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3. Multi-Threading – Create a simple framework where work items can be submitted

Posted on [March 9, 2016](#) by [Arulkumaran Kumaraswamipillai](#)



Q: Create a simple framework where work items can be submitted using Java 8 or later. Here are the use cases:

#1: A **work item** is an instance of a class.

#2: The definition of “**parallelism**” controls how many threads are created to execute the work items in parallel (aka **asynchronously**).

#3: The framework needs to ensure that the number of threads executing the work item should remain the same until

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the threads finished executing all the work items.

#4: If work item dies, the framework should retry it.

#5: No need to cater for timeouts.

Use the following interfaces

E.g. Take 5 work items and execute 3 in parallel (i.e. 3 asynchronously).

```

1
2 package com.homeassignment.task2;
3
4 import java.util.List;
5 import java.util.concurrent.ExecutionException;
6
7 public interface WorkItemExecutor
8 {
9     void executeWorkItem(List<WorkItem> w, int p
10 }
11
12
13
```

E.g. Work item execution. Takes a “WorkItemCompletionCallback”, which is called on completion of a work item.

```

1
2 package com.homeassignment.task2;
3
4 public interface WorkItem
5 {
6     void execute(WorkItemCompletionCallback callb
7 }
8
9
```

Callback logic.

```

1
2 package com.homeassignment.task2;
3
4 public interface WorkItemCompletionCallback
5 {
6     void complete(String name);
7 }
8
```

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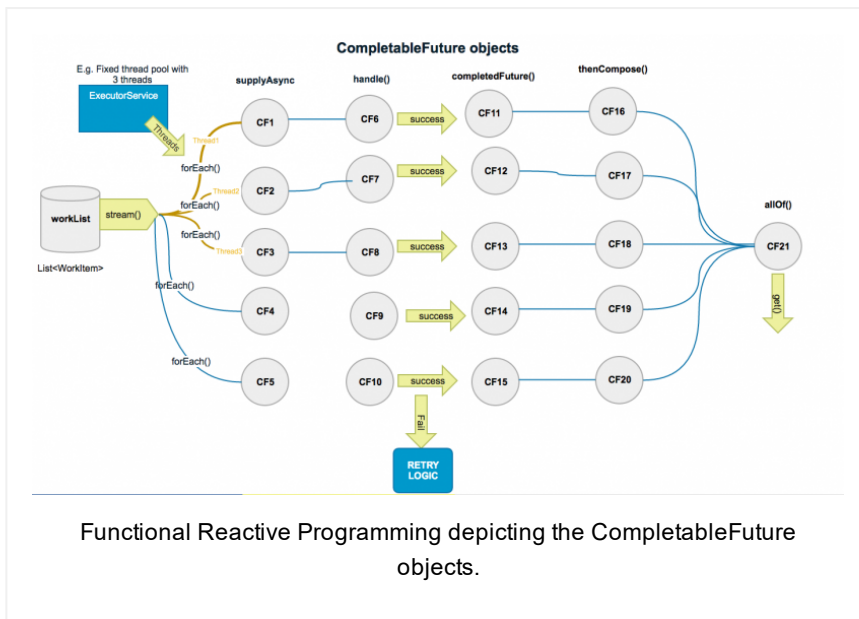
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A: Start implementing the logic to create a framework to execute work items in parallel using Java 8 “ExecutorService” and “CompletableFuture” APIs. The basics are covered in [ExecutorService Vs Fork/Join & Future Vs CompletableFuture Interview Q&A](#).

