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PROGRAMOWANIE WIELOWĄTKOWE – VIRTUAL THREADS

JDK 21 – Game Changer

Capgemini

ABOUT ME

Grzegorz Ząbek

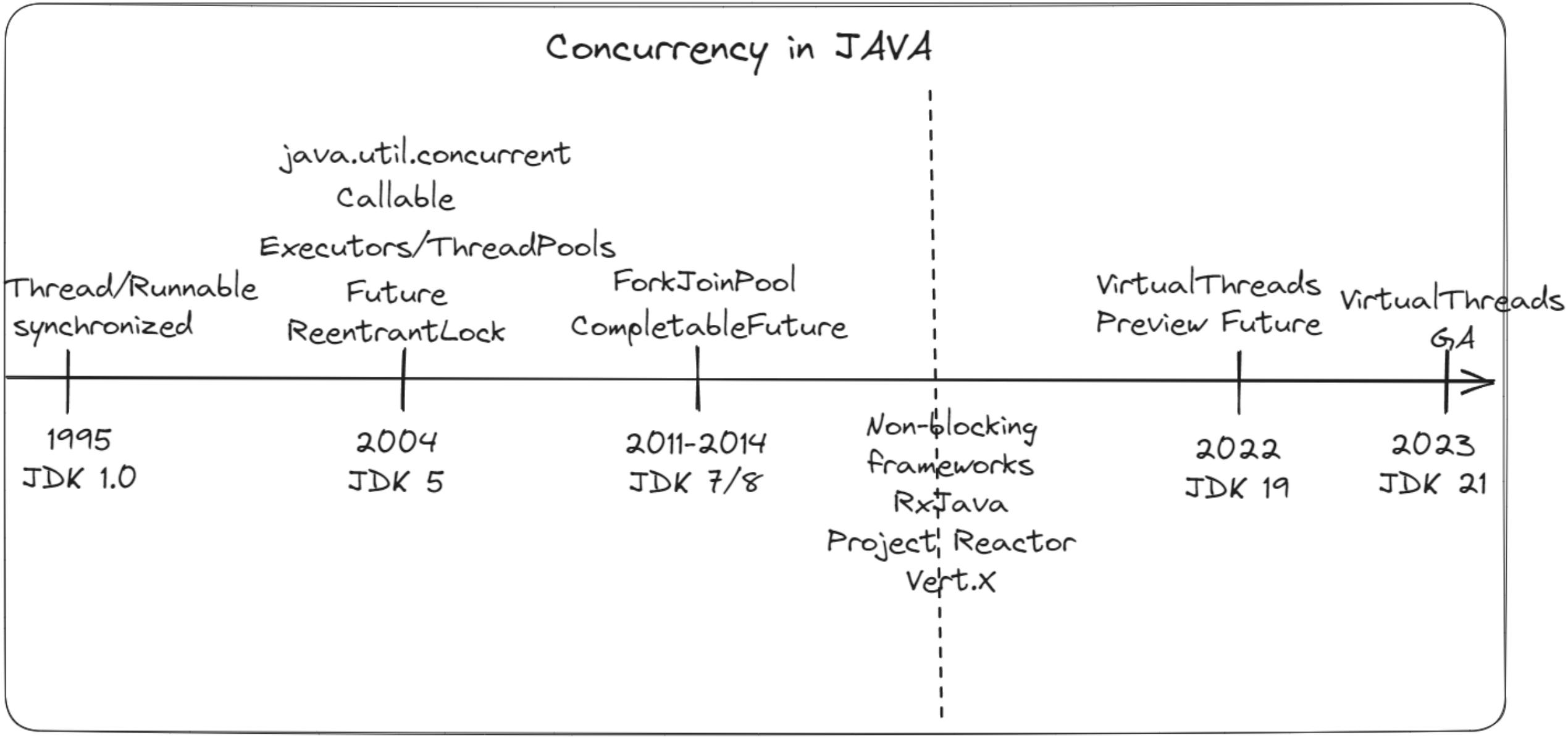
Senior Software Consultant

Over 10 years experience in programming.

Mostly focused in Java but have some frontend experience (Angular and Vue).

Seeking for new features and develop programing skills.

