Smart Coding using New Code Optimization Techniques in Java to Reduce Runtime Overhead of Java Compiler

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ABSTRACT
Java is a popular object oriented programming language suitable for writing Java programs. Sometimes programmers spend most of the time to increase the execution time of the program, but simultaneously its effect on code size. Therefore, the code become more complex and unreliable, so this leads to reduce the efficiency of code. Today so many compilers are exist like c, javac,c++,cobol,etc. we studied the code optimization techniques for java compiler separately and that time we come across some new code optimization strategies which is the smart way to do the coding in java. In this paper we applied some new java code optimization techniques on existing code. We verify the code optimization, performance using our executor. These code optimization strategies indirectly help to reduce the work of garbage collection, data structure and also work on loop optimization. So the results which we found after doing experimentations are quite satisfactory as compare to original results. so these techniques are help to improve the code quality.

Keywords
Code optimization, code efficiency, execution time, code quality, readability. Garbage Collection, Loop optimization, Data Structure.

1. INTRODUCTION
In compiler design, Optimization is the process of transforming a piece of code (un-optimized code) to make more efficient without changing its output. The optimized programmer is simply defined as a program is smaller in size, which consume less memory also which required less execution time. Most of the time while writing a java program the programmer can easily make simple mistakes that are harmless for small application. but as the application grows the performance of java application become slower.so to improve the performance of an java application code optimization is the important factor. On using different optimization techniques, the code can be optimized without affecting the original (actual) algorithm and final output with the intent of high performance. When performance is to be considered, then there is need to choose an algorithm which runs quickly and the available computing resources are being used.

Basically, Code optimization involves the employment rules and algorithms to the program segment with the goal, such that the code becomes efficient requires less memory and execute faster and so on. Optimization is classified as high level optimization and low level optimization. High level optimization are usually performed by those programmers who handles abstract entities and also keeps in mind the general framework of the task to optimize design of a system. On the other hand, low level optimization is performed at the stage when source code is compiled into a set of machine instructions.

Fig 1: Code optimization process
In the above fig shows how the optimization works in any compiler. The source code which is written in any programming language .

The major part of code optimization includes the output does not changes after applying the techniques. The semantic of the code optimization should be preserved.

The structure of the paper is as follows: section 2 contains literature survey of the existing code optimization techniques, section 3 contains proposed techniques which are working on java language. Section 4 contains results and analysis also this paper ended with conclusion and feature scope.
2. LITERATURE REVIEW

Table 1: Existing Code Optimization Techniques

<table>
<thead>
<tr>
<th>S.N</th>
<th>Code Optimization Techniques</th>
<th>Extract of the paper</th>
<th>How code optimization works</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Constant Folding</td>
<td>Optimization is done by replacing all expressions with constant result computed at compile time</td>
<td>public void CP() { int c= 4+1;//the value of c is always 5 so compiler replace the value of c by 5 directly System.out.println(c); }</td>
</tr>
<tr>
<td>2</td>
<td>Constant Propagation</td>
<td>Compute as many possible values at compile time for optimization of code</td>
<td>int b = 6; System.out.println(b);//b will always be 6, So the statement b=6 has no meaning in the program</td>
</tr>
<tr>
<td>3</td>
<td>Useless Expression Elimination</td>
<td>Done by eliminating unnecessary expressions</td>
<td>Sometimes we assign a value to the variable like s=2; bt this variable is not used in the program so there is no need to assign the extra variables</td>
</tr>
<tr>
<td>4</td>
<td>Copy Propagation</td>
<td>Done by replacing one variable by another when they are equal</td>
<td>public void CPI(int x) { int y = x; System.out.println(y);// y=x therefore optimization replace x by y }</td>
</tr>
<tr>
<td>5</td>
<td>Common SubExpression Elimination</td>
<td>This optimization uses the concept of temporary variables, temp variable help to store the intermediate result, so the common subexpressions are eliminated</td>
<td>public void CSE(int x,int y) { int p= x<em>y; int q = x</em>y; System.out.println(p);//so p==q System.out.println(q); }</td>
</tr>
<tr>
<td>6</td>
<td>Reduce Mathematical Strength</td>
<td>This optimization is done by changing the mathematical expression, which requires a longer time for computation are replaced by the expression which require less time for computing the same</td>
<td>If the expression is p=f*2 then for optimization you can replace above expression by p=f+f. For optimization replaces multiplication by addition, And exponential by multiplication.</td>
</tr>
<tr>
<td>7</td>
<td>Global Constant Propagation</td>
<td>Optimization is done throughout in program by replacing the constant expression by constant values at compile time.</td>
<td>public void GCP(boolean P) { int X= 5; int R; if(P) { R = X; } else { R=X; } int d = R; System.out.println(d); }</td>
</tr>
<tr>
<td>8</td>
<td>Global Common Subexpression Elimination</td>
<td>AS we know common subexpressions use the concept of temporary variables. So in this optimization the temporary values are computed at once during runtime</td>
<td>Here, if x=p<em>q; Y=p</em>q; // so x=y; G=p<em>q; // so here once the compiler computes value of p</em>q, so no need to compute the value of p*q again and again at this stage we can use the concept of temporary variable to store the result.</td>
</tr>
</tbody>
</table>
Dead Code Elimination

