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

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  {
10      void executeWorkItem(List<WorkItem> w, int p
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  {
7      void execute(WorkItemCompletionCallback callb
8  }
9
```

Callback logic.

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

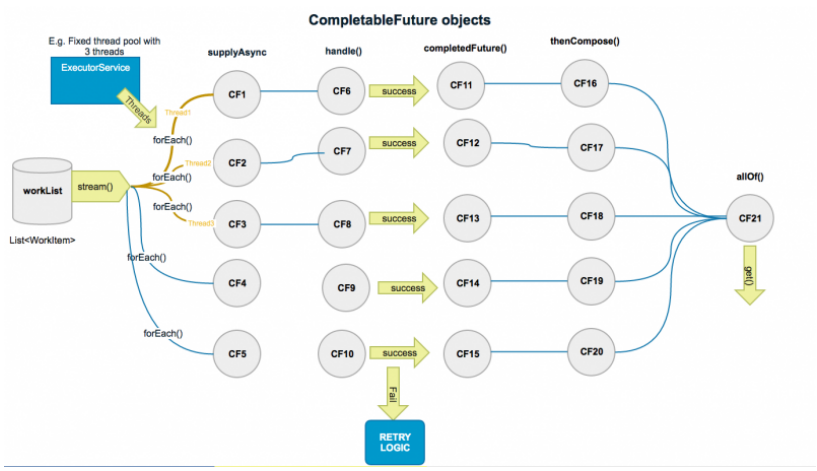

16 Technical Key Areas

```
9
```

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.



Functional Reactive Programming depicting the CompletableFuture objects.

```
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 CompletableFutures (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
11      private Logger LOG = LoggerFactory.getLogger
12
13      private String name;
14
15      public WorkItemImpl(String name) {
16          this.name = name;
17      }
18
19      @Override
20      public void execute(WorkItemCompletionCallba
21
22          LOG.info("Started processing " + name);
23
24          try {
25              TimeUnit.SECONDS.sleep(3);
26          } catch (InterruptedException e) {
27              LOG.error("" + e);
28          }
29
30          callback.complete(name);
31
32      }
33
34      @Override
35      public String toString() {
36          return "WorkItemImpl [name=" + name + "]
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 impl
8
9      private Logger LOG = LoggerFactory.getLogger
10
11     @Override
```

```
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 inn 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) throw
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.

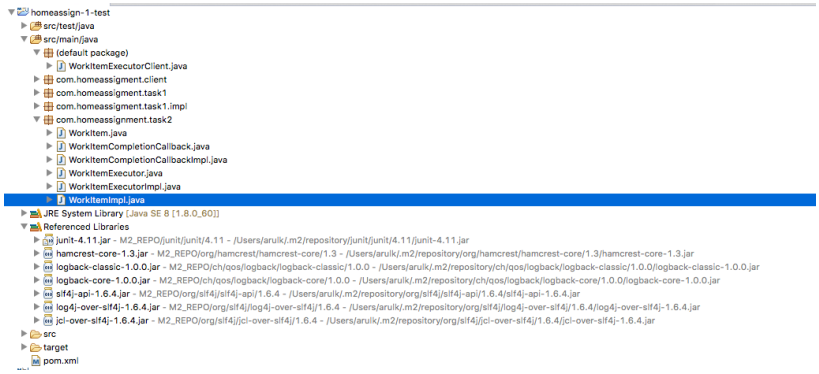
```
1
2  package com.homeassignment.task2;
3
4  import java.util.concurrent.TimeUnit;
5
6  import org.slf4j.Logger;
7  import org.slf4j.LoggerFactory;
8
9  public class WorkItemImpl implements WorkItem {
10
11     private Logger LOG = LoggerFactory.getLogger
12
13     private String name;
14
15     static int count = 0;
16
17     public WorkItemImpl(String name) {
18         this.name = name;
19     }
20
21     @Override
22     public void execute(WorkItemCompletionCallba
23
24         LOG.info("Started processing " + name);
25         ++count;
26
27         if (count % 3 == 0) {
28             throw new RuntimeException("Error pr
29         }
30
31         try {
32             TimeUnit.SECONDS.sleep(5);
33         } catch (InterruptedException e) {
34             LOG.error("" + 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:



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