Lets Talk About GIL

@aktech

Who am I?

Loves everything which is free and open!

Loves everything which is free and open!
including Software

The Telegraph

@Work

Process

an instance of a program running in a computer.

Thread

smallest sequence of programmed instructions

Thread

light weight and share memory.

Strength of Threads

Strength of Threads

shared state

"Everyone has everything"

- Raymond Hettinger

Weakness of Threads

Weakness of Threads

shared state

"Everyone can access everything"

Weakness of Threads

shared state

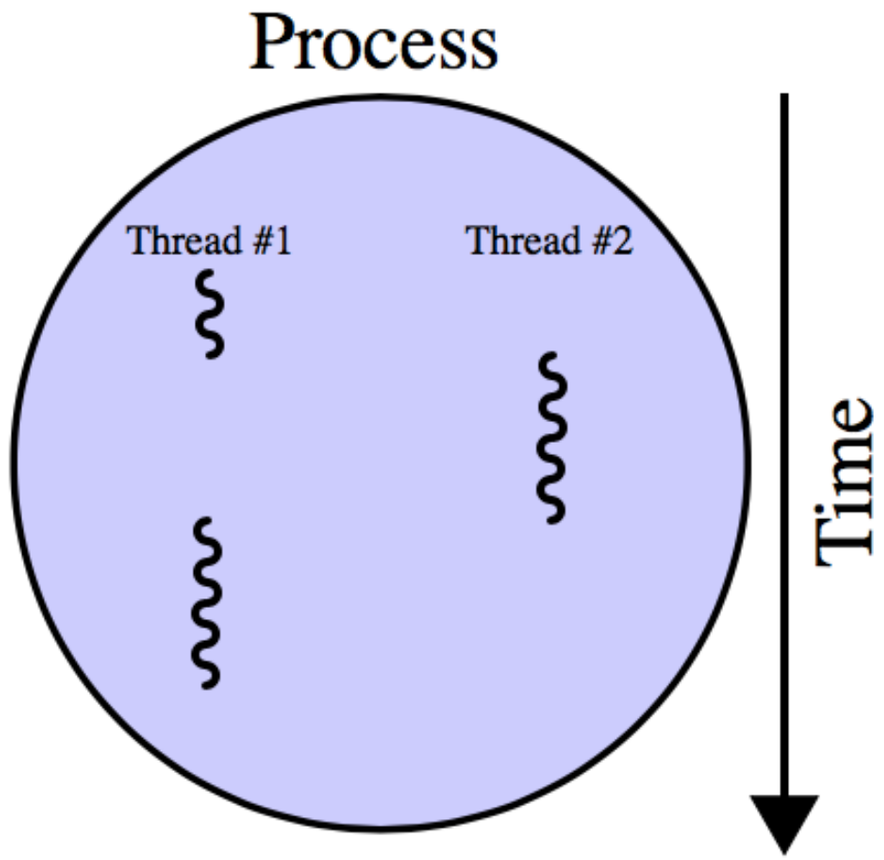
"Everyone can access everything"

Simultaneously!

Multithreading

The ability of a central processing unit (CPU) or a single core in a multi-core processor to execute multiple **threads concurrently**.

Multithreading



Why Multithreading?

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- Keep a Process Responsive

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- Keep a Processor Busy

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- Keep a Process Responsive
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- Keep Multiple Processors Busy

Why Multithreading?

- Keep a Process Responsive
- Keep a Processor Busy
- Keep Multiple Processors Busy
- Save Time

Multithreading in C++

Lets see an Example!

Multithreading in Python

Threading module in Python

Defining by Class

```
import time
import threading

class CustomThread(threading.Thread):
    def __init__(self, **kwargs):
        threading.Thread.__init__(self)
        self.param = kwargs.get('foo')

    def run(self):
        # This code executes in the Thread
```

Threading module in Python

functions as threads

```
def countdown(count):
      while count > 0:
          count -= 1
          time.sleep(5)

t1 = threading.Thread(target=countdown, args=(10,))
t1.start()
```

Lets See An Example

A Trivial Example

Lets do all the work **without** Threading

```
TOTAL_WORK = 10000000

def countdown(count):
    while count > 0:
        count -= 1

start = time.time()
countdown(TOTAL_WORK)  # Single Thread Execution
print(end - start)
```

- An Example by David Beazley

A Trivial Example

Lets do all the work **with** Threading

```
TOTAL_WORK = 10000000

def countdown(count):
     while count > 0:
          count -= 1

thread1 = threading.Thread(target=countdown, args=(TOTAL_WORK/2,))
thread2 = threading.Thread(target=countdown, args=(TOTAL_WORK/2,))

start = time.time()
thread1.start(); thread2.start()
thread1.join(); thread2.join()
end = time.time()

print(end - start)
```

Which one would be Faster?

All the work done sequentially ?

or

All the work divided in Two Threads?

All the work done sequentially took:
0.632690191269

All the work divided in Two Threads took:
0.91114282608

If **two people** divide a work, shouldn't it be faster than a **single person** doing all the work?

Lets Talk About GIL Now!

Global Interpreter Lock

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- The GIL ensures that only one thread runs in the interpreter at once.
- So, any time a thread is forced to wait, other "ready" threads get their chance to run.
- Whenever a thread runs, it holds the GIL

Processes

- I/O Bound:

  processes which are associated with input/output based activity like reading from files,etc.

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- I/O Bound:

  processes which are associated with input/output based activity like reading from files,etc.

- CPU Bound

  processes which spends the majority of its time simply using the CPU (doing calculations)

GIL Behaviour

For I/O Bound:

GIL is released on blocking I/O

GIL Behaviour

For CPU Bound:

Interpreter periodically performs a “check”,
every 100 interpreter "ticks"

Before Python 3.2

Tick?

- Roughly stated, a tick corresponds to a **Python bytecode operation**.
- For the most part that's true, however there are certain bytecode instructions that do not qualify as whole ticks.
- Ticks are **uninterruptible**. e.g. `>>> x in range(10^6)`
- The interpreter will not thread switch in the middle of a tick.

Why GIL?

Why GIL?

- Simplified implementation
- Easy to write C Extensions
- No Deadlocks!
- Works for I/O Bound processes!

Memory Management in Python

Reference Counting

os.getrefcount

Reference Counting

`Py_INCREF()`

`Py_DECREF()`

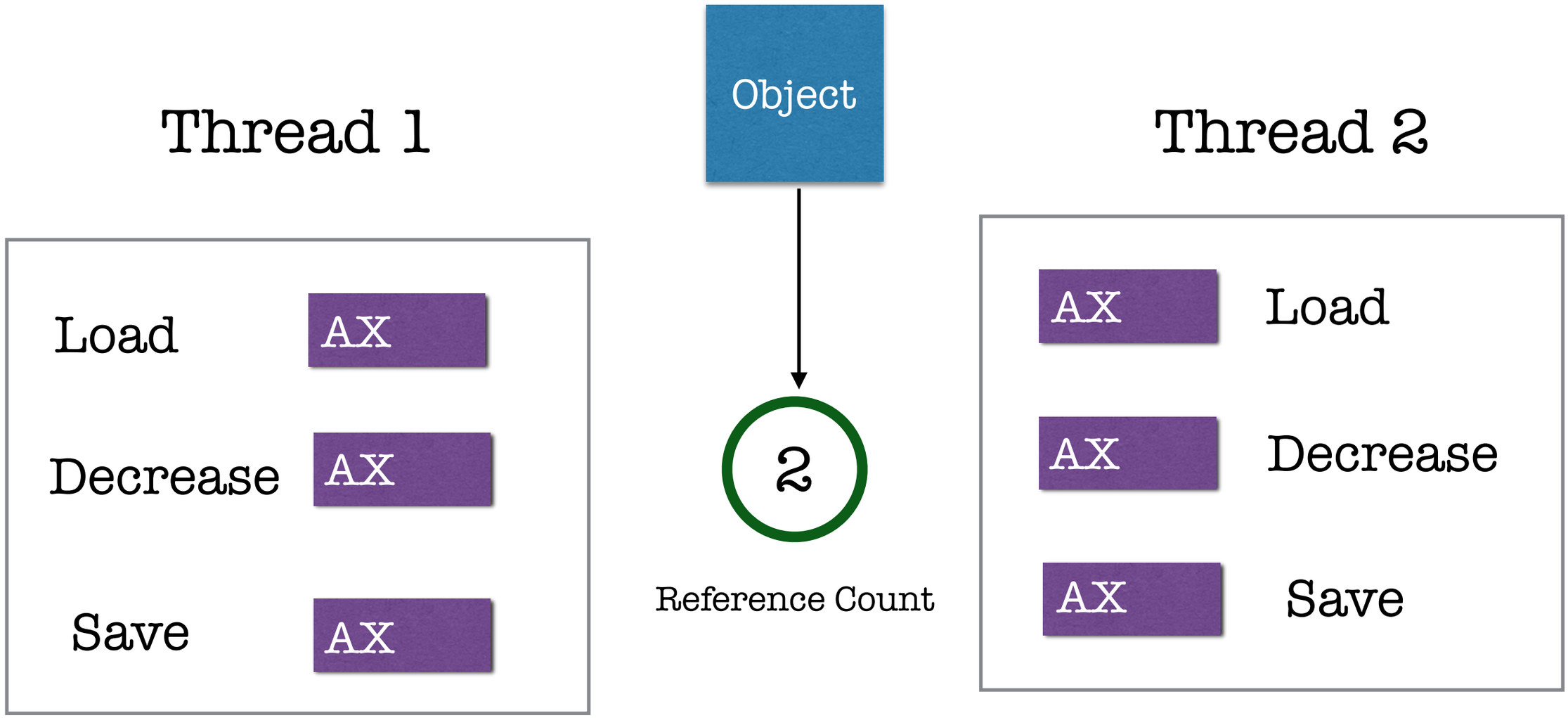
Methods in Python/C API

Reference Counting With Threads

Lets See an Example!