https://github.com/gzabek/



One thing stays the same

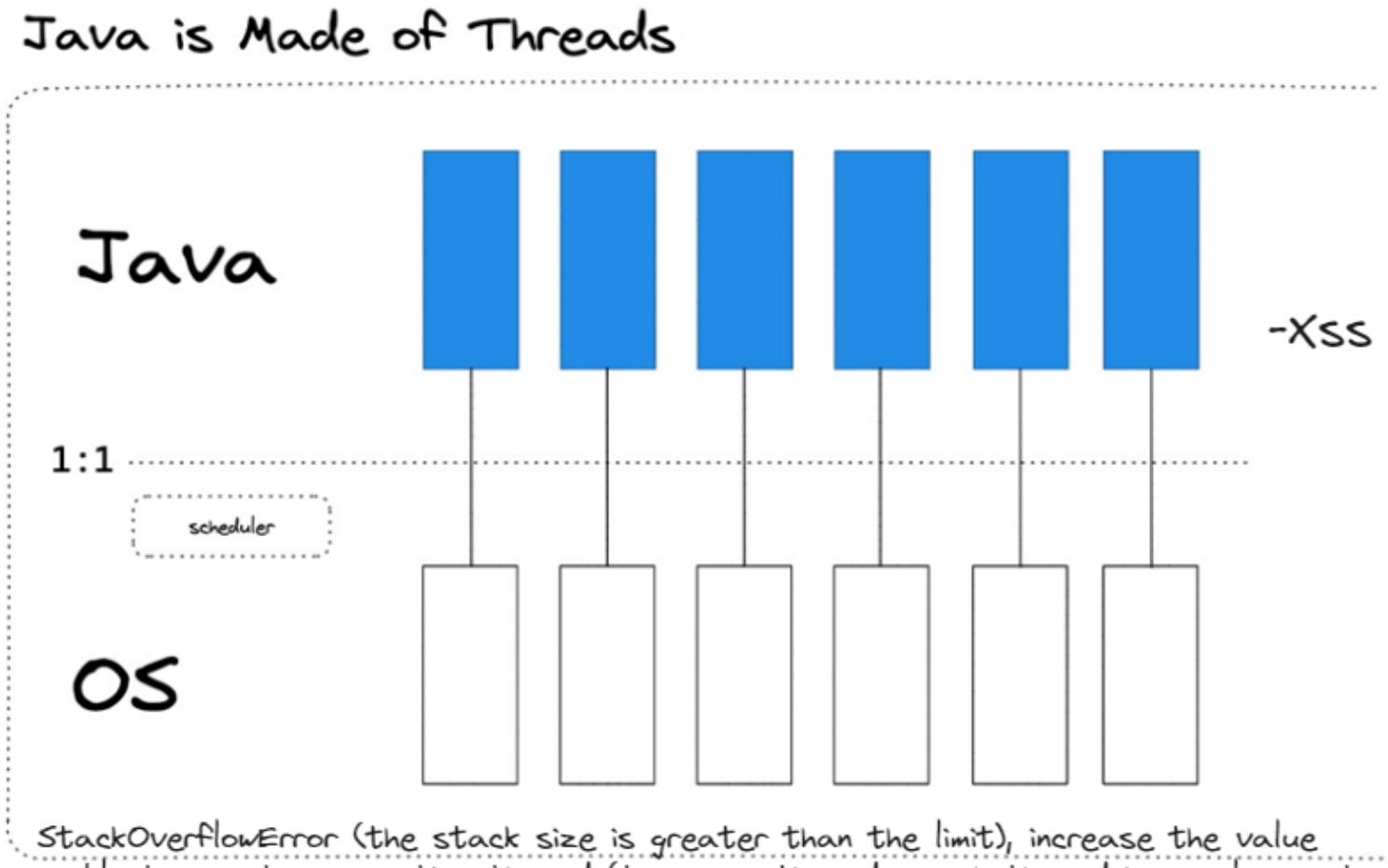
Once a thread begins to process a task it cannot release it

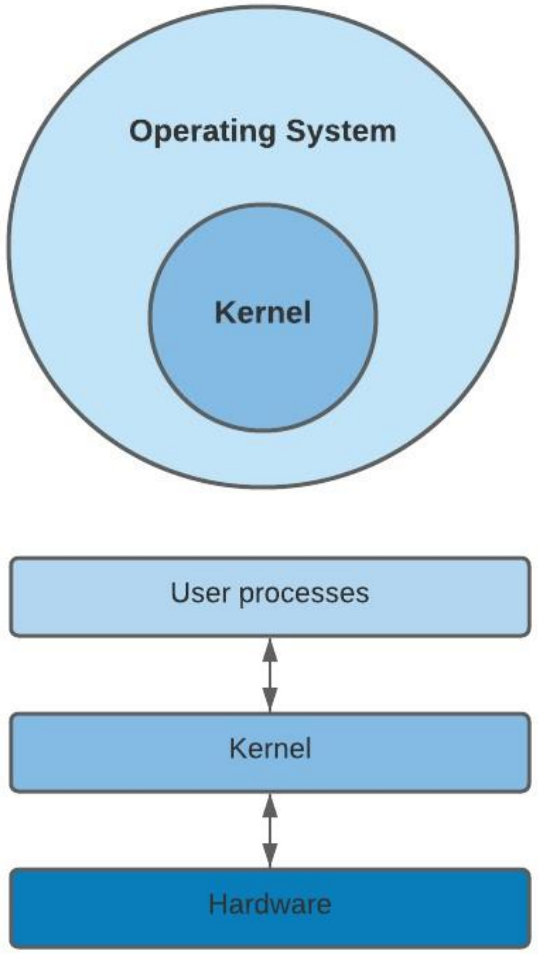
Either the task completes with a result

Or is completes with an exception

It may be an `InterruptedException`

THREADS IN JAVA – CURRENT MODEL





Concurrency: Computations vs. I/O

Concurrency may be used in two different contexts:

- processing in-memory data in parallel, using all the CPU cores
- handling numerous blocking requests / responses

Computing in parallel:

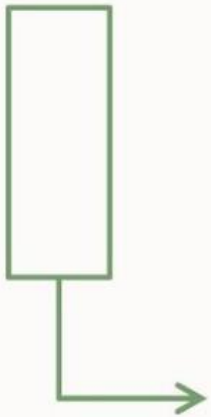
- Each thread uses 100% of your CPU cores
- Threads are mostly not blocking

