Controlling Concurrent Applications Using Barriers and Latches

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Agenda

Two more concurrent primitives

The barrier: to have several tasks wait for each other

The latch: to count down operations and let a task start

Barriers

Stating the Problem

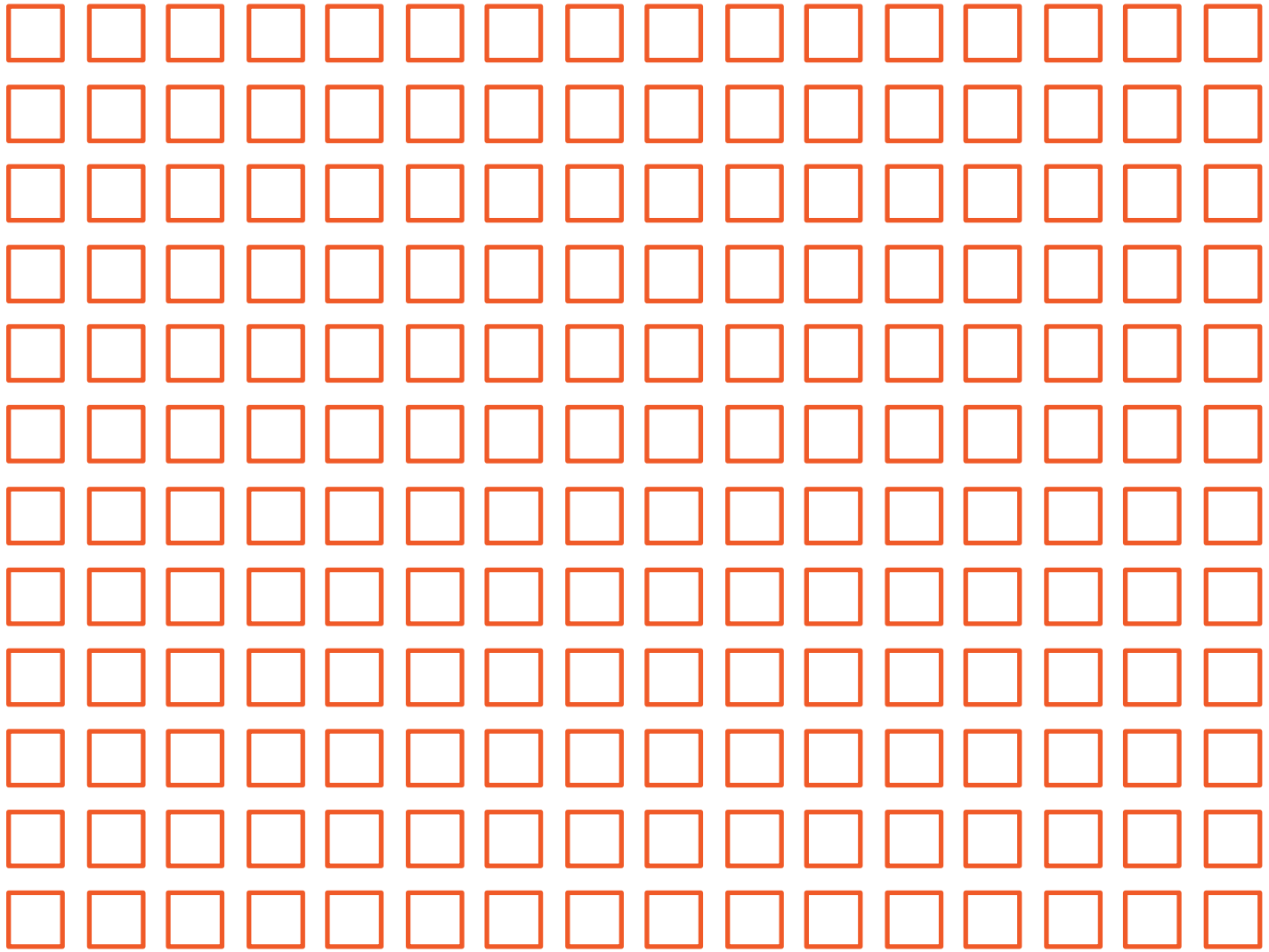
We need a given computation to be shared among several threads

