How Parallel Programs are Developed in Java (Part 3)

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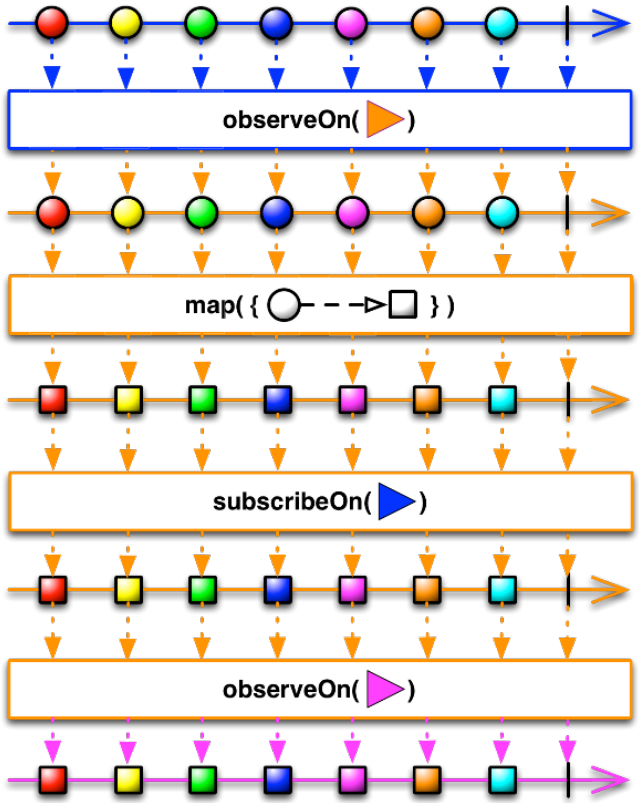
Learning Objectives in this Part of the Lesson

- Recognize the parallelism frameworks supported by Java, e.g.
  - Fork-join pools
  - Parallel streams
  - Completable futures
  - **Reactive streams**
    - An async programming paradigm concerned with processing data streams & propagating changes between publishers & subscribers



See en.wikipedia.org/wiki/Reactive_Streams

Overview of Java Reactive Parallelism Frameworks

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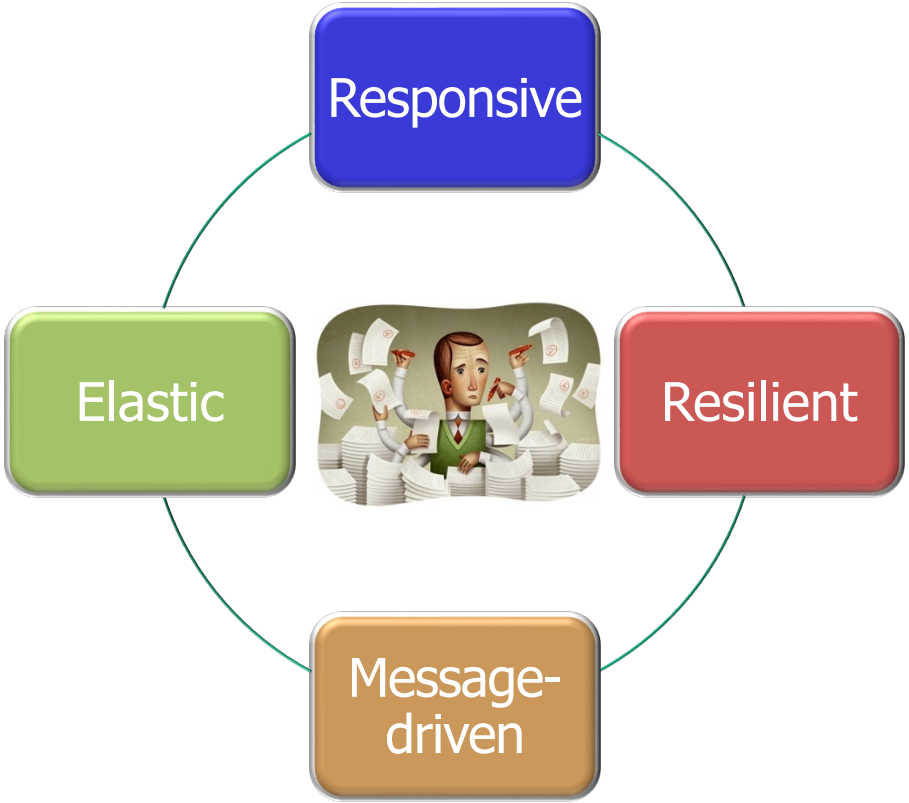
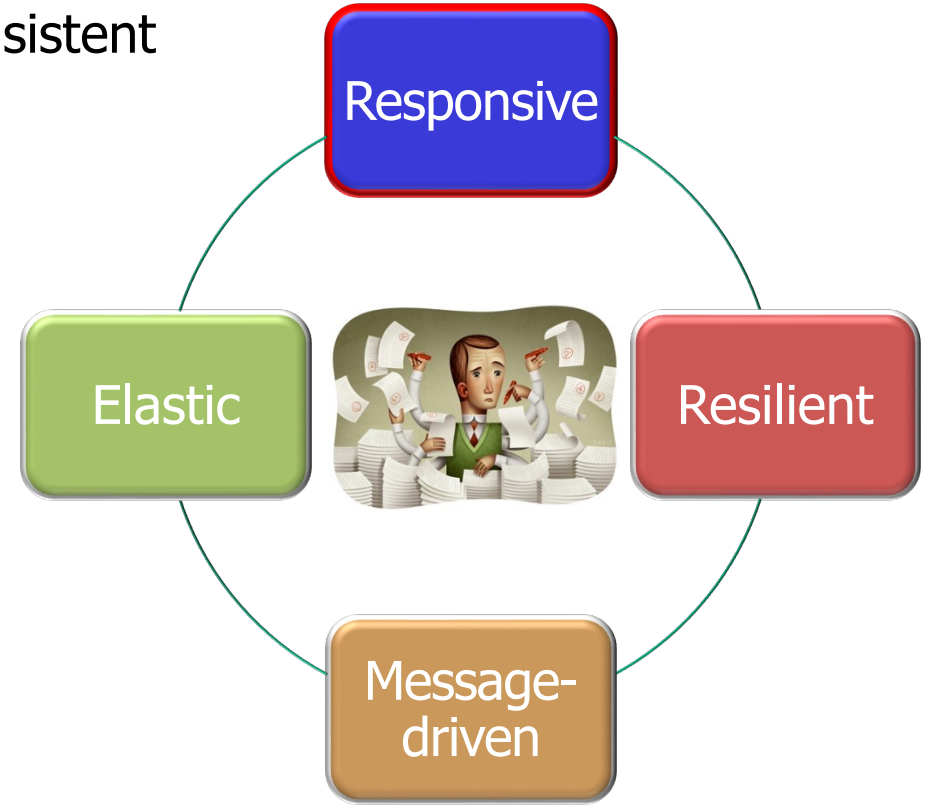
- Reactive programming is based on four key principles



