Mehrotra,Sanket

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# JEdit

Tool: Designitejava

## The metrics analyzed

1. **Method level metrics**
   1. **Lines of Code(LOC)**: Computes the lines of **non-comment, non-blank** code in the function.
   2. **Cyclomatic complexity(CC)**: At the method level, computes the number of possible paths to measure complexity of the function.
   3. **Parameter Count(PC)**: The number of arguments given to a function.
2. **Class level metrics**
   1. **Number of fields(NOF)**: calculates the number of data-members of a class.
   2. **Number of public fields(NOPF)):** calculates the number of public data-members in a class.
   3. **Number of methods(NOM):** calculates the total number of methods in a class.
   4. **Number of public methods(NOPM)**: calculates the number of public methods in a class.
   5. **Lines of code(LOC)**: Computes the number of lines of code in line with the conditions highlighted above (1.a) but for the whole class.
   6. **Weighted methods per class(WMC)**: The Cyclomatic Complexity values of each method in the class are summed to find the complexity of a class, this is the WMC. It can be used to determine whether a class needs to be restructured into smaller classes. WMC should be low, since it will keep classes restricted to a single responsibility and prevent a greater potential impact on derived classes.
   7. **Number of children(NOC)**: NOC equals the number of immediate child classes derived from a base class.
   8. **Depth of inheritance tree(DIT)**: Finds the position of the class in the Inheritance tree. This is used to measure the complexity of the class structure
   9. **Lack of cohesion in methods(LCOM)**: According to Chidamber & Kemerer, to calculate LCOM, two methods of a class are checked; if they accessed different variables, P is increased by one. However, if they access the same variable, Q is increased by one. The lower LCOM, the more cohesive class. . It can also be used to determine whether a class needs to be restructured into smaller classes, like WMC.

LCOM1 = P - Q , if P > Q

LCOM1 = 0 otherwise

LCOM1 = 0 indicates a cohesive class.

LCOM1 > 0 indicates that the class needs or can be split into two or more classes, since its variables belong in disjoint sets

* 1. **Fan-in(FANIN)**: For a given class X, the fan-in structural metric can be used to calculate how much code is being reused. It can be defined as the number of classes that depend on class X. Where ‘dependence’ could be using X’s methods, its variables, constants or use its sub-classes or enums.
  2. **Fan-out(FANOUT)**: Fan-out denotes how many classes a given class Y depends on. Here, Y’s dependence includes using other classes’ methods, variables, enums or constants. Fan out can be used to calculate the coupling of classes, high FO denotes strongly coupled code. The class Y depends on other code and is probably more complex to execute and test.

## Analyzing code metrics

### 2.1 Metrics for the original project modules.

Since the project has thousands of classes within large number of packages, we selected only some classes from some of the packages that involve the modifications to be shown in the report after analyzing the whole project. To see the whole results, you can see the attached CSV files.

* **Class level metrics**
  + **This package is org.gjt.sp.jedit.search**

Table 1: Class level metrics calculated by DesigniteJava for JEdit project

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Class Name | NOF | NOPF | NOM | NOPM | LOC | WMC | NC | DIT | LCOM | FANIN | FAN-OUT |
| SearchMatcher | 6 | 3 | 7 | 4 | 83 | 13 | 2 | 0 | 0.2857 | 7 | 2 |
| Match | 3 | 3 | 1 | 1 | 8 | 1 | 0 | 0 | 0 | 7 | 0 |
| SearchAndReplace | 12 | 0 | 44 | 33 | 805 | 151 | 0 | 0 | 0.0454 | 14 | 26 |
| HyperSearchResults | 26 | 6 | 60 | 37 | 637 | 132 | 0 | 1 | 0.2166 | 5 | 28 |
| ActionHandler | 0 | 0 | 1 | 1 | 27 | 8 | 0 | 0 | -1 | 1 | 5 |
| HighlightingTree | 2 | 0 | 2 | 1 | 54 | 9 | 0 | 0 | 0 | 0 | 4 |
| KeyHandler | 0 | 0 | 2 | 2 | 26 | 5 | 0 | 0 | -1 | 0 | 0 |
| MouseHandler | 1 | 0 | 2 | 1 | 44 | 10 | 0 | 0 | 0 | 0 | 3 |
| RemoveTreeNodeAction | 0 | 0 | 2 | 1 | 8 | 2 | 0 | 0 | -1 | 0 | 1 |
| RemoveAllTreeNodesAction | 0 | 0 | 2 | 1 | 8 | 2 | 0 | 0 | -1 | 0 | 1 |
| NewSearchAction | 0 | 0 | 2 | 1 | 15 | 3 | 0 | 0 | -1 | 0 | 5 |
| ExpandChildTreeNodesAction | 0 | 0 | 2 | 1 | 10 | 2 | 0 | 0 | -1 | 0 | 1 |
| CopyToClipboardAction | 0 | 0 | 2 | 1 | 14 | 2 | 0 | 0 | -1 | 0 | 3 |
| ToStringNodes | 1 | 0 | 1 | 1 | 14 | 3 | 0 | 1 | 0 | 3 | 1 |
| CollapseChildTreeNodesAction | 0 | 0 | 2 | 1 | 14 | 3 | 0 | 0 | -1 | 0 | 1 |
| RedoSearchAction | 1 | 0 | 2 | 1 | 16 | 2 | 0 | 0 | 0 | 0 | 3 |
| TreeDisplayAction | 0 | 0 | 1 | 1 | 30 | 4 | 0 | 0 | -1 | 0 | 1 |
| GoToNodeAction | 1 | 0 | 2 | 1 | 10 | 2 | 0 | 0 | 0 | 0 | 1 |
| ResultCellRenderer | 4 | 0 | 4 | 1 | 45 | 9 | 0 | 1 | 0.5 | 0 | 4 |
| CountNodes | 2 | 0 | 1 | 1 | 12 | 2 | 0 | 1 | 0 | 2 | 0 |
| ResultTreeTransferHandler | 0 | 0 | 1 | 1 | 13 | 2 | 0 | 0 | -1 | 0 | 1 |
| ResultVisitor | 0 | 0 | 1 | 0 | 3 | 1 | 2 | 0 | -1 | 1 | 2 |
| BufferLoadedVisitor | 0 | 0 | 1 | 1 | 5 | 1 | 0 | 1 | -1 | 0 | 2 |
| BufferClosedVisitor | 0 | 0 | 1 | 1 | 5 | 1 | 0 | 1 | -1 | 0 | 2 |
| TreeNodeCallbackAdapter | 0 | 0 | 1 | 1 | 5 | 1 | 0 | 1 | -1 | 0 | 0 |
| BoyerMooreSearchMatcher | 7 | 0 | 8 | 5 | 150 | 31 | 0 | 1 | 0 | 1 | 3 |
| HyperSearchFileNode | 4 | 2 | 7 | 7 | 51 | 10 | 0 | 1 | 0.2857 | 5 | 6 |
| PatternSearchMatcher | 3 | 0 | 7 | 6 | 170 | 36 | 0 | 1 | 0 | 2 | 3 |
| SearchFileSet | 0 | 0 | 7 | 0 | 43 | 7 | 2 | 0 | -1 | 6 | 1 |
| HyperSearchRequest | 7 | 0 | 8 | 4 | 172 | 27 | 0 | 2 | 0 | 0 | 16 |
| SearchBar | 16 | 0 | 16 | 12 | 262 | 51 | 0 | 0 | 0.125 | 1 | 12 |
| ActionHandler | 0 | 0 | 1 | 1 | 23 | 7 | 0 | 0 | -1 | 0 | 2 |
| DocumentHandler | 0 | 0 | 3 | 3 | 32 | 9 | 0 | 0 | -1 | 0 | 2 |
| KeyHandler | 0 | 0 | 1 | 1 | 19 | 5 | 0 | 0 | -1 | 0 | 0 |
| FocusHandler | 0 | 0 | 1 | 1 | 5 | 1 | 0 | 0 | -1 | 0 | 0 |

* **Method Level**
  + **HyperSearchResults.java**

Table 2: Method level metrics calculated by DesigniteJava for HyperSearchResults

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Class Name** | **Method Name** | **LOC** | **CC** | **PC** |
| HyperSearchResults | removeSelectedNode | 23 | 5 | 0 |
| removeAllNodes | 6 | 1 | 0 |
| hideDockable | 3 | 1 | 0 |
| trimSearchString | 8 | 2 | 0 |
| parseHighlightStyle | 4 | 1 | 1 |
| actionPerformed | 25 | 8 | 1 |
| HighlightingTree | 8 | 2 | 1 |
| convertValueToText | 42 | 7 | 6 |
| keyPressed | 24 | 4 | 1 |
| run | 3 | 1 | 0 |
| mousePressed | 10 | 4 | 1 |
| showPopupMenu | 31 | 6 | 1 |
| RemoveTreeNodeAction | 3 | 1 | 0 |
| actionPerformed | 3 | 1 | 1 |
| RemoveAllTreeNodesAction | 3 | 1 | 0 |
| actionPerformed | 3 | 1 | 1 |
| NewSearchAction | 3 | 1 | 0 |

