Profiling in Java with JProfiler

Helmes

Before we start

- git clone https://github.com/raitraidma/profiling.git
  - mvn clean install
  - mvn spring-boot:run
  - Do not peek into presentation folder!
- https://www.ej-technologies.com/download/jprofiler/files

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Versions

- Java 8
- JProfiler 11

Why and when?

Why and when?

- Something is slow
- Something uses too much memory
- There’s no one else to delegate it to

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Java optimizations

- Optimizations you get for free!

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Compilation time optimization (1.1)

```java
public class CompilerOptimizationWithFinalExample {
  private static final boolean IS_PRINTING = false;

  public static void main(String[] args) {
    for (int i = 0; i < 100_000_000; i++) {
      if (IS_PRINTING) {
        System.out.println("i = " + i);
      }
    }
  }
}
```

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Compilation time optimization (1.2)

```
public class CompilerOptimizationWithFinalExample {
  private static final boolean IS_PRINTING = false;

  public CompilerOptimizationWithFinalExample() {
  }

  public static void main(String[] args) {
    for(int i = 0; i < 100000000; ++i) {
    }

  }
}
```

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Compilation time optimization (2.1)

```java
public class CompilerOptimizationWithoutFinalExample {
  private static boolean IS_PRINTING = false;

  public static void main(String[] args) {
    for (int i = 0; i < 100_000_000; i++) {
      if (IS_PRINTING) {
        System.out.println("i = " + i);
      }
    }
  }
}
```

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Compilation time optimization (2.2)

```
public class CompilerOptimizationWithoutFinalExample {
  private static boolean IS_PRINTING = false;

  public CompilerOptimizationWithoutFinalExample() {
  }

  public static void main(String[] args) {
    for(int i = 0; i < 100000000; ++i) {
      if (IS_PRINTING) {
        System.out.println("i = " + i);
      }
    }
  }
}
```

Compilation time optimization (3.1)

```
public class LiteralConstantExample {
  public static void main(String[] args) {
    int age = 3 * 7 + 1;

    final String firstName = "Jon";
    final String lastName = "Snow";
    String fullName = firstName + " " + lastName;

    String firstName2 = "Daenerys";
    String lastName2 = "Targaryen";
    String fullName2 = firstName2 + " " + lastName2;

    System.out.println(fullName + " is " + age + " years old");
    System.out.println(fullName2 + " is also " + age + " years old");
  }
}
```

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Compilation time optimization (3.2)

```java
public class LiteralConstantExample {
  public LiteralConstantExample() {
  }

  public static void main(String[] args) {
    int age = 22;
    String firstName = "Jon";
    String lastName = "Snow";
    String fullName = "Jon Snow";
    String firstName2 = "Daenerys";
    String lastName2 = "Targaryen";
    String fullName2 = firstName2 + " " + lastName2;
    System.out.println(fullName + " is " + age + " years old");
    System.out.println(fullName2 + " is also " + age + " years old");
  }
}
```

Runtime optimization

- Hotspot JIT can detect what kind of processor you have and generates code accordingly.
- Inline methods – copy method to caller code
- Eliminate dead code
- ...

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Own intelligence

```
public class GarbageCollectorExample {
  public static void main(String[] args) {
    Long count = 0L;

    for (int i = 0; i < 100_000_000; i++) {
      count++;
    }
  }
}
```

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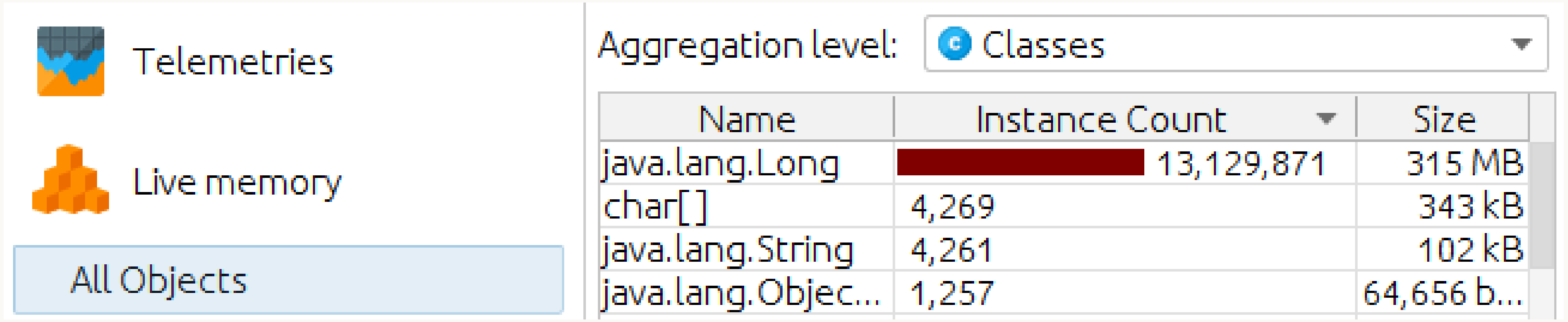
Own intelligence



Aggregation level: Classes

Name	Instance Count	Size
java.lang.Long	13,129,871	315 MB
char[]	4,269	343 kB
java.lang.String	4,261	102 kB
java.lang.Objec...	1,257	64,656 b...

- Took 519 ms

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Own intelligence

```java
public class GarbageCollectorFixExample {
  public static void main(String[] args) {
    long count = 0L;

    for (int i = 0; i < 100_000_000; i++) {
      count++;
    }
  }
}
```

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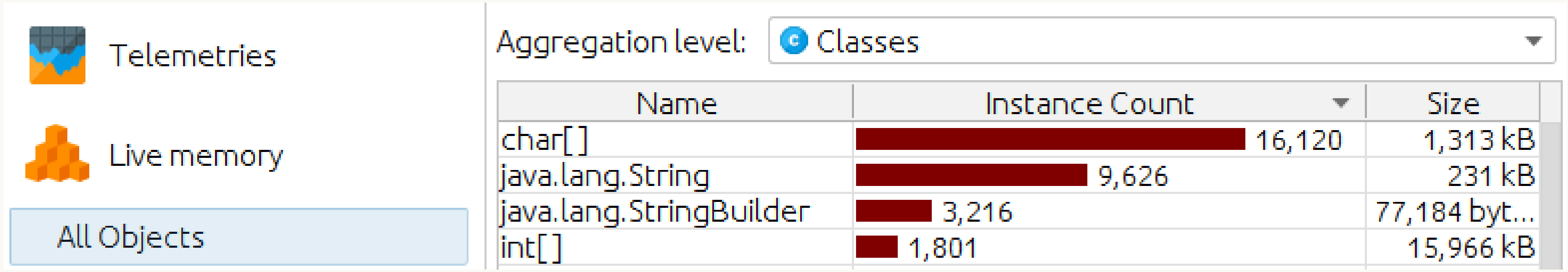
Own intelligence