See www.reactivemanifesto.org

Overview of Java Reactive Parallelism Frameworks

- Reactive programming is based on four key principles
  1. **Responsive** – provide rapid & consistent response times



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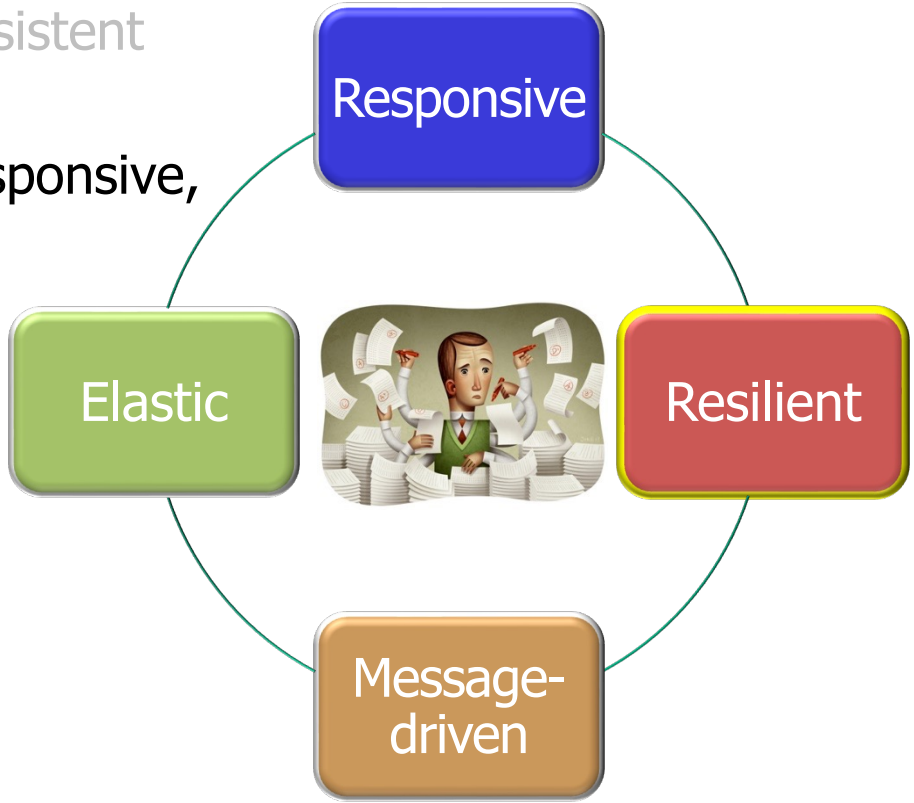
Overview of Java Reactive Parallelism Frameworks

- Reactive programming is based on four key principles
  1. **Responsive** – provide rapid & consistent response times
  2. **Resilient** – the system remains responsive, even in the face of failures



