Project Loom Overview

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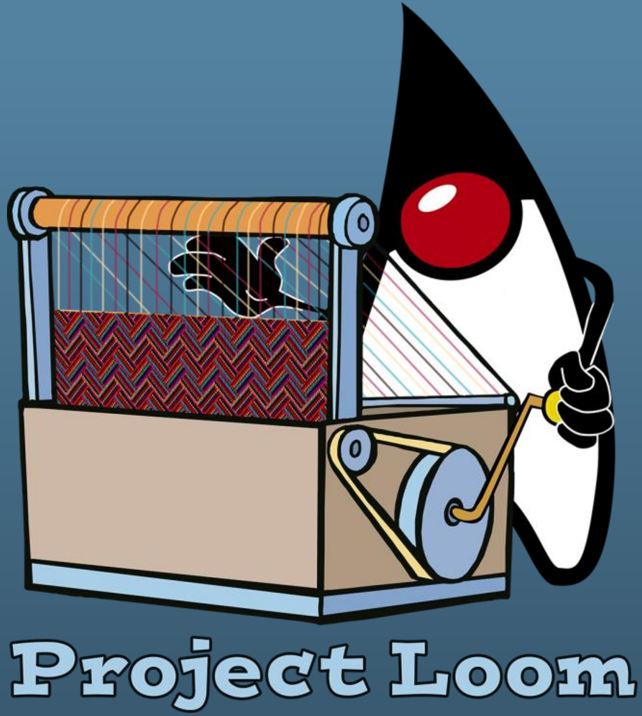

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A brief history of async programming

- In the 80s, we programmed with asynchronous code
  - Hard to write, hard to read, hard to debug
- Since the early 90s, threads have been our primary concurrency tool
  - Allows users to program with simple, sequential code
  - Sequential code is readable by humans!
- But, threads are somewhat heavyweight abstractions
  - Megabyte-scale entities, can’t have millions of them
- Recently, people have been reaching for reactive APIs
  - Kind of like what we did in the 80s, with the same effect

Server programming with threads

- When a request comes in, it is dispatched to a thread
  - Holds onto that thread for the duration of the request
- Processing the request might involve a lot of waiting
  - Reading request from socket
  - Database or other service requests
  - Writing response to socket
- Easy, but doesn't scale to millions of threads
  - Easy to read, write, debug
  - Limited number of threads means limited number of concurrent requests
    - Even if CPU has lots of free cycles

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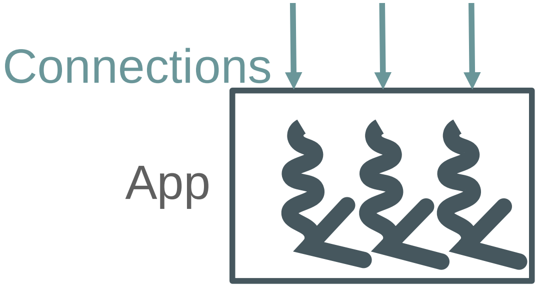
Server programming with reactive APIs

A transitional solution

- Reactive APIs let us express a sequence of async operations
  - “Do this, then this, then maybe that”
  - Request is not tied to a single thread for the duration
- More scalable, but *much* harder to debug
- Also harder to read
  - Framework ceremony obscures business logic
- Cannot mix synchronous and asynchronous APIs

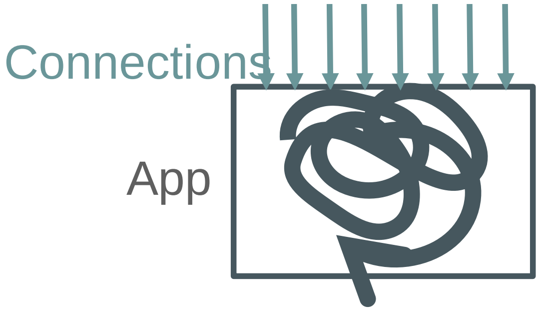
A bad choice



simple
less scalable

SYNC

OR



scalable,
complex,
non-interoperable,
hard to debug/profile

ASYNC

The best of both worlds?