Py_DECREF()

Reference Counting With Threads



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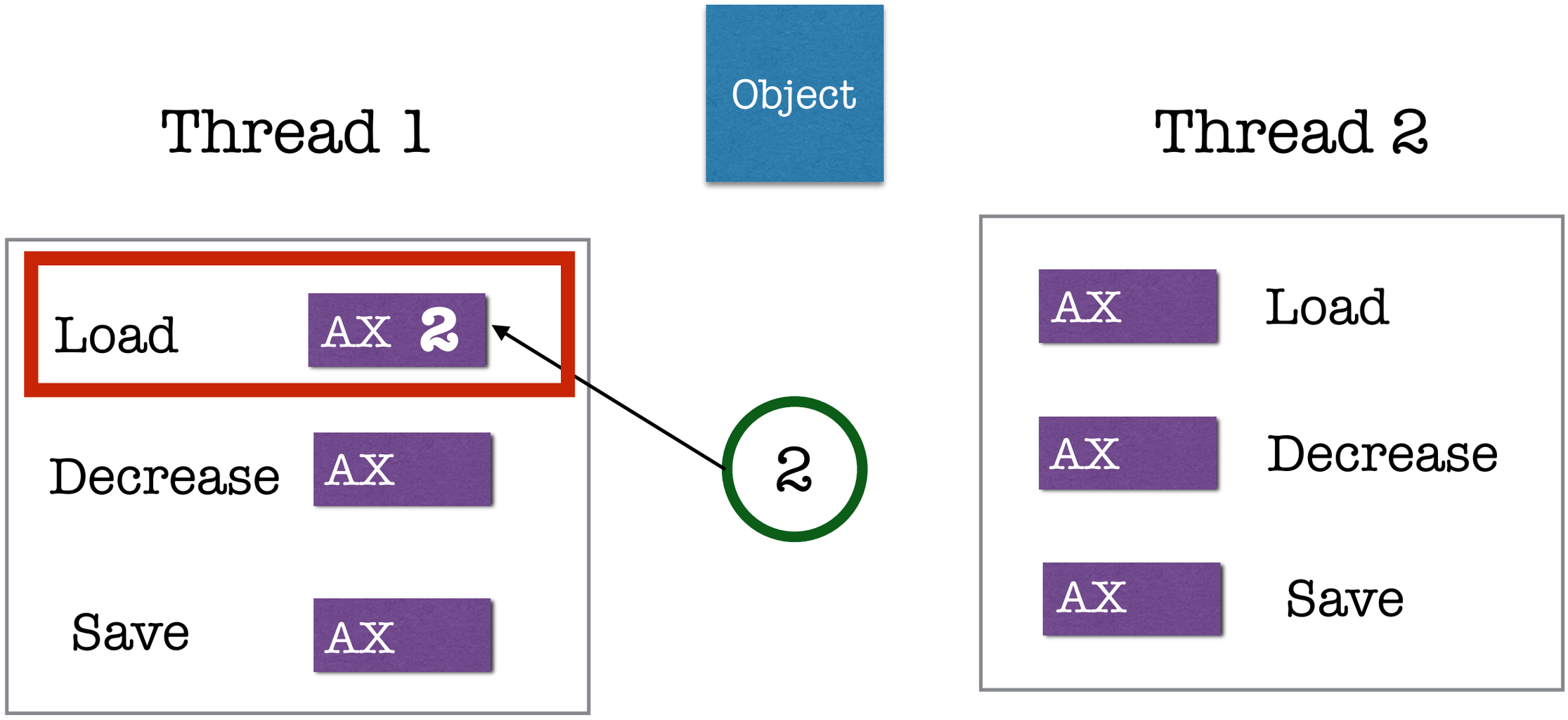

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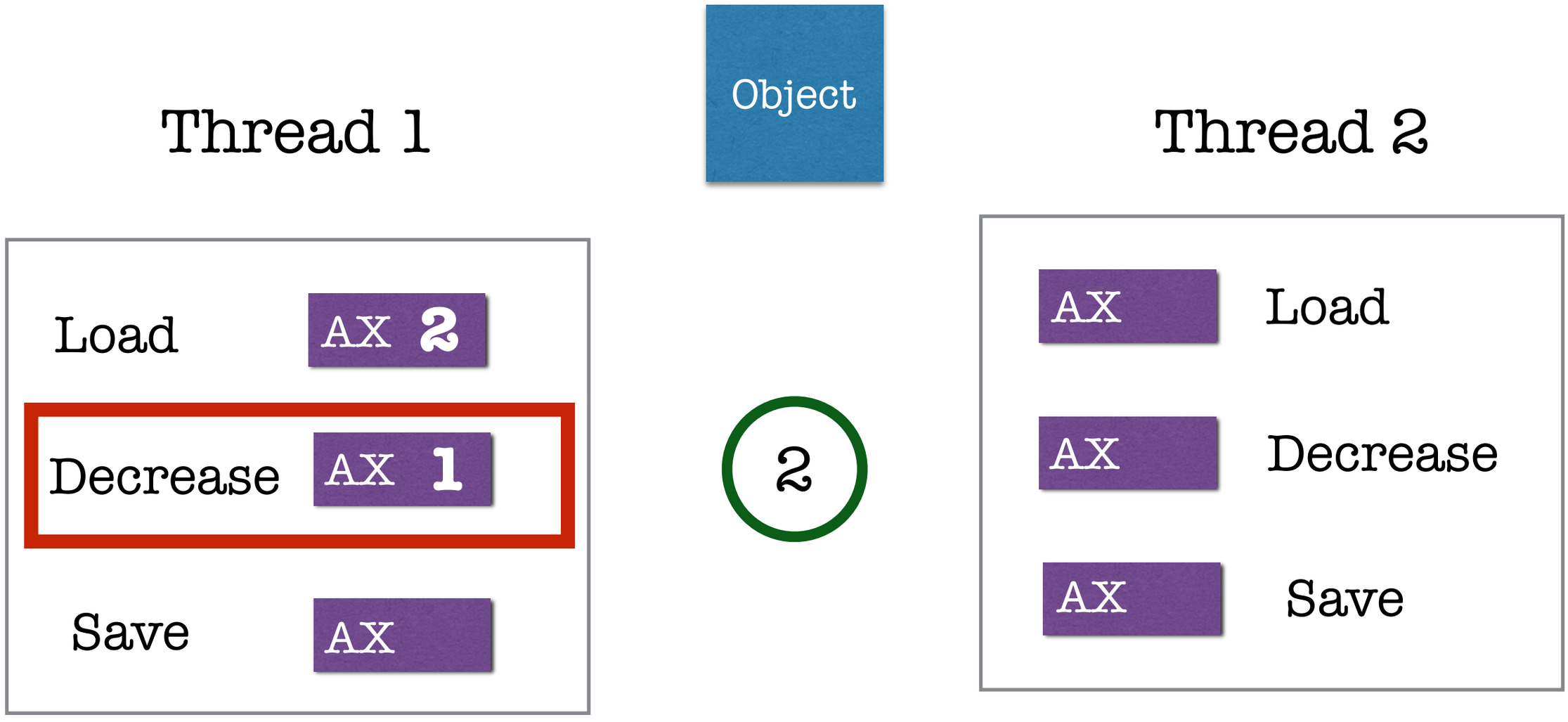

