Pauses/throughput/latency/aggressiveness

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- and that's what this lesson (an the whole course) is about 😎

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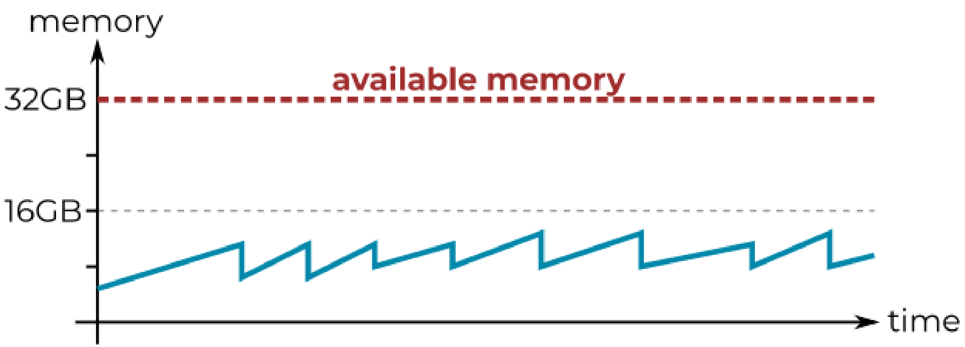

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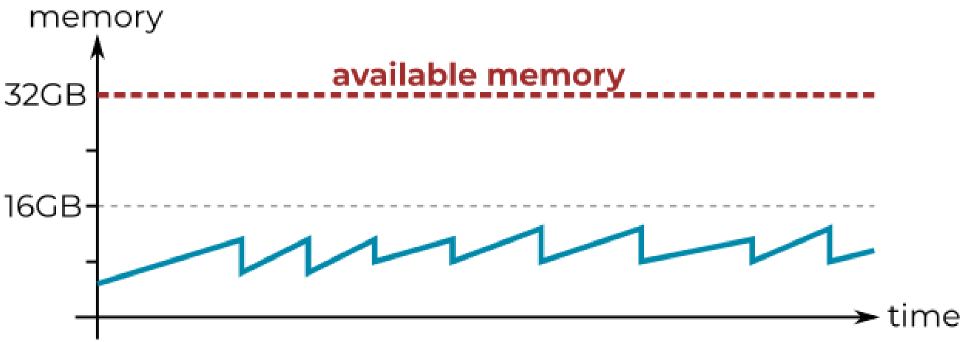

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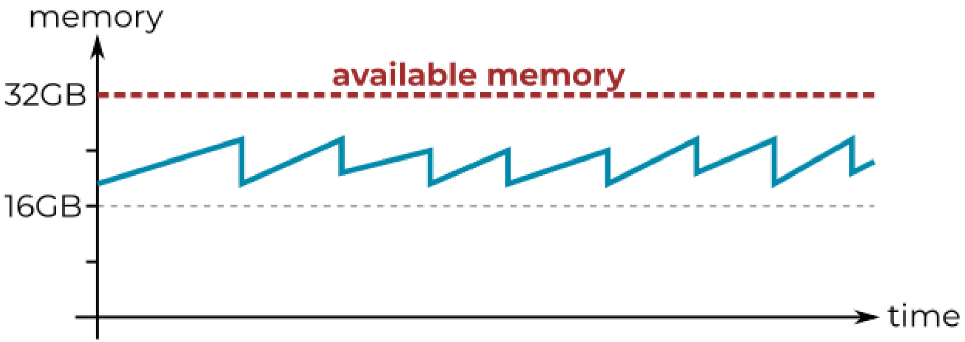

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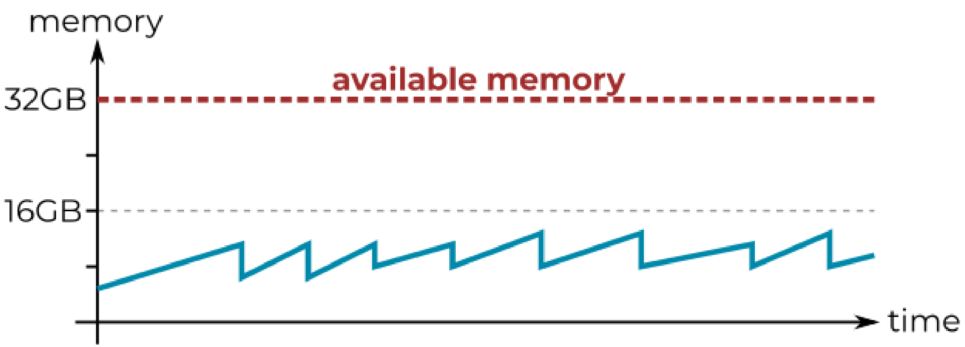

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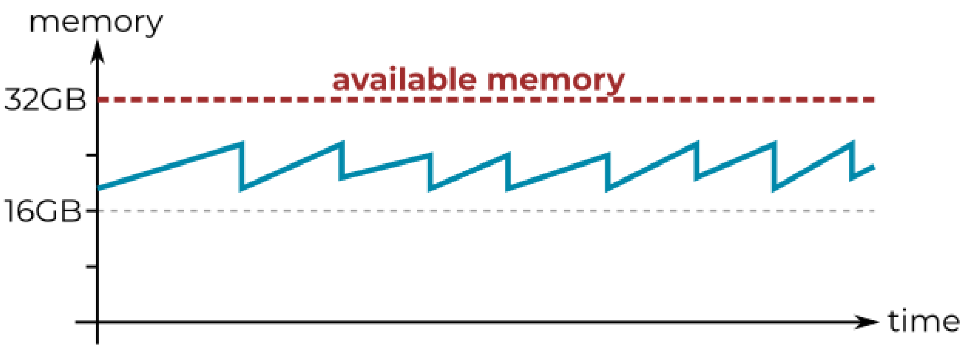

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- but... it is not so easy to say "good" or "bad" - what's **the cost** of smaller memory usage? CPU? application slowdown?
- if and only if all is the same except memory usage - we have better or worse GC

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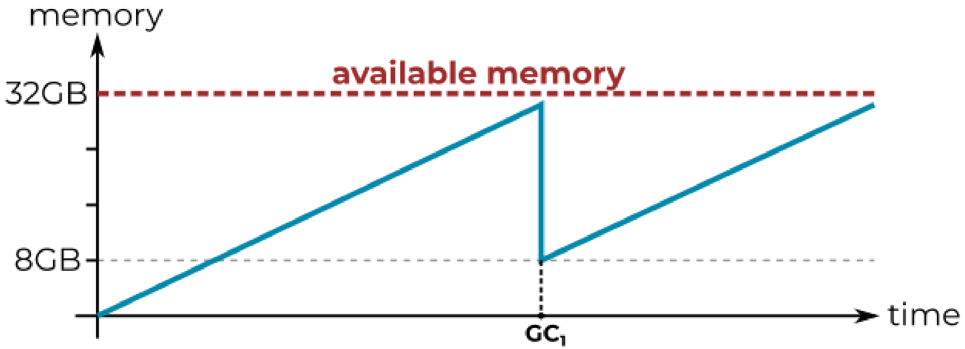

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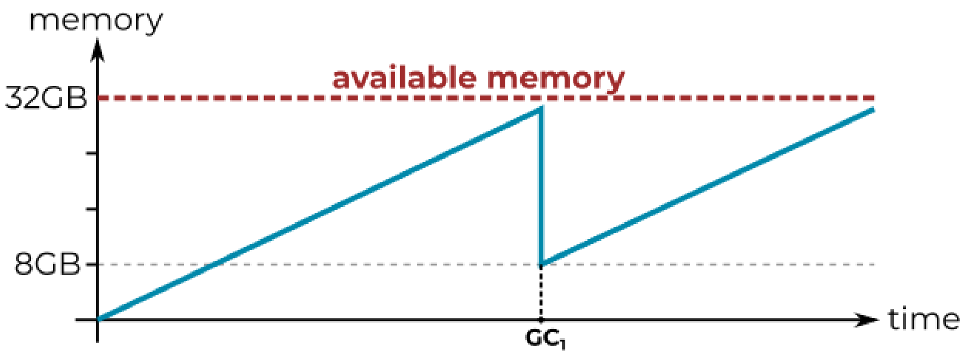

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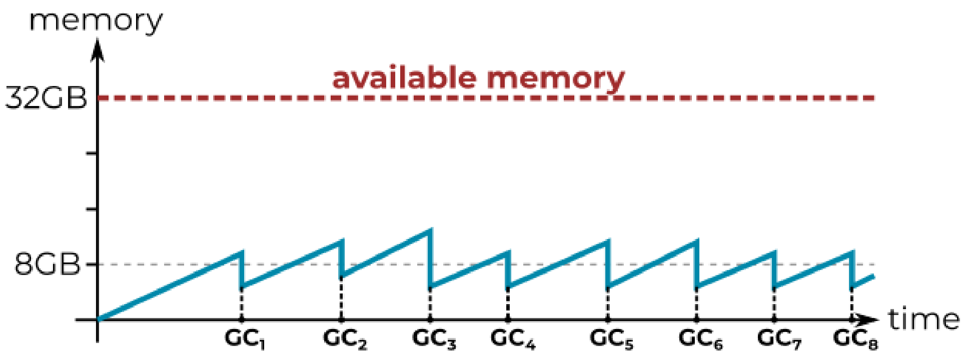

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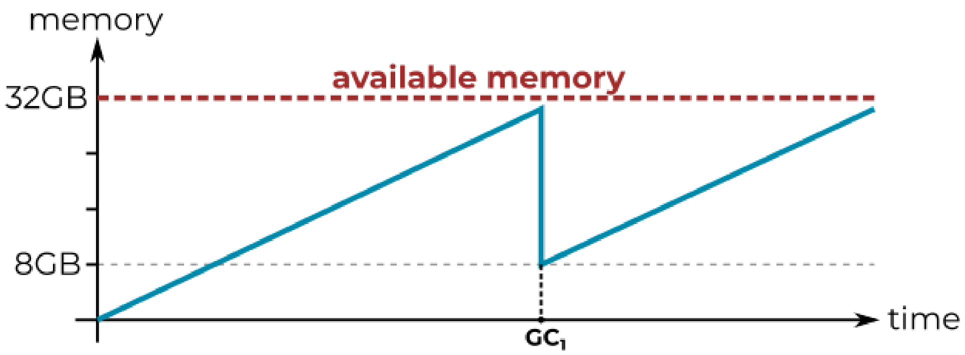

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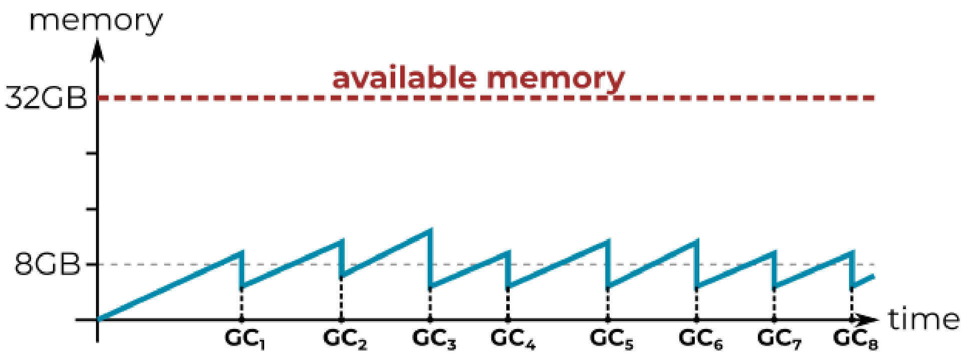

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Aggressiveness influences other metrics - the less frequent GCs, the bigger overhead they introduce (longer pauses, bigger CPU spikes).

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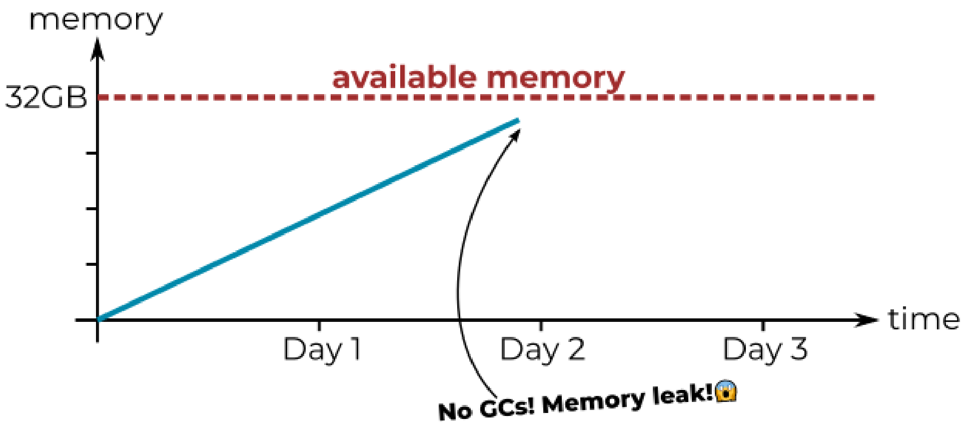

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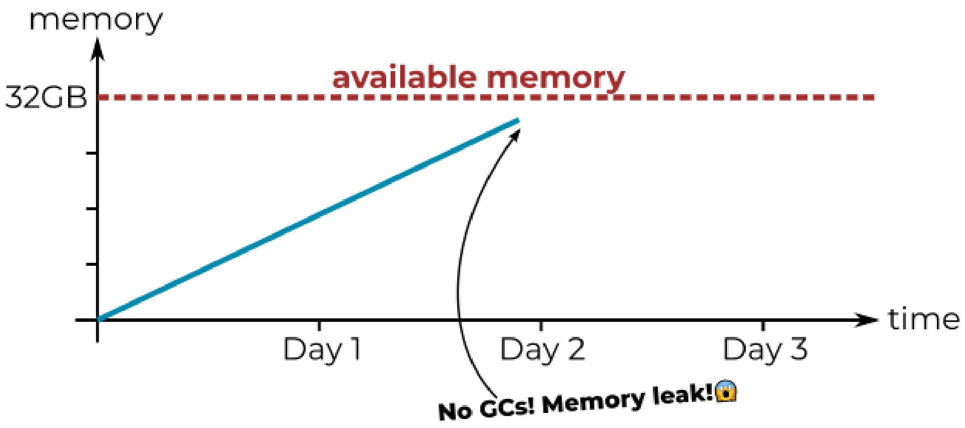
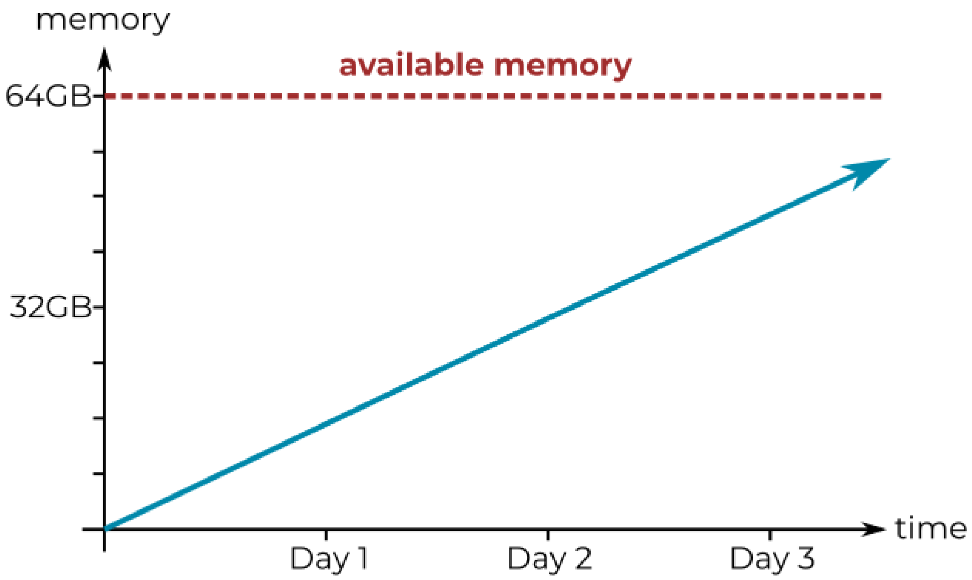


2. In fear, we add more RAM to avoid killing the process and "the leak" becomes even bigger!



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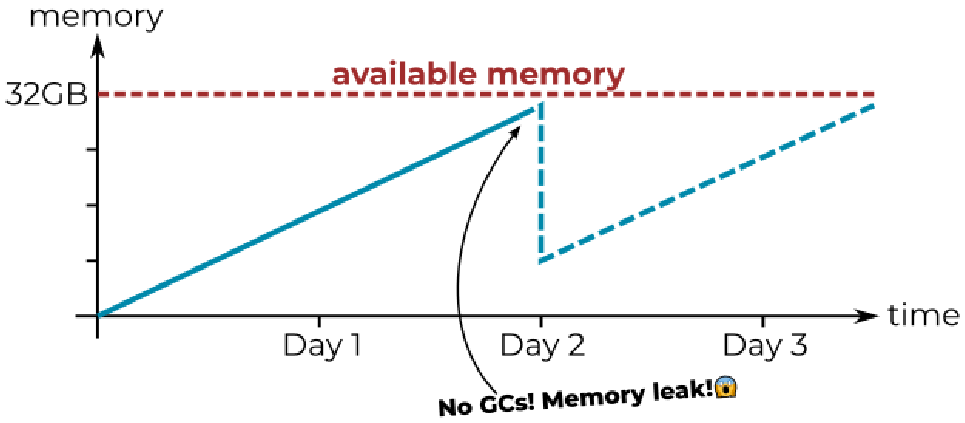

