ForkJoinPool, ScheduledThreadPoolExecutor, ThreadPoolExecutor

```java
public interface ExecutorService extends Executor
```

An Executor that provides methods to manage termination and methods that can produce a Future for tracking progress of one or more asynchronous tasks.

An ExecutorService can be shut down, which will cause it to reject new tasks. Two different methods are provided for shutting down an ExecutorService. The `shutdown()` method will allow previously submitted tasks to execute before terminating, while the `shutdownNow()` method prevents waiting tasks from starting and attempts to stop currently executing tasks. Upon termination, an executor has no tasks actively executing, no tasks awaiting execution, and no new tasks can be submitted. An unused ExecutorService should be shut down to allow reclamation of its resources.
Overview of Interfaces Related To ExecutorService
Overview of Interfaces Related to ExecutorService

- ExecutorService uses several other interfaces to manage task lifecycles

```
<<Java Interface>>

Runnable
  run():void

Future<V>
  cancel(boolean):boolean
  isCancelled():boolean
  isDone():boolean
  get()
  get(long, TimeUnit)

Callable<V>
  call()
```
Overview of Interfaces Related to ExecutorService

- ExecutorService uses two interfaces to define tasks

```java
<<Java Interface>>
Runnable

- run(): void

<<Java Interface>>
Callable<V>

- call()
```
Overview of Interfaces Related to ExecutorService

- ExecutorService uses two interfaces to define tasks, e.g.
  - Runnable
    - A “one-way” task that does not return a result

See docs.oracle.com/javase/8/docs/api/java/lang/Runnable.html
Overview of Interfaces Related to ExecutorService

- ExecutorService uses two interfaces to define tasks, e.g.
  - Runnable
  - Callable
    - A “two-way” task that returns a result

See [docs.oracle.com/javase/8/docs/api/java/util/concurrent/Callable.html](https://docs.oracle.com/javase/8/docs/api/java/util/concurrent/Callable.html)

Callable is also a functional interface
Overview of Interfaces Related to ExecutorService

- ExecutorService uses two interfaces to define tasks, e.g.
  - Runnable
  - Callable
    - A “two-way” task that returns a result
    - Typically used to run two-way async tasks
Overview of Interfaces Related to ExecutorService

- ExecutorService uses two interfaces to define tasks, e.g.
  - Runnable
  - Callable
    - A “two-way” task that returns a result
    - Typically used to run two-way async tasks
  - Implements the Active Object pattern

Decouples the thread that invokes a method from the thread that executes the method

See en.wikipedia.org/wiki/Active_object
Overview of Interfaces Related to ExecutorService

- The **Future** interface is used by ExecutorService to represent & control a task’s lifecycle

See [docs.oracle.com/javase/8/docs/api/java/util/concurrent/Future.html](https://docs.oracle.com/javase/8/docs/api/java/util/concurrent/Future.html)
Overview of Interfaces Related to ExecutorService

- A Java future defines a proxy to represent & control the result of an async computation.

1. Asynchronous computation

Result get_result ()
begin
  ## Suspend calling thread until result is available.
  if (result == NULL) then
    thread.wait ();
  return result;
end

2. Result obtained only after the computation completes

See en.wikipedia.org/wiki/Futures_and_promises
Overview of Interfaces Related to ExecutorService

- A Java future defines a proxy to represent & control the result of an async computation.

```
Result get_result ()
begin
  ## Suspend calling thread until result is available.
  if (result == NULL) then
    thread.wait ();
  return result;
end
```

Table tent #'s are a human-known-use of futures!

Overview of Interfaces Related to ExecutorService

- A Java future defines a proxy to represent & control the result of an async computation.

```java
Result get_result ()
begin
  ## Suspend calling thread until result is available.
  if (result == NULL) then
    thread.wait ();
  return result;
end
```

- Table tent #’s are a human-known-use of futures!

- e.g., McDonald’s vs Wendy’s model of preparing fast food
Overview of Interfaces Related to ExecutorService

- Programs use the **Future** interface to represent & control a task’s lifecycle via its five methods.

```java
Callable callable = ...;
ThreadPoolExecutor executor = ...;
Future<BigFraction> future = executor.submit(callable);

// Accessing Future
Future<BigFraction> future = executor.submit(...);

// Accessing ResultType
ResultType result = future.get();
```

- **Future** Interface Methods:
  - `cancel(boolean)`: boolean
  - `isCancelled()`: boolean
  - `isDone()`: boolean
  - `get()`: ResultType
  - `get(long, TimeUnit)`: ResultType

- **Callable** Interface:
  - `call()`: ResultType

- **ThreadPoolExecutor**:
  - `submit(Callable)`: Future
  - `take()`: Callable
  - `run()`: Callable
  - `offer(Callable)`: void

- **WorkQueue**:
  - `run()`: void
  - `take()`: Callable
  - `run()`: Callable

- **Fixed WorkerThreads**:
  - `run()`: Callable

- **Thread (main thread)**:
  - `submit(Callable)`: Future

- **Callable**:
  - `call()`: ResultType

- **Future**:
  - `get()`: ResultType
Overview of Interfaces Related to ExecutorService

- Programs use the `Future` interface to represent & control a task’s lifecycle via its five methods, e.g.
- Can be used to retrieve a two-way task’s result

```
ResultType result = future.get();
```
Overview of Interfaces Related to ExecutorService

- Programs use the `Future` interface to represent & control a task’s lifecycle via its five methods, e.g.
  - Can be used to retrieve a two-way task’s result
  - Can be tested for completion

```
<<Java Interface>>

Future<V>

- cancel(boolean): boolean
- isCancelled(): boolean
- isDone(): boolean
- get()
- get(long, TimeUnit)
```