* **Class level metrics** 
  + **This package is org.gjt.sp.jedit.gui**

*Table 3: Class level metrics calculated by DesigniteJava for jedit project*

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Class Name | NOF | NOPF | NOM | NOPM | LOC | WMC | NC | DIT | LCOM | FANIN | FANOUT |
| FocusHandler | 0 | 0 | 2 | 2 | 8 | 2 | 0 | 0 | -1 | 0 | 0 |
| EscapeHandler | 0 | 0 | 1 | 1 | 6 | 1 | 0 | 0 | -1 | 0 | 0 |
| TabHandler | 0 | 0 | 1 | 1 | 5 | 1 | 0 | 0 | -1 | 0 | 0 |
| InsertHandler | 0 | 0 | 1 | 1 | 5 | 1 | 0 | 0 | -1 | 0 | 0 |
| ClearHandler | 0 | 0 | 1 | 1 | 5 | 1 | 0 | 0 | -1 | 0 | 0 |
| Entry | 3 | 0 | 4 | 4 | 22 | 4 | 0 | 0 | 0 | 0 | 0 |
| DummyRenderer | 0 | 0 | 1 | 1 | 5 | 1 | 0 | 0 | -1 | 0 | 0 |
| LabelRenderer | 2 | 0 | 2 | 1 | 14 | 3 | 0 | 0 | 0 | 0 | 1 |
| CheckBoxListModel | 1 | 0 | 10 | 7 | 62 | 19 | 0 | 0 | 0.4 | 1 | 3 |
| AbstractContextOptionPane | 12 | 0 | 14 | 4 | 210 | 30 | 2 | 2 | 0 | 3 | 9 |
| MenuItemCompare | 0 | 0 | 1 | 1 | 5 | 1 | 0 | 0 | -1 | 0 | 2 |
| MenuItem | 2 | 0 | 2 | 1 | 11 | 2 | 0 | 0 | 0 | 4 | 1 |
| ActionHandler | 0 | 0 | 1 | 1 | 61 | 11 | 0 | 0 | -1 | 0 | 6 |
| ListHandler | 0 | 0 | 1 | 1 | 5 | 1 | 0 | 0 | -1 | 0 | 0 |
| MutableListModel | 0 | 0 | 2 | 2 | 7 | 2 | 2 | 0 | -1 | 1 | 0 |
| DefaultInputHandler | 0 | 0 | 8 | 8 | 139 | 28 | 0 | 2 | -1 | 1 | 5 |
| MouseHandler | 1 | 0 | 1 | 1 | 10 | 2 | 0 | 0 | 0 | 0 | 1 |
| ContainerHandler | 0 | 0 | 4 | 2 | 26 | 8 | 0 | 0 | -1 | 0 | 0 |
| KeyHandler | 0 | 0 | 2 | 1 | 49 | 18 | 0 | 0 | -1 | 3 | 2 |
| WindowHandler | 0 | 0 | 1 | 1 | 5 | 1 | 0 | 0 | -1 | 0 | 0 |
| StatusBar | 25 | 0 | 22 | 20 | 306 | 59 | 0 | 0 | 0.272 | 4 | 14 |
| MouseHandler | 0 | 0 | 1 | 1 | 8 | 2 | 0 | 0 | -1 | 0 | 0 |
| AbbrevEditor | 3 | 0 | 8 | 8 | 146 | 24 | 0 | 0 | 0 | 2 | 1 |
| RolloverButton | 2 | 0 | 9 | 9 | 70 | 11 | 6 | 0 | 0.444 | 8 | 0 |
| MouseOverHandler | 0 | 0 | 2 | 2 | 13 | 2 | 0 | 0 | -1 | 0 | 0 |
| InputHandler | 1 | 0 | 14 | 9 | 264 | 68 | 1 | 1 | 0.357 | 3 | 18 |
| AnimatedIcon | 6 | 0 | 10 | 10 | 68 | 12 | 0 | 0 | 0 | 0 | 0 |
| Animator | 0 | 0 | 1 | 1 | 7 | 1 | 0 | 0 | -1 | 0 | 0 |
| FontSelectorDialog | 12 | 0 | 14 | 8 | 209 | 30 | 0 | 1 | 0 | 1 | 4 |
| ActionHandler | 0 | 0 | 1 | 1 | 6 | 3 | 0 | 0 | -1 | 0 | 0 |
| ListHandler | 0 | 0 | 1 | 1 | 18 | 7 | 0 | 0 | -1 | 0 | 0 |
| BeanShellErrorDialog | 0 | 0 | 2 | 2 | 13 | 2 | 0 | 2 | -1 | 0 | 1 |
| DockableWindowFactory | 22 | 0 | 36 | 24 | 301 | 60 | 0 | 0 | 0.138 | 9 | 11 |

* **Method Level** 
  + **Statusbar.java**

*Table 4: Method level metrics calculated by DesigniteJava for Jedit Project*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Class Name** | **Method Name** | **LOC** | **CC** | **PC** |
| StatusBar | StatusBar | 28 | 1 | 1 |
| propertiesChanged | 54 | 6 | 0 |
| addNotify | 4 | 1 | 0 |
| removeNotify | 4 | 1 | 0 |
| run | 17 | 4 | 0 |
| waiting | 3 | 1 | 1 |
| running | 2 | 1 | 1 |
| done | 3 | 1 | 1 |
| statusUpdated | 2 | 1 | 1 |
| maximumUpdated | 2 | 1 | 1 |
| valueUpdated | 2 | 1 | 1 |
| getMessage | 3 | 1 | 0 |
| setMessageAndClear | 12 | 2 | 1 |
| actionPerformed | 3 | 2 | 1 |
| setMessage | 12 | 4 | 1 |
| setMessageComponent | 8 | 2 | 1 |
| updateCaretStatus | 54 | 12 | 0 |
| updateBufferStatus | 9 | 1 | 0 |
| updateMiscStatus | 5 | 1 | 0 |
| getWidget | 13 | 11 | 1 |
| \_getWidget | 7 | 2 | 1 |

* **Class Level**
  + **This package is org.gjt.sp.jedit.options**

*Table 5: Class level metrics calculated by DesigniteJava for jedit project*

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Class Name** | **NOF** | **NOPF** | **NOM** | **NOPM** | **LOC** | **WMC** | **NC** | **DIT** | **LCOM** | **FANIN** | **FANOUT** |
| MouseHandler | 0 | 0 | 1 | 1 | 11 | 3 | 0 | 0 | -1 | 0 | 1 |
| BrowserColorsModel | 3 | 0 | 16 | 10 | 115 | 27 | 0 | 0 | 0.4375 | 1 | 3 |
| Entry | 2 | 0 | 1 | 0 | 8 | 1 | 0 | 0 | 0 | 3 | 0 |
| ColorRenderer | 0 | 0 | 2 | 1 | 19 | 4 | 0 | 0 | -1 | 0 | 1 |
| ModeSettingsPane | 40 | 0 | 12 | 2 | 287 | 24 | 0 | 2 | 0.25 | 1 | 6 |
| ActionHandler | 0 | 0 | 1 | 1 | 13 | 3 | 0 | 0 | -1 | 0 | 0 |
| ModeProperties | 19 | 0 | 4 | 0 | 115 | 11 | 0 | 0 | 0.5 | 1 | 2 |
| ShortcutsOptionPane | 17 | 1 | 42 | 28 | 450 | 95 | 0 | 2 | 0.21428571 | 0 | 14 |
| HeaderMouseHandler | 0 | 0 | 1 | 1 | 17 | 4 | 0 | 0 | -1 | 0 | 1 |
| TableMouseHandler | 0 | 0 | 1 | 1 | 10 | 3 | 0 | 0 | -1 | 0 | 2 |
| ActionHandler | 0 | 0 | 1 | 1 | 63 | 14 | 0 | 0 | -1 | 0 | 4 |
| ShortcutsModel | 4 | 1 | 14 | 12 | 100 | 30 | 0 | 0 | 0.142857143 | 3 | 4 |
| KeyCompare | 1 | 0 | 2 | 1 | 26 | 7 | 0 | 0 | 0 | 0 | 1 |
| KeymapsModel | 2 | 0 | 7 | 4 | 33 | 11 | 0 | 0 | 0 | 2 | 2 |
| KeymapCellRenderer | 0 | 0 | 1 | 1 | 8 | 1 | 0 | 0 | -1 | 0 | 1 |
| GlobalOptions | 0 | 0 | 8 | 5 | 44 | 10 | 0 | 2 | -1 | 0 | 5 |
| PrintOptionPane | 10 | 0 | 3 | 1 | 62 | 3 | 0 | 2 | 0.666666667 | 0 | 2 |
| StatusBarOptionPane | 28 | 0 | 14 | 8 | 359 | 41 | 0 | 2 | 0.21428571 | 0 | 9 |
| ActionHandler | 0 | 0 | 1 | 1 | 58 | 12 | 0 | 0 | -1 | 0 | 1 |
| ListHandler | 0 | 0 | 1 | 1 | 5 | 1 | 0 | 0 | -1 | 0 | 0 |
| WidgetListCellRenderer | 0 | 0 | 1 | 1 | 10 | 2 | 0 | 0 | -1 | 0 | 1 |
| WidgetSelectionDialog | 9 | 0 | 6 | 4 | 129 | 16 | 0 | 1 | 0.33333333a | 2 | 4 |
| ActionHandler | 0 | 0 | 1 | 1 | 21 | 5 | 0 | 0 | -1 | 0 | 0 |
| EditModesPane | 9 | 0 | 15 | 10 | 247 | 42 | 0 | 2 | 0.2 | 1 | 9 |
| ActionHandler | 0 | 0 | 1 | 1 | 21 | 4 | 0 | 0 | -1 | 0 | 4 |
| MyCellRenderer | 0 | 0 | 1 | 1 | 10 | 1 | 0 | 0 | -1 | 0 | 1 |
| MyListSelectionListener | 0 | 0 | 1 | 1 | 13 | 3 | 0 | 0 | -1 | 0 | 0 |
| EditingOptionPane | 3 | 0 | 3 | 1 | 32 | 3 | 0 | 2 | 0.66666666 | 0 | 3 |
| EncodingsOptionPane | 6 | 0 | 3 | 1 | 85 | 13 | 0 | 2 | 0.66666666 | 0 | 5 |
| SyntaxHiliteOptionPane | 7 | 1 | 18 | 10 | 146 | 30 | 0 | 2 | 0.33333333 | 5 | 11 |
| MouseHandler | 0 | 0 | 1 | 1 | 16 | 4 | 0 | 0 | -1 | 0 | 4 |
| StyleTableModel | 4 | 0 | 12 | 8 | 89 | 21 | 0 | 0 | 0.41666666 | 1 | 8 |
| StyleChoice | 3 | 0 | 2 | 1 | 13 | 2 | 0 | 0 | 0 | 2 | 1 |

* **Method level** 
  + StatusBarOptionPane.java

*Table 6: Method level metrics calculated by DesigniteJava for Jedit Project*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Class Name** | **Method Name** | **LOC** | **CC** | **PC** |
| StatusBarOptionPane | StatusBarOptionPane | 3 | 1 | 0 |
| \_init | 89 | 2 | 0 |
| \_save | 20 | 3 | 0 |
| updateButtons | 7 | 1 | 0 |
| updatePreview | 10 | 3 | 0 |
| actionPerformed | 56 | 12 | 1 |
| valueChanged | 3 | 1 | 1 |
| getListCellRendererComponent | 8 | 2 | 5 |
| WidgetSelectionDialog | 78 | 6 | 2 |
| WidgetSelectionDialog | 3 | 1 | 1 |
| ok | 9 | 2 | 0 |
| cancel | 4 | 1 | 0 |
| getValue | 3 | 1 | 0 |
| actionPerformed | 19 | 5 | 1 |

### Metrics for the modified project modules.

1. **Class level metrics**
   * **This package is org.gjt.sp.jedit.search**

*Table 7: Class level metrics calculated by DesigniteJava for modified pdfsam-merge*