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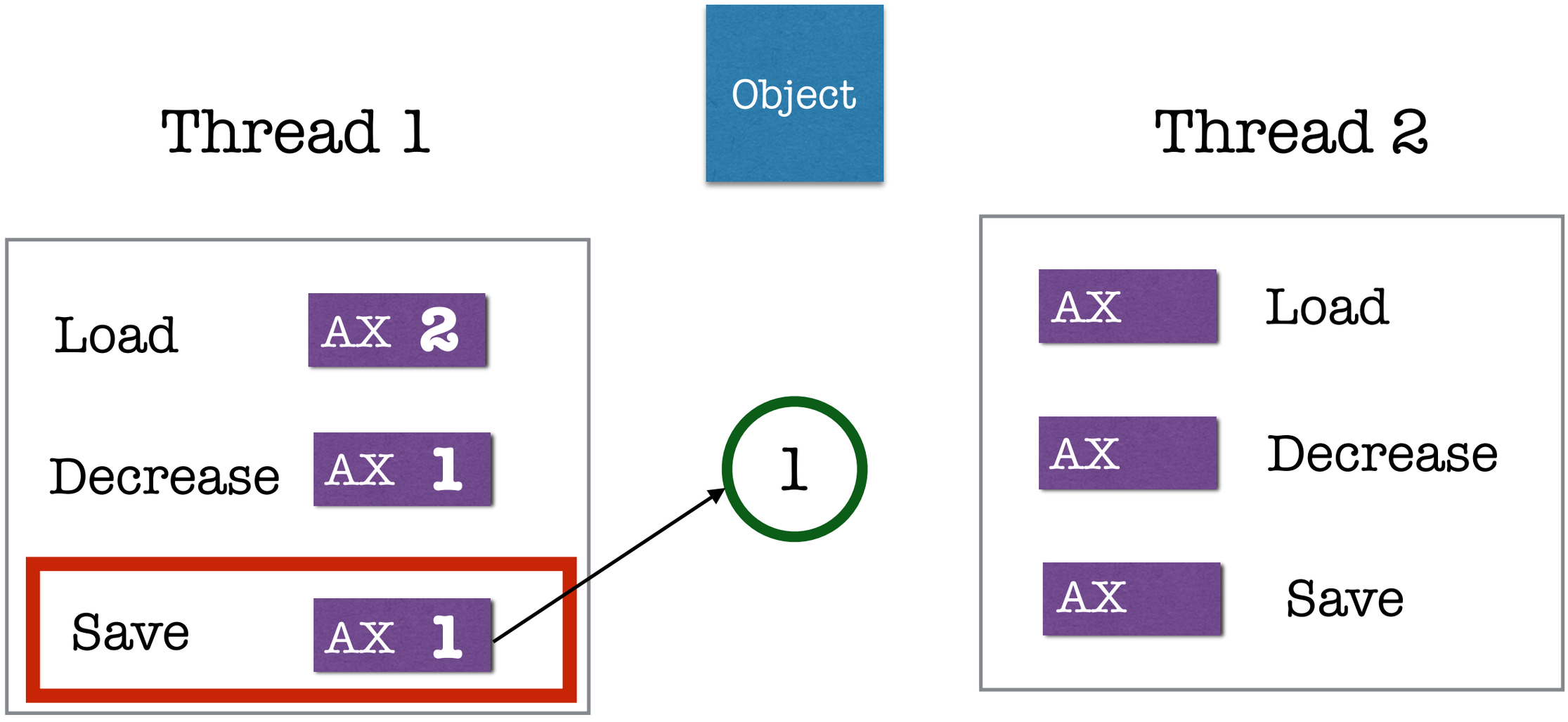

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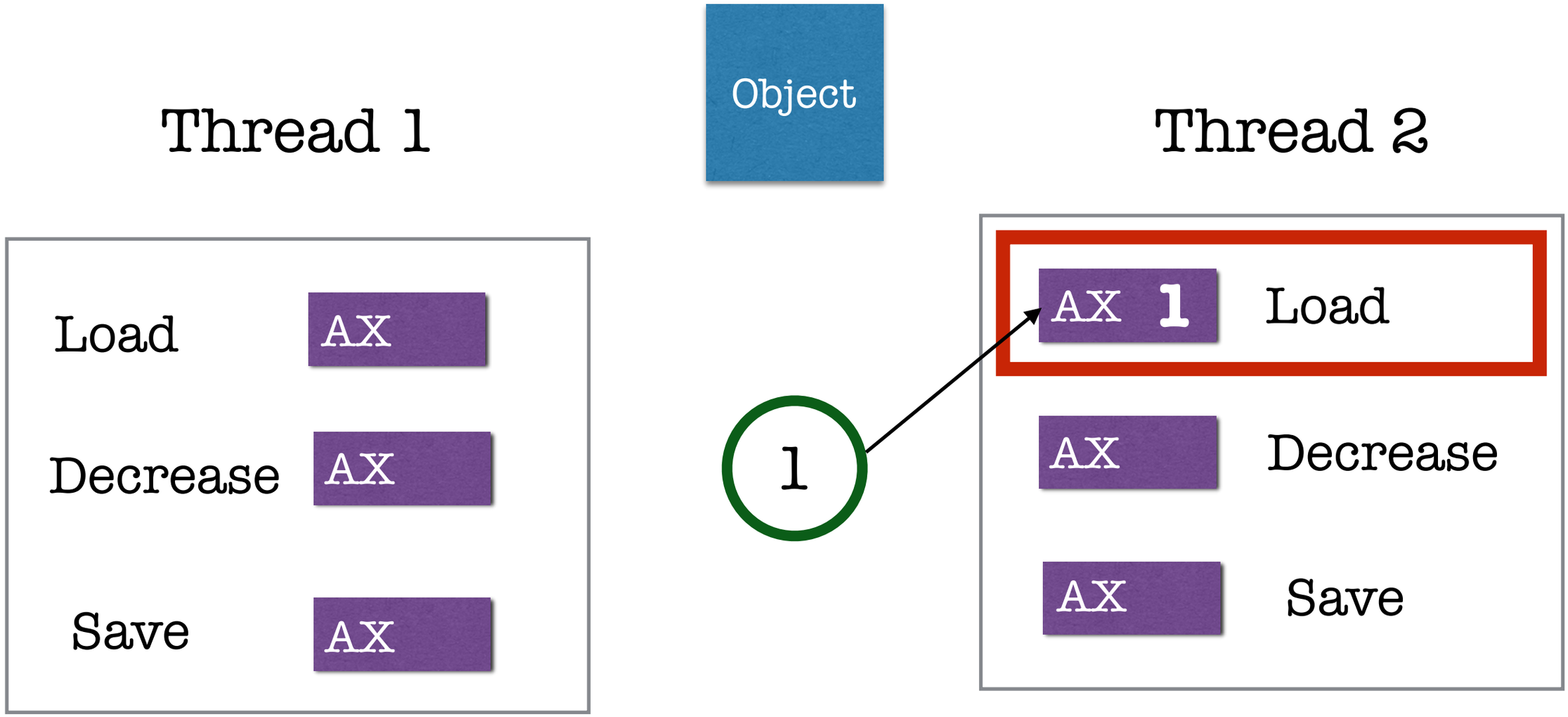

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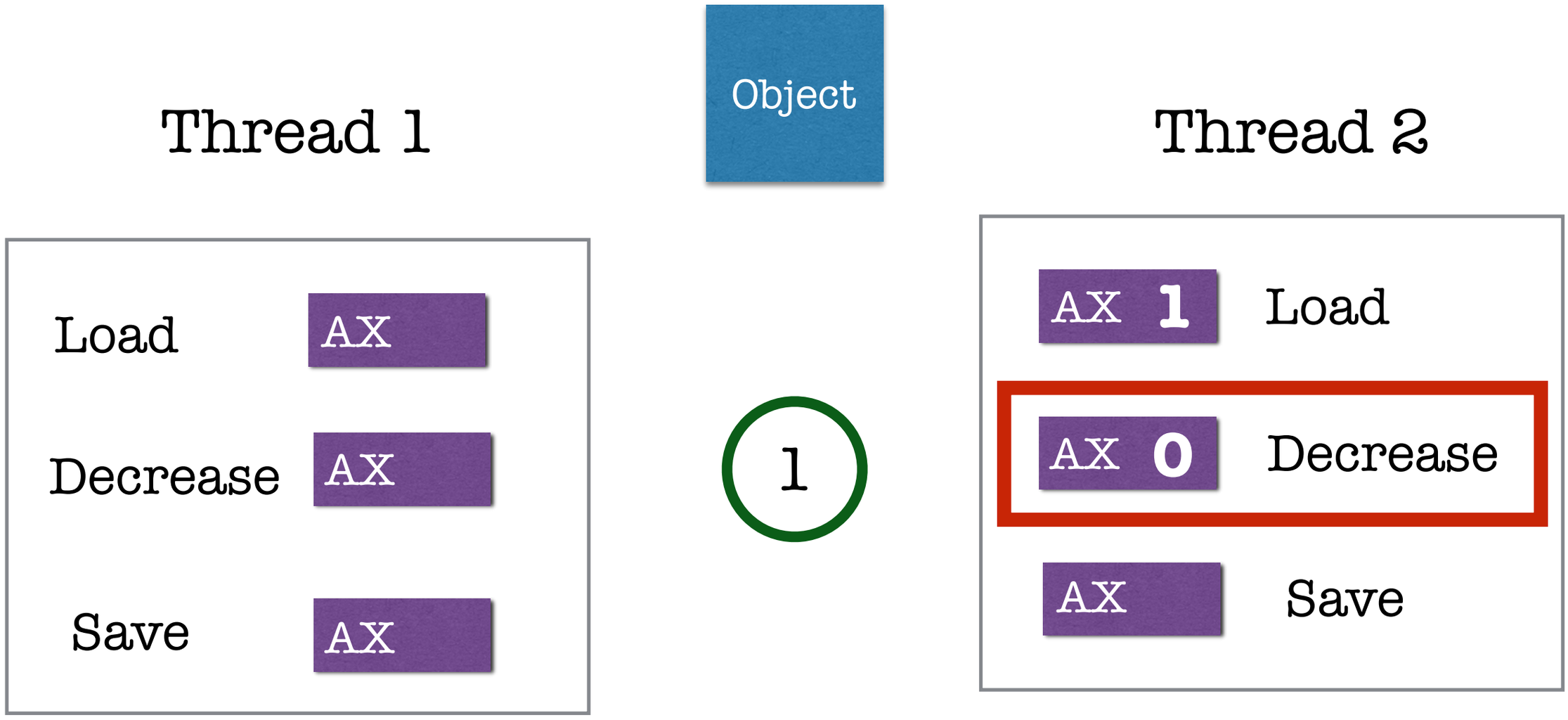