No need to have more threads than (physical) CPU cores

Concurrency for I/O

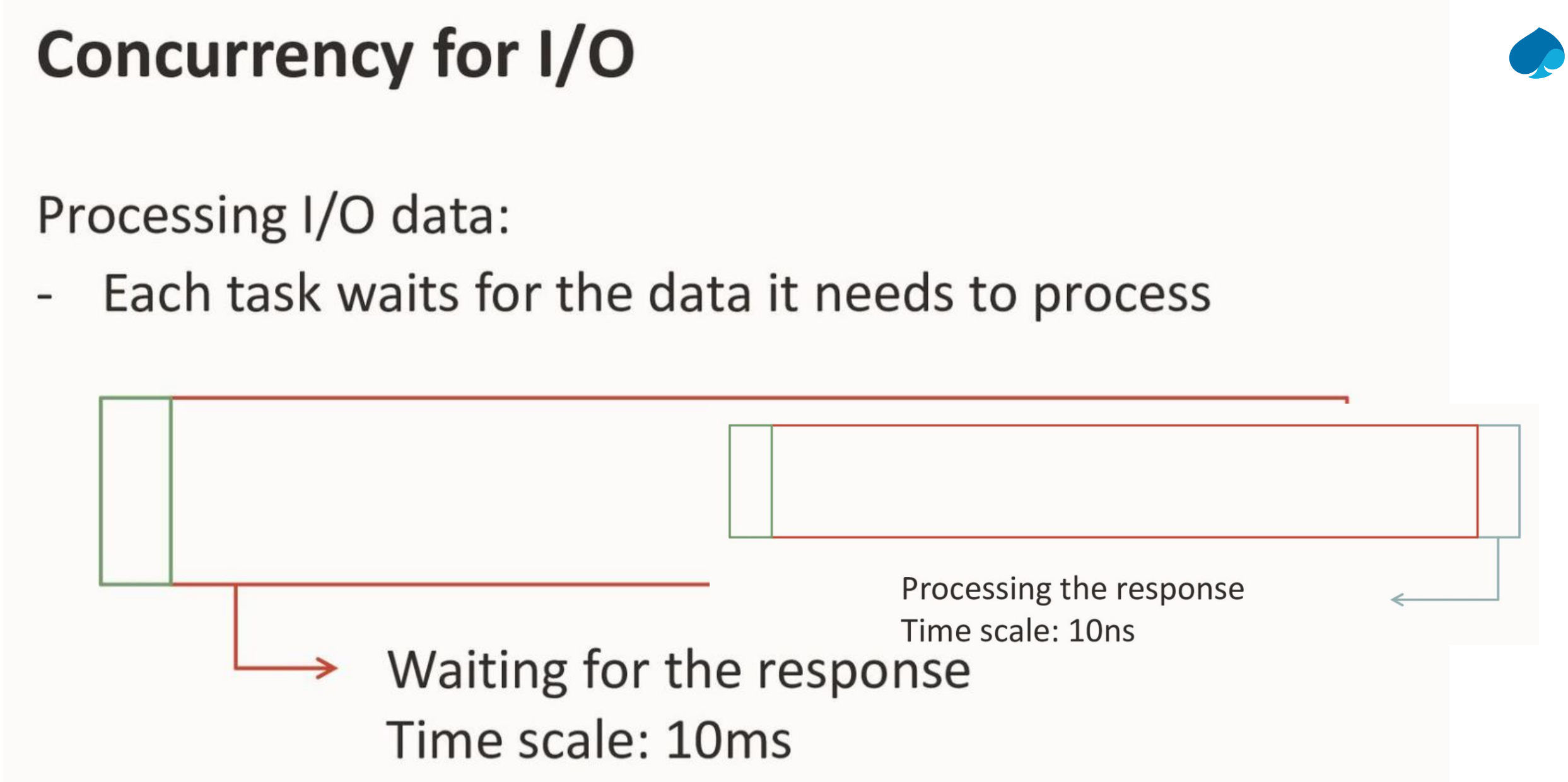
Processing I/O data:

- Each task waits for the data it needs to process



Preparing the request
Time scale: 10ns

Concurrency for I/O



Processing I/O data:

- Each task waits for the data it needs to process

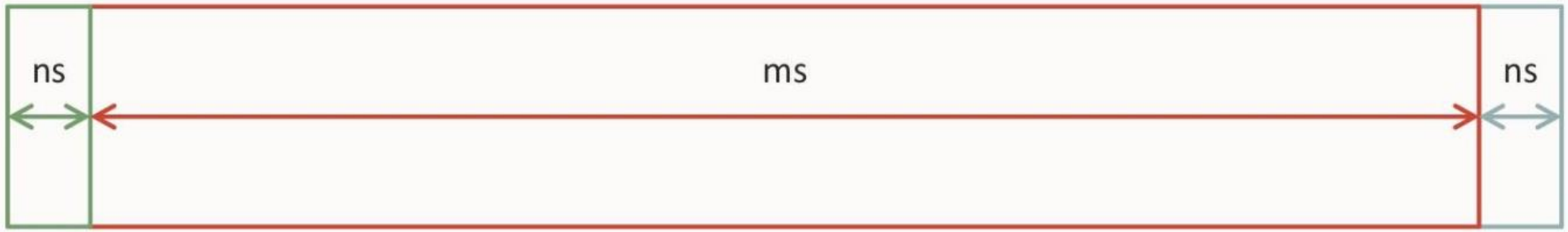
Processing the response
Time scale: 10ns

Waiting for the response
Time scale: 10ms

Concurrency for I/O

Processing I/O data:

A Thread is idle 99.9999% of the time!