Aggregation level: Classes

Name	Instance Count	Size
char[]	16,120	1,313 kB
java.lang.String	9,626	231 kB
java.lang.StringBuilder	3,216	77,184 byt...
int[]	1,801	15,966 kB

- Took 5 ms

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Install JProfiler

Download

- https://www.ej-technologies.com/download/jprofiler/files

IDE integration

- Close IDE
- Select IDE configuration folder

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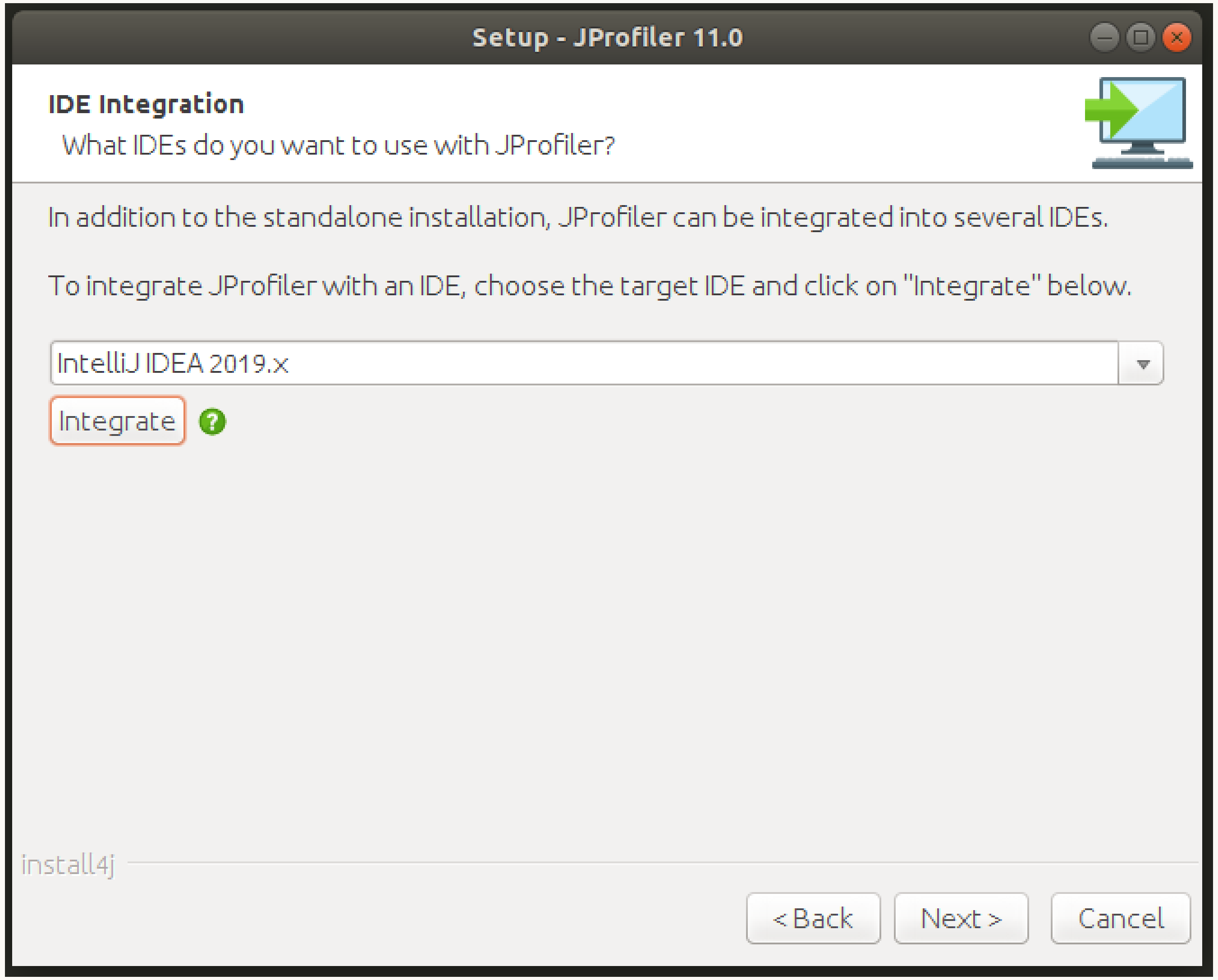

Setup - JProfiler 11.0

IDE Integration

What IDEs do you want to use with JProfiler?

In addition to the standalone installation, JProfiler can be integrated into several IDEs.

To integrate JProfiler with an IDE, choose the target IDE and click on "Integrate" below.

IntelliJ IDEA 2019.x

Attach JProfiler

- -agentpath VM parameter
  - -agentpath:/opt/jprofiler/bin/linux-x64/libjprofilerti.so=port=8849,nowait
  - If you run from IDE, then it will be added automatically

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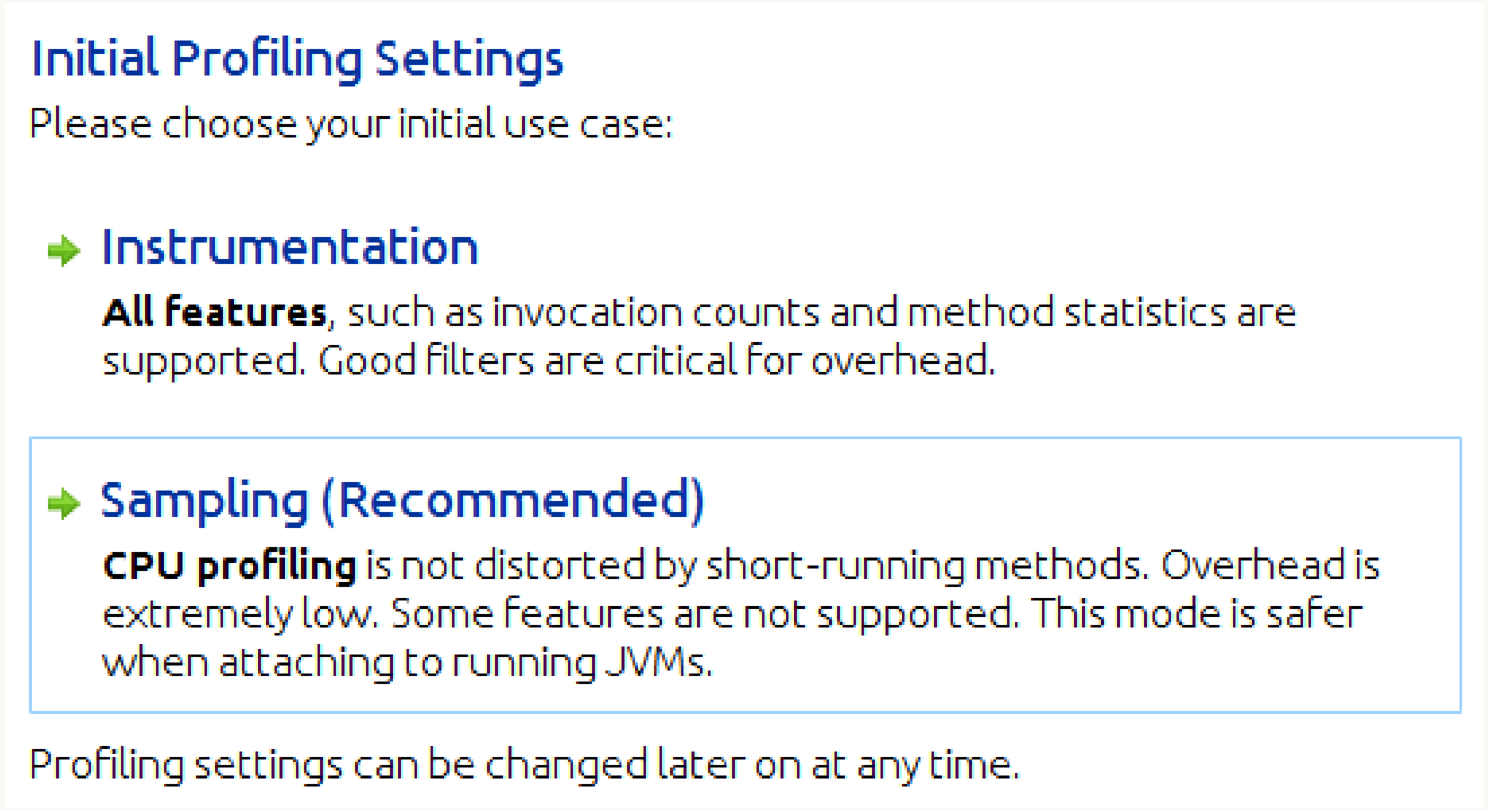
Instrumentation vs Sampling


