DEVELOPER LIVE

ZGC: The Future of Low-Latency Garbage Collection Is Here

Per Liden

Consulting Member of Technical Staff, Oracle

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A Scalable Low-Latency Garbage Collector

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Properties

Max GC pause time

1ms

Multi-terabyte heaps

TB

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What’s the Catch?

Expect some reduction in throughput

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Goal

Easy to tune!

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GC Landscape

Oracle supported garbage collectors

GC	Optimized For
Serial	Memory Footprint
Parallel	Throughput
G1	Throughput/Latency Balance
ZGC	Low Latency

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ZGC at a Glance

Concurrent
Tracing
Compacting
Single generation

Region-based
NUMA-aware
Load barriers
Colored pointers

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ZGC pauses are O(1)

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Available on All Commonly Used Platforms

Linux

x86 / Arm / PPC

Windows

x86 / Arm

macOS

x86 / Arm

(64-bit)

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Production Ready since JDK 15

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Performance

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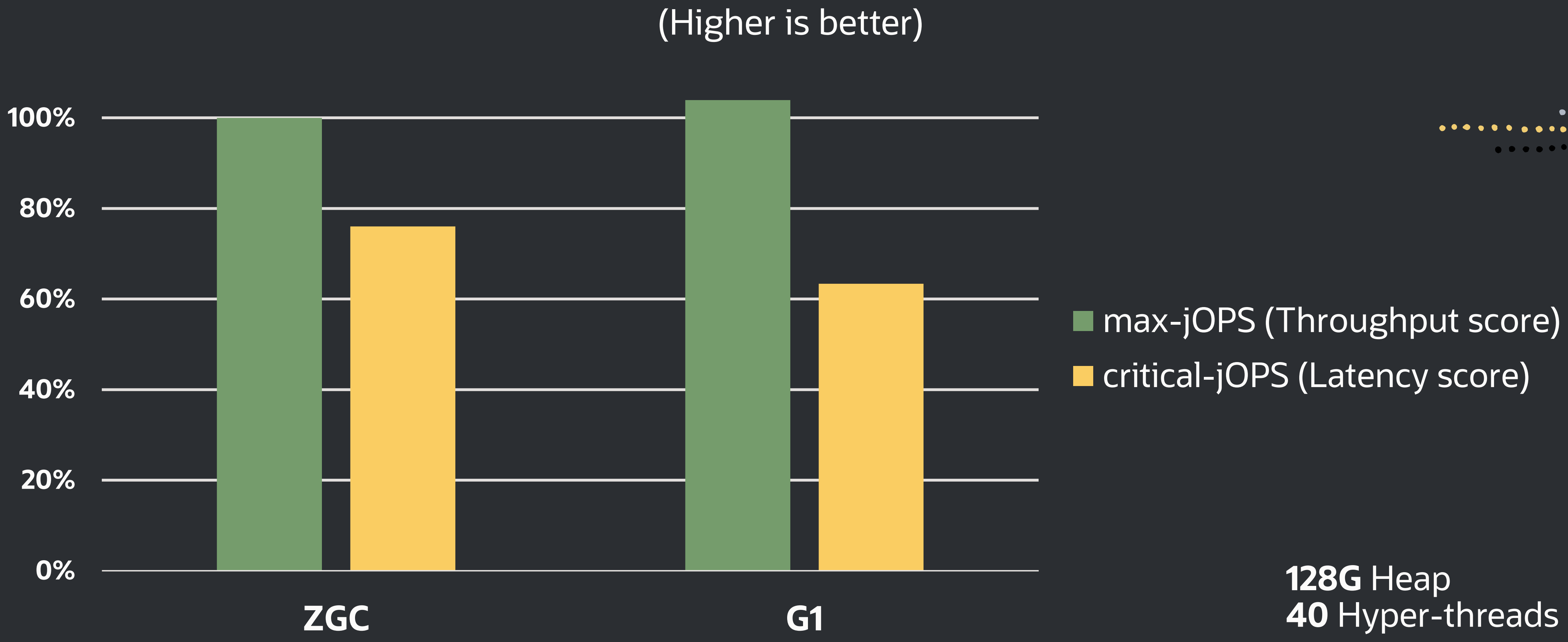
SPECjbb2015 – Benchmark Score



128G Heap
40 Hyper-threads (Intel)

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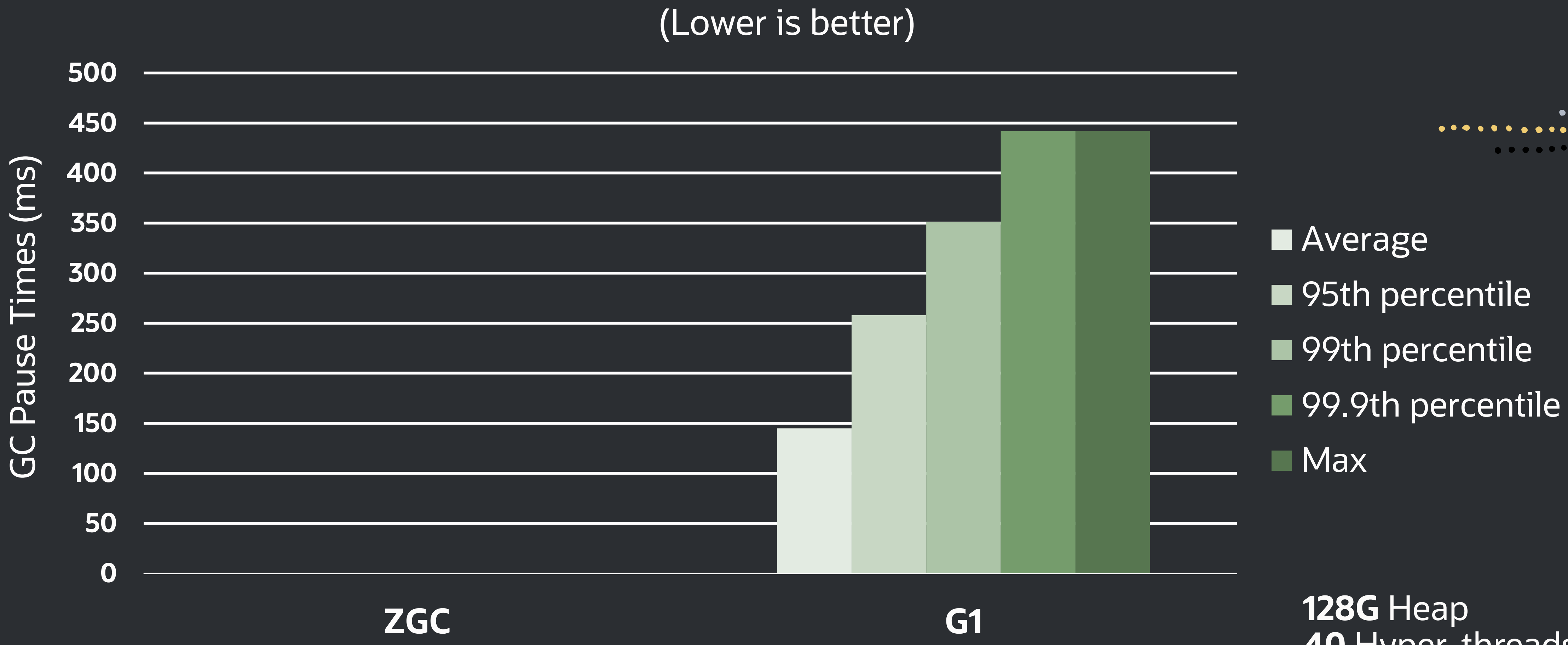
SPECjbb2015 – GC Pause Times



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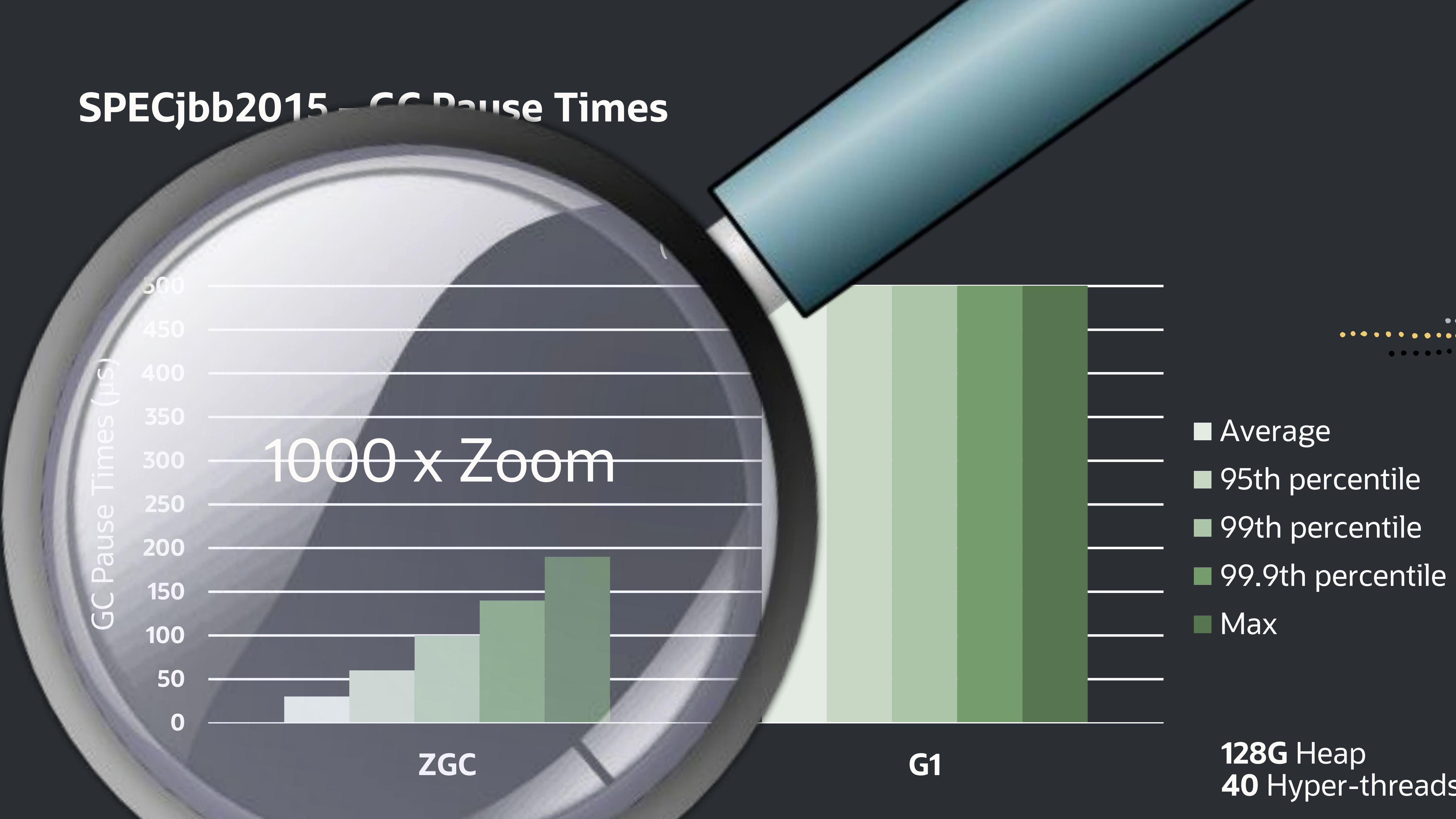