How many threads do you need to keep your CPU busy?

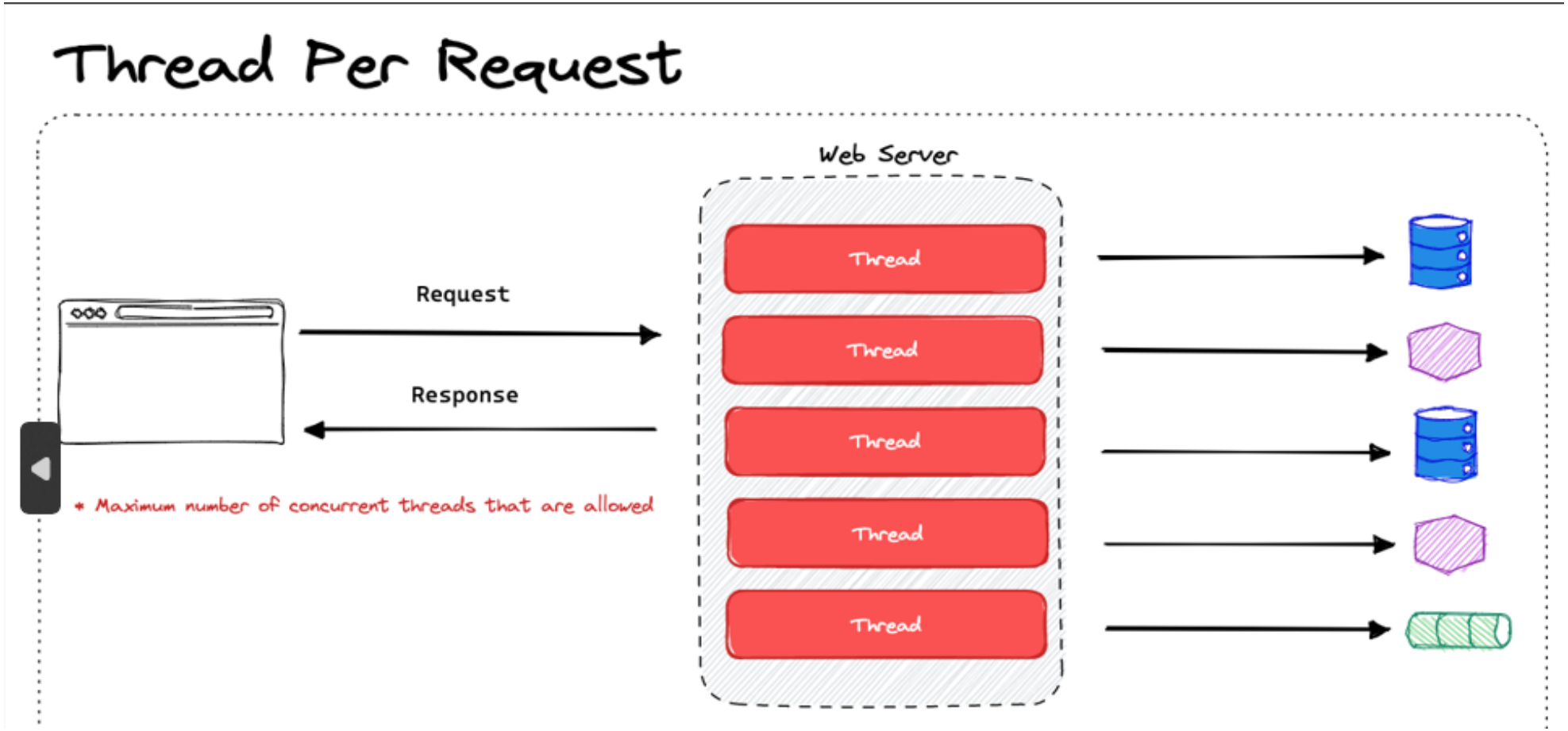
Concurrency for I/O

Because a thread cannot switch from one task to the other, the only solution is to have more threads

