Understanding CASing and Atomic Variables

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Agenda

CASing!

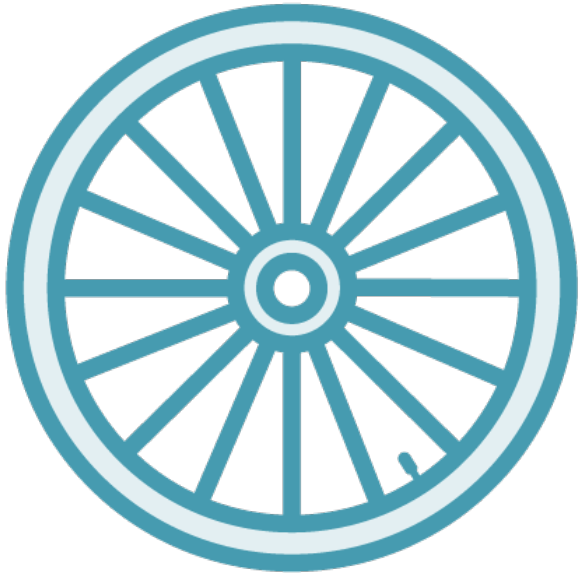
What does compare and swap mean?

And why is it useful?

What is in the JDK to implement CASing?

How and when to use it

CASing = “Compare And Swap”



The starting point is a set of assembly instructions

Very low level functionalities given by the CPU

That are exposed at the API level so that we can use them in our applications

What is CASing?

Concurrent Read / Write

The problem in concurrent programming is the concurrent access to shared memory

We used synchronization to handle that

But in certain cases, we have more tools

Concurrent Read / Write

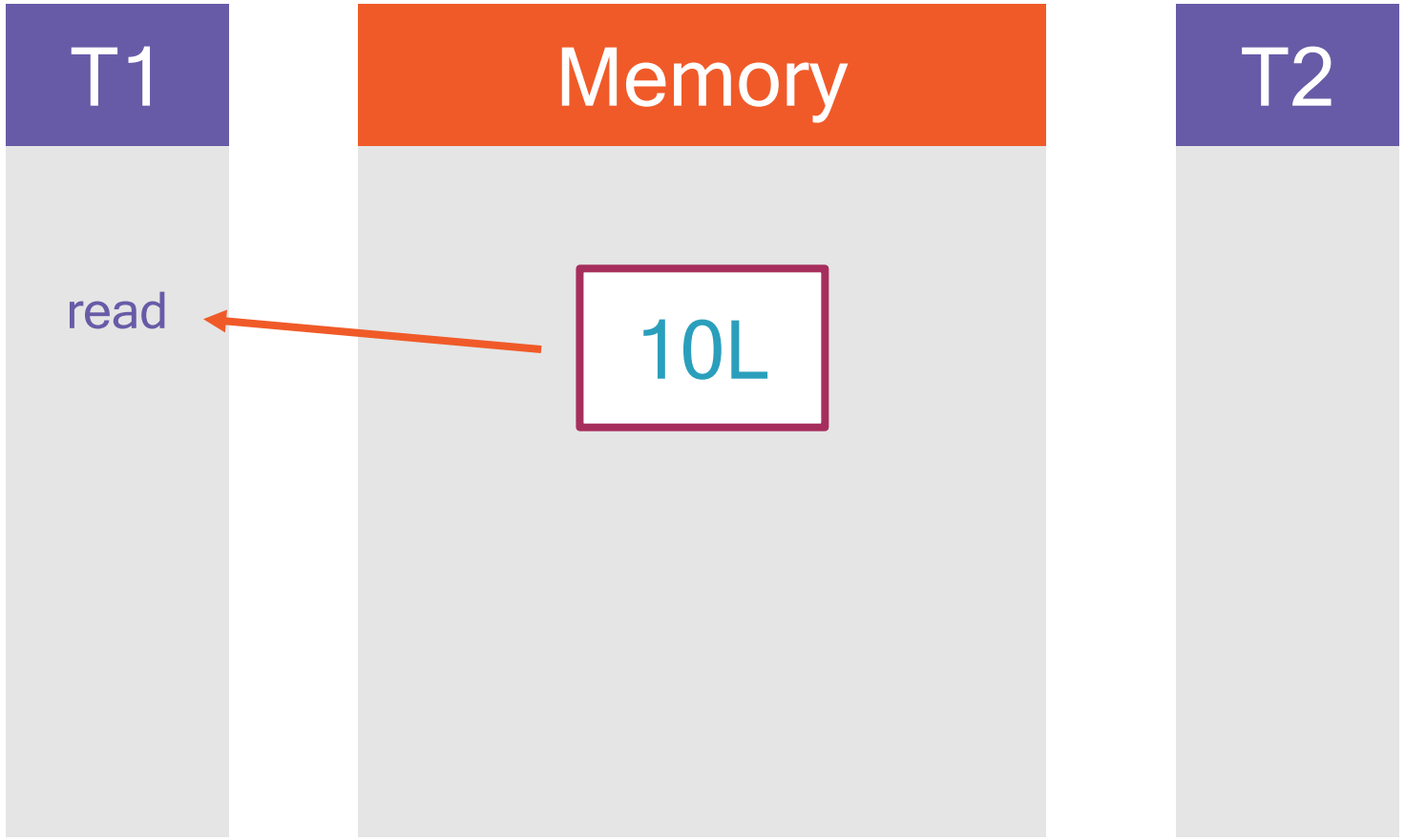
Synchronization has a cost...

