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## AVLTree.java

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```

1  /*
2  * OST - Uebungen 'Algorithmen & Datenstrukturen (AlgDat)'
3  * Version: Mon Sep 30 16:38:18 CEST 2024
4  */
5
6  package ex03.solution.task03;
7
8  import java.util.Collection;
9
10 import ex02.solution.task01.BinarySearchTree.Entry;
11
12
13 public class AVLTree <K extends Comparable<? super K>, V> {
14
15     private AVLTreeImpl<K, V> avlTreeImpl =
16         new AVLTreeImpl<>();
17         //new AVLTreeImplADV<>("AVL-Tree"); // Show in ADV
18         //new AVLTreeImplADV<>("AVL-Tree", 1, 3); // Show in ADV: Be aware of NodeFixation
19         Exception!
20
21     public V put(K key, V value) {
22         return avlTreeImpl.put(key, value);
23     }
24
25     public V get(K key) {
26         return avlTreeImpl.get(key);
27     }
28
29     public int getHeight() {
30         return avlTreeImpl.getHeight();
31     }
32
33     public int size() {
34         return avlTreeImpl.size();
35     }
36
37     public boolean isEmpty() {
38         return avlTreeImpl.isEmpty();
39     }
40
41     public void clear() {
42         avlTreeImpl.clear();
43     }
44
45     public Collection<Entry<K, V>> inorder() {
46         return avlTreeImpl.inorder();
47     }
48
49     public void printInorder() {
50         avlTreeImpl.printInorder();
51     }
52
53     public void print() {
54         avlTreeImpl.print();
55     }
56
57     protected AVLTreeImpl<K, V> getImpl() {
58         return avlTreeImpl;
59     }

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```

59
60     public static void main(String[] args) {
61
62         AVLTree<Integer, String> avlTree = new AVLTree<>();
63
64         System.out.println("Inserting 2:");
65         avlTree.put(2, "Str2");
66         avlTree.print();
67         System.out.println("=====");
68         System.out.println("Inserting 1:");
69         avlTree.put(1, "Str1");
70         avlTree.print();
71         System.out.println("=====");
72         System.out.println("Inserting 5:");
73         avlTree.put(5, "Str5");
74         avlTree.print();
75         System.out.println("=====");
76         System.out.println("Inserting 3:");
77         avlTree.put(3, "Str3");
78         avlTree.print();
79         System.out.println("=====");
80         System.out.println("Inserting 6:");
81         avlTree.put(6, "Str6");
82         avlTree.print();
83         System.out.println("=====");
84         System.out.println("Inserting 4:1:");
85         avlTree.put(4, "Str4:1");
86         avlTree.print();
87         System.out.println("=====");
88         System.out.println("Inserting 4:2:");
89         avlTree.put(4, "Str4:2");
90         avlTree.print();
91         System.out.println("=====");
92         System.out.println("Getting 3 : " + avlTree.get(3));
93         System.out.println("Getting 4 : " + avlTree.get(4));
94         System.out.println("Getting 7 : " + avlTree.get(7));
95
96     }
97
98 }
99

```

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```

100
101 /* Session-Log:
102
103 Inserting 2:
104   2 - Str2   : h=0 ROOT
105 =====
106 Inserting 1:
107   1 - Str1   : h=0 / parent(key)=2
108   2 - Str2   : h=1 ROOT
109 =====
110 Inserting 5:
111   1 - Str1   : h=0 / parent(key)=2
112   2 - Str2   : h=1 ROOT
113   5 - Str5   : h=0 \ parent(key)=2
114 =====
115 Inserting 3:
116   1 - Str1   : h=0 / parent(key)=2
117   2 - Str2   : h=2 ROOT
118   3 - Str3   : h=0 / parent(key)=5
119   5 - Str5   : h=1 \ parent(key)=2
120 =====
121 Inserting 6:
122   1 - Str1   : h=0 / parent(key)=2
123   2 - Str2   : h=2 ROOT
124   3 - Str3   : h=0 / parent(key)=5
125   5 - Str5   : h=1 \ parent(key)=2
126   6 - Str6   : h=0 \ parent(key)=5
127 =====
128 Inserting 4:1:
129   1 - Str1   : h=0 / parent(key)=2
130   2 - Str2   : h=3 ROOT
131   3 - Str3   : h=1 / parent(key)=5
132   4 - Str4:1 : h=0 \ parent(key)=3
133   5 - Str5   : h=2 \ parent(key)=2
134   6 - Str6   : h=0 \ parent(key)=5
135 =====
136 Inserting 4:2:
137   1 - Str1   : h=0 / parent(key)=2
138   2 - Str2   : h=3 ROOT
139   3 - Str3   : h=1 / parent(key)=5
140   4 - Str4:2 : h=0 \ parent(key)=3
141   5 - Str5   : h=2 \ parent(key)=2
142   6 - Str6   : h=0 \ parent(key)=5
143 =====
144 Getting 3 :Str3
145 Getting 4 :Str4:2
146 Getting 7 :null
147
148 */

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## AVLTreeImpl.java

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```

1  /*
2  * OST - Uebungen 'Algorithmen & Datenstrukturen (AlgDat)'
3  * Version: Mon Sep 30 16:38:18 CEST 2024
4  */
5
6  package ex03.solution.task03;
7
8  import java.util.Collection;
9  import java.util.LinkedList;
10 import java.util.List;
11
12 import ex02.solution.task01.BinarySearchTree;
13
14 class AVLTreeImpl<K extends Comparable<? super K>, V> extends
15     BinarySearchTree<K, V> {
16
17     /**
18      * After the BST-operation 'insert()':
19      * actionNode shall point to the parent of the new inserted node.
20      */
21     protected AVLNode actionNode;
22
23
24     protected class AVLNode extends BinarySearchTree<K, V>.Node {
25
26         private int height;
27         private Node parent;
28
29         AVLNode(Entry<K, V> entry) {
30             super(entry);
31         }
32
33         protected AVLNode setParent(AVLNode parent) {
34             AVLNode old = avlNode(this.parent);
35             this.parent = parent;
36             return old;
37         }
38
39         protected AVLNode getParent() {
40             return avlNode(parent);
41         }
42
43         protected int setHeight(int height) {
44             int old = this.height;
45             this.height = height;
46             return old;
47         }
48
49         protected int getHeight() {
50             return height;
51         }
52
53         @Override
54         public AVLNode getLeftChild() {
55             return avlNode(super.getLeftChild());
56         }
57
58         @Override
59         public AVLNode getRightChild() {
60             return avlNode(super.getRightChild());
61         }