Initial Profiling Settings

Please choose your initial use case:

Instrumentation

All features, such as invocation counts and method statistics are supported. Good filters are critical for overhead.

Sampling (Recommended)

CPU profiling is not distorted by short-running methods. Overhead is extremely low. Some features are not supported. This mode is safer when attaching to running JVMs.

Profiling settings can be changed later on at any time.

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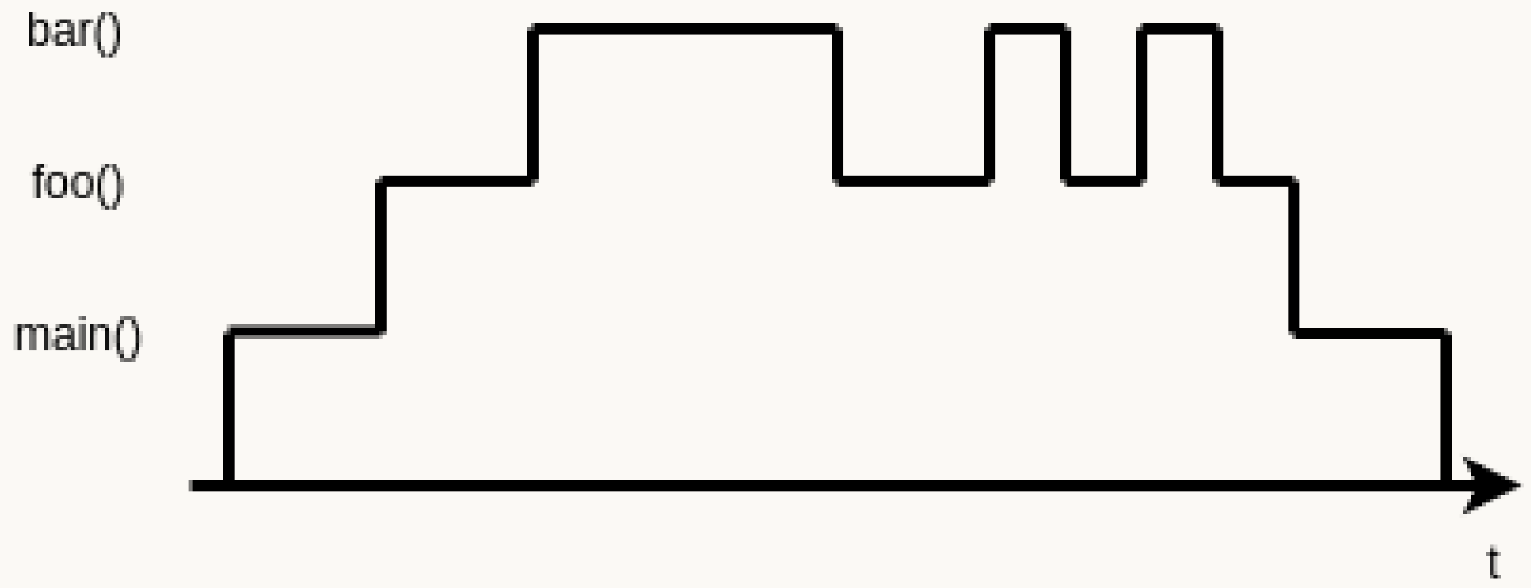
Instrumentation vs Sampling



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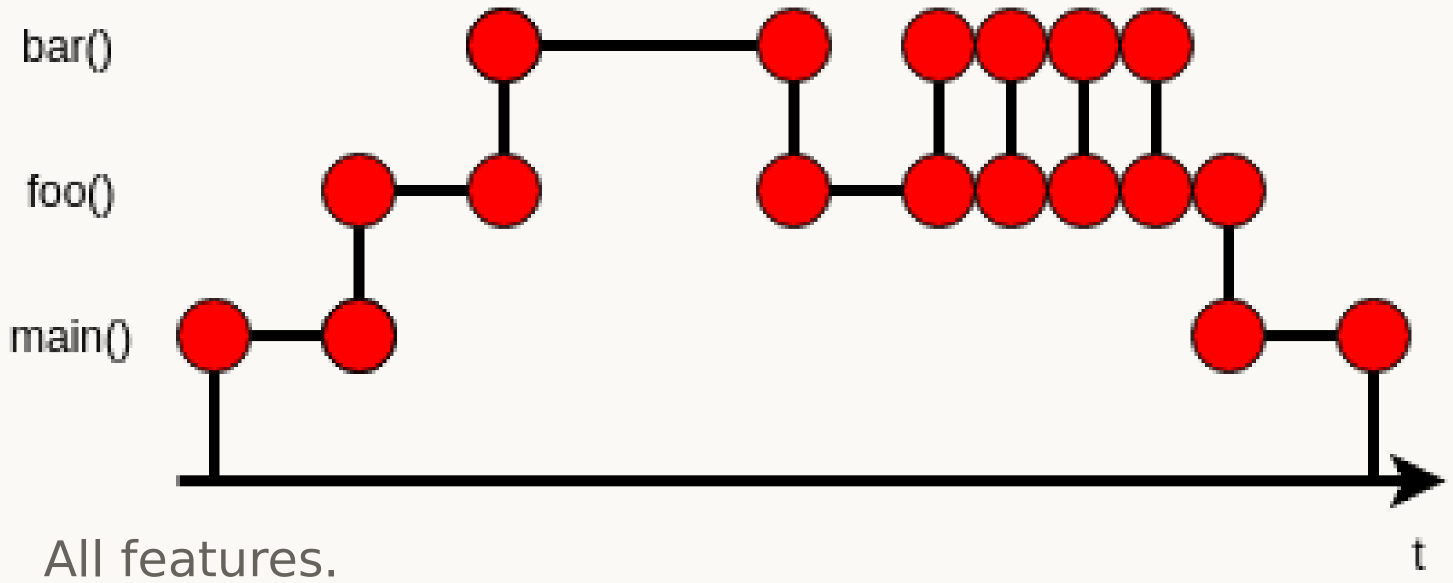
Instrumentation



- All features.
- Filters must be used correctly. Otherwise overhead.

