

Optimization: Java Optimization

**CPSC 501: Advanced Programming Techniques
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Java Specific Optimizations

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++

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

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

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

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

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

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

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();  
}
```

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)

Primitives

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

Code Tuning – Primitives

- Try to avoid BigInteger and BigDecimal, similarly
 - Only if you really need to exceed long, or need precision
 - `int > Integer > Bigtenger` `double > Double > BigDecimal`
- Integer is not a primitive (it is Object and is immutable)
 - `x = new Integer(1)` , `x = x + new Integer(2)`, `x = new Integer(3)`
 - 1,2,3 are all individual objects and x is 'pointed' towards a new one
 - `x = 1` , `x = x + 2`, `x = 3` , the memory spot x points to is changed from 1 to 3

Logging

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");
```

Code Tuning – Libraries

- Avoid regular expressions and instead use Apache Commons Lang.

Simple Recursion

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

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) ;  
}
```

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);
    }
}
```

Caching

Code Tuning – Hidden Caching/Pooling

- 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.

Iterators

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
}
```

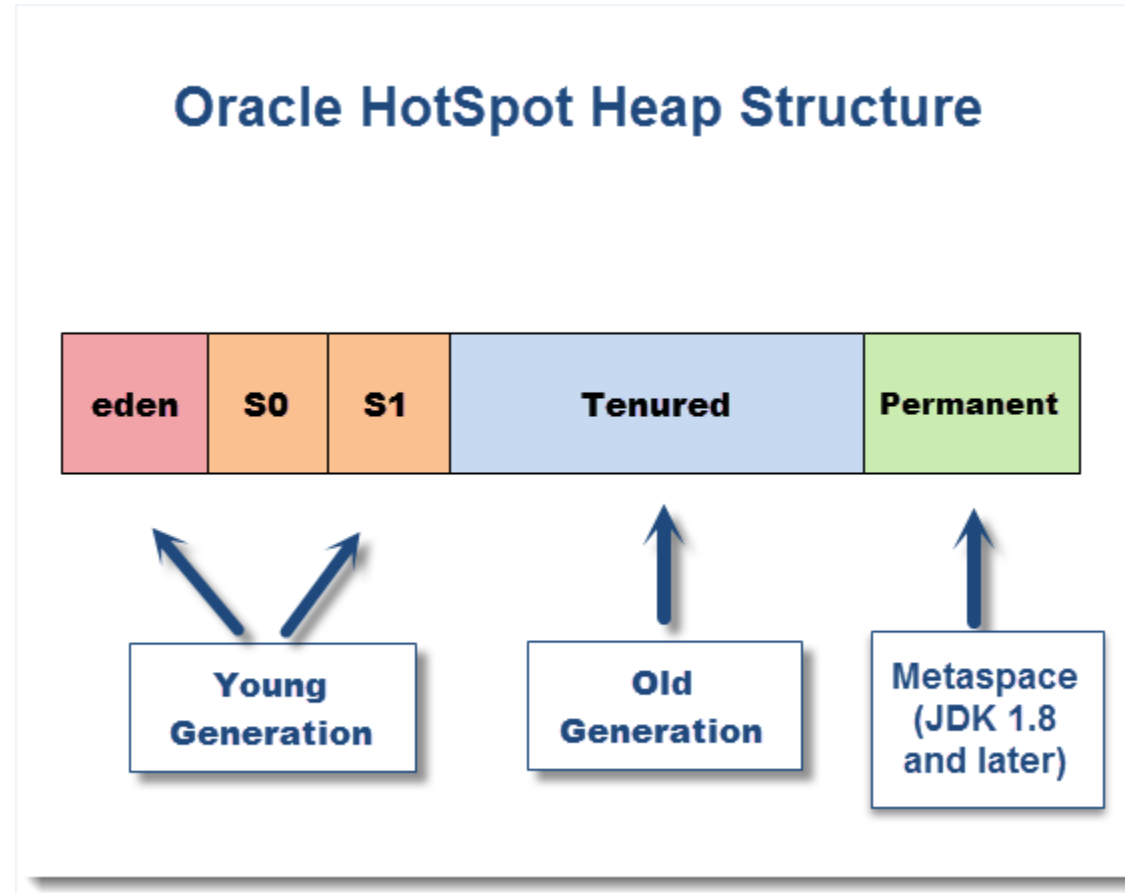
Memory

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

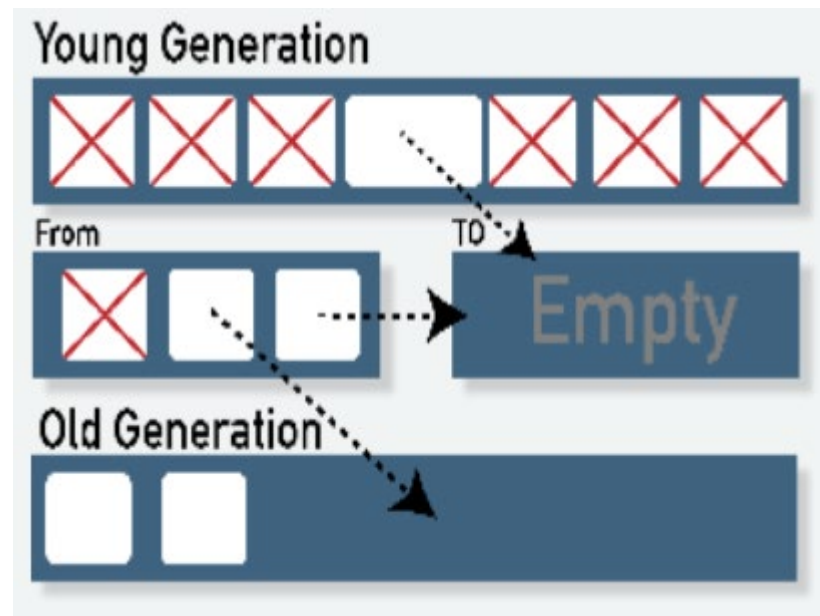
Code Tuning – Heap Structure

- 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



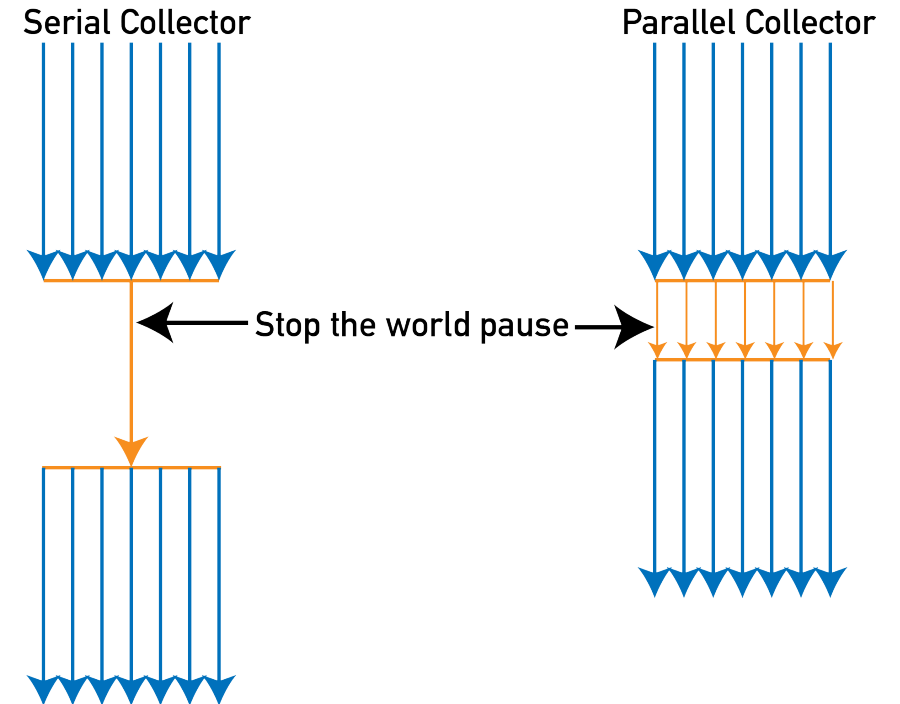
Code Tuning – Garbage Collectors

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



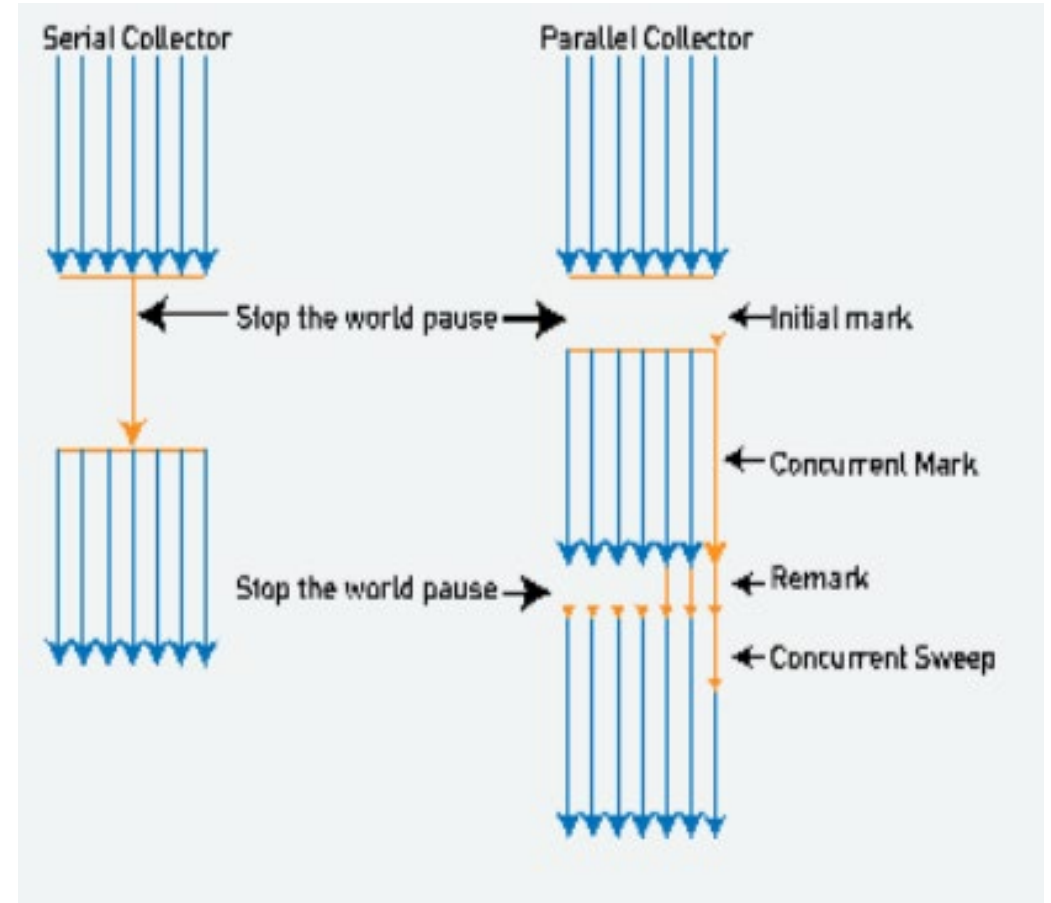
Code Tuning – Garbage Collectors

- 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.



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.

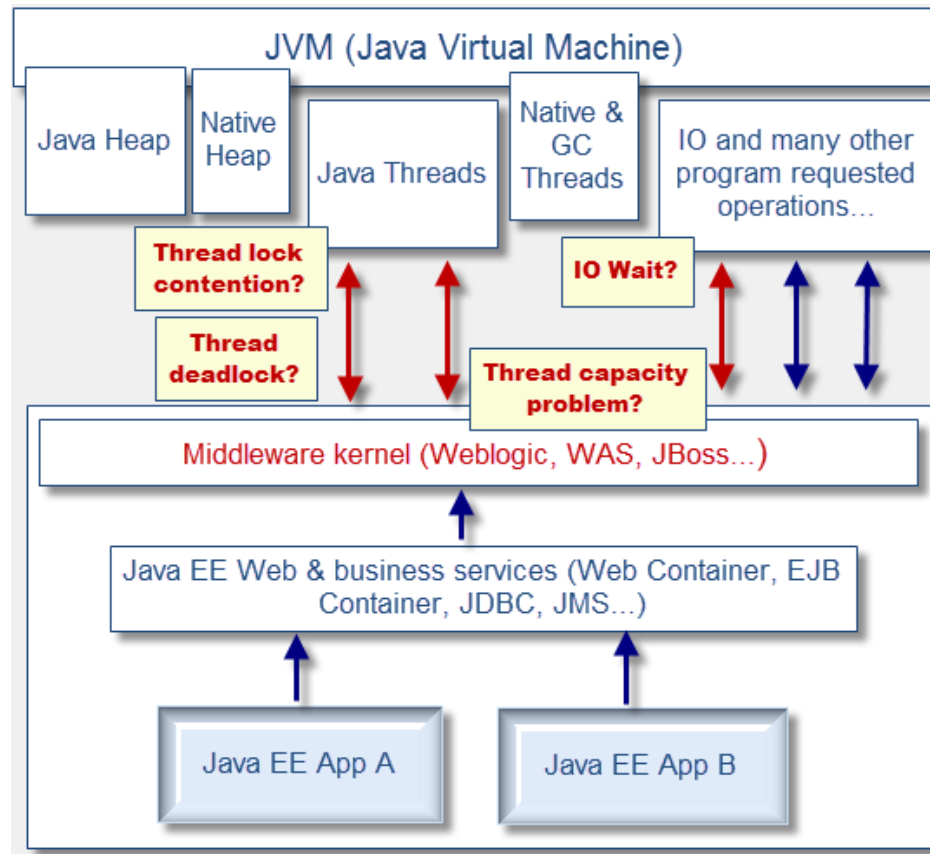
Code Tuning – Garbage Collectors

- Large heap not always better