```

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AVLTreImpl.java

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```

62
63     @Override
64     public String toString() {
65         String result = String.format("%2d - %-6s : h=%d",
66                                     getEntry().getKey(), getEntry().getValue(), height);
67         if (parent == null) {
68             result += " ROOT";
69         } else {
70             boolean left = (parent.getLeftChild() == this) ? true : false;
71             result += (left ? " / " : " \\ ") + "parent(key)="
72                     + parent.getEntry().getKey();
73         }
74         return result;
75     }
76 } // End of class AVLNode
77
78
79 protected AVLNode getRoot() {
80     return avlNode(root);
81 }
82
83
84 public V put(K key, V value) {
85     Entry<K, V> entry = find(key);
86     if (entry != null) {
87         // key already exists in the Tree
88         return entry.setValue(value);
89     }
90     // key does not exist in the Tree yet
91     super.insert(key, value);
92     assureHeights(actionNode);
93     actionNode = null;
94     return null;
95 }
96
97 public V get(K key) {
98     Entry<K, V> entry = super.find(key);
99     if (entry == null) {
100         return null;
101     }
102     return entry.getValue();
103 }
104
105 @Override
106 protected Node insert(Node node, Entry<K, V> entry) {
107     if (node != null) {
108         actionNode = avlNode(node);
109     }
110     // calling now the BST-insert() which will do the work:
111     AVLNode result = avlNode(super.insert(node, entry));
112     if (node == null) {
113         // In this case: result of super.insert() is the new node!
114         result.setParent(actionNode);
115     }
116     return result;
117 }