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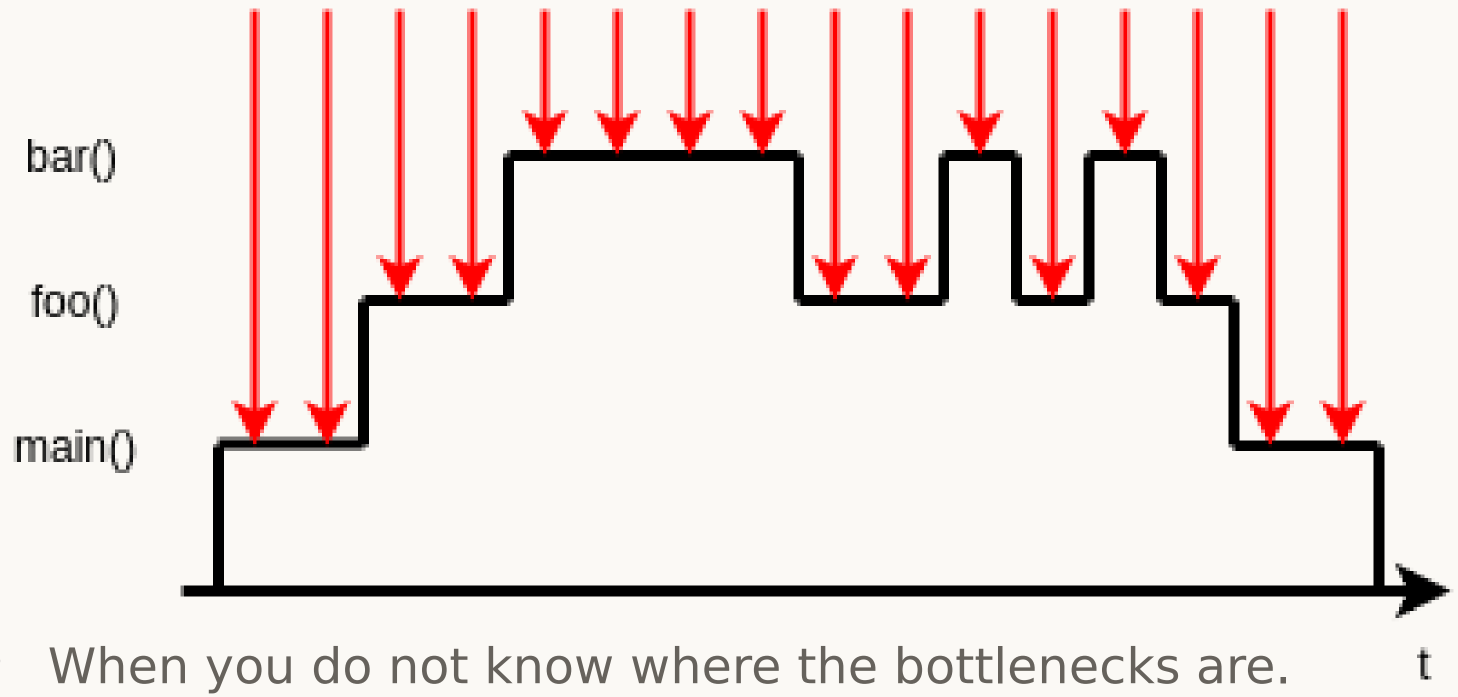
Sampling



- When you do not know where the bottlenecks are.
- Less overhead.

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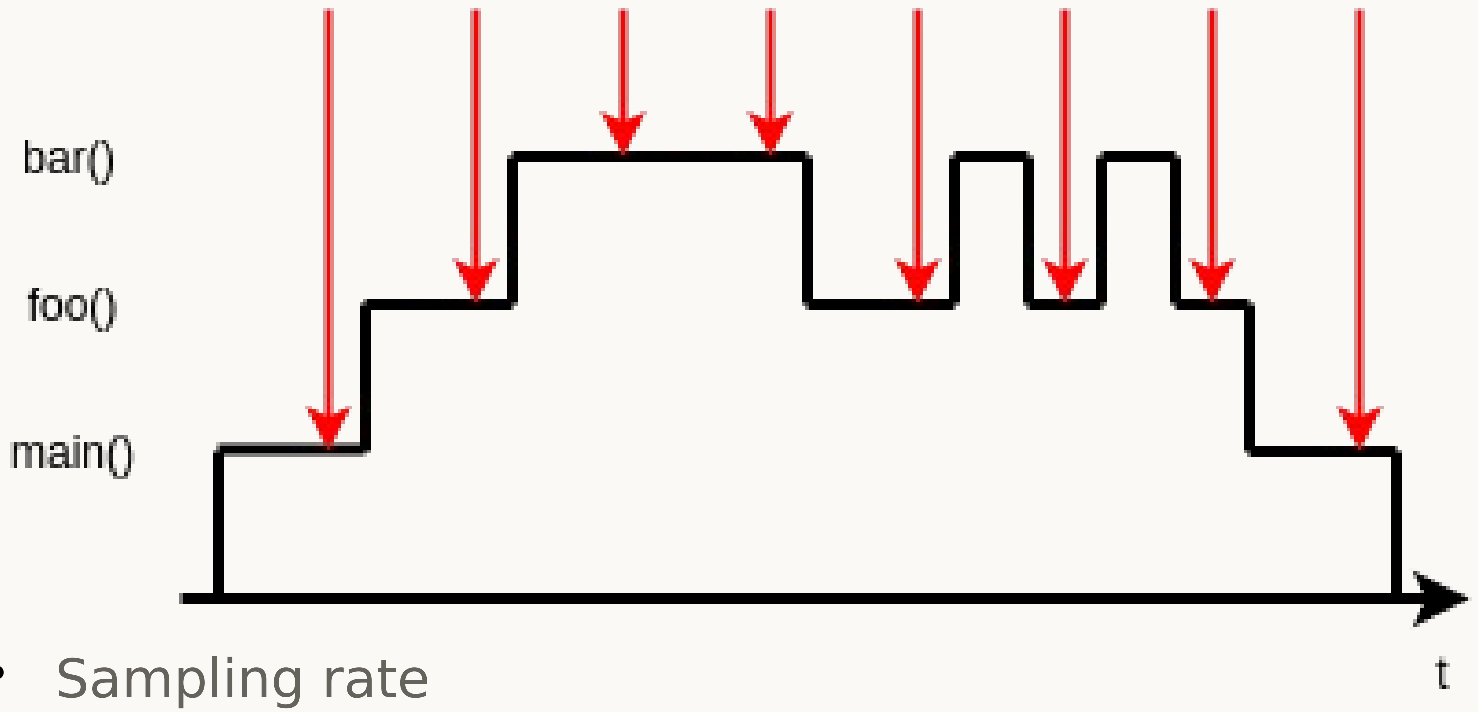
Sampling