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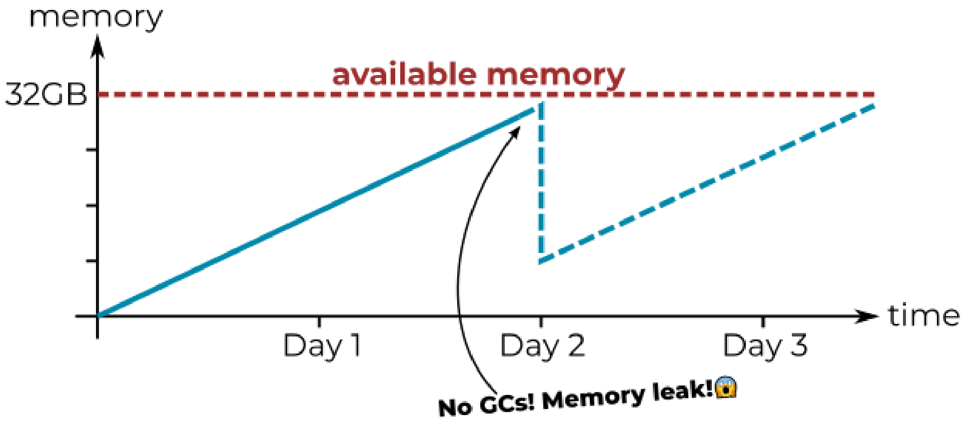

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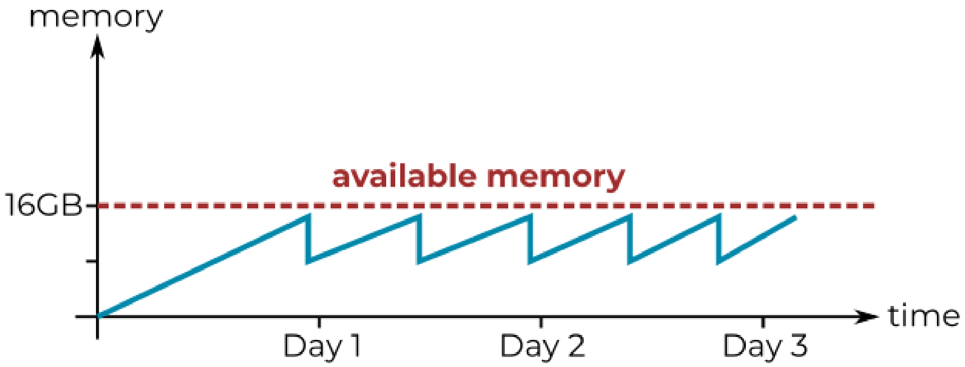

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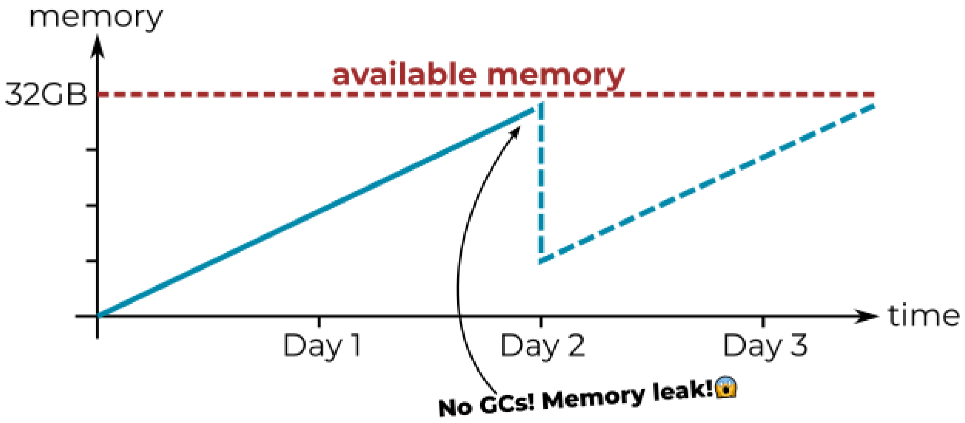

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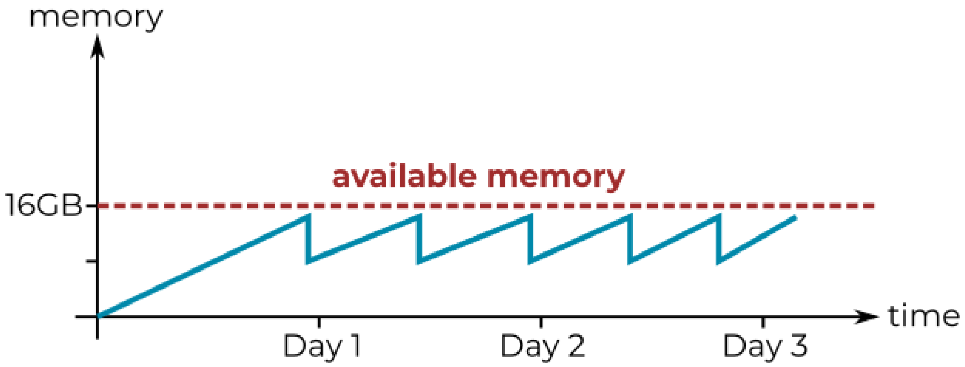

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GC's aggressiveness may be its **implementation detail**, but we can have some **control** over it - we will return to that when understanding the GC a little more 😇

Memory overhead

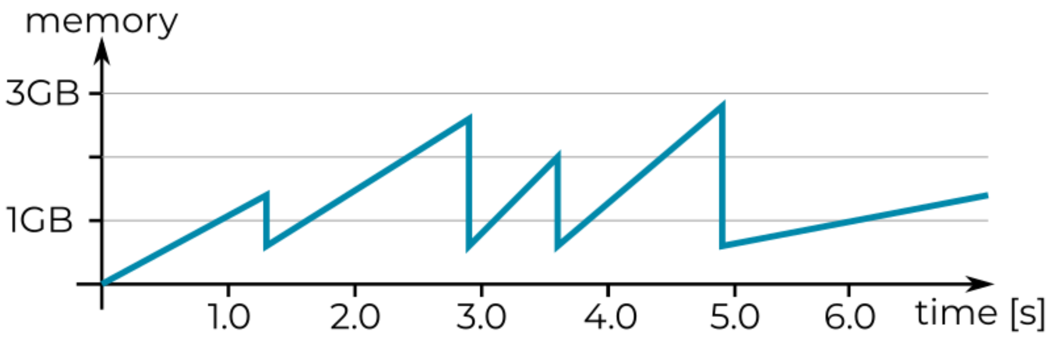
How to measure?

Memory overhead

How to measure? We will return to that when understanding GC more. In general - it is *"how much memory does this process use?"* question.

Memory overhead

But, remember about one little fact. Memory usage change in time due to allocations & GC:



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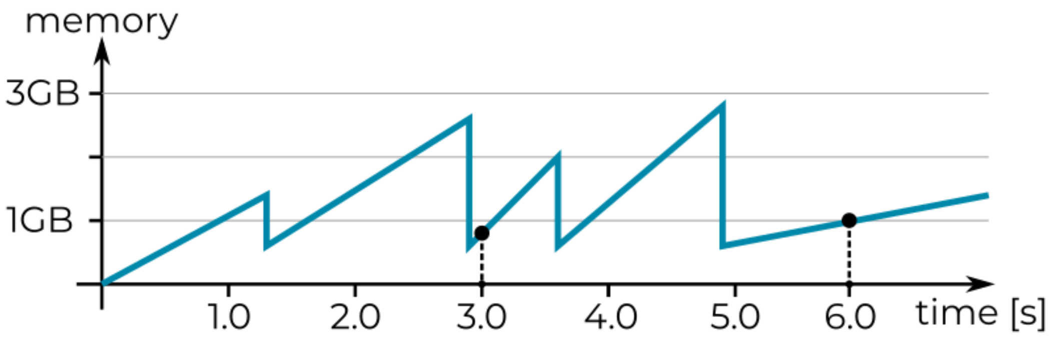

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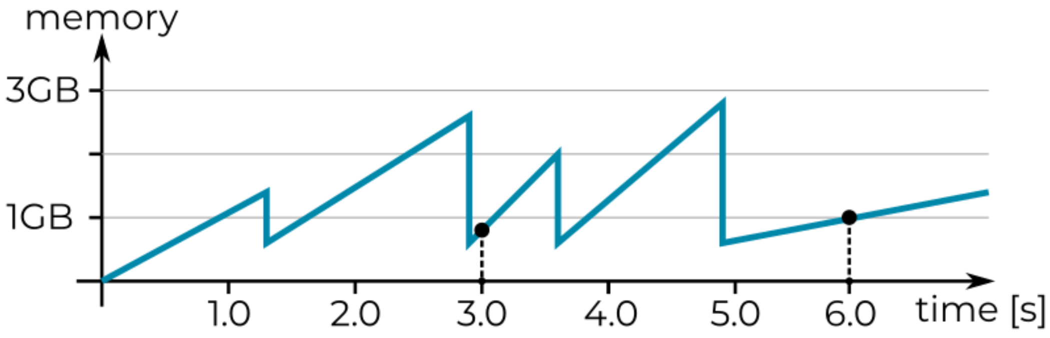

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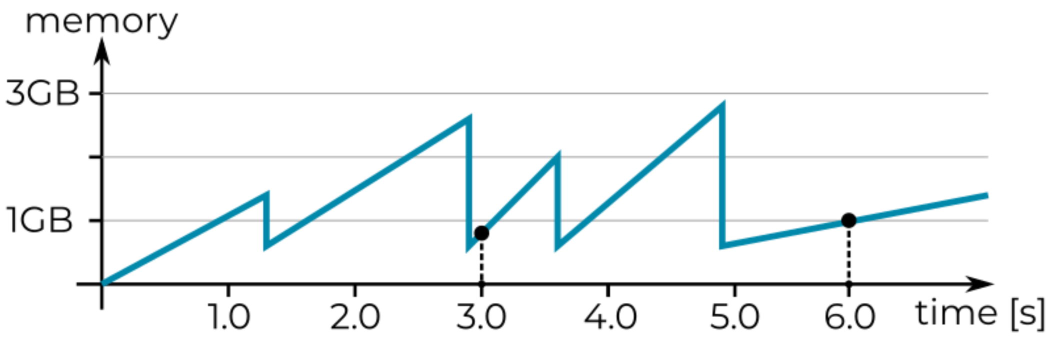

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(and I see it surprisingly often to analyze memory dump without knowledge how it relates to the surrounding GCs)

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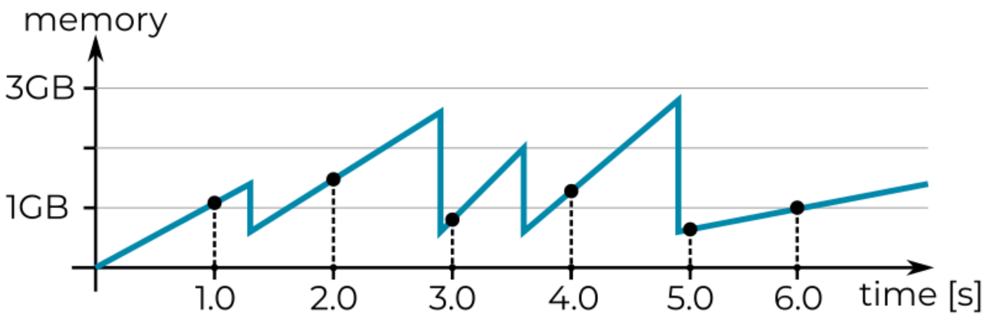

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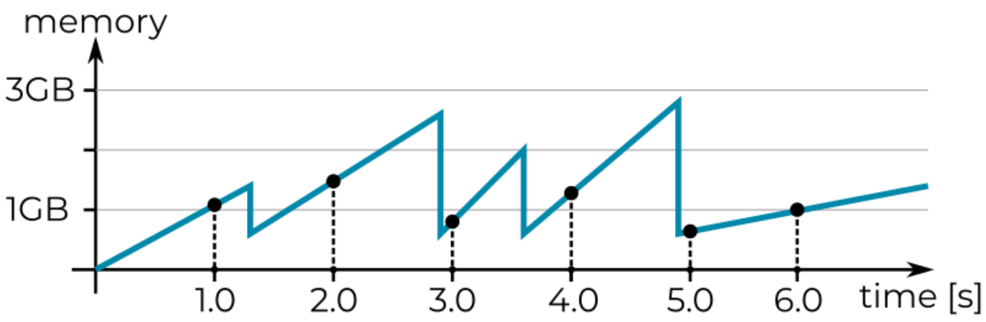

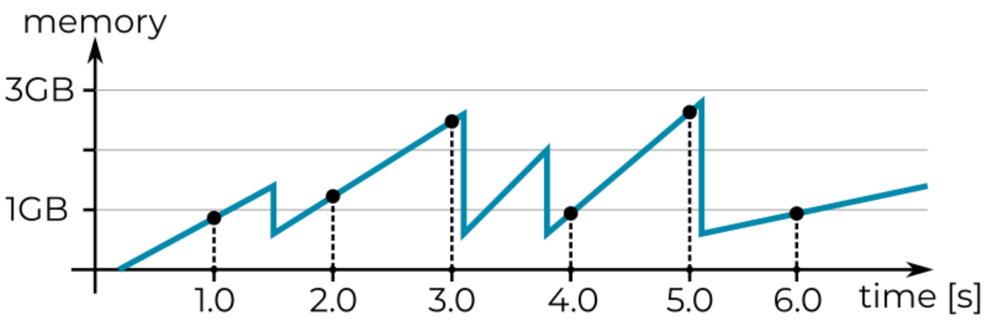

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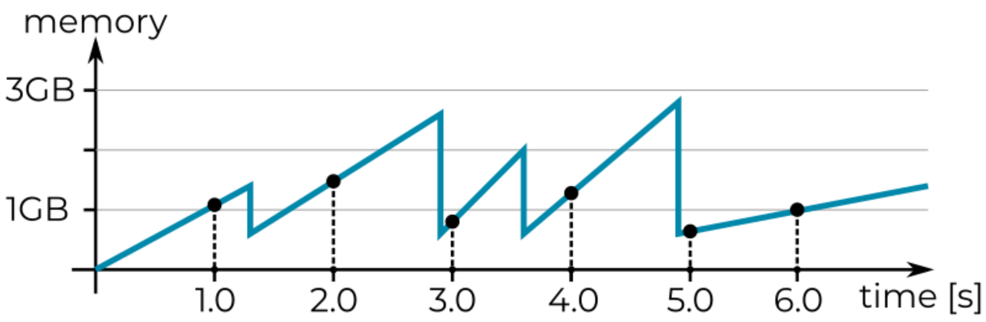

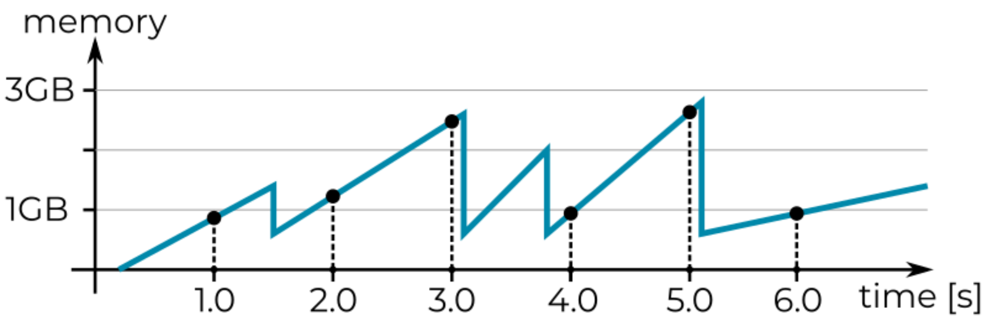

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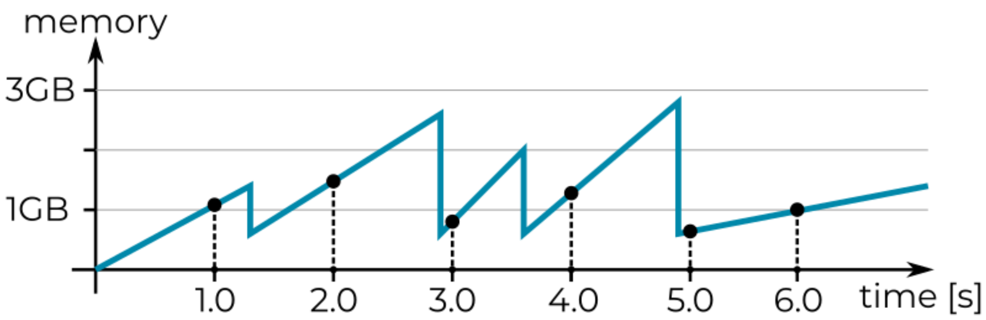