Each thread is given a subtask

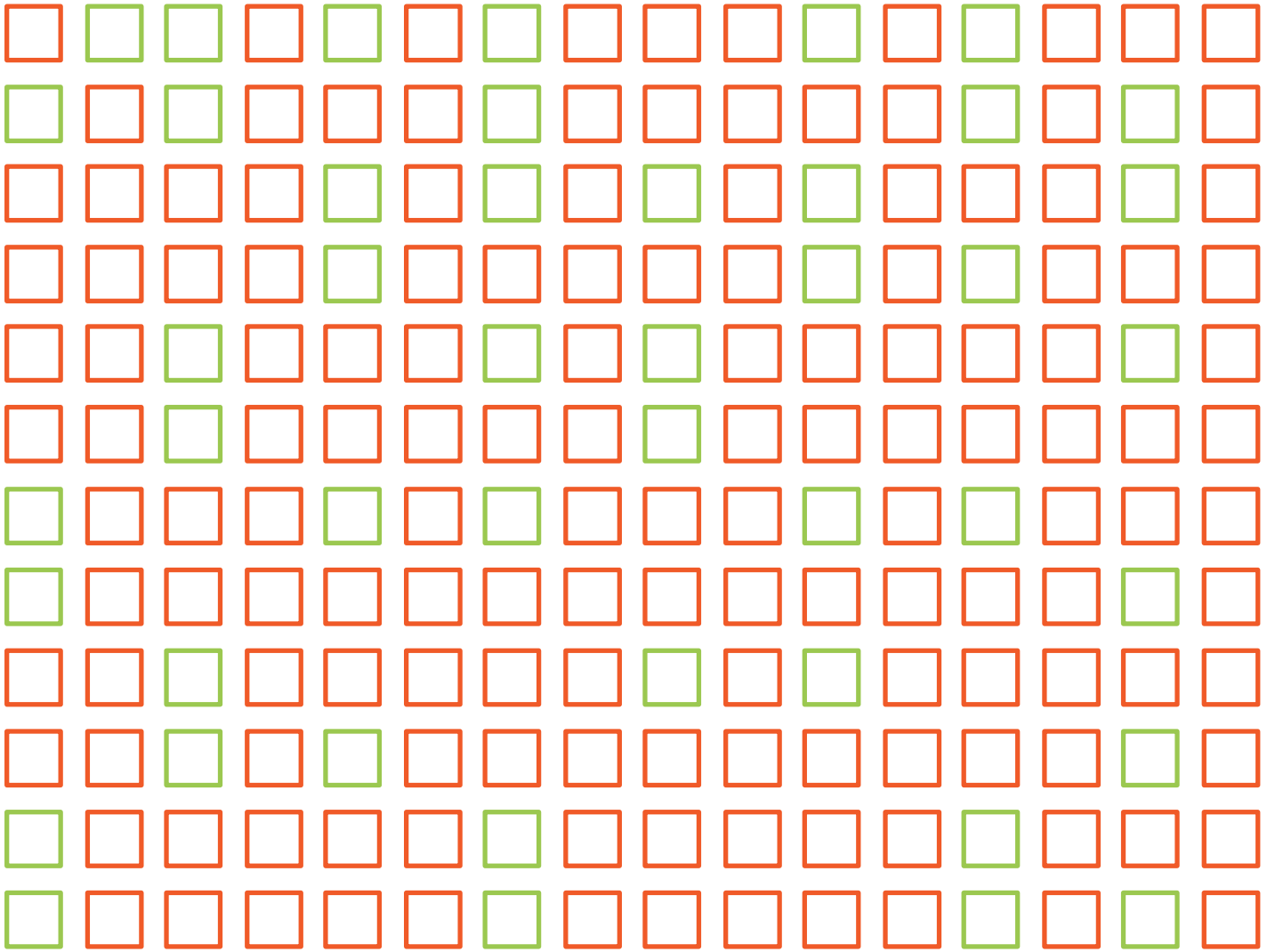
When all the threads are done, then a merging operation is run