- The threaded programming model is what users want
  - Code is readable, does what it looks like it does
  - But doesn’t (currently) scale beyond 10K threads
- If we could make threads scale better, we would be less tempted to reach for async!
- Project Loom aims to do just that
  - *Fibers* are lightweight threads
  - Few hundred bytes each, rather than megabytes
  - Can have millions of them
  - Same familiar, readable, debuggable programming model as threads

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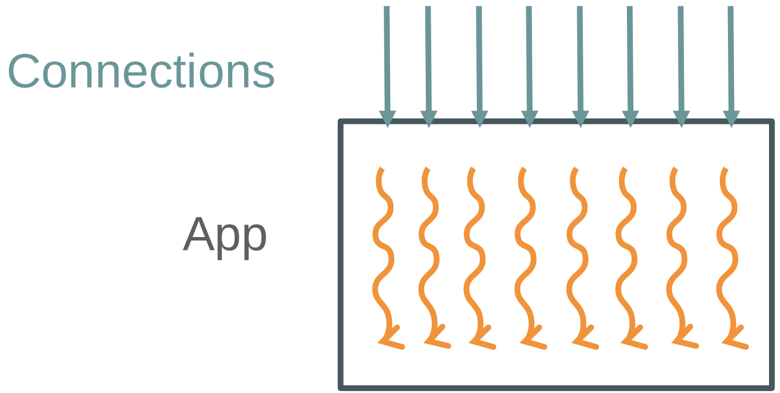
The best of both worlds?

Codes like sync, scales like async



Continuations

The low-level plumbing

- A *continuation* is a VM mechanism for restartable computations
  - Continuation extends Runnable
  - Low-level mechanism for creating concurrency primitives
- The task can *pause* the continuation
  - On pausing, control returns to the initiator
  - JVM unwinds call frames between initiator and pause point, stores in heap
  - Continuation can be resumed later – possibly on another thread
- Doesn’t tie up thread while paused!
  - Can pause before a blocking operation, and resume when it is complete
- Fast task switching

Fibers

Lightweight threads

- A *fiber* is a lightweight thread
  - Built on Continuation
  - Higher-level lightweight thread abstraction
  - Uses ForkJoinPool for task scheduling
- Fibers are lightweight
  - Few hundreds of bytes, not megabytes
  - Cheap to create and schedule
- JDK libraries instrumented to be fiber-aware
  - Blocking IO / JUC operations pause current fiber, resume when unblocked

Programming with Fibers

- Fibers have all the benefits of threads
  - Simple, sequential code
  - Easy to read and debug

```
Fiber<String> fiber = Fiber.schedule(task);
String result = fiber.join();
```

- But scale better
  - Can easily have 1M fibers on a desktop-class system
- And can interoperate with reactive code

```
CompletableFuture<?> result = Fiber.schedule(task).toFuture();
```


Show us the numbers!

- Here's a JAX-RS service that simulates a typical request
  - Assume computeValue() takes 100ms

```
@GET
@Path("greeting")
@Produces(MediaType.APPLICATION_JSON)
public String greeting() {
    return "{ \"message\": \"" + computeValue() + "\" }";
}
```

- Run it on Jetty+Jersey with 200 threads…
  - Little's Law says we can only get 2000 reqs/sec through this
  - Let's throw some additional load at it…