- Sampling rate

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Instrumentation vs Sampling - Example

- GarbageCollectorExample
- CPU recording enabled

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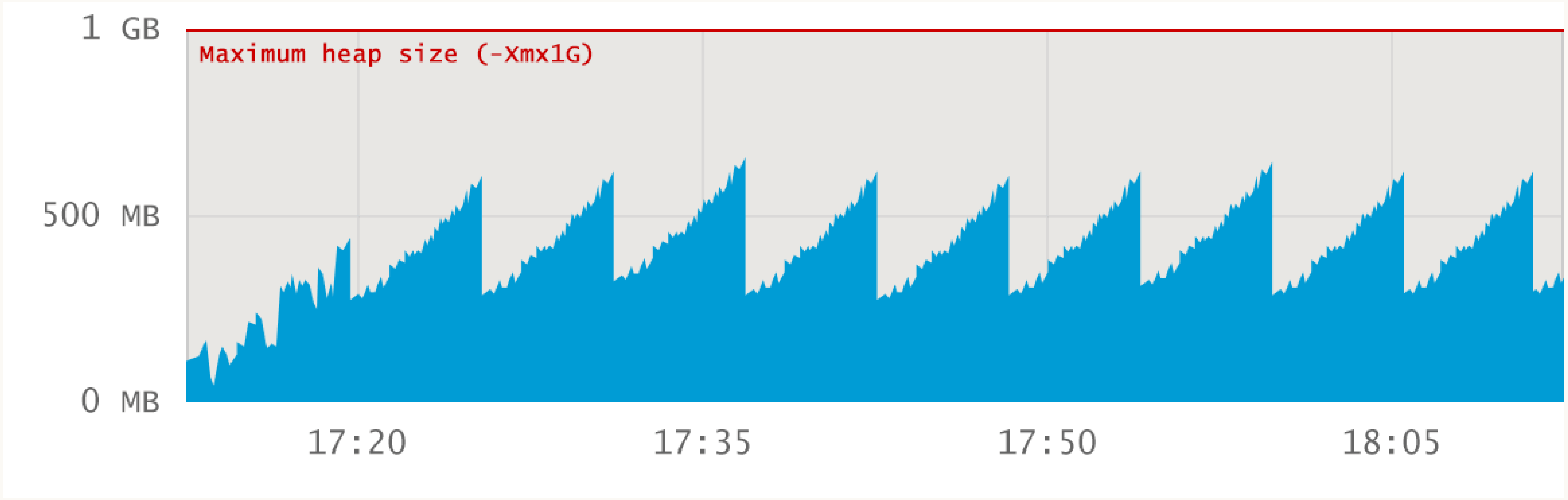
Memory profiling

- Memory leak

Memory profiling

- Memory leak: unused objects cannot be garbage collected.

Memory profiling



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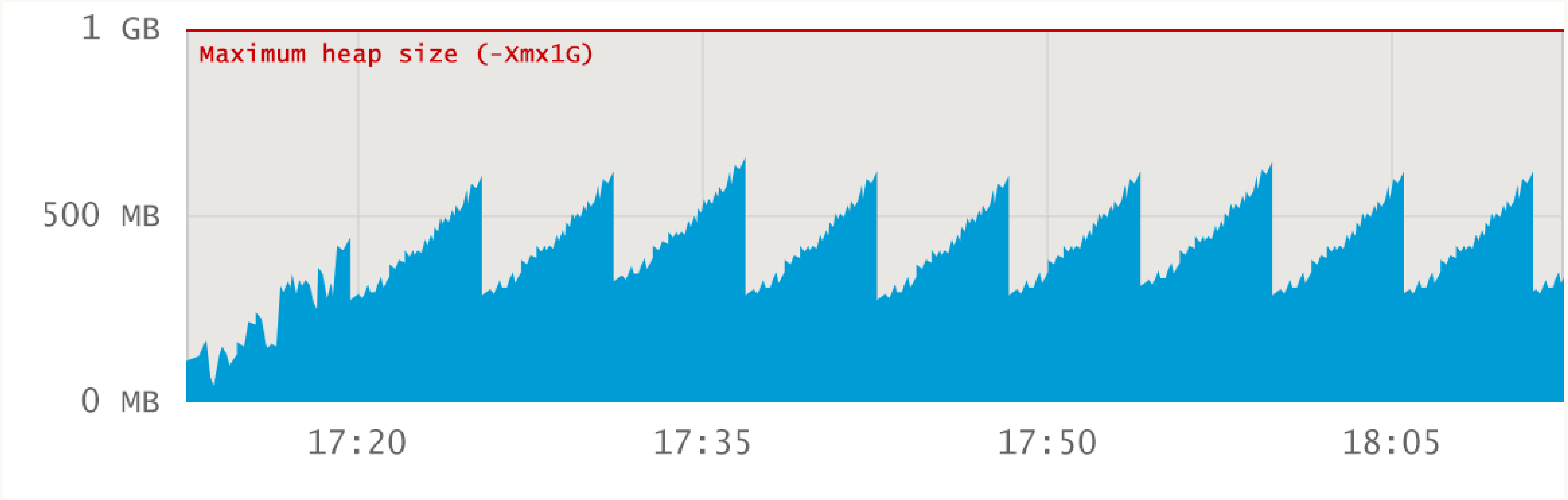
Memory profiling – Healthy JVM



- No memory leak. Flat baseline trend.