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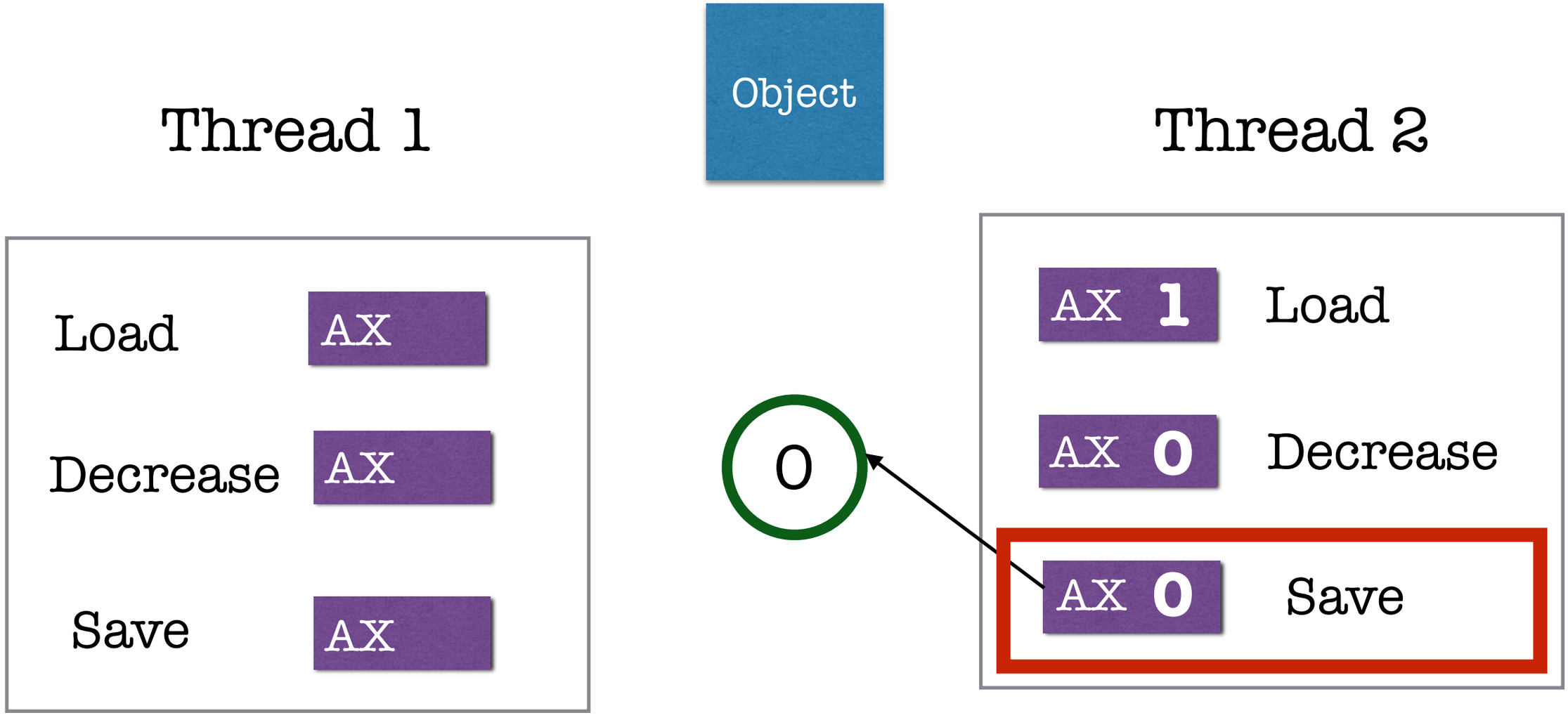

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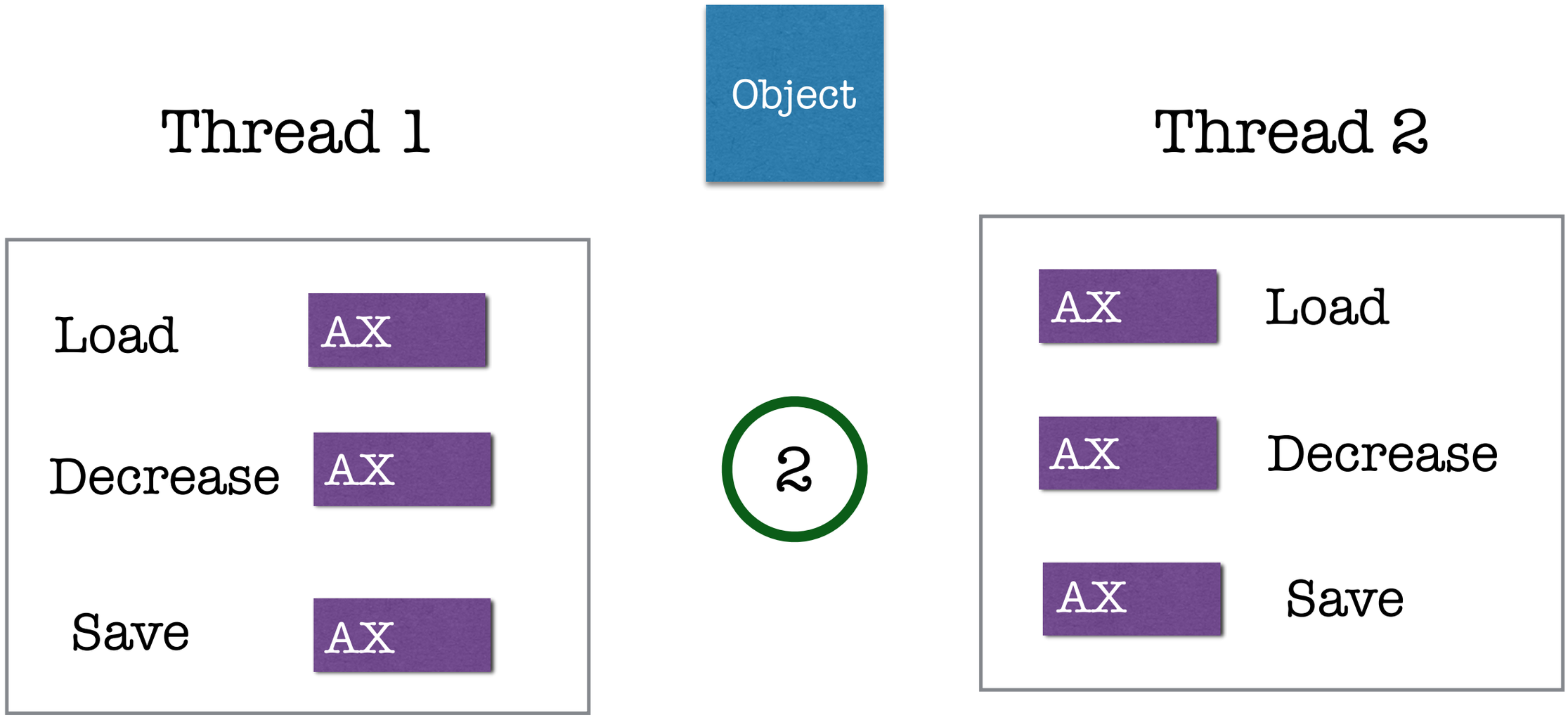

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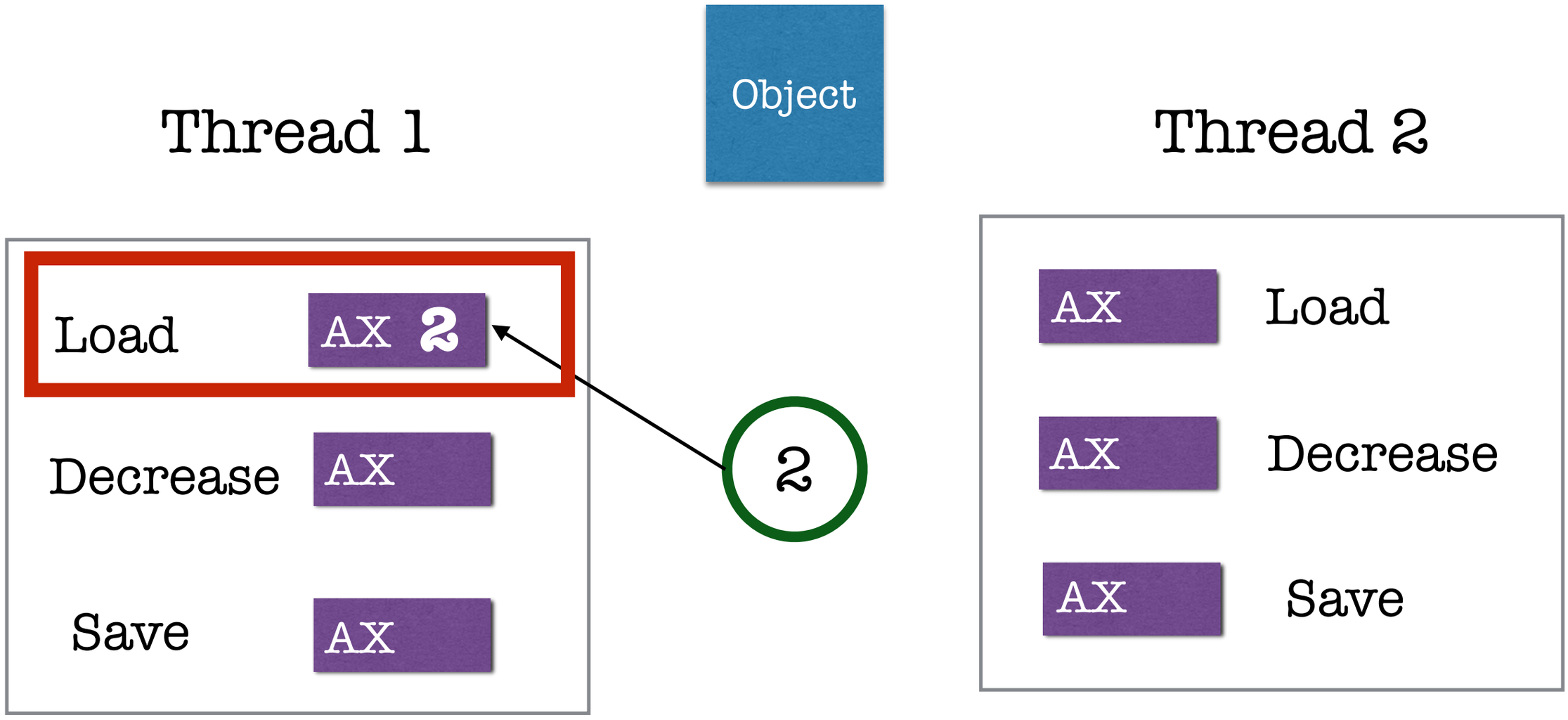