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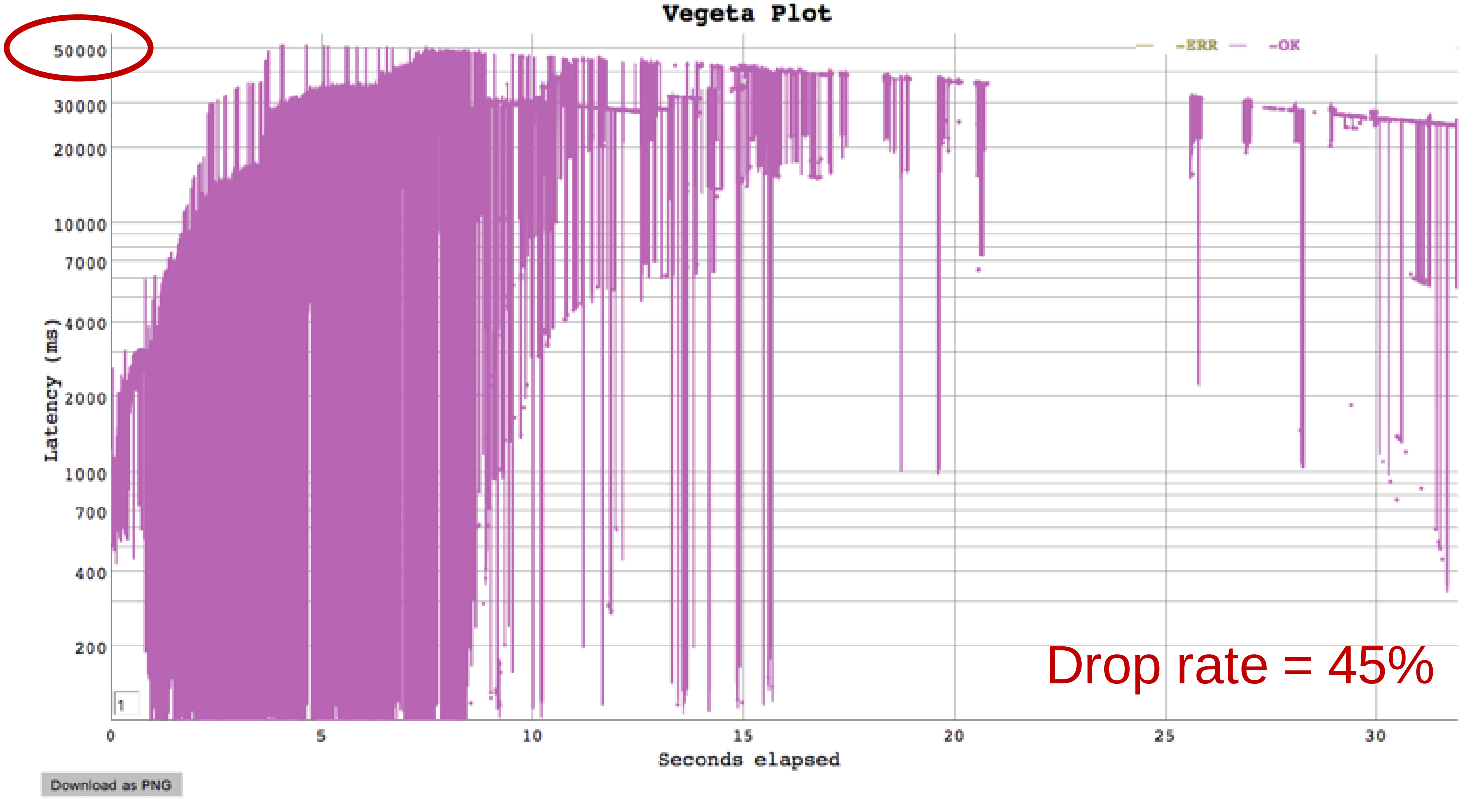
Show us the numbers!

