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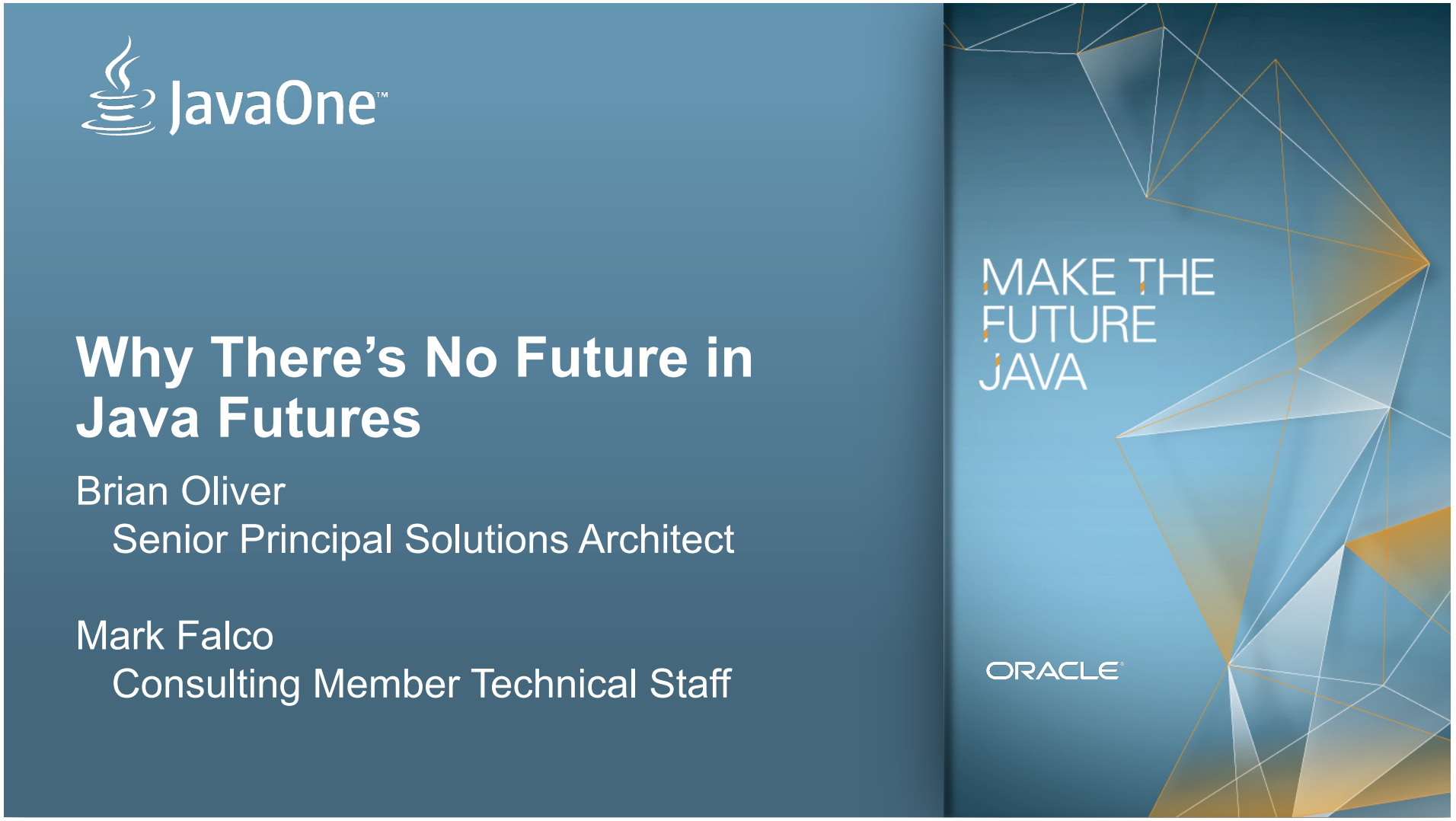
JavaOne™
Why There's No Future in Java Futures
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MAKE THE FUTURE JAVA
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Introduction to Java Futures

Clarification…

- This talk is not about…
  - The future of Java
  - Future predictions about the future of Java
- It's about concurrent software development with Java
  - ie: the java.util.concurrent package

Introduction to Java Futures

java.util.concurrent.Future (from the Java Documentation)

- "A Future represents the result of an asynchronous computation."
- "Methods are provided to check if the computation is complete, to wait for its completion, and to retrieve the result of the computation."
- "The result can only be retrieved using the method 'get' when the computation has completed, **blocking** if necessary until it is ready."