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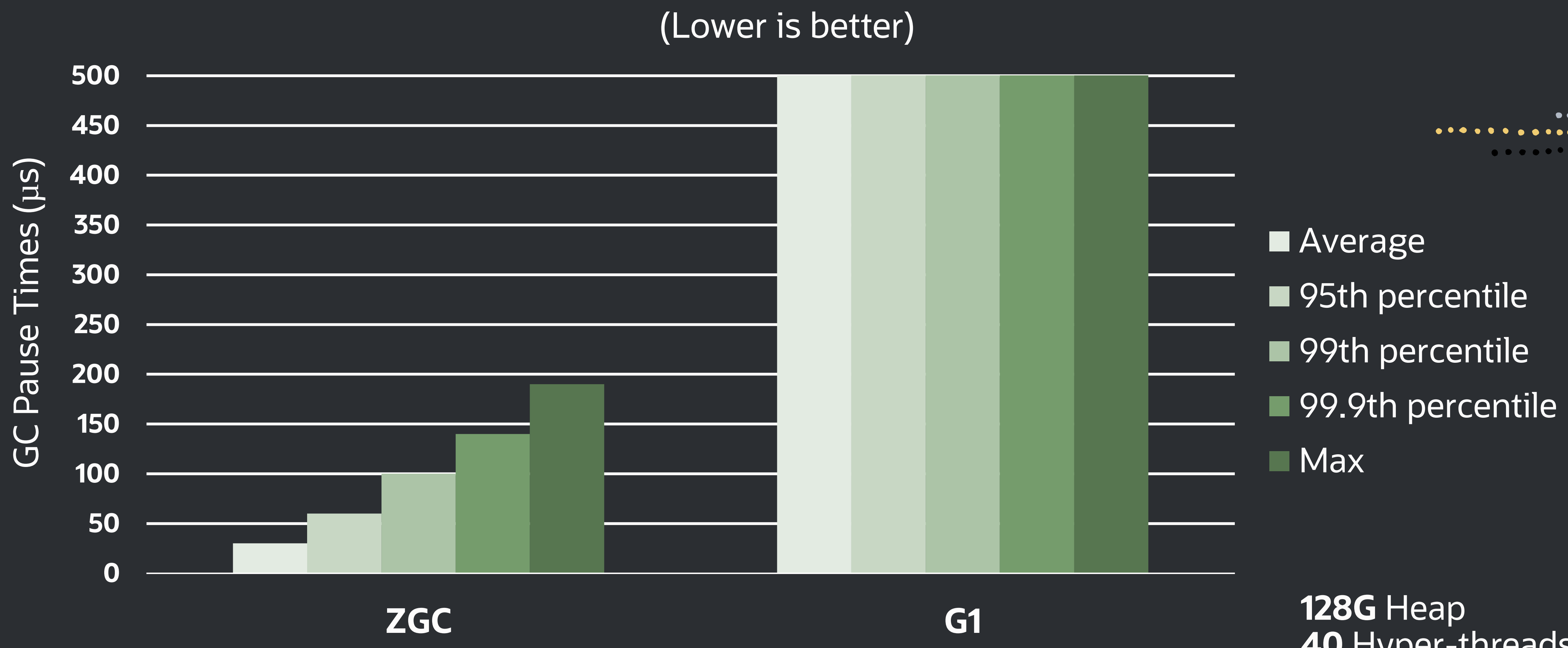
SPECjbb2015 – GC Pause Times



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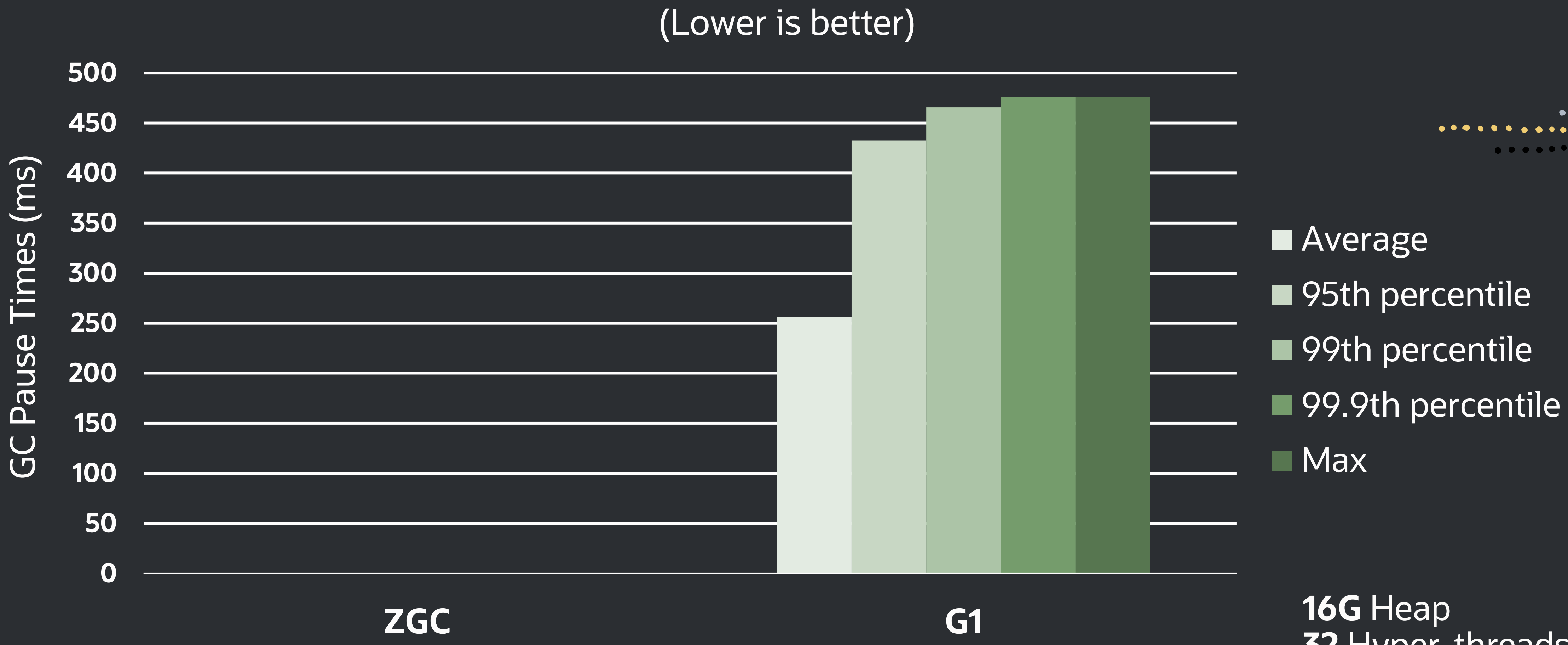
BigRamTester – GC Pause Times

Lots of heap fragmentation



16G Heap
32 Hyper-threads (Intel)

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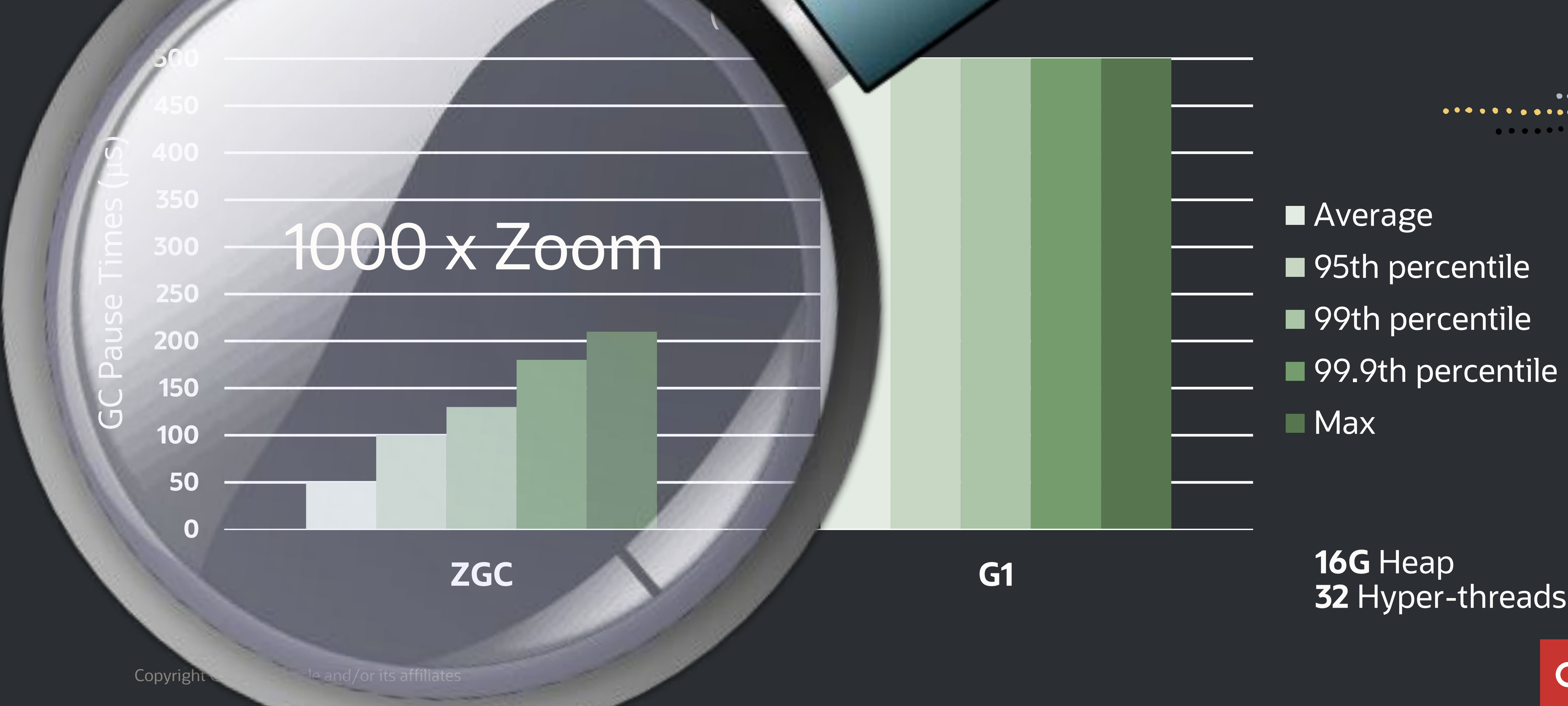
BigRamTester – GC Pause Times

Lots of heap fragmentation



16G Heap
32 Hyper-threads (Intel)

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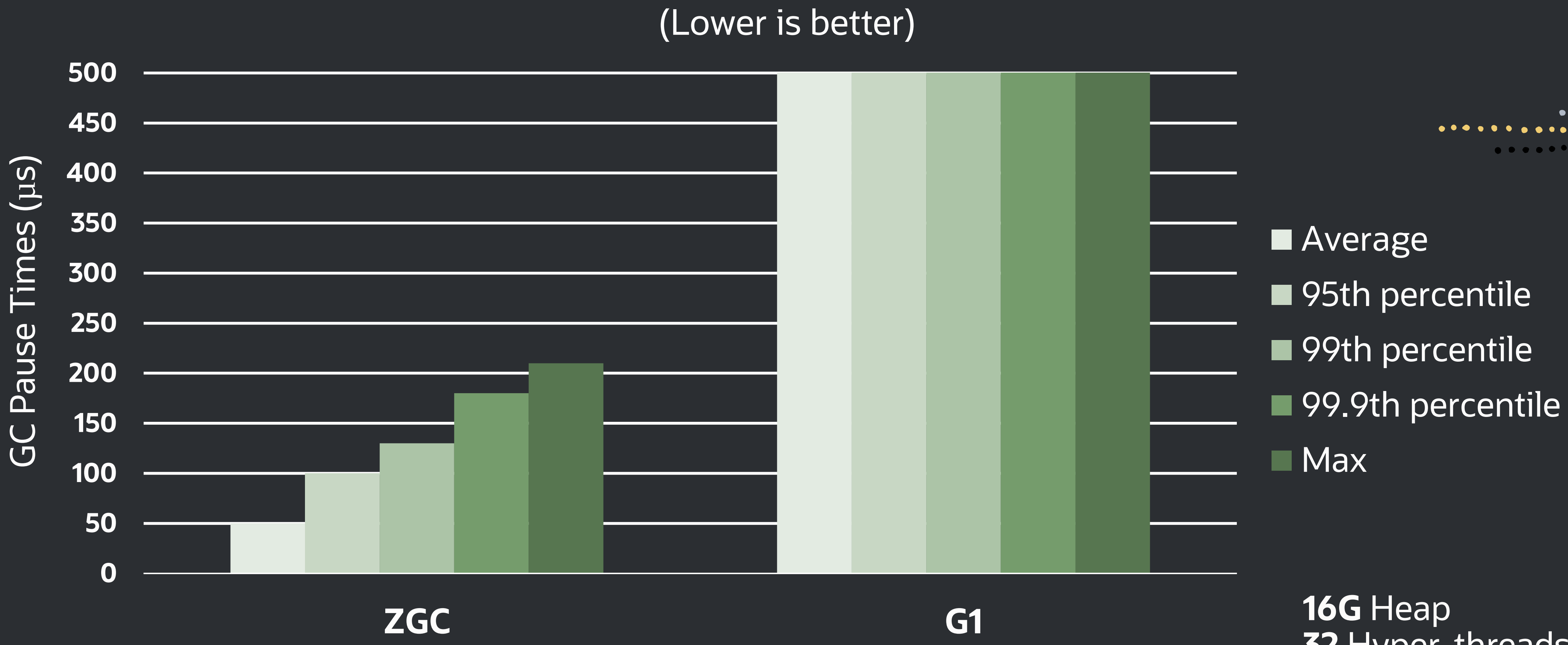
BigRamTester – GC Pause Times

Lots of heap fragmentation



16G Heap
32 Hyper-threads (Intel)