Is it really always essential to use it?

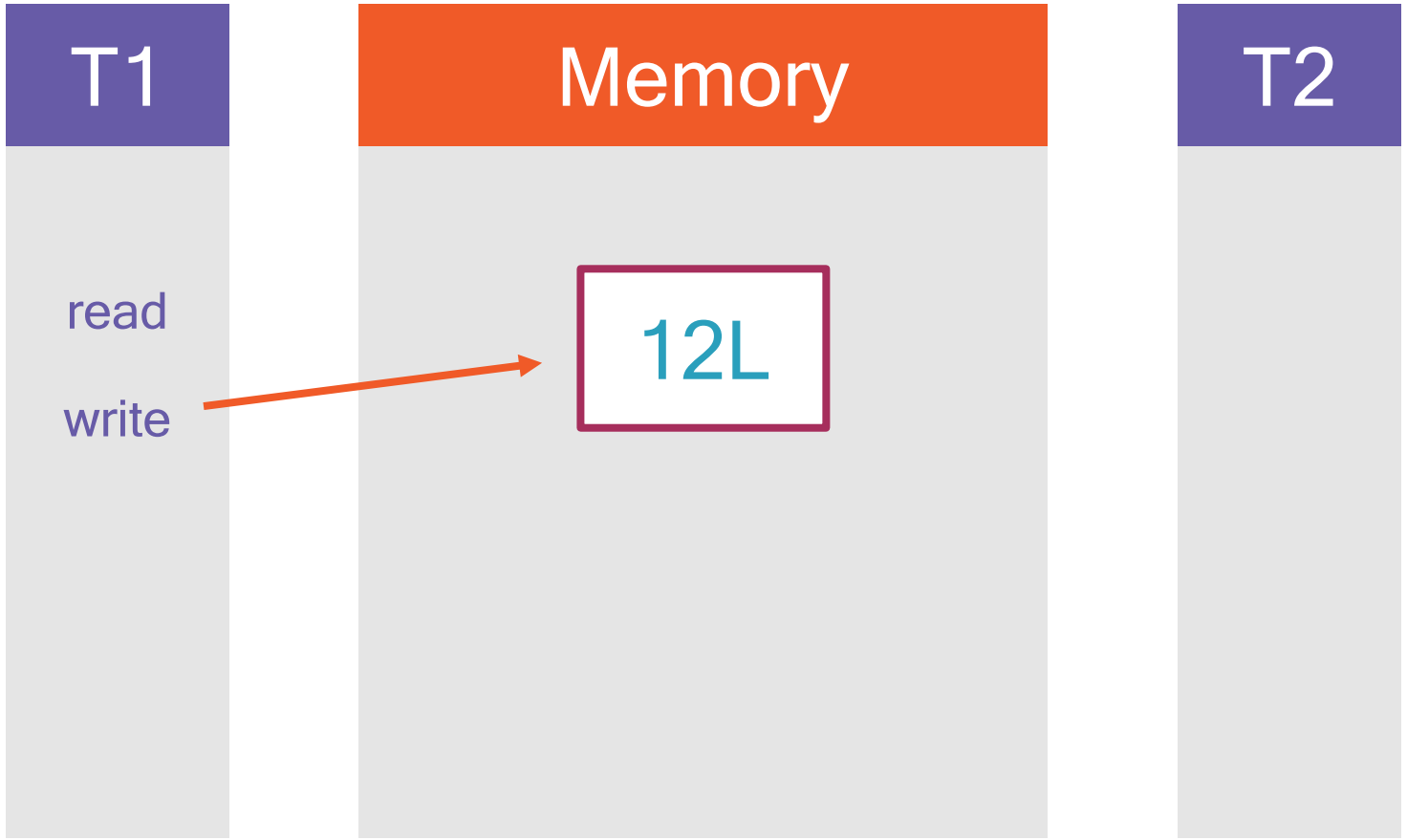
In fact we use it to be sure that our code is correct