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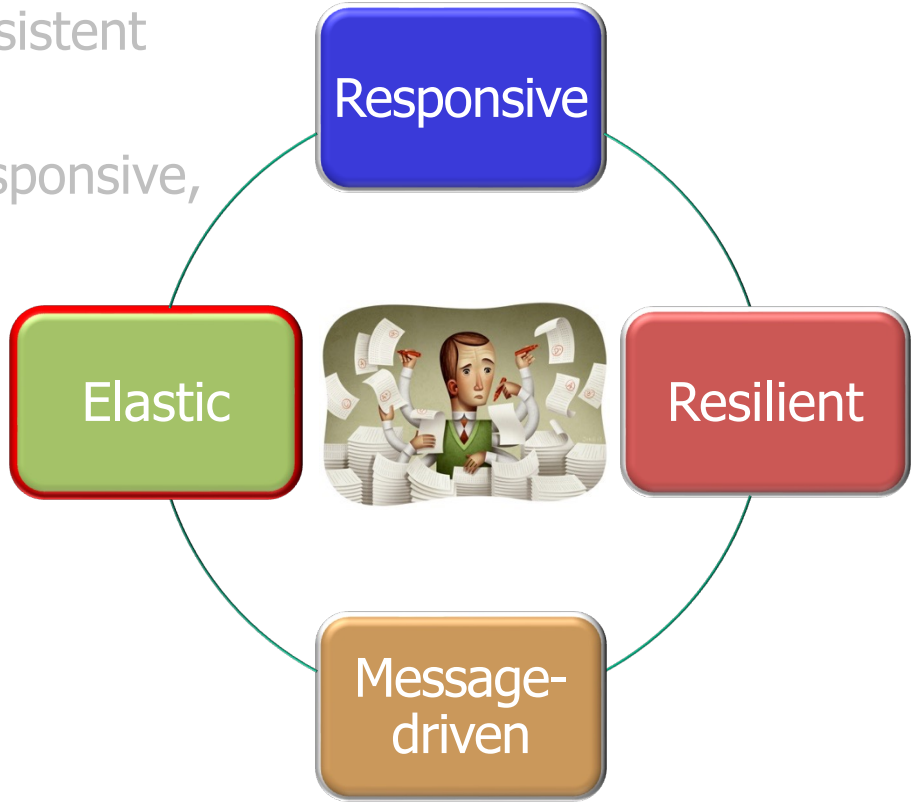

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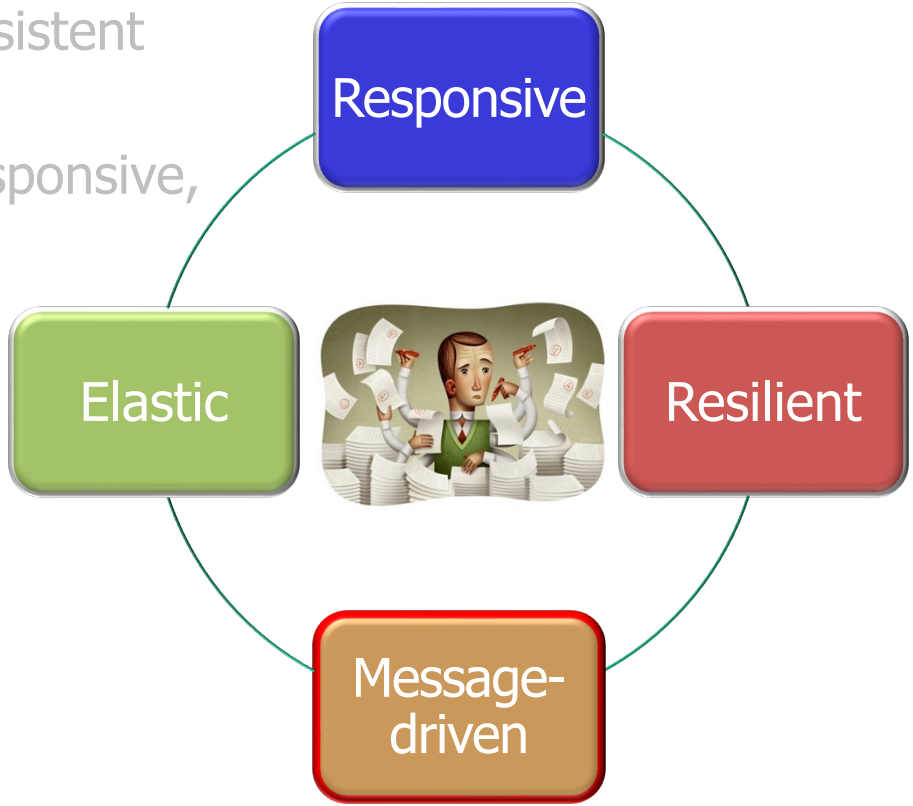
  4. **Message-driven** – asynchronous message-passing to ensure loose coupling, isolation, & location transparency between components



