Overview of Java Structured Concurrency

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Learning Objectives in this Part of the Lesson

• Understand Java’s structured concurrency model

• This model is designed to enable the processing of "embarrassingly parallel" tasks atop the virtual threading mechanisms available in Java 19 (& beyond)
Overview of Java Structured Concurrency
Structured concurrency was added recently to Java as a concurrent programming paradigm.

**Overview of Java Structured Concurrency**

**JEP 428: Structured Concurrency (Incubator)**

- **Authors**: Alan Bateman, Ron Pressler
- **Owner**: Alan Bateman
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- **Scope**: JDK
- **Status**: Closed / Delivered
- **Release**: 19
- **Component**: core-libs
- **Discussion**: [loom dash dev at openjdk dot java dot net](https://loom dash dev at openjdk dot java dot net)
- **Reviewed by**: Alex Buckley, Brian Goetz
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**Summary**

Simplify multithreaded programming by introducing an API for *structured concurrency*. Structured concurrency treats multiple tasks running in different threads as a single unit of work, thereby streamlining error handling and cancellation, improving reliability, and enhancing observability. This is an incubating API.

**Goals**

- Improve the maintainability, reliability, and observability of multithreaded code.
- Promote a style of concurrent programming which can eliminate common risks arising from cancellation and shutdown, such as thread leaks and cancellation delays.

See [openjdk.org/jeps/428](https://openjdk.org/jeps/428)
Overview of Java Structured Concurrency

- Structured concurrency was added recently to Java as a concurrent programming paradigm.
- It’s intended to make programs easier to read & understand, quicker to write, & safer.

See en.wikipedia.org/wiki/Structured_concurrency
Structured concurrency was recently added to Java as a concurrent programming paradigm.

- It’s intended to make programs easier to read & understand, quicker to write, & safer.
- “Safer” == avoiding thread leaks & orphan threads.

See [en.wikipedia.org/wiki/Orphan_process](en.wikipedia.org/wiki/Orphan_process)
Overview of Java Structured Concurrency

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- It’s intended to make programs easier to read & understand, quicker to write, & safer
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The lifetime of Thread T₁ & Thread T₂ are constrained to the enclosing scope
Overview of Java Structured Concurrency

- Java’s structured concurrency paradigm is designed to mimic structured programming

See [en.wikipedia.org/wiki/Structured_programming](en.wikipedia.org/wiki/Structured_programming)
Overview of Java Structured Concurrency

- Java’s structured concurrency paradigm is designed to mimic structured programming, i.e.

- Well-defined entry & exit points for the flow of execution through a block of code
Overview of Java Structured Concurrency

- Java’s structured concurrency paradigm is designed to mimic structured programming, i.e.
  - Well-defined entry & exit points for the flow of execution through a block of code
  - A strict nesting of the lifetimes of operations in a way that mirrors their syntactic nesting in the code
Overview of Java Structured Concurrency

- Java structured concurrency is intended for “embarrassingly parallel” programs.

“Embarrassingly parallel” tasks have little/no dependency or need for communication between tasks or for sharing results between them.

See [en.wikipedia.org/wiki/Embarrassingly_parallel](en.wikipedia.org/wiki/Embarrassingly_parallel)
Overview of Java Structured Concurrency

- Java structured concurrency is intended for “embarrassingly parallel” programs
- e.g., interacting with many micro-services in a cloud computing environment

See en.wikipedia.org/wiki/Microservices
Java Structured Concurrency Example
Java Structured Concurrency Example

Java structured concurrency makes the start & end of concurrent code explicit.

```java
try (var scope = new StructureTaskScope.ShutdownOnFailure()) {
    var results = new ArrayList<Future<BigFraction>>()
    for (var bigFraction : generateRandomBigFractions(count))
        results.add(scope.fork(() ->
            reduceAndMultiply(bigFraction,
            sBigReducedFraction));

    scope.join();
    ...
    sortAndPrintList(results);
}
```

We will walk through this example quickly now & will explore it in detail later on.

See github.com/douglascraigschmidt/LiveLessons/tree/master/Loom/ex3
Java Structured Concurrency Example

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                    sBigReducedFraction));

    scope.join();
    ...
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}
```

Define a scope for splitting a task into concurrent subtasks

Java Structured Concurrency Example

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    for (var bigFraction : generateRandomBigFractions(count))
        results.add(scope.fork()
            reduceAndMultiply(bigFraction, sBigReducedFraction));

    scope.join();
    ... sortAndPrintList(results);
}
```

See jdk.incubator.concurrent/jdk/incubator/concurrent/StructuredTaskScope.html#fork
Java Structured Concurrency Example

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    for (var bigFraction :
        generateRandomBigFractions(count))
        results.add(scope
            .fork(() ->
                reduceAndMultiply(
                    bigFraction,
                    sBigReducedFraction));

    scope.join();  // Wait for all threads to finish or the task scope to shut down
    ...
    sortAndPrintList(results);
}
```

See [jdk.incubator.concurrent/jdk/incubator/concurrent/StructuredTaskScope.ShutdownOnFailure.html#join()]
Java Structured Concurrency Example

• Java structured concurrency makes the start & end of concurrent code explicit

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try (var scope = new StructureTaskScope.ShutdownOnFailure()) {
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        results.add(scope.fork()
                      .fork() ->
                      reduceAndMultiply(bigFraction,
                                         sBigReducedFraction))
                      
    scope.join();

    ...  
    sortAndPrintList(results);
}
```

The close() method of `scope` is called automatically when this block of code exits
Java Structured Concurrency Benefits
Java Structured Concurrency Benefits

- Java structured concurrency provides several guarantees
Java Structured Concurrency Benefits

- Java structured concurrency provides several guarantees
- When a program’s flow of control is split into multiple threads these threads always complete at the end of a flow

*The flow of control splits into multiple threads at the beginning of the scope*

See theboreddev.com/understanding-structured-concurrency
Java Structured Concurrency Benefits

• Java structured concurrency provides several guarantees
• When a program’s flow of control is split into multiple threads these threads always complete at the end of a flow

**Subtasks work on behalf of a task, i.e., the task awaits the subtasks' results & monitors them for failures**
Java Structured Concurrency Benefits

- Java structured concurrency provides several guarantees
- When a program’s flow of control is split into multiple threads these threads always complete at the end of a flow

All these threads must complete by the end of the enclosing scope

The lifetime of a subtask is confined to the syntactic block of its parent task
Java Structured Concurrency Benefits

- Java structured concurrency provides several guarantees
  - When a program’s flow of control is split into multiple threads these threads always complete at the end of a flow
  - No “orphaned threads” occur in an application
End of Overview of Java
Structured Concurrency