Optimization: Java Optimization

CPSC 501: Advanced Programming Techniques
Fall 2020

Jonathan Hudson, Ph.D
Instructor
Department of Computer Science
University of Calgary

Wednesday, August 5, 2020

UNIVERSITY OF CALGARY

Java Specific Optimizations

UNIVERSITY OF CALGARY

Code Tuning – Java

- Java is an object oriented language
- That runs in a virtual machine
- There are more inefficiencies that can be improved than we've covered for a language like c++

UNIVERSITY OF CALGARY

Strings

Code Tuning – Strings

- Not null terminated
  - char[] and length are both stored

- Immutable
  - Any change attempt (making new string)

- char[] is better for secure data than String

- Also UTF-16 (uses two bytes for all)
  - if you want UTF-32 there's a lot of management steps

UNIVERSITY OF CALGARY

Code Tuning – Strings

- **String pool**
  - Java has a special memory location (PermGen Space)
    - Usually for things like class desc, and metadata (exist longterm)
  - If a new String literal (“hello”) is made matching existing Java will attempt to point at same data
    - No NEW object
  - new String(“hello”) by-passes this
  - Also dynamic strings like one created at runtime from input won’t be associated

Code Tuning – Strings

- **String pool**
  - Java has a special memory location (PermGen Space)
    - Usually for things like class desc, and metadata (exist longterm)

```
public static void main(String[] args){
    System.out.println(System.identityHashCode("hello"));
    System.out.println(System.identityHashCode("hello"));
    System.out.println(System.identityHashCode(new String("hello")));
}
```

- 366712642
- 366712642
- 1829164700

UNIVERSITY OF CALGARY

Code Tuning – Strings

```
Scanner s;
s = new Scanner(System.in);
System.out.println(System.identityHashCode("hello"));
System.out.println(System.identityHashCode("hello"));
System.out.println(System.identityHashCode(new String("hello")));
String str = s.nextLine();
str = str.trim();
System.out.println(System.identityHashCode(str));
```

- 1442407170
- 1442407170
- 1028566121
- hello
- 1118140819

UNIVERSITY OF CALGARY

Code Tuning – Strings

- **String pool**
  - Java has a special memory location (PermGen Space)
    - Usually for things like class desc, and metadata (exist longterm)
  - USE .equals()
    - To get consistent String comparisons on .equals() compares contents, == will give you differing behaviour whether or not the String Pool has been used

UNIVERSITY OF CALGARY

Code Tuning – Strings

- **String pool**

  - USE .equals()
    - To get consistent String comparisons on .equals() compares contents, == will give you differing behaviour whether or not the String Pool has been used

  - Example: Junit Testing
    - Setup will contain string literals String pool which re-use memory, thus == will work
    - however during operation == may fail
    - Strings during operation often collected via input steps

UNIVERSITY OF CALGARY

Code Tuning – Strings

- StringBuilder and StringBuffer
  - StringBuilder not thread-safe

- Let you compile a list of Strings which you can convert to a final String once
  - Much better than repetitive +, += operations

- Can even set expected capacity needed (like ArrayList) so that hidden array doesn’t need to expand

UNIVERSITY OF CALGARY

Maps

Code Tuning – Maps

- When you want to iterate through a Map, and you need both keys and values, instead of the following:

```
for (K key : map.keySet()) {
    V value : map.get(key);
}
```

- .. To this:

```
for (Entry<K, V> entry : map.entrySet()) {
    K key = entry.getKey();
    V value = entry.getValue();
}
```


UNIVERSITY OF CALGARY

Code Tuning – hashCode()/equals()

- Optimise your hashCode() and equals() methods
- A good hashCode() method is essential because it will prevent further calls to the much more expensive equals()
- Can store a calculated hashCode once in object (only update on modified object, when sets are called)

UNIVERSITY OF CALGARY

Primitives

UNIVERSITY OF CALGARY

Code Tuning – Primitives

- Reverse of refactoring
- Sometimes code tuning is called ‘defactoring’
- Use double instead of Double, int instead of Integer
- Java can store values on stack, instead of heap
- Try to avoid BigInteger and BigDecimal, similarly
  - Only if you really need to exceed long, or need precision

