

|     | Fix pattern   | Calculated clusters   | Manual clusters  | Expanded TBar FP   |   |
|-----|---|---|--|--|---|
| 1   | Insert a null pointer checker with return null<br>Insert: (IF, PARENTHESIZED, OPERATOR, IDENTIFIER, NULL_LITERAL, RETURN, NULL_LITERAL) | <u>jso-22</u> <sub>1..3</sub>   | jaD-13 <sub>1,2</sub> , <b>jso-22</b> <sub>1..3</sub> , mat-4 <sub>1,2</sub>   | Insert Null Pointer Checker<br>FP2.6.1:<br>+ if (exp == null) return null; |   |
| 2 3 | Insert variable initialisation<br>Insert: (IDENTIFIER, IDENTIFIER, EXPRESSION_STATEMENT, ASSIGNMENT)                                    | <u>com-29</u> <sub>1..6</sub> , <b>jaC-26</b> , <b>jso-85</b>   | <b>jaC-26</b>   <b>com-29</b> <sub>1..6</sub> , <b>jso-85</b>  | Insert Assignment<br>FP4.5:<br>+ var1 = var2                               | Insert Field Init.<br>FP4.6:<br>+ obj.field = var |
| 4   | Insert Declaration with Initialisation<br>Insert: (VARIABLE, MODIFIERS, PRIMITIVE_TYPE, LITERAL)  | -<br><b>clo-144</b> <sub>3</sub> , <b>clo-165</b> <sub>6</sub> , <u><b>com-3</b></u><br>-   | clo-26,<br><b>clo-144</b> <sub>3</sub> , <b>clo-165</b> <sub>6</sub> , <b>com-3</b> ,<br>-   | Insert Declaration with Initialisation<br>FP4.7:<br>+ mod T var = literal  |   |
|     | Insert Declaration with Initialisation<br>Insert: (VARIABLE, MODIFIERS, PRIMITIVE_TYPE, LITERAL)  | jaD-109<br><b>jaC-18</b> , <b>jso-67</b> , <u><b>lan-23</b></u>   | -<br><b>jaC-18</b> , jso-31, <b>jso-67</b> , <b>lan-23</b>   |  |   |
| 5   | Insert Declaration<br>Insert: (IDENTIFIER, VARIABLE)  | <b>cli-22</b> <sub>4</sub> , <b>clo-16</b> <sub>3</sub> , <b>clo-163</b> <sub>29..31</sub> ,<br><u><b>com-29</b></u> <sub>7,8</sub> , <b>csv-16</b> <sub>2</sub> , jso-87 <sub>14</sub> ,<br>jxP-13 <sub>6</sub>  | <b>cli-22</b> <sub>4</sub> , <b>clo-16</b> <sub>3</sub> , <b>clo-163</b> <sub>29..31</sub> ,<br><b>com-29</b> <sub>7</sub> , <b>csv-16</b> <sub>2</sub><br>- | Insert Declaration without Init.<br>FP4.8:<br>+ T var                      |   |
| 6   | Insert Case<br>Insert: (CASE, IDENTIFIER)   | <b>clo-80</b> , <u><b>clo-103</b></u> , <b>gso-11</b> <sub>1,2</sub> ,<br><b>jaD-32</b>   | <b>clo-80</b> , <b>clo-103</b> , <b>gso-11</b> <sub>1</sub> ,<br><b>jaD-32</b>   | Insert Case<br>FP4.9:<br>+ case exp  |   |
| 7   | Insert an assignment<br>Insert: (VARIABLE, PRIMITIVE_TYPE, LITERAL)   | <u>clo-30</u> <sub>2</sub> , <b>clo-148</b> <sub>41</sub> , jso-35,<br>jso-31   | <b>clo-148</b> <sub>41</sub><br>-  | Insert Initialisation<br>FP4.10:<br>- var<br>+ var = literal               |   |
| 8   | Replace null with a variable<br>Change: (NULL_LITERAL) to (IDENTIFIER)  | cli-34 <sub>2</sub> , <b>clo-144</b> <sub>2</sub> , <b>jaD-107</b> ,<br><u>jaD-95</u> <sub>2</sub>  | <b>clo-144</b> <sub>2</sub> , <b>jaD-107</b><br>-  | Mutate Literal<br>FP9.3:<br>- literal<br>+ var                             |   |
| 9   | Replace a method invocation with a variable<br>Change: (METHOD_INVOCATION, IDENTIFIER) to (IDENTIFIER)                                  | <b>cli-1</b> <sub>4</sub> , <b>clo-134</b> <sub>2,3</sub> , <b>com-34</b> ,<br><u><b>jaC-12</b></u> <sub>3</sub> , <b>jaD-95</b> <sub>1</sub>   | <b>cli-1</b> <sub>4</sub> , <b>clo-134</b> <sub>2</sub> , <b>com-34</b> ,<br><b>jaC-12</b> <sub>3</sub> , <b>jaD-95</b> <sub>1</sub>                         | Mutate Method<br>FP10.6:<br>- method<br>+ var                              |   |
| 10  | Replace a variable with a new instance<br>Change: (IDENTIFIER) to (NEW_CLASS, IDENTIFIER, IDENTIFIER)                                   | jaX-5, <u><b>moc-6</b></u> <sub>1..15</sub> , <b>moc-14</b> <sub>1</sub>  | <b>moc-6</b> <sub>1..15</sub> , <b>moc-14</b> <sub>1</sub>   | Mutate Variable<br>FP13.3:<br>- var<br>+ new instance                      |   |
| 11  | Insert a method invocation<br>Insert: (METHOD_INVOCATION, IDENTIFIER)   | <b>cha-10</b> , clo-3 <sub>3</sub> , clo-90,<br><b>com-20</b> <sub>1..3</sub> , <b>jso-6</b> , <u><b>jso-29</b></u> ,<br>jso-56 <sub>1,2</sub> , jso-88, lan-4 <sub>2</sub> ,<br><b>mat-26</b> , moc-10 <sub>5</sub> , moc-23 <sub>3</sub> ,<br><b>moc-4</b> <sub>1,2</sub> | <b>cha-10</b> ,<br><b>com-20</b> <sub>1..3</sub> , <b>jso-6</b> , <b>jso-29</b> ,<br>mat-24,<br><b>mat-26</b> ,<br><b>moc-4</b> <sub>1,2</sub>               | Mutate Variable<br>FP13.4:<br>- var<br>+ method(var, ...)                  |   |

Table 1: Fix patterns and centroids of the new clusters and proposed extension of the TBar fix pattern (FP) taxonomy.