Finding Prime Numbers

Finding Prime Numbers



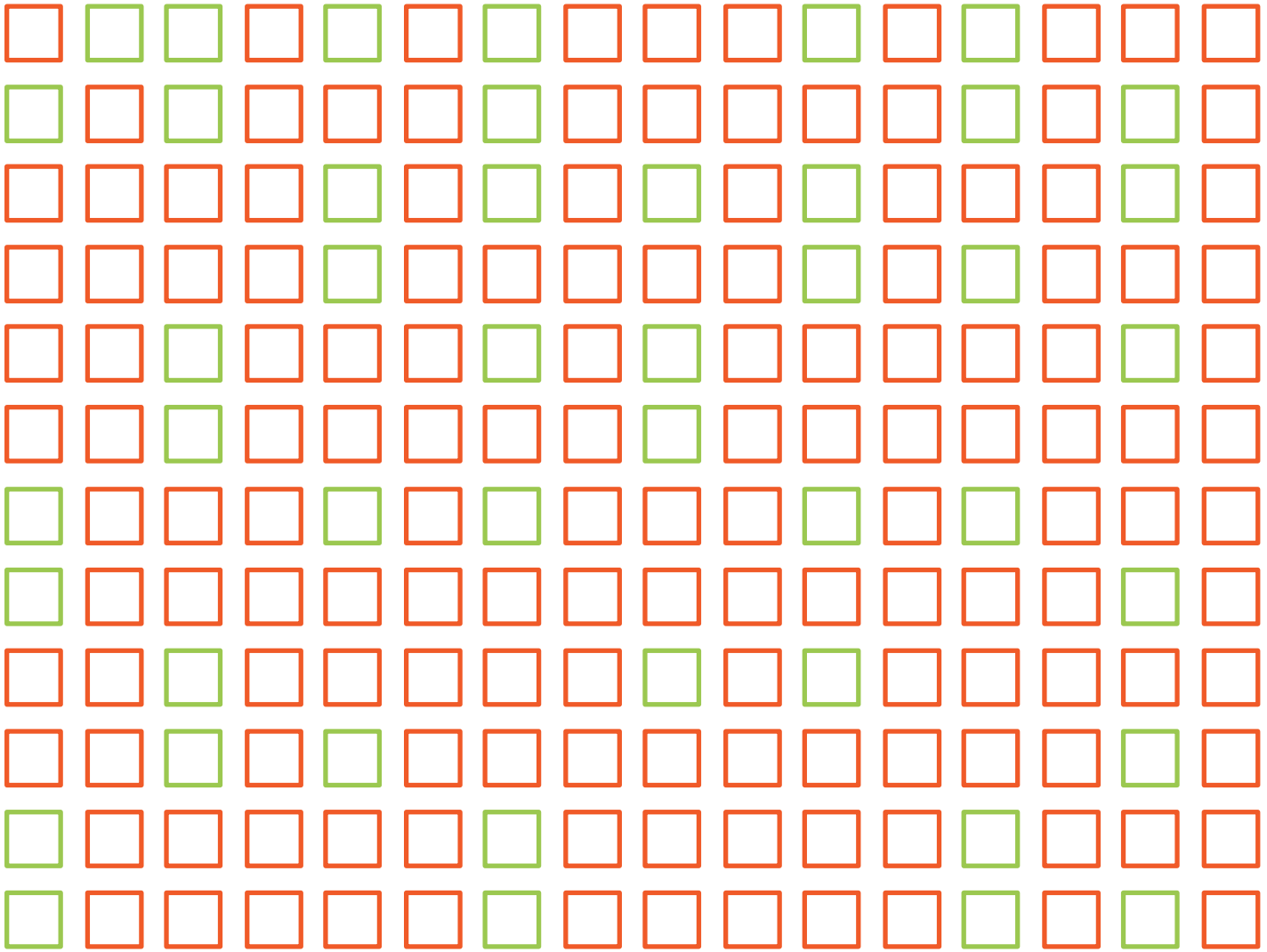
Finding Prime Numbers



Only 1 thead
is working

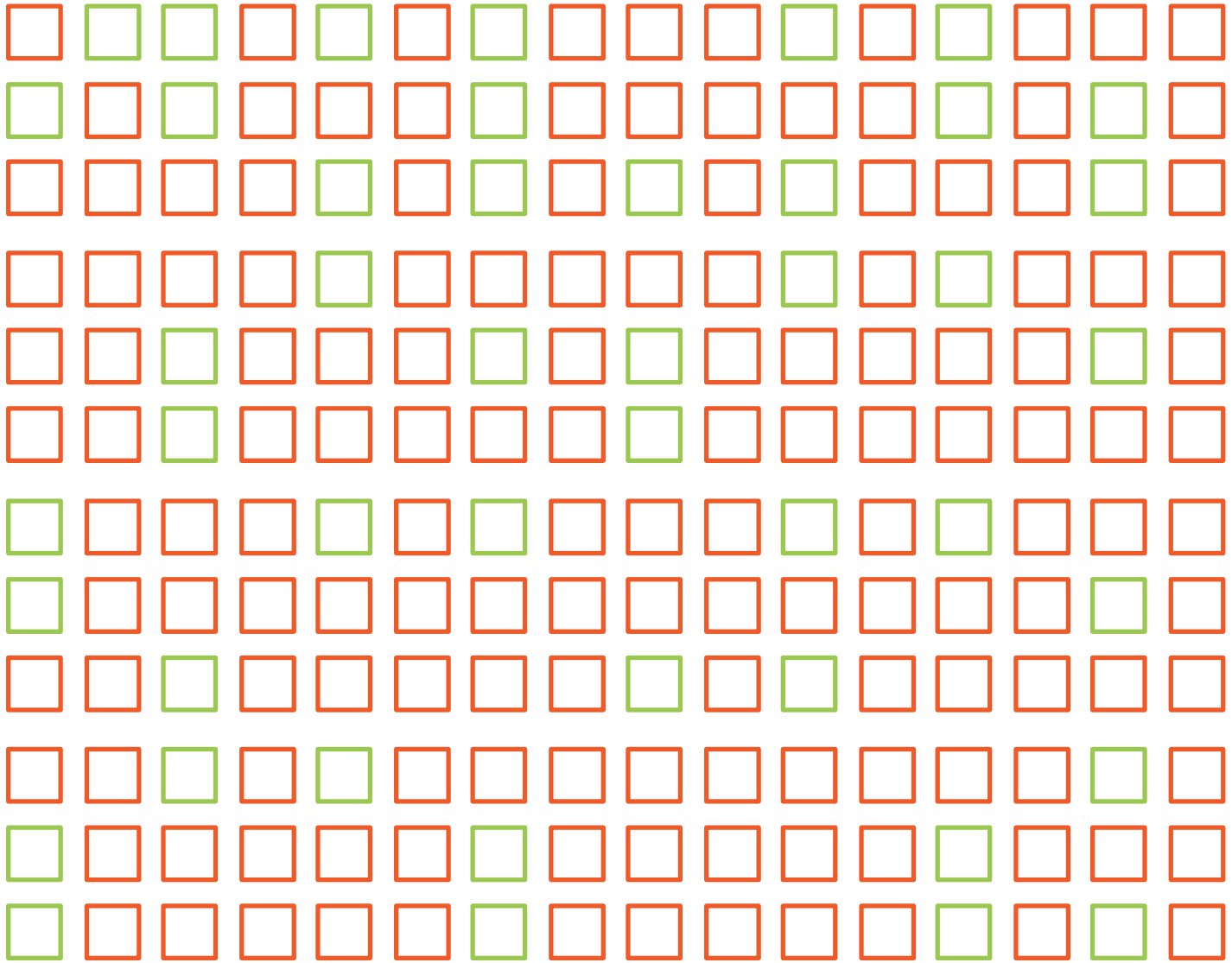
Meaning only
1 core
is used...

Finding Prime Numbers



With 4 cores
we could go faster!

