



# RAJSHAHI UNIVERSITY OF ENGINEERING AND TECHNOLOGY

Course No: CSE 2201

Course Title: Sessional Based on CSE-2201

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## Problem Name: Dijkstra Algorithm

### Source Code (Using BinaryHeap + Adjacency List ) :

```
package algorithm;

import java.util.LinkedList;
import java.util.Scanner;

public class dijkstra_heap_1803078{

    static class Edge{

        int source;
        int destination;
        int weight;

        public Edge(int source,int destination,int weight){
            this.source=source;
            this.destination=destination;
            this.weight=weight;
        }
    }

    static class HeapNode{

        int vertex;
        int distance;
    }

    static class Graph{

        int vertices;
        LinkedList<Edge>[] adjacencylist;

        Graph(int vertices){
            this.vertices=vertices;
            adjacencylist=new LinkedList[vertices];
            for(int i=0;i<vertices;i++){
                adjacencylist[i]=new LinkedList<>();
            }
        }

        public void addEdge(int source,int destination,int weight){
            Edge edge=new Edge(source,destination,weight);
            adjacencylist[source].addFirst(edge);
        }
    }
}
```

```

        edge=new Edge(destination,source,weight);
        adjacencylist[destination].addFirst(edge); //for undirected graph
    }

    public void dijkstra_GetMinDistances(int sourceVertex,int end){
        int INFINITY=Integer.MAX_VALUE;
        boolean[] SPT=new boolean[vertices];

        HeapNode[] heapNodes=new HeapNode[vertices];
        for(int i=0;i<vertices;i++){
            heapNodes[i]=new HeapNode();
            heapNodes[i].vertex=i;
            heapNodes[i].distance=INFINITY;
        }

        heapNodes[sourceVertex].distance=0;

        MinHeap minHeap=new MinHeap(vertices);
        for(int i=0;i<vertices;i++){
            minHeap.insert(heapNodes[i]);
        }
        while(!minHeap.isEmpty()){

            HeapNode extractedNode=minHeap.extractMin();

            int extractedVertex=extractedNode.vertex;
            SPT[extractedVertex]=true;

            LinkedList<Edge> list=adjacencylist[extractedVertex];
            for(int i=0;i<list.size();i++){
                Edge edge=list.get(i);
                int destination=edge.destination;

                if(SPT[destination]==false){

                    int
newKey=heapNodes[extractedVertex].distance+edge.weight;
                    int currentKey=heapNodes[destination].distance;
                    if(currentKey>newKey){
                        decreaseKey(minHeap,newKey,destination);
                        heapNodes[destination].distance=newKey;
                    }
                }
            }
        }

        printDijkstra(heapNodes,sourceVertex,end);
    }

```

```

        public void decreaseKey(MinHeap minHeap,int newKey,int vertex){

            int index=minHeap.indexes[vertex];

            HeapNode node=minHeap.mH[index];
            node.distance=newKey;
            minHeap.bubbleUp(index);
        }

        public void printDijkstra(HeapNode[] resultSet,int sourceVertex,int end){
            System.out.println("Smallest distance from Vertex: "+(sourceVertex+1)+"
to vertex "+end+" distance: "+resultSet[end-1].distance);

        }
    }

    static class MinHeap{

        int capacity;
        int currentSize;
        HeapNode[] mH;
        int[] indexes;

        public MinHeap(int capacity){
            this.capacity=capacity;
            mH=new HeapNode[capacity+1];
            indexes=new int[capacity];
            mH[0]=new HeapNode();
            mH[0].distance=Integer.MIN_VALUE;
            mH[0].vertex=-1;
            currentSize=0;
        }

        public void insert(HeapNode x){
            currentSize++;
            int idx=currentSize;
            mH[idx]=x;
            indexes[x.vertex]=idx;
            bubbleUp(idx);
        }

        public void bubbleUp(int pos){
            int parentIdx=pos/2;
            int currentIdx=pos;
            while(currentIdx>0&& mH[parentIdx].distance>mH[currentIdx].distance){
                HeapNode currentNode=mH[currentIdx];
                HeapNode parentNode=mH[parentIdx];
            }
        }
    }