Step 1: WorkItemExecutorImpl that implements WorkItemExecutor

This implementation has the most of the logic, lambda expressions, use and chaining of CompletableFuture, retry logic, and use of ExecutorService thread pool.



```

1
2 package com.homeassignment.task2;
3
4 import java.util.ArrayList;
5 import java.util.List;
6 import java.util.concurrent.CompletableFuture;
7 import java.util.concurrent.ExecutionException;
8 import java.util.concurrent.ExecutorService;
9 import java.util.concurrent.Executors;
10 import java.util.concurrent.TimeUnit;
11
12 import org.slf4j.Logger;
13 import org.slf4j.LoggerFactory;

```

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```

14
15 public class WorkItemExecutorImpl implements Wor
16
17     private Logger LOG = LoggerFactory.getLogger
18
19     private ExecutorService concurrentThreadExec
20
21     @Override
22     public void executeWorkItem(List<WorkItem> w
23
24         //Pool of threads
25         concurrentThreadExecutor = Executors.new
26
27         //callback
28         WorkItemCompletionCallback callback = ne
29
30         List<CompletableFuture<Object>> listCf =
31
32         //run asynchronously on concurrentThread
33         workList.stream().forEach(wi -> {
34             CompletableFuture<Object> thenCompose = Co
35             wi.execute(callback);
36             return null;
37         }, concurrentThreadExecutor).handle(
38
39             if (e == null) { // no error
40                 return CompletableFuture
41             } else { // retry
42                 retry(wi, callback);
43                 return null;
44             }
45
46         }).thenCompose(x -> x);
47
48         listCf.add(thenCompose);
49
50     });
51
52     @SuppressWarnings("unchecked")
53     CompletableFuture<WorkItem>[] cfArray =
54
55     // executes after all work items have co
56     // of workList
57     CompletableFuture<Void> thenRun = Comple
58         callback.complete(workList.size() +
59     });
60
61     try {
62         thenRun.get(); // blocking call that
63     } catch (InterruptedException | Executio
64         LOG.error("" + e);
65     }
66
67     concurrentThreadExecutor.shutdown();
68
69 }
70
71 //handle failed executions by retrying x num
72 private void retry(WorkItem wi, WorkItemComp
73     int retries = 5;
74
75     for (int i = 1; i <= retries; i++) {
76         try {
77             TimeUnit.SECONDS.sleep(1);
78             LOG.error("Error processing " +
79             wi.execute(callback);

```

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```

80         return;
81     } catch (Throwable t) {
82         LOG.error("" + t);
83     }
84 }
85 throw new RuntimeException("All " + retr
86 }
87
88 }
89
90
91

```

1) The `supplyAsync(...)` executes asynchronously and returns a new “`CompletableFuture<Object>`” stage object.

2) The `handle(...)` executes after `supplyAsync(..)` stage is completed and returns a new `CompletableFuture<CompletableFuture<Object>>` stage object. The given function is invoked with the result (or null if none) and the exception (or null if none) of this stage.

3) The `completedFuture(...)` returns a new “`CompletableFuture<Object>`” that is already returned with a given value.

4) The `thenCompose(...)` returns a new “`CompletableFuture<Object>`” when this stage completes normally. The main reason to do is because “**2)** `handle(...)`” returns of type “`CompletableFuture<CompletableFuture<Object>>`” and “`thenCompose(..)`” returns “`CompletableFuture<Object>`”.

5) The `allOf(...)` returns a new “`CompletableFuture<Void>`” that is completed when all of the given `CompletableFuture`s (i.e. `listCf`) are complete.

6) The “`thenRun.get();`” is an optional blocking call that returns a result or throws an exception from the `allOf(...)` stage.

Step 2: WorkItemImpl that implements WorkItem

```
1
2 package com.homeassignment.task2;
3
4 import java.util.concurrent.TimeUnit;
5
6 import org.slf4j.Logger;
7 import org.slf4j.LoggerFactory;
8
9 public class WorkItemImpl implements WorkItem {
10     private Logger LOG = LoggerFactory.getLogger(WorkItemImpl.class);
11     private String name;
12
13     public WorkItemImpl(String name) {
14         this.name = name;
15     }
16
17     @Override
18     public void execute(WorkItemCompletionCallback callback) {
19         LOG.info("Started processing " + name);
20
21         try {
22             TimeUnit.SECONDS.sleep(3);
23         } catch (InterruptedException e) {
24             LOG.error(e.getMessage());
25         }
26
27         callback.complete(name);
28     }
29
30     @Override
31     public String toString() {
32         return "WorkItemImpl [name=" + name + "]"
33     }
34 }
35
36
37
38
39
40
```