Finding Prime Numbers



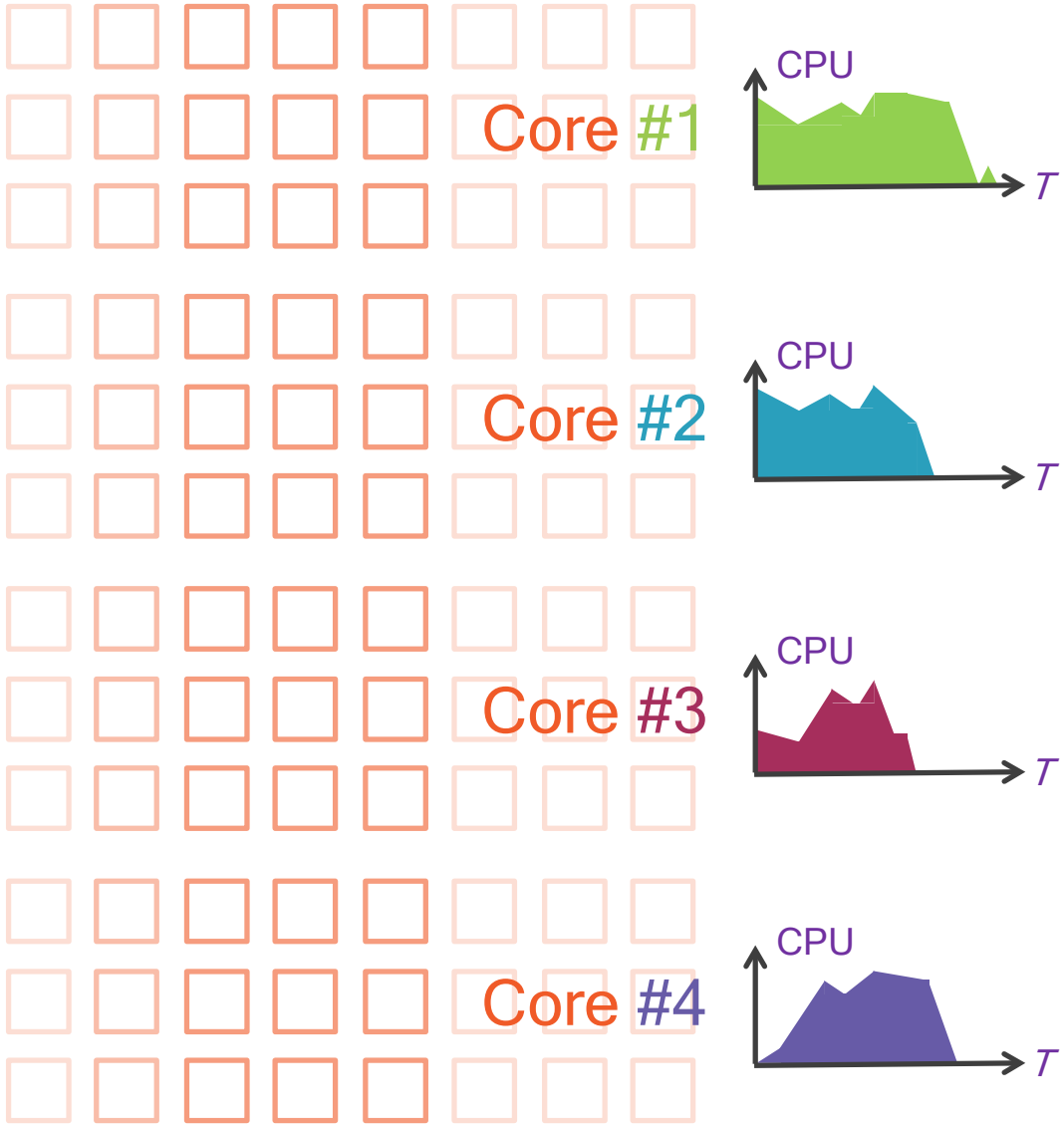
Core #1

Core #2

Core #3

Core #4

Finding Prime Numbers



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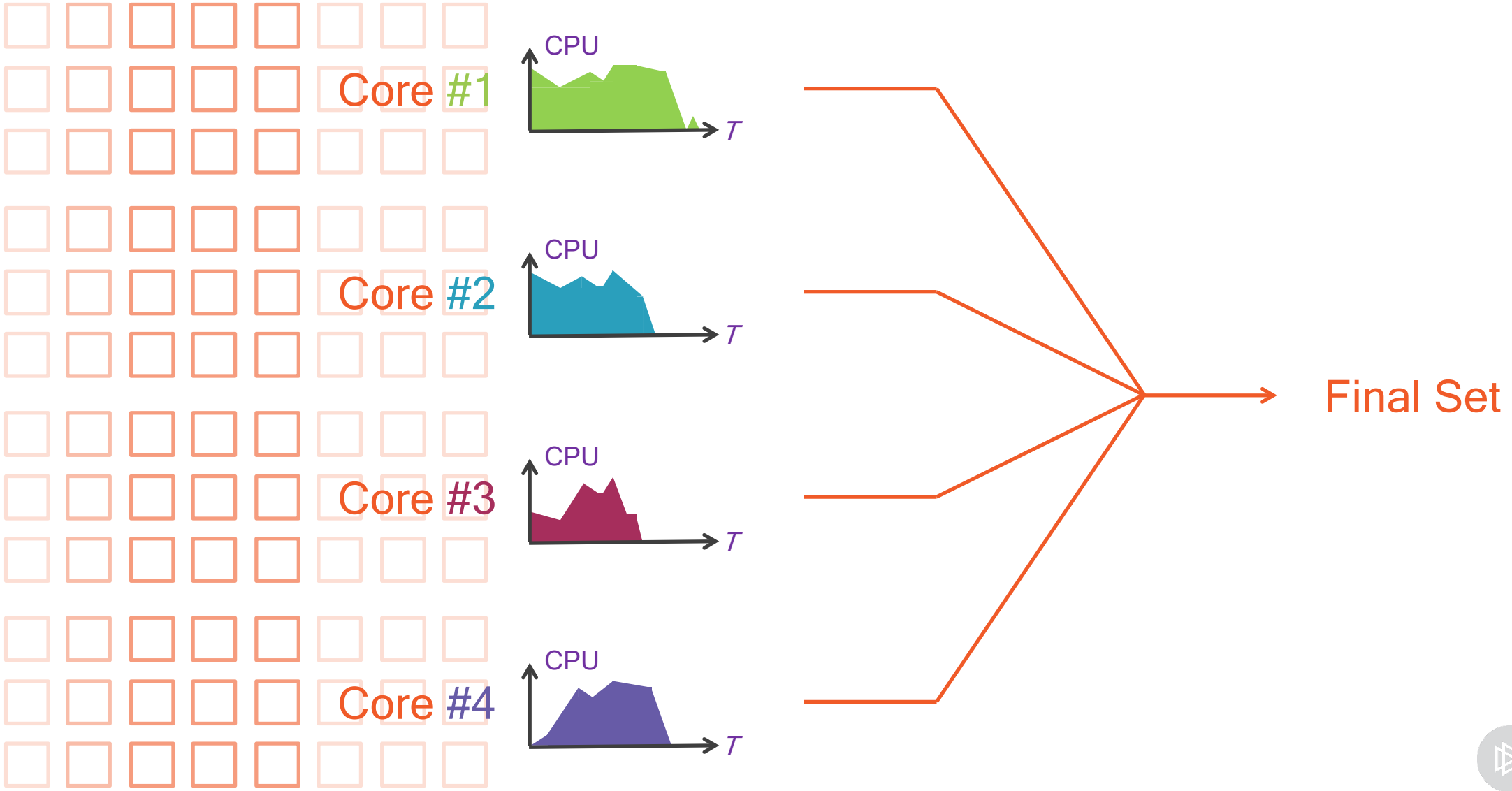

