

Jakarta Concurrency Guide

JEUS 9

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1. Jakarta Concurrency

This chapter describes the background to the introduction of Jakarta Concurrency and its functionality.

1.1. Overview

It is recommended that application servers do not use concurrency APIs such as Thread, Timer, and ExecutorService provided in Java SE in the EJB or a web component. It is assumed that Jakarta EE application components such as Servlets and EJB are executed in a thread managed by an application server. It is also assumed that the functions provided in a container are executed in the same thread.

For these reasons, application components cannot safely use Jakarta EE services in a thread that is not managed by a container. Furthermore, if resources are used in a thread that is not managed by a container, potential issues regarding usability, security, reliability, and scalability can occur in Jakarta EE.

To solve problems that occur in unmanaged threads, Jakarta Concurrency specification, which extended the concurrency utilities of Java SE, is provided.

This technology guarantees the execution of applications without damaging the integrity of containers in the Jakarta EE environment.

1.2. Managed Task

In order to reduce consumption of unnecessary resources, a container must pool resources and manage life cycles. However, if asynchronous tasks are executed in a component by using the concurrency APIs provided in Java SE, then the container cannot manage the resources as it cannot recognize them.

As a result, this specification has defined managed tasks by expanding on the tasks defined in `java.util.concurrent` in the existing Java SE. This allows a container to manage general tasks as managed tasks, and maintains the execution context when a task is executed asynchronously.

1.3. Container Thread Context

In the Jakarta EE environment, a container contains the context information of each service when a service is executed.

If the Java SE's concurrency API is used in a component, then to maintain the context information of a service in a thread where a new container has been created, application developers must propagate the context in the following method.

1. Store the container context of the application component thread.

2. Determine which container context to store and propagate.
3. Apply the container context in the newly created thread.
4. Restore the context of the original component thread.

By using the above method, a task can be executed while maintaining the context of Java SE's concurrency API. However, if the Jakarta Concurrency services is used, user-defined tasks can be easily sent to managed objects. This allows the context to be automatically maintained and restored.

When Executing a Task by Maintaining the Context

- `java.util.concurrent.Callable`
 - `call()`
- `java.lang.Runnable`
 - `run()`
- `jakarta.enterprise.concurrent.ManagedTaskListener`
 - `taskAborted`
 - `taskSubmitted`
 - `taskStarting`
- `jakarta.enterprise.concurrent.ManagedTaskListener`
 - `taskAborted`
 - `taskSubmitted`
 - `taskStarting`
- `jakarta.enterprise.concurrent.Trigger`
 - `getNextRuntime()`
 - `skipRun()`

2. Managed Objects

This chapter describes the managed objects provided by Jakarta Concurrency by using examples.

2.1. ManagedExecutorService

The `jakarta.enterprise.concurrent.ManagedExecutorService` interface inherits Java SE's `java.util.concurrent.ExecutorService`. Just like `ExecutorService`, it is used for executing asynchronous tasks, and the application server maintains the context of the tasks that have been executed asynchronously.

Resource Definition Example

The following is an example of defining `ManagedExecutorService` as a resource.

Example of Defining `ManagedExecutorService` as a Resource: `<domain.xml>`

```
<domain>
  ...
  <server>
    <data-sources>
      <data-source>testdb</data-source>
    </data-sources>
    <managed-executor-service>mes1</managed-executor-service>
  </server>

  <resources>
    <managed-executor-service>
      <export-name>mes1</export-name>
      <long-running-task>true</long-running-task>
      <thread-pool>
        <min>10</min>
        <max>20</max>
        <keep-alive-time>60000</keep-alive-time>
        <queue-size>4096</queue-size>
        <stuck-thread-handling>
          <max-stuck-thread-time>3600000</max-stuck-thread-time>
          <action-on-stuck-thread>None</action-on-stuck-thread>
          <stuck-thread-check-period>300000</stuck-thread-check-period>
        </stuck-thread-handling>
      </thread-pool>
    </managed-executor-service>
  </resources>
  ...
</domain>
```

The configuration items are as follows.

- Basic Items

| Item | Description |
|-------------------|--|
| Export Name | Sets the name that will be used to register a managed executor service with the naming server. |
| Long Running Task | Indicates whether a task run by a managed executor service is long-running. Boolean type. |

- Thread Pool

Configures the thread pool used in a managed executor service.

| Item | Description |
|-----------------|--|
| Min | Minimum number of threads managed by a thread pool. |
| Max | Maximum number of threads managed by a thread pool. |
| Keep Alive Time | Keep-alive time for inactive threads. If a thread pool contains more than the minimum number of threads, inactive threads for the specified time will be automatically removed. If this option is set to 0, threads will not be removed. |
| Queue Size | Size of the queue which stores the application objects processed by a thread pool. |

- Stuck Thread Handling

Configures how to handle a thread when it is occupied by a specific task for longer than specified.