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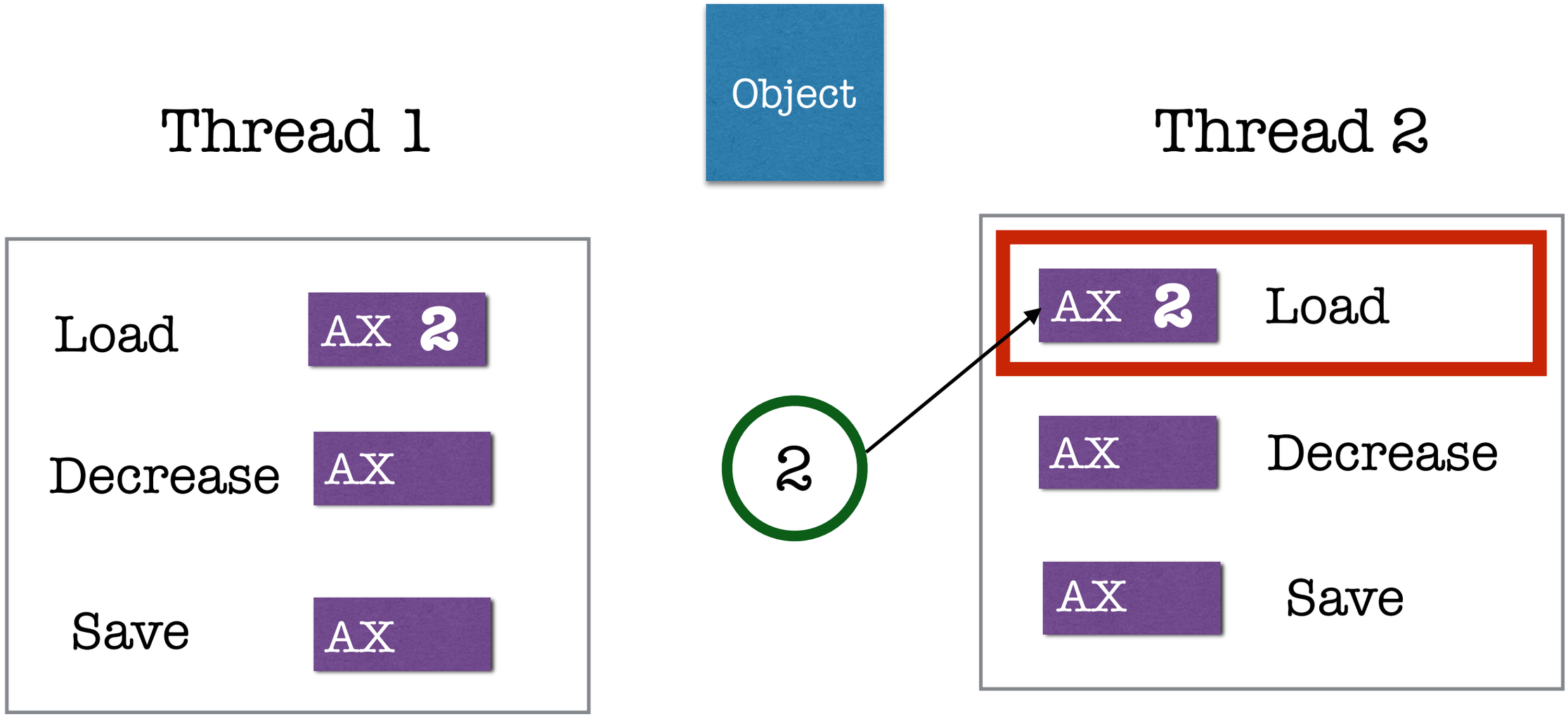

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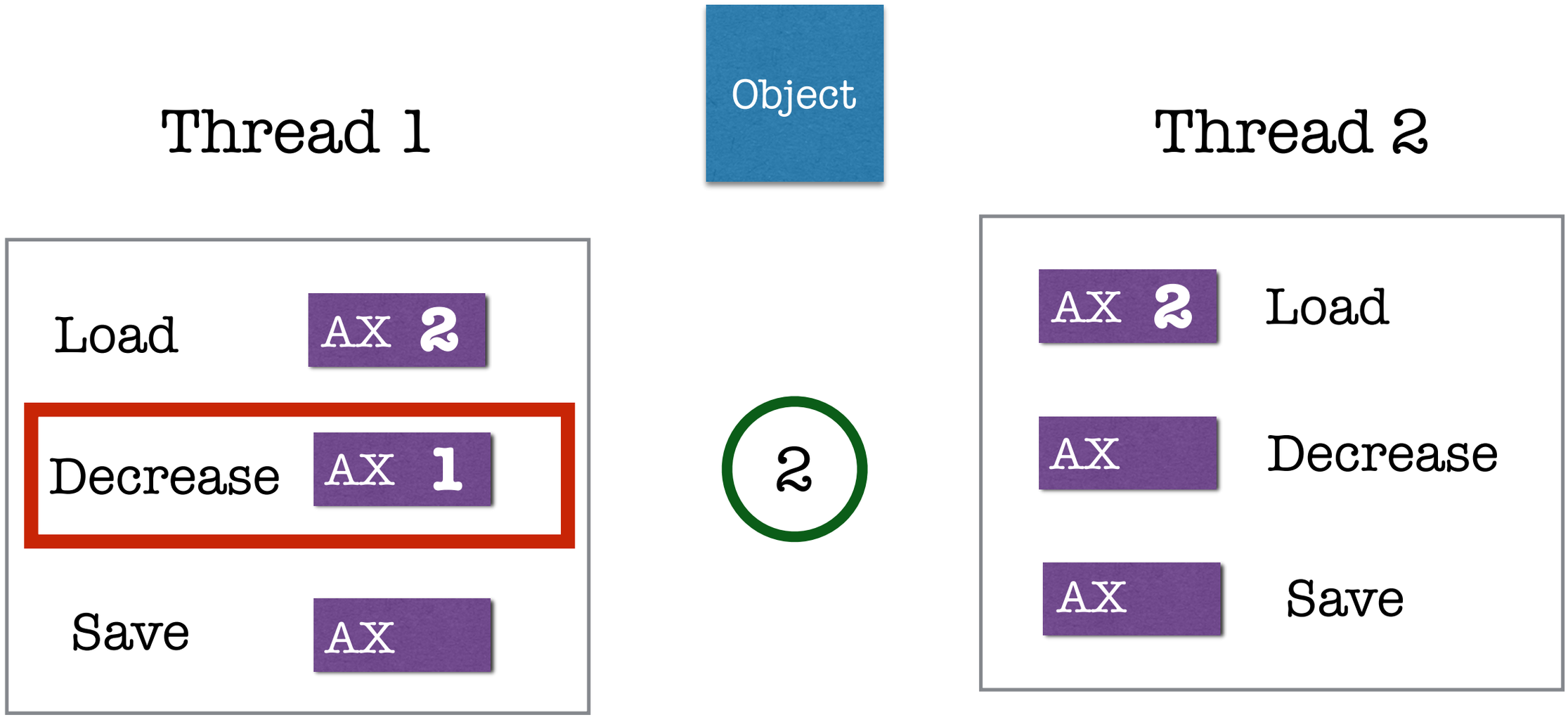