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Class Name | NOF | NOPF | NOM | NOPM | LOC | WMC | NC | DIT | LCOM | FANIN | FAN-OUT |
| SearchMatcher | 6 | 3 | 7 | 4 | 83 | 13 | 2 | 0 | 0.2857 | 7 | 2 |
| Match | 3 | 3 | 1 | 1 | 8 | 1 | 0 | 0 | 0 | 7 | 0 |
| SearchAndReplace | 12 | 0 | 44 | 33 | 805 | 151 | 0 | 0 | 0.0454 | 14 | 26 |
| HyperSearchResults | 26 | 6 | 60 | 37 | 634 | 132 | 0 | 1 | 0.2166 | 5 | 28 |
| ActionHandler | 0 | 0 | 1 | 1 | 27 | 8 | 0 | 0 | -1 | 1 | 5 |
| HighlightingTree | 2 | 0 | 2 | 1 | 51 | 9 | 0 | 0 | 0 | 0 | 4 |
| KeyHandler | 0 | 0 | 2 | 2 | 26 | 5 | 0 | 0 | -1 | 0 | 0 |
| MouseHandler | 1 | 0 | 2 | 1 | 44 | 10 | 0 | 0 | 0 | 0 | 3 |
| RemoveTreeNodeAction | 0 | 0 | 2 | 1 | 8 | 2 | 0 | 0 | -1 | 0 | 1 |
| RemoveAllTreeNodesAction | 0 | 0 | 2 | 1 | 8 | 2 | 0 | 0 | -1 | 0 | 1 |
| NewSearchAction | 0 | 0 | 2 | 1 | 15 | 3 | 0 | 0 | -1 | 0 | 5 |
| ExpandChildTreeNodesAction | 0 | 0 | 2 | 1 | 10 | 2 | 0 | 0 | -1 | 0 | 1 |
| CopyToClipboardAction | 0 | 0 | 2 | 1 | 14 | 2 | 0 | 0 | -1 | 0 | 3 |
| ToStringNodes | 1 | 0 | 1 | 1 | 14 | 3 | 0 | 1 | 0 | 3 | 1 |
| CollapseChildTreeNodesAction | 0 | 0 | 2 | 1 | 14 | 3 | 0 | 0 | -1 | 0 | 1 |
| RedoSearchAction | 1 | 0 | 2 | 1 | 16 | 2 | 0 | 0 | 0 | 0 | 3 |
| TreeDisplayAction | 0 | 0 | 1 | 1 | 30 | 4 | 0 | 0 | -1 | 0 | 1 |
| GoToNodeAction | 1 | 0 | 2 | 1 | 10 | 2 | 0 | 0 | 0 | 0 | 1 |
| ResultCellRenderer | 4 | 0 | 4 | 1 | 45 | 9 | 0 | 1 | 0.5 | 0 | 4 |
| CountNodes | 2 | 0 | 1 | 1 | 12 | 2 | 0 | 1 | 0 | 2 | 0 |
| ResultTreeTransferHandler | 0 | 0 | 1 | 1 | 13 | 2 | 0 | 0 | -1 | 0 | 1 |
| ResultVisitor | 0 | 0 | 1 | 0 | 3 | 1 | 2 | 0 | -1 | 1 | 2 |
| BufferLoadedVisitor | 0 | 0 | 1 | 1 | 5 | 1 | 0 | 1 | -1 | 0 | 2 |
| BufferClosedVisitor | 0 | 0 | 1 | 1 | 5 | 1 | 0 | 1 | -1 | 0 | 2 |
| TreeNodeCallbackAdapter | 0 | 0 | 1 | 1 | 5 | 1 | 0 | 1 | -1 | 0 | 0 |
| BoyerMooreSearchMatcher | 7 | 0 | 8 | 5 | 150 | 31 | 0 | 1 | 0 | 1 | 3 |
| HyperSearchFileNode | 4 | 2 | 7 | 7 | 51 | 10 | 0 | 1 | 0.2857 | 5 | 6 |
| PatternSearchMatcher | 3 | 0 | 7 | 6 | 170 | 36 | 0 | 1 | 0 | 2 | 3 |
| SearchFileSet | 0 | 0 | 7 | 0 | 43 | 7 | 2 | 0 | -1 | 6 | 1 |
| HyperSearchRequest | 7 | 0 | 8 | 4 | 172 | 27 | 0 | 2 | 0 | 0 | 16 |
| SearchBar | 16 | 0 | 16 | 12 | 262 | 51 | 0 | 0 | 0.125 | 1 | 12 |
| ActionHandler | 0 | 0 | 1 | 1 | 23 | 7 | 0 | 0 | -1 | 0 | 2 |
| DocumentHandler | 0 | 0 | 3 | 3 | 32 | 9 | 0 | 0 | -1 | 0 | 2 |
| KeyHandler | 0 | 0 | 1 | 1 | 19 | 5 | 0 | 0 | -1 | 0 | 0 |
| FocusHandler | 0 | 0 | 1 | 1 | 5 | 1 | 0 | 0 | -1 | 0 | 0 |
| HyperSearchFolderNode | 3 | 0 | 3 | 3 | 24 | 4 | 0 | 0 | 0 | 3 | 0 |
| DirectoryListSet | 3 | 0 | 9 | 8 | 68 | 9 | 0 | 2 | 0 | 2 | 4 |
| CurrentBufferSet | 0 | 0 | 7 | 7 | 30 | 9 | 0 | 1 | -1 | 0 | 1 |
| HyperSearchResult | 13 | 11 | 17 | 7 | 139 | 31 | 0 | 1 | 0 | 7 | 12 |
| Occur | 5 | 5 | 3 | 0 | 19 | 4 | 0 | 0 | 0 | 2 | 1 |
| GotoDelayed | 2 | 0 | 4 | 2 | 41 | 10 | 0 | 0 | 0 | 0 | 4 |
| HyperSearchNode | 0 | 0 | 2 | 0 | 8 | 2 | 2 | 0 | -1 | 1 | 2 |
| HyperSearchOperationNode | 5 | 0 | 10 | 10 | 128 | 30 | 0 | 0 | 0.3 | 5 | 4 |
| SearchDialog | 36 | 3 | 33 | 20 | 721 | 94 | 0 | 1 | 0.0606 | 6 | 17 |
| ReplaceActionHandler | 0 | 0 | 1 | 1 | 6 | 1 | 0 | 0 | -1 | 0 | 1 |
| SettingsActionHandler | 0 | 0 | 1 | 1 | 9 | 3 | 0 | 0 | -1 | 0 | 0 |
| MultiFileActionHandler | 0 | 0 | 2 | 1 | 24 | 7 | 0 | 0 | -1 | 0 | 4 |
| ButtonActionHandler | 0 | 0 | 1 | 1 | 39 | 12 | 0 | 0 | -1 | 0 | 2 |
| FocusOrder | 1 | 0 | 7 | 7 | 46 | 11 | 0 | 0 | 0 | 0 | 0 |
| BufferListSet | 1 | 0 | 10 | 8 | 85 | 30 | 2 | 1 | 0.2 | 0 | 4 |
| HyperSearchTreeNodeCallback | 0 | 0 | 1 | 1 | 6 | 1 | 3 | 0 | -1 | 1 | 0 |
| AllBufferSet | 2 | 0 | 5 | 4 | 55 | 7 | 0 | 2 | 0 | 0 | 3 |

* **Method Level**
  + **HyperSearchResults.Java**

*Table 8: Method level metrics calculated by DesigniteJava for modified jedit project*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Class Name** | **Method Name** | **LOC** | **CC** | **PC** |
| HyperSearchResults | removeSelectedNode | 23 | 5 | 0 |
| removeAllNodes | 6 | 1 | 0 |
| hideDockable | 3 | 1 | 0 |
| trimSearchString | 8 | 2 | 0 |
| parseHighlightStyle | 4 | 1 | 1 |
| actionPerformed | 25 | 8 | 1 |
| HighlightingTree | 8 | 2 | 1 |
| convertValueToText | 39 | 7 | 6 |
| keyPressed | 24 | 4 | 1 |
| run | 3 | 1 | 0 |
| mousePressed | 10 | 4 | 1 |
| showPopupMenu | 31 | 6 | 1 |
| RemoveTreeNodeAction | 3 | 1 | 0 |
| actionPerformed | 3 | 1 | 1 |
| RemoveAllTreeNodesAction | 3 | 1 | 0 |
| actionPerformed | 3 | 1 | 1 |
| NewSearchAction | 3 | 1 | 0 |

* **Class Level** 
  + **This package is org.gjt.sp.jedit.gui**

*Table 9: Class level metrics calculated by DesigniteJava for modified jedit project*

