

Welcome

# Advanced Java TT Parallel Streams

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Hello...

About me...



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# Prerequisites

## This course assumes you

- Solid understanding of the Java programming language to Java 8 including lambda expressions
- Good understanding of basic Stream concepts, including filter, map, flatMap, and reduce



## Why study this subject?

- Modern CPUs are generally getting more cores, rather than getting particularly faster. To benefit from these cores, we must find a way to create multi-threaded execution.
- Writing with threads is greatly simplified by certain design approaches, and the stream API embodies one of those approaches. However, to safely benefit from parallel streams, some understanding is required.



# My pledge to you

## I will...

- Make this interactive
- Ask you questions
- Ensure everyone can speak
- Create an inclusive learning environment
- Use an on-screen timer for breaks

**...also, if you have an accessibility need, please let me know**



# Objectives

## At the end of this course you will be able to:

- Write code that conforms to the requirements for reliable execution in a parallel stream
- Write code using the three-argument collect method of a stream
- Describe the requirements for operations in a parallel reduction / collection situation
- Explain the costs of running a stream in ordered mode
- Express the architectural considerations that influence whether a parallel stream mode will be beneficial or not





## How we're going to work together

- Discussions, whiteboard diagrams
- Code examples
- You'll have a copy of all the course materials in github
  - Please note, the git repository will be deleted—clone it if you want it!

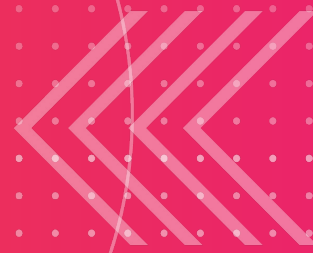
# Student Introductions



- Job title?
- Where are you based?
- Experience with Java
- Fun fact?



# Thank you!





# Parallel Stream Operations



If operations on individual data items are entirely independent of one another, these operations can be performed by concurrent threads, provided that the infrastructure handles data-visibility (*happens-before*) requirements.

Java's Streams API supports this directly. Operations on the stream elements should generally be *non-interfering* and *stateless*.

Non-interfering means an operation does not affect the source of data.



# Thread safety for parallel streams



Generally, operations should

- Not mutate existing data, but create new data for results
- Avoid visible side-effects
- Use only their own arguments as input



# Parallel collections



Java's `collect` operation is a variation of a reduce operation, modified to mutate data, rather than continually create new objects to represent intermediate results. The effect is to reduce object allocation and initialization load on the CPUs and also reduce load on the garbage collector.

For such an approach to be safe, the objects being mutated must either be thread-safe (which is likely to create thread contention in the general case) or thread-confined.

The behavior of Java's three-argument `collect` method is built around thread-confined mutable objects.



# A mutating version of reduce



Each thread must have its own work-in-progress mutable result

The system decides how many threads, so we must provide a means of building those result objects, hence a `Supplier<R>` for a result type `R`.

The second operation merges data one at a time into the current thread's result object.

The third operation merges one thread's result into that of another. This will be used only for parallel streams and will be called enough times to get all the accumulated results into a single result object.



# Constraints on reduce/collect



Reduce/collect operations generally should be associative.

If the operation is also commutative, then order need not be maintained in the stream.

Order is generally maintained if the source and collector are ordered, but this can be disabled using `mystream.unordered()`.





# Architectural considerations for parallel operation



Concurrency always involves some additional overhead. Throughput gains might depend on ratio of real computation work to that overhead.

If your process completes faster, parallel might be an option, but would you be taking those CPUs away from other equally important work? If so it's unlikely to be a smart choice to run parallel. In a multi-client server system, those CPUs usually do have something else important to do.

Maintaining order in a streams can be hugely expensive if many items arrive substantially out of order.

If the arrival rate of items from the streams is low relative to the time taken to update results, a single threadsafe / synchronized result object might be preferred.