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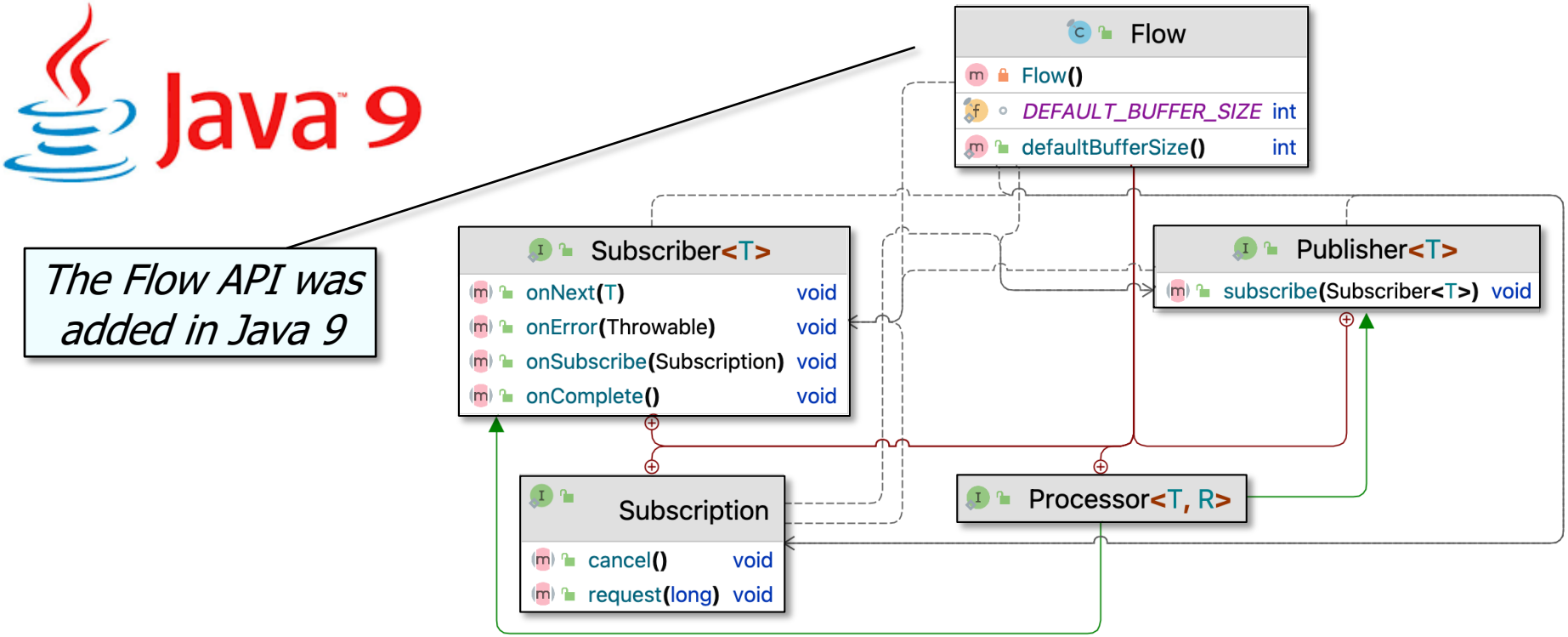
Overview of Java Reactive Parallelism Frameworks

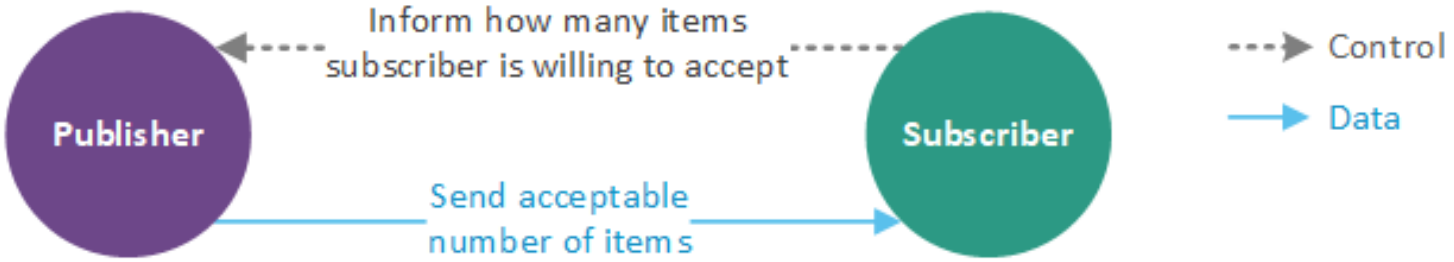
- Java supports reactive parallelism via the "Flow" API



See docs.oracle.com/en/java/javase/20/docs/api/java.base/java/util/concurrent/Flow.html

Overview of Java Reactive Parallelism Frameworks

- Java supports reactive parallelism via the "Flow" API
  - Implements a reactive streams pub/sub framework via two patterns



See javasampleapproach.com/java/java-9/java-9-flow-api-example-publisher-and-subscriber

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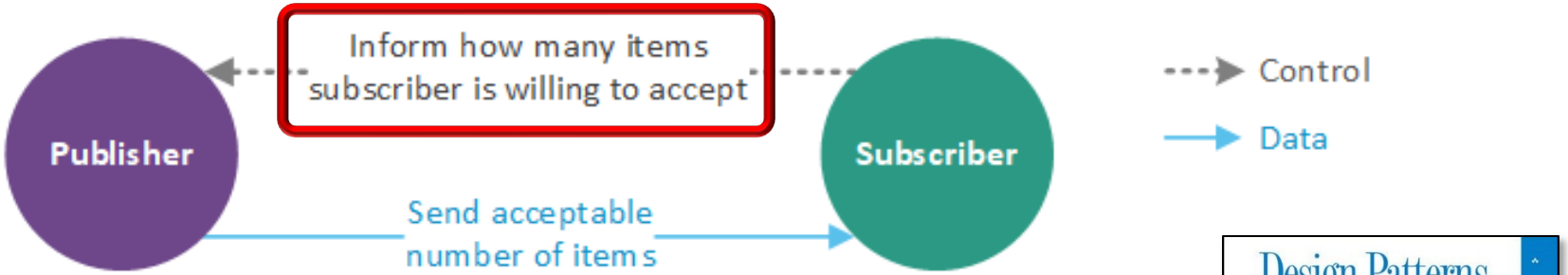
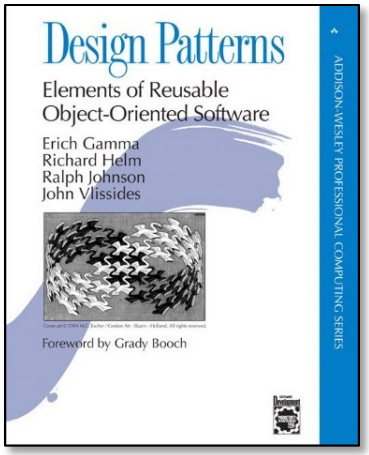