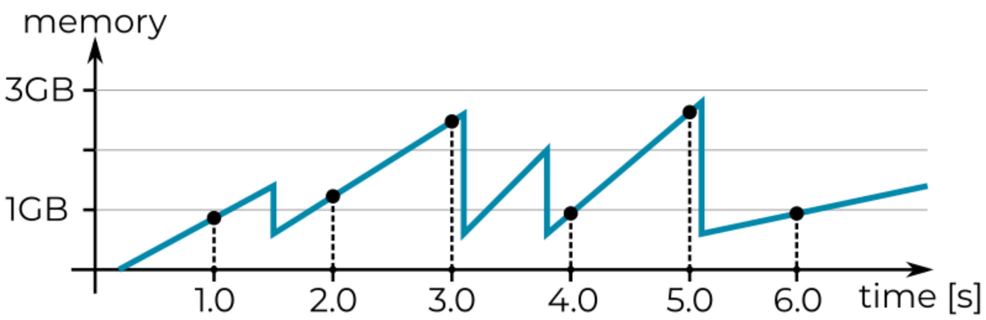

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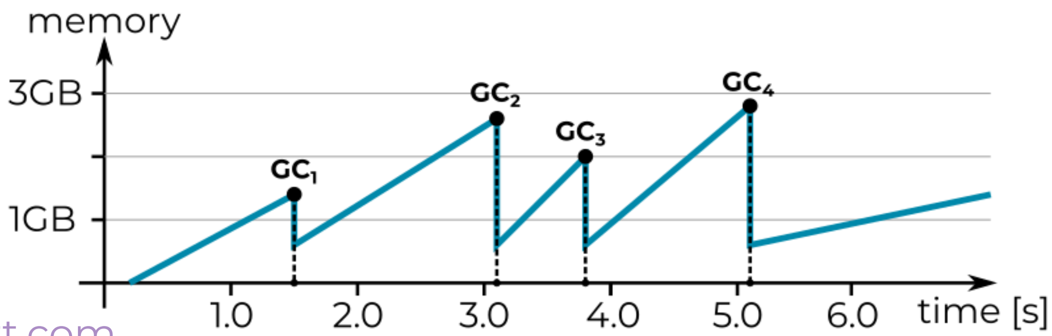
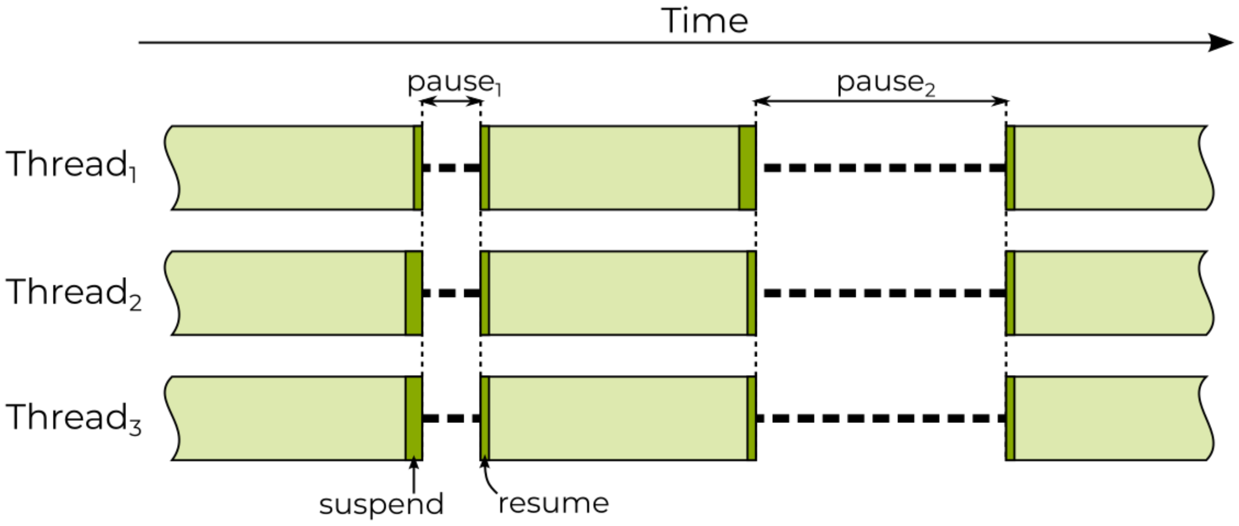
- this is a typical *sampling problem* - we may sample very often...
- or even better - measure with respect to the GC to know exact values **before** and **after**:



Pauses

All GCs need to occasionally pause an application (threads) for shorter or longer amount of time:

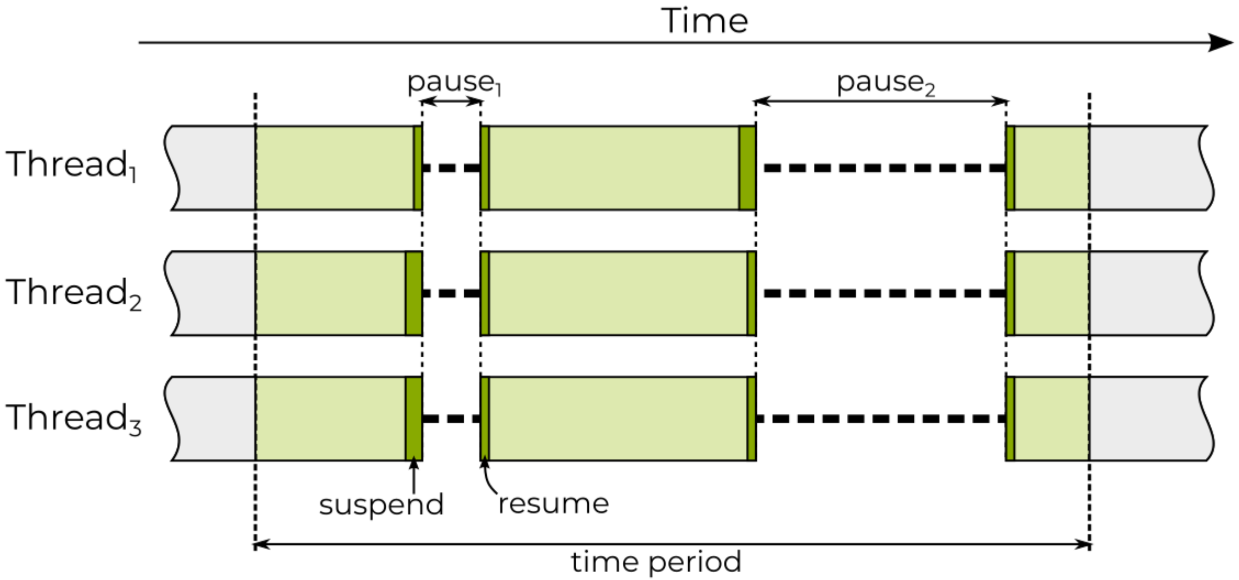


This is typically not-so-good:

- in interactive application - it affects the user who may notice worse responsiveness
- in request processing application (like web) - it affects some requests processing times

Pauses

We can intuitively reflect it by relative pause time of the application:



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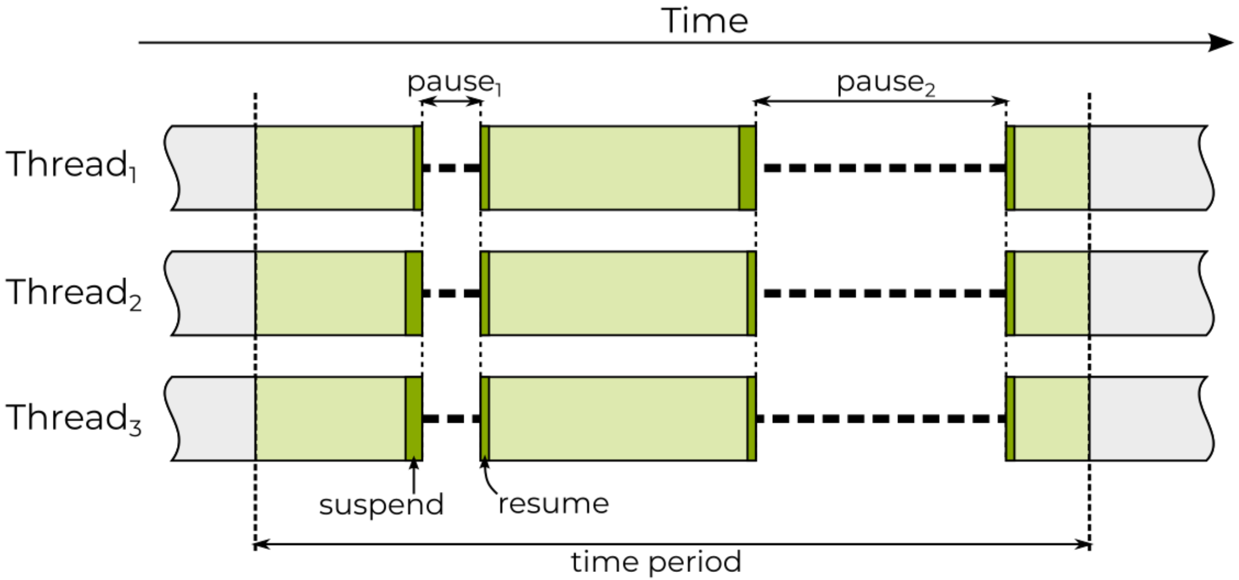

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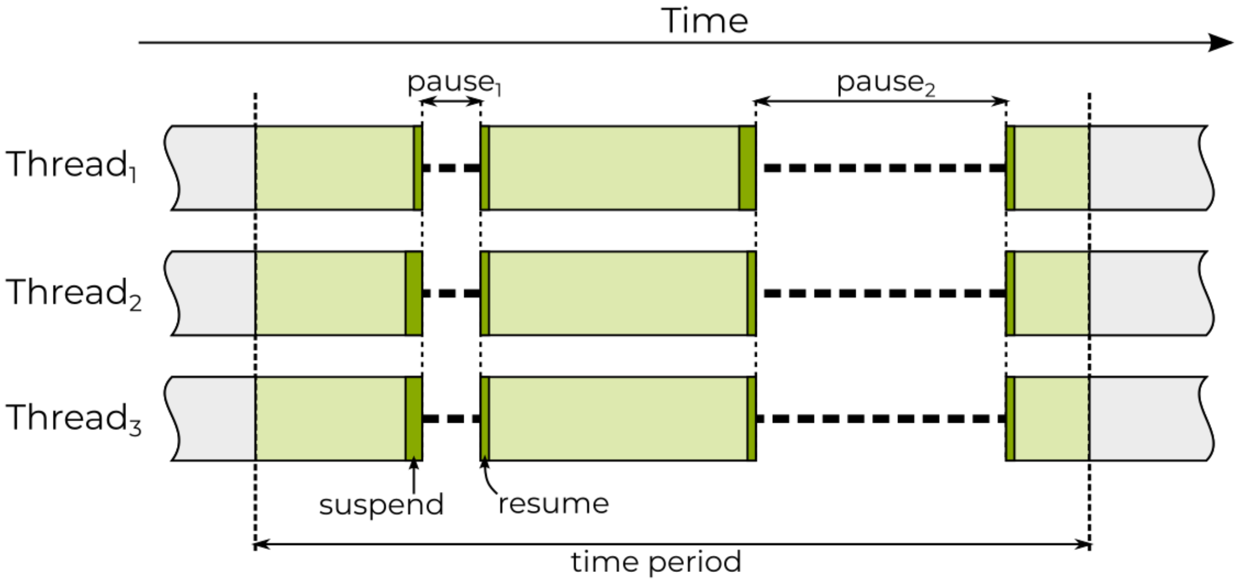

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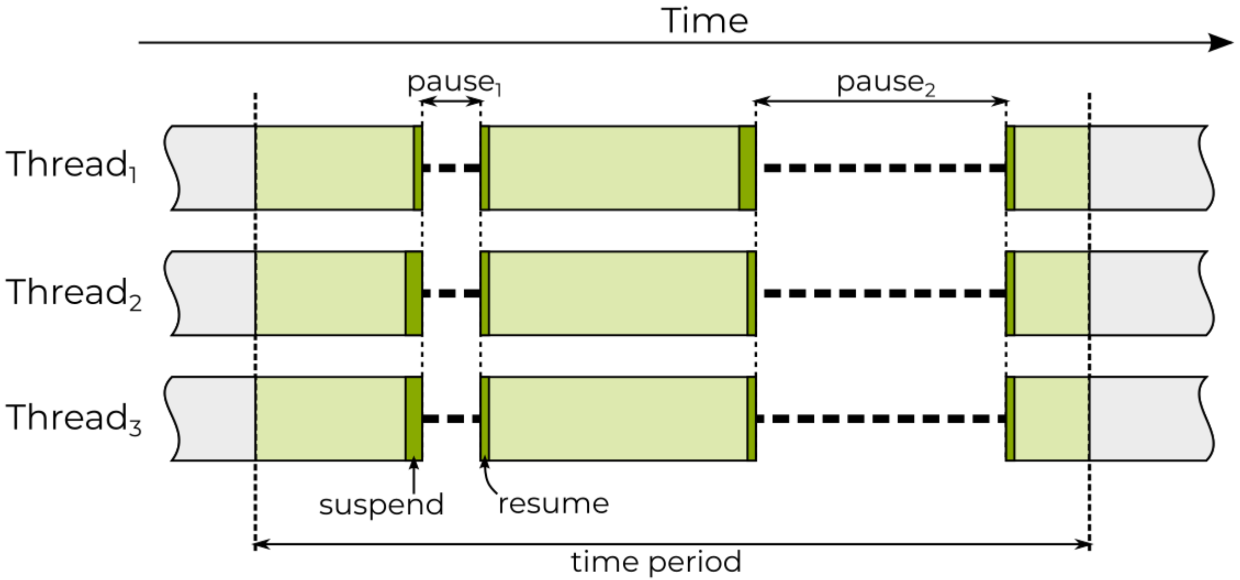

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"Usually a well behaved app has < 5% Pause time in GC while it's actively handling workloads."