The optimization is done by removing the byte code which is generated at output that should not be executed.

Some conditions or statements which never be true should be eliminated for optimization.

Code Hoisting

The optimization is done by computing busy expressions as early as possible. So this will help to reduce the size of code.

Code hoisting is performed in Java to reduce the size of code.

3. PROPOSED TECHNIQUE:

In this section we proposed new code optimization techniques which help to reduce runtime overhead on java compiler. So by using the below techniques the programmer can speed up the execution time as well as code quality will improve too. The implementation part is done on following:

Section 1. the Controller control the input file and generation of output file call the patterns.

Section 2. both input and output files goes through the executor which compile both file and calculate the execution time of both the files. The executor creates .class file and .jar file for both the inputs while compilation.

Section 3 Report generator will display the runtime and difference between both the files.

A) String append pattern:

This technique helps to reduce the work of garbage collection. Garbage collection is automatic in Java programs. When the object is no longer more useful than it will available for GC, so disposing a Java object is called as garbage collection. The two techniques can apply which can help reduce the work of GC.

In the first technique, applications can use the existing object so there will be no need to create and destroy the object again and again, but in this case the programmer has to do the extra work. Because the value of the object is needed to be reinitialized.

The 2nd technique which can reduce the work of GC is use the appropriate object only which can meet the exact requirement.

We all know the fact that concatenation of Two strings is expensive because of the immutable property of the string. immutable means the value of the string can not be change. So whenever we performed the string concatenation the intermediate result is created which is string object so each of the string object is needed to be GC.

1. Sample code (un optimized and optimized code)

```java
9
package com.codeoptimizationoutput;

class StringAppendPattern{
    public static String appendPattern(String var1, String var2)
    {
        String variable = “hello”,
        for (int i = 0; i < 100; i++)
        {
            variable = ‘a’ + var1,
            System.out.print(variable);
        }
        variable.append(var2);
    }

    public static void main(String args)
    {
        new StringAppendPattern();
    }
}

public class StringAppendPattern{
    String variable = “hello”,
        for (int i = 0; i < 100; i++)
        {
            variable = ‘a’ + var1,
            System.out.print(variable);
        }
        variable.append(var2);
    }
}

Fig 2: Java Code Optimization framework
```

Above code shows the un-optimized and optimized code. in this experimentation we gave an un-optimized file as input to our controller which check all the pattern related to + operator and then produced a new optimized code which new function in place of + operator is .append().

2. Executor

Process both unoptimized and optimized files on executor so it will process both files, this executor will generate .class and .jar file for both the input and output file.

Fig 2: Executor working
3. Result Formation
After executing both the files on executor, the executor compilers both the files and find out the how much time is required for both files for execution and the difference between them. Also this result will displayed in html page.

![Performance report](image)