UNIVERSITY OF CALGARY

Logging

UNIVERSITY OF CALGARY

Code Tuning – Logging

- Strings take a lot of time to create (program-wise)
- Check the current log level first before making log string

```
// don’t do this
log.debug(“User [” + userName + “] called method X with [” + i + “]”);

// or this
log.debug(String.format(“User [%s] called method X with [%d]”,
userName, i));

// do this
if (log.isDebugEnabled()) {
log.debug(“User [” + userName + “] called method X with [” + i + “]”);
}
```

Libraries

Code Tuning – Libraries

- Use Apache Commons StringUtils.replace instead of String.replace
  - Java 9 improved String replace but if on Java 8

```
// replace this
test.replace("test", "simple test");

// with this
StringUtils.replace(test, "test", "simple test");
```


UNIVERSITY OF CALGARY

Code Tuning – Libraries

- Avoid regular expressions and instead use Apache Commons Lang.

UNIVERSITY OF CALGARY

Simple Recursion

UNIVERSITY OF CALGARY

Code Tuning – Recursion

- Recursion is great for design of algorithms but not great for optimization

- Stay away from recursion.
  - **Recursion is very resource intensive!**

- Very beneficial to code tune algorithms to be loops instead of recursive calls
  - Replace program stack with self-managed stack structure for data that would normally be passed in recursive call

UNIVERSITY OF CALGARY

Code Tuning – Recursion

```
public void countDown(int n) {
    if (n == 0) {
        return;
    }
    System.out.println(n + "...");
    waitASecond();
    countDown(n - 1);
}

public void countDown(int n) {
    while (n > 0) {
        System.out.println(n + "...");
        waitASecond();
        n -= 1;
    }
}
```

Code Tuning – Recursion

```
public void DFS(Node root) {
    System.out.print(" " + root.data);
    DFS(x.left);
    DFS(x.right);
}
```


UNIVERSITY OF CALGARY

Code Tuning – Recursion

```
public void DFS(Node root) {
    Stack<Node> s = new Stack<Node>();
    s.add(root);
    while (s.isEmpty() == false) {
        Node x = s.pop();
        if (x.right != null) {
            s.add(x.right);
        }
        if (x.left != null) {
            s.add(x.left);
        }
        System.out.print(" " + x.data);
    }
}
```


UNIVERSITY OF CALGARY

Caching

UNIVERSITY OF CALGARY

Code Tuning – Hidden Caching

- A typical example is caching database connections in a pool.
  - The creation of a new connection takes time, which you can avoid if you reuse an existing connection.

- You can also find other examples in the Java language itself.
  - The valueOf method of the Integer class, for example, caches the values between -128 and 127.

UNIVERSITY OF CALGARY

Iterators

UNIVERSITY OF CALGARY

Code Tuning – Iterators

- Common now to use Java iterators
  - Is a good refactoring, but depending…
  - for (String value: strings) { // Do something useful here }

- a new iterator instance will be created

```
int size = strings.size();
for (int i = 0; i < size; i++) {
    String value: strings.get(i);
    // Do something useful here
}
```