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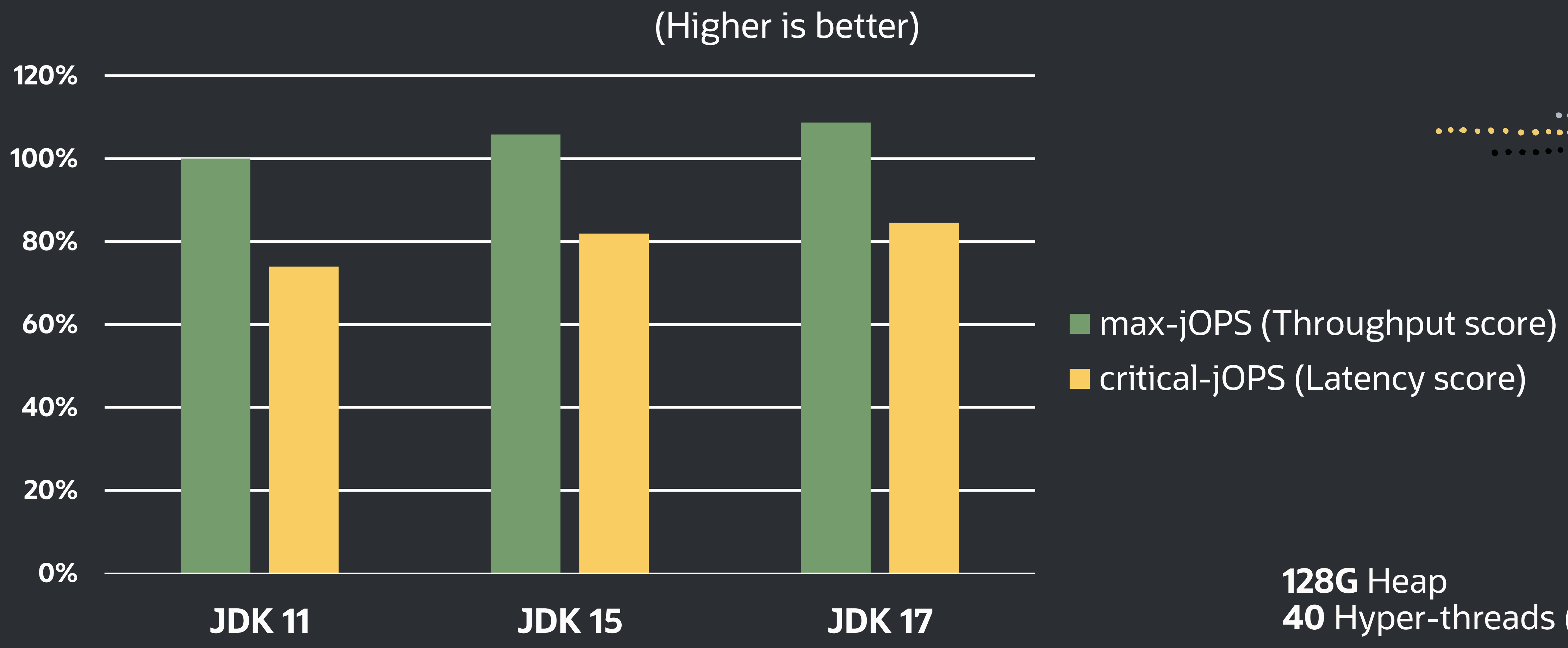
ZGC Improvements Over Time

SPECjbb2015 – Benchmark Score



128G Heap
40 Hyper-threads (Intel)

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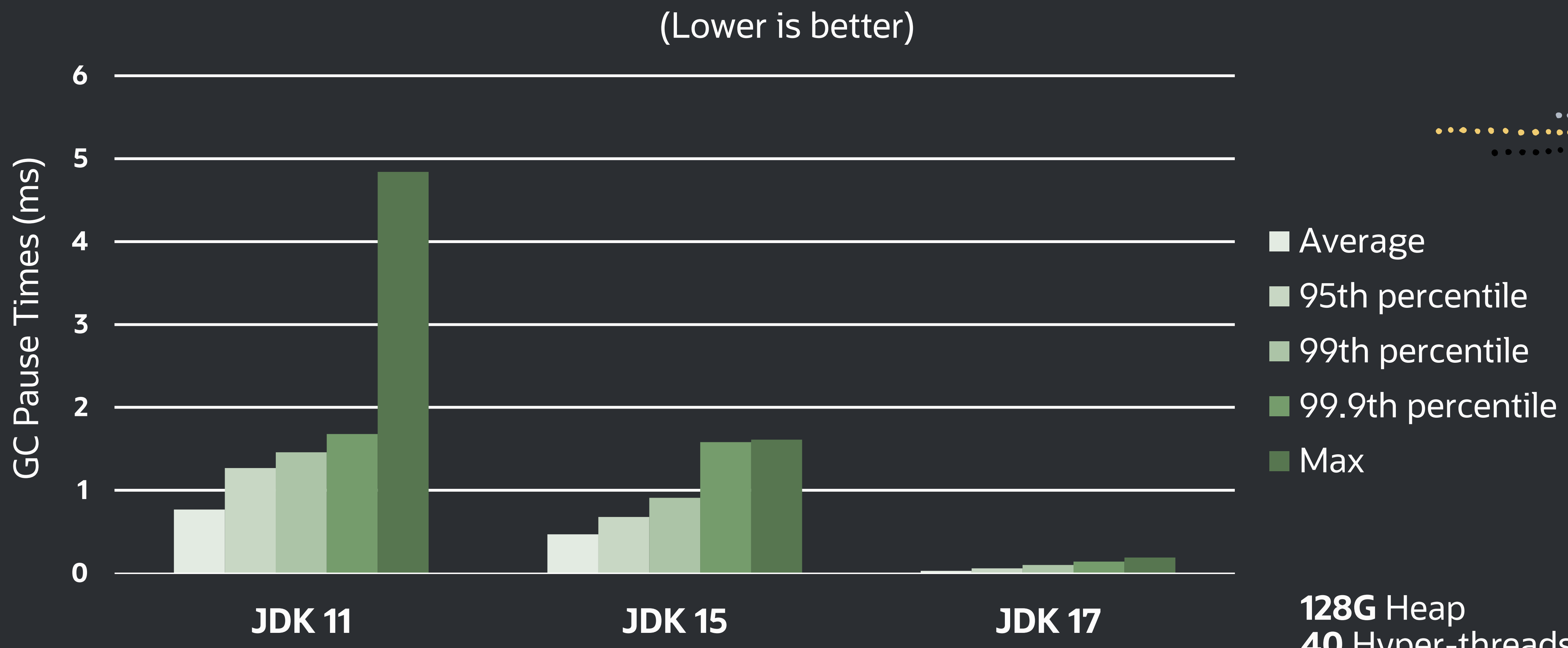
ZGC Improvements Over Time

SPECjbb2015 – GC Pause Times



128G Heap
40 Hyper-threads (Intel)

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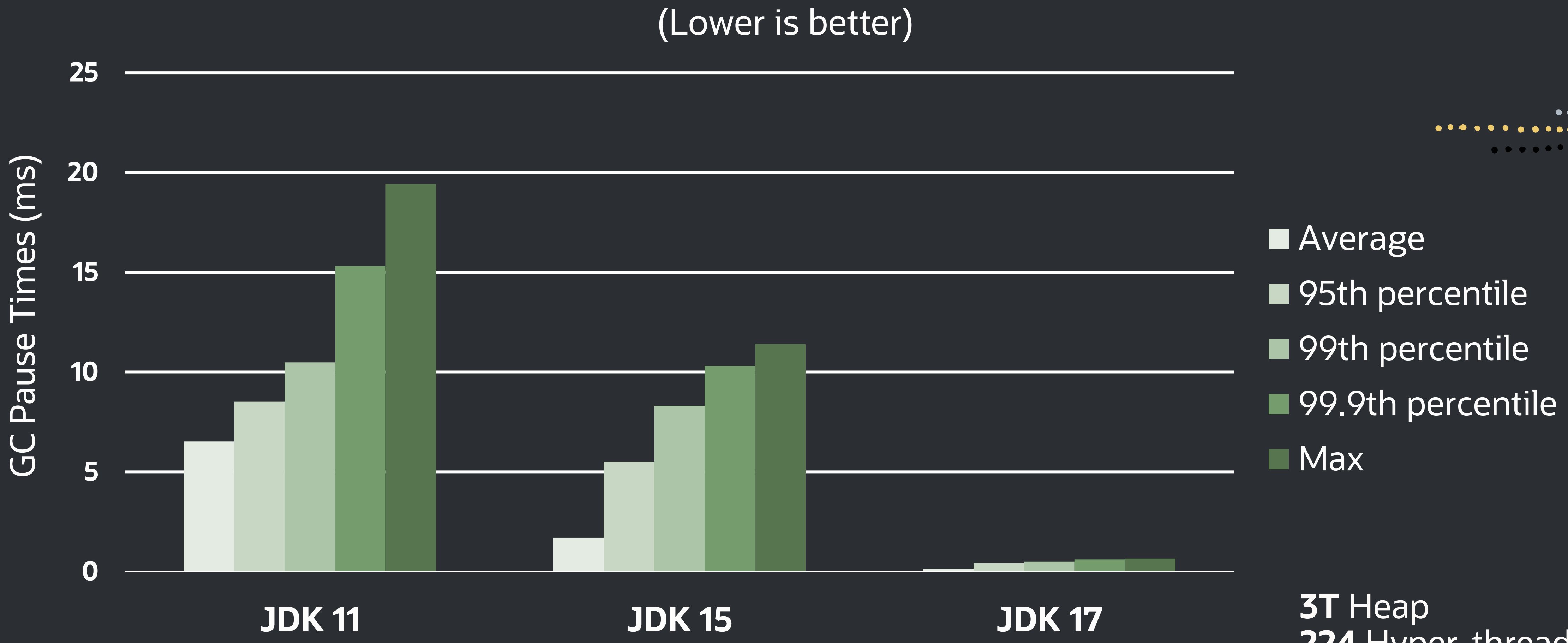
ZGC Improvements Over Time (Large System)

SPECjbb2015 – GC Pause Times



3T Heap
224 Hyper-threads (Intel)

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Using ZGC

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Enable

```
-XX:+UseZGC
```

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Tuning

Set Max Heap Size

```
-Xmx<size>
```

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Logging

`-Xlog:gc` (basic)

`-Xlog:gc*` (detailed)

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Roadmap

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Generational ZGC

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The Generational Hypothesis

A very common patten in Java applications is that ***most objects are short lived***

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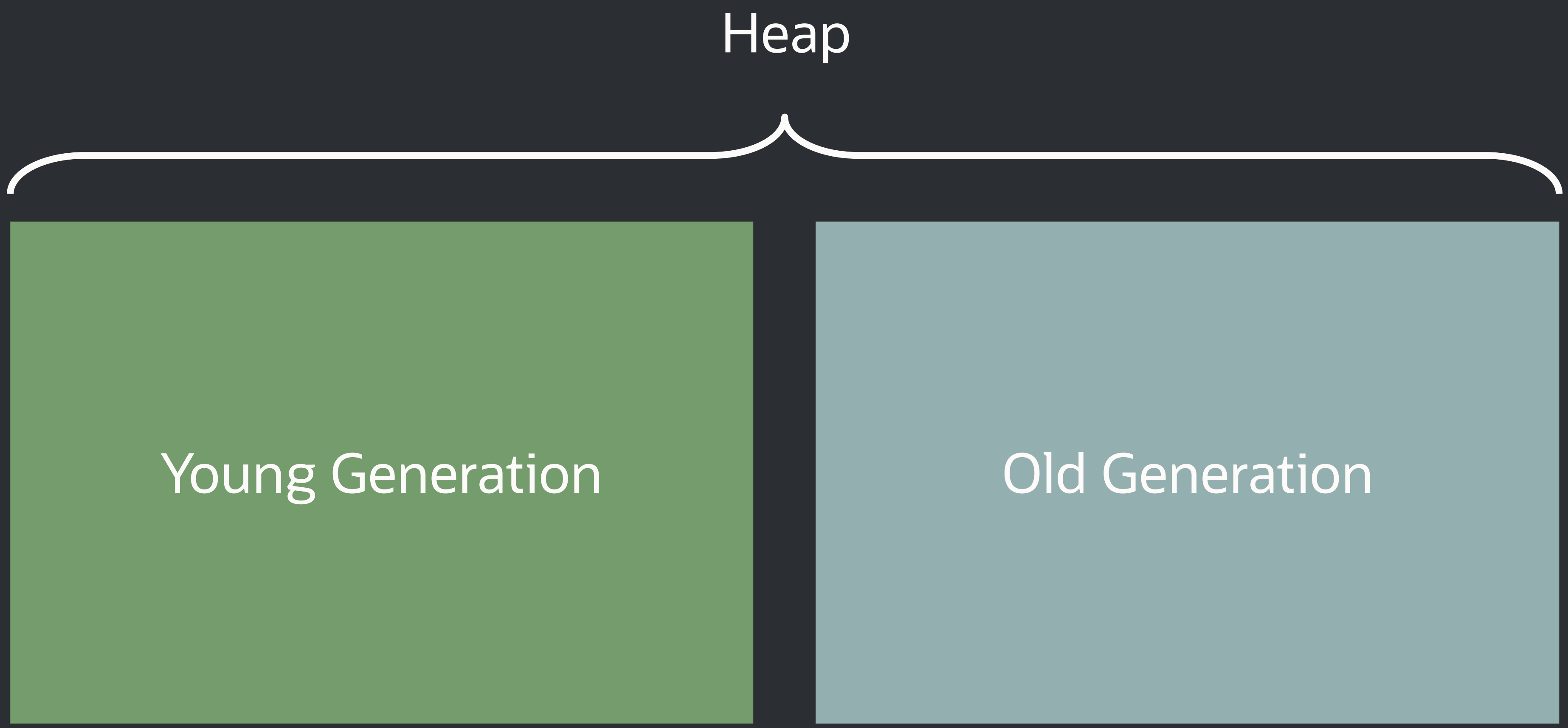