Step 3: WorkItemCompletionCallbackImpl that implements WorkItemCompletionCallback

```
1
2 package com.homeassignment.task2;
3
4 import org.slf4j.Logger;
5 import org.slf4j.LoggerFactory;
6
7 public class WorkItemCompletionCallbackImpl implements WorkItemCompletionCallback {
8     private Logger LOG = LoggerFactory.getLogger(WorkItemCompletionCallbackImpl.class);
9
10     @Override
11     public void complete(String name) {
12         LOG.info("Completed processing " + name);
13     }
14 }
15
```

```

12     public void complete(String name) {
13         LOG.info("completed processing " + name)
14     }
15 }
16
17

```

Step 4: Finally, a client to run standalone

Let's create 5 work items and run 3 of them in parallel.

```

1
2 import java.util.ArrayList;
3 import java.util.List;
4 import java.util.concurrent.ExecutionException;
5
6 import com.homeassignment.task2.WorkItem;
7 import com.homeassignment.task2.WorkItemExecutor
8 import com.homeassignment.task2.WorkItemExecutor
9 import com.homeassignment.task2.WorkItemImpl;
10
11 public class WorkItemExecutorClient {
12
13     public static void main(String[] args) throws
14         WorkItemExecutor wie = new WorkItemExecu
15
16         List<WorkItem> workList = new ArrayList<
17
18         for (int i = 1; i <= 5; i++) {
19             WorkItem wi = new WorkItemImpl("Work
20             workList.add(wi);
21         }
22
23         wie.executeWorkItem(workList, 3);
24     }
25 }
26
27

```

Output:

```

1
2 14:15:17.549 [pool-2-thread-3] INFO c.homeassig
3 14:15:17.549 [pool-2-thread-1] INFO c.homeassig
4 14:15:17.549 [pool-2-thread-2] INFO c.homeassig
5 14:15:20.557 [pool-2-thread-3] INFO c.h.t.WorkI
6 14:15:20.557 [pool-2-thread-2] INFO c.h.t.WorkI
7 14:15:20.557 [pool-2-thread-1] INFO c.h.t.WorkI
8 14:15:20.558 [pool-2-thread-3] INFO c.homeassig
9 14:15:20.558 [pool-2-thread-1] INFO c.homeassig
10 14:15:23.562 [pool-2-thread-3] INFO c.h.t.WorkI
11 14:15:23.562 [pool-2-thread-1] INFO c.h.t.WorkI
12 14:15:23.562 [pool-2-thread-1] INFO c.h.t.WorkI
13

```

Step 5: Unhappy path:

Let's purposely modify "WorkItemImpl" to throw exception to test the failure scenarios. A counter variable "count" was introduced and every multiples of 3, throw an error on purpose.

```
1
2 package com.homeassignment.task2;
3
4 import java.util.concurrent.TimeUnit;
5
6 import org.slf4j.Logger;
7 import org.slf4j.LoggerFactory;
8
9 public class WorkItemImpl implements WorkItem {
10
11     private Logger LOG = LoggerFactory.getLogger(WorkItemImpl.class);
12
13     private String name;
14
15     static int count = 0;
16
17     public WorkItemImpl(String name) {
18         this.name = name;
19     }
20
21     @Override
22     public void execute(WorkItemCompletionCallback callback) {
23
24         LOG.info("Started processing " + name);
25         ++count;
26
27         if (count % 3 == 0) {
28             throw new RuntimeException("Error processing " + name);
29         }
30
31         try {
32             TimeUnit.SECONDS.sleep(5);
33         } catch (InterruptedException e) {
34             LOG.error("Interrupted " + e);
35         }
36
37         callback.complete(name);
38     }
39
40
41     @Override
42     public String toString() {
43         return "WorkItemImpl [name=" + name + "]";
44     }
45 }
46
47
```