  - *Iterator*
    - Applies a "pull model" where app subscribe(s) pull items from a publisher source



See en.wikipedia.org/wiki/Iterator_pattern

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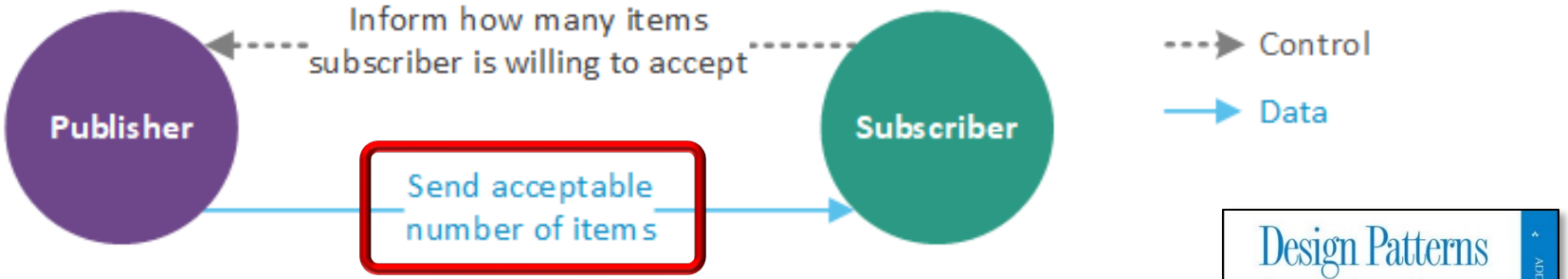
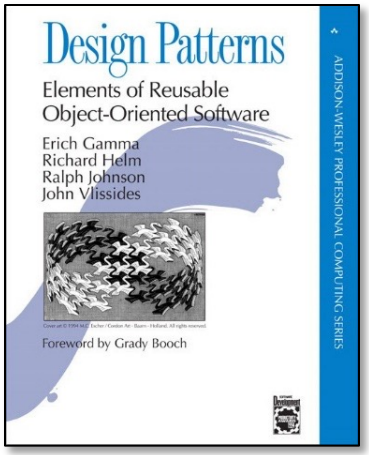


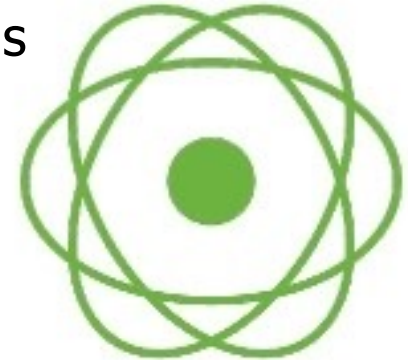
  - *Iterator*
  - *Observer*
    - Applies a "push model" that reacts when a publisher source pushes items to subscriber sink(s)