What if in fact, real concurrency is rare?

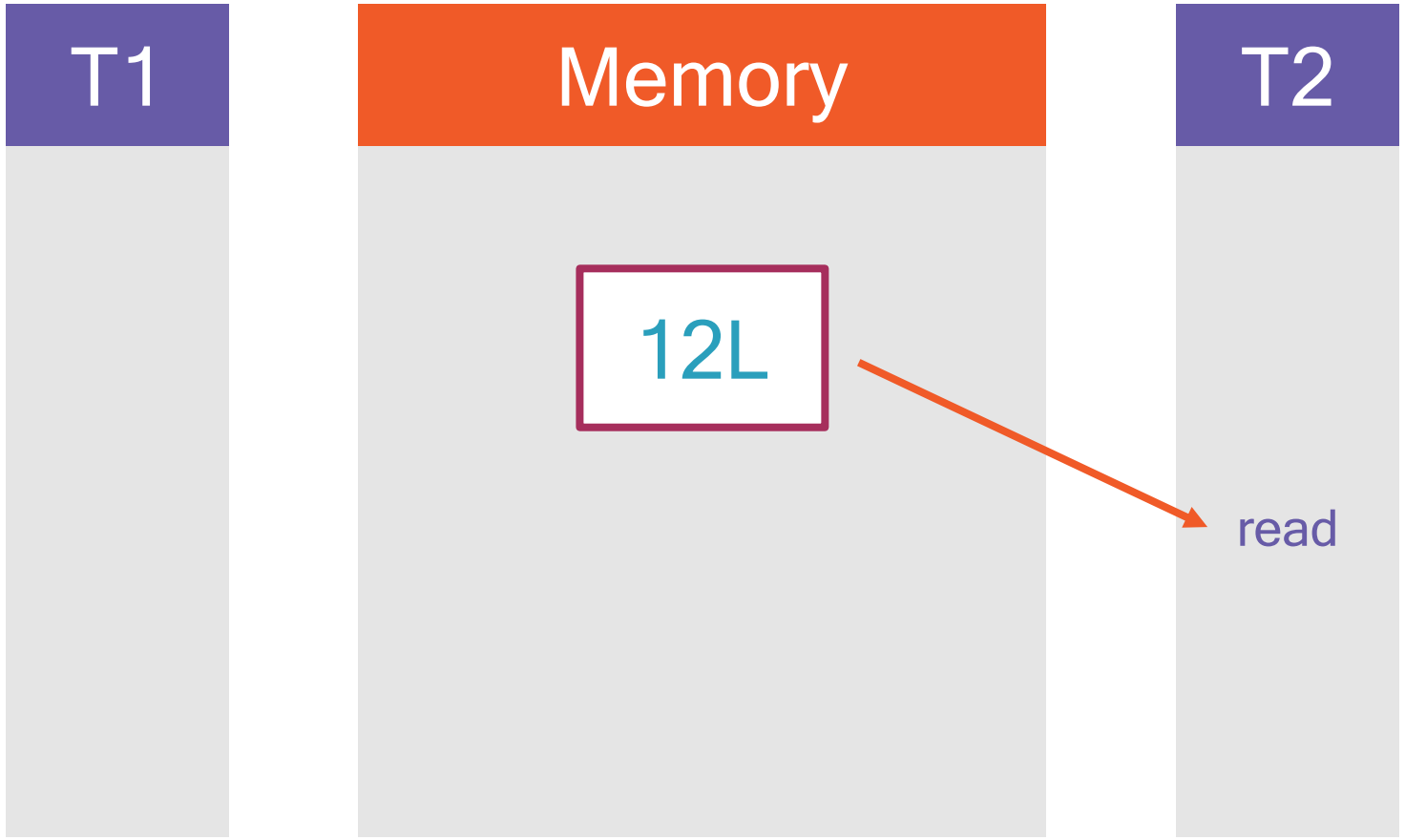
Synchronized Memory



Synchronized Memory