 - Profile your application for possible memory leaks using tools such as Java VisualVM or Plumb (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.

Threads

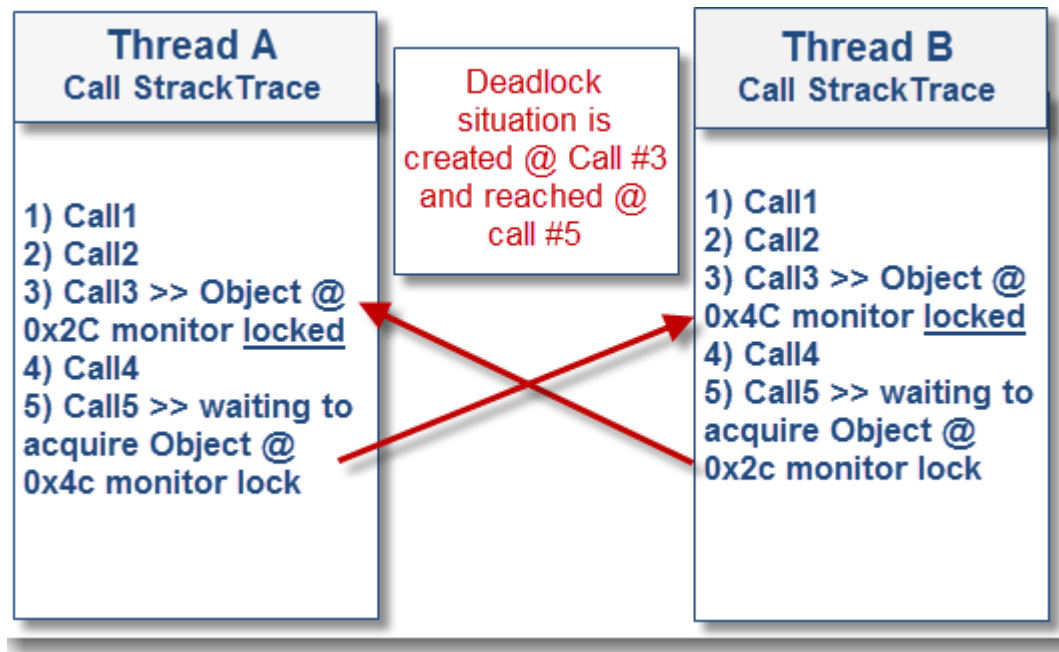
Code Tuning – Thread-Lock/Contention

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



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.



Code Tuning – Thread-Lock/Contention

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

Profiler

Profile: CPU Memory Stop

Status: application terminated

JVisualVM

Profiling results

Snapshot

CPU burn profiling
Top method contributors

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

Timeout Management

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.

Onward to ... python optimization.

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