SHRI VILEPARLE KELAVANI MANDAL'S
DWARKADAS J. SANGHVI COLLEGE OF ENGINEERING
(Autonomous College Affiliated to the University of Mumbai)
NAAC ACCREDITED with "A" GRADE (CGPA : 3.18)

Department of Information Technology

COURSE CODE: DJS22ITL502 **DATE: 7-10-2024**

COURSE NAME: Advanced Data Structures Laboratory **CLASS:** TY B. TECH

NAME: Anish Sharma **DIV:** IT 1 **ROLL:** I011

EXPERIMENT NO. 3

CO/LO: Choose appropriate data structure and use it to design algorithm for solving a specific problem

AIM / OBJECTIVE: To implement various operations on Binomial Heap.

DESCRIPTION OF EXPERIMENT:

Properties of Binomial Heap:
Collection of Binomial Trees: A heap is made of binomial trees, with each tree structured recursively.
Heap Property: Each tree obeys the min-heap property, with the smallest key at the root.
Logarithmic Merging: Merging two heaps takes O(logn) by combining trees of the same order.
Find Min: Locating the minimum element takes O(logn)) by scanning root nodes.
Delete Min: Deleting the minimum element and restructuring takes O(logn)

TECHNOLOGY STACK USED: C, C++, JAVA

SOURCE CODE:

```java
import java.io.*;
class BinomialHeapNode {
    int key, degree;
    BinomialHeapNode parent;
    BinomialHeapNode sibling;
    BinomialHeapNode child;
    public BinomialHeapNode(int k)
    {
        key = k;
        degree = 0;
        parent = null;
        sibling = null;
        child = null;
    }
    public BinomialHeapNode reverse(BinomialHeapNode sibl)
    {
        BinomialHeapNode ret;
        if (sibling != null)
            ret = sibling.reverse(this);
```

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```
        else
            ret = this;
        sibling = sibl;
        return ret;
    }
    public BinomialHeapNode findMinNode()
    {
        BinomialHeapNode x = this, y = this;
        int min = x.key;

        while (x != null) {
            if (x.key < min) {
                y = x;
                min = x.key;
            }

            x = x.sibling;
        }

        return y;
    }
    public BinomialHeapNode findANodeWithKey(int value)
    {

        BinomialHeapNode temp = this, node = null;

        while (temp != null) {
            if (temp.key == value) {
                node = temp;
                break;
            }

            if (temp.child == null)
                temp = temp.sibling;

            else {
                node = temp.child.findANodeWithKey(value);
                if (node == null)
                    temp = temp.sibling;
                else
                    break;
            }
        }
        return node;
    }

    public int getSize()
    {
        return (
```

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```
            1 + ((child == null) ? 0 : child.getSize())
            + ((sibling == null) ? 0 : sibling.getSize()));
    }
}
class BinomialHeap {
    private BinomialHeapNode Nodes;
    private int size;
    public BinomialHeap()
    {
        Nodes = null;
        size = 0;
    }
    public boolean isEmpty() { return Nodes == null; }
    public int getSize() { return size; }
    public void makeEmpty()
    {
        Nodes = null;
        size = 0;
    }
    public void insert(int value)
    {
        if (value > 0) {
            BinomialHeapNode temp
                = new BinomialHeapNode(value);
            if (Nodes == null) {
                Nodes = temp;
                size = 1;
            }
            else {
                unionNodes(temp);
                size++;
            }
        }
    }
    private void merge(BinomialHeapNode binHeap)
    {
        BinomialHeapNode temp1 = Nodes, temp2 = binHeap;

        while ((temp1 != null) && (temp2 != null)) {

            if (temp1.degree == temp2.degree) {

                BinomialHeapNode tmp = temp2;
                temp2 = temp2.sibling;
                tmp.sibling = temp1.sibling;
                temp1.sibling = tmp;
                temp1 = tmp.sibling;
            }
            else {
```

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```
            if (temp1.degree < temp2.degree) {

                if ((temp1.sibling == null)
                    || (temp1.sibling.degree
                        > temp2.degree)) {
                    BinomialHeapNode tmp = temp2;
                    temp2 = temp2.sibling;
                    tmp.sibling = temp1.sibling;
                    temp1.sibling = tmp;
                    temp1 = tmp.sibling;
                }
                else {
                    temp1 = temp1.sibling;
                }
            }
            else {
                BinomialHeapNode tmp = temp1;
                temp1 = temp2;
                temp2 = temp2.sibling;
                temp1.sibling = tmp;