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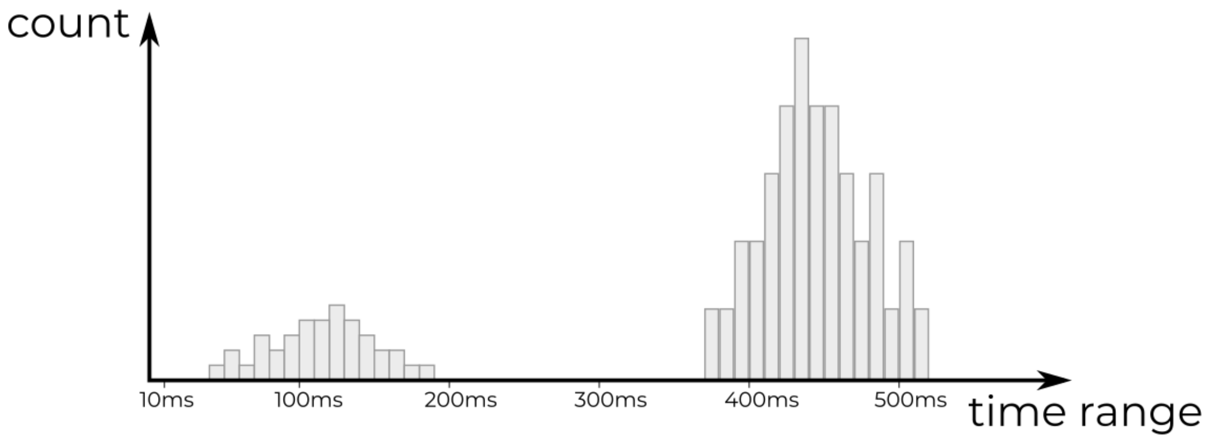
An interesting point of view is to see **pauses histogram** - it may reveal a little bit more complex (and useful) image that a single *% Pause Time in GC*:



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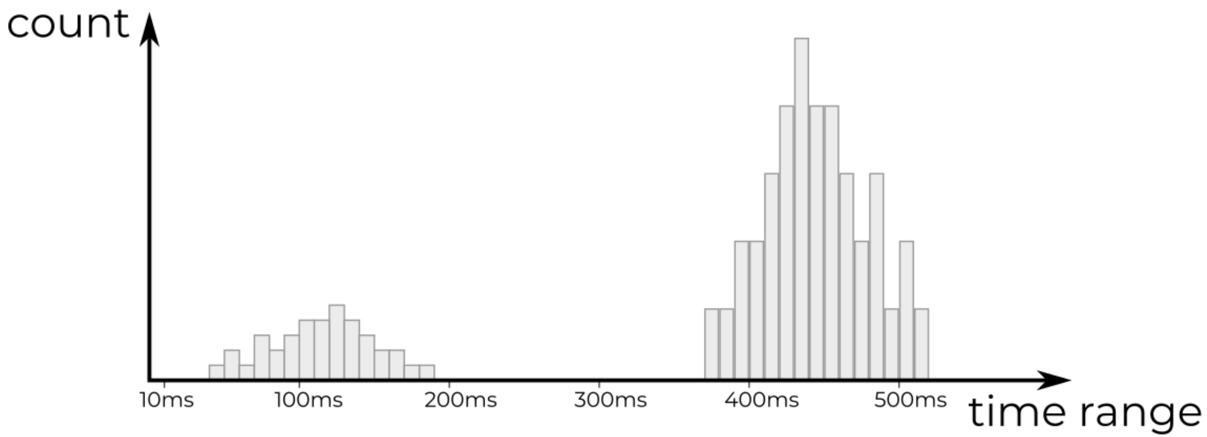

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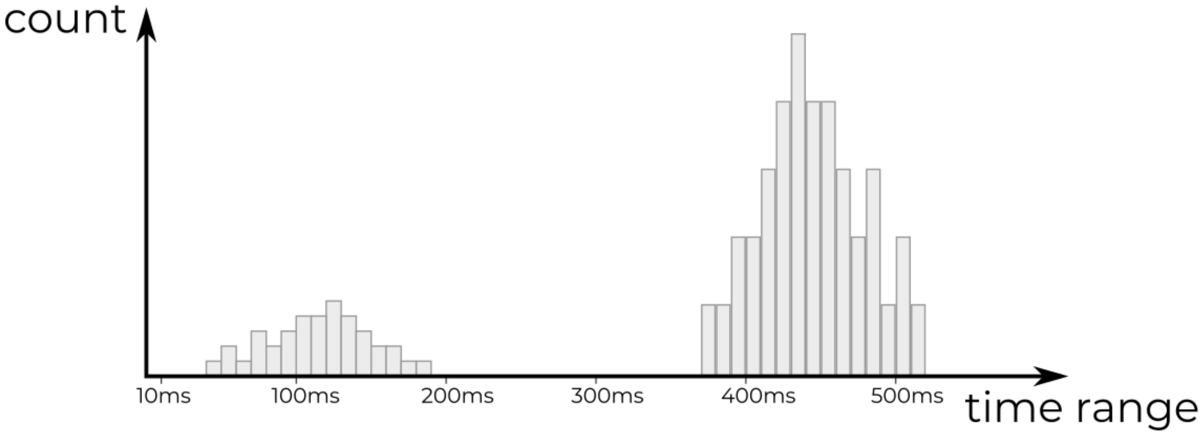

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Obviously, we may be interested in reducing those longer ones. Especially since they affect so-called **tail latency**.

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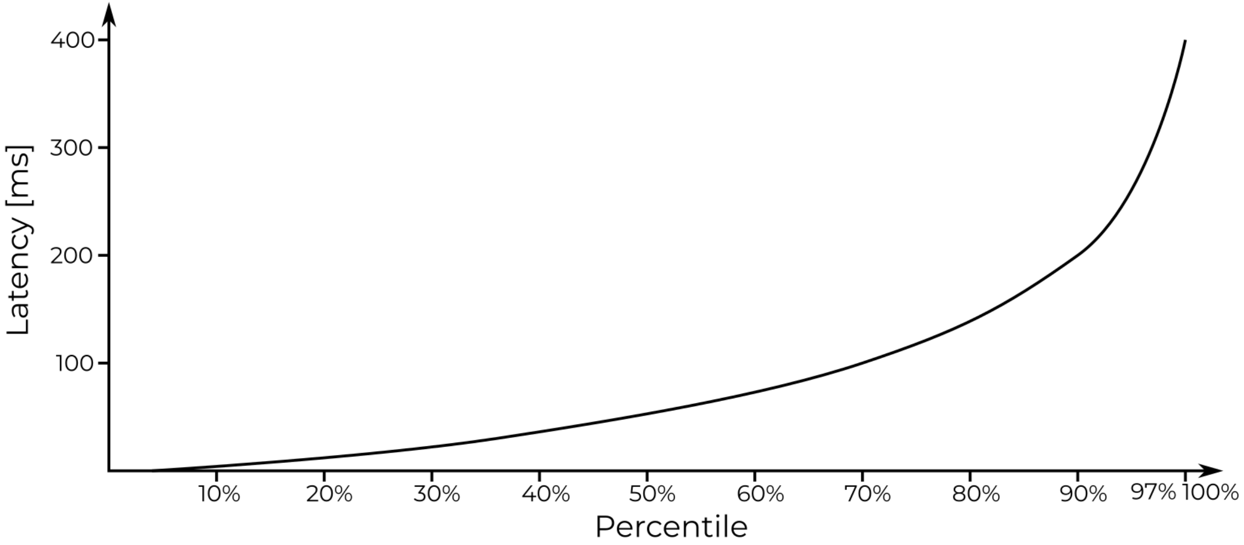
    - but... still there is this 5% or 1% which may be hit be the long latency (and leave with their 💸)

Pauses vs Latency

We can get a broad picture by visualizing latency in spectrum of percentiles:



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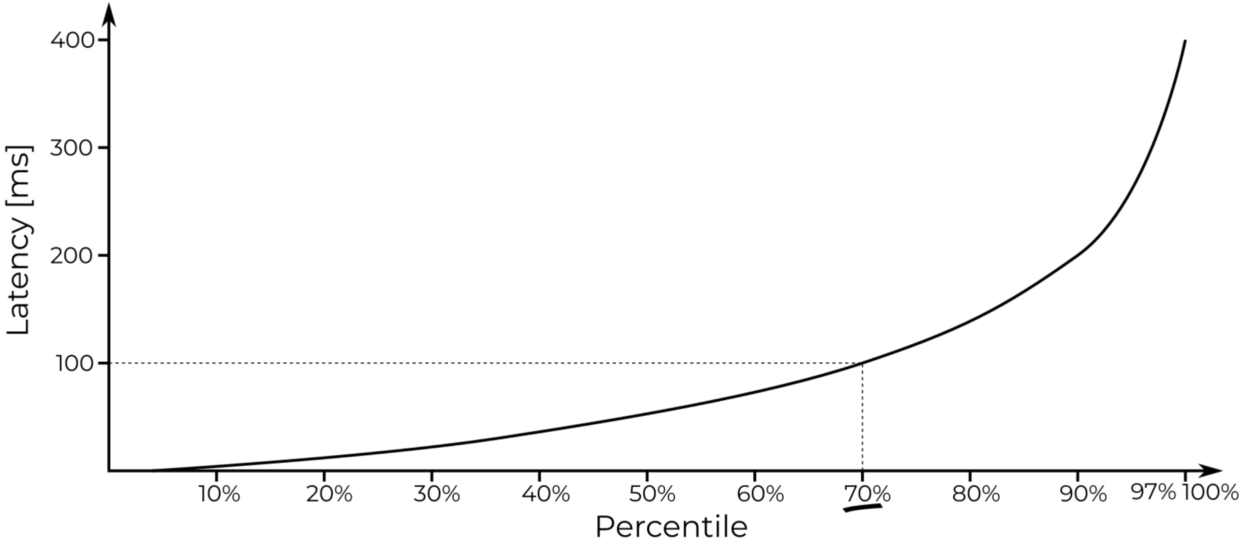

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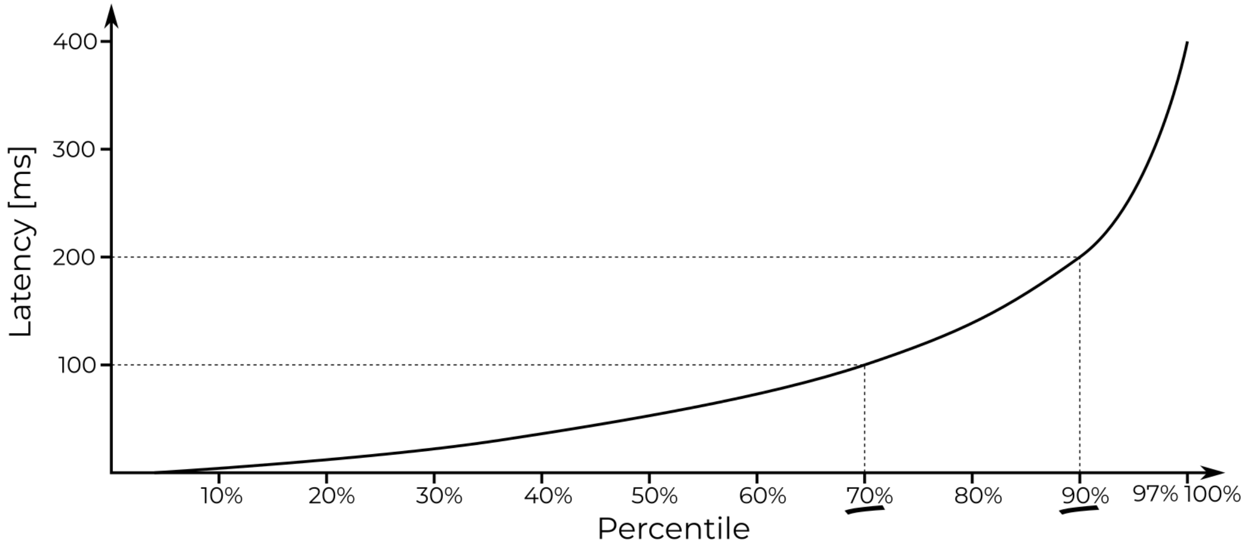

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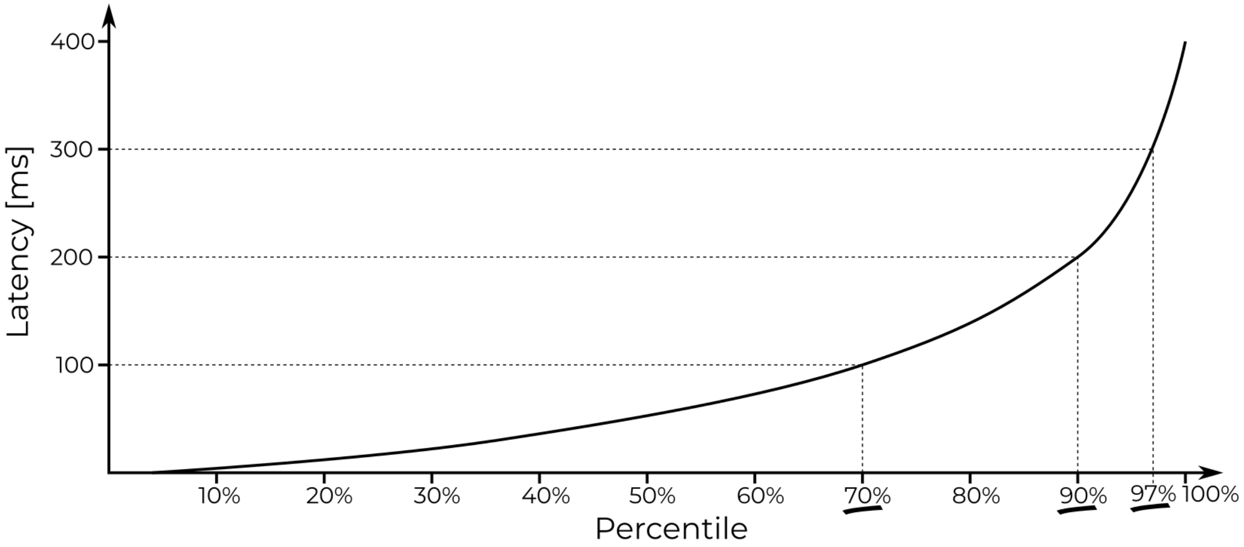

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  (which leaves 3% people observing times slower than 300ms)

Pauses vs Latency

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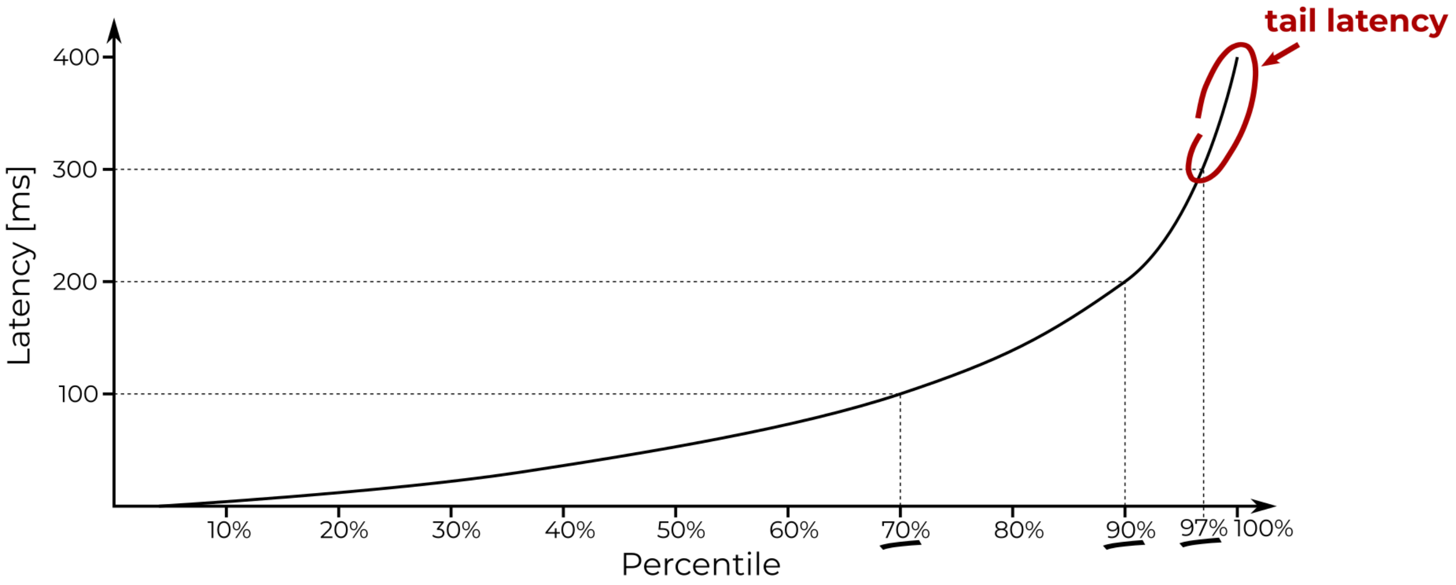

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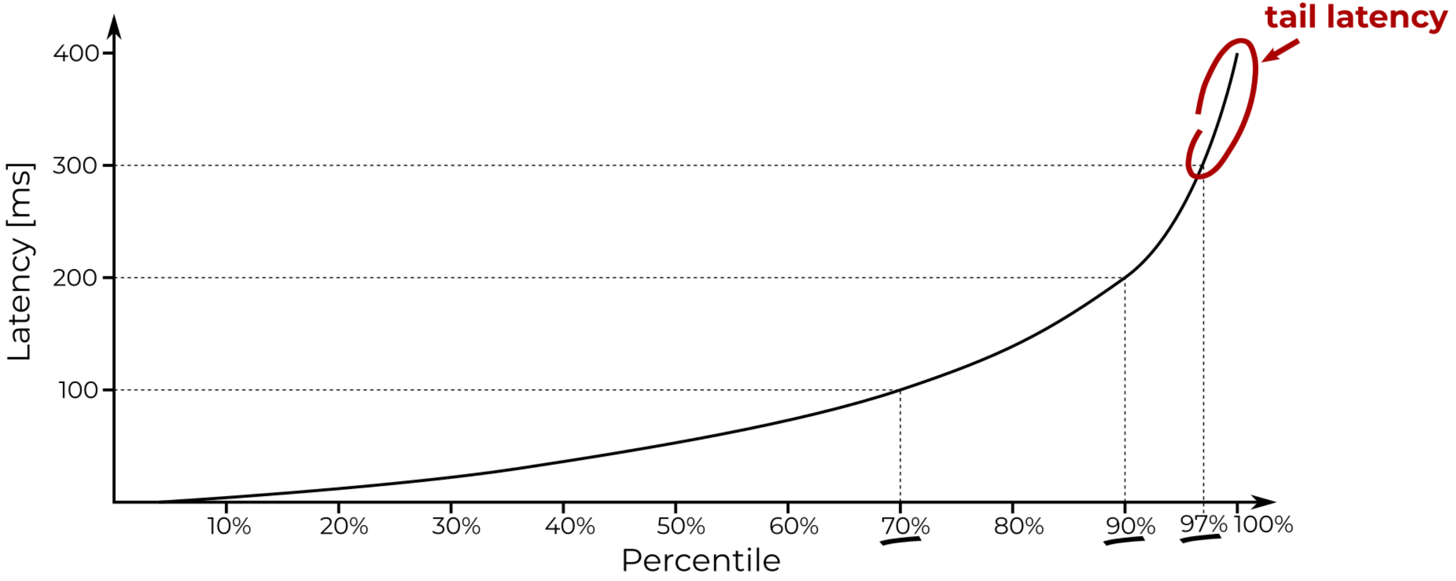

