

Java application performance issues and how to debug them

- Using GC patterns,
Heap Dump and Thread
dumps



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Agenda

- JVM performance goals
- Garbage Collection
- Heap dump
- Thread dump
- Metrics
- Further reading
- Useful tools

JVM Performance Goals

Responsiveness

Responsiveness is the measure of how quickly the application responds with the requested piece of data

Example – How fast a REST service sends back response

Problem example – Suddenly, application is taking long time to respond

JVM Performance Goals

Throughput

Intend to maximize amount of work done by application in specific period of time

Example – Number of requests a REST service can handle in a given period of time

Problem example – A Java application did not respond to many requests and they timed out.

Garbage Collection

Garbage collection patterns can help point to the causes of JVM performance issues causing reduced responsiveness

Example problem – Your application has many incoming requests waiting or timing out.

Debug approach – See when and how many times full GCs are happening. Too frequent or long GCs can cause such problems.

Garbage Collection

Garbage collection patterns can indicate problems like

- Code issues – References remain for unrequired objects or resources, thereby making them ineligible for GC.
- Memory leaks
- Insufficient memory allocation – Less heap memory allocated to app than what it needs

Heap dump

A heap dump is a snapshot of all objects in the JVM heap at that point of time when the heap dump is taken

Example problem – Your application crashed due to OutOfMemory error.

Debug approach – The heap dump at that time will show you which objects were taking up more space than expected causing the memory error.

Heap dump

- Heap dump files have extension .hprof
- Heap dump can be taken on demand using various tools listed further.
- Below JVM option can be used for JVM to automatically take heap dump if it crashes due to OutOfMemory error

`java -XX:+HeapDumpOnOutOfMemoryError`

Thread dump

- A thread dump is a snapshot of all threads that are part of a given process
- The state of each thread is presented with a stack trace, which shows the contents of a thread's stack

Example Problem – Applications memory usage is increasing steadily.

Debug approach – It may indicate that threads are waiting on some resources or are deadlocked. Thread dump will help reveal the cause of problem.

Thread dump

Analyzing thread dumps helps indicate problems like

- Thread deadlock
- Timeouts not set , causing threads to wait on external resources like files or DB connections
- Code issues like buggy for loops

Metrics

- Recording metrics for various key operations in your application will help you determine bottlenecks.

Example problem – For a particular use case, request takes up lot more time than expected.

Debug approach – Log the times for each step. It may help you find if the extra time being taken is to execute certain function or for a certain DB query execution.

Metrics

- Libraries like 'dropwizard metrics' can help capture metrics
- Logging is another way to determine code flow and execution times

Further reading topics

- Setting appropriate timeouts for clients – socket, connect and socket timeouts
- Circuit breakers
- Slow DB queries execution –

Optimize queries, add index, Normalize tables

- Garbage collection – Sawtooth pattern

Further reading

- <https://dzone.com/articles/interesting-garbage-collection-patterns>
- <https://docs.oracle.com/en/java/javase/18/gctuning/factors-affecting-garbage-collection-performance.html>
- <https://www.baeldung.com/java-heap-dump-capture>
- https://docs.oracle.com/cd/E13150_01/jrockit_jvm/jrockit/geninfo/diagnos/using_threaddumps.html

Useful Tools

- Java Visual VM
- Jmap
- JMX
- <https://github.com/spotify/threaddump-analyzer>

Over to you

- What performance issues have you encountered and how have you fixed it ?
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