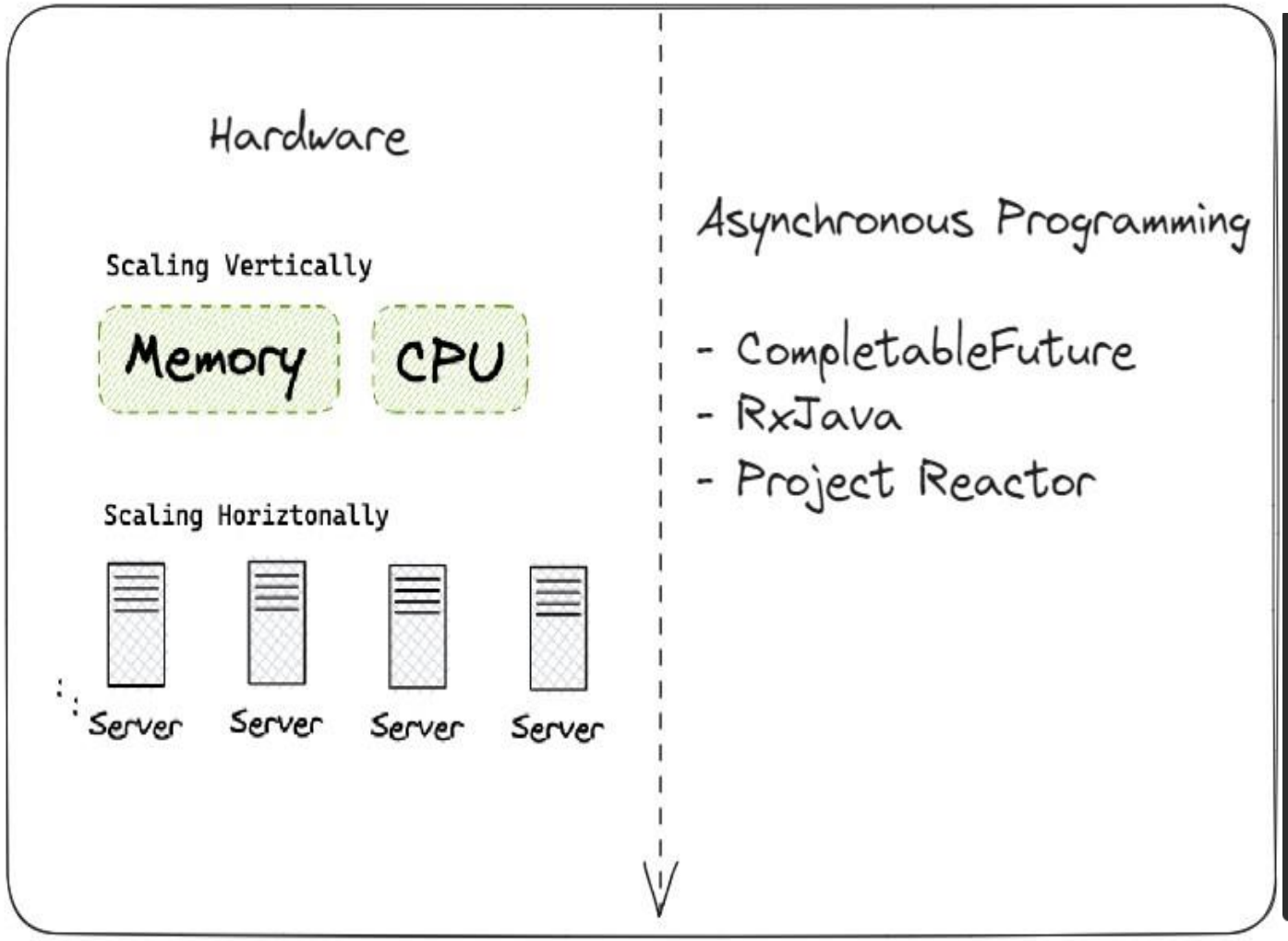
But a thread is not cheap!

- Thread startup time: ~1ms
- Thread memory consumption: 2MB of stack
- Context switching: ~100µs (depends on the OS)

