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Übungen zur Vorlesung Informatik II (D-BAUG) FS 2017

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http://lec.inf.ethz.ch/baug/informatik2/2017

Solution to exercise sheet # 10 **15.5.2017 – 23.5.2017**

Problem 10.1. Online Median

For this task open the project on codeboard: https://codeboard.ethz.ch/inf2baugex10t01

In the exercise you learned about how Heaps could be used to implement an Online Median Heap. Your task for the first part of this exercise is to implement exactly this algorithm. First study the code of `ArrayHeap.java` which was partially introduced in the exercise session. Then complete two functions in `OnlineMedian.java`. Start of with

```
public void Insert(double value) { .. }
```

Next you should complete the method:

```
public double GetMedian() { ... }
```

Do not be surprised if your solution for this method is very short - it is supposed to be like this.

To test your implementation, you can use the following commands which are implement in the `Main` class:

```
insert 5.5
median
```

The `insert` command takes a value (5.5) and inserts into the heap. The `median` command returns the median of all values currently in the heap.

To run the automatic test, un-comment the annotation `@RunTests` at the beginning of the class `Main`. Once you pass the automatic test you can submit your program.

Solution of Problem 10.1.

```
public void Insert(double value) {
    if (minHeap.size() == 0 || value > minHeap.GetRoot()) {
        minHeap.Insert(value);
    } else {
        maxHeap.Insert(value);
    }
    n++;
    if (maxHeap.size() < n/2) {
        maxHeap.Insert(minHeap.ExtractRoot());
    } else if (maxHeap.size() > n/2) {
        minHeap.Insert(maxHeap.ExtractRoot());
    }
}

public double GetMedian() {
    if (n%2 == 0) {
        return (minHeap.GetRoot() + maxHeap.GetRoot()) / 2;
    } else {
        return minHeap.GetRoot();
    }
}
```

Problem 10.2. Dijkstra's Algorithm

Within the second part of this exercise we asked you to implement Dijkstra's shortest path algorithm that was also introduced in the lecture, please open the code template at https://codeboard.ethz.

ch/inf2baugex10t02. While all parts that are needed for the implementation have been demonstrated in the lecture already, we recommend that you again study

- `Edge.java` - implementation of an edge of the graph
- `Node.java` - implementation of a node within the graph
- `Heap.java` - a heap implementation as seen in the previous task. Required for the algorithm

Once you familiarized yourself with the code, you should try to complete the method `ShortestPath` inside `Graph.java`.
Since the code is a bit more involved then most code you have seen so far we basically just left out gaps in the algorithm and your task is to fill them in. Use the visual illustration of the algorithm from the lecture for help. Every `???` should only require a single line of code to fill it. See next page for the code with the gaps.
To test your implementation, you can use the following commands which are implement in the `Main` class:

```
edge a b 8
path a b
```

The `edge` command insert a new edge from `a` to `b` with distance `8` into the graph. The `path` finds the shortest path from `a` to `b` and prints it out.
To run the automatic test, un-comment the annotation `@RunTests` at the beginning of the class `Main`. Once you pass the automatic test you can submit your program.

```
    public Vector<Node> ShortestPath(Node S, Node E) {
        //we start of by traversing through all nodes
        for (Node node : nodes) {
            ??? //for each node update its pathlen value to Integer.MAX_VALUE
            ??? //and set its parent node to null
        }

        ??? //create a vector to store the path
        ??? //create a Heap to work with during the algorithm
        ??? //set the path length at the startnode to 0
        Node newNode = start;

        while (newNode != null && newNode != end) {
            Vector<Edge> edges = ??? //get all the edges from the newNode

            //for each of the edges
            for (Edge edge : edges) {
            ??? //calculate the length the newNode plus this edge length
            ??? //get the Node that we would reach with this edge
            ??? //get the PathLength that node had so far (the one we just reached)
            if (newLength < prevLength) { //if previous is longer (which is always true if we did not
                visit that node yet)
                ??? //set its length to the newly calculated length
                ???//set its parent to the node we just came from
                if (prevLength == Integer.MAX_VALUE) { // we did not see this node yet
                    ??? //therefore we would like to insert it to the heap
                } else {
                    ??? //otherwise update its value in the heap
                }
            }
        }
        newNode = ??? //we then continue by taking node with shortest path out of the heap (the root)
                    //and the simply continue the loop from there
    }


    //now we backtrack from the final node
    while (newNode != null) {
        path.add(newNode);
        newNode = newNode.GetPathParent();
    }

    return path;
}
```

