JSRs 236 and 237; Concurrency Utilities for Java EE in Practice

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Goals of This Talk
What Your Audience Will Gain

Learn how to leverage concurrency in your Java EE applications.
Agenda

Introduction
Overview
ManagedThreadFactory
ManagedExecutorService
ManagedScheduledExecutorService
ContextService
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Introduction

Brief History

- Java SE APIs
  - Java SE Timer and Thread
  - JSR-166 concurrent utilities for Java SE 5 (TS-4915)
- Java EE APIs
  - BEA-IBM Commonj API for Java EE environment
  - JSR 236-237 provides context aware Thread Pools and Timers to Java EE applications
  - Vendor-propietary APIs
- Reusing and extending existing Java SE 5 concurrency foundations
- Formalize Java EE concurrency specification through JCP. Adopt in next version of Java EE.
Introduction
JSR 236-237 group composition

- Specification Leads
  - Chris D Johnson, IBM
  - Naresh Revanuru, BEA

- Expert Group members
  - Andrew Evers, Redwood Software
  - Cameron Purdy, Tangosol
  - Cyril Bouteille, Hotwire
  - Doug Lea, JSR-166 lead
  - Gene Gleyzer, Tangosol
  - Pierre Vignéras
Introduction

Current Status

- Early draft preview published on 4/28/2006
- Draft available at
  - http://gee.cs.oswego.edu/dl/concurrencyee-interest
- Comments are very welcome
- Plan to turn it into official JSR draft
- EG discussion currently happening outside of JCP site
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Overview

Limitation of concurrency in Java EE

- Servlet and EJB specifications explicitly prohibit or are ambiguous about threading support. (Promotes synchronous activity.)
- Java SE threads and timers are not well integrated with Java EE containers
- java.util.concurrent APIs are extensible
  - Need some enhancements for Java EE environments
  - Basis for these JSRs
- Existing solutions do not propagate thread context like class loader, security, naming and do not have manageability and isolation semantics.
Overview

Concurrency uses in Java EE

- Decouple user execution from slow moving background processing
- Improvements in processor architecture promote parallelism
- One big task into smaller concurrent tasks
- Asynchronous notification use case
- Timer use cases like periodic cleanup, cache maintenance
Overview

Special Java EE requirements

- Coordination between application server lifecycle and asynchronous task lifecycle
  - Server shutdown
  - Application deployment/undeployment
- Application-scoped threads
- Thread scheduling based on application resource constraints
- Intelligent workload classification and routing
- Application isolation
Overview

Goals of Concurrency Utilities for Java EE

- Provide consistent programming model
- Leverage existing technology to provide migration from Java SE
- Allow adding concurrency to existing applications
- Allow integration with previous Java EE versions
- Provide simple API for simple use cases
- Provide flexible API for advanced use cases
Extending Java SE
Administered Objects

- Extend existing Java SE 5 concurrency utilities by providing managed versions:
  - ManagedThreadFactory
  - ManagedExecutorService
  - ManagedScheduledExecutorService

- Add Java EE extensions
  - ContextService
  - ManagedTaskListener
  - Trigger
  - Identifiable
Extending Java SE
Managed Objects

- Provide manageability using JMX MBeans
  - ManagedThread
  - ManagedThreadFactory
  - ManagedExecutorService
Extending Java EE
Java EE Architecture Diagram with Concurrency

[Diagram of Java EE architecture with emphasis on concurrency services]
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ManagedThreadFactory

Overview

- Standard interface and method for creating threads
  - `Thread newThread(Runnable r)`
- Centrally defined on an application server
- Indirectly referenced by applications
- Java EE product providers provide the thread
- Extension of Java SE 5 ThreadFactory
  - Adds container context and manageability
  - `UserTransaction` support (does not enlist in parent component's transaction)
ManagedThreadFactory

Usage Scenarios

- Long Running Tasks
  - Work Consumers/Producers
  - Batch jobs
  - Embedded servers