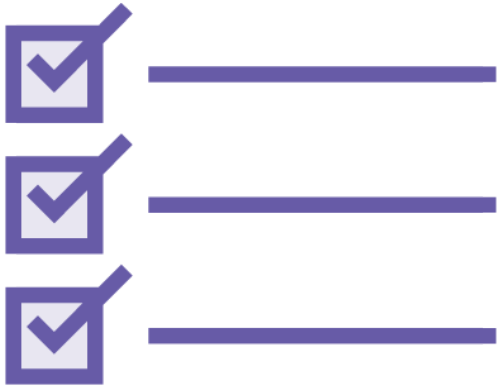

We need a way to distribute the computation on several threads

We need to know when all the threads have finished their task

We need to launch a post-processing at that moment

```
Callable<List<Integer>> task = () -> findPrimes(inputSet);
```

First we need a task that takes a set of numbers

And returns the set of prime numbers among them

This task is a Callable

```
CyclicBarrier barrier = new CyclicBarrier(4);
```

This callable has to wait for the other tasks launched in parallel, when its task is done

For that, we create a CyclicBarrier object

The parameter is the number of tasks that will be launched

```
Callable<List<Integer>> task = () -> {
   Set<Integer> result = findPrimes(inputSet);
   try {
      barrier.await(); // Blocks until everybody is ready
   } catch (Exception e) {...}
   return result;
}
```

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The await call blocks...

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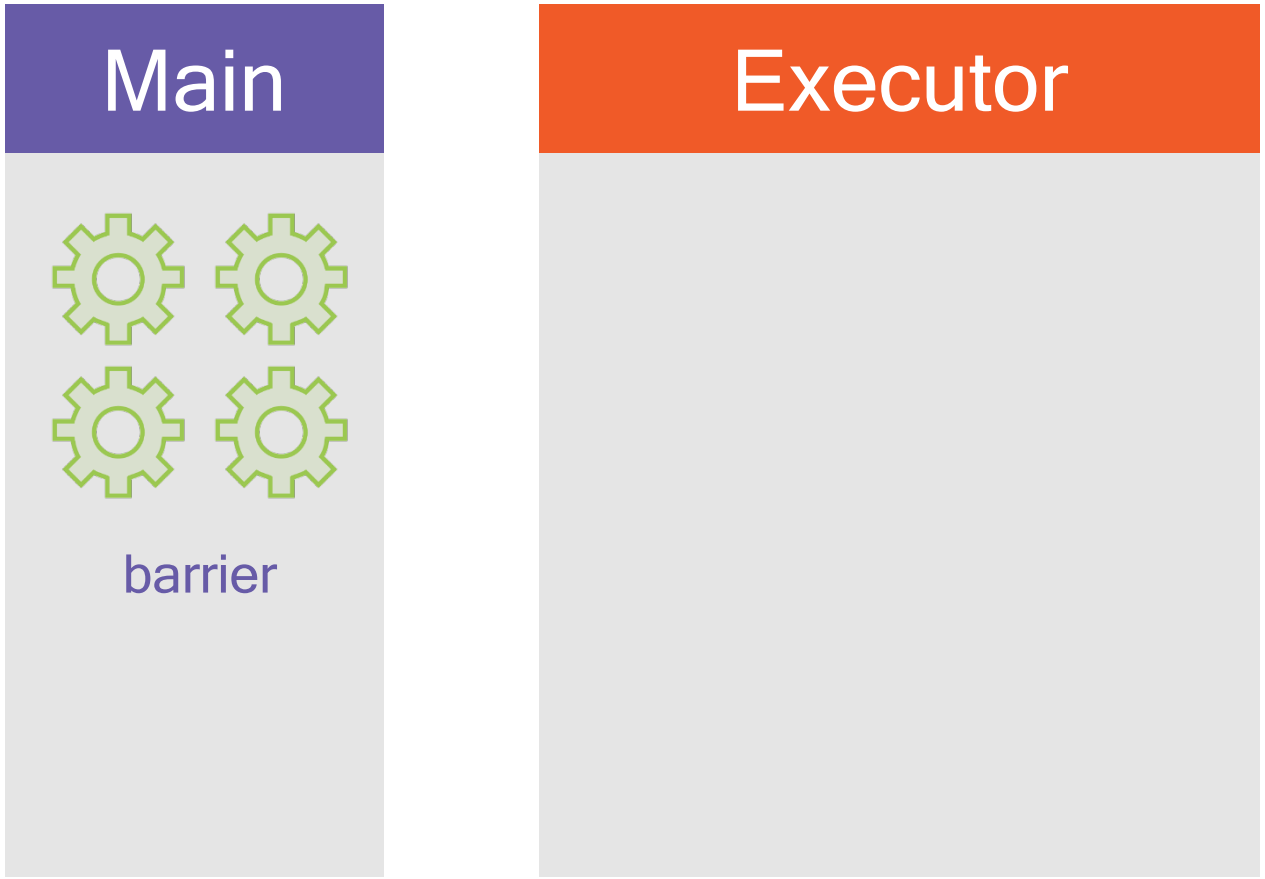
We then tell the callable to wait for the barrier to open