BLOCKING MODEL

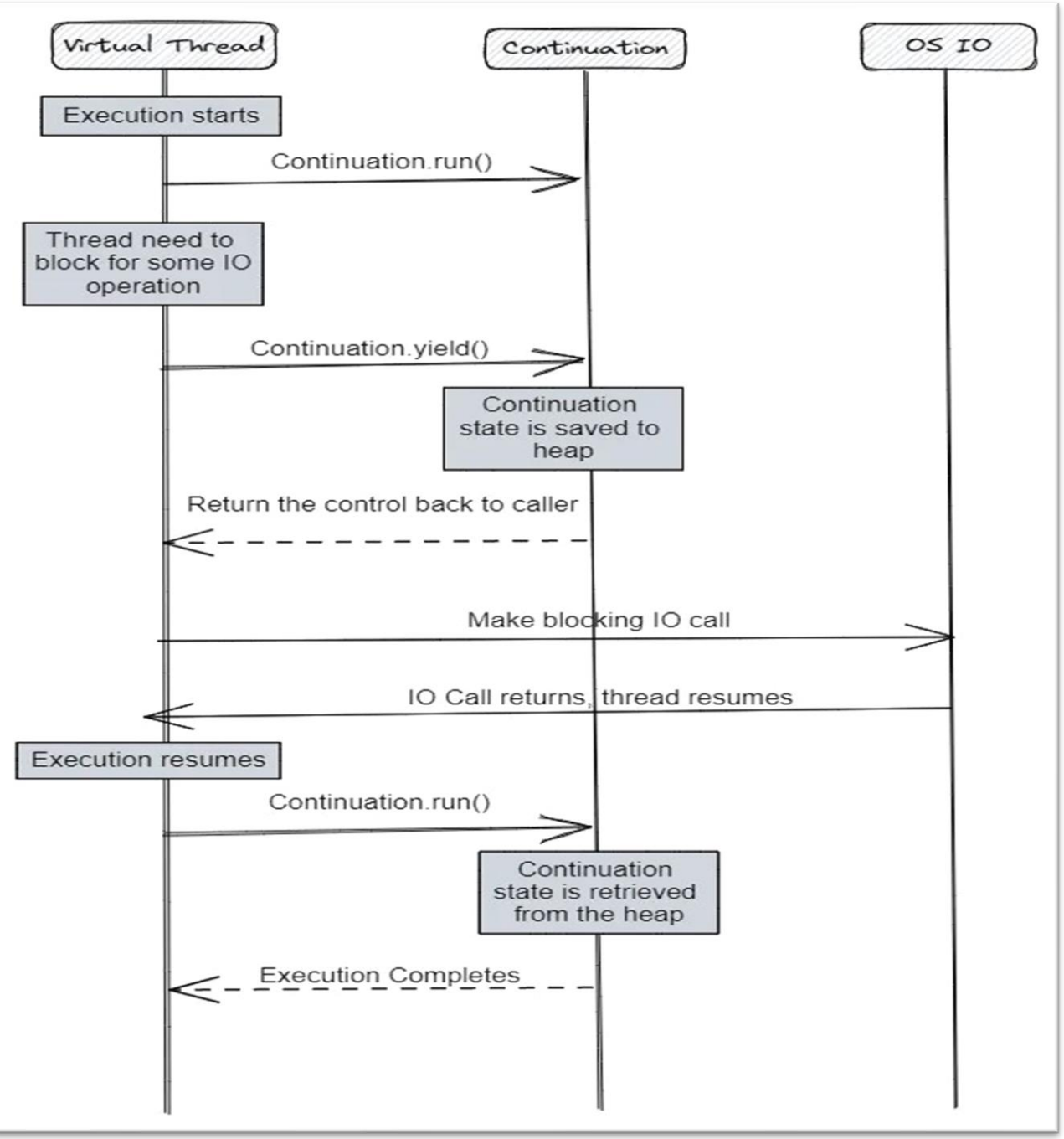


SCALABILITY SOLUTION



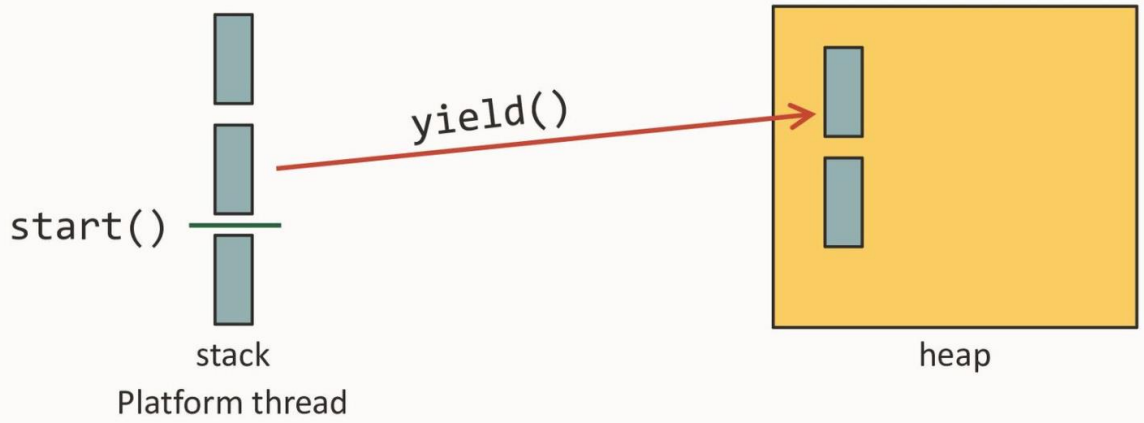

```
public DeferredResult<ResponseEntity<?>> createOrder(
    CreateOrderRequest createOrderRequest, Long sessionId, HttpServletRequest context) {
  DeferredResult<ResponseEntity<?>> deferredResult = new DeferredResult<>();

  Observable.just(createOrderRequest)
      .doOnNext(this::validateRequest)
      .flatMap(
          request ->
              sessionService
                  .getSessionContainer(request.getClientId(), sessionId)
                  .toObservable()
                  .map(ResponseEntity::getBody))
      .map(
          sessionContainer ->
              enrichCreateOrderRequest(createOrderRequest, sessionContainer, context))
      .flatMap(
          enrichedRequest ->
              orderPersistenceService.persistOrder(enrichedRequest).toObservable())
      .subscribeOn(Schedulers.io())
      .subscribe(
          success -> deferredResult.setResult(ResponseEntity.noContent()),
          error -> deferredResult.setErrorResult(error));

  return deferredResult;
}
```

VIRTUAL THREADS



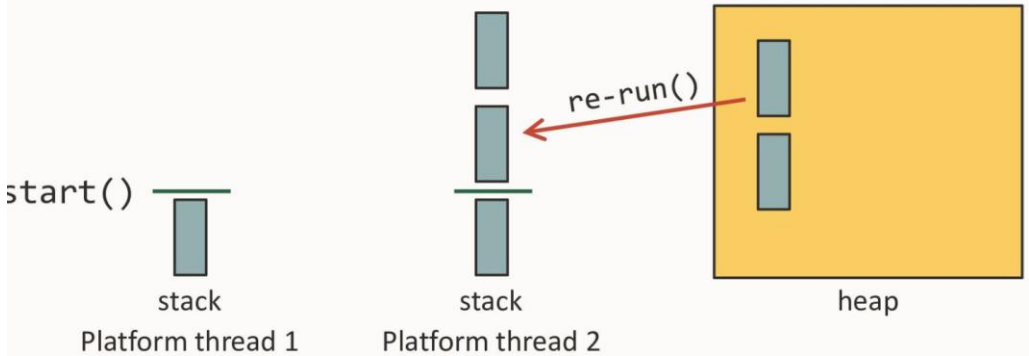
Continuation.yield()