Heap

Young Generation

Old Generation

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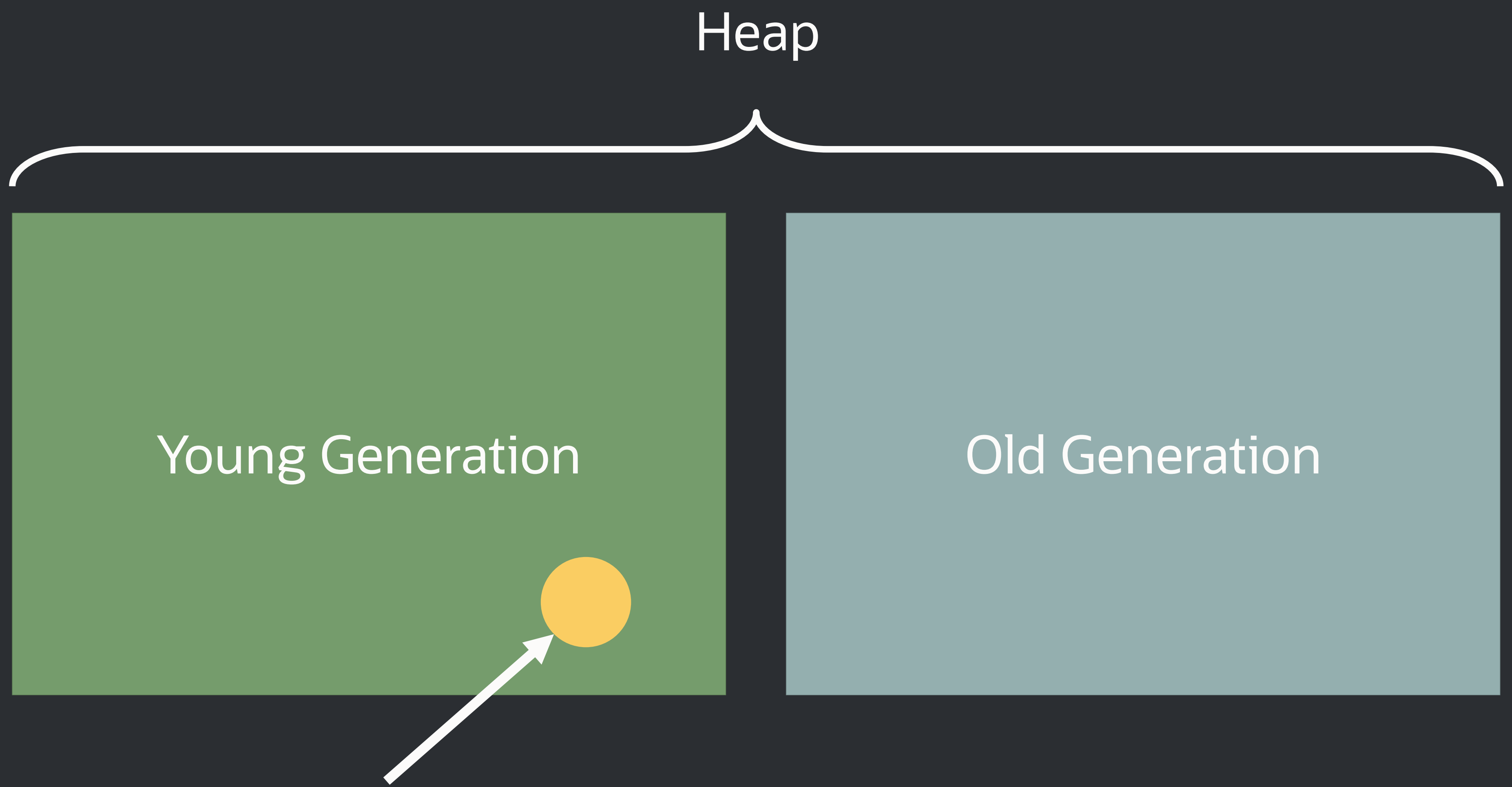

Heap

Young Generation

Old Generation

New object allocated in the young generation

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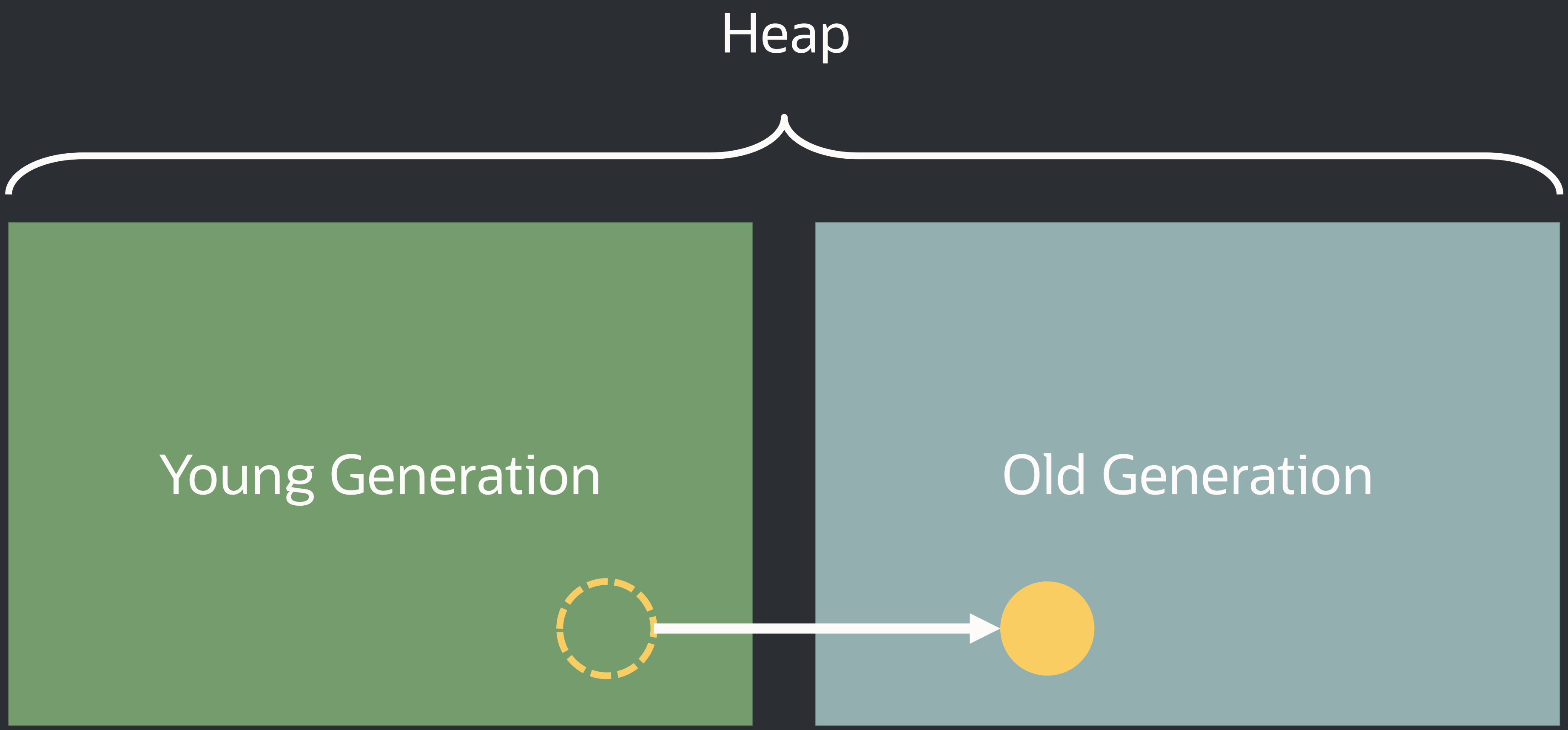

Object promoted to the old generation

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Reduced Effort to Collect Garbage

Withstand higher allocation rates

Lower heap headroom

Lower CPU usage

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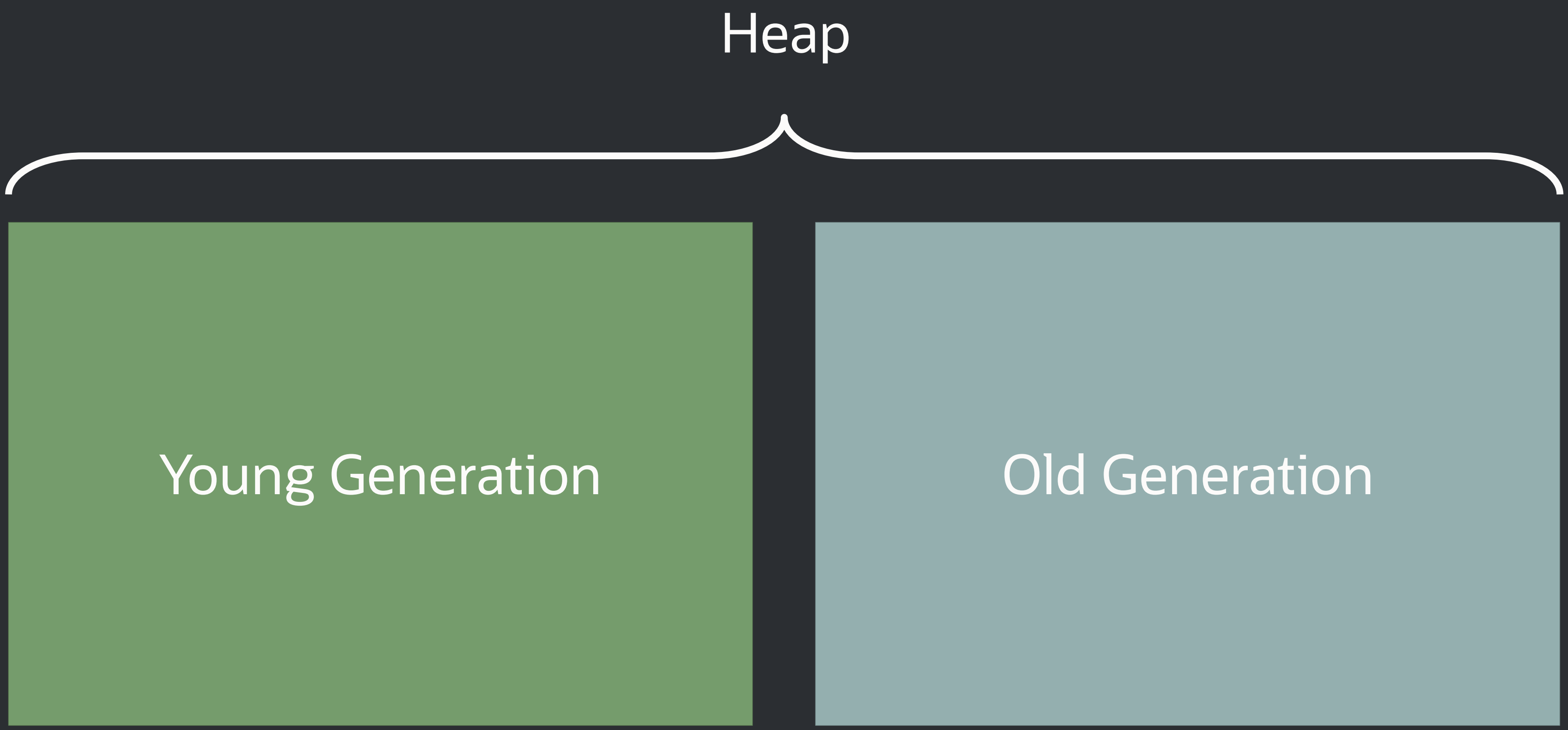