Response time plot with 200 threads, 5000 reqs/sec



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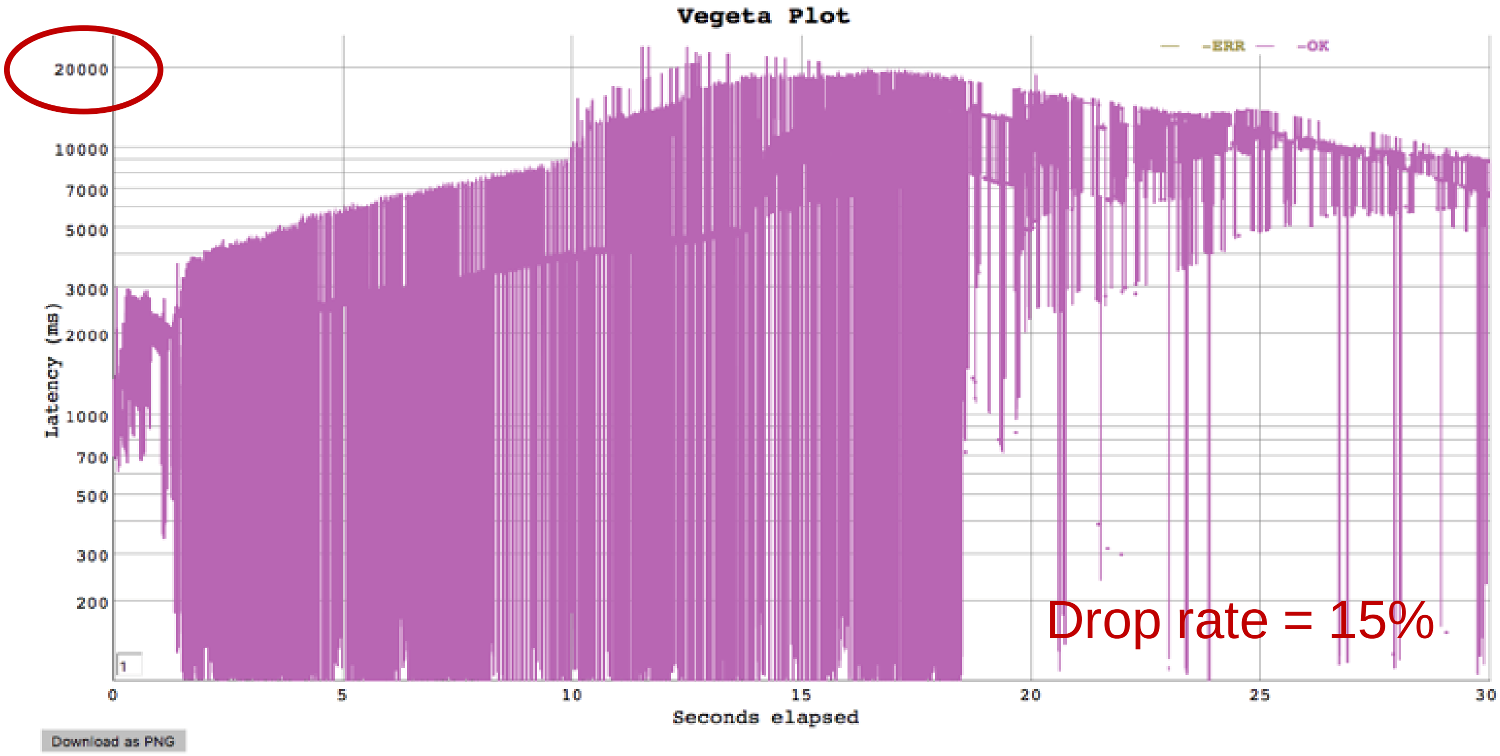
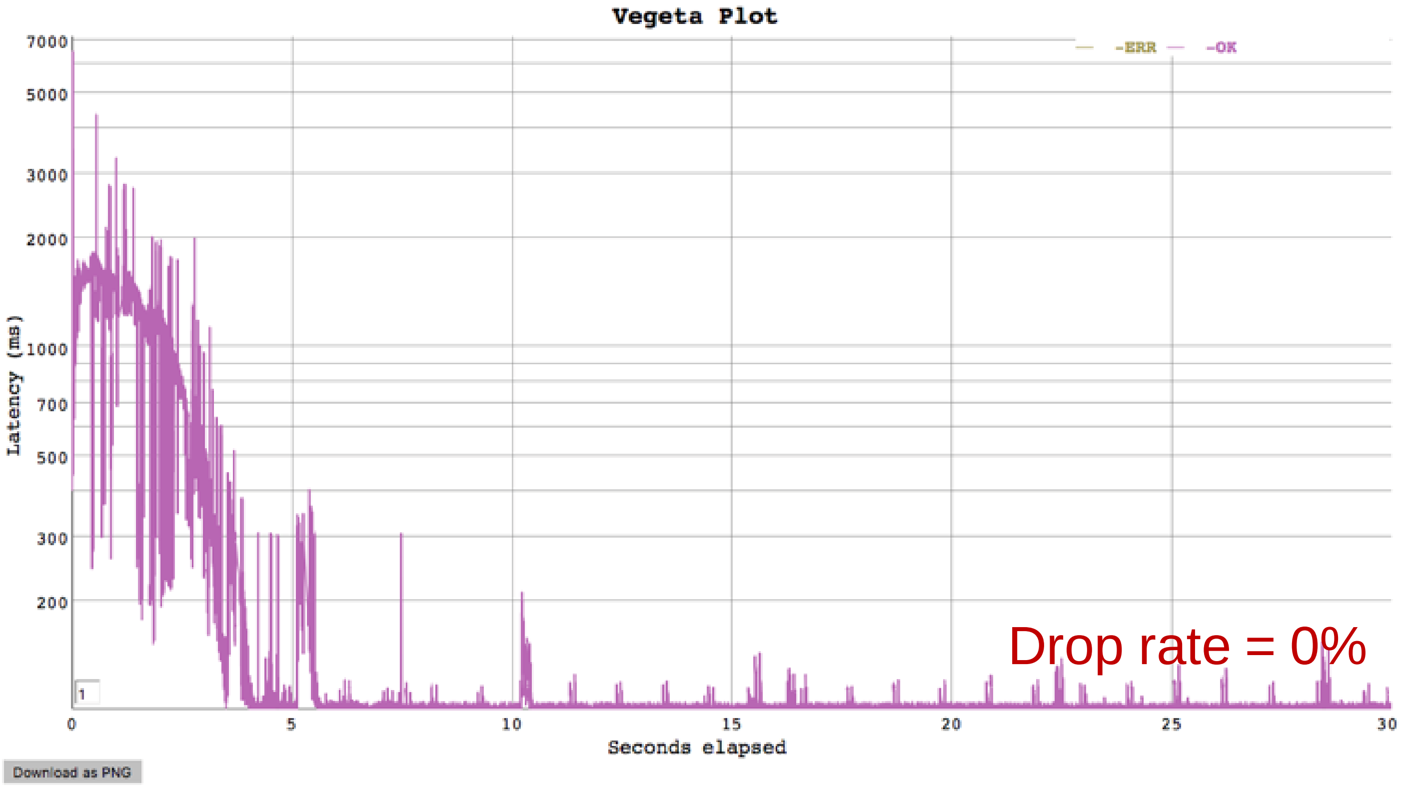
Show us the numbers!