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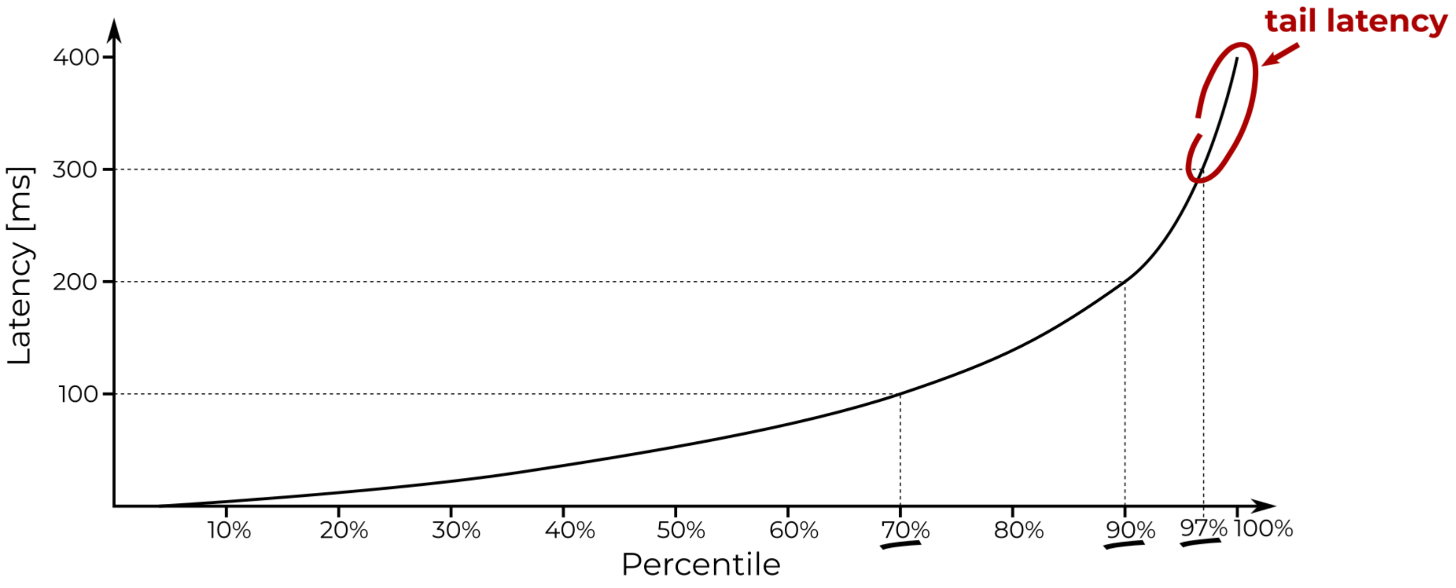

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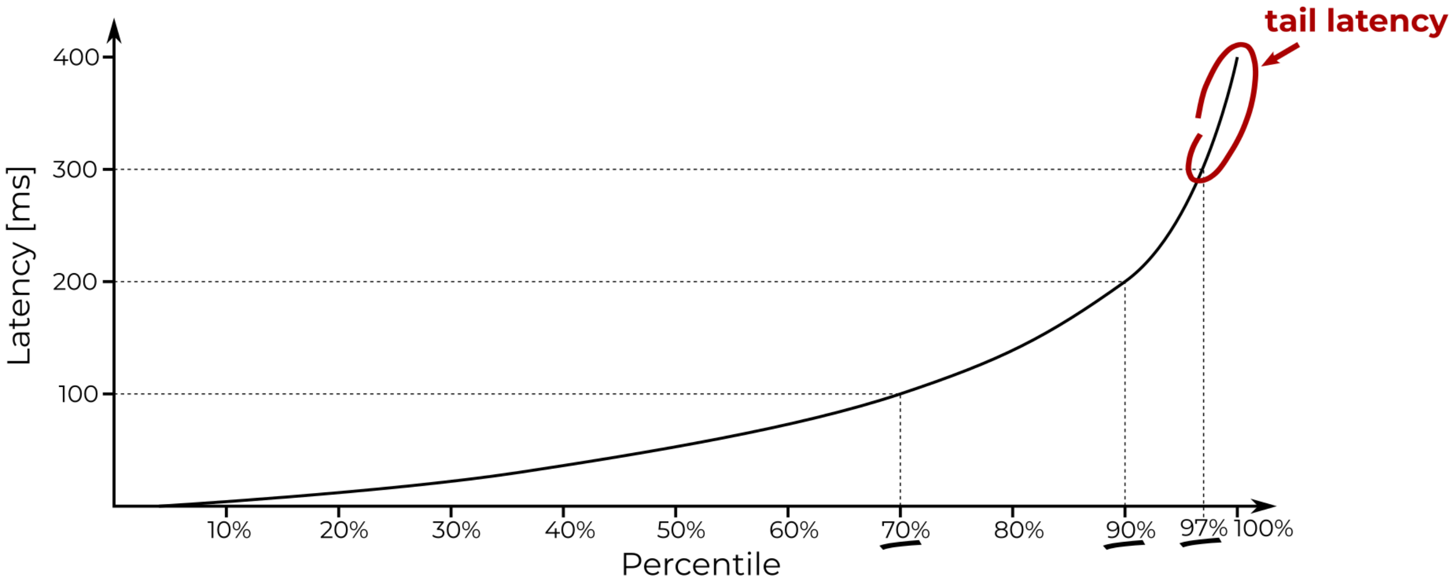

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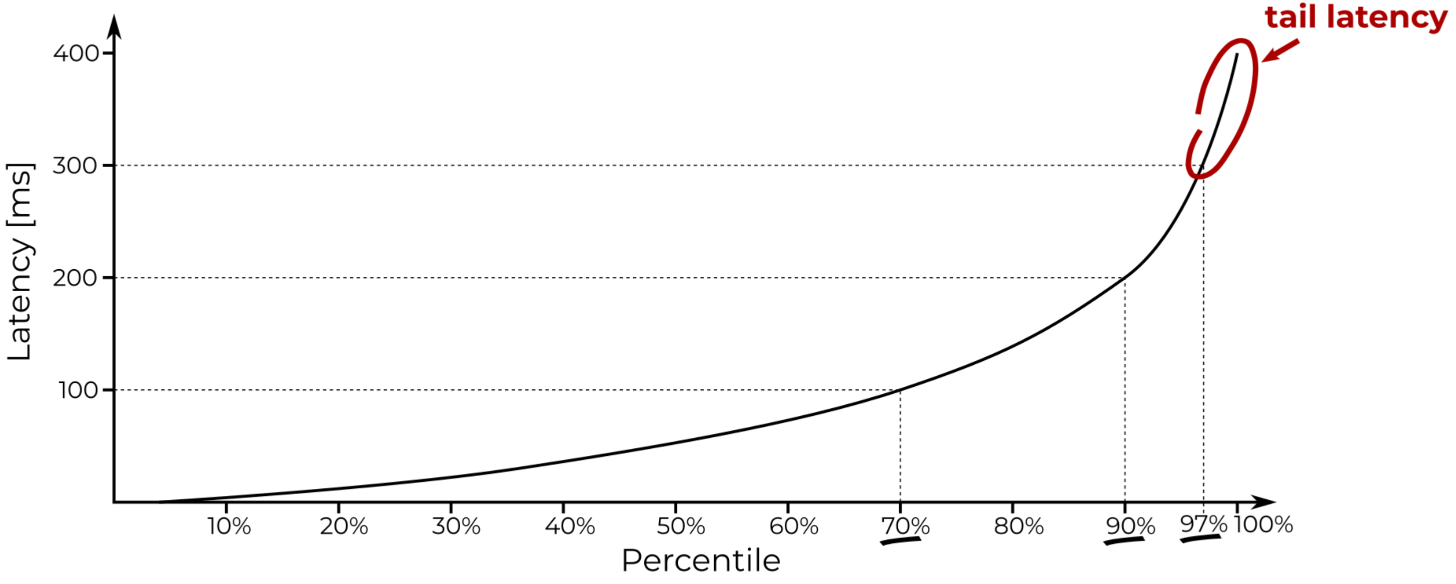

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  - ...and GC pauses may be one of them!

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We simply need to control how much CPU it takes to do the GC work. Again, typically it is a compromise with some other metrics like memory footprint, pauses, …

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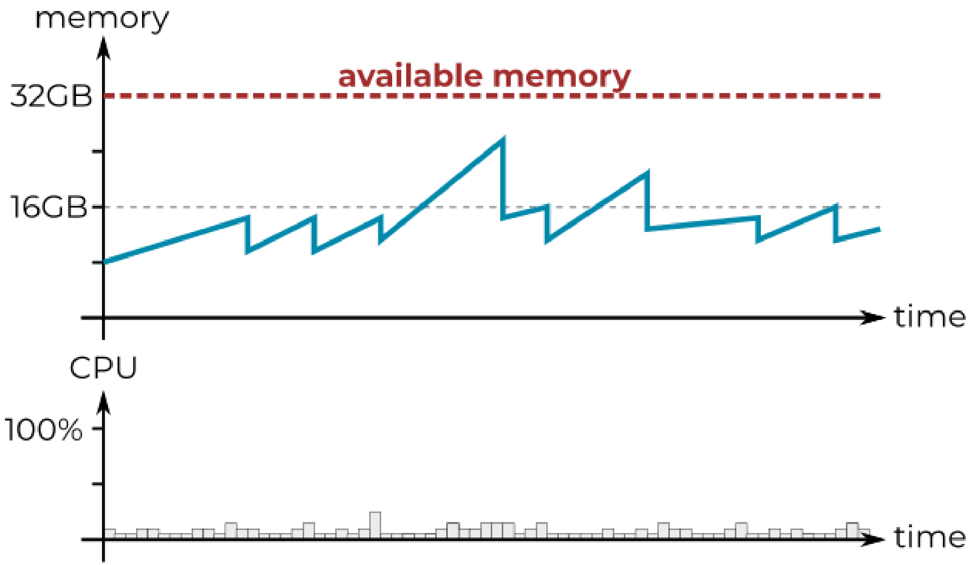
"Good" GC



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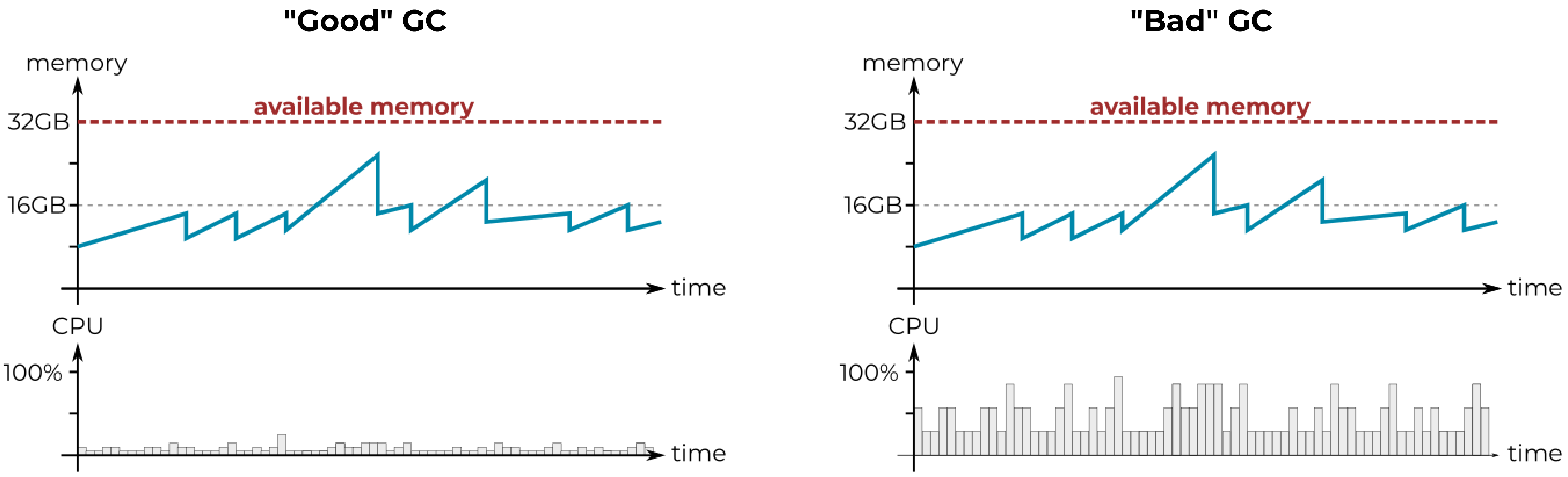

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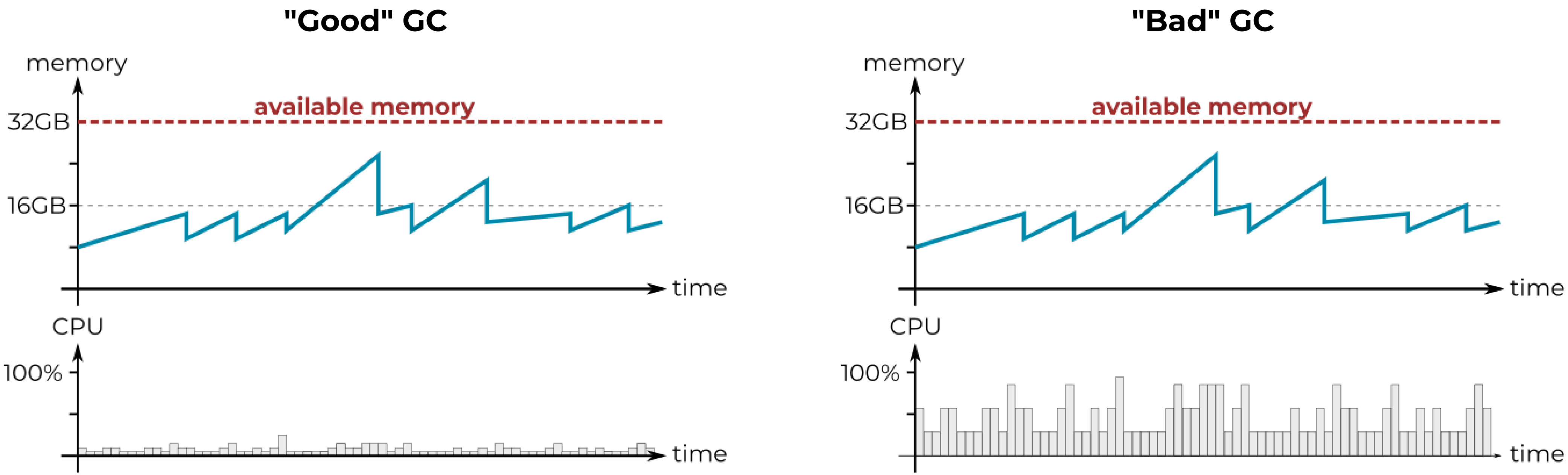
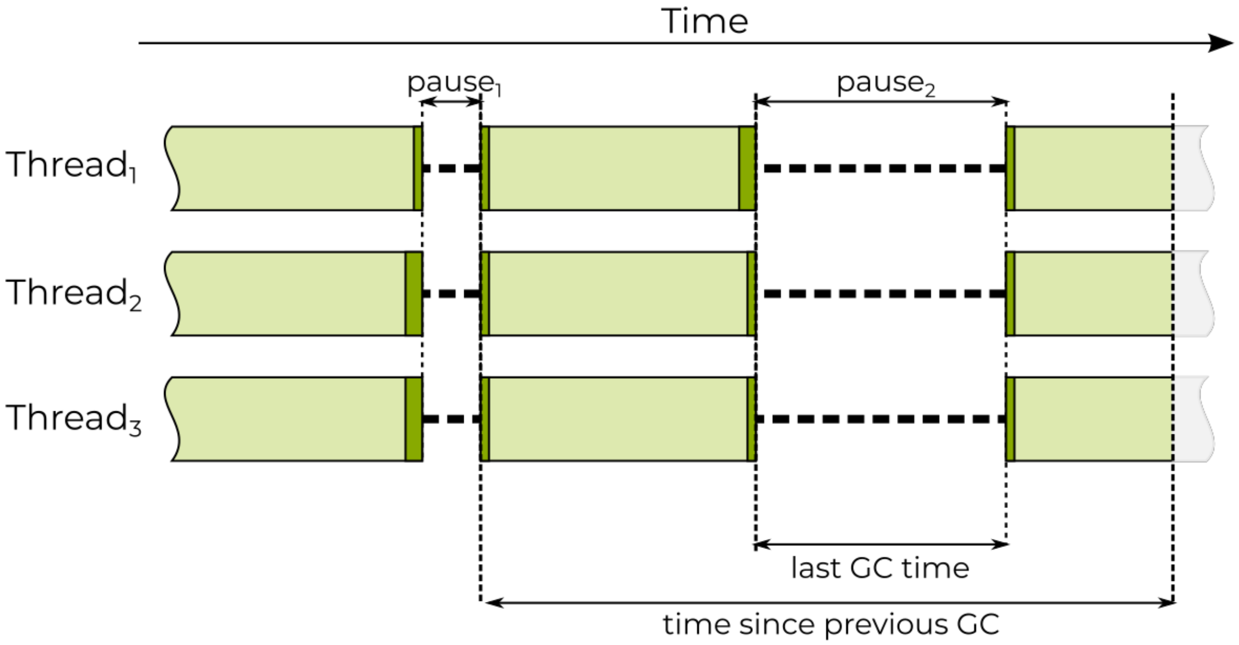


We could measure **the whole machine CPU usage** or **our process CPU usage**.