UNIVERSITY OF CALGARY

Memory

UNIVERSITY OF CALGARY

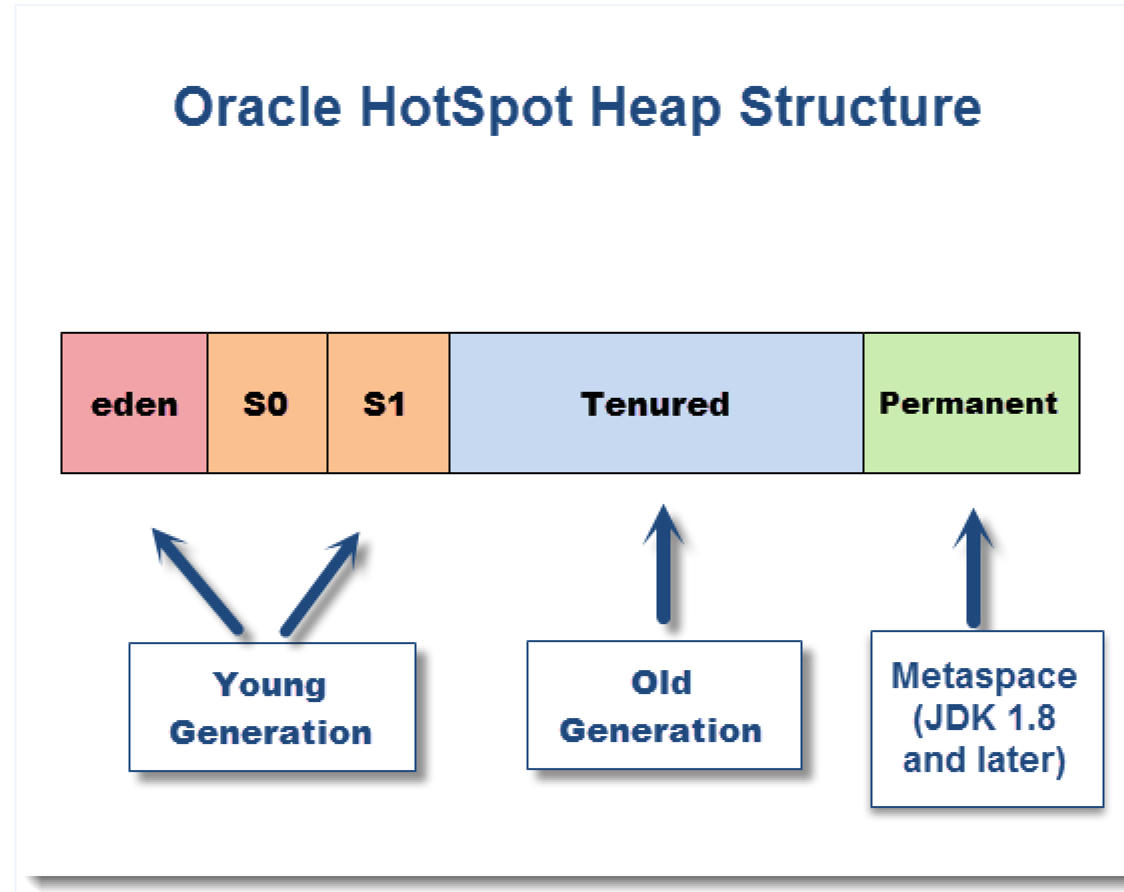
Code Tuning – Memory Leaks

- Java is stuck with garbage collection
- We can stop point at things but not delete them
- If your program naively leaves created objects connected to current code (heap will continue to grow)
- You can generally see this via Profiling and heap dumps

UNIVERSITY OF CALGARY

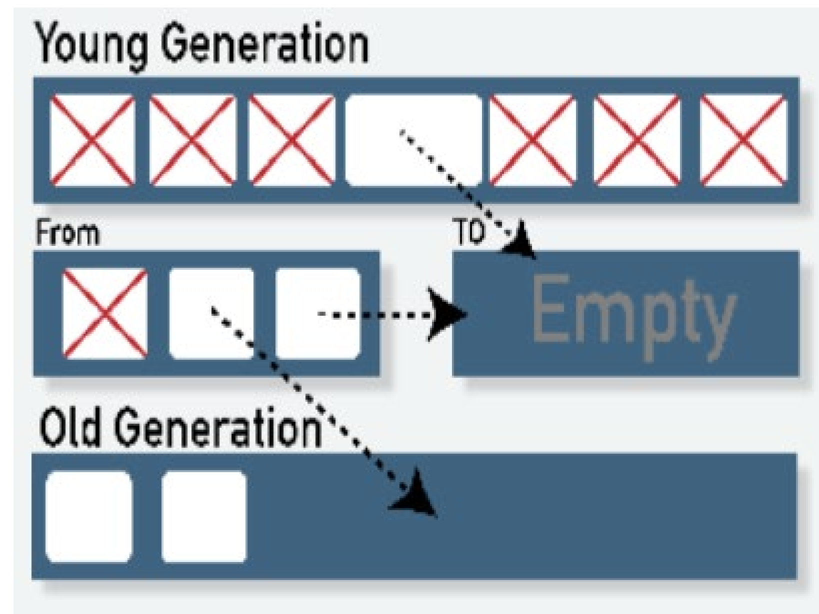
Code Tuning – Heap Structure

- The young generation is actually garbage collected quicker than the older generation
- Lots of new objects, or aggressive GC in young generation slows down program