The await call blocks...

... until 4 calls have been made on it

How Does the CyclicBarrier Work?



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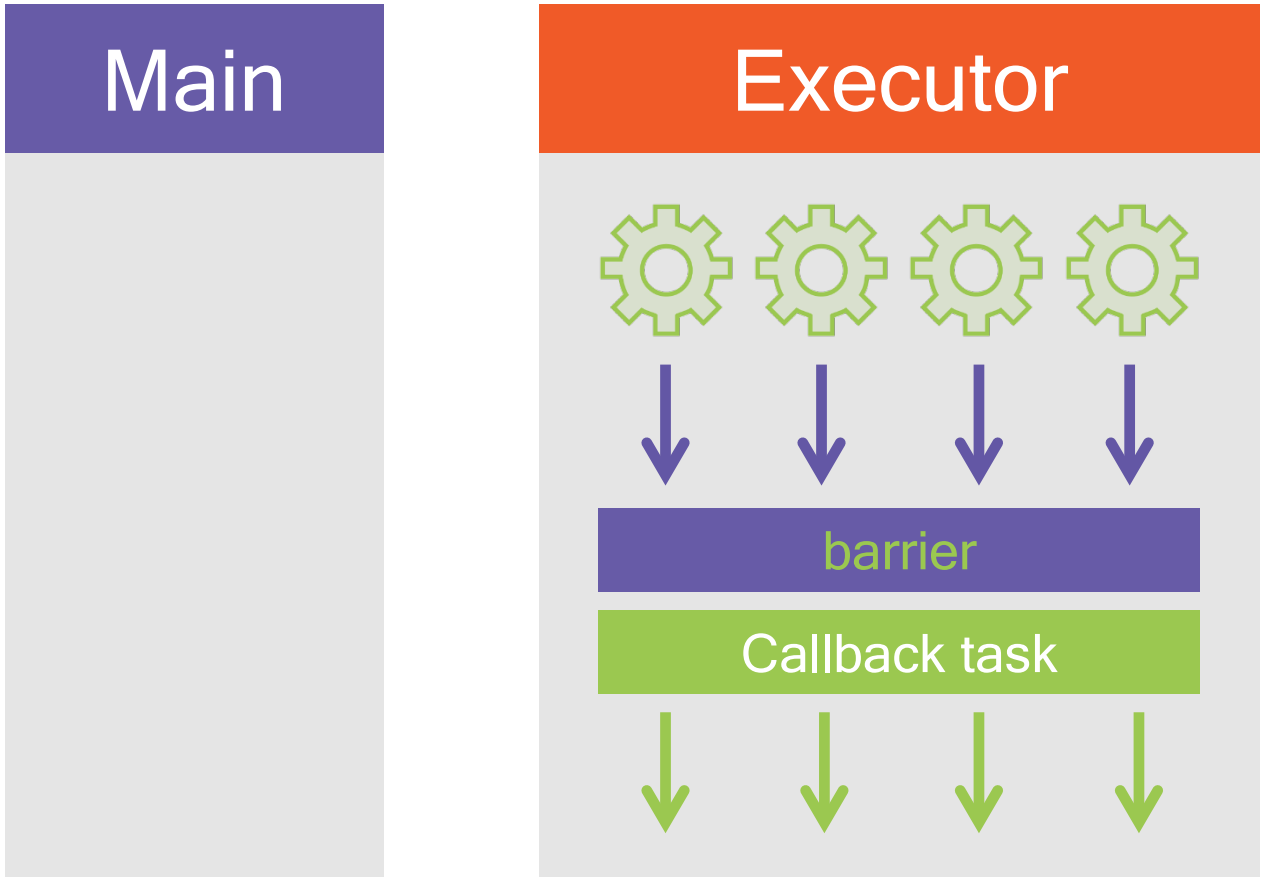

```
public class Worker implements Callable<List<Integer>> {

  private CyclicBarrier barrier;
  private List<Integer> inputList;

  public void Worker(CyclicBarrier barrier, List<Integer> inputList) {
    this.barrier = barrier;
    this.inputList = inputList;
  }

  public List<Integer> call() {
    List<Integer> result = findPrimes(inputList);
    try {
      barrier.await();
    } catch(InterruptedException | BrokenBarrierException e) {
      // Error handling
    }
    return result;
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    }
    return result;
  }
}
```

```
CyclicBarrier barrier = new CyclicBarrier(4);
ExecutorService service = Executors.newFixedThreadPool(4);

Worker worker1 = new Worker(barrier, inputList1);
// More workers

Future<List<Integer>> future1 = service.submit(worker1);
// More submissions

List<Integer> finalResult = new ArrayList<>(future1.get());
finalResult.addAll(future2.get());
// More results
```