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Class Name | NOF | NOPF | NOM | NOPM | LOC | WMC | NC | DIT | LCOM | FANIN | FANOUT |
| BufferSwitcherTransferable | 3 | 0 | 4 | 4 | 19 | 5 | 0 | 0 | 0.5 | 0 | 2 |
| BufferTransferableData | 2 | 0 | 3 | 3 | 14 | 3 | 0 | 0 | 0 | 2 | 1 |
| BufferSwitcherTransferHandler | 0 | 0 | 5 | 5 | 103 | 15 | 0 | 0 | -1 | 0 | 9 |
| ErrorListDialog | 4 | 0 | 9 | 9 | 128 | 19 | 0 | 1 | 0.333 | 3 | 5 |
| ErrorEntry | 2 | 0 | 4 | 4 | 43 | 9 | 0 | 0 | 0 | 3 | 3 |
| JTextPaneSized | 0 | 0 | 1 | 1 | 11 | 1 | 0 | 0 | -1 | 0 | 0 |
| ActionHandler | 0 | 0 | 1 | 1 | 8 | 3 | 0 | 0 | -1 | 1 | 1 |
| DockingLayoutManager | 10 | 0 | 20 | 9 | 166 | 52 | 0 | 1 | 0.1 | 3 | 14 |
| LoadPerspectiveAction | 1 | 0 | 2 | 2 | 10 | 2 | 0 | 2 | 1 | 0 | 3 |
| TipOfTheDay | 5 | 0 | 5 | 4 | 84 | 10 | 0 | 1 | 0.6 | 0 | 4 |
| ActionHandler | 0 | 0 | 1 | 1 | 10 | 4 | 0 | 0 | -1 | 0 | 1 |
| AddModeDialog | 8 | 0 | 9 | 9 | 116 | 16 | 0 | 1 | 0 | 0 | 5 |
| ActionHandler | 0 | 0 | 1 | 1 | 24 | 5 | 0 | 0 | -1 | 0 | 4 |
| PingPongList | 16 | 1 | 47 | 42 | 301 | 70 | 0 | 0 | 0.148 | 2 | 5 |
| MyListModel | 1 | 0 | 8 | 7 | 35 | 10 | 0 | 0 | 0 | 2 | 0 |
| MyTransferHandler | 2 | 0 | 4 | 3 | 58 | 10 | 0 | 0 | 0.75 | 1 | 3 |
| MyTransferable | 2 | 1 | 5 | 3 | 19 | 5 | 0 | 0 | 0.4 | 2 | 0 |
| ActionHandler | 0 | 0 | 1 | 1 | 15 | 3 | 0 | 0 | -1 | 0 | 0 |
| MyListDataListener | 0 | 0 | 4 | 3 | 15 | 4 | 0 | 0 | -1 | 0 | 0 |
| CloseDialog | 9 | 0 | 8 | 7 | 150 | 23 | 0 | 1 | 0 | 0 | 8 |
| ActionHandler | 0 | 0 | 1 | 1 | 51 | 11 | 0 | 0 | -1 | 0 | 4 |
| ListHandler | 0 | 0 | 1 | 1 | 18 | 4 | 0 | 0 | -1 | 1 | 3 |
| FilePropertiesDialog | 9 | 0 | 11 | 10 | 195 | 29 | 0 | 1 | 0 | 0 | 12 |
| ButtonActionHandler | 0 | 0 | 1 | 1 | 11 | 3 | 0 | 0 | -1 | 1 | 0 |
| AboutPanel | 25 | 0 | 9 | 6 | 152 | 24 | 0 | 0 | 0 | 2 | 5 |
| HistoryModel | 8 | 0 | 20 | 19 | 158 | 31 | 0 | 1 | 0 | 11 | 2 |
| Renderer | 0 | 0 | 1 | 1 | 27 | 8 | 0 | 0 | -1 | 0 | 3 |
| ListHandler | 0 | 0 | 1 | 1 | 26 | 6 | 0 | 0 | -1 | 0 | 2 |
| MouseHandler | 0 | 0 | 1 | 1 | 18 | 5 | 0 | 0 | -1 | 1 | 3 |
| DocumentHandler | 0 | 0 | 5 | 3 | 26 | 6 | 0 | 0 | -1 | 0 | 0 |
| FocusHandler | 0 | 0 | 2 | 2 | 8 | 2 | 0 | 0 | -1 | 0 | 0 |
| EscapeHandler | 0 | 0 | 1 | 1 | 6 | 1 | 0 | 0 | -1 | 0 | 0 |
| TabHandler | 0 | 0 | 1 | 1 | 5 | 1 | 0 | 0 | -1 | 0 | 0 |
| InsertHandler | 0 | 0 | 1 | 1 | 5 | 1 | 0 | 0 | -1 | 0 | 0 |
| ClearHandler | 0 | 0 | 1 | 1 | 5 | 1 | 0 | 0 | -1 | 0 | 0 |
| Entry | 3 | 0 | 4 | 4 | 22 | 4 | 0 | 0 | 0 | 0 | 0 |
| DummyRenderer | 0 | 0 | 1 | 1 | 5 | 1 | 0 | 0 | -1 | 0 | 0 |
| LabelRenderer | 2 | 0 | 2 | 1 | 14 | 3 | 0 | 0 | 0 | 0 | 1 |
| CheckBoxListModel | 1 | 0 | 10 | 7 | 62 | 19 | 0 | 0 | 0.4 | 1 | 3 |
| AbstractContextOptionPane | 12 | 0 | 14 | 4 | 210 | 30 | 2 | 2 | 0 | 3 | 9 |
| MenuItemCompare | 0 | 0 | 1 | 1 | 5 | 1 | 0 | 0 | -1 | 0 | 2 |
| MenuItem | 2 | 0 | 2 | 1 | 11 | 2 | 0 | 0 | 0 | 4 | 1 |
| ActionHandler | 0 | 0 | 1 | 1 | 61 | 11 | 0 | 0 | -1 | 0 | 6 |
| ListHandler | 0 | 0 | 1 | 1 | 5 | 1 | 0 | 0 | -1 | 0 | 0 |
| MutableListModel | 0 | 0 | 2 | 2 | 7 | 2 | 2 | 0 | -1 | 1 | 0 |
| DefaultInputHandler | 0 | 0 | 8 | 8 | 139 | 28 | 0 | 2 | -1 | 1 | 5 |
| MouseHandler | 1 | 0 | 1 | 1 | 10 | 2 | 0 | 0 | 0 | 0 | 1 |
| ContainerHandler | 0 | 0 | 4 | 2 | 26 | 8 | 0 | 0 | -1 | 0 | 0 |
| KeyHandler | 0 | 0 | 2 | 1 | 49 | 18 | 0 | 0 | -1 | 3 | 2 |
| WindowHandler | 0 | 0 | 1 | 1 | 5 | 1 | 0 | 0 | -1 | 0 | 0 |
| StatusBar | 25 | 0 | 22 | 20 | 329 | 62 | 0 | 0 | 0.272 | 4 | 14 |
| MouseHandler | 0 | 0 | 1 | 1 | 8 | 2 | 0 | 0 | -1 | 0 | 0 |
| AbbrevEditor | 3 | 0 | 8 | 8 | 146 | 24 | 0 | 0 | 0 | 2 | 1 |
| RolloverButton | 2 | 0 | 9 | 9 | 70 | 11 | 6 | 0 | 0.444 | 8 | 0 |
| MouseOverHandler | 0 | 0 | 2 | 2 | 13 | 2 | 0 | 0 | -1 | 0 | 0 |
| InputHandler | 1 | 0 | 14 | 9 | 264 | 68 | 1 | 1 | 0.357 | 3 | 18 |
| AnimatedIcon | 6 | 0 | 10 | 10 | 68 | 12 | 0 | 0 | 0 | 0 | 0 |
| Animator | 0 | 0 | 1 | 1 | 7 | 1 | 0 | 0 | -1 | 0 | 0 |
| FontSelectorDialog | 12 | 0 | 14 | 8 | 209 | 30 | 0 | 1 | 0 | 1 | 4 |
| ActionHandler | 0 | 0 | 1 | 1 | 6 | 3 | 0 | 0 | -1 | 0 | 0 |
| ListHandler | 0 | 0 | 1 | 1 | 18 | 7 | 0 | 0 | -1 | 0 | 0 |
| BeanShellErrorDialog | 0 | 0 | 2 | 2 | 13 | 2 | 0 | 2 | -1 | 0 | 1 |
| DockableWindowFactory | 22 | 0 | 36 | 24 | 301 | 60 | 0 | 0 | 0.138 | 9 | 11 |

* **Method Level**
  + Statusbar.java

*Table 10: Method level metrics calculated by DesigniteJava for modified Jedit project*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Class Name** | **Method Name** | **LOC** | **CC** | **PC** |
| StatusBar | StatusBar | 28 | 1 | 1 |
| propertiesChanged | 54 | 6 | 0 |
| addNotify | 4 | 1 | 0 |
| removeNotify | 4 | 1 | 0 |
| run | 17 | 4 | 0 |
| waiting | 3 | 1 | 1 |
| running | 2 | 1 | 1 |
| done | 3 | 1 | 1 |
| statusUpdated | 2 | 1 | 1 |
| maximumUpdated | 2 | 1 | 1 |
| valueUpdated | 2 | 1 | 1 |
| getMessage | 3 | 1 | 0 |
| setMessageAndClear | 12 | 2 | 1 |
| actionPerformed | 3 | 2 | 1 |
| setMessage | 12 | 4 | 1 |
| setMessageComponent | 8 | 2 | 1 |
| updateCaretStatus | 77 | 15 | 0 |
| updateBufferStatus | 9 | 1 | 0 |
| updateMiscStatus | 5 | 1 | 0 |
| getWidget | 13 | 11 | 1 |
| \_getWidget | 7 | 2 | 1 |

* **Class level**
* **Org.gjt.sp.jedit.options**

*Table 11: Class level metrics calculated by DesigniteJava for modified jedit project*

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Class Name** | **NOF** | **NOPF** | **NOM** | **NOPM** | **LOC** | **WMC** | **NC** | **DIT** | **LCOM** | **FANIN** | **FANOUT** |
| MouseHandler | 0 | 0 | 1 | 1 | 11 | 3 | 0 | 0 | -1 | 0 | 1 |
| BrowserColorsModel | 3 | 0 | 16 | 10 | 115 | 27 | 0 | 0 | 0.4375 | 1 | 3 |
| Entry | 2 | 0 | 1 | 0 | 8 | 1 | 0 | 0 | 0 | 3 | 0 |
| ColorRenderer | 0 | 0 | 2 | 1 | 19 | 4 | 0 | 0 | -1 | 0 | 1 |
| ModeSettingsPane | 40 | 0 | 12 | 2 | 287 | 24 | 0 | 2 | 0.25 | 1 | 6 |
| ActionHandler | 0 | 0 | 1 | 1 | 13 | 3 | 0 | 0 | -1 | 0 | 0 |
| ModeProperties | 19 | 0 | 4 | 0 | 115 | 11 | 0 | 0 | 0.5 | 1 | 2 |
| ShortcutsOptionPane | 17 | 1 | 42 | 28 | 450 | 95 | 0 | 2 | 0.214285714 | 0 | 14 |
| HeaderMouseHandler | 0 | 0 | 1 | 1 | 17 | 4 | 0 | 0 | -1 | 0 | 1 |
| TableMouseHandler | 0 | 0 | 1 | 1 | 10 | 3 | 0 | 0 | -1 | 0 | 2 |
| ActionHandler | 0 | 0 | 1 | 1 | 63 | 14 | 0 | 0 | -1 | 0 | 4 |
| ShortcutsModel | 4 | 1 | 14 | 12 | 100 | 30 | 0 | 0 | 0.142857143 | 3 | 4 |
| KeyCompare | 1 | 0 | 2 | 1 | 26 | 7 | 0 | 0 | 0 | 0 | 1 |
| KeymapsModel | 2 | 0 | 7 | 4 | 33 | 11 | 0 | 0 | 0 | 2 | 2 |
| KeymapCellRenderer | 0 | 0 | 1 | 1 | 8 | 1 | 0 | 0 | -1 | 0 | 1 |
| GlobalOptions | 0 | 0 | 8 | 5 | 44 | 10 | 0 | 2 | -1 | 0 | 5 |
| PrintOptionPane | 10 | 0 | 3 | 1 | 62 | 3 | 0 | 2 | 0.6666 | 0 | 2 |
| StatusBarOptionPane | 30 | 0 | 14 | 8 | 369 | 41 | 0 | 2 | 0.2142 | 0 | 9 |
| ActionHandler | 0 | 0 | 1 | 1 | 58 | 12 | 0 | 0 | -1 | 0 | 1 |
| ListHandler | 0 | 0 | 1 | 1 | 5 | 1 | 0 | 0 | -1 | 0 | 0 |
| WidgetListCellRenderer | 0 | 0 | 1 | 1 | 10 | 2 | 0 | 0 | -1 | 0 | 1 |
| WidgetSelectionDialog | 9 | 0 | 6 | 4 | 129 | 16 | 0 | 1 | 0.333333333 | 2 | 4 |
| ActionHandler | 0 | 0 | 1 | 1 | 21 | 5 | 0 | 0 | -1 | 0 | 0 |
| EditModesPane | 9 | 0 | 15 | 10 | 247 | 42 | 0 | 2 | 0.2 | 1 | 9 |
| ActionHandler | 0 | 0 | 1 | 1 | 21 | 4 | 0 | 0 | -1 | 0 | 4 |
| MyCellRenderer | 0 | 0 | 1 | 1 | 10 | 1 | 0 | 0 | -1 | 0 | 1 |
| MyListSelectionListener | 0 | 0 | 1 | 1 | 13 | 3 | 0 | 0 | -1 | 0 | 0 |
| EditingOptionPane | 3 | 0 | 3 | 1 | 32 | 3 | 0 | 2 | 0.6666 | 0 | 3 |
| EncodingsOptionPane | 6 | 0 | 3 | 1 | 85 | 13 | 0 | 2 | 0.6666 | 0 | 5 |
| SyntaxHiliteOptionPane | 7 | 1 | 18 | 10 | 146 | 30 | 0 | 2 | 0.3333 | 5 | 11 |
| MouseHandler | 0 | 0 | 1 | 1 | 16 | 4 | 0 | 0 | -1 | 0 | 4 |
| StyleTableModel | 4 | 0 | 12 | 8 | 89 | 21 | 0 | 0 | 0.4166 | 1 | 8 |
| StyleChoice | 3 | 0 | 2 | 1 | 13 | 2 | 0 | 0 | 0 | 2 | 1 |