Synchronized Memory



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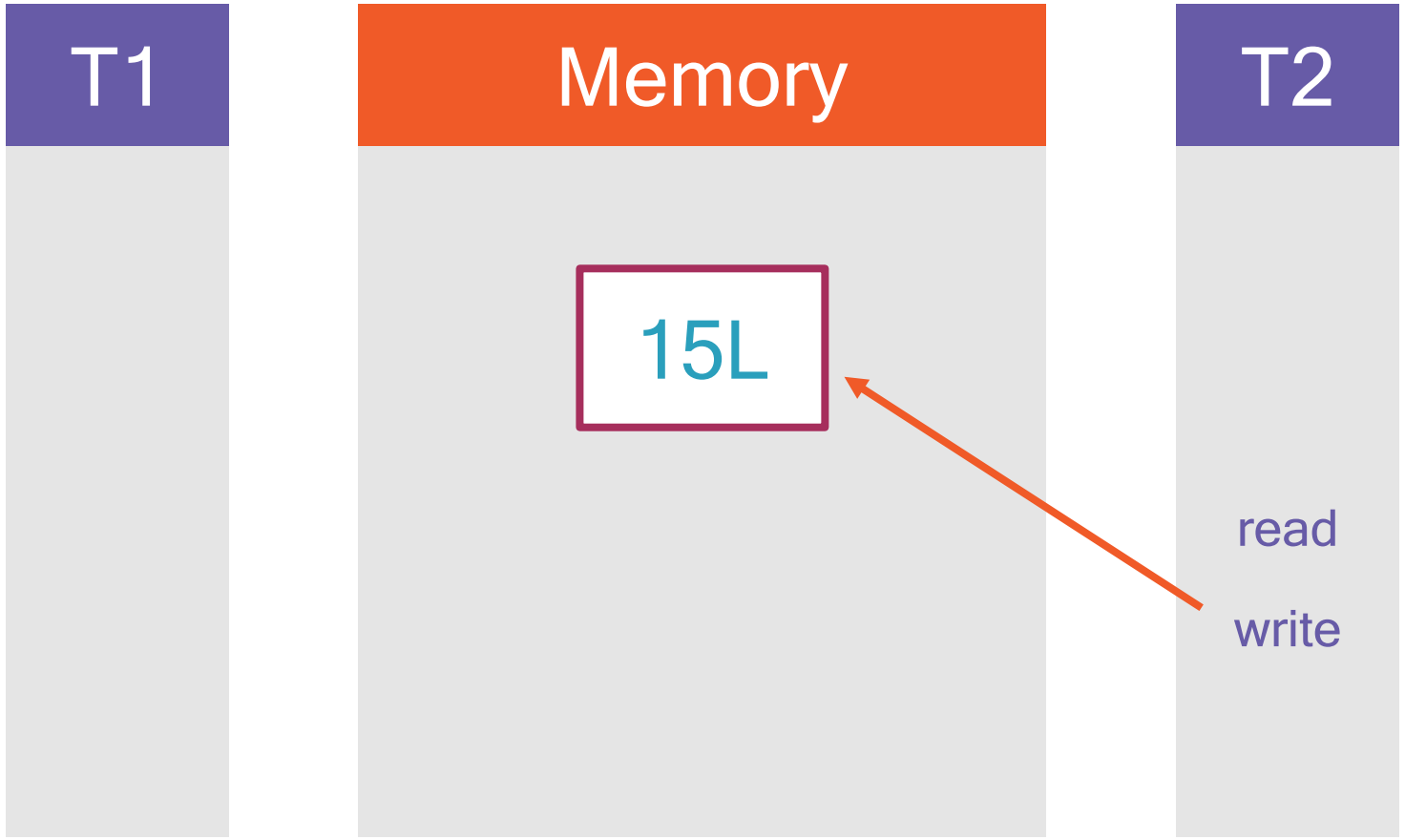