CPU overhead

The simplest measurement is the relative time spent in the CC to the application time:



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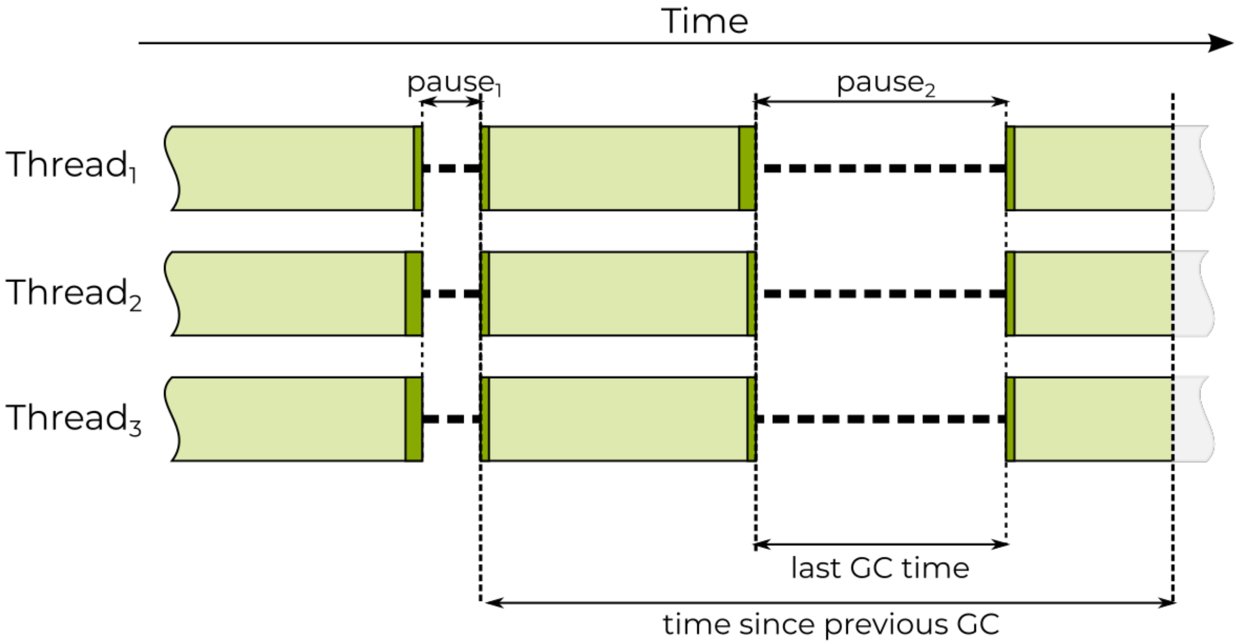

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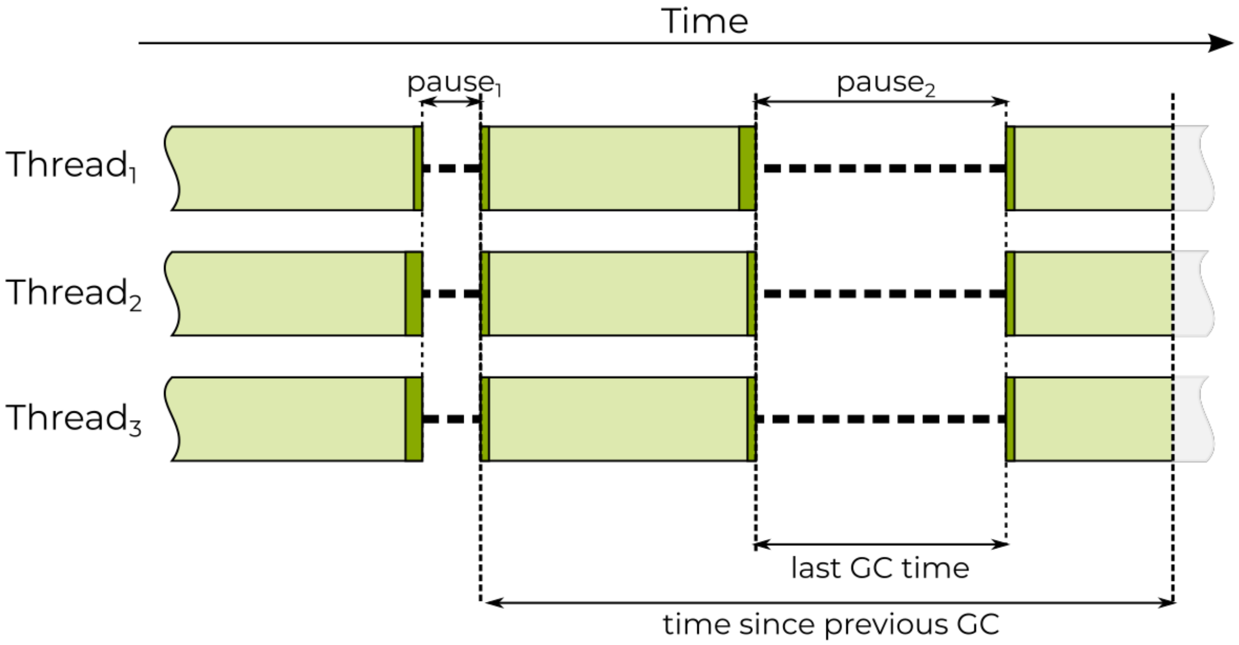

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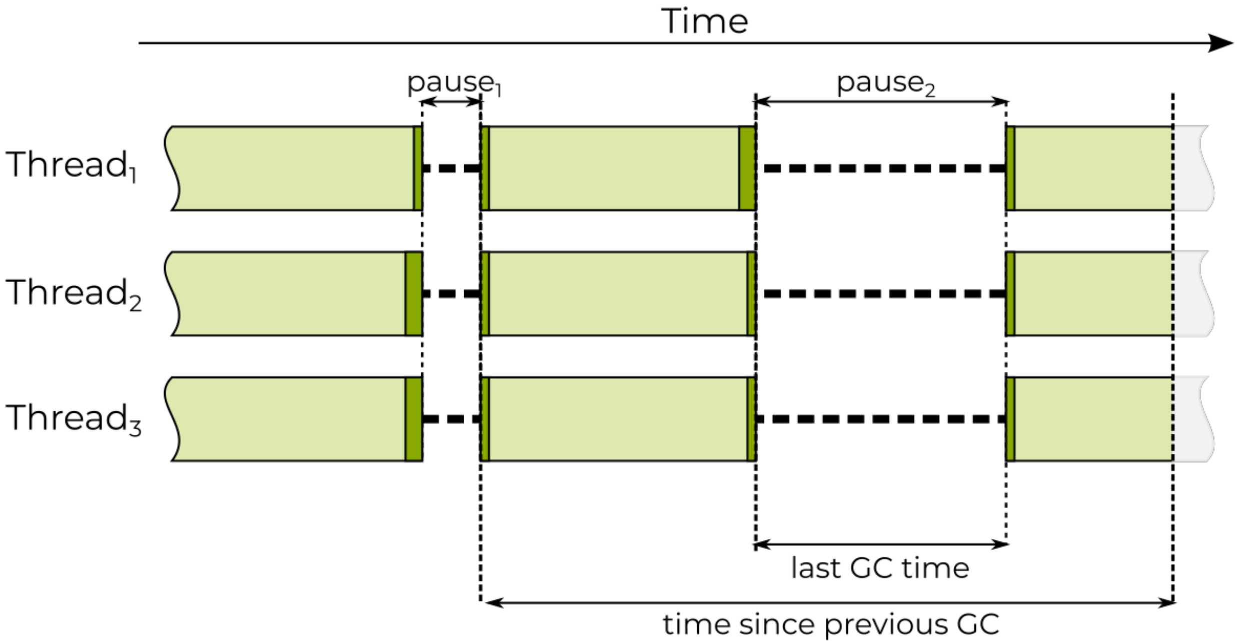

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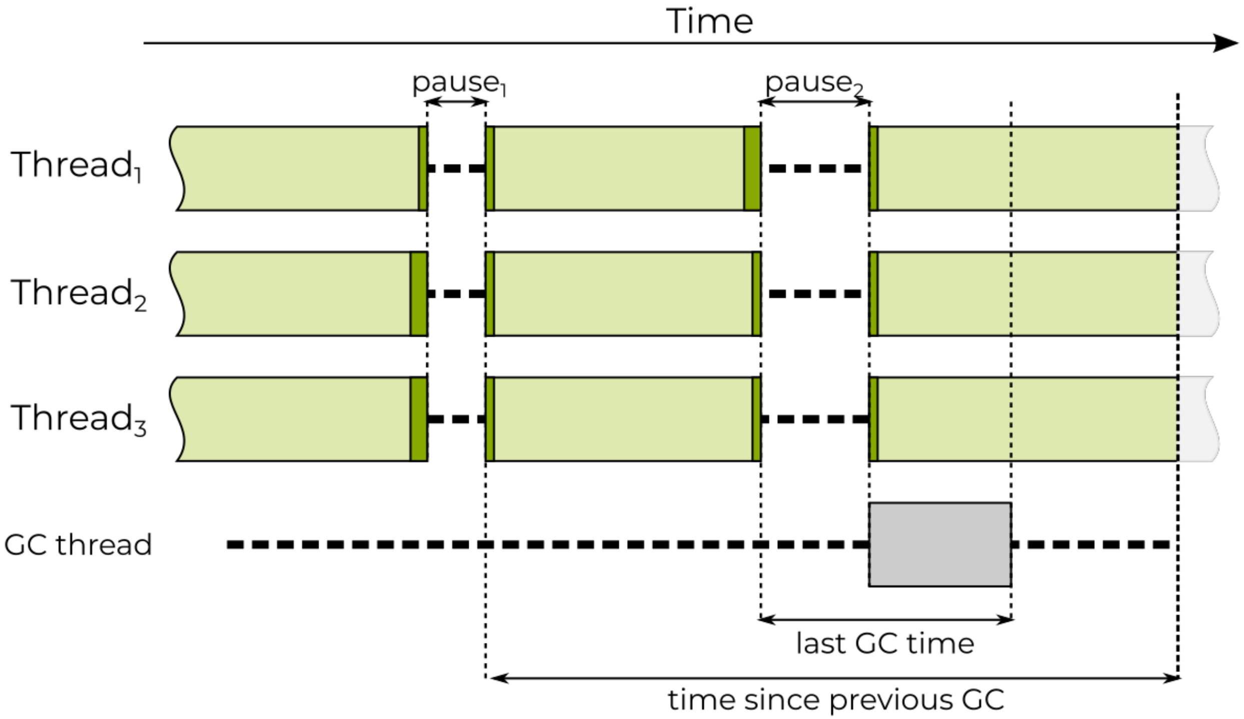
In case of GC work done only during pauses - it's the same as *% Pause time in GC* (as above).

CPU overhead

If part of the GC work is done **concurrently**, it also counts:



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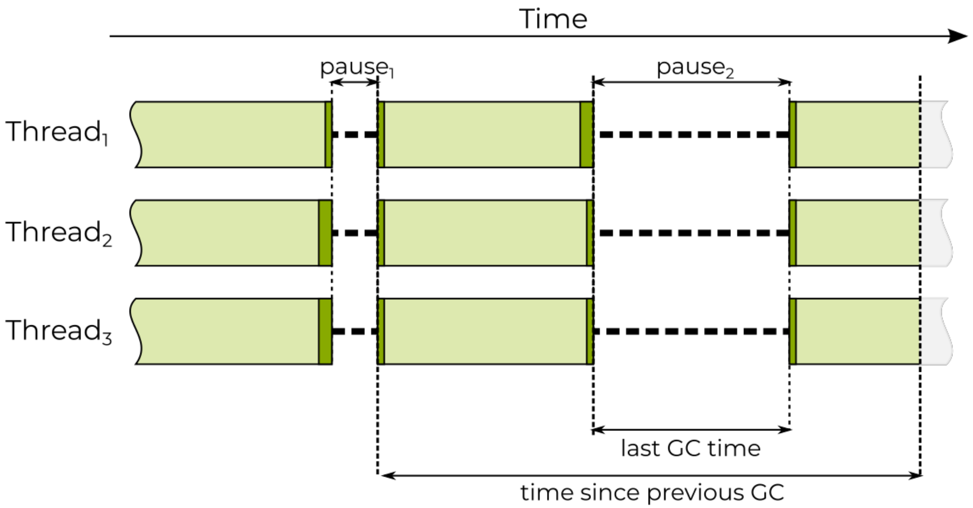

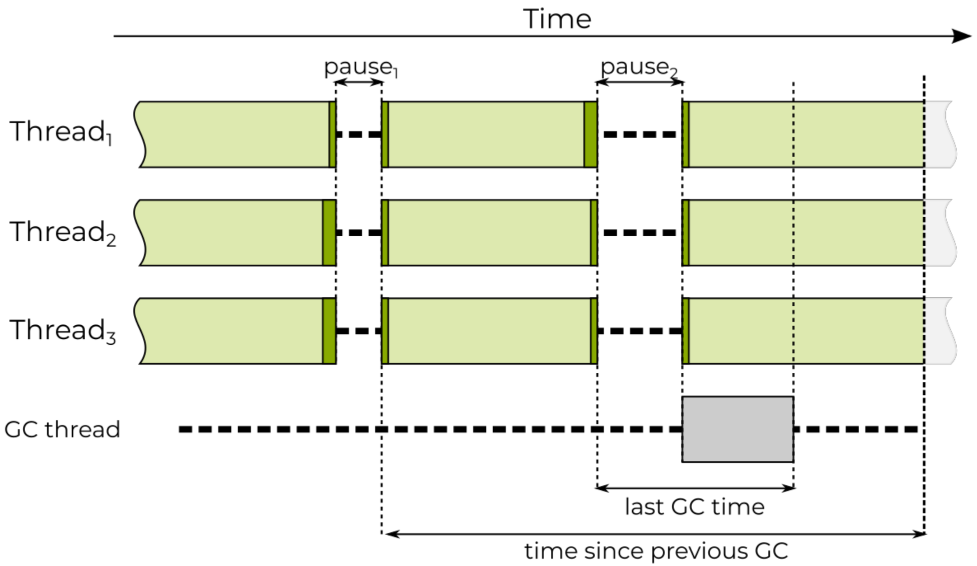

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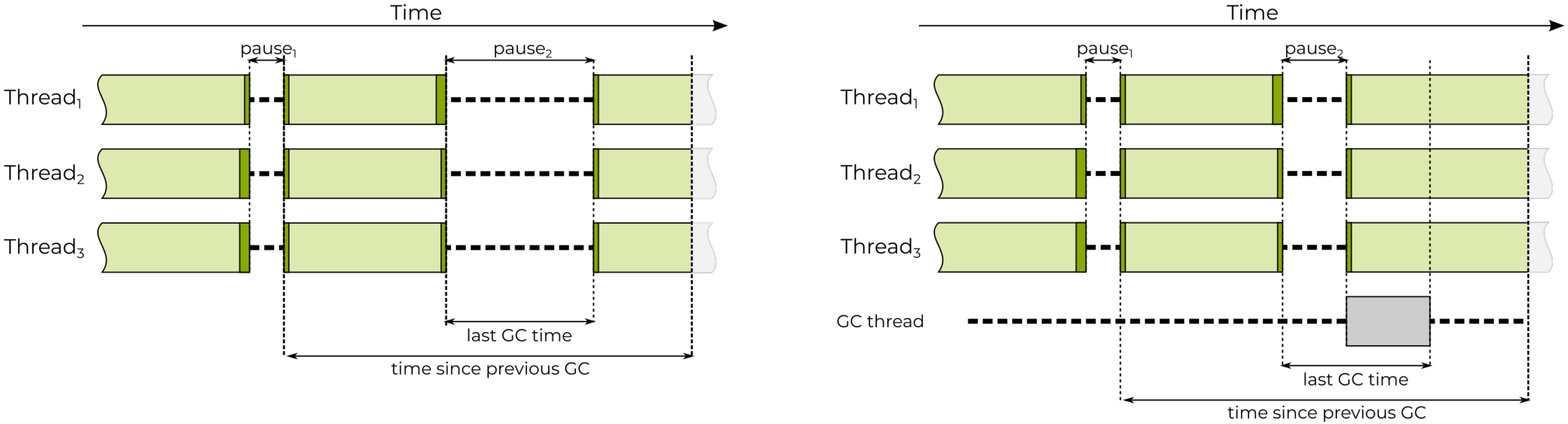

But we don't know which case consumes more CPU - it depends how CPU-intensive is the GC work during pause and concurrent phase.