* **Method level** 
  + StatusBarOptionPane.java

*Table 12: Method level metrics calculated by DesigniteJava for modified Jedit project*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Class Name | Method Name | LOC | CC | PC |
| StatusBarOptionPane | StatusBarOptionPane | 3 | 1 | 0 |
| \_init | 95 | 2 | 0 |
| \_save | 22 | 3 | 0 |
| updateButtons | 7 | 1 | 0 |
| updatePreview | 10 | 3 | 0 |
| actionPerformed | 56 | 12 | 1 |
| valueChanged | 3 | 1 | 1 |
| getListCellRendererComponent | 8 | 2 | 5 |
| WidgetSelectionDialog | 78 | 6 | 2 |
| WidgetSelectionDialog | 3 | 1 | 1 |
| ok | 9 | 2 | 0 |
| cancel | 4 | 1 | 0 |
| getValue | 3 | 1 | 0 |
| actionPerformed | 19 | 5 | 1 |

### Affected Metrics

* **Class level Metrics**

*Table 13: Affected Metrics in the Class Level for Jedit project*

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Version** | **Class Name** | **NOF** | **NOPF** | **NOM** | **NOPM** | **LOC** | **WMC** | **NC** | **DIT** | **LCOM** | **FANIN** | **FAN-OUT** |
| Original | HyperSearchResults | 26 | 6 | 60 | 37 | 637 | 132 | 0 | 1 | 0.216 | 5 | 28 |
| Modified | HyperSearchResults | 26 | 6 | 60 | 37 | 634 | 132 | 0 | 1 | 0.216 | 5 | 28 |
| Original | HighlightingTree | 2 | 0 | 2 | 1 | 54 | 9 | 0 | 0 | 0 | 0 | 4 |
| Modified | HighlightingTree | 2 | 0 | 2 | 1 | 51 | 9 | 0 | 0 | 0 | 0 | 4 |
| Original | StatusBar | 25 | 0 | 22 | 20 | 306 | 59 | 0 | 0 | 0.272 | 4 | 14 |
| Modified | StatusBar | 25 | 0 | 22 | 20 | 329 | 62 | 0 | 0 | 0.272 | 4 | 14 |
| Original | StatusBarOptionPane | 28 | 0 | 14 | 8 | 359 | 41 | 0 | 2 | 0.214 | 0 | 9 |
| Modified | StatusBarOptionPane | 30 | 0 | 14 | 8 | 369 | 41 | 0 | 2 | 0.214 | 0 | 9 |

* **Method Level Metrics**

*Table 14: Affected Metrics in the method Level for Jedit project*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **version** | **Class Name** | **Method Name** | **LOC** | **CC** | **PC** |
| Original | HyperSearchResults | convertValueToText | 42 | 7 | 6 |
| Modified | HyperSearchResults | convertValueToText | 39 | 7 | 6 |
| Original | StatusBar | updateCaretStatus | 54 | 12 | 0 |
| Modified | StatusBar | updateCaretStatus | 77 | 15 | 0 |
| Original | StatusBarOptionPane | \_init | 89 | 2 | 0 |
| Modified | StatusBarOptionPane | \_init | 95 | 2 | 0 |
| Original | StatusBarOptionPane | \_save | 20 | 3 | 0 |
| Modified | StatusBarOptionPane | \_save | 22 | 3 | 0 |

As we noticed, the metrics that have changed the most at the method-level are Lines of code and Cyclomatic complexity. At the class level however, there are other measures which are as Weighted methods per class, number of fields and LOC of classes that have been affected.

The **lines of code** that we had added when making these changes is the direct cause of increase of the LOC metric. But more interestingly is the unexpected increase in cyclomatic complexity.

After looking into our code changes, we see that we have added certain four statements that create independent paths that will definitely increase the number of paths in the updateCaretStatus() function which definitely leads to the increase of **Cyclomatic Complexity.**

The increase of Cyclomatic Complexity reflects in increasing the values of **Weighted methods per class**. As we mentioned above, Weighted Methods per Class metric is the sum of the cyclomatic complexity of the functions in the statusbar.java class. Therefore, an increase in the WMC can be attributed to the increase in Cyclomatic complexity of each method. The final metric is the **number of fields** in statusbarOptionPane class. There are two additional checkboxes which are defined to implement the configurability of the change in the Options -> StatusBar menu; that is why this metric is affected.

## Cohesion and Coupling

### Cohesion

#### Types of Cohesion measured

**LCOM (Lack of Cohesion in Methods – Class level metric)**: The metric that is shown by the tool to measure the cohesion is LCOM. This metric measures the **functional cohesion** since it focuses on how class elements (methods and attributes) are related to each other. As it is mentioned in the descriptions above, LCOM analyzes the relation between attributes and methods.

*Table 15: High/Low Cohesion Classes for Jedit project*

#### Classes and their Cohesion values

|  |  |  |
| --- | --- | --- |
| Classes | Level of cohesion (High /Low) | LCOM |
| PrintRangeType.java  Org/gjt/sp/jedit/print/ | Low | 1 |
| BSHFormalParameter  org.gjt.sp.jedit.bsh | Low | 1 |
| BSHEnhancedForStatement.jav  org.gjt.sp.jedit.bsh | Low | 1 |
| BSHWhileStatement.java  Org.gjt.sp.jedit.bsh | Low | 1 |
| ColumnBlockLine  Org/gjt/sp/jedit/textarea | high | 0 |
| BufferOptions.java  Org.gjt.sp.jedit.gui | high | 0 |
| Debug.java  Org/gjt/sp/jedit/ | high | 0 |
| RectSelectWidgetFactory.java  Org/gjt/sp/jedit/gui/statusbar/ | High | 0 |

In terms of low cohesion classes, according to the data in the cohesion table, LCOM value for **PrintRangeType**, **BSHFormalParameter**, **BSHEnhancedForStatement**, and **BSHWhileStatement** is 1 which the highest LCOM values among all classes’ cohesion values in Jedit project. In the case of **BSHWhileStatement** and **BSHEnhancedForStatement**, which are child classes of **SimpleNode**.java and **ParserConstants** interface, LCOM considers all attributes of parent classes and only accessed by derived classes (**BSHWhileStatement**). There are 131 attributes in the parent class; only 3 attributes are accessed in the child class. Similarly, the **BSHFormalParameter** which is derived from the SimpleNode parent class, does not access attributes of the base class and the methods of this class do not intersect in using instance variables of the same child class. The **PrintRangeType** class which is a child class of **IntegerSyntax** has the same problem of the previous classes that leads to low cohesion of the class.

However, in terms of high cohesion classes, all next four class have high value of LCOM, which is 0. this the lowest LCOM value for non*-*trivial classes. After looking at these classes (**ColumnBlockLine**, **BufferOptions and RectSelectWidgetFactory),** we found thatthe methods of these classes intersect in accessing the instance variables of the class and These methods leads to one objective of the class. In case of **Debug** class, there are not instance variables for the class and it has only only one method. Therefore, LCOM equals to 0.

#### The difference between the higher and lower cohesion classes

After we checked the classes, we found that the high cohesion classes have one functionality that is intended to be implemented, and if there are attributes in the classes, they are mostly accessed. However, in the low cohesion classes, most of methods in the child classes do not access the instance variables in the base class which leads to considerable number of components to be occurred in the class. This might lead to misunderstanding of code, which causes the complexity of code maintenance.

CouplingAfter we checked the classes, we found that the high-cohesion classes have one function that is intended to be implemented and if there are attributes in the classes, they are mostly accessed. However, in the low cohesion classes, most of methods in the child classes do not access the instance variables in the bas class which leads to considerable number of components to be occurred in the class. This might lead to misunderstanding of code, which causes the complexity of code maintenance.

#### Types of Coupling measured

#### Classes with high/low coupling(and why)

*Table 16: High/Low Coupling Classes for Jedit project*

|  |  |  |
| --- | --- | --- |
| Classes | Level of coupling (High /Low) | FANIN |
| Jedit.java  Org/gjt/sp/jedit/ | high | 331 |
| Log.java  Org/gjt/sp/unit/ | high | 191 |
| view.java  Org/gjt/sp/jedit/ | high | 147 |
| GUIUtilities.java  Org/gjt/sp/jedit/help/ | high | 128 |
| HyperSearchRequest.java  Org/gjt/sp/jedit/search | Low | 0 |
| TabbedOptionDialog.java  Org/gjt/sp/jedit/ | Low | 0 |
| JEditMode.java  Org/gjt/sp/jedit/ | Low | 0 |
| WhitespaceRule.java  Org/gjt/sp/jedit/ | Low | 0 |

As it is shown by DesigniteJava tool, there are 2 metrics that measure the coupling between classes. We chose FANIN metric to measure the cooupling in Jedit project while we chose FANOUT to measure coupling of pdfsam projects. The first four classes have high coupling based on FANIN results. The first class I (**jedit)** has the highest FANIN value in the project since it is referenced in 331 classes. Moving to **log** which has the second highest value for FANIN metric (191), this refers the number of classes that depend on this **log** class. The next two classes that have the high coupling are **view** and **GUIUtilities**, which means also that they are used by large number of classes 147 and 128, respectively, as it is computed by FANIN. The second four classes have lowest coupling values based on the results of FANIN metric. This metric returns 0 for these classes; **HyperSearchRequest, TabbedOptionDialog**, **JEditMode**, and **WhitespaceRule.** That means these four classes are not referenced in other classes.

#### The difference between the higher and lower coupling classes

In the case of high coupling classes, the modification of code needs effort and time because of the dependency between the classes. As we notice from this table, there are large numbers of classes depend on other classes depend on other classes. If any change is applied on a class that is reference by others, the change of these classes must be considered. Therefore, the high dependency leads to less ability of maintenance; however, the low dependency facilitates the change of code by maintainers.

# PDFsam

Tool: Designitejava

## The metrics analyzed

1. Method level metrics
   1. **Lines of Code(LOC)**: Computes the lines of **non-comment, non-blank** code in the function.
   2. **Cyclomatic complexity(CC)**: At the method level, computes the number of possible paths to measure complexity of the function.
   3. **Parameter Count(PC)**: The number of arguments given to a function.
2. Class level metrics
   1. **Number of fields(NOF)**: calculates the number of data-members of a class.
   2. **Number of public fields(NOPF)):** calculates the number of public data-members in a class.
   3. **Number of methods(NOM):** calculates the total number of methods in a class.
   4. **Number of public methods(NOPM)**: calculates the number of public methods in a class.
   5. **Lines of code(LOC)**: Computes the number of lines of code in line with the conditions highlighted above (1.a) but for the whole class.
   6. **Weighted methods per class(WMC)**: The Cyclomatic Complexity values of each method in the class are summed to find the complexity of a class, this is the WMC. It can be used to determine whether a class needs to be restructured into smaller classes. WMC should be low, since it will keep classes restricted to a single responsibility and prevent a greater potential impact on derived classes.
   7. **Number of children(NOC)**: NOC equals the number of immediate child classes derived from a base class.
   8. **Depth of inheritance tree(DIT)**: Finds the position of the class in the Inheritance tree. This is used to measure the complexity of the class structure
   9. **Lack of cohesion in methods(LCOM)**: According to Chidamber & Kemerer, to calculate LCOM, two methods of a class are checked; if they accessed different variables, P is increased by one. However, if they access the same variable, Q is increased by one. The lower LCOM, the more cohesive class. It can also be used to determine whether a class needs to be restructured into smaller classes, like WMC.