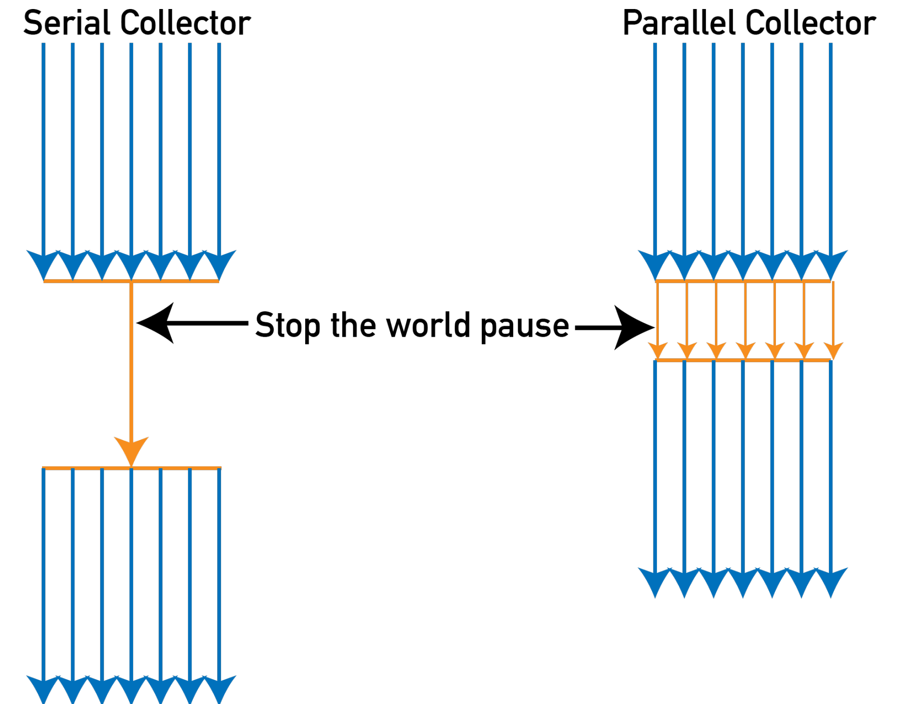
Code Tuning – Garbage Collectors

- Serial Collector
  - Both Young and Old collections are done serially, using a single CPU and in a stop-the-world fashion.
  - Best client-side