CPU overhead

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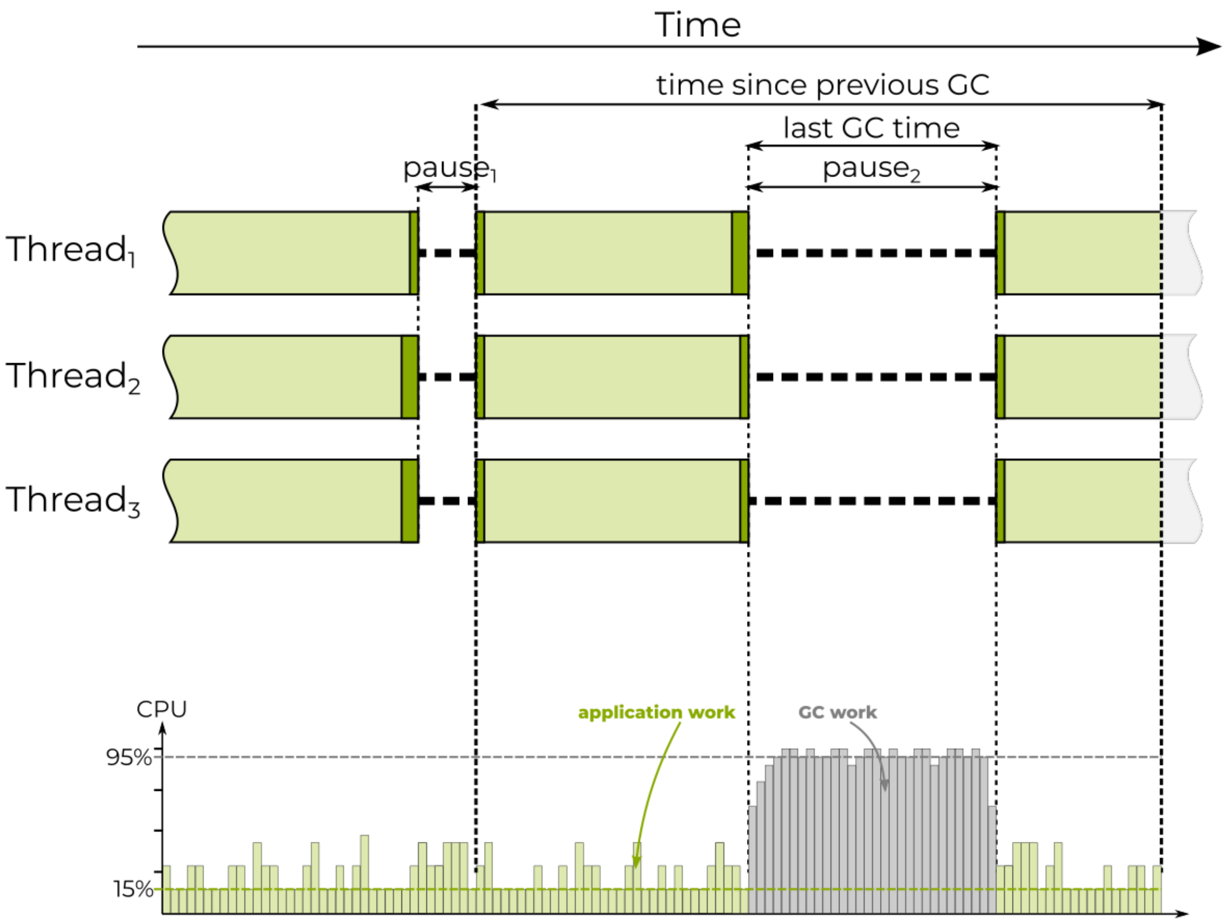

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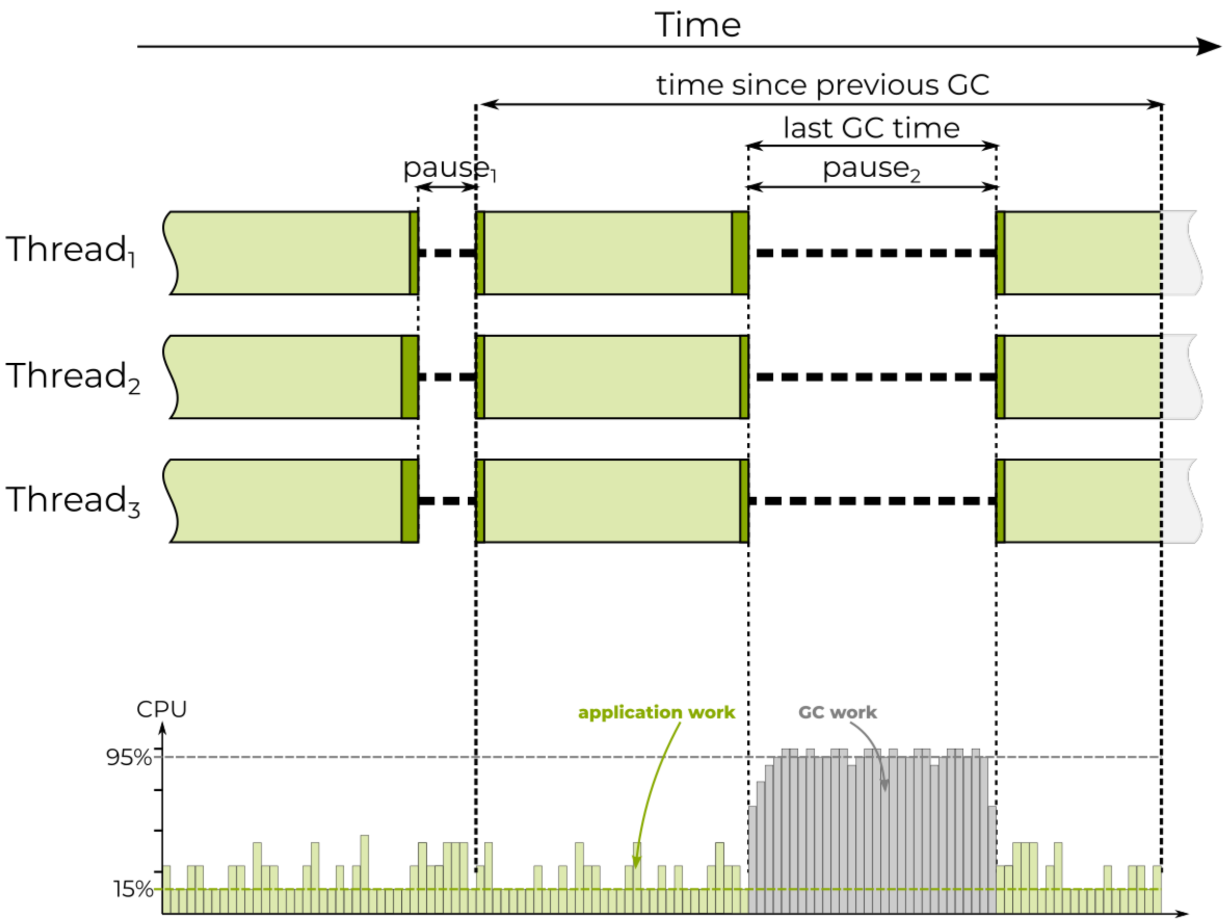

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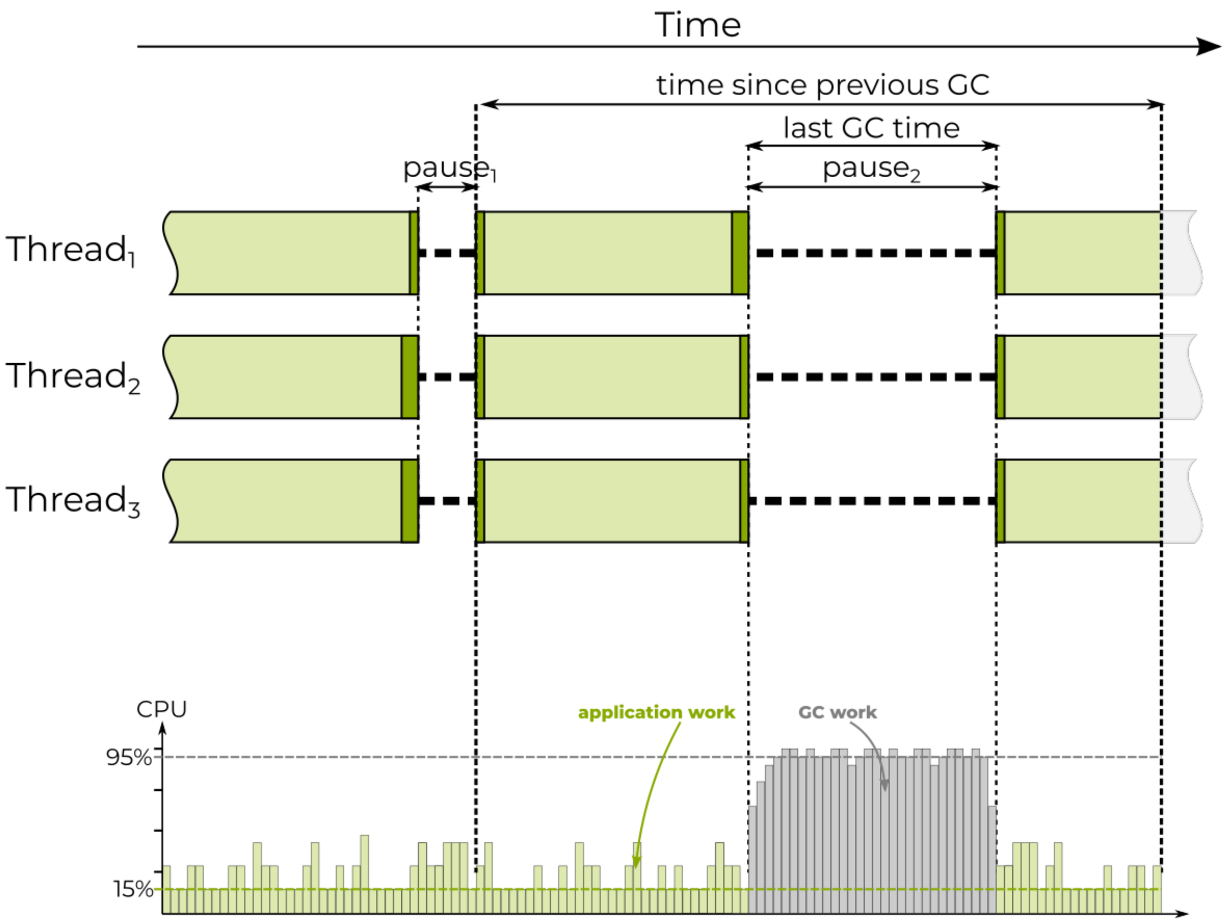

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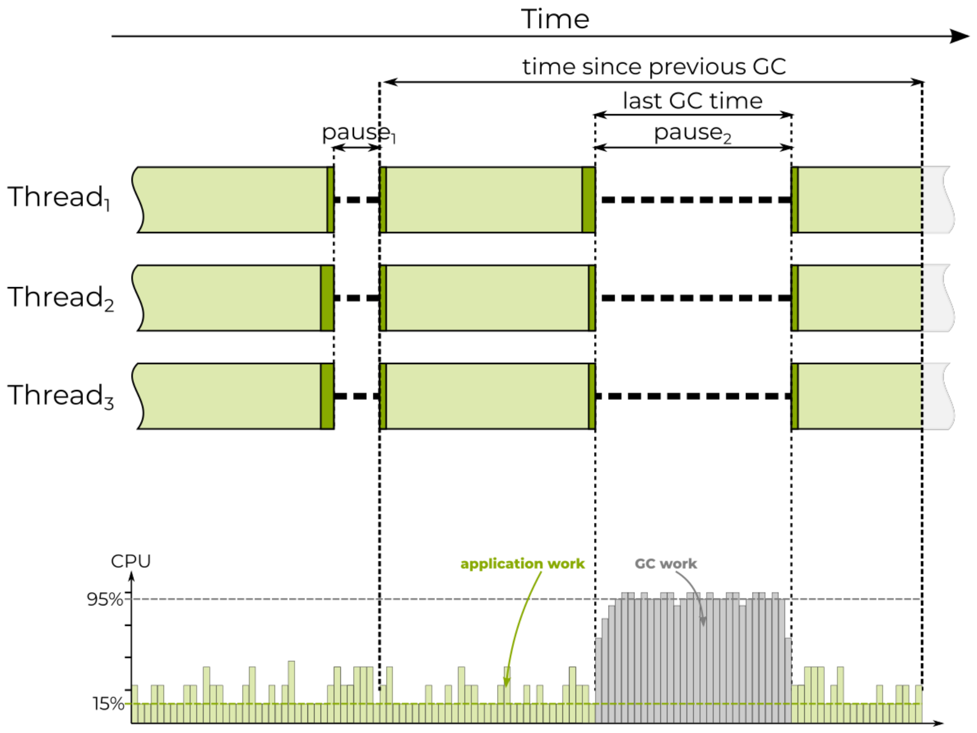

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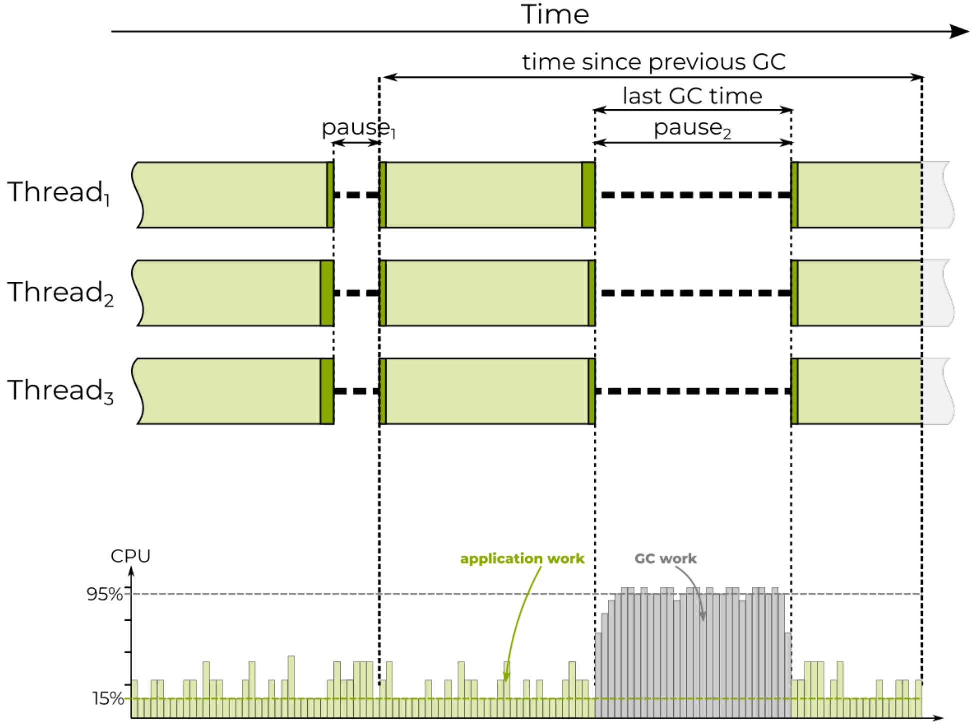