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AVLTreImpl.java

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```

118
119 /**
120  * The height of the tree.
121  *
122  * @return The current height. -1 for an empty tree.
123  */
124 @Override
125 public int getHeight() {
126     return height(avlNode(root));
127 }
128
129 /**
130  * Returns the height of this node.
131  *
132  * @param node
133  * @return The height or -1 if null.
134  */
135 @SuppressWarnings("static-method")
136 protected int height(AVLNode node) {
137     return (node != null) ? node.getHeight() : -1;
138 }
139
140 /**
141  * Assures the heights of the tree from 'node' up to the root.
142  *
143  * @param node
144  *         The node from where to start.
145  */
146 protected void assureHeights(AVLNode node) {
147     while (node != null) {
148         setHeight(node);
149         node = node.getParent();
150     }
151 }
152
153 /**
154  * Assures the correct height for node.
155  *
156  * @param node
157  *         The node to assure its height.
158  */
159 protected void setHeight(AVLNode node) {
160     if (node == null) {
161         return;
162     }
163     int heightLeftChild = height(node.getLeftChild());
164     int heightRightChild = height(node.getRightChild());
165     node.setHeight(1 + Math.max(heightLeftChild, heightRightChild));
166 }
167
168 /**
169  * Factory-Method. Creates a new node.
170  *
171  * @param entry
172  *         The entry to be inserted in the new node.
173  * @return The new created node.
174  */
175 @Override
176 protected Node newNode(Entry<K, V> entry) {
177     return new AVLNode(entry);
178 }

```

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AVLTreeImpl.java

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```

179
180 @Override
181 protected void inorder(Node node, Collection<Node> inorderList) {
182     super.inorder(node, inorderList);
183 }
184
185 // Type-Casting: Node -> AVLNode (Cast-Encapsulation)
186 @SuppressWarnings({ "unchecked", "static-method" })
187 protected AVLNode avlNode(Node node) {
188     return (AVLNode)node;
189 }
190
191 public void print() {
192     List<Node> nodeList = new LinkedList<>();
193     inorder(root, nodeList);
194     for (Node node: nodeList) {
195         System.out.println(node + " ");
196     }
197 }
198
199 }
200
201

```

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AVLTreeImplADV.java

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```

1  /*
2   * OST - Uebungen 'Algorithmen & Datenstrukturen (AlgDat)'
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4   */
5
6  package ex03.solution.task03;
7
8  import ch.hsr.adv.commons.core.logic.domain.styles.ADVStyle;
9  import ch.hsr.adv.commons.core.logic.util.ADVException;
10 import ch.hsr.adv.commons.tree.logic.domain.ADVBinaryTreeNode;
11 import ch.hsr.adv.lib.bootstrapper.ADV;
12 import ch.hsr.adv.lib.tree.logic.binarytree.BinaryTreeModule;
13
14 @SuppressWarnings("unchecked")
15 public class AVLTreeImplADV<K extends Comparable<? super K>, V>
16     extends AVLTreeImpl<K, V> {
17
18     protected BinaryTreeModule advTree;
19
20     protected class AVLNodeADV extends AVLTreeImpl<K, V>.AVLNode
21         implements ADVBinaryTreeNode<String> {
22
23         protected AVLNodeADV(Entry<K, V> entry) {
24             super(entry);
25         }
26
27         @Override
28         public String getContent() {
29             return getEntry().getKey() + " / " + getEntry().getValue() + " (" + getHeight()
30                 + ")";
31         }
32
33         @Override
34         public ADVStyle getStyle() {
35             return null;
36         }
37
38         @Override
39         public AVLNodeADV getLeftChild() {
40             return (AVLNodeADV) super.getLeftChild();
41         }
42
43         @Override
44         public AVLNodeADV getRightChild() {
45             return (AVLNodeADV) super.getRightChild();
46         }
47     } // class AVLTreeImplADV.AVLNodeADV
48
49     public AVLTreeImplADV(String sessionName) {
50         this(sessionName, -1, -1);
51     }
52
53     public AVLTreeImplADV(String sessionName,
54         int maxLeftHeight, int maxRightHeight) {
55         advTree = new BinaryTreeModule(sessionName);
56         if ((maxLeftHeight != -1) && (maxRightHeight != -1)) {
57             advTree.setFixedTreeHeight(maxLeftHeight, maxRightHeight);
58         }
59         try {
60             ADV.launch(null);
61         } catch (ADVException e) {
62             e.printStackTrace();
63             System.exit(1);
64         }
65     }

```

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AVLTreeImplADV.java

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```

66
67  @Override
68  protected Node newNode(Entry<K, V> entry) {
69      return new AVLNodeADV(entry);
70  }
71
72  @Override
73  public V put(K key, V value) {
74      V result = super.put(key, value);
75      displayOnADV("put(" + key + ", " + value + ")");
76      return result;
77  }
78
79  protected void displayOnADV(String advMessage) {
80      advTree.setRoot((AVLNodeADV) root);
81      try {
82          ADV.snapshot(advTree, "\n" + advMessage);
83      } catch (ADVException e) {
84          e.printStackTrace();
85          System.exit(2);
86      }
87  }
88
89  }