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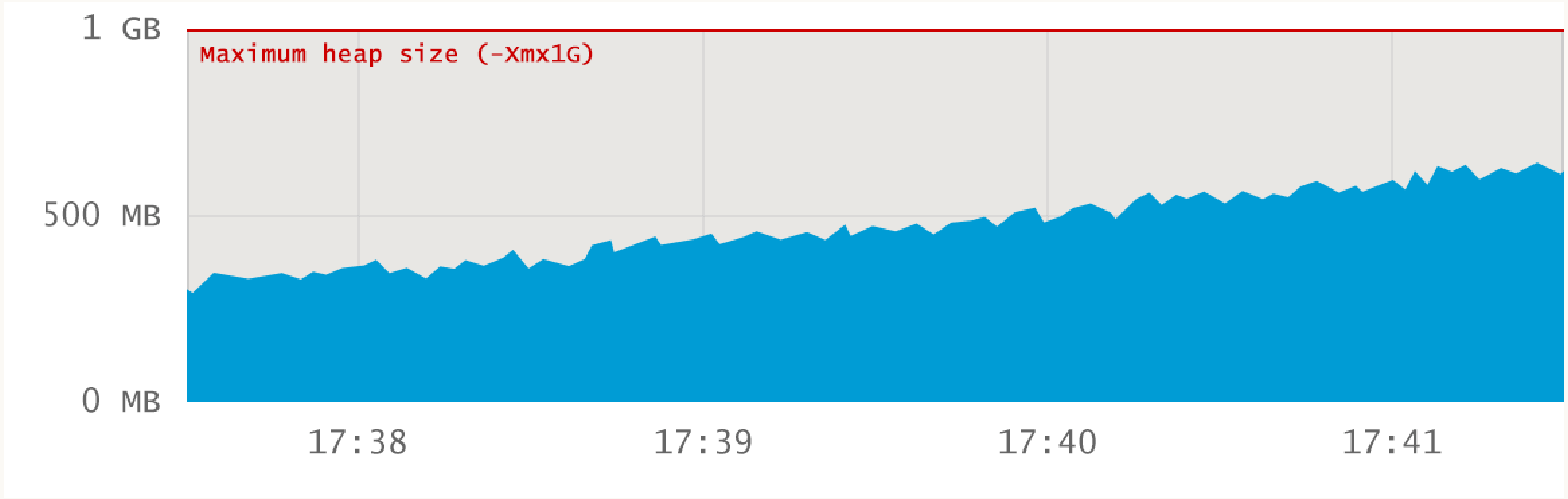
Memory profiling



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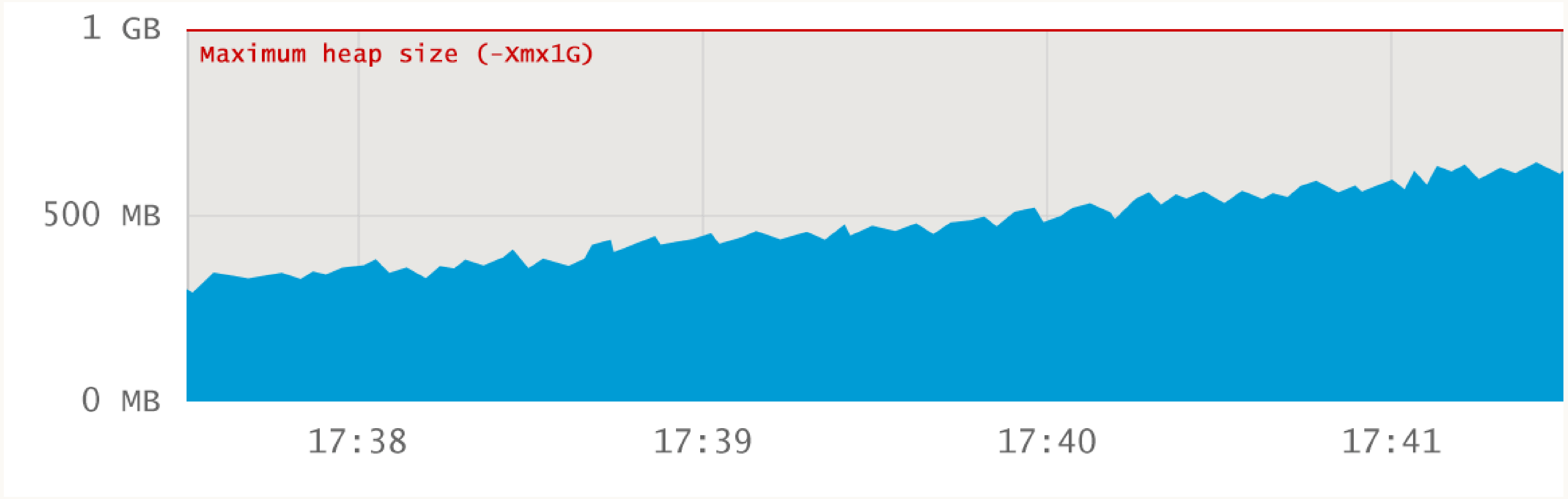
Memory profiling – Healthy JVM



- No memory leak. Period does not contain major GC events.

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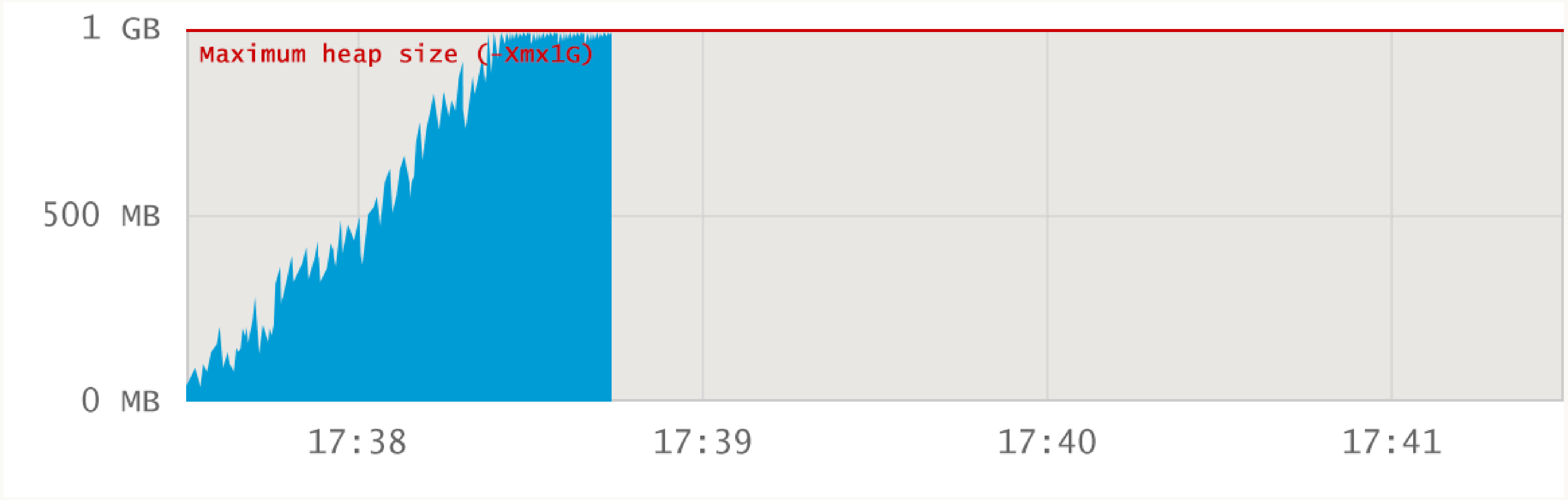
Memory profiling