Introduction to Java Futures

java.util.concurrent.Future (from the Java Documentation)

Type	Method & Description
V	**get**() *Waits if necessary for the computation to complete*, and then retrieves its result.*
V	**get**(long timeout, TimeUnit unit) *Waits if necessary* for at most the given time for the computation to complete, and then retrieves its result, if available.*
boolean	**cancel**(boolean mayInterruptIfRunning) *Attempts to cancel execution of this task.*
boolean	**isCancelled**() *Returns true if this task was cancelled before it completed normally.*
boolean	**isDone**() *Returns true if this task completed.*

** unless an exception is thrown*

Introduction to Java Futures

java.util.concurrent.Future

- Consider the following:

```
/**
 * Provides a mechanism to search an archive.
 */
interface ArchiveSearcher {
   /**
    * Search an archive for some artifact, returning the result location.
    */
   String search(String artifact);
}
```


Introduction to Java Futures

Asynchronous Search Example

```
void showSearch(final String artifact,
                ExecutorService executor,
                final ArchiveSearcher searcher) throws InterruptedException {

   Future<String> future = executor.submit(new Callable<String>() {
      public String call() {
         return searcher.search(artifact);
      }});

   displayOtherThings(); // do other things while searching

   try {
      displayText(future.get());       // use future
   } catch (ExecutionException ex) {
      cleanup();
   }
}
```


Introduction to the Java ExecutorService

java.util.concurrent.ExecutorService

- Most instances of Java Futures come from Java ExecutorServices
- “An Executor … provides methods to manage termination and methods that can produce a Future for tracking progress of one or more asynchronous tasks.”
- And by “tracking progress” we mean isDone, isCancelled (not percentage complete)

Introduction to the Java ExecutorService

java.util.concurrent.ExecutorService (selected methods)

Type	Method & Description
Future<T>	**submit(Callable<T> task)** *Submits a value-returning task for execution and returns a Future representing the pending results of the task.*
Future<?>	**submit(Runnable task)** *Submits a Runnable task for execution and returns a Future representing that task.*
<T> List<Future<T>>	**invokeAll(Collection<? extends Callable<T>> tasks)** *Executes the given tasks, returning a list of Futures holding their status and results when all complete.*
<T> T	**invokeAny(Collection<? extends Callable<T>> tasks)** *Executes the given tasks, returning the result of one that has completed successfully (i.e., without throwing an exception), if any do.*

Styles of adoption – Blocking

Blocking wastes a thread ☹

```
Future<Double> f = executor.submit(task);

// do something else for a while (or nothing at all)

Double d = f.get(); // block!
```


Styles of adoption - Polling

Polling wastes a core ☹

```
Future<Double> f = executor.submit(task);

while (!f.isDone()) { // poll
    // do something else for awhile (or nothing)
    }

Double d = f.get());
```

ExecutorService… is just gets worse

Go parallel and block ☹

```
List<Future<Double>> futures = service.invokeAll(tasks);
double total = 0;
for (Future f : futures) {
    total += f.get();  //block, block, block …
    }
double avg = total / tasks.size();
proceed(avg);
```


Typical Requirements For “going async”.

Let’s step back a minute… what do you really do?

- Perform a task in the background and we either…
  a. Don’t care if or when it completes
  b. Do care if and/or when it completes, in which case…
     i. We do something with the result (or exception)
     ii. We don’t care about the result (or exception)

     In Summary:
     We want to do something after a task has completed, perhaps with the result… ie: A Continuation!

- This is not exactly what Futures or ExecutorServices provide

Introduction to Continuations

(Wikipedia)

- “a continuation is an abstract representation of the control state of a computer program”
- Useful for representing “control mechanisms in programming languages such as exceptions, generators, co-routines, and so on.”
- ie: Continuations are a way to represent “do this after completion of a task”.

What's Missing?

A callback from the Future…

- ExecutorService methods should take a "callback" or an "observer" to notify upon completion of a task
  - Allows us to know about completion (when it occurs)
  - Allows us to proceed immediately with other work (not wait)
  - Removes the need for blocking for results
  - Removes the need for polling of results
  - Allows for continuation style processing (good for Java 8)

Updating Async APIs for callbacks

- Asynchronous methods should **always** return **void** but take an ObservableFuture

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

thus becomes

```
<T> void executor.invoke(Callable<T> task, ObservableFuture<T>);
```

- When a task has completed, the executor “notifies” the supplied ObservableFuture.