Heap

Young Generation

Old Generation

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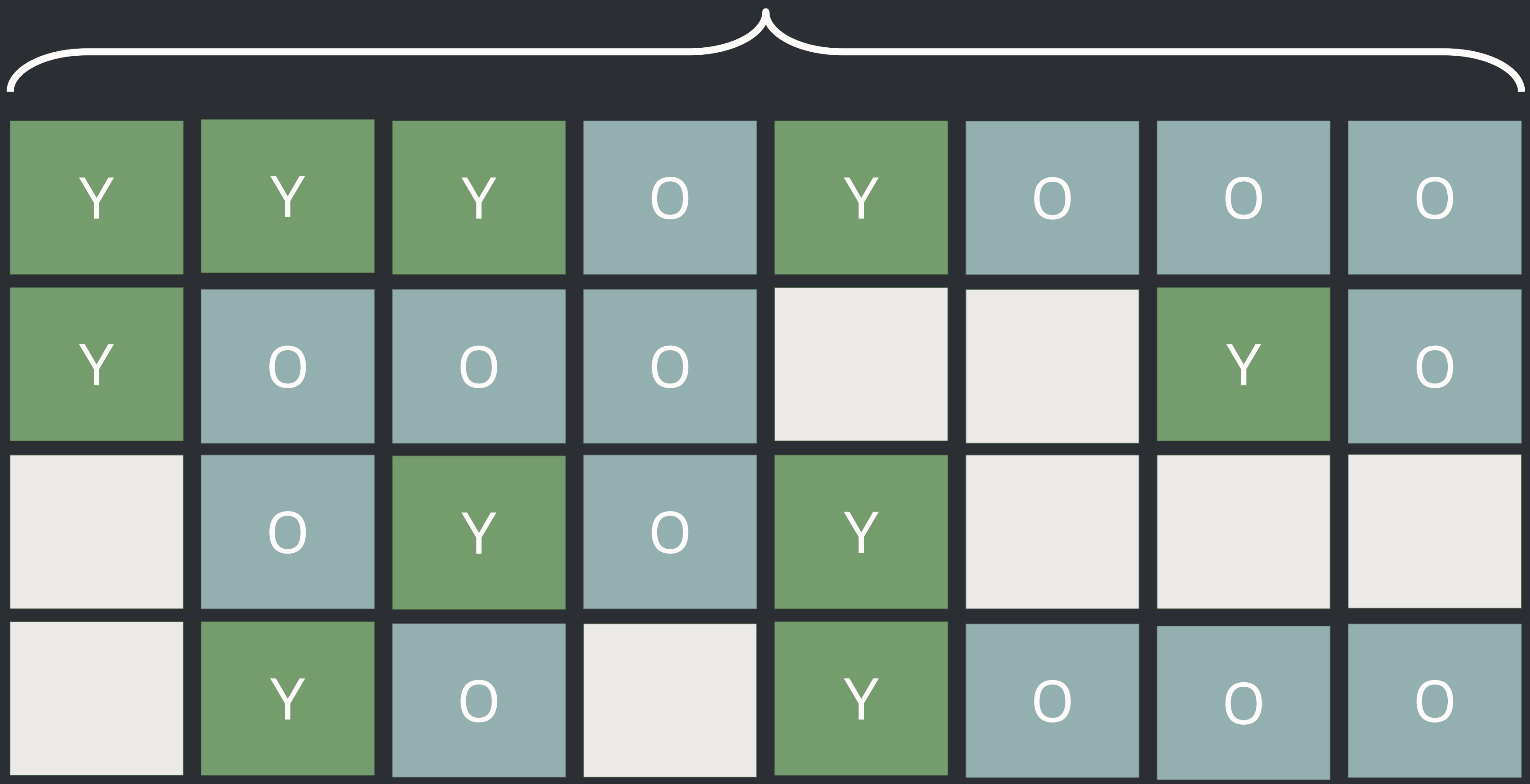
ZGC Heap



Y	Y	Y	O	Y	O	O	O
Y	O	O	O			Y	O
	O	Y	O	Y			
	Y	O		Y	O	O	O

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Minor & Major Collections

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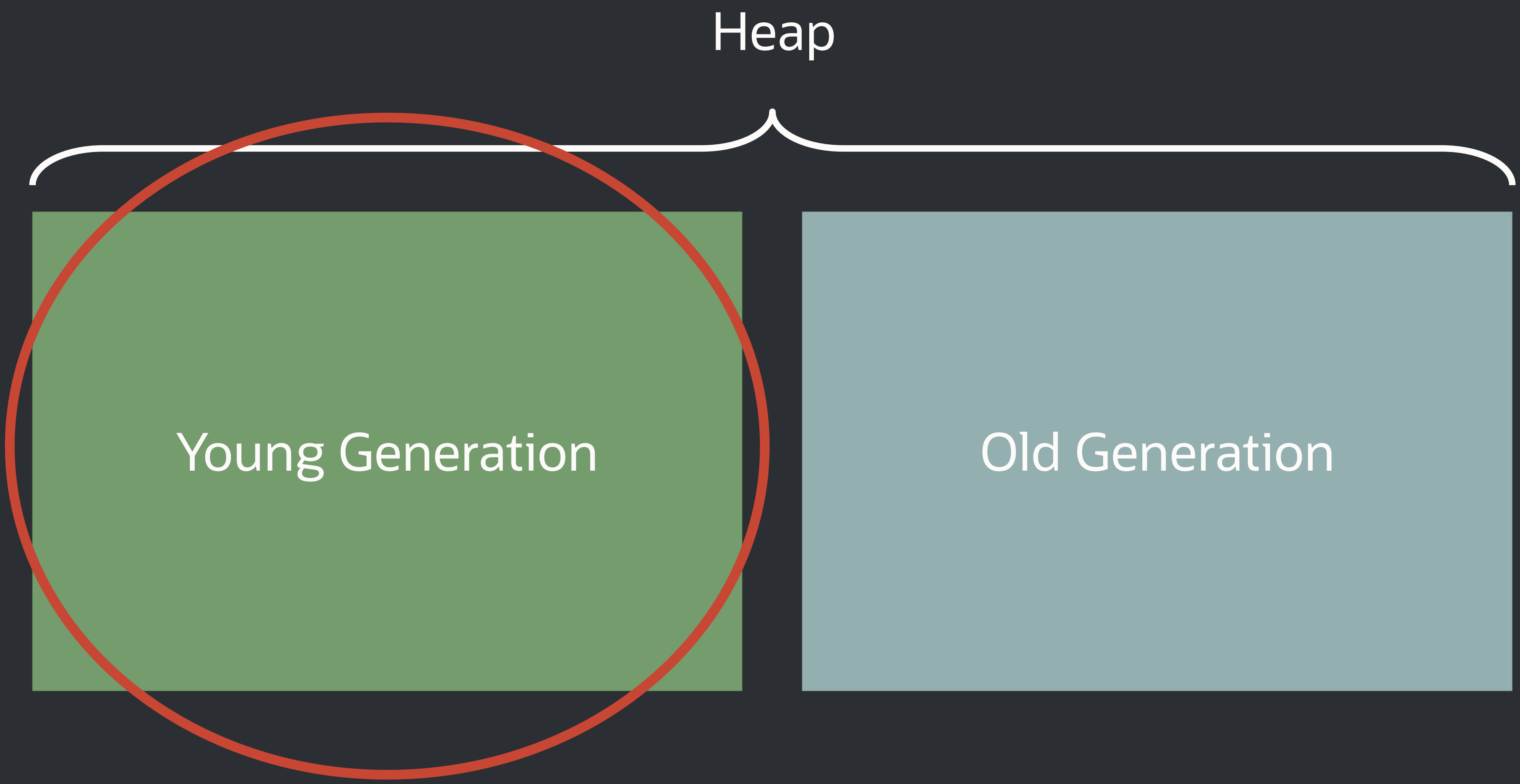

Heap

Young Generation

Old Generation

Minor Collection

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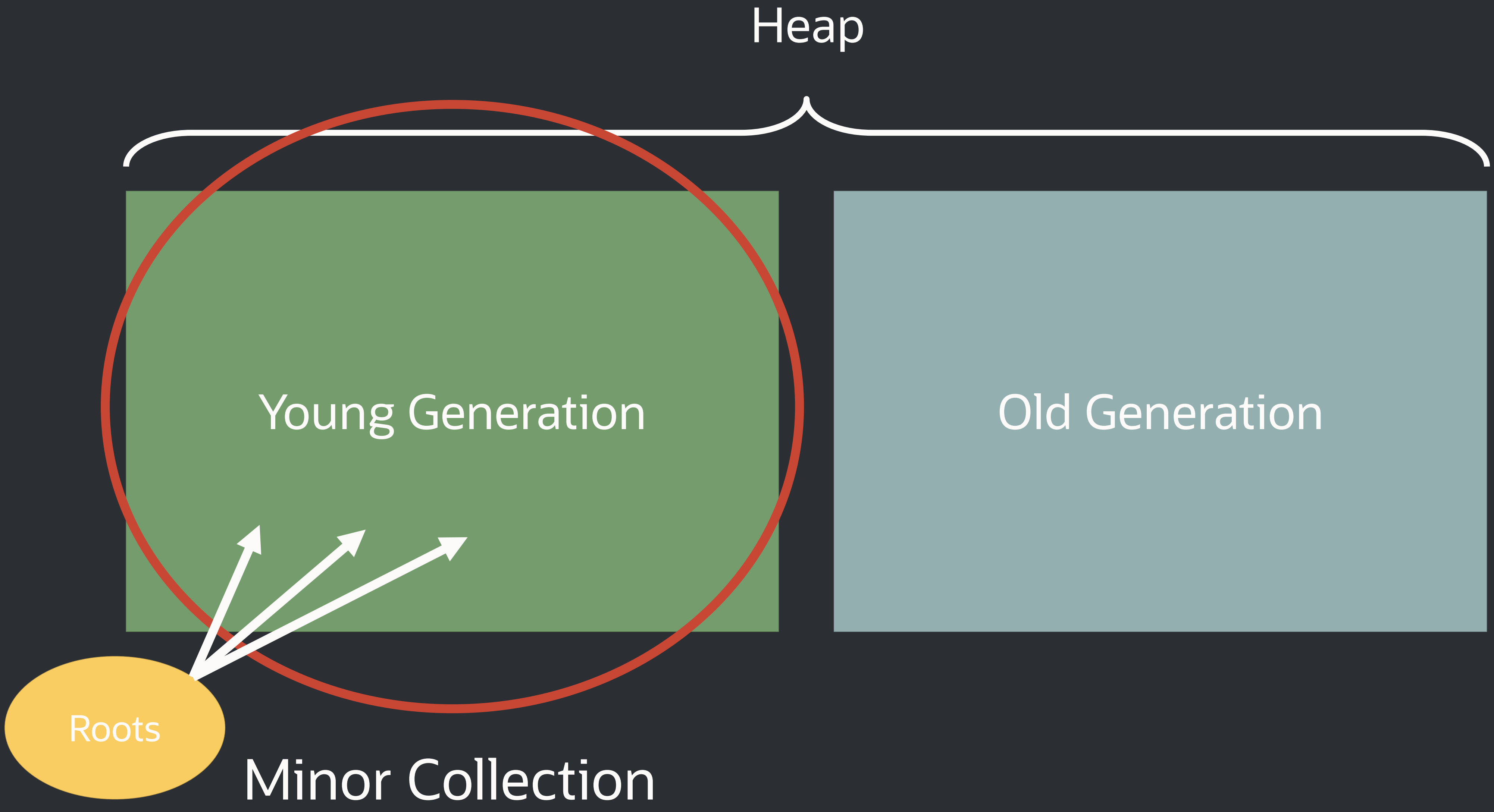