- Custom Thread Pools
  - Use Java SE thread pools
  - Any service that can use ThreadFactory
Code Sample - Daemon

// Within your servlet or EJB method...
// Lookup the ThreadFactory
InitialContext ctx = new InitialContext();
ManagedThreadFactory tf = (ManagedThreadFactory)
    ctx.lookup("java:comp/env/concurrent/myTF");

// Create and start the thread.
Thread daemonThread = tf.newThread(myDaemonRunnable);
daemonThread.start();

// The runnable behaves as-if it were running in the
// servlet or EJB container.
// The thread's lifecycle is tied to the application and
// is interrupted.
Code Sample – Custom Thread Pool

// Within your servlet or EJB method...
// Lookup the ThreadFactory
@Resource
ManagedThreadFactory tf;

void businessMethod() {
    // Use a custom Java SE ThreadPoolExecutor
    CustomThreadPoolExecutor pool =
        new CustomThreadPoolExecutor(coreSize, maxSize, tf);

    // When the executor allocates a new thread, the
    // thread will use the current container context.
ManagedThreadFactory

Thread Management with JMX

- Monitor when threads are allocated using the ManagedThreadFactory MBean
- Monitor thread activity and health
  - What task is running on the thread?
  - How long has the task been running?
  - Correlate to the Java SE thread name and id.
- Cancel a thread (cooperative)
  - Hung threshold notifications help identify problems.
  - Proper interruption detection is essential in the task implementation.
ManagedThreadFactory

Identifiable Tasks

- Runnables that are run on a managed thread may optionally implement the `Identifiable` interface.
- Allows runtime introspection of thread's current state.
- Exposed on the ManagedThread MBean
- Short name available as an attribute
- Locale-specific description available as an attribute for the current locale or an operation for alternative locales.
Code Sample - Identifiable

class MyConsumerTask implements Runnable, Identifiable {
    private String currentName;
    public void run() {
        // Update the identity name periodically
        currentName="MonitorApp:MyConsumerTask:Phase1";
        ...
        currentName="MonitorApp:MyConsumerTask:Phase2";
    }
    public String getIdentityName() {
        // Called by ManagedThread.taskIdentityName
        return currentName;
    }
    public String getIdentityDescription(Locale l) {
        // Called by ManagedThread.taskIdentityDescription
        // Get description from NLS bundle
    }
}

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ManagedExecutorService

Overview

- Typical way of running tasks asynchronously from a Java EE container method
- Centrally defined on an application server
- Indirectly referenced by applications
- Java EE product providers provide the implementation
- Typically used for centralized thread pooling
- Implementations may offer extended capabilities
ManagedExecutorService
Overview continued…

- Extension of Java SE 5 ExecutorService
  - Adds container context, manageability and lifecycle tracking and constraints
  - UserTransaction support (does not enlist in parent component transaction)
  - Distributed (remote) capability

- Container context may be component-managed or server-managed
  - Server-managed is most common. Share a single executor between applications and components.
  - Component-managed is faster, but restricted to a single component (no container context switching)
ManagedExecutorService

Usage Scenarios

- Single server-managed thread pool
  - Most typical usage.
  - Easiest to use. Server manages the lifecycle.
  - Multiple applications share a single executor
  - Application developer defines the requirements of the executor:
    - What container contexts to propagate (e.g. namespace)
    - Server-managed
  - Deployer configures the appropriate executor and maps the resource environment reference to the executor
ManagedExecutorService

Usage Scenarios continued…

- Multiple component-managed thread pools
  - High performance scenario
  - A component has one executor and controls its lifecycle.
  - Container context is fixed.
  - Application developer defines the requirements of the executor:
    - What container contexts to propagate (e.g. namespace)
    - Component-managed
  - Deployer configures the appropriate executor definition and maps the resource environment reference to the executor
ManagedExecutorService

interface ManagedExecutorService extends ExecutorService {
    Future<?> submit(Runnable task,
                     ManagedTaskListener taskListener);

    <T> Future<T> submit(Runnable task, T result,
                          ManagedTaskListener taskListener);