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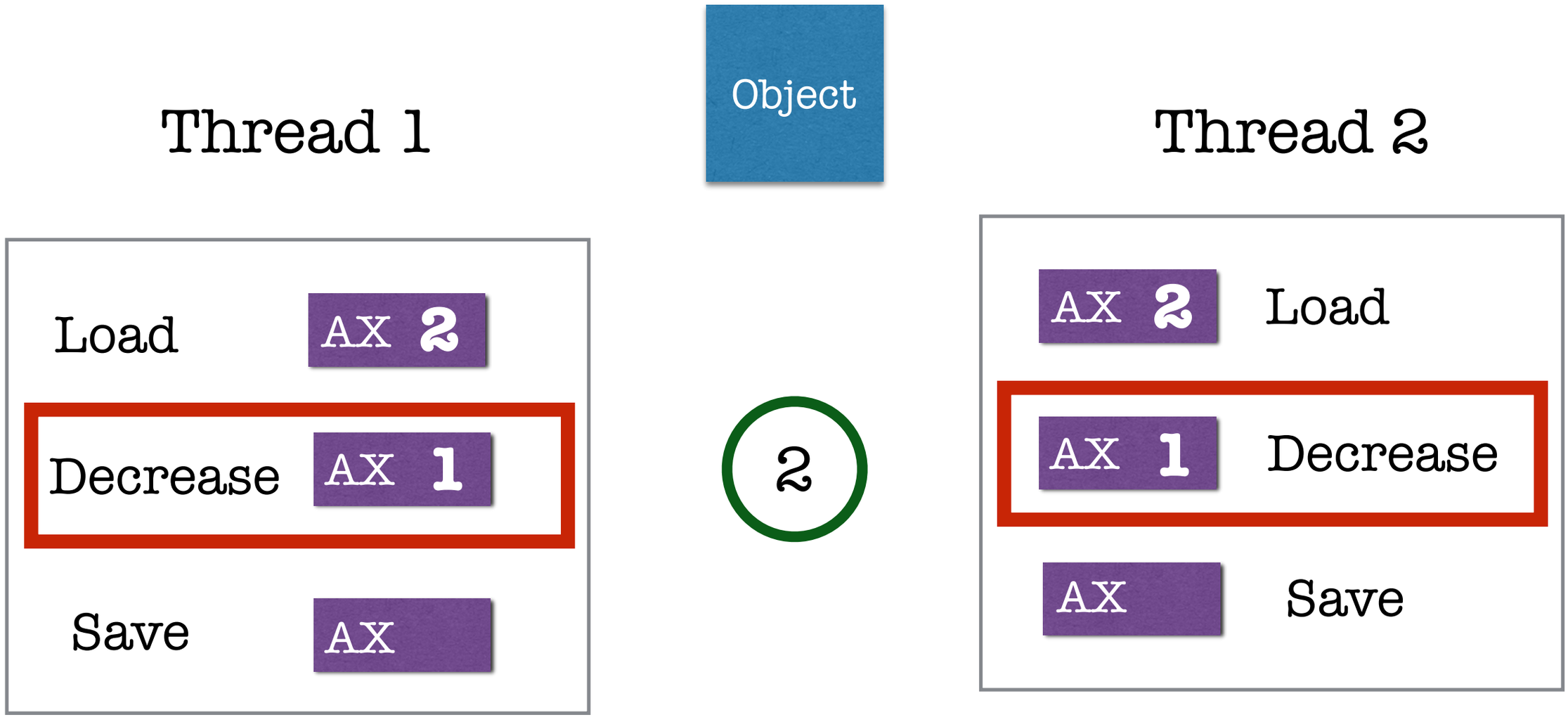

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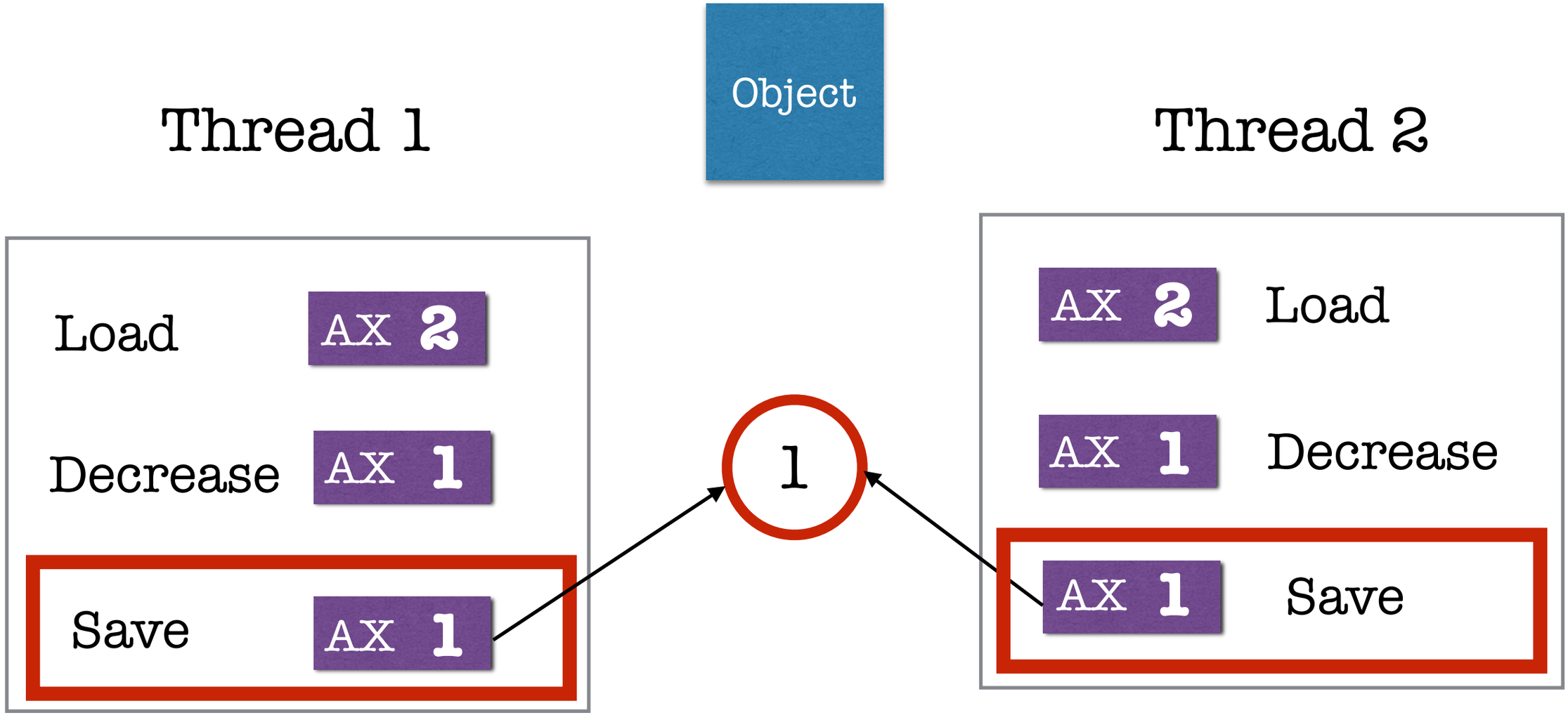
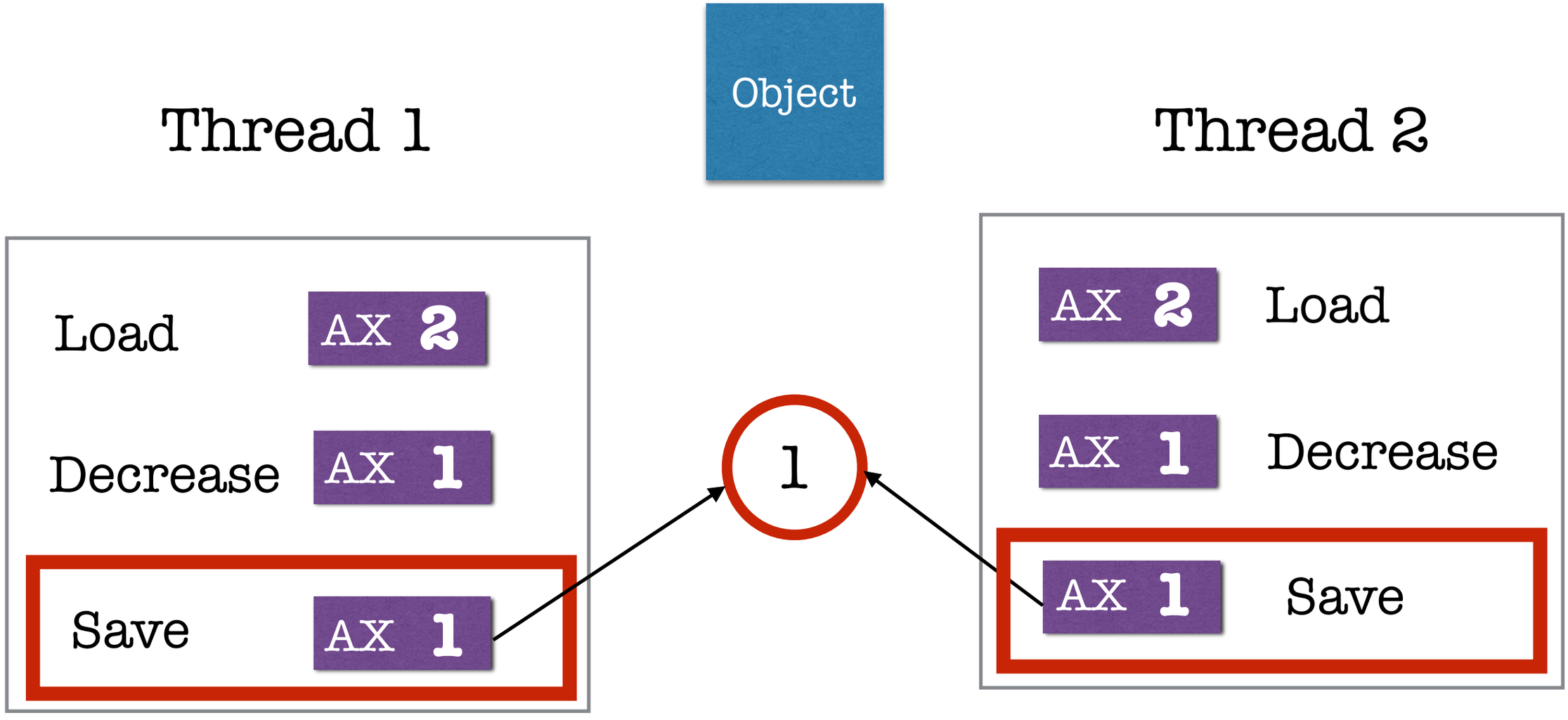


Should have been 0, isn't it?