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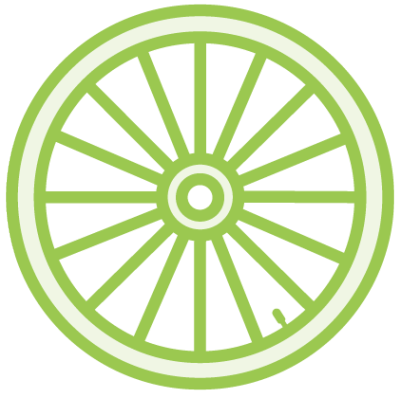


The await() call is blocking

There are two versions:
- await()
- await(time, timeUnit)

Once opened a barrier is normally reset

The reset() method resets the barrier exceptionnally, causing the waiting tasks to throw a BrokenBarrierException

Handling of Errors

A BrokenBarrierException is raised if:

- a thread is interrupted while waiting

- the barrier is reset while some threads are waiting

CyclicBarrier

A tool to synchronize several threads between them, and let them continue when they reach a common point

A CyclicBarrier closes again once opened, allowing for cyclic computations, can also be reset

The threads can wait for each other on time outs

Latches

Stating the Problem

We need to start our application

An AuthenticationService, a DataService and an OrderService

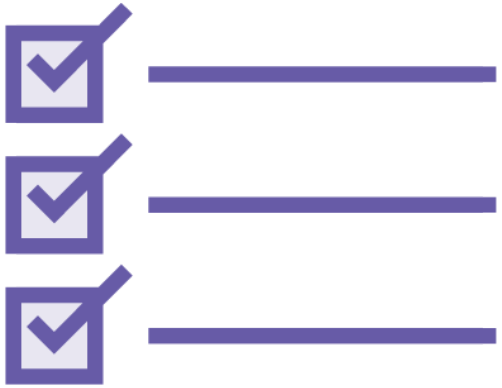
Before serving clients, our application needs to make sure that several resources are properly initialized

Can We Use a CyclicBarrier?

It seems that we can use a CyclicBarrier

But once all the services are available and our application starts…

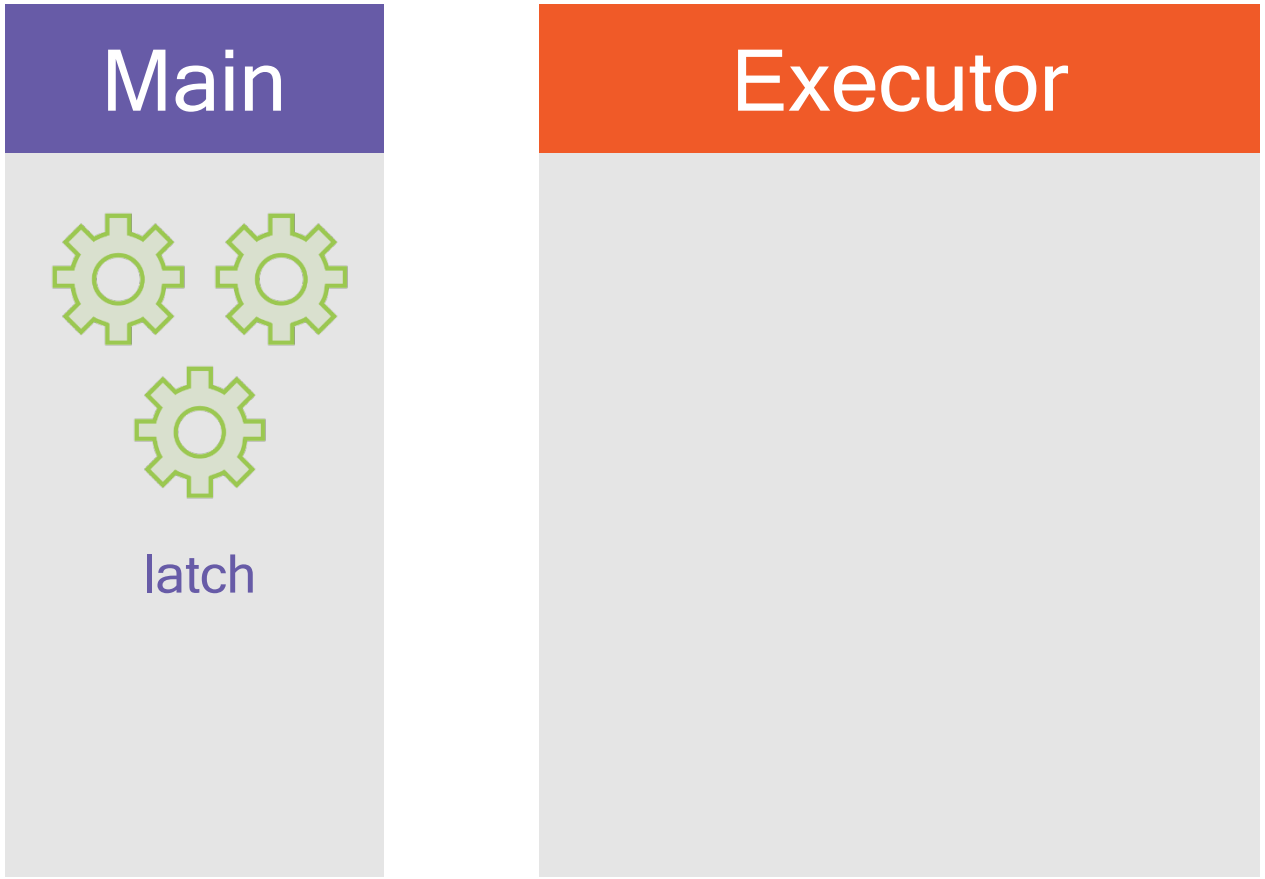
…we do not want the barrier to reset, thus blocking everything!