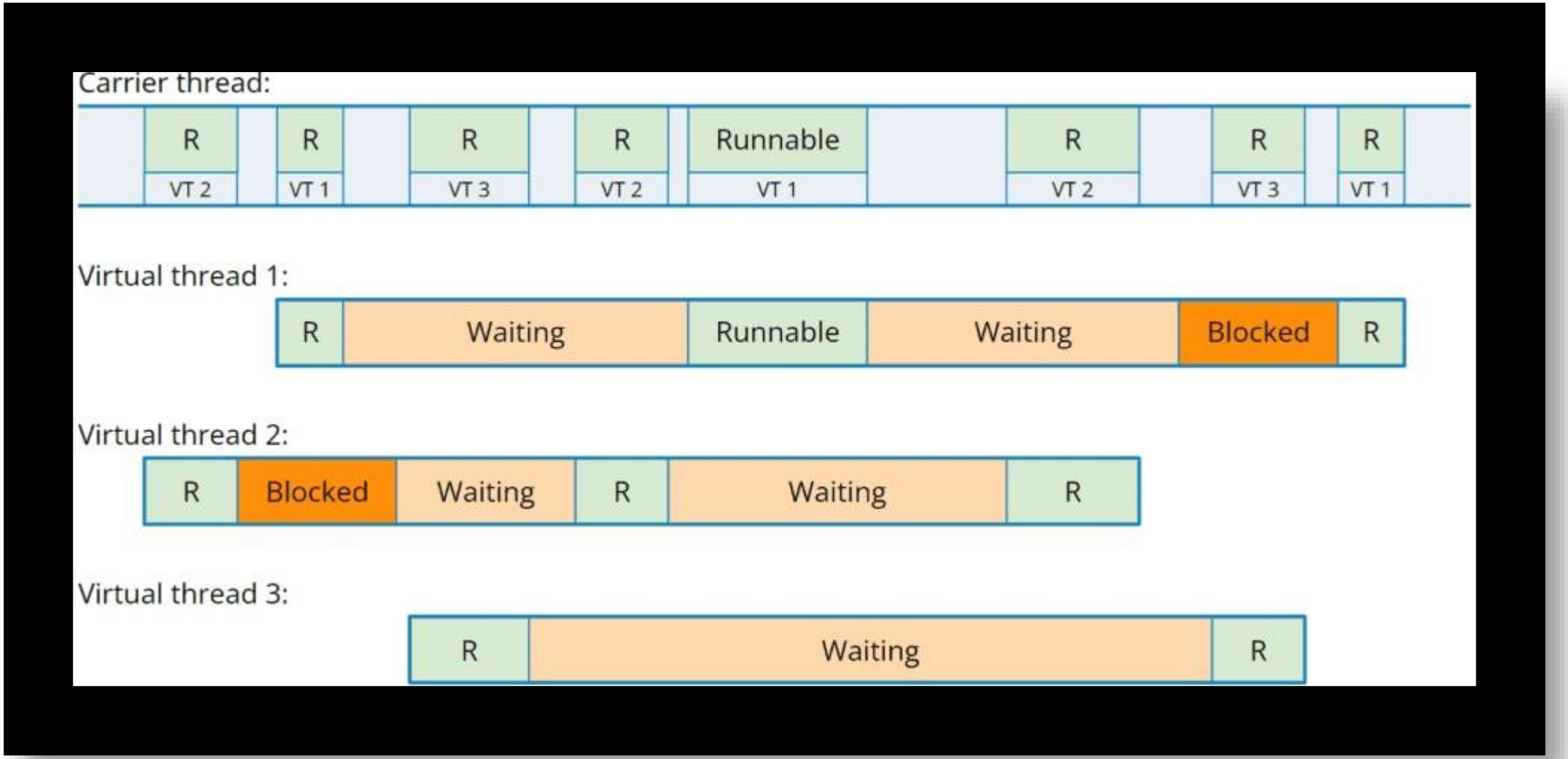
`yield()` copies the stack to the heap



Continuation.run()

`run()` copies from the heap to another stack
(optimization: only copies the topmost stack frames)