LCOM1 = P - Q , if P > Q

LCOM1 = 0 otherwise

LCOM1 = 0 indicates a cohesive class.

LCOM1 > 0 indicates that the class needs or can be split into two or more classes, since its variables belong in disjoint sets.

* 1. **Fan-in(FANIN)**: For a given class X, the fan-in structural metric can be used to calculate how much code is being reused. It can be defined as the number of classes that depend on class X. Where ‘dependence’ could be using X’s methods, its variables, constants or use its sub-classes or enums.
  2. **Fan-out(FANOUT)**: Fan-out denotes how many classes a given class Y depends on. Here, Y’s dependence includes using other classes’ methods, variables, enums or constants. Fan out can be used to calculate the coupling of classes, high FO denotes strongly coupled code. The class Y depends on other code and is probably more complex to execute and test.

## The projects analyzed

## Analyzing code metrics

### Metrics for the original project modules.

A limitation we faced here was the fact that each of the modified projects, pdfsam-merge and pdfsam-rotate had a total of 8 class files each. Of these 8 classes, 4 were used in the functionality of the application, 3 were test classes and one class(Cycles.java) was an empty class. These projects are designed in a highly independent manner(one stand-alone module each for the merge and rotate functionalities). This makes them highly cohesive internally and with low coupling to the rest of the code.

pdfsam-merge

Table 17: Class level metrics calculated by DesigniteJava for pdfsam-merge

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Class Name** | **NOF** | **NOPF** | **NOM** | **NOPM** | **LOC** | **WMC** | **NC** | **DIT** | **LCOM** | **FANIN** | **FANOUT** |
| MergeModule | 6 | 0 | 13 | 11 | 74 | 14 | 0 | 0 | 0.23077 | 0 | 3 |
| ModuleConfig | 0 | 0 | 4 | 4 | 14 | 4 | 0 | 0 | -1 | 0 | 0 |
| MergeOptionsPane | 6 | 0 | 5 | 4 | 91 | 5 | 0 | 0 | 0 | 2 | 1 |
| MergeParametersBuilder | 8 | 0 | 10 | 2 | 56 | 10 | 0 | 0 | 0 | 6 | 0 |
| MergeSelectionPane | 1 | 0 | 2 | 2 | 22 | 3 | 0 | 0 | 1 | 2 | 1 |
| MergeOptionsPaneTest | 4 | 1 | 6 | 6 | 92 | 6 | 0 | 0 | 0 | 0 | 2 |
| MergeParametersBuilderTest | 1 | 1 | 1 | 1 | 36 | 1 | 0 | 0 | 0 | 0 | 1 |
| MergeSelectionPaneTest | 7 | 3 | 7 | 6 | 61 | 7 | 0 | 0 | 0 | 0 | 2 |
| Cycles | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | -1 | 0 | 0 |

Table 18: Method level metrics calculated by DesigniteJava for pdfsam-merge

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Class Name** | **Method Name** | **LOC** | **CC** | **PC** |
| MergeModule | MergeModule | 6 | 1 | 3 |
| descriptor | 3 | 1 | 0 |
| onSaveWorkspace | 6 | 1 | 1 |
| onLoadWorkspace | 6 | 1 | 1 |
| getBuilder | 8 | 1 | 1 |
| settingPanel | 7 | 1 | 0 |
| id | 3 | 1 | 0 |
| onClearModule | 6 | 2 | 1 |
| graphic | 3 | 1 | 0 |
| destinationFileField | 3 | 1 | 0 |
| destinationPane | 3 | 1 | 2 |
| footer | 3 | 1 | 2 |
| openButton | 3 | 1 | 0 |
| ModuleConfig | destinationFileField | 3 | 1 | 0 |
| destinationPane | 3 | 1 | 2 |
| footer | 3 | 1 | 2 |
| openButton | 3 | 1 | 0 |
| MergeOptionsPane | MergeOptionsPane | 47 | 1 | 0 |
| resetView | 8 | 1 | 0 |
| apply | 8 | 1 | 2 |
| saveStateTo | 8 | 1 | 1 |
| restoreStateFrom | 8 | 1 | 1 |
| MergeParametersBuilder | addInput | 3 | 1 | 1 |
| hasInput | 3 | 1 | 0 |
| outlinePolicy | 3 | 1 | 1 |
| MergeParametersBuilder | blankPageIfOdd | 3 | 1 | 1 |
| footer | 3 | 1 | 1 |
| normalize | 3 | 1 | 1 |
| acroFormsPolicy | 3 | 1 | 1 |
| tocPolicy | 3 | 1 | 1 |
| output | 3 | 1 | 1 |
| build | 15 | 1 | 0 |
| MergeSelectionPane | MergeSelectionPane | 3 | 1 | 1 |
| apply | 12 | 2 | 2 |
| MergeOptionsPaneTest | setUp | 4 | 1 | 0 |
| start | 6 | 1 | 1 |
| validSteps | 11 | 1 | 0 |
| onSaveWorkspace | 11 | 1 | 0 |
| restoreStateFrom | 22 | 1 | 0 |
| reset | 29 | 1 | 0 |
| MergeParametersBuilderTest | build | 30 | 1 | 0 |
| MergeSelectionPaneTest | setUp | 5 | 1 | 0 |
| empty | 5 | 1 | 0 |
| emptyByZeroPagesSelected | 7 | 1 | 0 |
| emptyPageSelection | 9 | 1 | 0 |
| notEmptyPageSelection | 10 | 1 | 0 |
| converstionException | 7 | 1 | 0 |
| populate | 6 | 1 | 0 |

pdfsam-rotate

Table 19: Class level metrics calculated by DesigniteJava for pdfsam-rotate

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Class Name** | **NOF** | **NOPF** | **NOM** | **NOPM** | **LOC** | **WMC** | **NC** | **DIT** | **LCOM** | **FANIN** | **FANOUT** |
| RotateModule | 7 | 0 | 14 | 12 | 87 | 15 | 0 | 0 | 0.21429 | 0 | 3 |
| ModuleConfig | 0 | 0 | 5 | 5 | 17 | 5 | 0 | 0 | -1 | 0 | 0 |
| RotateOptionsPane | 2 | 0 | 5 | 4 | 39 | 5 | 0 | 0 | 0 | 2 | 1 |
| RotateParametersBuilder | 5 | 0 | 9 | 5 | 50 | 10 | 0 | 0 | 0 | 6 | 0 |
| RotateSelectionPane | 1 | 0 | 2 | 2 | 22 | 3 | 0 | 0 | 1 | 2 | 1 |
| RotateOptionsPaneTest | 2 | 1 | 5 | 5 | 50 | 5 | 0 | 0 | 0 | 0 | 2 |
| RotateParametersBuilderTest | 2 | 1 | 4 | 4 | 60 | 4 | 0 | 0 | 0 | 0 | 1 |
| RotateSelectionPaneTest | 7 | 3 | 7 | 6 | 61 | 7 | 0 | 0 | 0 | 0 | 2 |
| Cycles | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | -1 | 0 | 0 |

Table 20: Method level metrics calculated by DesigniteJava for pdfsam-rotate

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Class Name** | **Method Name** | **LOC** | **CC** | **PC** |
| RotateModule | RotateModule | 7 | 1 | 4 |
| descriptor | 3 | 1 | 0 |
| getBuilder | 9 | 1 | 1 |
| onSaveWorkspace | 7 | 1 | 1 |
| onLoadWorkspace | 7 | 1 | 1 |
| settingPanel | 11 | 1 | 0 |
| id | 3 | 1 | 0 |
| onClearModule | 7 | 2 | 1 |
| graphic | 3 | 1 | 0 |
| destinationDirectoryField | 3 | 1 | 0 |
| destinationPane | 3 | 1 | 2 |
| footer | 3 | 1 | 2 |
| openButton | 3 | 1 | 0 |
| prefixPane | 3 | 1 | 1 |
| ModuleConfig | destinationDirectoryField | 3 | 1 | 0 |
| destinationPane | 3 | 1 | 2 |
| footer | 3 | 1 | 2 |
| openButton | 3 | 1 | 0 |
| prefixPane | 3 | 1 | 1 |
| RotateOptionsPane | RotateOptionsPane | 15 | 1 | 0 |
| resetView | 4 | 1 | 0 |
| apply | 4 | 1 | 2 |
| saveStateTo | 4 | 1 | 1 |
| restoreStateFrom | 4 | 1 | 1 |
| RotateParametersBuilder | addInput | 8 | 2 | 2 |
| hasInput | 3 | 1 | 0 |
| output | 3 | 1 | 1 |
| prefix | 3 | 1 | 1 |
| getOutput | 3 | 1 | 0 |
| RotateParametersBuilder | getPrefix | 3 | 1 | 0 |
| rotation | 3 | 1 | 1 |
| rotationType | 3 | 1 | 1 |
| build | 10 | 1 | 0 |
| RotateSelectionPane | RotateSelectionPane | 3 | 1 | 1 |
| apply | 12 | 2 | 2 |
| RotateOptionsPaneTest | start | 6 | 1 | 1 |
| validSteps | 8 | 1 | 0 |
| onSaveWorkspace | 6 | 1 | 0 |
| restoreStateFrom | 10 | 1 | 0 |
| reset | 13 | 1 | 0 |
| RotateParametersBuilderTest | setUp | 8 | 1 | 0 |
| buildDefaultSelection | 20 | 1 | 0 |
| buildRanges | 14 | 1 | 0 |
| buildMultiple | 11 | 1 | 0 |
| RotateSelectionPaneTest | setUp | 5 | 1 | 0 |
| empty | 5 | 1 | 0 |
| emptyPageSelection | 9 | 1 | 0 |
| notEmptyPageSelection | 10 | 1 | 0 |
| converstionException | 7 | 1 | 0 |
| emptyByZeroPagesSelected | 7 | 1 | 0 |
| populate | 6 | 1 | 0 |

### Metrics for the modified project modules.

Our changes to the code to implement the change requests were minimal, with minor adjustments to how the input was handled. We did not expect many changes in the code quality metrics of these modules. In fact, the Eclipse tool o3smeasures that we used did not show us any change to any of the 26 metrics calculated by it. Some of the modified metrics shown by DesigniteJava were expected, but a few surprised us.

pdfsam-merge

Table 21: Class level metrics calculated by DesigniteJava for modified pdfsam-merge