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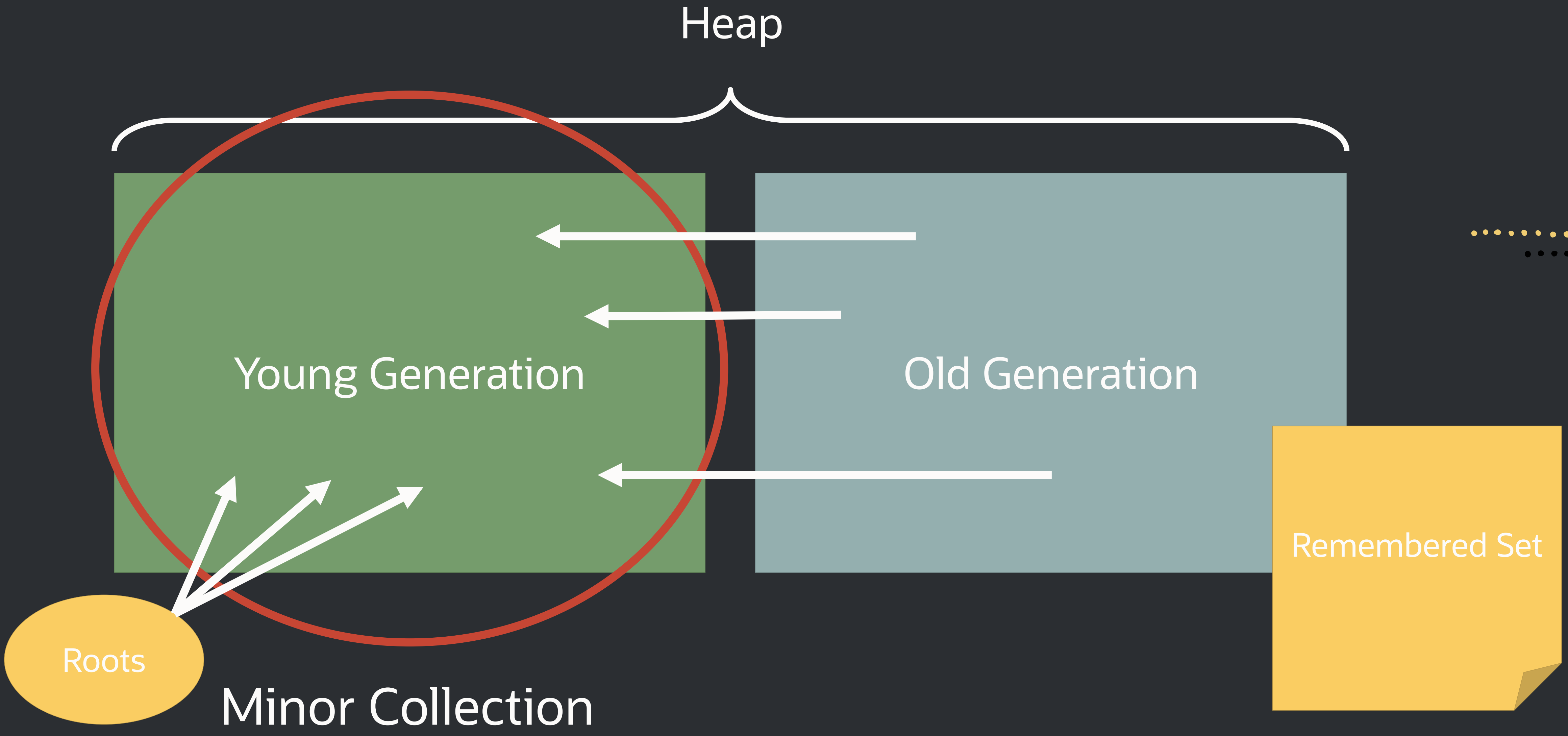

Heap

Young Generation

Old Generation

Remembered Set

Roots

Minor Collection

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Major Collection

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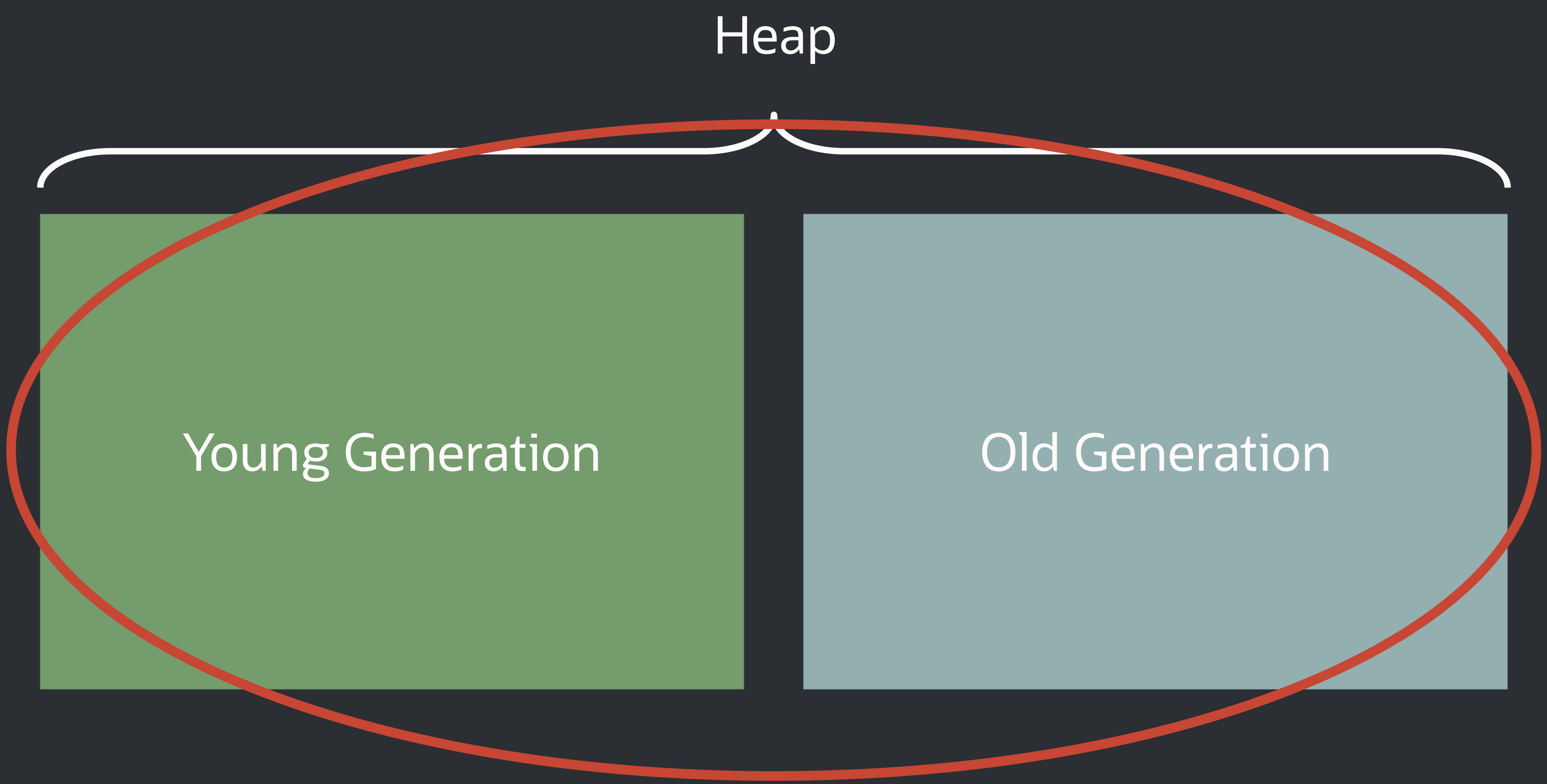

Major Collection

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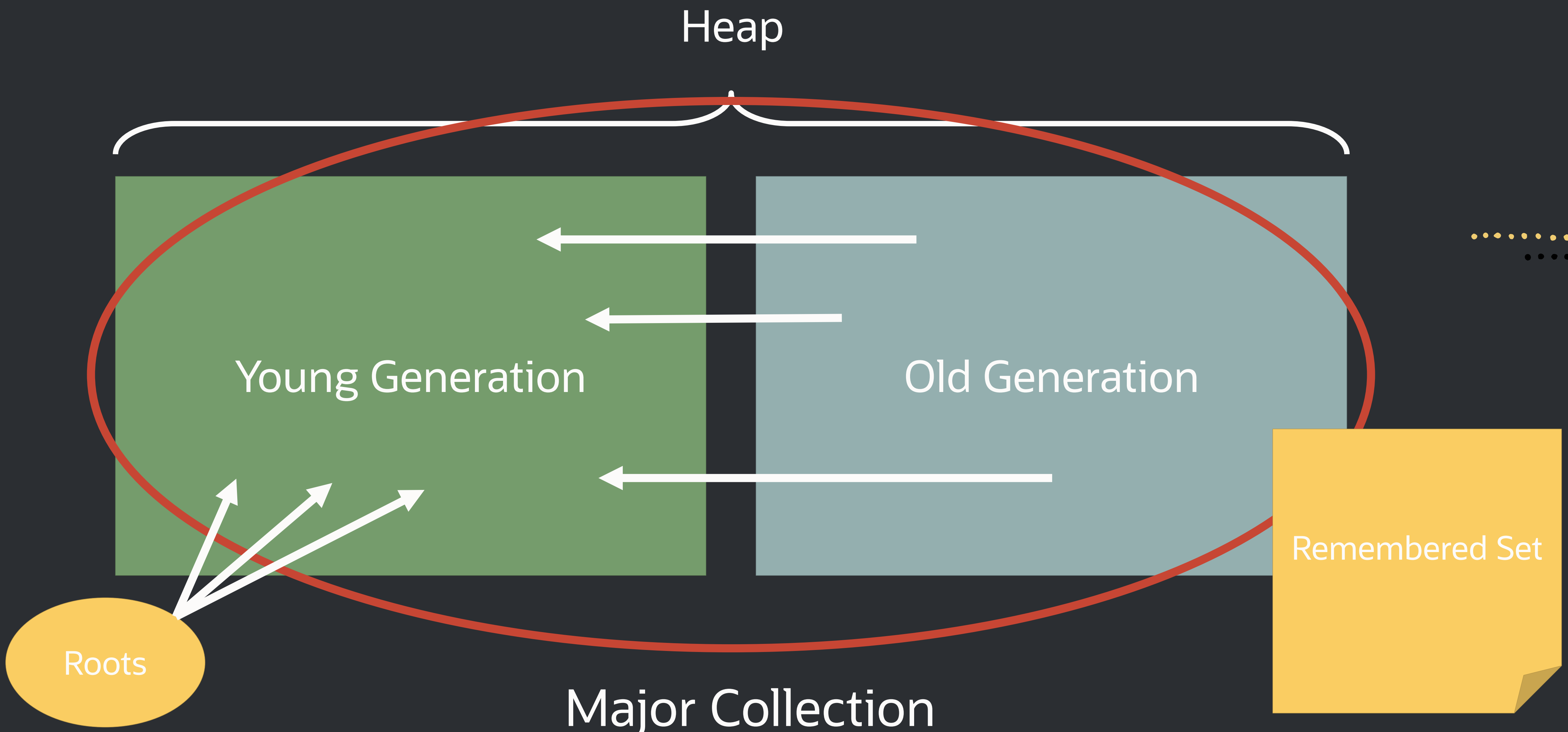

Major Collection

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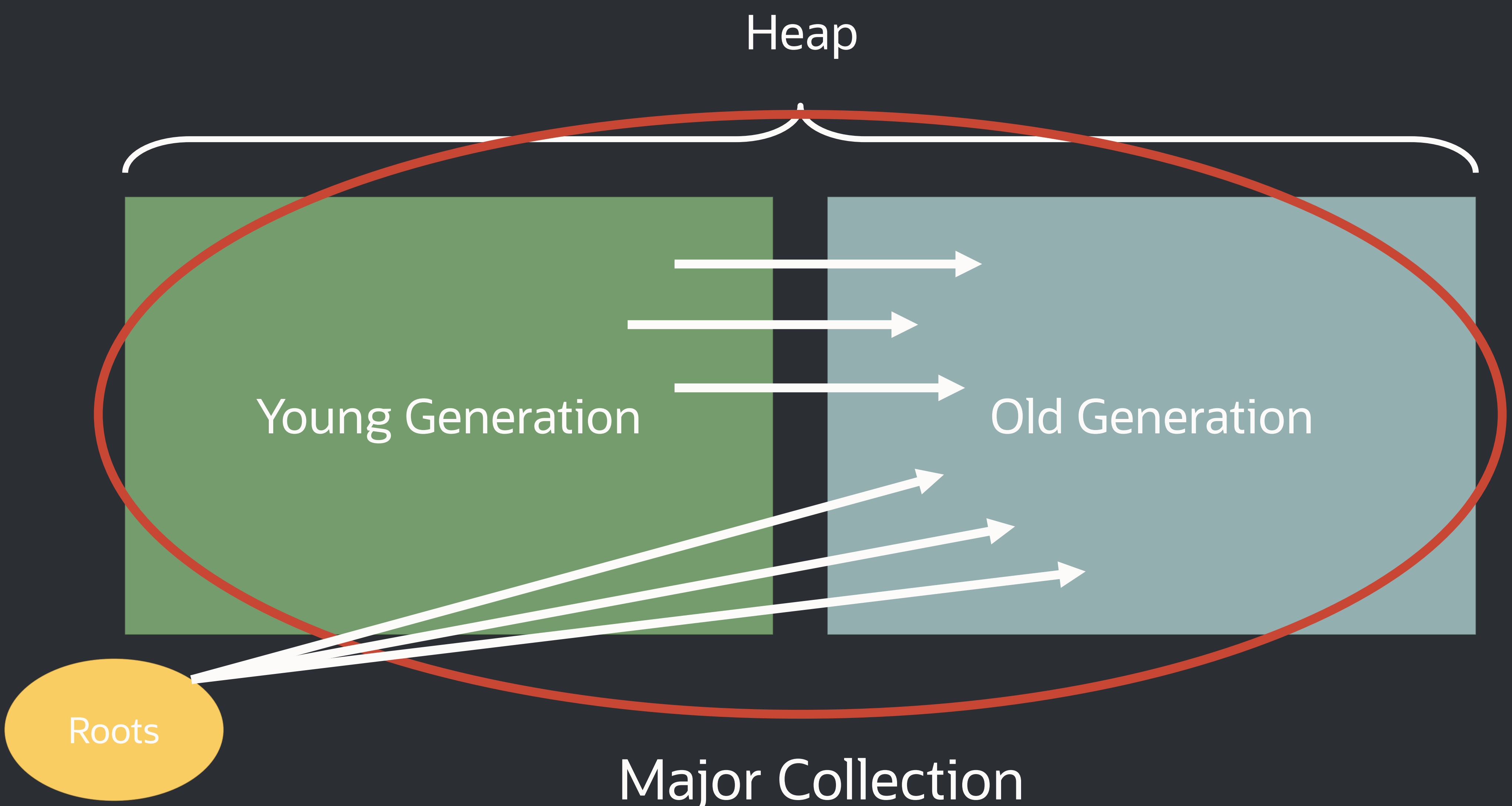

Major Collection

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Automatic Tuning

Dynamic generation sizing

(No `–Xmn` needed)

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Automatic Tuning

Dynamic tenuring threshold

(No `-XX:TenuringThreshold` needed)

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Automatic Tuning

Dynamic number of threads

(No `-XX:ConcGCThreads` needed)

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Automatic Tuning

Just set the max heap size!