Concurrent Read / Write

We need to write a correct code, so protection by lock is essential

But in fact, there is no real concurrency at runtime…

This is where CASing can be used

CASing

Compare and Swap works with three parameters:

- a location in memory
- an existing value at that location
- a new value to replace this existing value

CASing

If the current value at that address is the expected value, then it is replaced by the new value and returns true

If not, it returns false

All in a single, atomic assembly instruction

```
// Create an atomic long
AtomicLong counter = new AtomicLong(10L);

// Safely increment the value
long newValue = counter.incrementAndGet();
```

Example with AtomicLong

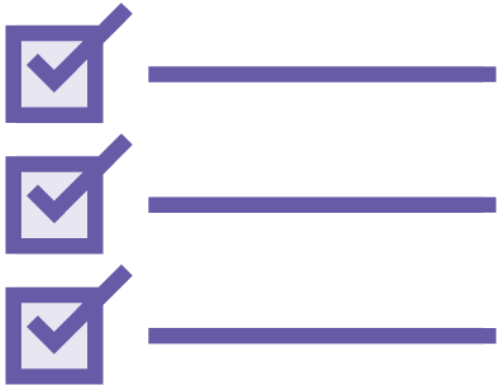
Safe incrementation of a counter without synchronization

Under the Hood

The Java API tries to apply the incrementation

The CASing tells the calling code if the incrementation failed

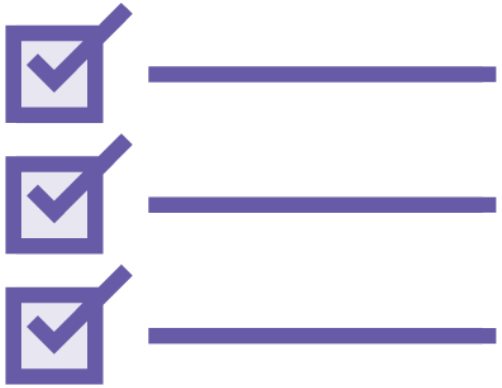
If it did, the API tries again



Let us browse through the API

We have several classes

With different functionalities...



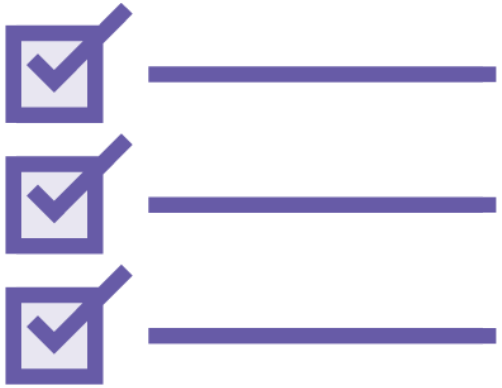
We have:

AtomicBoolean

- get(), set()

- getAndSet(value)

- compareAndSet(expected, value)



We have:

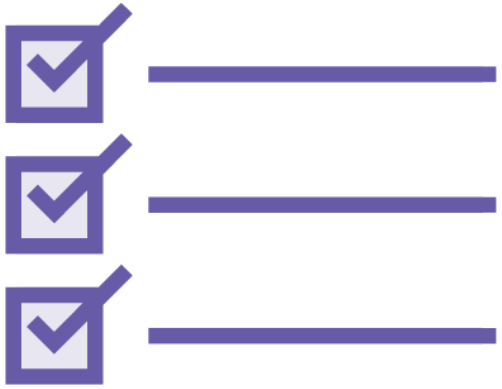
AtomicInteger, AtomicLong

- get(), set()

- getAndSet(value)

- compareAndSet(expected, value)

- getAndUpdate(unaryOp), updateAndGet(unaryOp)



We have:

AtomicInteger, AtomicLong

- getAndIncrement(), getAndDecrement()

- getAndAdd(value), addAndGet(value)

- getAndAccumulate(value, binOp), accumulateAndGet(value, binOp)

We have:

AtomicReference<V>

- get(), set()

- getAndSet(value)

- getAndUpdate(unaryOp), updateAndGet(unaryOp)

- getAndAccumulate(value, binOp), accumulateAndGet(value, binOp)

- compareAndSet(expected, value)