We need a kind of barrier that, once opened, cannot be closed

This is the countdown latch

How Does the CountDownLatch Work?



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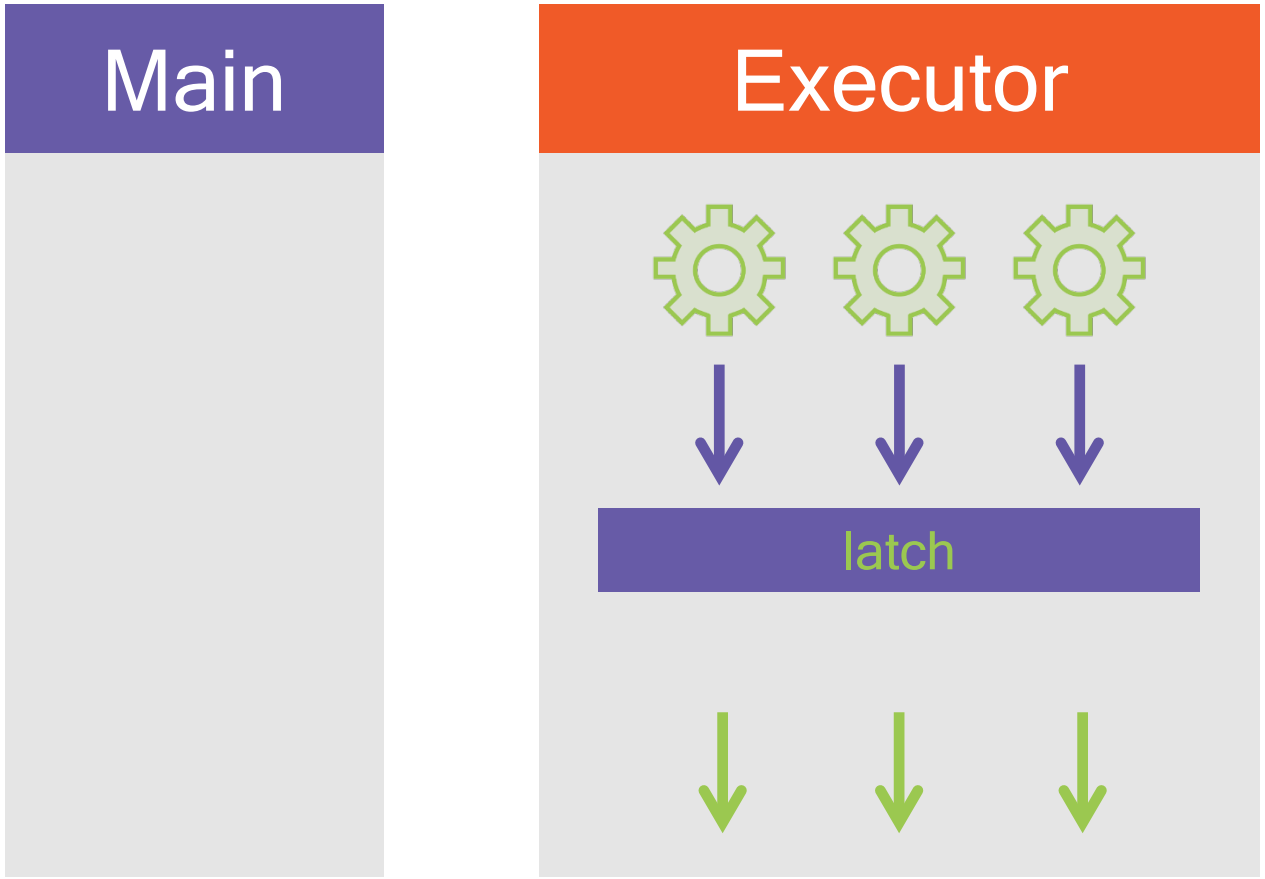

```
public class ServiceWorker implements Callable<List<Integer>> {

   private CountDownLatch latch;
   private Service service;

   public boolean Worker(CountDownLatch latch, Service service) {
      this.latch = latch;
      this.service = service;
   }

   public void call() {
      service.init();

      latch.countDown();
   }
}
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```

```
CountDownLatch latch = new CountDownLatch(3);
ExecutorService executor = Executors.newFixedThreadPool(4);

ServiceWorker worker1 = new Worker(latch, dataService);
// More workers

Future<Boolean> future1 = executor.submit(worker1);
// More submissions

try {
   latch.await(10, TimeUnit.SECONDS); // blocks until the count reaches 0
   server.start();
} catch(InterruptedException e) {
   // Error handling
}
```

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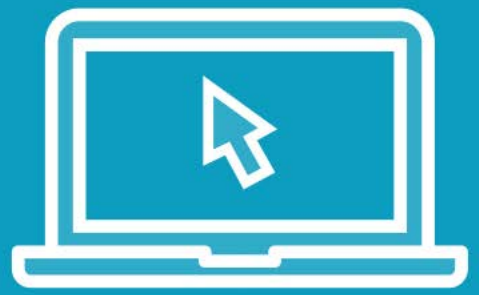
CountDownLatch

A tool to check that different threads did their task

And synchronize the beginning of subsequent tasks on the last one to complete

Once open CountDownLatch cannot be closed again

Demo



Let us see some code!

Let us see a barrier in action

Demo Wrapup

What did we see?

How to create barriers with callbacks to have threads wait for each other

How to set a time out on the CyclicBarrier.await() call

How to set a time out and a cancel on a Future.get() call

Module Wrapup

What did we learn?

There are two tools to trigger an action on the completion of other actions

The CyclicBarrier: useful for parallel computations

The CountDownLatch: useful for starting an application on the completion of different initializations