Reference Counting With Threads



Memory Leak!

Utilising Multiple Cores

alternative approaches

Utilising Multiple Cores

Utilising Multiple Cores

- Process based concurrency

Utilising Multiple Cores

- Process based concurrency
- C Extensions

Utilising Multiple Cores

- Process based concurrency
- C Extensions
- Cython

C-Extensions

Extending Python with C or C++

C-Extensions

Releasing the GIL from extension code

Save the thread state in a local variable.

Release the GIL

... Do some blocking I/O operation ...

Reacquire the GIL

Restore the thread state from the local variable.

C-Extensions

`Py_BEGIN_ALLOW_THREADS`

..Don't Talk to CPython Interpreter..

`Py_END_ALLOW_THREADS`

C-Extensions

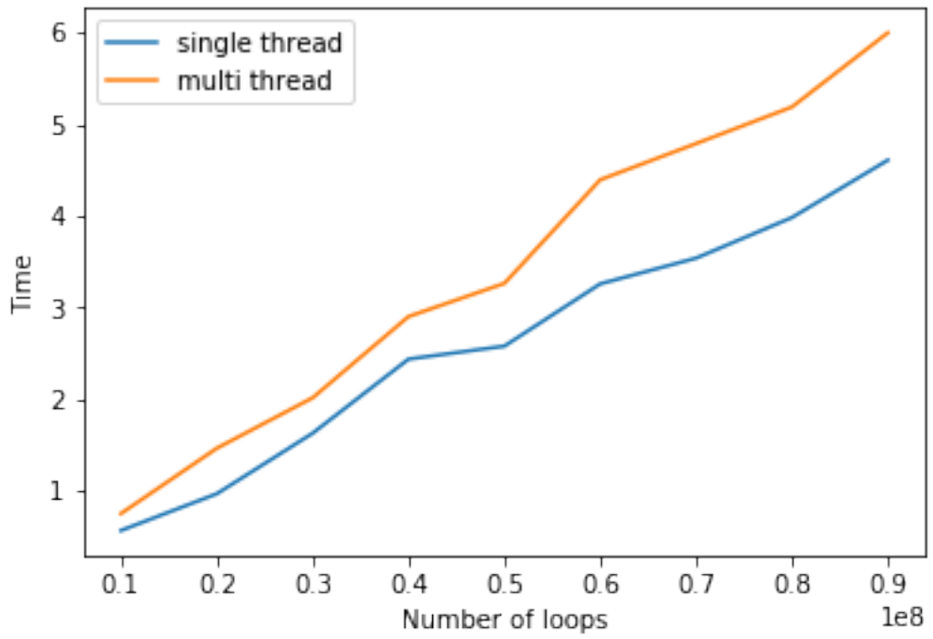
Example Demo

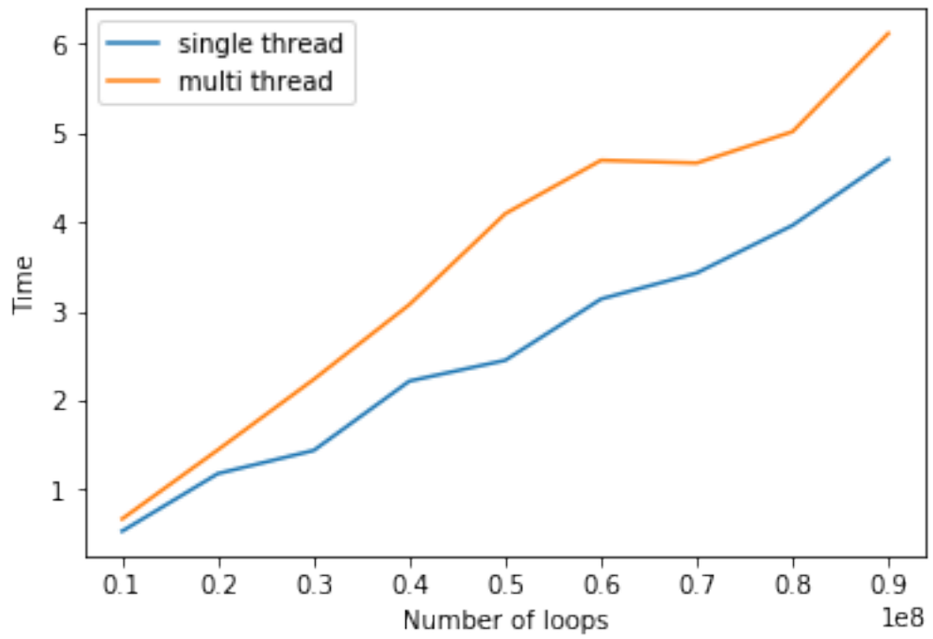
Threading in Python

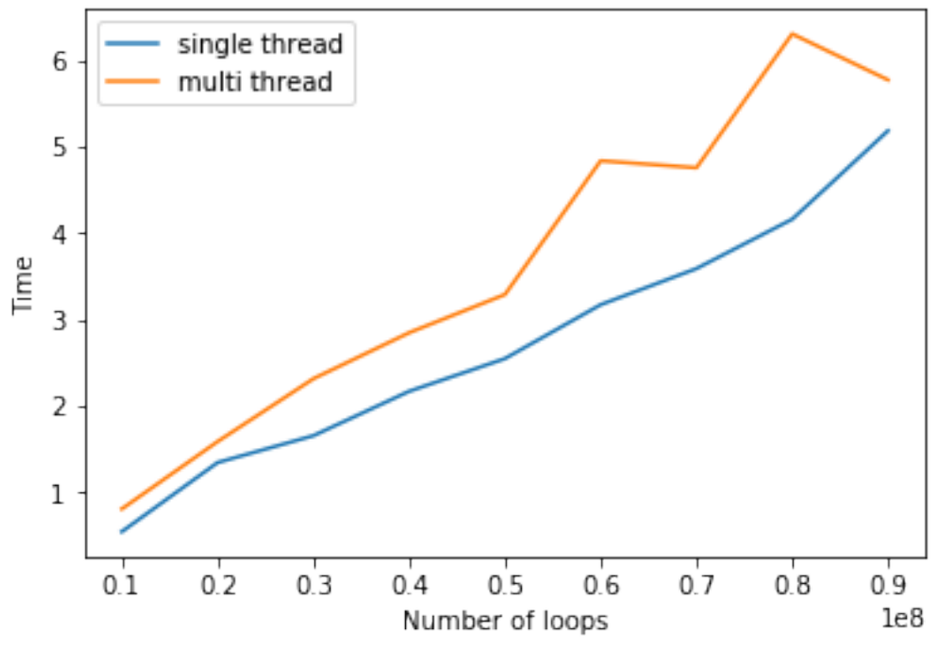
Lets see some Visualisations

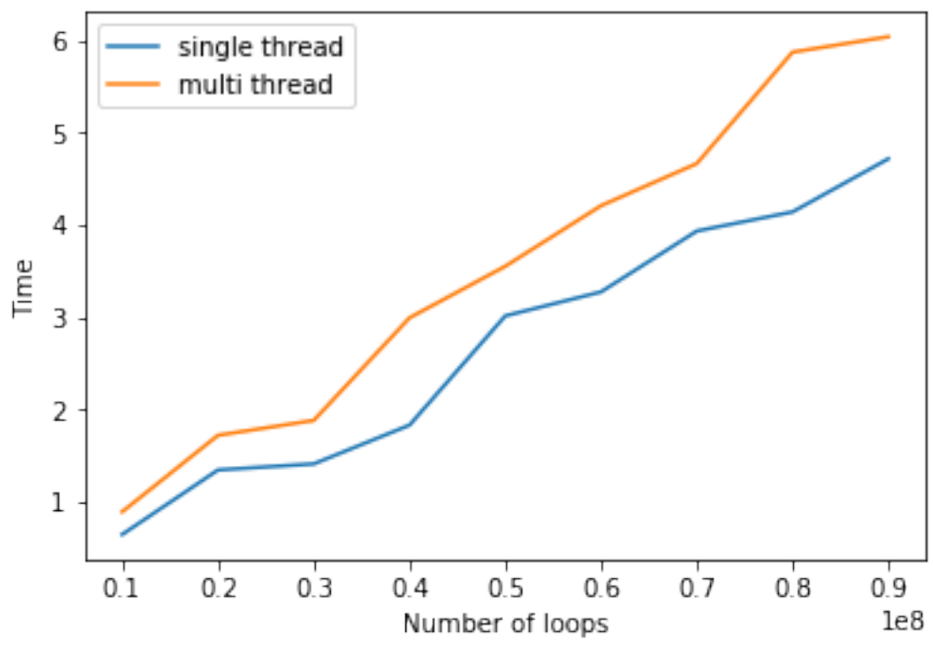
Benchmarked on:
MacBook Air (13-inch, Early 2015)
1.6 GHz Intel Core i5
4 GB 1600 MHz DDR3