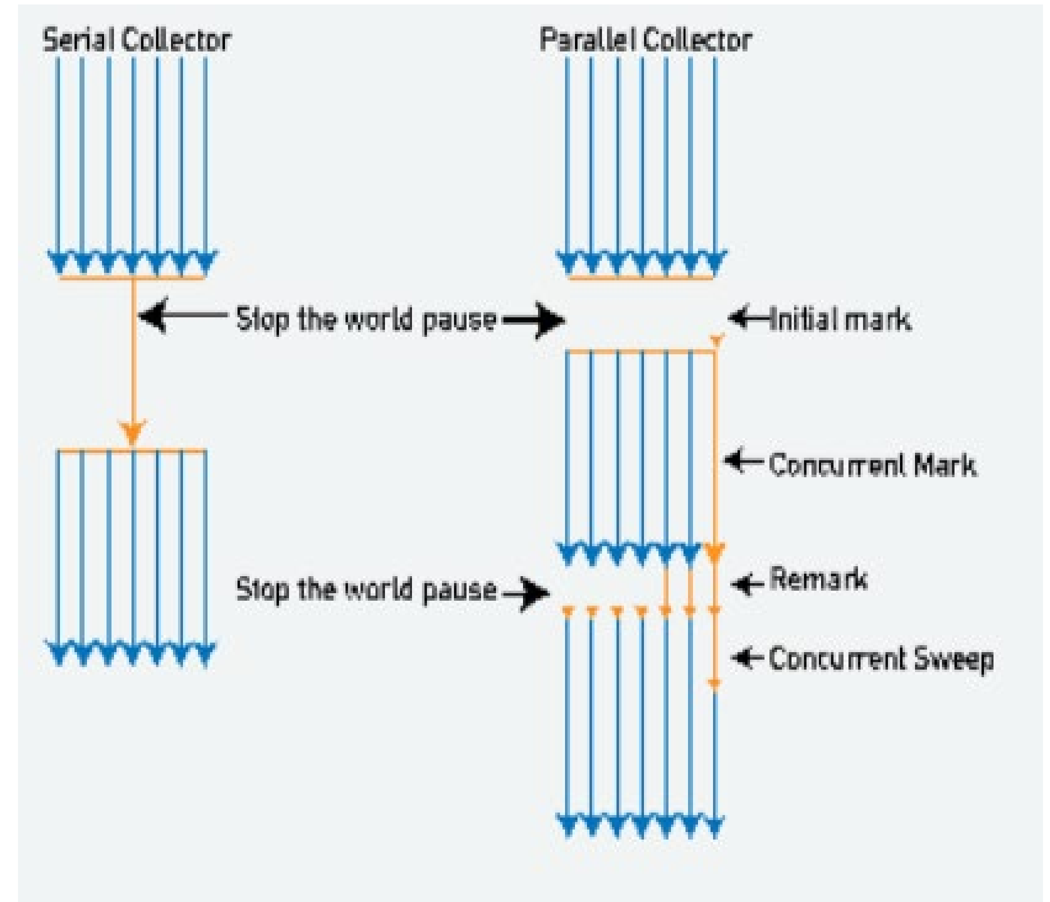
Code Tuning – Garbage Collectors

- Serial Collector
  - Both Young and Old collections are done serially, using a single CPU and in a stop-the-world fashion.
  - Best client-side
- Parallel Collector(throughput collector)
  - Designed to take advantage of available CPU cores. Both Young and Old collections are done using multiple Gcthreads.



Code Tuning – Garbage Collectors

- Mostly concurrent collectors (low-latency collectors)
  - Designed to minimize impact on application response time associated with Old generation stop-the-world collections.
  - Most of the collection of the old generation using the CMS collector is done concurrently with the execution of the application.



UNIVERSITY OF CALGARY

Code Tuning – Garbage Collectors

- Choose wisely between 32-bit or 64-bit VMs
  - going from a 32-bit to a 64-bit machine increases heap requirement for an existing Java application by up to 1.5 times (bigger ordinary object pointers)
  - -XX:+UseCompressedOops in Java version prior to 1.7 (which is now default)
    - This tuning argument greatly alleviates the performance penalty associated with a 64-bit JVM.

Code Tuning – Garbage Collectors

- Large heap not always better
  - Profile your application for possible memory leaks using tools such as Java VisualVM or Plumbr (Java memory leak detector).
  - Focus your analysis on the biggest Java object accumulation points
  - Reducing your application memory footprint will translate in improved performance due to reduced GC activity.