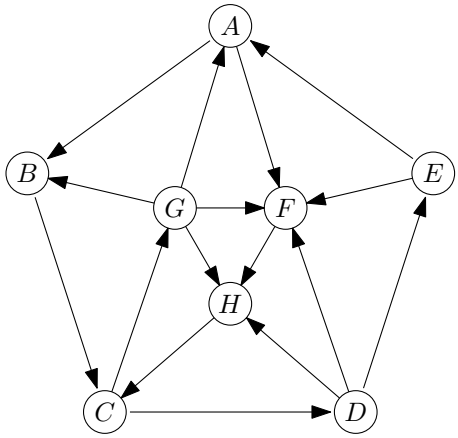
Solution of Problem 10.2.

```
public Vector<Node> ShortestPath(Node start, Node end) {
    //we start of by traversing through all nodes
    for (Node node : nodes) {
        node.SetPathLen(Integer.MAX_VALUE); //for each node update its pathlen
            value to Integer.MAX_VALUE
        node.SetPathParent(null); //and set its parent node to null
    }

    Vector<Node> path = new Vector<Node>(); //create a vector to store the path
    Heap R=new Heap(); //create a Heap to work with during the algorithm
    start.SetPathLen(0); //set the path length at the startnode to 0
    Node newNode = start; //create a new node

    while (newNode != null && newNode != end) {
        Vector<Edge> edges = newNode.Edges(); //get all the edges from the
            newNode

        //for each of the edges
        for (Edge edge : edges) {
            int newLength = newNode.GetPathLen() + edge.GetLength(); //calculate
                the length the newNode plus this edge length
            Node dest = edge.GetDestination(); //get the Node that we would reach
                with this edge
            int prevLength = dest.GetPathLen(); //get the PathLength that node
                had so far
            if (newLength < prevLength) { //if previous is longer (which is
                always true if we did not visit that node yet)
                dest.SetPathLen(newLength); //set its length to the newly
                    calculated length
                dest.SetPathParent(newNode); //set its parent to the node we just
                    came from
                if (prevLength == Integer.MAX_VALUE) { // we did not see this
                    node yet
                    R.Insert(dest); //therefore we would like to insert it to the
                        heap
                } else {
                    R.DecreaseKey(dest); //otherwise update its value in the heap
                }
            }
        }
        newNode = R.ExtractRoot(); //we then continue by taking node with
            shortest path out of the heap (the root)
        //and the simply continue the loop from there
    }

    //now we backtrack from the final node
    while (newNode != null) {
        path.add(newNode);
        newNode = newNode.GetPathParent();
    }

    return path;
```

```
}
```

Problem 10.3. Depth-first-search and breadth-first-search

Both depth-first-search (DFS) and breadth-first-search (BFS) admit a certain degree of freedom: one may choose the order in which the neighbors of a vertex are considered. For the graph shown below, let us assume that both DFS and BFS visit the neighbors of a vertex in alphabetical order.



1. Give the DFS and BFS ordering of the graph (i.e., the sequence in which the vertices are visited by DFS and BFS, respectively), starting from vertex A.
2. Is there a starting vertex in this graph from which the DFS ordering is the same as the BFS ordering?

Submission link: https://codeboard.ethz.ch/inf2baugex10t03

Solution of Problem 10.3.

1. DFS: A, B, C, D, E, F, H, G
   BFS: A, B, F, C, H, D, G, E
2. No, the orders are different for all starting vertices.