    <T> Future<T> submit(Callable<T> task,
                          ManagedTaskListener taskListener);

    // Time-out versions of invokeAll/Any available too...
    <T> List<Future<T>> invokeAll(Collection<? Extends Callable<T>> tasks,
                                   ManagedTaskListener taskListener);

    <T> T invokeAny(Collection<? extends Callable<T>> tasks,
                     ManagedTaskListener taskListener)
}
ManagedExecutorService

Management

- Hung tasks can be monitored and cancelled using JMX.
  - Threads are created from a ManagedThreadFactory
  - Each thread therefore is associated with a ManagedThread MBean
  - Tasks can be Identifiable

- Task lifecycle can be monitored using ManagedTaskListeners
  - Monitoring extensions (logging)
  - Work-flow control and management
ManagedExecutorService
ManagedTaskListener

- Listeners are Java objects that are registered with the task when submitted to the executor.
- The listener method runs in the same container context as the task.
  - `taskSubmitted` – The task was submitted to the executor
  - `taskAborted` – The task was unable to start or was cancelled.
  - `taskStarting` – The task is about to start
  - `taskDone` – The task has completed (successfully or otherwise)
ManagedTaskListener

interface ManagedTaskListener {
    void taskSubmitted(Future<?> future,
                        ManagedExecutorService executor);

    void taskAborted(Future<?> future,
                     ManagedExecutorService executor);

    void taskDone(Future<?> future,
                   ManagedExecutorService executor);

    void taskStarting(Future<?> future,
                      ManagedExecutorService executor);
}

ManagedExecutorService
ManagedTaskListener - Lifecycle

submit()

<table>
<thead>
<tr>
<th>taskSubmitted</th>
<th>Submitted</th>
<th>taskStarting</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Submit successful</td>
<td>start</td>
</tr>
<tr>
<td>Cancel or abort</td>
<td>Running task</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>taskAborted</th>
<th>Started</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cancelled or aborted</td>
<td>Task has finished</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>taskDone</th>
<th>Done</th>
</tr>
</thead>
</table>
Code Sample – Typical Parallelism

// Within your servlet or EJB method...
@Resource
ManagedExecutorService mes;
void businessMethod() {
    Callable<Integer> c = new Callable<Integer>() {
        Integer call() {
            // Interact with a database... Return answer.
            // The namespace is available here!
        }
    }
    // Submit the task and do something else. The task
    // will run asynchronously on another thread.
    Future result = mes.submit(c);
    ...
    // Get the result when ready...
    int theValue = result.get();
    ...
}
ManagedExecutorService

Distributable Overview

- Same rules as a ManagedExecutorService
- Allows distributing the task to a peer on another server instance (JVM).
  - Task must implement serializable
- Providers do not have to supply a distributable version.
- Two distributable types are available:
  - With and without affinity
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ManagedScheduledExecutorService

Overview

- Typical way of running periodic tasks asynchronously from a Java EE container method
- Typically used for transient timers
- Inherits semantics of ManagedExecutorService:
  - Centrally defined on an application server
  - Indirectly referenced by applications
  - Java EE product providers provide the implementation
  - Implementations may offer extended capabilities
ManagedScheduledExecutorService
Overview continued…
- Extension of ScheduledExecutorService
  - Adds container context, manageability and lifecycle tracking and constraints
  - UserTransaction support (does not enlist in parent component transaction)
  - Trigger mechanism.
- Container context may be component-managed or server-managed
  - Server-managed is most common. Share a single executor between applications and components.
  - Component-managed is faster, but restricted to a single component.
ManagedScheduledExecutorService

Usage Scenarios

- Periodic cache invalidations
- Request timeouts
- Polling

Custom Scheduler

- Would need implementation extension to support persistence.
- Use Triggers for custom calendaring:
  - N-time fixed-rate with time-sensitive skip.
  - Run time based on previous task calculation result.
  - Condition-based trigger
  - Centralized business calendar.
ManagedScheduledExecutorService

interface ManagedScheduledExecutorService extends ScheduledExecutorService {
    // Same methods as ScheduledExecutorService...
    // Add ManagedTaskListener and Trigger
    ScheduledFuture<?> schedule(Runnable command,
                                 long delay, TimeUnit unit,
                                 ManagedTaskListener taskListener);