```

```

        indexes[currentNode.vertex]=parentIdx;
        indexes[parentNode.vertex]=currentIdx;
        swap(currentIdx,parentIdx);
        currentIdx=parentIdx;
        parentIdx=parentIdx/2;
    }
}

public HeapNode extractMin(){
    HeapNode min=mH[1];
    HeapNode lastNode=mH[currentSize];

    indexes[lastNode.vertex]=1;
    mH[1]=lastNode;
    mH[currentSize]=null;
    sinkDown(1);
    currentSize--;
    return min;
}

public void sinkDown(int k){
    int smallest=k;
    int leftChildIdx=2*k;
    int rightChildIdx=2*k+1;

    if(leftChildIdx<heapSize()&& mH[smallest].distance>mH[leftChildIdx].distance){
        smallest=leftChildIdx;
    }

    if(rightChildIdx<heapSize()&& mH[smallest].distance>mH[rightChildIdx].distance){
        smallest=rightChildIdx;
    }
    if(smallest!=k){

        HeapNode smallestNode=mH[smallest];
        HeapNode kNode=mH[k];

        indexes[smallestNode.vertex]=k;
        indexes[kNode.vertex]=smallest;
        swap(k,smallest);
        sinkDown(smallest);
    }
}

public void swap(int a,int b){
    HeapNode temp=mH[a];
    mH[a]=mH[b];

```

```

        mH[b]=temp;
    }

    public boolean isEmpty(){
        return currentSize==0;
    }

    public int heapSize(){
        return currentSize;
    }
}

public static void main(String[] args){
    Scanner ob=new Scanner(System.in);

    int v=ob.nextInt();
    int e=ob.nextInt();
    Graph graph=new Graph(v);
    for(int i=0;i<e;i++){
        int u1=ob.nextInt();
        int v1=ob.nextInt();
        int c=ob.nextInt();
        graph.addEdge(u1-1,v1-1,c);
    }
    System.out.println("Enter start node: ");
    int start=ob.nextInt();
    System.out.println("Enter end node: ");
    int end=ob.nextInt();

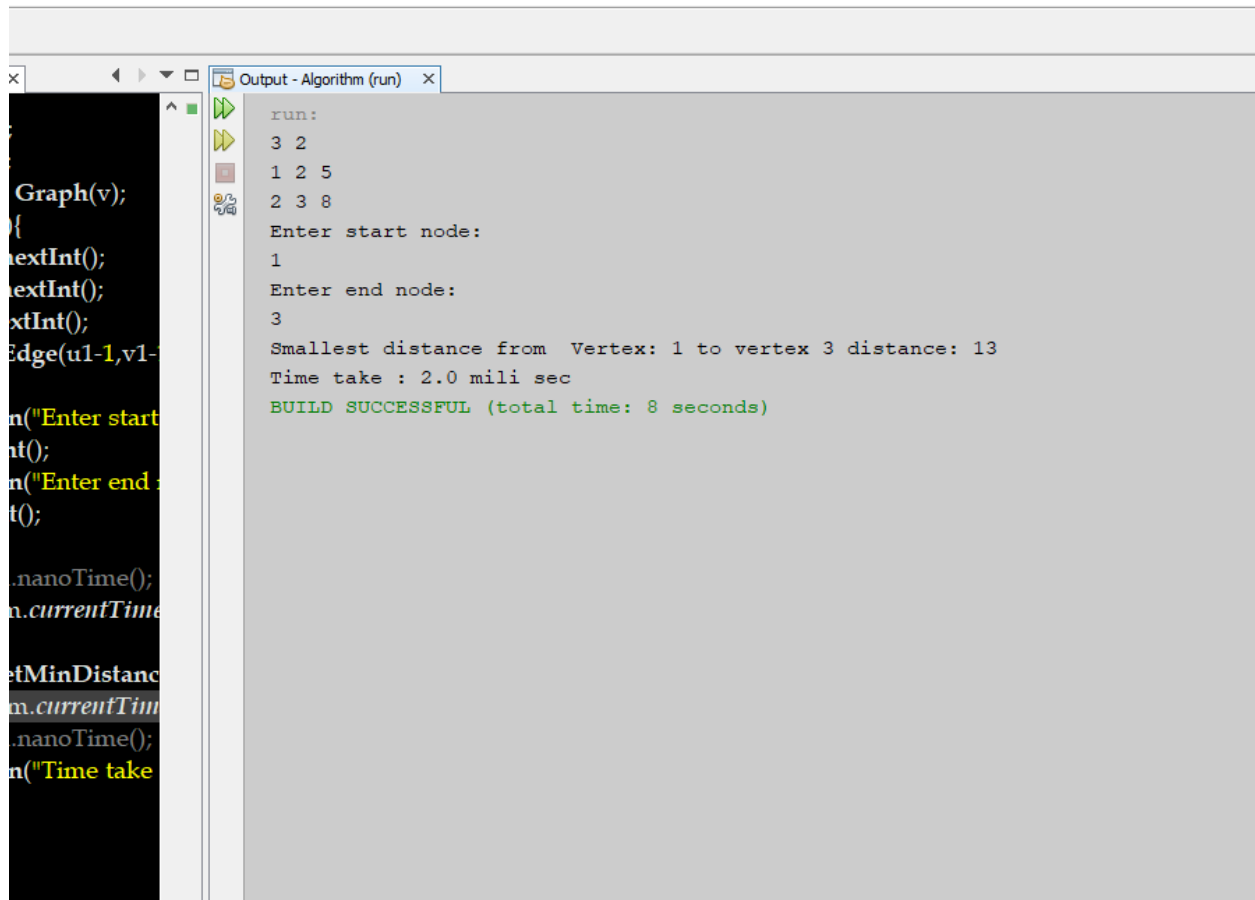
    //long t1=System.nanoTime();
    double t11=System.currentTimeMillis();

    graph.dijkstra_GetMinDistances(start-1,end);
    double t22=System.currentTimeMillis();
    //long t2=System.nanoTime();
    System.out.println("Time take : "+(t22-t11)+" mili sec");

}
}