Step 6: Rerun for unhappy path:

Rerunning the “WorkItemExecutorClient” after the above change will yield an output as shown below.

```

1
2 14:20:08.525 [pool-2-thread-3] INFO c.homeassig
3 14:20:08.525 [pool-2-thread-1] INFO c.homeassig
4 14:20:08.525 [pool-2-thread-2] INFO c.homeassig
5 14:20:09.534 [pool-2-thread-2] ERROR c.h.task2.W
6 14:20:09.534 [pool-2-thread-2] INFO c.homeassig
7 14:20:13.531 [pool-2-thread-1] INFO c.h.t.WorkI
8 14:20:13.531 [pool-2-thread-3] INFO c.h.t.WorkI
9 14:20:13.532 [pool-2-thread-1] INFO c.homeassig
10 14:20:13.532 [pool-2-thread-3] INFO c.homeassig
11 14:20:14.534 [pool-2-thread-3] ERROR c.h.task2.W
12 14:20:14.535 [pool-2-thread-3] INFO c.homeassig
13 14:20:14.537 [pool-2-thread-2] INFO c.h.t.WorkI
14

```

The project structure:

```

▼ homeassig-1-test
  ▸ src/test/java
  ▼ src/main/java
    ▼ (default package)
      ▸ WorkItemExecutorClient.java
      ▸ com.homeassigment.client
      ▸ com.homeassigment.task1
      ▸ com.homeassigment.task1.impl
      ▼ com.homeassigment.task2
        ▸ WorkItem.java
        ▸ WorkItemCompletionCallback.java
        ▸ WorkItemCompletionCallbackimpl.java
        ▸ WorkItemExecutor.java
        ▸ WorkItemExecutorimpl.java
        ▸ WorkItemimpl.java
      ▸ JRE System Library [Java SE 8 [1.8.0_60]]
      ▼ Referenced Libraries
        ▸ junit-4.11.jar - M2_REPO\junit\4.11 - \Users\arulk\m2\repository\junit\4.11\junit-4.11.jar
        ▸ hamcrest-core-1.3.jar - M2_REPO\org\hamcrest\hamcrest-core\1.3 - \Users\arulk\m2\repository\org\hamcrest\hamcrest-core\1.3\hamcrest-core-1.3.jar
        ▸ logback-classic-1.0.0.jar - M2_REPO\ch/qos/logback/logback-classic\1.0.0 - \Users\arulk\m2\repository\ch/qos/logback/logback-classic\1.0.0\logback-classic-1.0.0.jar
        ▸ logback-core-1.0.0.jar - M2_REPO\ch/qos/logback/logback-core\1.0.0 - \Users\arulk\m2\repository\ch/qos/logback/logback-core\1.0.0\logback-core-1.0.0.jar
        ▸ slf4j-api-1.6.4.jar - M2_REPO\org\slf4j\slf4j-api\1.6.4 - \Users\arulk\m2\repository\org\slf4j\slf4j-api\1.6.4\slf4j-api-1.6.4.jar
        ▸ log4j-over-slf4j-1.6.4.jar - M2_REPO\org\slf4j\log4j-over-slf4j\1.6.4 - \Users\arulk\m2\repository\org\slf4j\log4j-over-slf4j\1.6.4\log4j-over-slf4j-1.6.4.jar
        ▸ jcl-over-slf4j-1.6.4.jar - M2_REPO\org\slf4j\jcl-over-slf4j\1.6.4 - \Users\arulk\m2\repository\org\slf4j\jcl-over-slf4j\1.6.4\jcl-over-slf4j-1.6.4.jar
      ▸ src
      ▸ target
      ▸ pom.xml
    
```

Maven Project Structure

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