                if (tmp == Nodes) {
                    Nodes = temp1;
                }

                else {
                }
            }
        }
    }
    if (temp1 == null) {
        temp1 = Nodes;
        while (temp1.sibling != null) {
            temp1 = temp1.sibling;
        }
        temp1.sibling = temp2;
    }
    else {
    }
}
private void unionNodes(BinomialHeapNode binHeap)
{
    merge(binHeap);
    BinomialHeapNode prevTemp = null, temp = Nodes,
                     nextTemp = Nodes.sibling;
    while (nextTemp != null) {
        if ((temp.degree != nextTemp.degree)
            || ((nextTemp.sibling != null)
                && (nextTemp.sibling.degree
```

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```
                    == temp.degree))) {
                prevTemp = temp;
                temp = nextTemp;
            }
            else {
                if (temp.key <= nextTemp.key) {
                    temp.sibling = nextTemp.sibling;
                    nextTemp.parent = temp;
                    nextTemp.sibling = temp.child;
                    temp.child = nextTemp;
                    temp.degree++;
                }

                else {

                    if (prevTemp == null) {
                        Nodes = nextTemp;
                    }

                    else {
                        prevTemp.sibling = nextTemp;
                    }

                    temp.parent = nextTemp;
                    temp.sibling = nextTemp.child;
                    nextTemp.child = temp;
                    nextTemp.degree++;
                    temp = nextTemp;
                }
            }
            nextTemp = temp.sibling;
        }
    }
    public int findMinimum()
    {
        return Nodes.findMinNode().key;
    }
    public void delete(int value)
    {
        if ((Nodes != null)
            && (Nodes.findANodeWithKey(value) != null)) {
            decreaseKeyValue(value, findMinimum() - 1);
            extractMin();
        }
    }
    public void decreaseKeyValue(int old_value,
                                 int new_value)
    {
        BinomialHeapNode temp
```

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```
            = Nodes.findANodeWithKey(old_value);
        if (temp == null)
            return;
        temp.key = new_value;
        BinomialHeapNode tempParent = temp.parent;

        while ((tempParent != null)
            && (temp.key < tempParent.key)) {
            int z = temp.key;
            temp.key = tempParent.key;
            tempParent.key = z;

            temp = tempParent;
            tempParent = tempParent.parent;
        }
    }
    public int extractMin()
    {
        if (Nodes == null)
            return -1;

        BinomialHeapNode temp = Nodes, prevTemp = null;
        BinomialHeapNode minNode = Nodes.findMinNode();

        while (temp.key != minNode.key) {
            prevTemp = temp;
            temp = temp.sibling;
        }

        if (prevTemp == null) {
            Nodes = temp.sibling;
        }
        else {
            prevTemp.sibling = temp.sibling;
        }

        temp = temp.child;
        BinomialHeapNode fakeNode = temp;

        while (temp != null) {
            temp.parent = null;
            temp = temp.sibling;
        }

        if ((Nodes == null) && (fakeNode == null)) {
            size = 0;
        }
        else {
            if ((Nodes == null) && (fakeNode != null)) {
```

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```
                Nodes = fakeNode.reverse(null);
                size = Nodes.getSize();
            }
            else {
                if ((Nodes != null) && (fakeNode == null)) {
                    size = Nodes.getSize();
                }
                else {
                    unionNodes(fakeNode.reverse(null));
                    size = Nodes.getSize();
                }
            }
        }

        return minNode.key;
    }
    public void displayHeap()
    {
        System.out.print("\nHeap : ");
        displayHeap(Nodes);
        System.out.println("\n");
    }

    private void displayHeap(BinomialHeapNode r)
    {
        if (r != null) {
            displayHeap(r.child);
            System.out.print(r.key + " ");
            displayHeap(r.sibling);
        }
    }
}
public class GFG {
    public static void main(String[] args)
    {
        BinomialHeap binHeap = new BinomialHeap();
        binHeap.insert(12);
        binHeap.insert(8);
        binHeap.insert(5);
        binHeap.insert(15);
        binHeap.insert(7);
        binHeap.insert(2);
        binHeap.insert(9);
        System.out.println("Size of the binomial heap is "
                           + binHeap.getSize());
        binHeap.displayHeap();
        binHeap.delete(15);
        binHeap.delete(8);
```

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```
        System.out.println("Size of the binomial heap is "
                        + binHeap.getSize());

        binHeap.displayHeap();
        binHeap.makeEmpty();
        System.out.println(binHeap.isEmpty());
    }
}
```

OUTPUT:

```
Size of the binomial heap is 7

Heap : 9 7 2 12 8 15 5

Size of the binomial heap is 5

Heap : 7 9 5 12 2

true
```

CONCLUSION: In this experiment we understood the implementation of binomial heap.

REFERENCES:

1. Peter Brass, "Advanced Data Structures", Cambridge University Press, 2008
2. Robert Sedgewick & Kevin Wayne, "Algorithms", 4th Edition, Addison-Wesley Professional, 2011.