See en.wikipedia.org/wiki/Observer_pattern

Overview of Java Reactive Parallelism Frameworks

- RxJava & Project Reactor are popular Java reactive streams implementations

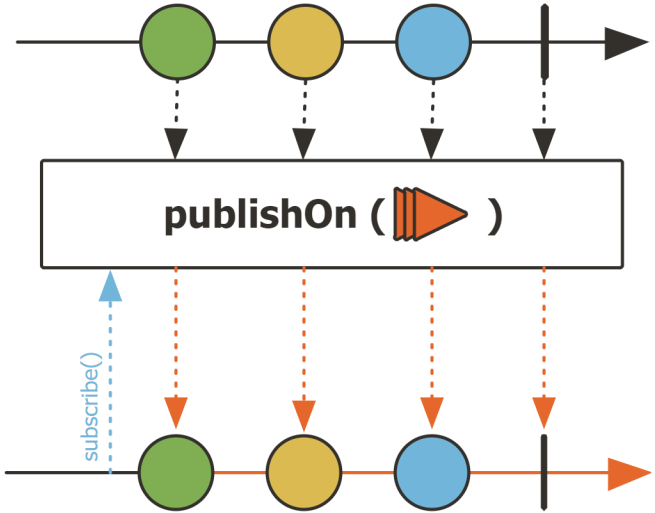


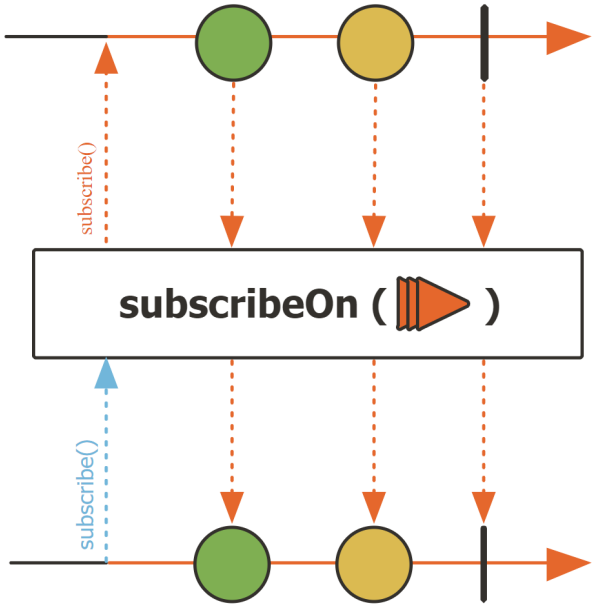
Project Reactor

See www.baeldung.com/rx-java & projectreactor.io

Overview of Java Reactive Parallelism Frameworks

- RxJava & Project Reactor are popular Java reactive streams implementations
  - The subscribeOn(), publishOn(), & observeOn() operators map events to threads & thread pools





See zoltanaltfatter.com/2018/08/26/subscribeOn-publishOn-in-Reactor

Overview of Java Reactive Parallelism Frameworks

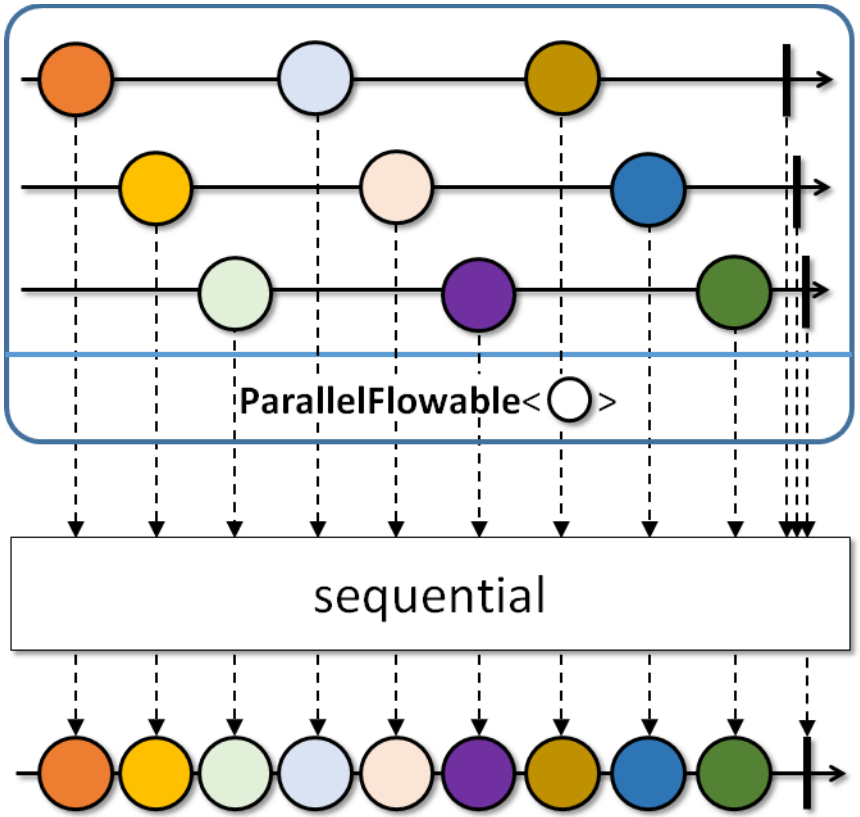
- RxJava & Project Reactor are popular Java reactive streams implementations
  - The subscribeOn(), publishOn(), & observeOn() operators map events to threads & thread pools
  - Threads & thread pools are managed by Schedulers

Name	Description
Schedulers.computation()	Schedules computation bound work (ScheduledExecutorService with pool size = NCPU, LRU worker select strategy)
Schedulers.immediate()	Schedules work on current thread
Schedulers.io()	I/O bound work (ScheduledExecutorService with growing thread pool)
Schedulers.trampoline()	Queues work on the current thread
Schedulers.newThread()	Creates new thread for every unit of work
Schedulers.test()	Schedules work on scheduler supporting virtual time
Schedulers.from(Executor e)	Schedules work to be executed on provided executor

See reactivex.io/RxJava/3.x/javadoc/io/reactivex/rxjava3/schedulers/Schedulers.html

Overview of Java Reactive Parallelism Frameworks

- RxJava & Project Reactor are popular Java reactive streams implementations
  - The subscribeOn(), publishOn(), & observeOn() operators map events to threads & thread pools
  - Threads & thread pools are managed by Schedulers
  - There are also specialized parallel processing classes



See reactivex.io/RxJava/3.x/javadoc/io/reactivex/rxjava3/parallel/ParallelFlowable.html