Introducing ObservableFutures

A simple solution

```
interface ObservableFuture<T> extends Future<T> {
    void onResult(T);
    void onFailure(Exception);
    }
```


Using Observable Futures

Improved Asynchronous Search Example

```
void showSearch(final String artifact,
                ExecutorService executor,
                final ArchiveSearcher searcher) throws InterruptedException {

   ObservableFuture<String> future = new ObservableFuture<String>() {
      public void onResult(String result) { displayTest(result); }
      public void onFailure(ExecutionException e) { cleanup(); }
   };

   executor.submit(new Callable<String>() {
      public String call() {
         return searcher.search(artifact);
      }}, future);

   displayOtherThings(); // do other things while searching
}
```


Using Async APIs with callbacks

- It is what happens after invocation that matters…
  - Previously we were doing a:

```
future.get();
… now we do …
return;
```

- With ObservableFutures, we're now **non-blocking and non-polling!**

Continuations are key

- Rather than block and wait for a result, when one is provided to you, you process or act upon it (ie: Event Driven!)
- ObservableFuture becomes a Continuation

AggregatingFuture

Last Future result proceeds with calculation

```
class AggregatingFuture<T> impl ObservableFuture<T> {
    void onResult(T result) {
        synchronized (sharedResults) {
            sharedResults.add(result);
            if (sharedResults.size() == cRequired) {
                proceed(aggregate(sharedResults));
            }
        }
    }
}
```


The big problem with ObservableFutures!

- In our example we didn't implement all of the Future methods! Oops! Where's cancel(), isCancelled(), get(), isDone()…

```
interface ObservableFuture<T> extends Future<T> { … }
```

```
ObservableFuture<String> future = new ObservableFuture<String>() {
  public void onResult(String result) { displayTest(result); }
  public void onFailure(ExecutionException e) { cleanup(); }
};
```

- Do we actually need the other methods?

Introducing Collectors

A more flexible option

```
interface Collector<T> {
    void add(T);
    void flush()  default { };
}
```


Collector

Basics

Type	Method & Description
<T> void	**add**(T result) *Called by asynchronous implementations to provide (potentially a partial) result.*
void	**flush**() *Called by asynchronous implementations to signal it's time to process previously added results.*

- This combination permits map reduce style processing
  - (if that's what you're into)

Using Collectors

Improved Asynchronous Search Example

```
void showSearch(final String artifact,
                ExecutorService executor,
                ArchiveSearcher searcher) throws InterruptedException {

   Collector<String> collector = new Collector<String>() {
      public void add(String result) { displayTest(result); }
   };

   executor.submit(new Callable<String>() {
      public String call() {
         return searcher.search(artifact);
      }}, collector);

   displayOtherThings(); // do other things while searching
}
```


Supporting Exceptions?

Ok, this is getting a bit harder

- How does an implementation “notify” a Collector about an Exception?
- Poor
  - `Collector<?> + instanceof Exception`
- Better
  - `Collector.onFailure(ExecutionException e)`
- Best

```
interface Result<T> {
   T get() throws ExecutionException;   //does not block!
}
…
<T> void submit(Task, Collector<Result<T>>);
```


Using Result Collectors for Exceptions

```
void showSearch(final String artifact,
                ExecutorService executor,
                final ArchiveSearcher searcher) throws InterruptedException {

   Collector<Result<String>> collector = new Collector<Result<String>>() {
      public void add(Result<String> result) {
         try {
            displayTest(result.get());
         } catch (ExecutionException e) { cleanup(); }
      }
   };

   executor.submit(new Callable<String>() {
      public String call() {
         return searcher.search(artifact);
      }}, collector);

   displayOtherThings(); // do other things while searching
}
```


Supporting Cancellation / Interruption?

Please stop!!!

- Not all types of work can or should be cancelled / interrupted
  - Futures actually allow this! ☹
- How to cancel / interrupt?
  - Should the “request” to interrupt be on the “task” or on the “result”?
- How to know if a task was cancelled / interrupted?
  - Represented via `CancelledException` from `Result.get()`
  - Represented via `InterruptedException` from `Result.get()`
- `Future.cancel()` is optional!

Introducing Interruptable

Use a “wrapper” to support cancellation and interruption

```
interface Interruptable {
   void interrupt();
   boolean isInterrupted();
}

class InterruptableCallable<T> implements Callable<T>, Interruptable {
…
}

Class InterruptableRunnable implements Runnable, Interruptable {
…
}
```


Changes to Result

Interruption indicated via Exceptions

```
interface Result<T> {
   T get() throws ExecutionException,
                  CancelledException,
                  InterruptedException
}
```

```
Interruptable task = new InterruptableCallable(callable);
executor.submit(task, collector);

// do stuff… oops must interrupt!
task.interrupt();
```


Supporting Timeouts?