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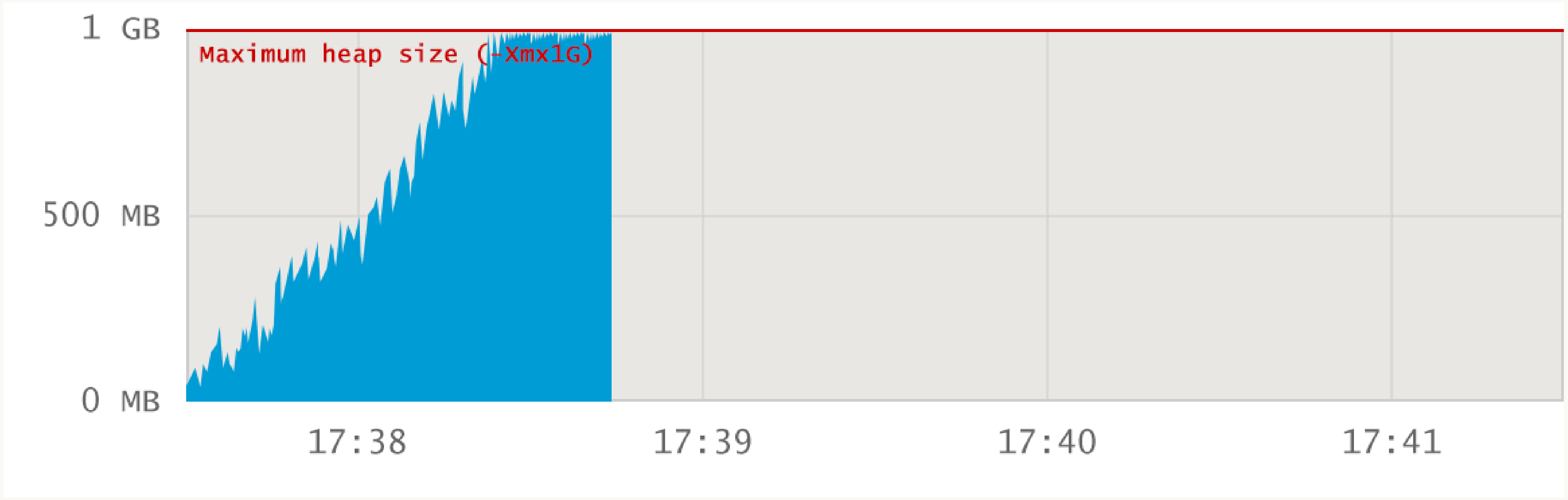
Memory profiling – Memory explosion at startup



- Probably not a memory leak. Big application has not given enough heap space.

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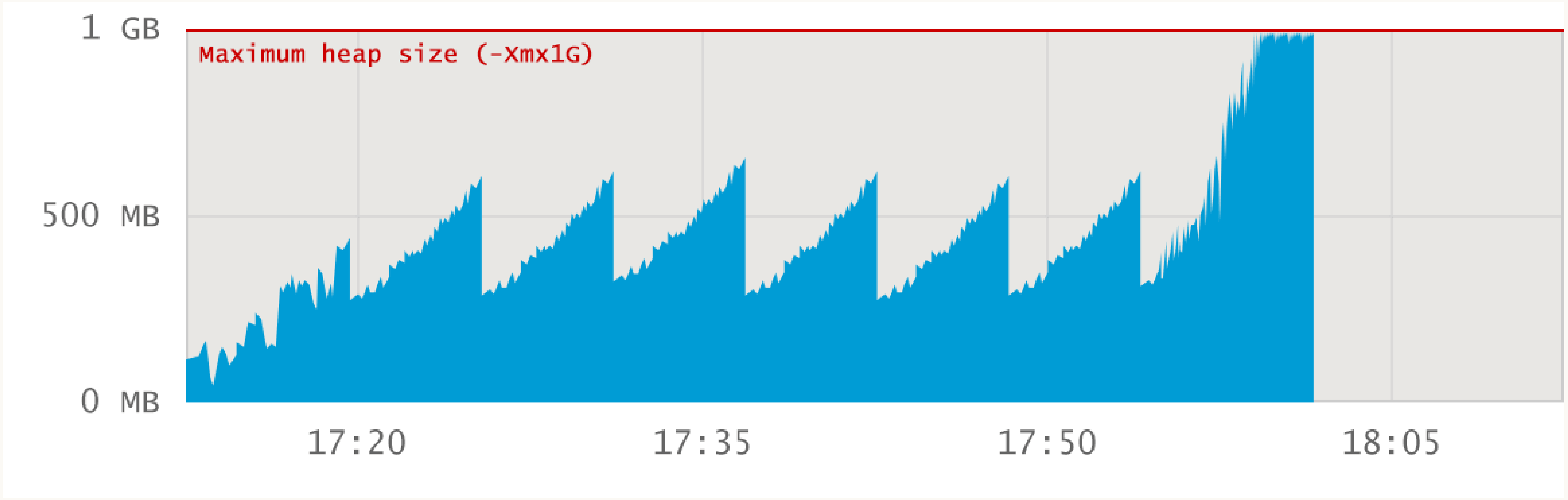
Memory profiling



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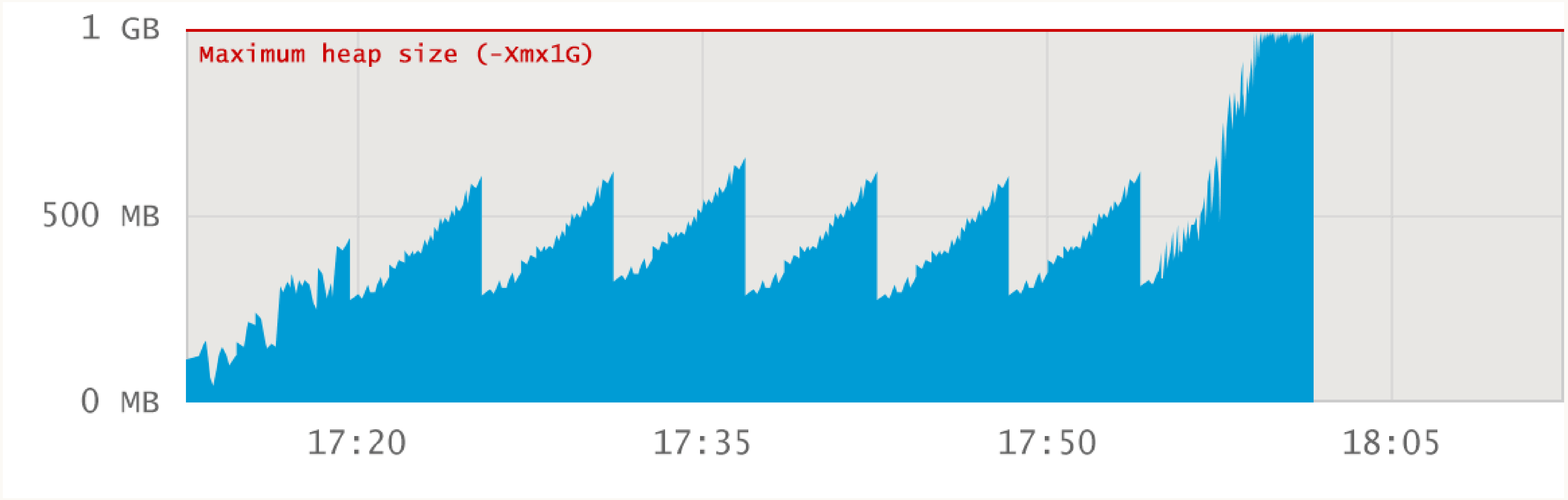
Memory profiling – Surge allocation



- Probably not a memory leak. Too much data is loaded via specific action.