Increase thread pool to 400 threads, same load



Show us the numbers!

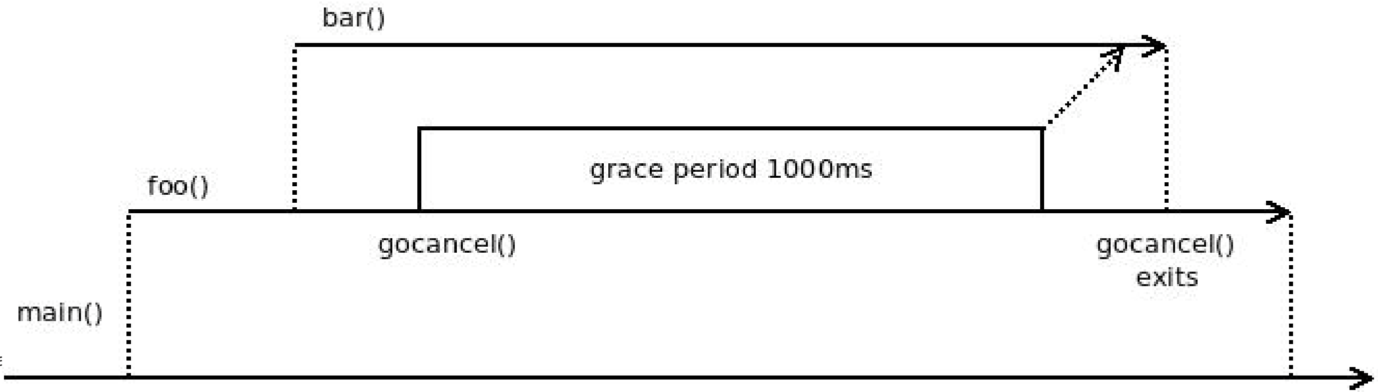
Replace thread pool with fibers, same load



Drop rate = 0%

Structured concurrency

- Other languages are starting to embrace *structured concurrency*
  - Sustrik, *Structured Concurrency*
  - Smith, *Go statement considered harmful*
- All fibers have a *parent fiber*
  - Parent cannot exit until all children exit
- Creates a natural locus for cancellation, deadlines, etc



Structured concurrency

- Fibers live in a *fiber scope*
  - Fiber scopes can be nested arbitrarily deeply, forming a tree
  - Cancelling / interrupting a scope will cancel all fibers in that scope
  - Scopes are AutoClosable, where close() waits for all children
    - Plays nicely with try-with-resources

```
try (var scope = FiberScope.cancellable()) {
    Fiber<?> child1 = scope.schedule(task1);
    Fiber<?> child2 = scope.schedule(task2);
}
```

Q & A