```

## Sample Input and Output:



The screenshot shows a C++ IDE with a dark-themed editor on the left and a light-themed output window on the right. The editor contains code for a graph algorithm, including functions for reading input, calculating shortest paths, and timing the execution. The output window, titled "Output - Algorithm (run)", displays the program's execution results, including the input graph, the start and end nodes, the shortest distance, and the execution time.

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Edge(u1-1,v1-1);

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```
run:
3 2
1 2 5
2 3 8
Enter start node:
1
Enter end node:
3
Smallest distance from Vertex: 1 to vertex 3 distance: 13
Time take : 2.0 mili sec
BUILD SUCCESSFUL (total time: 8 seconds)
```

## Source Code (Using Priority Queue + Adjacency Matrix ) :

```
package algorithm;

import java.util.Scanner;

public class Dijkstra{

    public static void dijkstra(int[][] graph,int source,int start_node,int end_node){
        int count=graph.length;
        boolean[] visitedVertex=new boolean[count+1+1];
        int[] distance=new int[count];
        for(int i=1;i<count;i++){
            visitedVertex[i]=false;
            distance[i]=Integer.MAX_VALUE;
        }

        distance[source]=0;
        for(int i=1;i<count;i++){
            int u=findMinDistance(distance,visitedVertex);
            visitedVertex[u]=true;
            for(int v=1;v<count;v++){

                if(!visitedVertex[v]&&graph[u][v]!=0&&(distance[u]+graph[u][v]<distance[v])){
                    distance[v]=distance[u]+graph[u][v];
                }
            }
        }
        System.out.println("Shortest distance from node "+start_node+"th to node "+
end_node+"th is : "+distance[end_node]);
    }

    private static int findMinDistance(int[] distance,boolean[] visitedVertex){
        int minDistance=Integer.MAX_VALUE;
        int minDistanceVertex=-1;
        for(int i=1;i<distance.length;i++){
            if(!visitedVertex[i]&&distance[i]<minDistance){
                minDistance=distance[i];
                minDistanceVertex=i;
            }
        }
        return minDistanceVertex;
    }

    public static void main(String[] args){
```



```

Scanner ob=new Scanner (System.in);
int v=ob.nextInt();
int e=ob.nextInt();
int graph[][]=new int[v+1][v+1];