Fig 3: Final Report Generation

### Table 2: Proposed code optimization techniques

<table>
<thead>
<tr>
<th>S.N</th>
<th>OPTIMIZATION TECHNIQUES</th>
<th>CODE BEFORE OPTIMIZATION</th>
<th>EXECUTION TIME IN MILLISECONDS</th>
<th>CODE AFTER OPTIMIZATION</th>
<th>EXECUTION TIME IN MILLISECONDS</th>
</tr>
</thead>
</table>
| 1   | Avoid new with string to reduce stack pool size | String str = new String("string");
String str1 = new String();
String str2 = new String(str1); | 995 | String str = "string";
String str1 = "";
String str2 = str1; | 20 |
| 2   | Use stringbuffer append pattern. | String variable="abc";
Variable="india"+variable; | 949 | public StringAppendPattern() {
  StringBuffer variable = new StringBuffer("abc");
  for (int i = 0; i < 1000; i++) {
      variable.append("India");
      variable.append(variable);
  }
} | 29 |
| 3   | Avoid creating thread without run method | public class TR {
  public void method() throws Exception {
    new Thread().start();
    System.out.println("hiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiii
<p>| | | | | | |</p>
<table>
<thead>
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</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Avoid using <code>java.lang.Class.forName()</code>.</td>
<td>Class.forName(java.lang.Integer.getName());</td>
<td>968</td>
<td>System.out.println(java.lang.Integer.class.getName()); // CORRECTION</td>
<td>62</td>
</tr>
<tr>
<td>6</td>
<td>Use <code>ArrayList</code> instead of <code>LinkedList</code>.</td>
<td>LinkedList&lt;Object&gt; list = new LinkedList&lt;Object&gt;();</td>
<td>15</td>
<td>ArrayList&lt;Object&gt; list = new ArrayList&lt;Object&gt;();</td>
<td>13</td>
</tr>
<tr>
<td>7</td>
<td>Do not use empty static initialize.</td>
<td>public class SI{ static // VIOLATION { // empty } }</td>
<td>33</td>
<td>public class SI{ // ... } }</td>
<td>27</td>
</tr>
<tr>
<td>8</td>
<td>Use short circuit <code>Boolean</code> operator instead Of <code>BinaryOperator</code>.</td>
<td>String sValue = &quot;binary&quot;; if(sValue.equals(&quot;true&quot;)</td>
<td></td>
<td>sValue.equals(&quot;false&quot;)) { // unoptimize code System.out.println(&quot;valid boolean&quot;); }</td>
<td>931</td>
</tr>
<tr>
<td>9</td>
<td>For optimization Avoid empty if</td>
<td>if (n&lt;0) // without optimization { n =0; } }</td>
<td>867</td>
<td>if (n&lt;0) // optimization { } } */ N=0;; } }</td>
<td>24</td>
</tr>
<tr>
<td>10</td>
<td>String equal pattern</td>
<td>String str = &quot;new String(); if(str.equals(&quot;&quot;))</td>
<td>939</td>
<td>public void stringEqualPattern() { String str = &quot;&quot;; if (str.length() == 0) {} }</td>
<td>23</td>
</tr>
<tr>
<td>11</td>
<td>Optimize array size</td>
<td>public static void main(String[] args) { ArrayList&lt;String&gt; list = new ArrayList&lt;String&gt;(); for( int index = 0 ; index &lt; 200 ; index++){ list.add(index ++); } int size = 10; ArrayList&lt;Integer&gt; integerlist = new ArrayList&lt;Integer&gt;(); for(int index = 0 ; index &lt; list.size() ; index++){ integerlist.add(index); } }</td>
<td>28</td>
<td>ArrayList&lt;String&gt; list = new ArrayList&lt;String&gt;(); for( int index = 0 ; index &lt; 200 ; index++){ list.add(index ++); } int size = 10; ArrayList&lt;Integer&gt; integerlist = new ArrayList&lt;Integer&gt;(); for(int index = 0 ; index &lt; list.size() ; index++){ integerlist.add(index); integerlist.clear(); }</td>
<td>16</td>
</tr>
<tr>
<td>12</td>
<td>Avoid input output</td>
<td>try{</td>
<td>1906</td>
<td>try {</td>
<td>1021</td>
</tr>
</tbody>
</table>
**4. CONCLUSION AND FUTURE SCOPE**

In this paper the experimentation shows our approach for code optimization using above techniques. These techniques are used to speed up the program execution without affecting the final output. So this tool provides a way to optimize the unoptimized code and reduce complexity of code. One more benefit of this tool is this will increase the quality of the code.

In future work we will incorporate the other techniques which will suggest the programmer how to do the smart coding. This will also helpful for the beginner of the programmer.

| operations in loop | FileWriter  FileWriter = new FileWriter(new File("temp.txt"));  
|------------------|----------------------|----------------------|
| for(int i = 0 ; i < 500000000 ; i++)  
| FileWriter.write(i + "")  
| FileWriter.flush();  
| })  
| FileWriter fileWriter = new FileWriter(new File("temp.txt"));  
| StringBuffer var = new StringBuffer();  
| for (int i = 0; i < 500000000; i++)  
| {var.append(i + "")  
| fileWriter.flush();  
| }  
| fileWriter.write(var.toString());  
| fileWriter.flush();  
| }  
| String str = "goods"  
| System.out.println(str);  
| String s = "abc " + str.substring(0);  
| System.out.println(s.tostring());  
| System.out.println(s.substring(0));  
| AvoidTostring a = new AvoidTostring();  
| a.xyz (s)  
| 13| 946| 72|

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