You only have so much time to do this…

- A task must execute with in a certain period of time, after which you give up!

- Similar solution to Interruptable… but add parameter to executor.
  - Represented via `TimedOutExecption` from `Result.get()`

```
void submit(Callable<T>, Collector<T>, int timeout, TimeUnit timeoutUnit);


interface Result<T> {
   T get() throws ExecutionException, InterruptedException
                  CancelledException, TimedOutException
}
```


Supporting Progress Feedback

How much work has been done?

- Two forms of progress?
  - Declared progress from serial set of tasks.
  - Inferred progress from multiple parallel tasks

- One solution?
  - Represent Progress as a Result with more “fidelity”

```
interface Progress<T> extends Result<T> {
   int getPercentageComplete();
   long getTimeRemaining(TimeUnit unit);
}
```


Replace Callables and Runnables with Tasks

Cleaning up the API… do we really need Callables/Runnables?

- Introduce Task
  - Provides a Collector to the Task
  - The Task can then provide Results (and Progress) or flush()
  - Provide wrapper and/or support for Callables and Runnables;

```
/**
 * An task to be performed asynchronously, the result of
 * which is placed in the provided Collector.
 */
interface Task<T> {
   void execute(Collector<? extends Result<T>> collector);
}
```


Using Collectors with Multiple Results

Go parallel and continue

```
abstract class AggregatingCollector<X, Y> implements Collector<X> {
   private List<X> results;
   . . .
   void add(X result) {
      results.add(result);
   }

   void flush() {
      proceed(aggregate(results));
   }

   abstract Y aggregate(List<X> results);

   abstract void proceed(Y result);
}
```


FutureCollector

Futures “we’re not dead yet”… You can have it both ways… ☺

```
class FutureCollector<T> implements Future<T>, Collector<Result<T>> {
   private T result = null;

   void synchronized add(Result<T> result) {
      this.result = result;
      notifyAll();
   }

   T synchronized get() throws … {
      while (result == null) {
         wait();
      }
      return result.get();
   }
   …
}
```


The CollectorExecutorService

Perhaps it should be like this?

Type	Method & Description
void	**submit(Task<T> task, Collector<? Extends Result<T>> collector)** *Submits a task for execution, the result of which is added to the provided collector. A null collector indicates no result is required.*
void	**submit(Task<T> task, Collector<? Extends Result<T>> collector, long timeout, TimeUnit timeUnits)** *Submits a task for execution, the result of which is added to the provided collector. A null collector indicates no result is required. The result must be provided with in the specified time, otherwise a TimedOutException will be added as the result.*
void	**invokeAll(Collection<? extends Task<T>>, Collector<? extends Result<T>>)** *Executes the given tasks, added each result into the provided collector. A null collector indicates no result is required.*

Questions

Sessions of Interest

Session	Day/Time	Location
Distributed Caching to Data Grids: The Past, Present and Future of Scalable Java	Monday 3:00 – 4:00	Parc 55 Market Street
Sharding Middleware to Achieve Elasticity and High Availability in the Cloud	Wednesday 1:00 – 2:00	Parc 55 Market Street
Using the New javax.cache Caching Standard	Thursday 11:00 – 12:00	Parc 55 Cyril Magnin 1
NoSQL Usage Patterns in Java Enterprise Applications	Thursday 3:30 – 4:30	Parc 55 Mission

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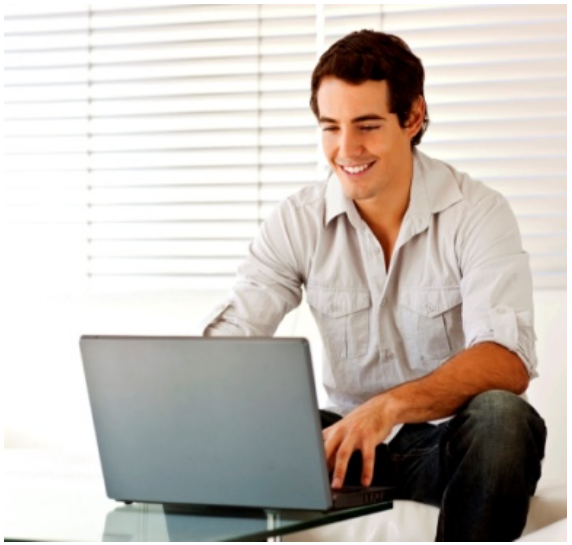

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