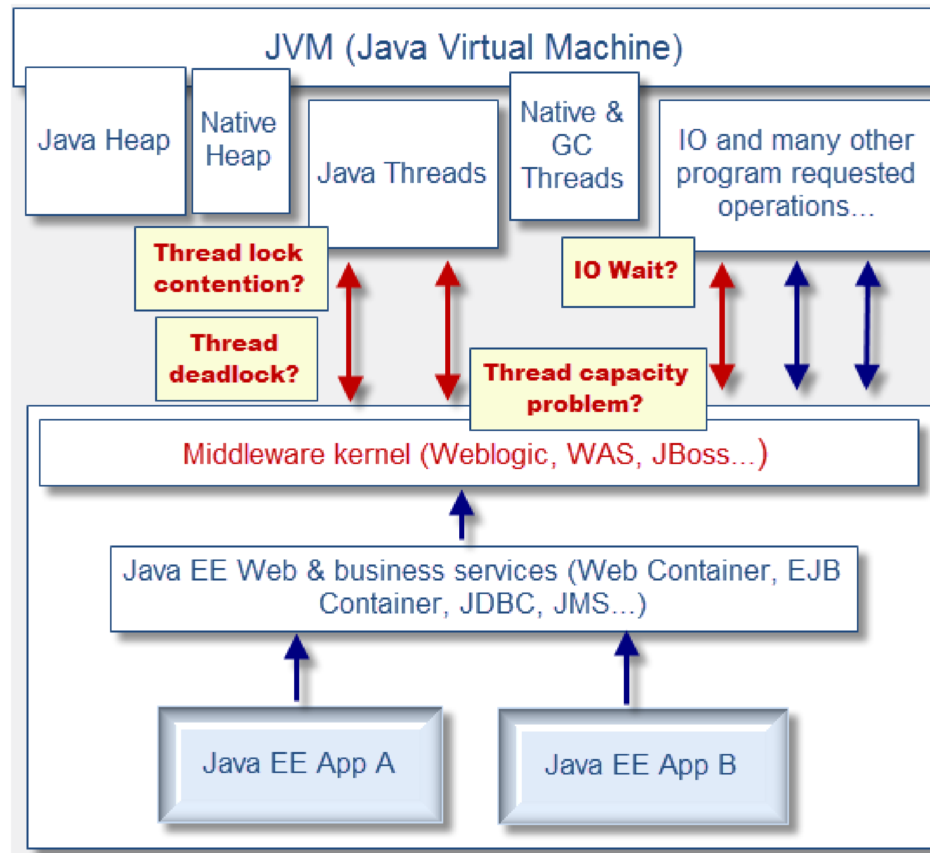
UNIVERSITY OF CALGARY

Threads

UNIVERSITY OF CALGARY

Code Tuning – Thread-Lock/Contention

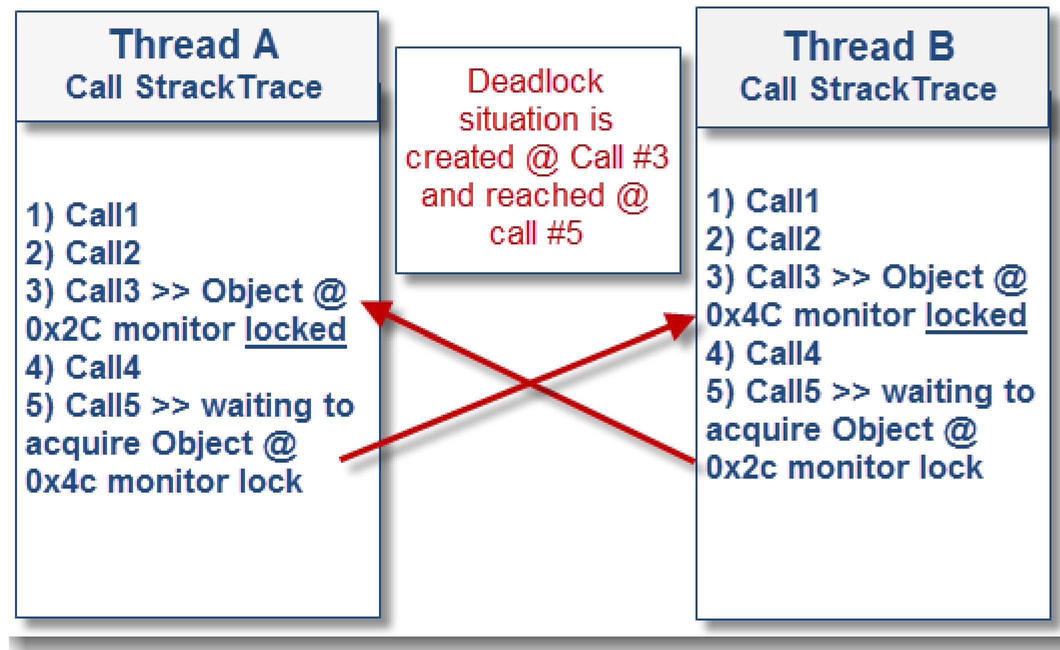
- Thread lock contention is by far the most common Java concurrency problem



UNIVERSITY OF CALGARY

Code Tuning – Thread-Lock/Contention

- True Java-level deadlocks, while less common, are triggered when two or more threads are blocked forever, waiting for each other.



UNIVERSITY OF CALGARY

Code Tuning – Thread-Lock/Contention

- Clock Time and CPU Burn
  - Ex. worker not doing anything, just spinning in a loop

Profiler

JVisualVM

Profile: CPU Memory Stop

Status: application terminated

Profiling results

Snapshot

CPU burn profiling
Top method contributors

Hot Spots - Method	Self time [%]	Self time	Invocations
org.ph.javaee.training4.WorkerThread.**run** ()		2621 ms (100%)	11
java.util.concurrent.ThreadPoolExecutor$Worker.**run** ()		0.479 ms (0%)	11
java.util.logging.LogManager$Cleaner.**run** ()		0.109 ms (0%)	1
org.ph.javaee.training4.WorkerThread.**<init>** (java.ut...		0.036 ms (0%)	10
java.lang.ApplicationShutdownHooks$1.**run** ()		0.000 ms (0%)	1

Timeout Management

UNIVERSITY OF CALGARY

Code Tuning – Timeout Management

- Lack of proper HTTP/HTTPS/TCP IP timeouts between your Java application and external systems
  - lead to severe performance degradation and outage due to middleware and JVM threads depletion (blocking IO calls).

- Proper timeout implementation will prevent Java threads from waiting for too long in the event of major slowdown of your external service providers.

UNIVERSITY OF CALGARY

Onward to … next topic.

Jonathan Hudson
jwhudson@ucalgary.ca
https://pages.cpsc.ucalgary.ca/~hudsonj/

UNIVERSITY OF CALGARY