Evaluating Pros & Cons of Reactive Streams Programming Frameworks

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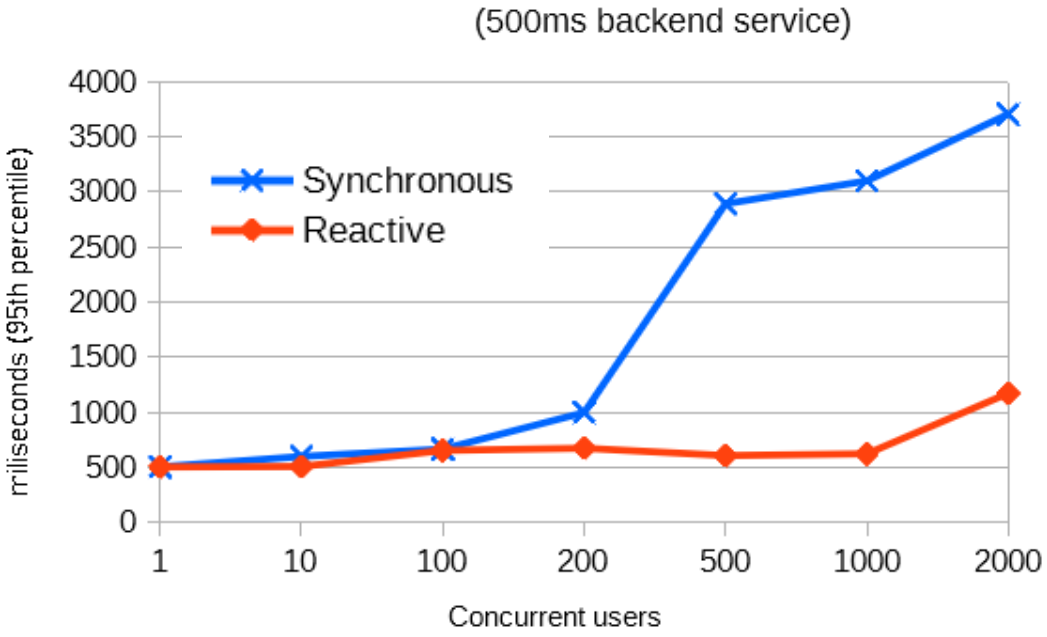
See www.baeldung.com/rxjava-schedulers

Evaluating Pros & Cons of Reactive Streams Programming Frameworks

- Pros of the reactive streams programming frameworks
  - Support parallelism with a minimal number of threads via a range of thread pools
    - Scale up performance with relatively few resources



See dzone.com/articles/spring-boot-20-webflux-reactive-performance-test

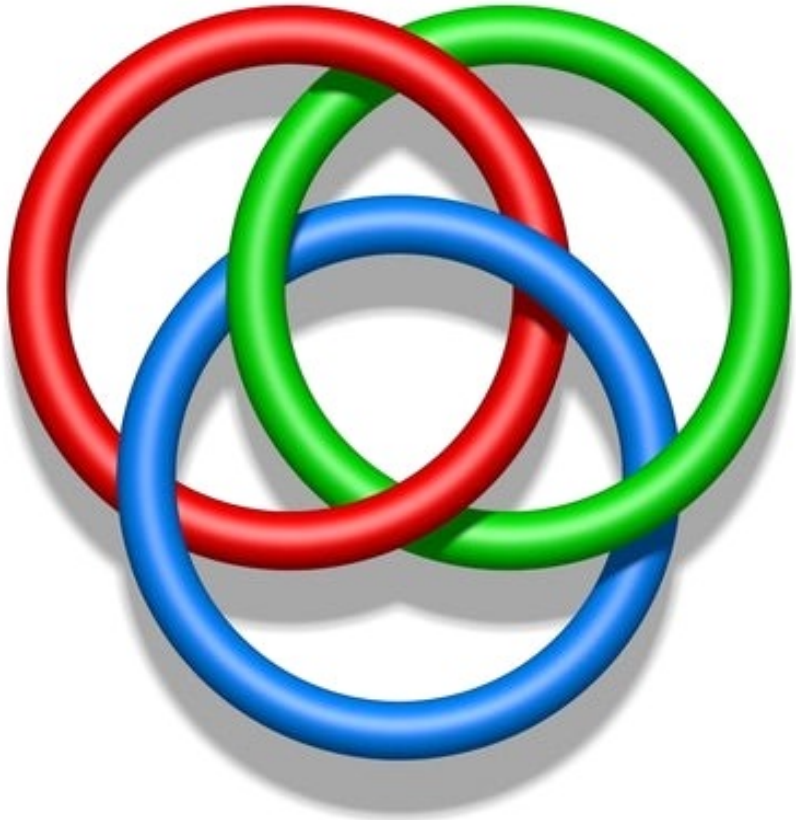
Evaluating Pros & Cons of Reactive Streams Programming Frameworks

- Pros of the reactive streams programming frameworks
  - Support parallelism with a minimal number of threads via a range of thread pools
  - Explicit synchronization and/or threading is rarely needed when applying these frameworks