About CASing

CASing works well when concurrency is not “too” high

CASing: many tries until it is accepted…

Synchronization: waiting threads until one can enter the synchronized block

CASing may create load on the memory and / or CPU

Atomic Variables

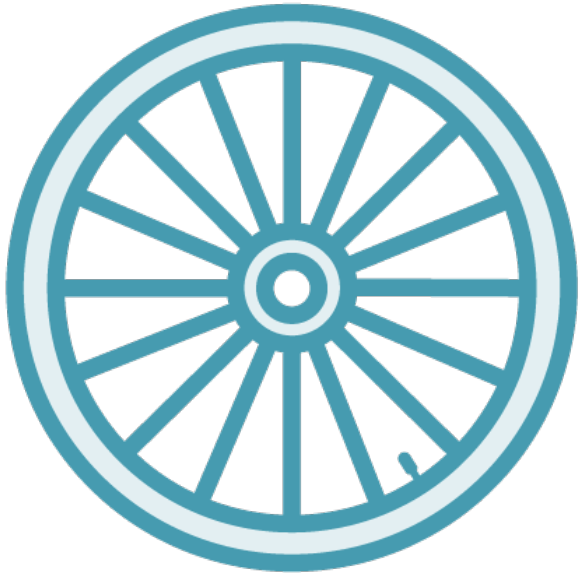
CASing is another tool to handle concurrent reads and writes

It is different from synchronization

Can lead to better performances

It should be used with care!

Adders and Accumulators



All the methods are built on the “modify and get” or “get and modify”

Sometimes we do not need the “get” part at each modification

Thus the LongAdder and LongAccumulator classes (Java 8)

LongAdder & LongAccumulator

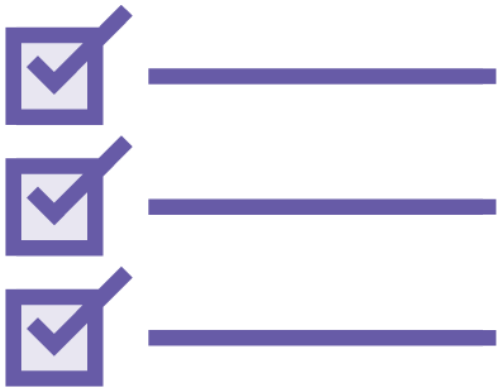
It work as an AtomicLong

It does not return the updated value

So it can distribute the update on different cells

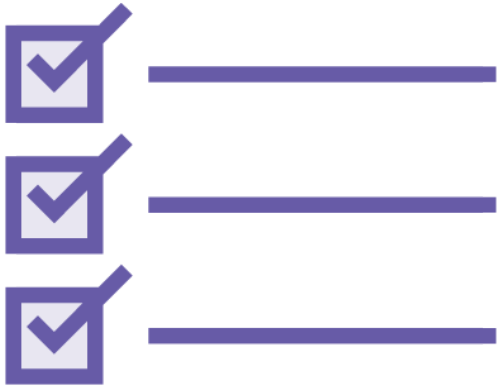
And merge the results on a get call

These are tailored for high concurrency



For the LongAdder:

- increment(), decrement()
- add(long)
- sum(), longValue(), intValue()
- sumThenReset()



For the LongAccumulator:

- built on a binary operator

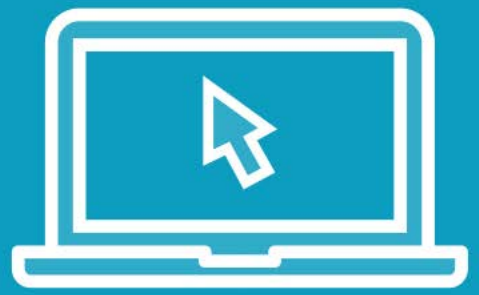
- accumulate(long)

- get()

- intValue(), longValue(), floatValue(), doubleValue()

- getThenReset()

Demo



Let us see some code!

Let us see some atomic counters in action

Demo Wrapup

What did we see?

How to create an atomic counter in a thread safe way without synchronization

Retrying is normal when using atomic operations, and should be expected

Module Wrapup

What did we learn?

When we need to update values or references in memory, CASing may be a better solution than locking

We have several tools with common operations

We still need to choose the right one, depending on the level of concurrency