Threading in Python









Threading with C-Extensions

Lets see some Visualisations

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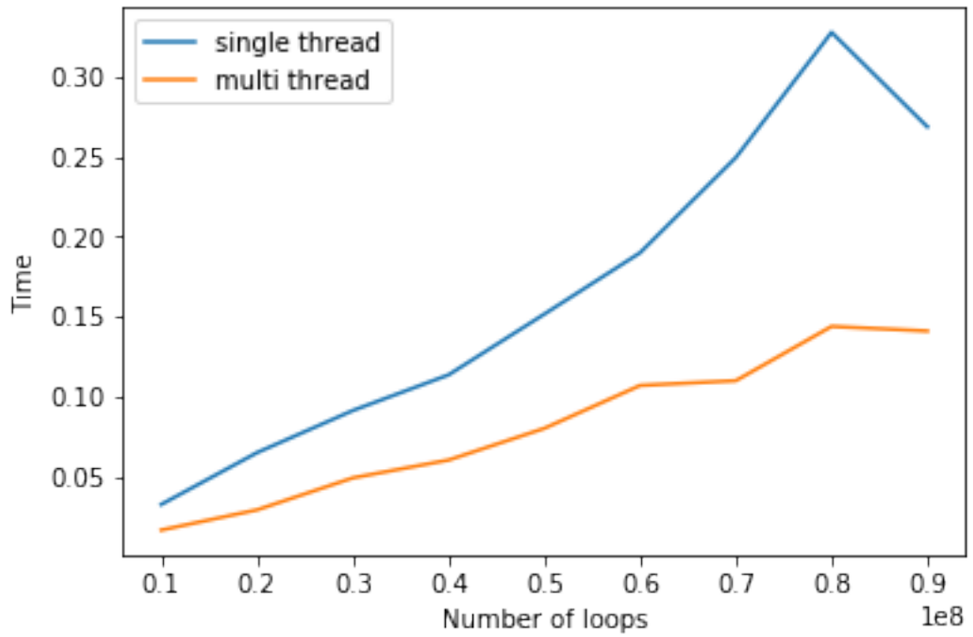
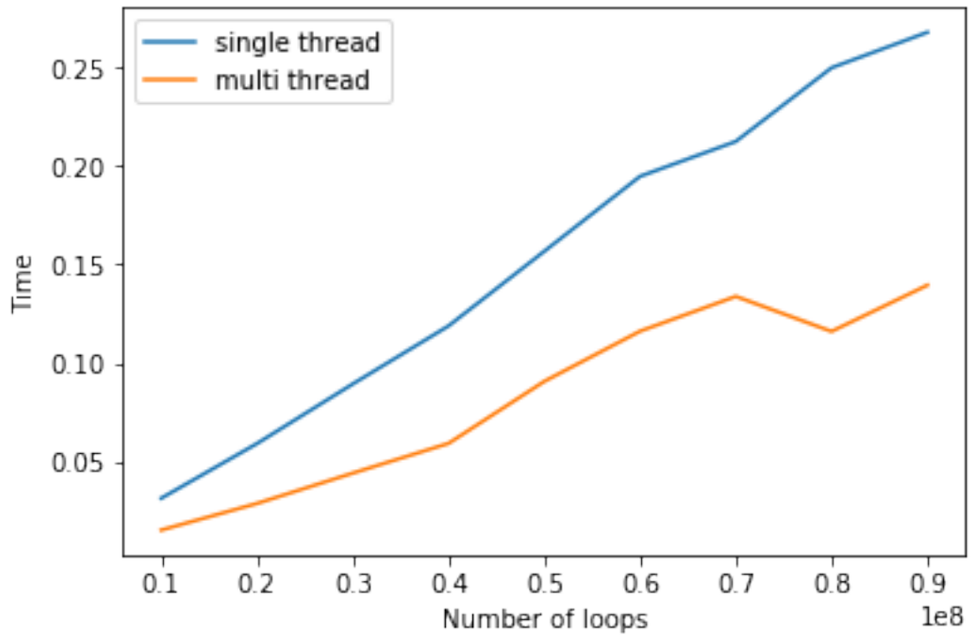
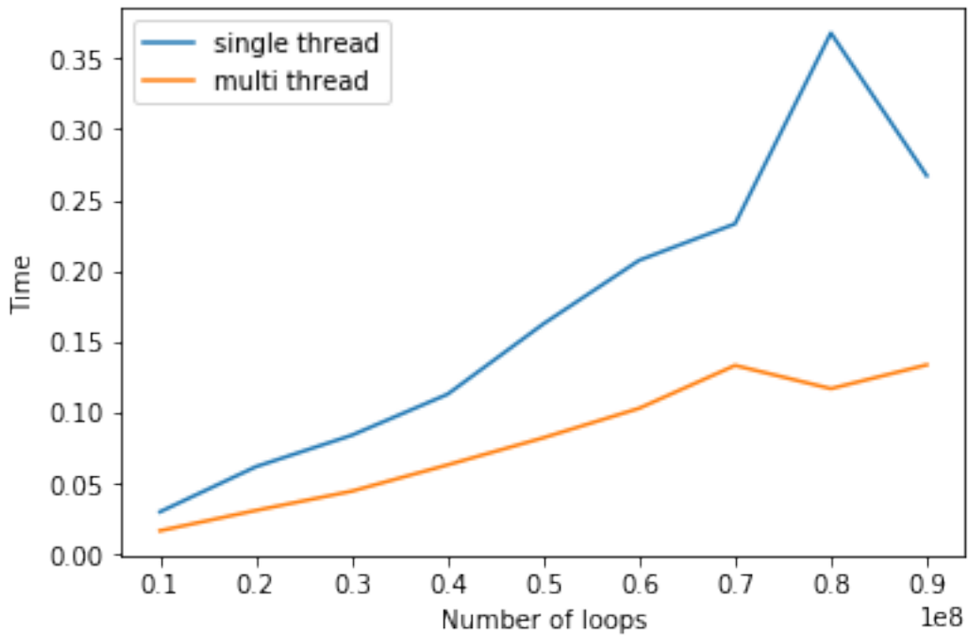
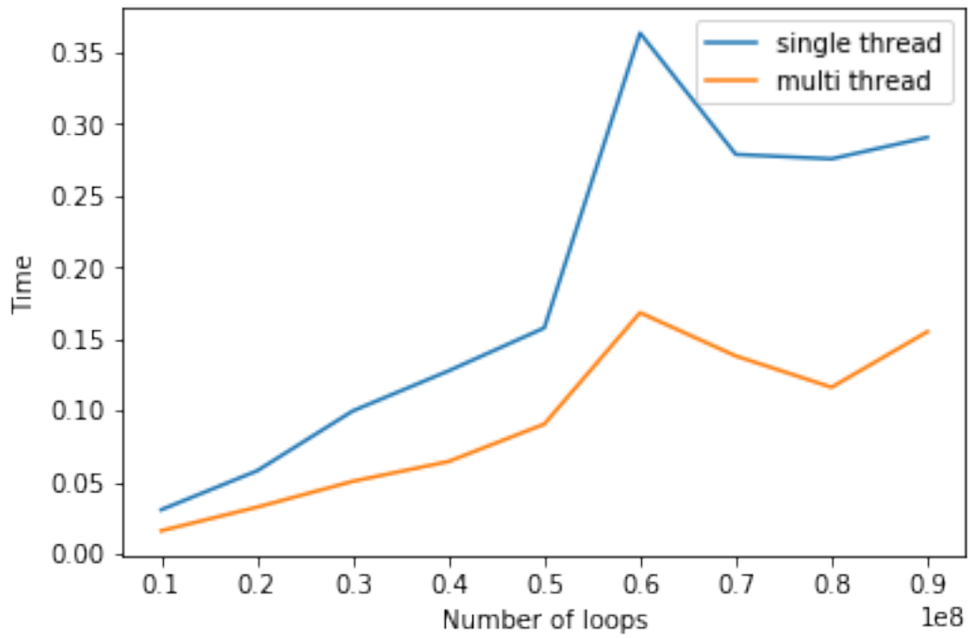
Threading with C-Extensions









Guido on GIL

I'd welcome a set of patches into Py3k only if:

- performance for a **single-threaded** program and
- for a multi-threaded but **I/O-bound** program

does NOT decrease.

The Famous GIL Removal Patch

The Famous GIL Patch of Greg

Idea: Each thread has to isolate its interpreter state and not rely on C global variables.

- moved into a **per-thread data structure**.

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Idea: Each thread has to isolate its interpreter state and not rely on C global variables.

- moved into a **per-thread data structure**.
- patch introduces a **global reference-counting mutex lock**
- Mutable builtins such as lists and dicts need their **own locking** to synchronise modifications.

The Famous GIL Patch of Greg

patch made the performance of single-threaded applications much worse

The Famous GIL Patch of Greg

patch made the performance of single-threaded applications much worse

so much so that the patch couldn't be adopted.

The New Gil

The New Gil

by Antoine Pitrou

Since Python 3.2

The New Gil

Earlier:“ticks" based

Now: time based

The New Gil

Benefits:

- new GIL allows a thread to run for 5ms regardless of other threads
- Eliminates the Battle for GIL
- Eliminates Excessive Thrashing/Context Switching

References

- http://www.dabeaz.com/GIL/
- Larry Hastings - Python's Infamous GIL
- Brett canon on GIL
- Nick Coghlan’s utilising multiple cores
- Raymond Hettinger on Concurrency
- Python C API docs

Thank You!

Github: @aktech **Twitter**: @**i**aktech

http://iamit.in