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Class Name** | **NOF** | **NOPF** | **NOM** | **NOPM** | **LOC** | **WMC** | **NC** | **DIT** | **LCOM** | **FANIN** | **FANOUT** |
| MergeModule | 6 | 0 | 13 | 11 | 74 | 14 | 0 | 0 | 0.23077 | 0 | 3 |
| ModuleConfig | 0 | 0 | 4 | 4 | 14 | 4 | 0 | 0 | -1 | 0 | 0 |
| MergeOptionsPane | 6 | 0 | 5 | 4 | 91 | 5 | 0 | 0 | 0 | 2 | 1 |
| MergeParametersBuilder | 8 | 0 | 10 | 2 | 62 | 11 | 0 | 0 | 0 | 6 | 0 |
| MergeSelectionPane | 1 | 0 | 2 | 2 | 22 | 3 | 0 | 0 | 1 | 2 | 1 |
| MergeOptionsPaneTest | 4 | 1 | 6 | 6 | 92 | 6 | 0 | 0 | 0 | 0 | 2 |
| MergeParametersBuilderTest | 1 | 1 | 1 | 1 | 36 | 1 | 0 | 0 | 0 | 0 | 1 |
| MergeSelectionPaneTest | 7 | 3 | 7 | 6 | 61 | 7 | 0 | 0 | 0 | 0 | 2 |
| Cycles | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | -1 | 0 | 0 |

Table 22: Method level metrics calculated by DesigniteJava for modified pdfsam-merge

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Class Name** | **Method Name** | **LOC** | **CC** | **PC** |
| MergeModule | MergeModule | 6 | 1 | 3 |
| descriptor | 3 | 1 | 0 |
| onSaveWorkspace | 6 | 1 | 1 |
| onLoadWorkspace | 6 | 1 | 1 |
| getBuilder | 8 | 1 | 1 |
| settingPanel | 7 | 1 | 0 |
| id | 3 | 1 | 0 |
| onClearModule | 6 | 2 | 1 |
| graphic | 3 | 1 | 0 |
| destinationFileField | 3 | 1 | 0 |
| destinationPane | 3 | 1 | 2 |
| footer | 3 | 1 | 2 |
| openButton | 3 | 1 | 0 |
| ModuleConfig | destinationFileField | 3 | 1 | 0 |
| destinationPane | 3 | 1 | 2 |
| footer | 3 | 1 | 2 |
| openButton | 3 | 1 | 0 |
| MergeOptionsPane | MergeOptionsPane | 47 | 1 | 0 |
| resetView | 8 | 1 | 0 |
| apply | 8 | 1 | 2 |
| saveStateTo | 8 | 1 | 1 |
| restoreStateFrom | 8 | 1 | 1 |
| MergeParametersBuilder | addInput | 9 | 2 | 1 |
| hasInput | 3 | 1 | 0 |
| outlinePolicy | 3 | 1 | 1 |
| blankPageIfOdd | 3 | 1 | 1 |
| MergeParametersBuilder | footer | 3 | 1 | 1 |
| normalize | 3 | 1 | 1 |
| acroFormsPolicy | 3 | 1 | 1 |
| tocPolicy | 3 | 1 | 1 |
| output | 3 | 1 | 1 |
| build | 15 | 1 | 0 |
| MergeSelectionPane | MergeSelectionPane | 3 | 1 | 1 |
| apply | 12 | 2 | 2 |
| MergeOptionsPaneTest | setUp | 4 | 1 | 0 |
| MergeOptionsPaneTest | start | 6 | 1 | 1 |
| validSteps | 11 | 1 | 0 |
| onSaveWorkspace | 11 | 1 | 0 |
| restoreStateFrom | 22 | 1 | 0 |
| reset | 29 | 1 | 0 |
| MergeParametersBuilderTest | build | 30 | 1 | 0 |
| MergeSelectionPaneTest | setUp | 5 | 1 | 0 |
| empty | 5 | 1 | 0 |
| emptyByZeroPagesSelected | 7 | 1 | 0 |
| emptyPageSelection | 9 | 1 | 0 |
| notEmptyPageSelection | 10 | 1 | 0 |
| converstionException | 7 | 1 | 0 |
| populate | 6 | 1 | 0 |

pdfsam-rotate

Table 23: Class level metrics calculated by DesigniteJava for modified pdfsam-rotate

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Class Name** | **NOF** | **NOPF** | **NOM** | **NOPM** | **LOC** | **WMC** | **NC** | **DIT** | **LCOM** | **FANIN** | **FANOUT** |
| RotateModule | 7 | 0 | 14 | 12 | 87 | 15 | 0 | 0 | 0.214286 | 0 | 3 |
| ModuleConfig | 0 | 0 | 5 | 5 | 17 | 5 | 0 | 0 | -1 | 0 | 0 |
| RotateOptionsPane | 2 | 0 | 5 | 4 | 39 | 5 | 0 | 0 | 0 | 2 | 1 |
| RotateParametersBuilder | 5 | 0 | 11 | 7 | 79 | 23 | 0 | 0 | 0.272727 | 6 | 0 |
| RotateSelectionPane | 1 | 0 | 2 | 2 | 22 | 3 | 0 | 0 | 1 | 2 | 1 |
| RotateOptionsPaneTest | 2 | 1 | 5 | 5 | 50 | 5 | 0 | 0 | 0 | 0 | 2 |
| RotateParametersBuilderTest | 2 | 1 | 4 | 4 | 60 | 4 | 0 | 0 | 0 | 0 | 1 |
| RotateSelectionPaneTest | 7 | 3 | 7 | 6 | 61 | 7 | 0 | 0 | 0 | 0 | 2 |
| Cycles | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | -1 | 0 | 0 |

Table 24: Method level metrics calculated by DesigniteJava for modified pdfsam-rotate

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Class Name** | **Method Name** | **LOC** | **CC** | **PC** |
| RotateModule | RotateModule | 7 | 1 | 4 |
| descriptor | 3 | 1 | 0 |
| getBuilder | 9 | 1 | 1 |
| onSaveWorkspace | 7 | 1 | 1 |
| onLoadWorkspace | 7 | 1 | 1 |
| settingPanel | 11 | 1 | 0 |
| id | 3 | 1 | 0 |
| onClearModule | 7 | 2 | 1 |
| graphic | 3 | 1 | 0 |
| destinationDirectoryField | 3 | 1 | 0 |
| destinationPane | 3 | 1 | 2 |
| footer | 3 | 1 | 2 |
| openButton | 3 | 1 | 0 |
| prefixPane | 3 | 1 | 1 |
| ModuleConfig | destinationDirectoryField | 3 | 1 | 0 |
| destinationPane | 3 | 1 | 2 |
| footer | 3 | 1 | 2 |
| openButton | 3 | 1 | 0 |
| prefixPane | 3 | 1 | 1 |
| RotateOptionsPane | RotateOptionsPane | 15 | 1 | 0 |
| resetView | 4 | 1 | 0 |
| apply | 4 | 1 | 2 |
| saveStateTo | 4 | 1 | 1 |
| restoreStateFrom | 4 | 1 | 1 |
| RotateParametersBuilder | addInput | 37 | 9 | 2 |
| accept | 7 | 3 | 1 |
| accept | 7 | 3 | 1 |
| RotateParametersBuilder | hasInput | 3 | 1 | 0 |
| output | 3 | 1 | 1 |
| prefix | 3 | 1 | 1 |
| getOutput | 3 | 1 | 0 |
| getPrefix | 3 | 1 | 0 |
| rotation | 3 | 1 | 1 |
| rotationType | 3 | 1 | 1 |
| build | 10 | 1 | 0 |
| RotateSelectionPane | RotateSelectionPane | 3 | 1 | 1 |
| apply | 12 | 2 | 2 |
| RotateOptionsPaneTest | start | 6 | 1 | 1 |
| validSteps | 8 | 1 | 0 |
| onSaveWorkspace | 6 | 1 | 0 |
| restoreStateFrom | 10 | 1 | 0 |
| reset | 13 | 1 | 0 |
| RotateParametersBuilderTest | setUp | 8 | 1 | 0 |
| buildDefaultSelection | 20 | 1 | 0 |
| buildRanges | 14 | 1 | 0 |
| buildMultiple | 11 | 1 | 0 |
| RotateSelectionPaneTest | setUp | 5 | 1 | 0 |
| empty | 5 | 1 | 0 |
| emptyPageSelection | 9 | 1 | 0 |
| notEmptyPageSelection | 10 | 1 | 0 |
| converstionException | 7 | 1 | 0 |
| emptyByZeroPagesSelected | 7 | 1 | 0 |
| populate | 6 | 1 | 0 |

### Affected Metrics

To summarize the changes that we have seen reflected in the metrics calculated by DesigniteJava, we present the tables below, showing relevant classes and the changes in the values of their measures.

pdfsam-merge

Table 25: Contrast of class-level metrics before and after the change request implementation

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Class Name** | **NOF** | **NOPF** | **NOM** | **NOPM** | **LOC** | **WMC** | **NC** | **DIT** | **LCOM** | **FANIN** | **FANOUT** |
| **Before Changes** |  | | | | | | | | | | |
| MergeParametersBuilder | 8 | 0 | 10 | 2 | 56 | 10 | 0 | 0 | 0 | 6 | 0 |
| **After Changes** |  | | | | | | | | | | |
| MergeParametersBuilder | 8 | 0 | 10 | 2 | 62 | 11 | 0 | 0 | 0 | 6 | 0 |

Table 26: Contrast of method-level metrics before and after the change request implementation

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Class Name** | **Method Name** | **LOC** | **CC** | **PC** |  | **Mod. LOC** | **Mod. CC** | **Mod. PC** |
| MergeParametersBuilder | addInput | 3 | 1 | 1 | 9 | 2 | 1 |
| hasInput | 3 | 1 | 0 | 3 | 1 | 0 |
| outlinePolicy | 3 | 1 | 1 | 3 | 1 | 1 |
| blankPageIfOdd | 3 | 1 | 1 | 3 | 1 | 1 |
| footer | 3 | 1 | 1 | 3 | 1 | 1 |
| normalize | 3 | 1 | 1 | 3 | 1 | 1 |
| acroFormsPolicy | 3 | 1 | 1 | 3 | 1 | 1 |
| tocPolicy | 3 | 1 | 1 | 3 | 1 | 1 |
| output | 3 | 1 | 1 | 3 | 1 | 1 |
| build | 15 | 1 | 0 | 15 | 1 | 0 |

pdfsam-rotate

Table 27: Contrast of class-level metrics before and after the change request implementation

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Class Name** | **NOF** | **NOPF** | **NOM** | **NOPM** | **LOC** | **WMC** | **NC** | **DIT** | **LCOM** | **FANIN** | **FANOUT** |
| **Before Changes** |  | | | | | | | | | | |
| RotateParametersBuilder | 5 | 0 | 9 | 5 | 50 | 10 | 0 | 0 | 0 | 6 | 0 |
| **After Changes** |  | | | | | | | | | | |
| RotateParametersBuilder | 5 | 0 | 11 | 7 | 79 | 23 | 0 | 0 | 0.272727 | 6 | 0 |

Table 28: Contrast of class-level metrics before and after the change request implementation

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Class Name** | **Method Name** | **LOC** | **CC** | **PC** |  | **Mod. LOC** | **Mod. CC** | **Mod. PC** |
| RotateParametersBuilder | addInput | 8 | 2 | 2 | 37 | 9 | 2 |
| accept |  |  |  | 7 | 3 | 1 |
| accept |  |  |  | 7 | 3 | 1 |
| hasInput | 3 | 1 | 0 | 3 | 1 | 0 |
| output | 3 | 1 | 1 | 3 | 1 | 1 |
| prefix | 3 | 1 | 1 | 3 | 1 | 1 |
| getOutput | 3 | 1 | 0 | 3 | 1 | 0 |
| getPrefix | 3 | 1 | 0 | 3 | 1 | 0 |
| rotation | 3 | 1 | 1 | 3 | 1 | 1 |
| rotationType | 3 | 1 | 1 | 3 | 1 | 1 |
| build | 10 | 1 | 0 | 10 | 1 | 0 |

Notably, the metrics that have changed the most at the method-level are **Lines of code** and **Cyclomatic complexity**. At the class level however, there are other measures such as **Weighted methods per class**, **number of methods, number of weighted methods**, and **Lack of cohesion in methods** that have been affected.