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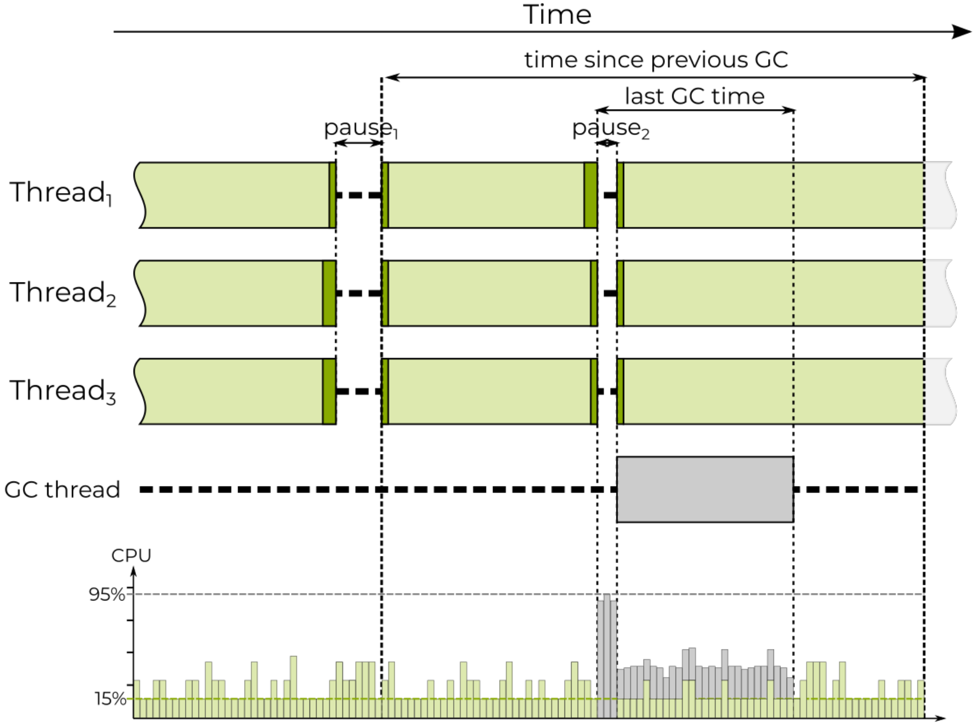

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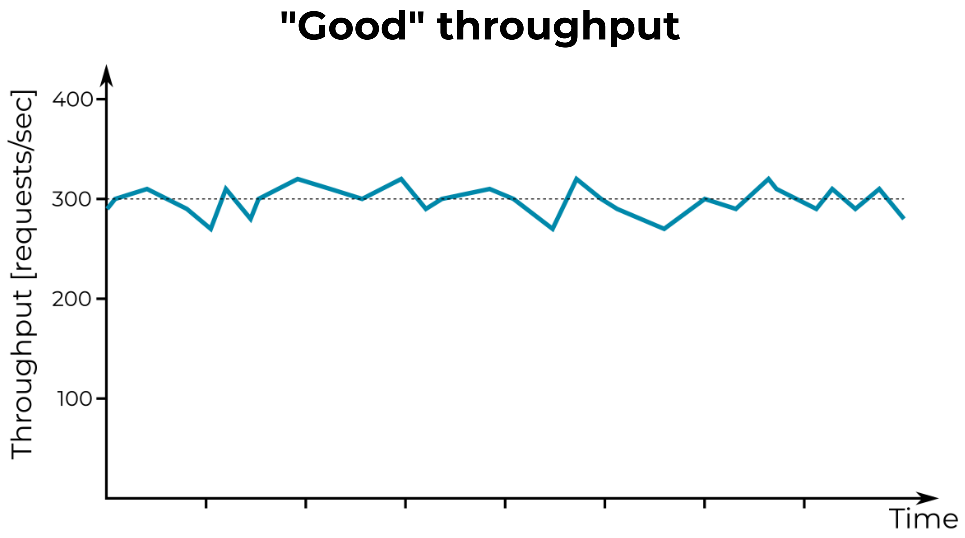

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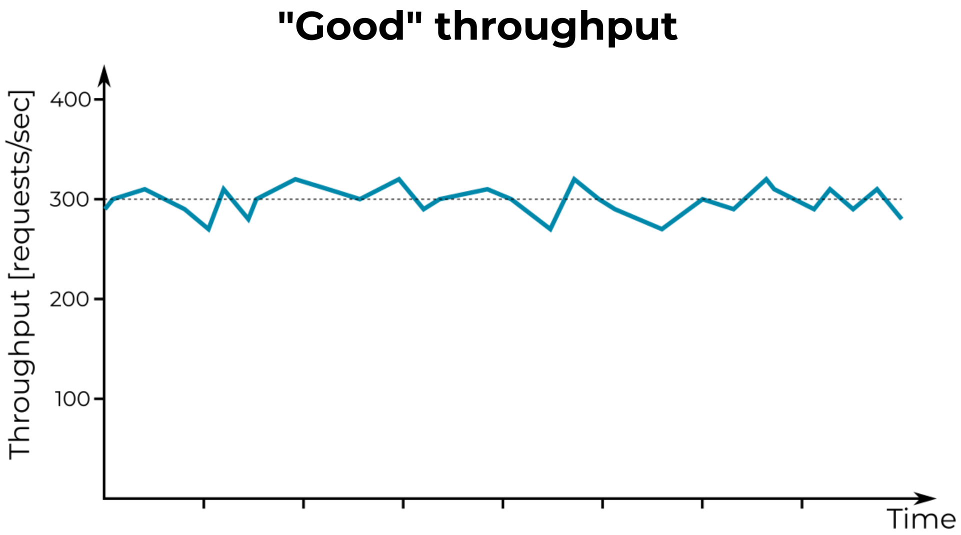

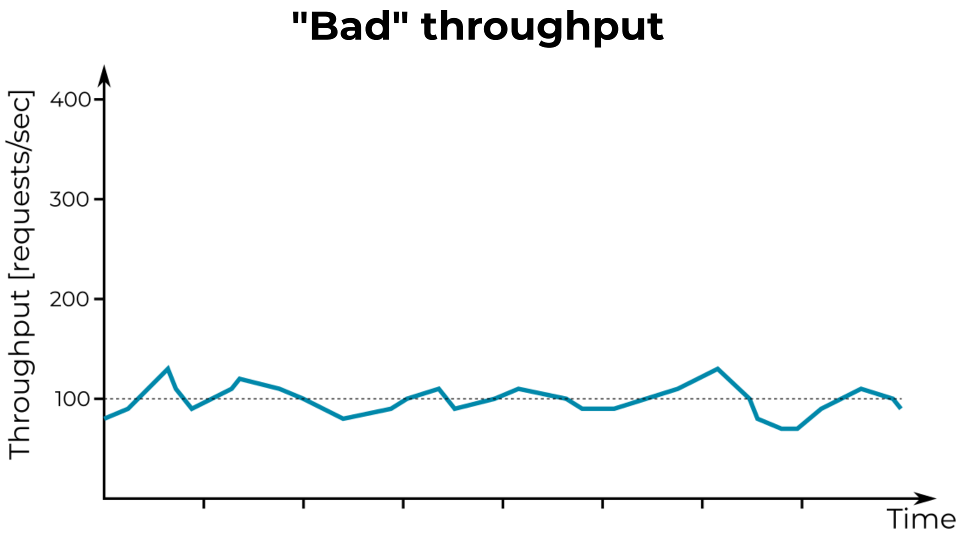

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  - but in the end, pretty often we optimize one aspect as a trade off with the others

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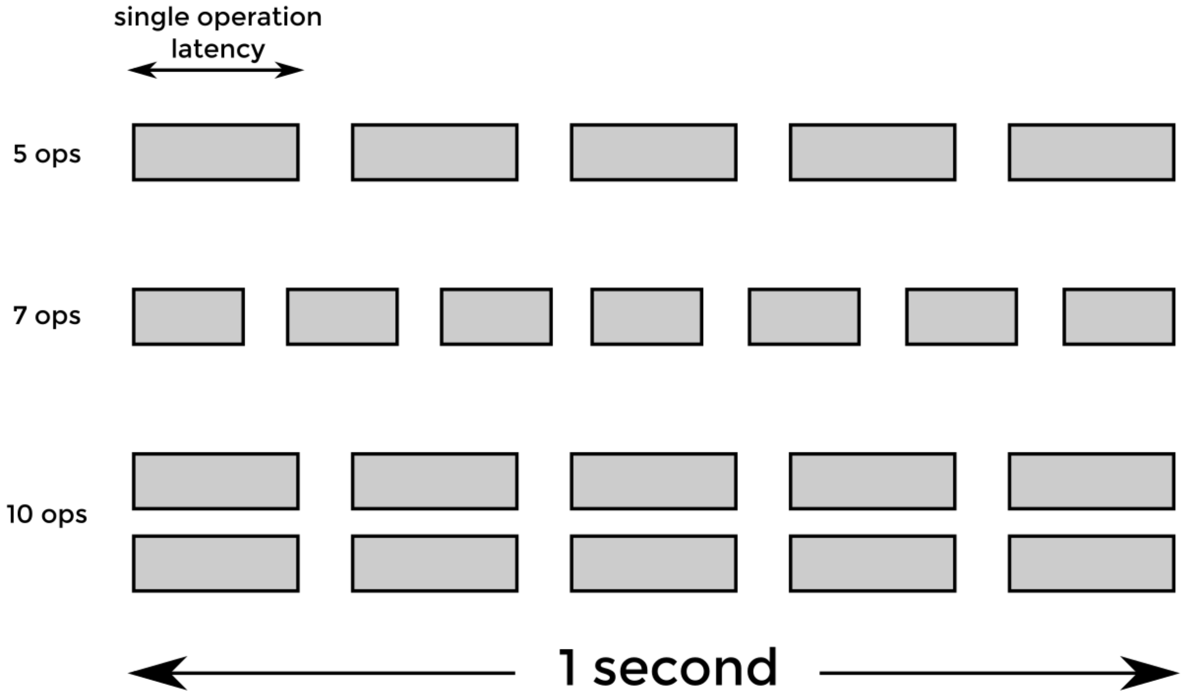

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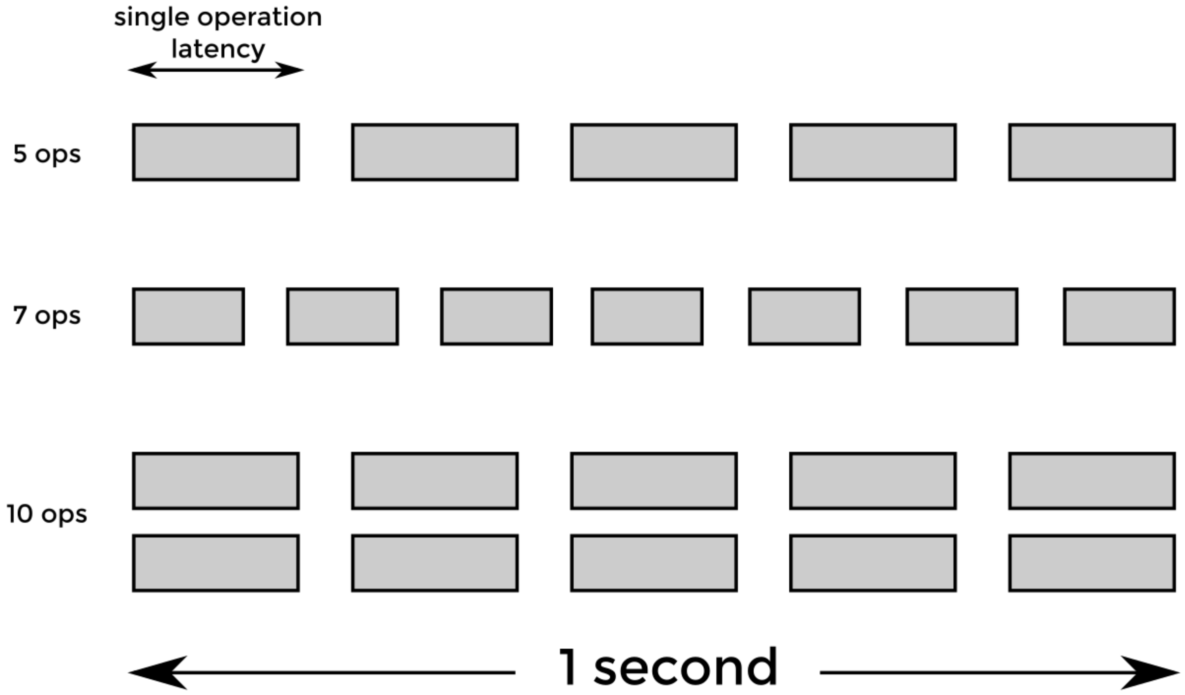

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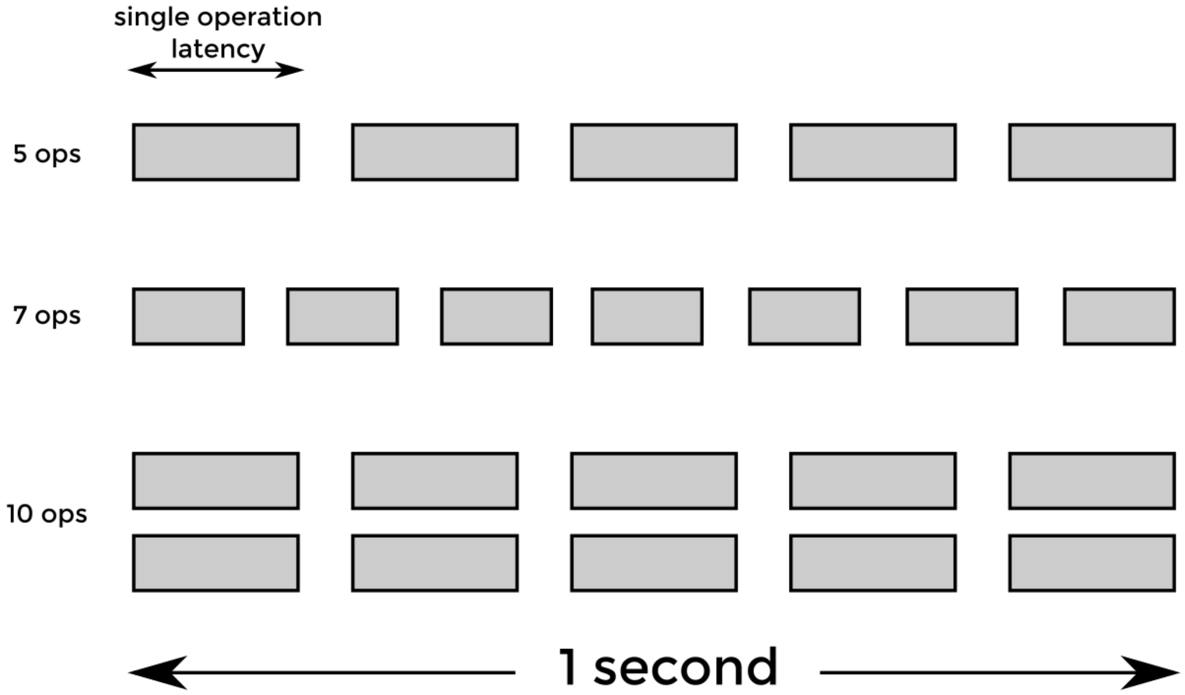

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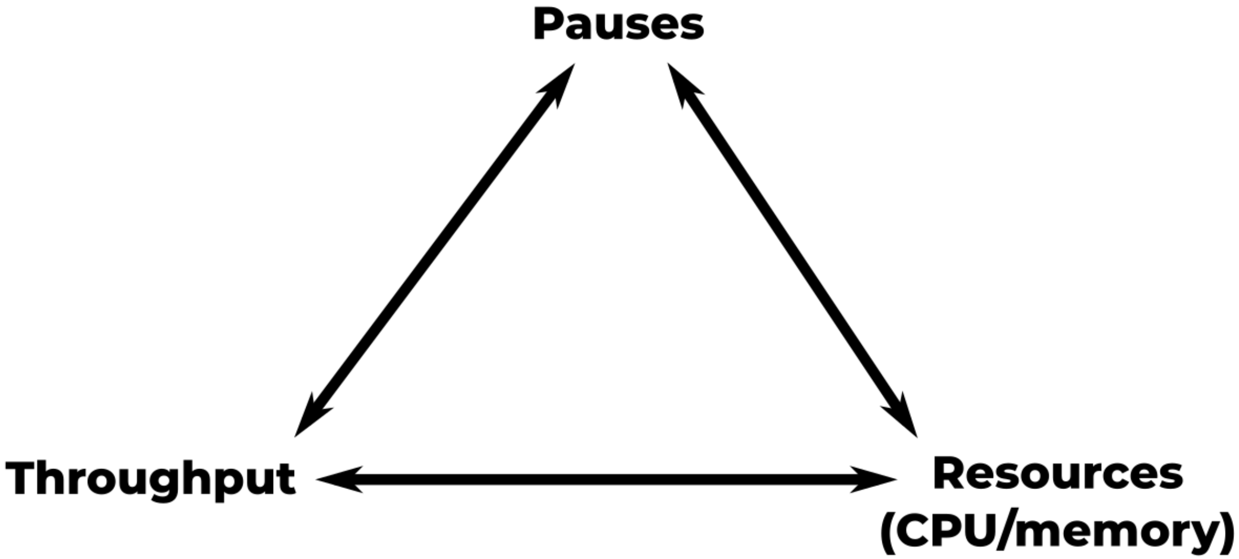
- we can increase **throughput** by parallelizing work (e.g. consuming more CPU cores)

Garbage Collection Trilemma

The "impossible triangle" of the GC features:



Materials

- .NET Memory Performance Analysis