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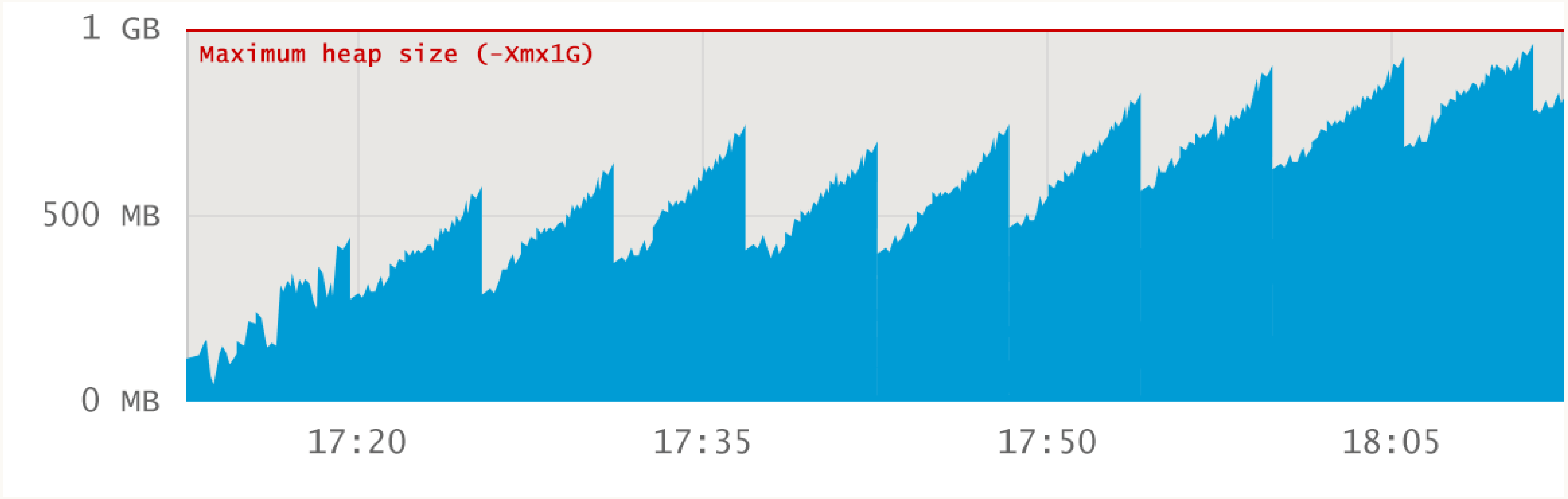
Memory profiling



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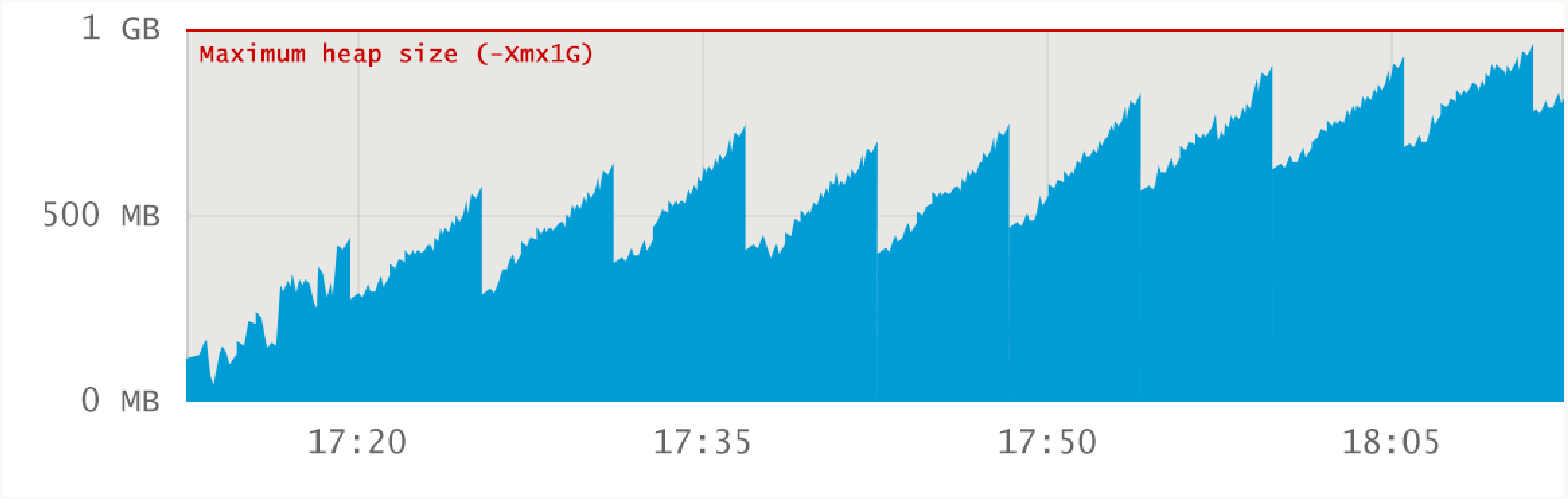
Memory profiling – Leaking application



- Memory leak. Baseline growth.

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Memory profiling – Example

- Call tree Recording: `Instrumentation`
- Initial recording profile: `Allocation call stacks`
- `Heap Walker`
- Pin `Mark Heap`
- `Take a Snapshot`
- `Use new` > `Classes` > `Ok`
- Double-click on "interesting" class name
  - `References` > `Incoming references`
- Select "interesting" object
  - `Show Paths To GC Root` > `Single root`
  - Now you see where leaked objects are stored
- Select `Merged incoming references`
- Allocations
  - Show code

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CPU profiling

- Issues:
  - Frequently invoked
  - Inefficient code/algorithm

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CPU profiling - Example

- Call tree Recording: `Instrumentation`
- Initial recording profile: `CPU recording`
- `CPU views`
  - `Hot Spots`
    - Thread status: All states
- Watch `Self Time`, `Average Time` and `Invocations`

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Hands on!

- Run application: ProfilingApplication
- Create load:
  - mvn gatling:test

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Happy Profiling!

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