```

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AVLTreeJUnitTest.java

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```

1  /*
2  * OST - Uebungen 'Algorithmen & Datenstrukturen (AlgDat)'
3  * Version: Mon Sep 30 16:38:18 CEST 2024
4  */
5
6  package ex03.solution.task03;
7
8  import static org.junit.Assert.assertEquals;
9  import static org.junit.Assert.assertNull;
10
11  import java.util.Collection;
12  import java.util.LinkedList;
13
14  import org.junit.Before;
15  import org.junit.FixMethodOrder;
16  import org.junit.Test;
17  import org.junit.runners.MethodSorters;
18
19  import ex02.solution.task01.BinarySearchTree;
20
21
22  @FixMethodOrder(MethodSorters.NAME_ASCENDING)
23  public class AVLTreeJUnitTest {
24
25      AVLTreeImpl<Integer, String> avlTree;
26
27      @Before
28      public void setUp() {
29          avlTree = new AVLTreeImpl<>();
30      }
31
32      @Test
33      public void test01Put() {
34          int[] keys = { 2, 1, 3 };
35          String[] expected = {
36              " 1 - Str1   : h=0 / parent(key)=2",
37              " 2 - Str2   : h=1 ROOT",
38              " 3 - Str3   : h=0 \\ parent(key)=2",
39          };
40          runTest(keys, expected);
41          assertEquals(1, avlTree.getHeight());
42      }
43
44      @Test
45      public void test02Get() {
46          int[] keys = { 2, 1, 4, 5, 3 };
47          String[] expected = {
48              " 1 - Str1   : h=0 / parent(key)=2",
49              " 2 - Str2   : h=2 ROOT",
50              " 3 - Str3   : h=0 / parent(key)=4",
51              " 4 - Str4   : h=1 \\ parent(key)=2",
52              " 5 - Str5   : h=0 \\ parent(key)=4",
53          };
54          runTest(keys, expected);
55          assertEquals(2, avlTree.getHeight());
56          assertEquals("Str2", avlTree.get(2));
57          assertEquals("Str5", avlTree.get(5));
58          assertNull(avlTree.get(0));
59          assertNull(avlTree.get(6));
60      }

```

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AVLTreeJUnitTest.java

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```

61
62 @Test
63 public void test03() {
64     int[] keys = { 2, 3, 1 };
65     String[] expected = {
66         " 1 - Str1   : h=0 / parent(key)=2",
67         " 2 - Str2   : h=1 ROOT",
68         " 3 - Str3   : h=0 \\ parent(key)=2",
69     };
70     runTest(keys, expected);
71     assertEquals(1, avlTree.getHeight());
72     avlTree.put(2, "Str2:2");
73     avlTree.put(2, "Str2:3");
74     assertEquals(1, avlTree.getHeight());
75     expected = new String[] {
76         " 1 - Str1   : h=0 / parent(key)=2",
77         " 2 - Str2:3 : h=1 ROOT",
78         " 3 - Str3   : h=0 \\ parent(key)=2",
79     };
80     Collection<BinarySearchTree<Integer, String>.Node> nodes = new LinkedList<>();
81     avlTree.inorder(avlTree.getRoot(), nodes);
82     verify(nodes, expected);
83 }
84
85
86 private void runTest(int[] keys, String[] expected) {
87     for (int key : keys) {
88         avlTree.put(key, "Str" + key);
89     }
90     Collection<BinarySearchTree<Integer, String>.Node> nodes = new LinkedList<>();
91     avlTree.inorder(avlTree.getRoot(), nodes);
92     assertEquals(expected.length, nodes.size());
93     verify(nodes, expected);
94 }
95
96 private static void verify(Collection<BinarySearchTree<Integer, String>.Node> nodes,
97 String[] expected) {
98     int i = 0;
99     for (BinarySearchTree<Integer, String>.Node node: nodes) {
100         String nodeStr = node.toString();
101         String expectedStr = expected[i];
102         assertEquals(expectedStr, nodeStr);
103         i++;
104     }
105 }
106 }
107

```