| Item | Description |
|---------------------------|---|
| Max Stuck Thread Time | Length of time before a thread is identified as stuck. |
| Action On Stuck Thread | <p>Action to take when stuck threads are detected. Choose one of the following:</p> <ul style="list-style-type: none"> • None: Takes no action. • Interrupt: Sends an interrupt signal by calling <code>java.lang.Thread#interrupt()</code>. • IgnoreAndReplace: Ignores the Stuck Thread and replace it with a new thread. When the Stuck state is released, the ignored thread is discarded. • Warning: Leaves a thread dump with a warning in the log. |
| Stuck Thread Check Period | Interval in milliseconds between each consecutive check for the stuck thread status. |
| User Warning Class | If action-on-stuck-thread is set to Warning, the default value for this option is thread dump. However, you can write a class to execute the action you want by configuring this option. The class must implement the <code>jeus.util.pool.Warning</code> in <code>jclient.jar</code> . After writing the class, locate in <code>SERVER_HOME/lib/application</code> . |

Application Example

The following is an example of an application using `ManagedExecutorService`.

Example of an Application using `ManagedExecutorService`

```
public class AppServlet extends HttpServlet implements Servlet {
    // Retrieve our executor instance.
    @Resource(name="mes1")
    ManagedExecutorService mes;

    protected void doPost(HttpServletRequest req, HttpServletResponse resp)
        throws ServletException, IOException {
        ArrayList<Callable> builderTasks = new ArrayList<Callable>();
        builderTasks.add(new AccountTask(reqID, accountID));
        builderTasks.add(new InsuranceTask(reqID, accountID));

        // Submit the tasks and wait.
        List<Future<Object>> results = mes.invokeAll(builderTasks);

        AccountInfo accountInfo = (AccountInfo) results.get(0).get();
        InsuranceInfo insInfo = (InsuranceInfo) results.get(1).get();
        // Process the results
    }
}
```

2.2. ManagedScheduledExecutorService

The `jakarta.enterprise.concurrent.ManagedScheduledExecutorService` interface inherits all the functions of `ManagedExecutorService`, as well as the functions of Java SE's `java.util.concurrent.ScheduledExecutorService`. This enables the interface to be able to execute tasks periodically/delays. In addition, tasks can be controlled by using the trigger and `ManagedTaskListener` interfaces.

Resource Definition Example

The following is an example of defining `ManagedScheduledExecutorService` as a resource.

Example of Defining `ManagedScheduledExecutorService` as a Resource: `<domain.xml>`

```
<domain>
...
<server>
    <data-sources>
        <data-source>testdb</data-source>
    </data-sources>
    <managed-scheduled-executor-service>mses1</managed-scheduled-executor-service>
</server>
<resources>
    <managed-scheduled-executor-service>
        <export-name>mses1</export-name>
        <long-running-task>true</long-running-task>
        <thread-pool>
            <min>10</min>
```

```

        <max>20</max>
        <keep-alive-time>60000</keep-alive-time>
        <queue-size>4096</queue-size>
        <stuck-thread-handling>
            <max-stuck-thread-time>3600000</max-stuck-thread-time>
            <action-on-stuck-thread>None</action-on-stuck-thread>
            <stuck-thread-check-period>300000</stuck-thread-check-period>
        </stuck-thread-handling>
    </thread-pool>
</managed-scheduled-executor-service>
</resources>
...
</domain>

```

The configuration items are as follows.

- Basic Items

| Item | Description |
|-------------------|---|
| Export Name | Sets the name that will be used to register a managed scheduler executor service with the JNDI naming server. |
| Long Running Task | Indicates whether a task run by a managed scheduled executor service is long-running. Boolean type. |

- Thread Pool

Configures the thread pool used in a managed executor service.

| Item | Description |
|-----------------|--|
| Min | Minimum number of threads managed by a thread pool. |
| Max | Maximum number of threads managed by a thread pool. |
| Keep Alive Time | Keep-alive time for inactive threads. If a thread pool contains more than the minimum number of threads, inactive threads for the specified time will be automatically removed. If this option is set to 0, threads will not be removed. |
| Queue Size | Size of the queue which stores the application objects processed by a thread pool. |

- Stuck Thread Handling

Configures how to handle a thread when it is occupied by a specific task for longer than specified.

| Item | Description |
|-----------------------|--|
| Max Stuck Thread Time | Length of time before a thread is identified as stuck. |

| Item | Description |
|---------------------------|---|
| Action On Stuck Thread | <p>Action to take when stuck threads are detected. Choose one of the following:</p> <ul style="list-style-type: none"> • None: Takes no action. • Interrupt: Sends an interrupt signal by calling <code>java.lang.Thread#interrupt()</code>. • IgnoreAndReplace: Ignores the Stuck Thread and replace it with a new thread. When the Stuck state is released, the ignored thread is discarded. • Warning: Leaves a thread dump with a warning in the log. |
| Stuck Thread Check Period | Interval in milliseconds between each consecutive check for the stuck thread status. |
| User Warning Class | If action-on-stuck-thread is set to Warning, the default value for this option is thread dump. However, you can write a class to execute the action you want by configuring this option. The class must implement the <code>jeus.util.pool.Warning</code> in <code>jclient.jar</code> . After writing the class, locate in <code>SERVER_HOME/lib/application</code> . |

Application Example

The following is an example of an application using `ManagedScheduledExecutorService`.