    ScheduledFuture<?> schedule(Runnable command,
                                 Trigger trigger, ManagedTaskListener taskListener);

    ScheduledFuture<?> scheduleAtFixedRate(Runnable command,
                                             long initialDelay, long period, TimeUnit unit,
                                             ManagedTaskListener taskListener);

    ScheduledFuture<?> scheduleWithFixedDelay(
                                             Runnable command, long initialDelay, long delay,
                                             TimeUnit unit, ManagedTaskListener taskListener);
}

interface Trigger {

    // Return true if you want to skip the
    // currently-scheduled execution. Is invoked after
    // taskStarting().
    boolean skipRun(Future lastFuture,
                    Date scheduledRunTime);

    // Retrieves the time in which to run the task next.
    // Invoked during submit time and after each task has
    // completed.
    Date getNextRunTime(Future lastFuture, Date baseTime,
                        Date lastActualRunTime, Date lastScheduledRunTime,
                        Date lastCompleteTime);

}
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ContextService

Overview

- Mechanism for applications to capture container context and run within that context later
  - ManagedExecutorServices likely to use this service internally to propagate container context.
- Centrally defined on an application server
- Indirectly referenced by applications
- Java EE product providers provide the implementation
- Implementations may offer extended capabilities
ContextService
Overview continued…

- Current thread context is captured and stored within a context proxy for your object
- Serializable
- Customizable
  - Can enable transaction pass-through
- Used in advanced scenarios.
- Use with non-ManagedThreadFactory-created threads (threads created with new Thread())
ContextService

Use Cases

- Workflow
  - Store and propagate user identity

- Java SE or third-party thread reuse
  - Allows thread to behave as-if it were on a container thread.

- Hybrid ManagedExecutorService
  - Use component-managed executor from multiple components.
interface ContextService {
    String USE_PARENT_TRANSACTION = "ctxsvc.useparenttran";

    Object createContextObject(Object instance,
                                Class[] interfaces);

    Object createContextObject(Object instance,
                                Class[] interfaces, Properties contextProperties);

    void setProperties(Object contextObject,
                        Properties contextProperties);

    Properties getProperties(Object contextObject);
}
Code Example – Creating Context

// Within your servlet or EJB method...
@Resource
ContextService ctxSvc;
void businessMethod() {
    Runnable runnableTask = new Runnable() {
        void run() {
            // Interact with a database... use component's security
        }
    }
    // Wrap with the current context
    Runnable runnableTaskWithCtx = (Runnable) ctxSvc.createContextObject(runnableTask,
        new Class[]{Runnable.class})

    // Store the runnable with context somewhere and run
    // later..
    store.putIt(runnableTaskWithCtx);
Code Example – Using Context

    // Retreive the Runnable with Context
    Runnable runnableTaskWithContext = store.getIt();
    // Runnable will run on this thread, but with the context
    // of the servlet/EJB that created it.
    runnableTaskWithContext.run();
    // If the Runnable implemented Serializable and it
    // was serialized/deserialized... the context would still
    // come with it.
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- The Concurrency Utilities for Java EE is in Early Draft Review stage.
  - Mailing list available for comments.
- Extends Java SE concurrency utilities
- Provides simple and advanced APIs for adding concurrency to J2EE 1.3 and later applications:
  - ManagedThreadFactory
  - ManagedExecutorService
  - ManagedScheduledExecutorService
  - ContextService
For More Information

- Concurrency EE Interest Site and Specification
  - http://gee.cs.oswego.edu/dl/concurrencyee-interest/
- JSR 236 and 237
- Related Sessions
  - TS-4915 – Concurrency Utilities in Java SE 5
Q&A

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