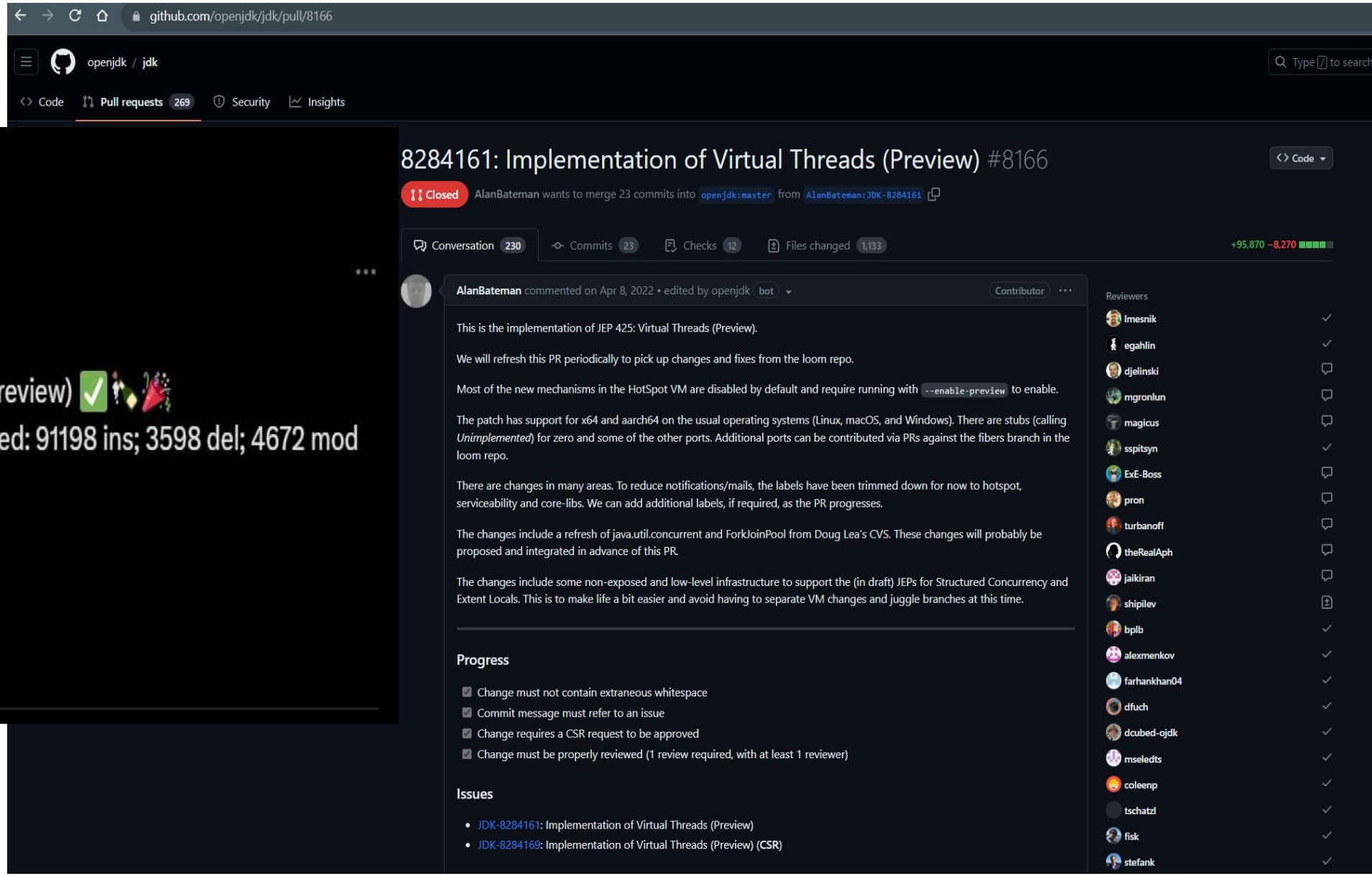




In the JDK

All blocking codes are changed to

- Check if current thread is a virtual thread
  - If it is, instead of blocking:
    - Register a handler that will be called when the OS is ready (using NIO)
      - When the handler is called, find a carrier thread and called `Continuation.start()`
    - Call `Continuation.yield()`



WHEN TO USE VIRTUAL THREADS

- Blocking code, many I/O operations. Virtual threads are not intended for long running CPU intensive operations.”
- Many requests that need to be processed asynchronously
- Synchronous code - We can write synchronous/blocking code, without having the decrease in performance or scalability. The cost of blocking a virtual thread is close to zero!
- With Project Loom we might no longer need reactive, non-blocking programming as it is known today.
- Just with usage of virtual thread CPU core become much more concurrent, the combination of virtual threads and multi core CPU with CompletableFutures to parallelized code is very powerful
- Easy to switch from current thread model to virtual threads, the same ExecutorService just different thread pool. Backward compatibility with threads.
- Some frameworks, libraries are already ready, like Spring or Tomcat.

CAUTIONS WHEN USING VIRTUAL THREADS

- When already all CPU is used then it won’t speed up application, only make sense in blocking, waiting threads scenario,
- Long tasks in synchronized block can pin virtual thread to the carrier thread, use ReentrantLock instead,
- Native call that does upcall to Java can as well pin thread, problem with some external libraries using native codes: Hadoop, Spark.
- Using Thread Local variables is not recommended, wait for Scoped values – preview future in JDK 20
- It needs latest frameworks and libraries that suport VirtualThreads
- When ExecutorService are used to limit the number of threads that can concurrently access a shared resource, e.g. an I/O device, or a remote web service then it’s recommended to use a Semaphore instead.

MORE TO COME

Structured Concurrency (Preview) in JDK 21
Scoped Values (Preview) in JDK 21

LIVE CODING

WORTH TO READ & WATCH

1

Project Loom & JDK spec

https://www.baeldung.com/openjdk-project-loom
https://openjdk.org/projects/jdk/21/
https://jdk.java.net/loom/
https://inside.java/
https://dev.java/future/innovation/
https://openjdk.org/jeps/425 ---virtual threads preview
https://openjdk.org/jeps/429 ---scoped values
https://openjdk.org/jeps/428 ---structured concurrency
https://openjdk.org/jeps/444 - virtual threads GA

2

VirtualThreads in Spring

https://spring.io/blog/2022/10/11/embracing-virtual-threads
https://spring.io/blog/2023/02/27/web-applications-and-project-loom
https://github.com/danvega/loom

3

YouTube

https://www.youtube.com/watch?v=9P9DZCZTq4E&ab_channel=InfoQ
https://www.youtube.com/watch?v=QxxG66eQoTc&ab_channel=IntelliJIDEAbyJetBrains
https://www.youtube.com/watch?v=Is5HXJhC3jE&ab_channel=DanVega

W prezentacji użyto slajdów José Paumarda

Q&A

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