Alleviates many accidental & inherent complexities of concurrency/parallelism

Evaluating Pros & Cons of Reactive Streams Programming Frameworks

- Pros of the reactive streams programming frameworks
  - Support parallelism with a minimal number of threads via a range of thread pools
  - Explicit synchronization and/or threading is rarely needed when applying these frameworks
  - Integrates streams, asynchrony, & pub/sub paradigms cleanly



Evaluating Pros & Cons of Reactive Streams Programming Frameworks

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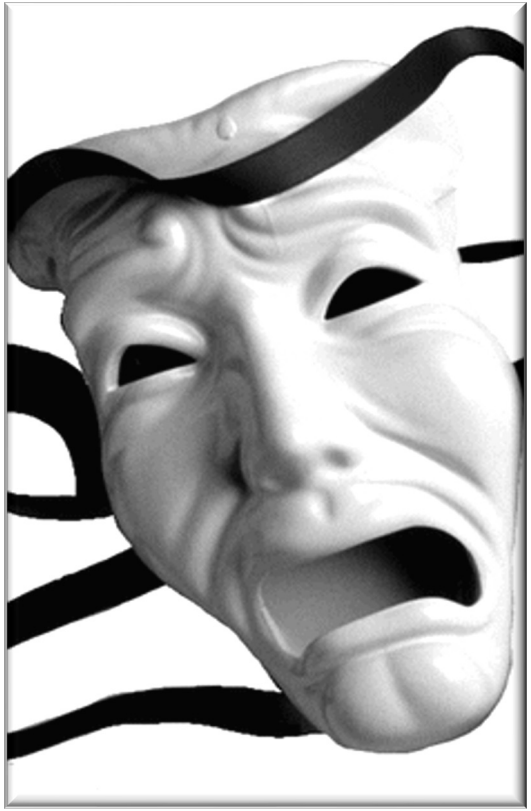
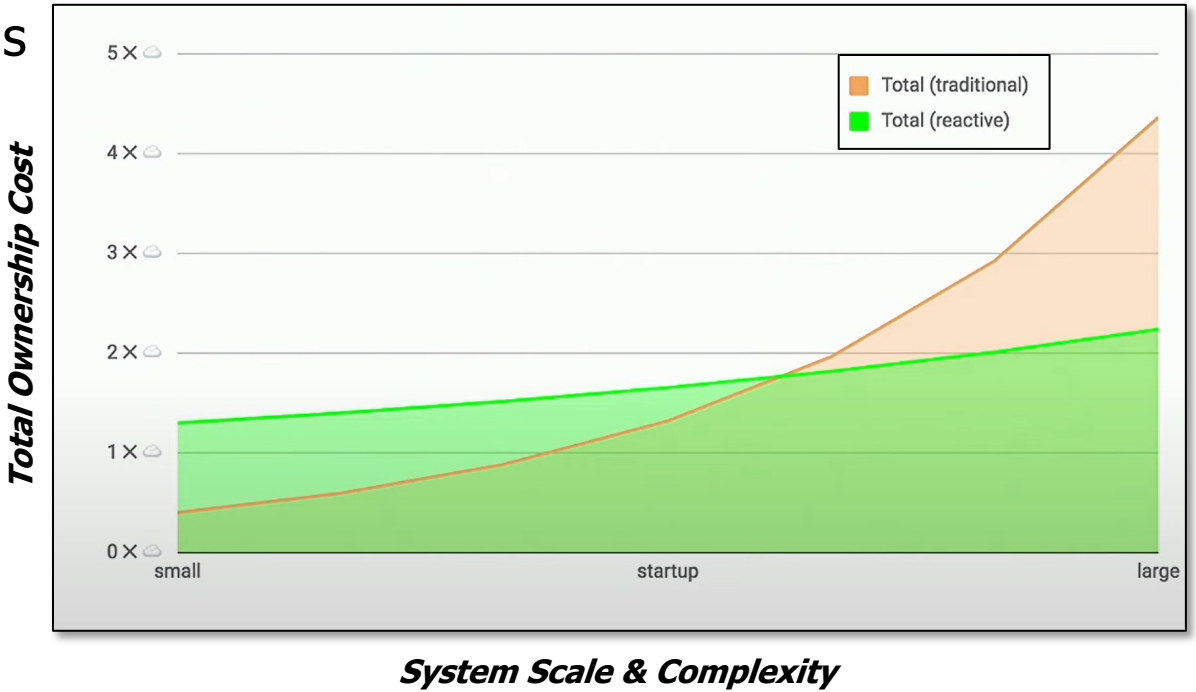


Evaluating Pros & Cons of Reactive Streams Programming Frameworks

- Cons of the reactive streams programming frameworks
  - It isn't appropriate in all situations



See www.youtube.com/watch?v=z0a0N9OgaAA

Evaluating Pros & Cons of Reactive Streams Programming Frameworks

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Reactive programming can have a fairly steep learning curve to the uninitiated

See www.freecodecamp.org/news/a-complete-roadmap-for-learning-rxjava-9316ee6aeda7

Evaluating Pros & Cons of Reactive Streams Programming Frameworks

- Cons of the reactive streams programming frameworks
  - It isn't appropriate in all situations
  - We emphasize reactive streams programming later in this course to show where & when to apply it

See upcoming module on Reactive Streams & RxJava

End of How Parallel Programs Are Developed in Java (Part 3)