(−Xmx)

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Preliminary Benchmarks

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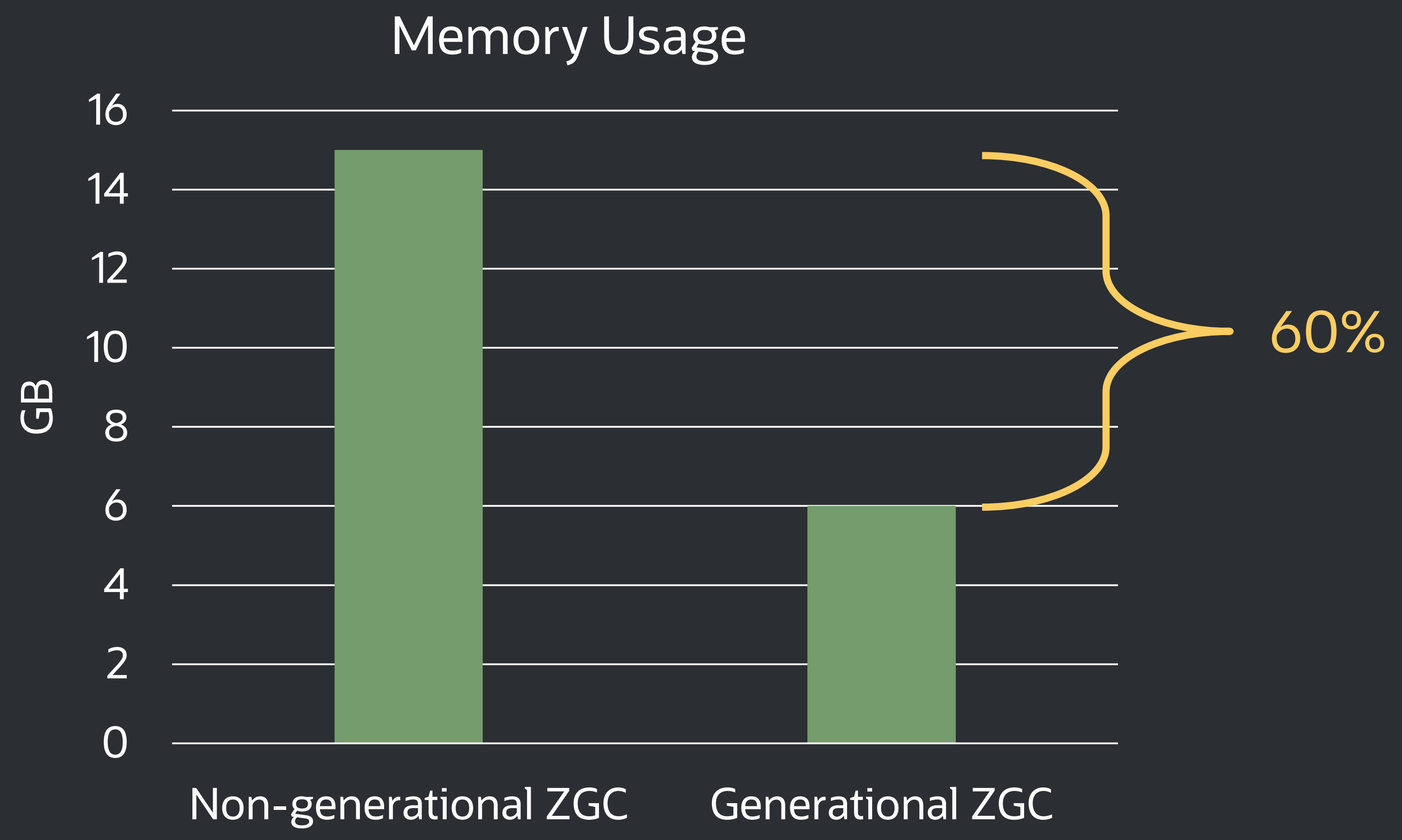
Memory Needed to Maintain Low Latency

Using the SPECjbb2005 benchmark with 1.5G live-set



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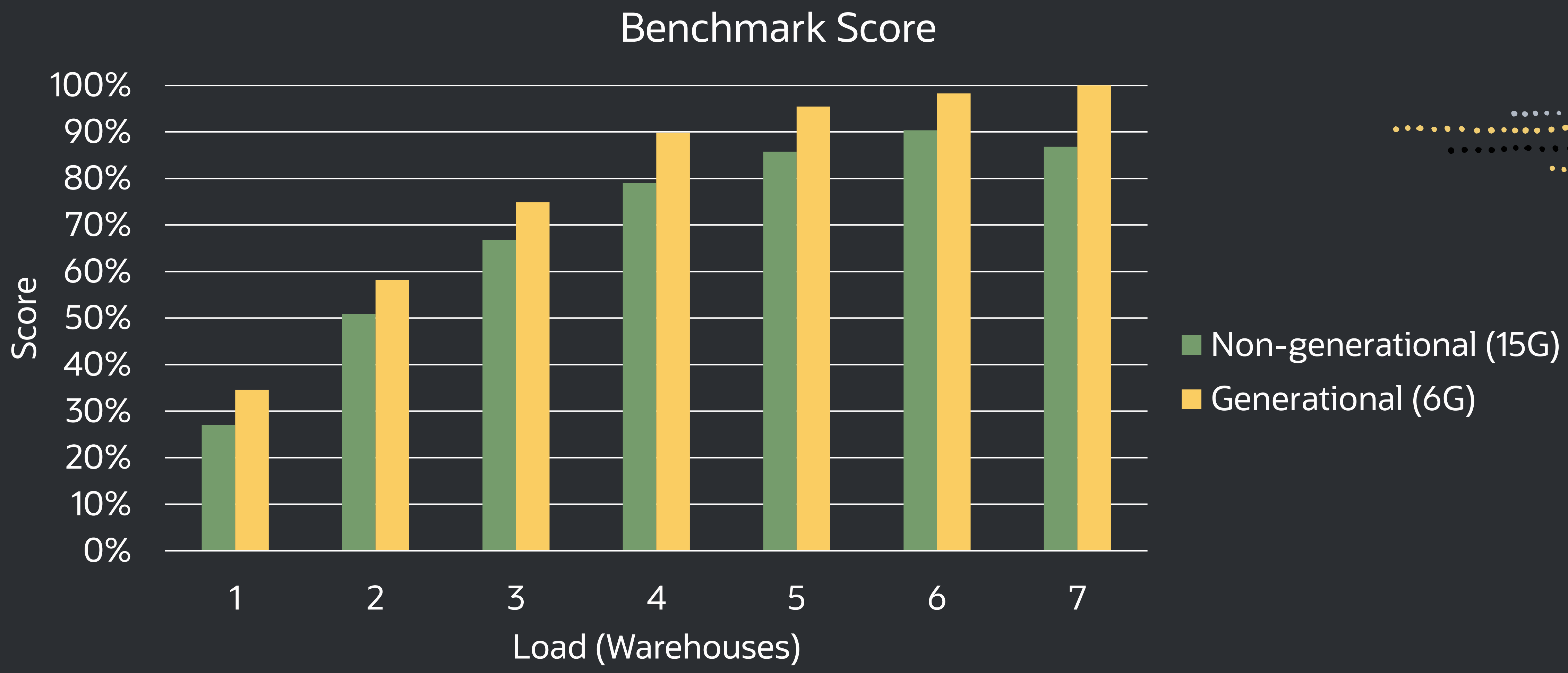
Benchmark Score

Using the SPECjbb2005 benchmark with 1.5G live-set



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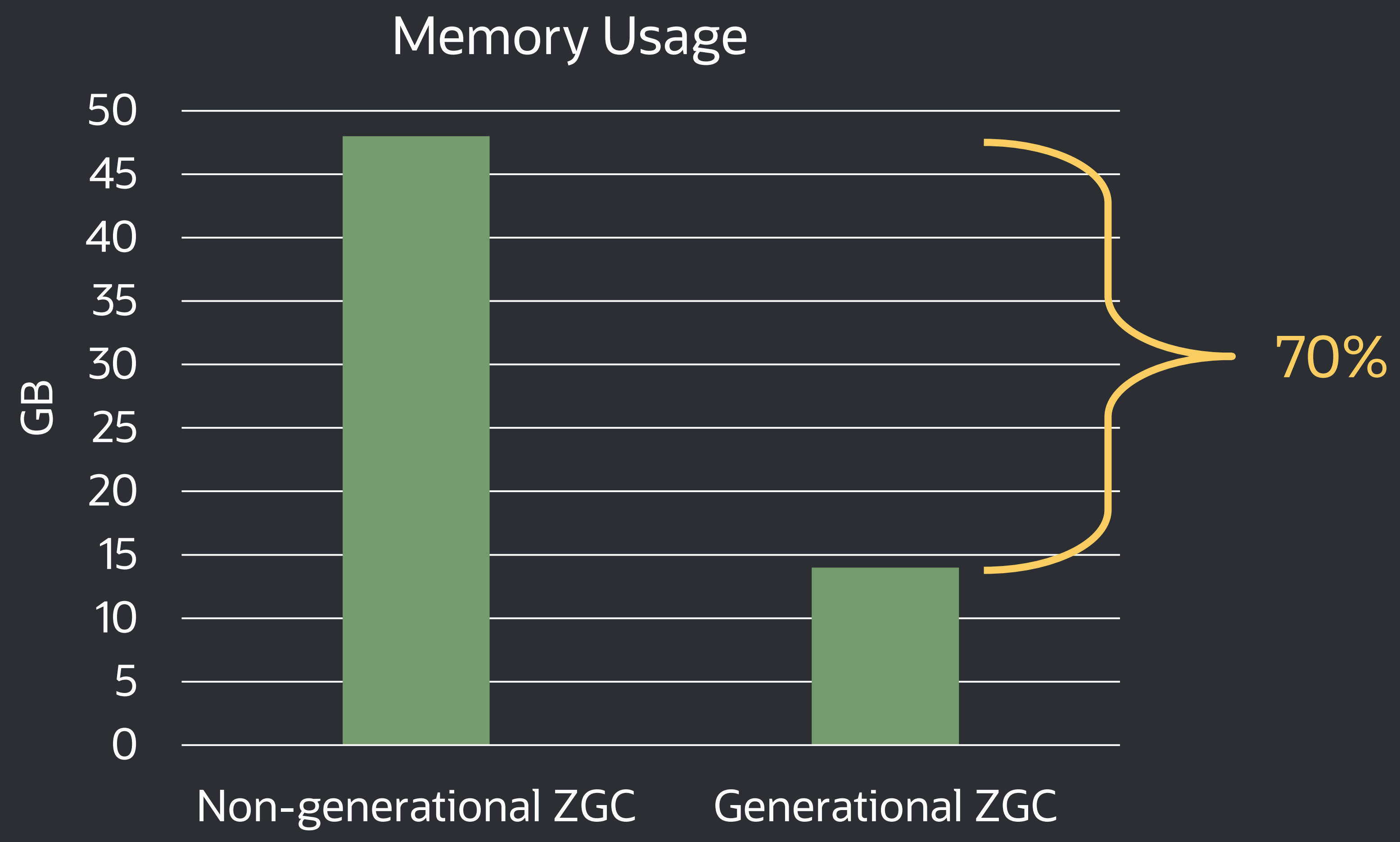
Memory Needed to Maintain Low Latency