![Diagram of ThreadPoolExecutor and Future interface interactions](image)

1. `submit(task)`
2. Return future
3. `offer()` to WorkQueue
4. `take()`
5. `run()`
6. `isDone()`
Overview of Interfaces Related to ExecutorService

- Programs use the **Future** interface to represent & control a task’s lifecycle via its five methods, e.g.
  - Can be used to retrieve a two-way task’s result
  - Can be tested for completion
  - Can be tested for cancellation & cancelled

```java
<<Java Interface>>
Future<V>
- cancel(boolean): boolean
- isCancelled(): boolean
- isDone(): boolean
- get()
- get(long, TimeUnit)
```

**WorkQueue**
- callable
- callable
- callable

**ThreadPoolExecutor**
- submit()
- callable
- execute()
- shutdown()

**Future**
- run()
- submit(task)
- take()
- get()
- cancel()
Overview of Interfaces Related to ExecutorService

• ExecutorService.submit() can initiate an async computation in Java.

```java
ExecutorService executorService = Executors.newFixedThreadPool(sMax_THREADS);
```
Overview of Interfaces Related to ExecutorService

- ExecutorService.submit() can initiate an async computation in Java.

```java
Callable<BigFraction> task = () -> {
    BigFraction bf1 = new BigFraction(f1);
    BigFraction bf2 = new BigFraction(f2);
    return bf1.multiply(bf2);
};

Future<BigFraction> future = mExecutorService.submit(task);
```
Overview of Interfaces Related to ExecutorService

- `ExecutorService.submit()` can initiate an async computation in Java.
- It returns a `Future` implemented as a `FutureTask`.

```java
Callable<BigFraction> task = () -> {
    BigFraction bf1 = new BigFraction(f1);
    BigFraction bf2 = new BigFraction(f2);
    return bf1.multiply(bf2);
};

Future<BigFraction> future = mExecutorService.submit(task);
```

See upcoming lesson on "Java FutureTask"
Overview of Interfaces Related to ExecutorService

- ExecutorService.submit() can initiate an async computation in Java.
- It returns a Future implemented as a FutureTask.
- Async computation runs in a worker thread.

```java
Callable<BigFraction> task = () -> {
    BigFraction bf1 = new BigFraction(f1);
    BigFraction bf2 = new BigFraction(f2);
    return bf1.multiply(bf2);
};

Future<BigFraction> future = mExecutorService.submit(task);
```

See upcoming part of this lesson on "Overview of Java ThreadPoolExecutor"
Overview of Interfaces Related to ExecutorService

- When the async computation completes the future is triggered & the result is available

```java
BigFraction result = future.get();
```

See [www.nurkiewicz.com/2013/02/javauitlconcurrentfuture-basics.html](http://www.nurkiewicz.com/2013/02/javauitlconcurrentfuture-basics.html)
Overview of Interfaces Related to ExecutorService

- When the async computation completes the future is triggered & the result is available
- `get()` can block or (timed-)poll

BigFraction result = future.get();

See docs.oracle.com/javase/8/docs/api/java/util/concurrent/Future.html#get
Overview of Interfaces Related to ExecutorService

- When the async computation completes the future is triggered & the result is available
  - get() can block or (timed-)poll
  - Results can occur in a different order than the original calls were made
Futures are applied in the *Active Object* pattern.

Overview of Interfaces Related to ExecutorService

1. Async computation runs in a pool thread.
2. Client uses future to obtain a result only after async computation completes.

See [en.wikipedia.org/wiki/Active_object](en.wikipedia.org/wiki/Active_object)
Other variants of Future are applied by implementations of the ExecutorService.
Overview of Interfaces Related to ExecutorService

- Other variants of Future are applied by implementations of the ExecutorService, e.g.
  - **RunnableFuture**
    - Execution of run() method will complete the future & allow access to its results

See [docs.oracle.com/javase/8/docs/api/java/util/concurrent/RunnableFuture.html](docs.oracle.com/javase/8/docs/api/java/util/concurrent/RunnableFuture.html)
Overview of Interfaces Related to ExecutorService

- Other variants of Future are applied by implementations of the ExecutorService, e.g.
  - RunnableFuture
  - FutureTask
    - Conveys result from thread running a task to thread(s) retrieving result

See [docs.oracle.com/javase/8/docs/api/java/util/concurrent/FutureTask.html](docs.oracle.com/javase/8/docs/api/java/util/concurrent/FutureTask.html)
Overview of Interfaces Related to ExecutorService

- A CompletableFuture is an implementation of Future that supports dependent actions triggered upon an async operation completion.

See [docs.oracle.com/javase/8/docs/api/java/util/concurrent/CompletableFuture.html](docs.oracle.com/javase/8/docs/api/java/util/concurrent/CompletableFuture.html)

CompletableFuture isn’t part of the Java Executor framework
Overview of Interfaces Related to ExecutorService

- A CompletableFuture is an implementation of Future that supports dependent actions triggered upon an async operation completion.

See [www.dre.vanderbilt.edu/~schmidt/DigitalLearning](http://www.dre.vanderbilt.edu/~schmidt/DigitalLearning)
Overview of Interfaces Related to ExecutorService

- ExecutorService also forms the basis for key Java Executor framework subclasses

See `src/share/classes/java/util/concurrent`
Overview of Interfaces Related to ExecutorService

• ExecutorService also forms the basis for key Java Executor framework subclasses
• We cover these subclasses later in this course
End of Interfaces Related to the Java ExecutorService