The lines of code that we had added when making these changes is the direct cause of increase of the LOC metric. But more interestingly is the unexpected increase in **cyclomatic complexity**.

O3smeasures, the eclipse plugin tool that we had used before had not shown us these changes. Now that we look into our code changes, we see that we **have added if-else conditions** that will definitely **increase the number of paths** in the addInput() function (i.e. the Cyclomatic Complexity). We would have expected it to increase by the sum of the cyclomatic complexity of the two new functions in the Rotate Parameters Builder class, but it increased by 7, not 6 (3+3). This made us investigate the change itself, and after counting **the number of if-else statements**, we realized that there were 7.

A common change in both modified modules is the **Weighted methods per class** metric. This metric initially had us a little puzzled. We initially came across a definition describing WMC as a modification of number of methods. Only after understanding how WCM was reflected in our changed modules, we could see that it was also a **sum of the cyclic complexity(**try it!**)**. This was a surprising connection that we were not expecting. Thus, an increase in the WMC can be attributed to the increase in Cyclomatic complexity explained above.

The **Lack of cohesion between modules** value changed for the pdfsam-rotate module after our modifications. This means that our changes, apart from increasing the number of paths in a class and the WMC, also reduced the overall cohesion of the class. Now going on the metric definition of LCOM provided in section 1, we see that its value is affected by whether methods of a class operate on the same variables. We suspect our introduction of a new local variable ‘**tempPageArray1’** to hold intermediate odd/even page ranges and **two** new lambda methods to operate exclusively on this variable are probably responsible for this change.

An interesting unexpected outcome is the addition of two new methods in the Rotate Parameters Builder class. This is because of our use of two anonymous functions implementing the **Consumer** interface. These two functions were part of **forEach** loops used iterate over collections of Page Ranges.

A direct consequence of these forEach implementations is the increase in the **Number of methods** and **Number of public methods** metrics as shown in the table above. We expected these anonymous functions to be interpreted like lambda functions and not affect the metrics. However, what we learnt after examining the output of DesigniteJava is that even these anonymous Consumer functions are included in the calculation of these metrics.

Designitejava also measures **code smells**, and It has indicated that our changes have in places introduced a **magic number code smell** into the code. This probably refers to the calculation deciding whether a page range is even or odd in the pdfsam-rotate project, in which we perform a modulo operation(mod2) on the given input page numbers. It also classifies the function that we had changed with a **complex class code smell**, indicating that our changes have transformed an earlier simple class to something convoluted and labyrinthine.

## Cohesion and Coupling

### Cohesion

#### Types of Cohesion measured

**LCOM (Lack of Cohesion in Methods – Class level metric)**: The metric that is shown by the tool to measure the cohesion is LCOM. This metric measures the **functional cohesion** since it focuses on how class elements (methods and attributes) are related to each other. As it is mentioned in the descriptions above, LCOM analyzes the relation between attributes and methods.

#### Classes and their Cohesion values

* + - **Pdfsam-Merge**

Table 29: LCOM values and the level of cohesion for classes in pdfsam-merge

|  |  |  |
| --- | --- | --- |
| **Classes** | **Level of cohesion (High /Low)** | **LCOM** |
| ModuleConfig | NA | -1 |
| Cycles | NA | -1 |
| MergeOptionsPane | High | 0 |
| MergeParametersBuilder | High | 0 |
| MergeOptionsPaneTest | High | 0 |
| MergeParametersBuilderTest | High | 0 |
| MergeSelectionPaneTest | High | 0 |
| MergeModule | Low | 0.230769 |
| MergeSelectionPane | Low | 1 |

* + - **Pdfsam-Rotate**

|  |  |  |
| --- | --- | --- |
| **Classes** | **Level of cohesion (High /Low)** | **LCOM** |
| ModuleConfig | NA | -1 |
| Cycles | NA | -1 |
| RotateOptionsPane | High | 0 |
| RotateOptionsPaneTest | High | 0 |
| RotateParametersBuilderTest | High | 0 |
| RotateSelectionPaneTest | High | 0 |
| RotateModule | Low | 0.214286 |
| RotateParametersBuilder | Low | 0.272727 |
| RotateSelectionPane | Low | 1 |

A high LCOM value(closer to 1) indicates a conflict in the functionality written in a class. This metric can be used to identify classes that are attempting to achieve multiple objectives. Such classes could be more error prone and more difficult to test and could possibly be split into two or more classes that are more well defined in their behavior[[1]](#footnote-1).

These two projects(merge and rotate) are developed as **independent** modules of the main application, and show many good code practices, such a **single-responsibility classes** (RotateOptionsPane, RotateParametersBuilderTest). Therefore, it is not surprising to see the values of LCOM staying low, around zero or in most cases, 0.

As discussed earlier in section 3.3, the modification of the RotateParametersBuilder class **increased** its LCOM value from 0 to **0.272727**.

Other patterns visible are the fact that the RotateModule class and the MergeModule class both have values that are > 0, this is possibly because they differ from other intra-project classes in that they contain an **extra component sub-class**(ModuleConfig). This sub-class is **not visibly called** anywhere within the class. This **seemingly** **unrelated class** being put inside the MergeModule/RotateModule classes may lead to the **increase of LCOM** compared to the other classes in the projects.

It was mentioned in a post by the developer of DesigniteJava[[2]](#footnote-2) that one of the main challenges faced by modern LCOM calculation tools was the **dependence on method-attribute access**. It stated that the calculation of LCOM relied on **common attribute accesses** from methods as a basis to decide whether two methods are cohesive and that in the absence of such accesses, as seen in Cycles.java or in the ModuleConfig sub-class, it is possible that the tool will produce either a 0 or a non-deterministic LCOM value. The calculation of LCOM here for these respective classes is indeed a garbage-type value of -1.

#### The difference between the higher and lower cohesion classes

Above we discuss the cohesion values for different classes and possible reasons why they have these values. If asked specifically about the difference between the higher and lower cohesion value classes, we would point out the presence of extra sub-classes in these higher LCOM classes, which makes them more complex and thus more likely to have a higher LCOM. As mentioned earlier, the classes with LCOM = 0 such as the MergeOptionPane class are single-purposely designed to be components in other classes(MergeModule.java) and others like MergeOptionPaneTest class are tests targeted to only one class. These test classes are also pretty independent of other components apart from the one they are testing.

Finally, the highest classes with LCOMs of 1(MergeSelectionPane and RotateSelectionPane), though another type of component, have only two methods, which do not share any parameters. These disjoint methods obviously lead to a higher calculated LCOM, making the calculating tool believe that they are unrealted methods because they do not operate on the same attributes.

### Coupling

#### Types of Coupling measured

**FANIN and FANOUT (Class level metric):** Fan-in and Fan-out values measure the relationships between classes and between procedures. In the pdfsam modules, the Fan-in for a class can be understood as the number of classes in the same module that refer to the class. The Fan-out can conversely be defined as the number of classes that a given class depends on.

As mentioned earlier in section 3, this class ‘dependency’ may be a procedure call in another class, reading/writing of variables, accessing constants, or using sub-classes, interfaces, or enum declarations.

Since any form of inter-class reference is considered under this umbrella term, We feel that It would measure **Data, Stamp, Control and Content coupling** very well.

* + - 1. Content Coupling: Any direct reference between class members(attributes or methods) will be counted as part of the fan-in metric for the referenced class and the fan-out metric for the referring class.
      2. Control Coupling: This kind of coupling involves the passing of a control switch between modules. This passing in most cases would involve a method call. Which again would be counted in the fan-in and fan-out metrics as explained above.
      3. Stamp Coupling: Similarly, any controlled, intentional passing of data between classes as takes place in stamp coupling would also require a function-call of sorts. These would count as dependencies between methods and be included in the Fan-in/fan-out metric calculation.
      4. Data Coupling: A better form of stamp coupling, there is no doubt that data coupling will be counted through these metrics.

#### Classes with high/low coupling(and why)

* + - **Pdfsam-merge**

|  |  |  |
| --- | --- | --- |
| **Type Name** | **Level of coupling (High /Low)** | **FANOUT** |
| ModuleConfig | Low | 0 |
| MergeParametersBuilder | Low | 0 |
| Cycles | Low | 0 |
| MergeOptionsPane | Low | 1 |
| MergeSelectionPane | High | 1 |
| MergeParametersBuilderTest | High | 1 |
| MergeOptionsPaneTest | High | 2 |
| MergeSelectionPaneTest | High | 2 |
| MergeModule | High | 3 |

* + - Pdfsam-Rotate

|  |  |  |
| --- | --- | --- |
| **Type Name** | **Level of coupling (High /Low)** | **FANOUT** |
| ModuleConfig | Low | 0 |
| RotateParametersBuilder | Low | 0 |
| Cycles | Low | 0 |
| RotateOptionsPane | Low | 1 |
| RotateSelectionPane | High | 1 |
| RotateParametersBuilderTest | High | 1 |
| RotateOptionsPaneTest | High | 2 |
| RotateSelectionPaneTest | High | 2 |
| RotateModule | High | 3 |

This tool shows different fan out values compared to the value shown by the o3smeasures. A high Fan-in indicates a heavily used class, while a low Fan-in is the opposite. A high Fan-out means the class depends on many others. A class with Fan-out=0 is independent of others. While a high Fan-in can be an indication of good reuse of code, relatively large values within a project can represent a lot of cross-class coupling. A high Fan-out denotes strongly coupled code. The code depends on other code and is probably more complex to execute and test. A low or zero fan-out means independent, self-sufficient code. This kind of code is easier to reuse in another project or for another purpose.

The above tables use fanout

Explain the difference between the classes with highest coupling versus the classes with lowest coupling.

Do not forget this !

1. https://www.aivosto.com/project/help/pm-oo-cohesion.html [↑](#footnote-ref-1)
2. http://www.tusharma.in/technical/revisiting-lcom/ [↑](#footnote-ref-2)