Using the Extremem benchmark



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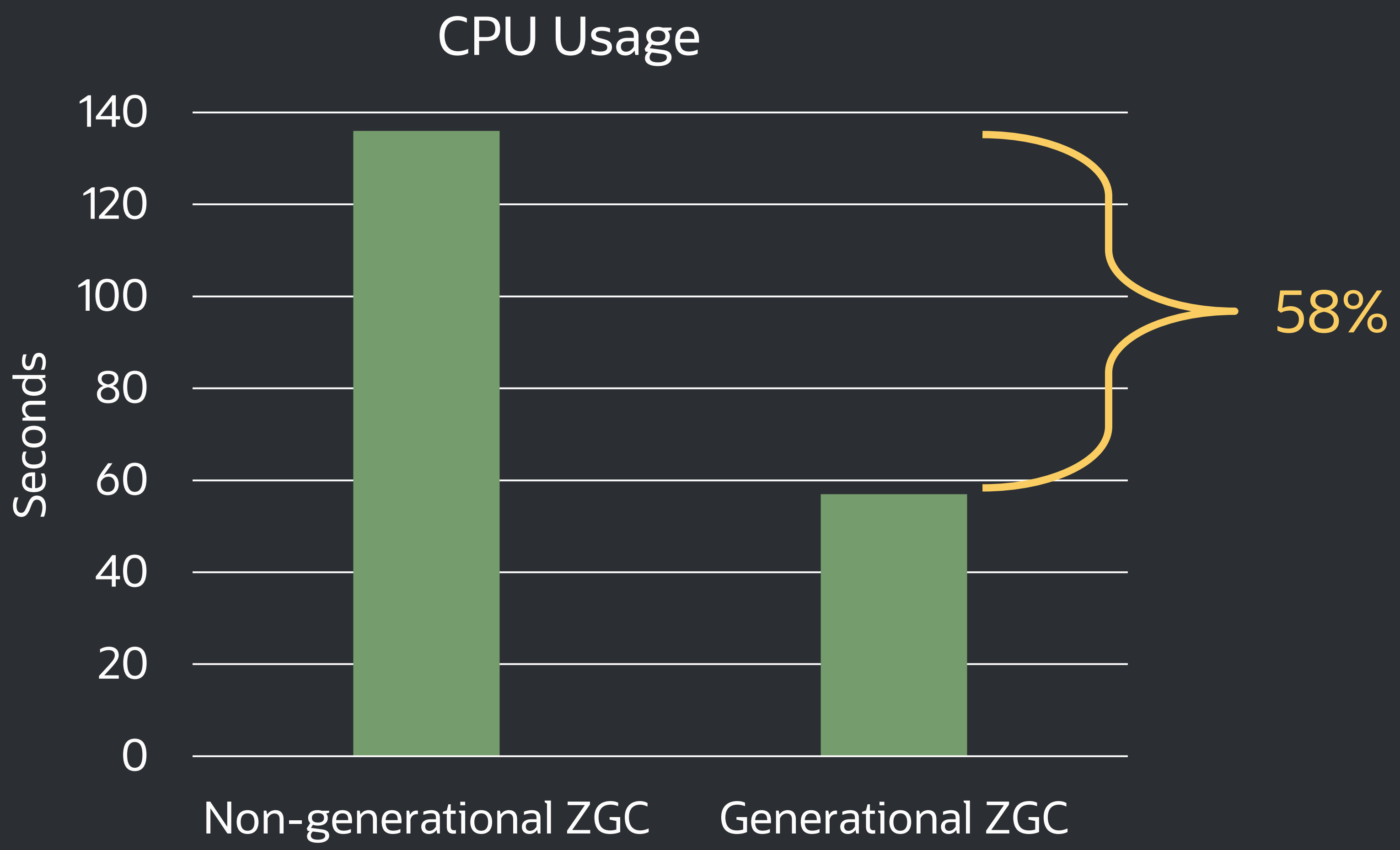
CPU Usage When Given the Same About of Memory

Using the Extremem benchmark



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More Information

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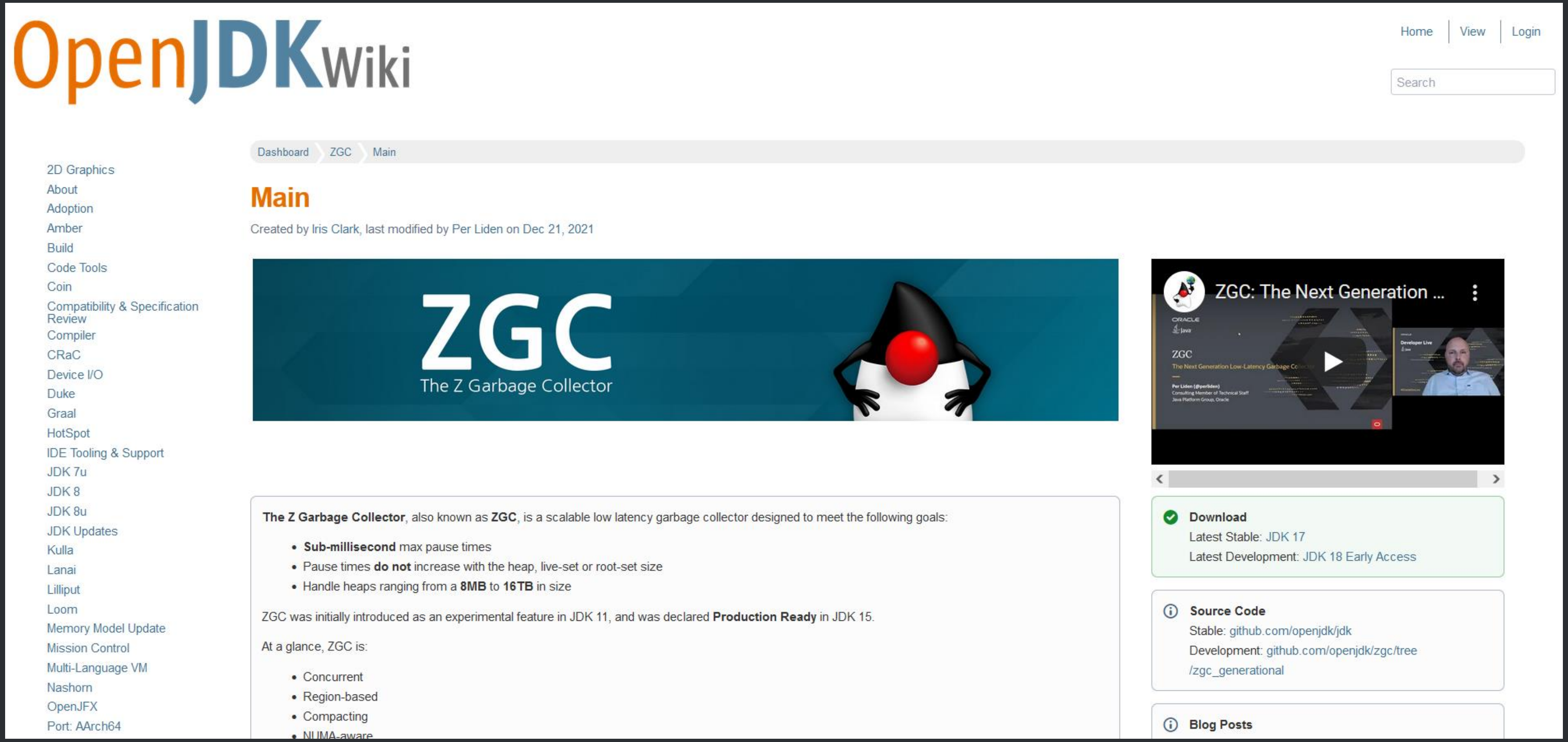
ZGC Wiki



Main

Created by Iris Clark, last modified by Per Liden on Dec 21, 2021

The Z Garbage Collector, also known as **ZGC**, is a scalable low latency garbage collector designed to meet the following goals:

- **Sub-millisecond** max pause times
- Pause times **do not** increase with the heap, live-set or root-set size
- Handle heaps ranging from a **8MB** to **16TB** in size

ZGC was initially introduced as an experimental feature in JDK 11, and was declared **Production Ready** in JDK 15.

At a glance, ZGC is:

- Concurrent
- Region-based
- Compacting
- NUMA-aware

Download
Latest Stable: JDK 17
Latest Development: JDK 18 Early Access

Source Code
Stable: github.com/openjdk/jdk
Development: github.com/openjdk/zgc/tree/zgc_generational

Blog Posts

https://wiki.openjdk.java.net/display/zgc

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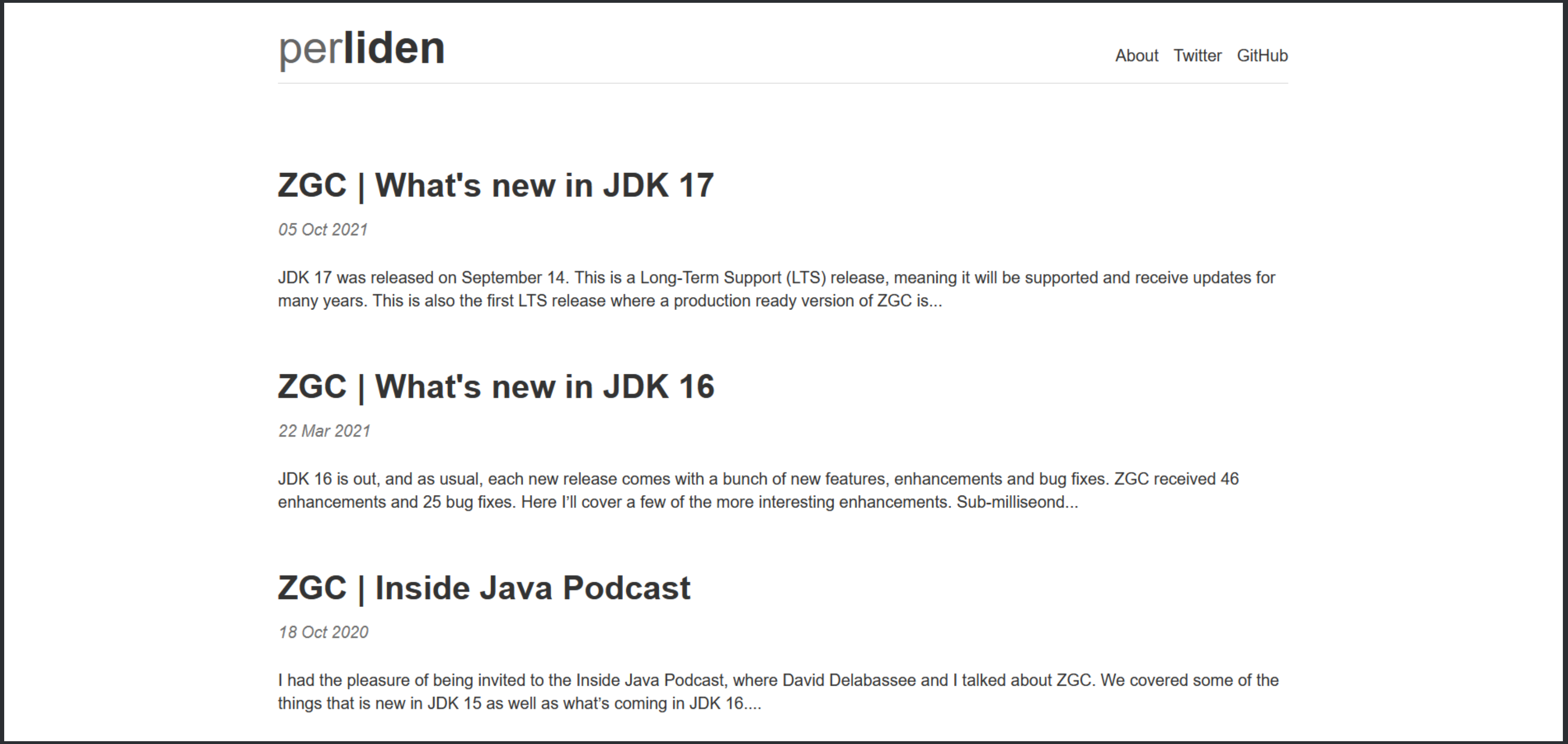
Blog



perliden

ZGC | What's new in JDK 17

05 Oct 2021

JDK 17 was released on September 14. This is a Long-Term Support (LTS) release, meaning it will be supported and receive updates for many years. This is also the first LTS release where a production ready version of ZGC is...

ZGC | What's new in JDK 16

22 Mar 2021

JDK 16 is out, and as usual, each new release comes with a bunch of new features, enhancements and bug fixes. ZGC received 46 enhancements and 25 bug fixes. Here I'll cover a few of the more interesting enhancements. Sub-milliseond...

ZGC | Inside Java Podcast

18 Oct 2020

I had the pleasure of being invited to the Inside Java Podcast, where David Delabassee and I talked about ZGC. We covered some of the things that is new in JDK 15 as well as what's coming in JDK 16....

https://malloc.se

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Thanks!

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