Example of an Application using `ManagedScheduledExecutorService`

```
public class AppServlet extends HttpServlet implements Servlet {
    @Resource(name="mses1")
    ManagedScheduledExecutorService mses;

    protected void doPost(HttpServletRequest req, HttpServletResponse resp)
        throws ServletException, IOException {
        Runnable printTask = new Runnable() {
            @Override
            public void run() {
                System.out.println(System.currentTimeMillis());
            }
        };
        // printTask is executed every 5 seconds
        mses.schedule(printTask, 5, TimeUnit.SECONDS);
    }
}
```

2.3. ContextService

The `ContextService` function provides a method for creating managed tasks instead of `ExecutorService`. By using the `ContextService` function, you do not have to worry about the context when creating a task, as the context is maintained when a task is executed in the application server.

Before executing a task by using a dynamic proxy, you configure the context in the thread, and then execute the task. Then, after all tasks have been performed, restore the context.

Resource Definition Example

The following is an example of defining ContextService as a resource.

Example of Defining ContextService as a Resource: <domain.xml>

```
<domain>
  ...
  <server>
    <data-sources>
      <data-source>testdb</data-source>
    </data-sources>
    <context-service>cs1</context-service>
  </server>

  <resources>
    <context-service>
      <export-name>cs1</export-name>
    </context-service>
  </resources>
  ...
</domain>
```

The configuration items are as follows.

- Basic Items

| Item | Description |
|-------------|--|
| Export Name | Sets the name that will be used to register a context service with the JNDI naming server. |

Application Example

The following is an example of an application using ContextService.

Example of an Application using ContextService

```
public class AppServlet extends HttpServlet implements Servlet {
    @Resource(name="cs1")
    ContextService cs;

    protected void doPost(HttpServletRequest req, HttpServletResponse resp)
        throws ServletException, IOException {
        // Regular Runnable task
        Runnable simpleTask = new Runnable() {
            @Override
            public void run() {
                int sum = 0;
                for (int i = 0; i < 10; i++) { sum += i; }
                System.out.println(sum);
            }
        };
    }
}
```

```

    }
};

// Convert a regular task to a contextual task through ContextService
cs.createContextualProxy(simpleTask, Runnable.class);

// Pass a contextual task to the Java SE executor
ExecutorService es = Executors.newFixedThreadPool(1);
es.submit(simpleTask);
}
}

```

2.4. ManagedThreadFactory

The `jakarta.enterprise.concurrent.ManagedThreadFactory` interface inherits Java SE's `java.util.concurrent.ThreadFactory` function, which enables it to create threads. Typically, it is used to submit `ThreadFactory` as the constructor's parameter when creating `ThreadPoolExecutor`. Therefore, even in Java SE's concurrency API, the context for a task can be maintained when a worker thread executes a task.

Resource Definition Example

The following is an example of defining `ManagedThreadFactory` as a resource.

Example of Defining `ManagedThreadFactory` as a Resource: `<domain.xml>`

```

<domain>
  ...
  <server>
    <data-sources>
      <data-source>testdb</data-source>
    </data-sources>
    <managed-thread-factory>mtf1</managed-thread-factory>
  </server>

  <resources>
    <managed-thread-factory>
      <export-name>mtf1</export-name>
      <thread-priority>5</thread-priority>
    </managed-thread-factory>
  </resources>
  ...
</domain>

```

The configuration items are as follows.

- Basic Items

| Item | Description |
|-------------|---|
| Export Name | Sets the name that will be used to register a managed thread factory with the JNDI naming server. |

| Item | Description |
|-----------------|--|
| Thread Priority | Sets thread priority. (Default value: 5) |

Application Example

The following is an example of an application using `ManagedThreadFactory`.

Example of an Application using `ManagedThreadFactory`

```
public class AppServlet extends HttpServlet implements Servlet {
    // Retrieve our executor instance.
    @Resource(name="mtf1")
    ManagedThreadFactory mtf;

    protected void doPost(HttpServletRequest req, HttpServletResponse resp)
        throws ServletException, IOException {
        // Regular Runnable task
        Runnable simpleTask = new Runnable() {
            @Override
            public void run() {
                int sum = 0;
                for (int i = 0; i < 10; i++) { sum += i; }
                System.out.println(sum);
            }
        };

        // Execute simpleTask in a thread provided by ManagedThreadFactory
        mtf.newThread(simpleTask).start();

        // Or pass ThreadFactory as a parameter of ThreadPoolExecutor
        Executor e = new ThreadPoolExecutor(5, 10, 6L, TimeUnit.MINUTES,
            new ArrayBlockingQueue<Runnable>(4096), mtf);
        e.execute(new SimpleTask());
    }
}
```