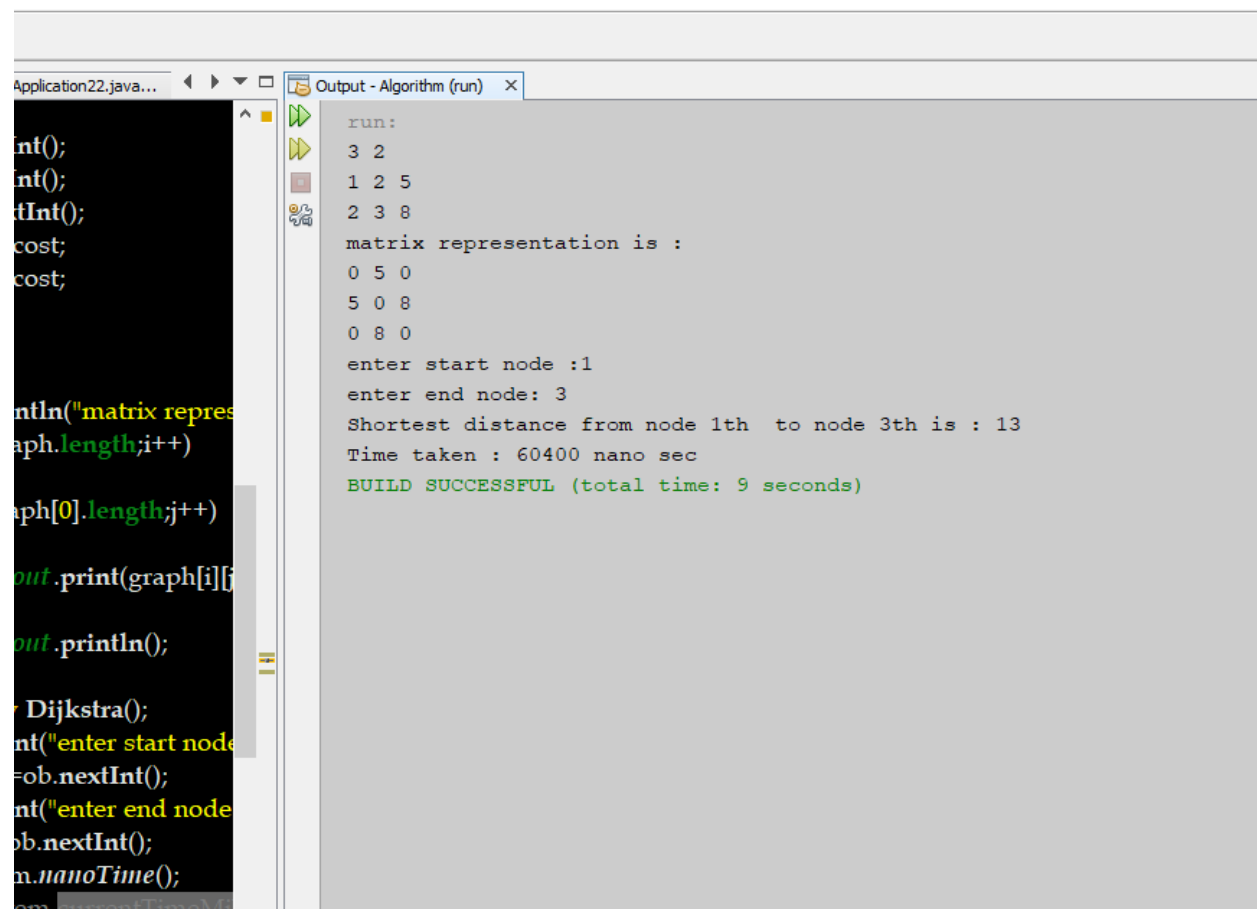
for(int j=0;j<e;j++)
{
int v1=ob.nextInt();
int v2=ob.nextInt();
int cost=ob.nextInt();
graph[v1][v2]=cost;
graph[v2][v1]=cost;

}

System.out.println("matrix representation is : ");
for(int i=1;i<graph.length;i++)
{
for(int j=1;j<graph[0].length;j++)
{
System.out.print(graph[i][j]+" ");
}
System.out.println();
}
Dijkstra T=new Dijkstra();
System.out.print("enter start node :");
int start_node =ob.nextInt();
System.out.print("enter end node: ");
int end_node=ob.nextInt();
long t11=System.nanoTime();
//long t1=System.currentTimeMillis();
T.dijkstra(graph,start_node,start_node,end_node);
//long t2=System.currentTimeMillis();
long t22=System.nanoTime();
System.out.println("Time taken : "+(t22-t11)+" nano sec");
}
}

```

## Sample output:



The screenshot shows a Java IDE with a file named 'Application22.java' and an 'Output - Algorithm (run)' window. The code on the left is partially visible, showing a Dijkstra's algorithm implementation. The output window on the right displays the following text:

```
run:
3 2
1 2 5
2 3 8
matrix representation is :
0 5 0
5 0 8
0 8 0
enter start node :1
enter end node: 3
Shortest distance from node 1th  to node 3th is : 13
Time taken : 60400 nano sec
BUILD SUCCESSFUL (total time: 9 seconds)
```

## Source Code (Using Priority Queue + Adjacency List ) :

```
package algorithm;

import javafx.util.Pair;
import java.util.Comparator;
import java.util.LinkedList;
import java.util.PriorityQueue;
import java.util.Scanner;

public class Dijkstra_PQ{

    static class Edge{

        int source;
        int destination;
        int weight;

        public Edge(int source,int destination,int weight){
            this.source=source;
            this.destination=destination;
            this.weight=weight;
        }
    }

    static class Graph{

        int vertices;
        static LinkedList<Edge>[] adjacencylist;

        Graph(int vertices){
            this.vertices=vertices;
            adjacencylist=new LinkedList[vertices];

            for(int i=0;i<vertices;i++){
                adjacencylist[i]=new LinkedList<>();
            }
        }

        public void addEdge(int source,int destination,int weight){
            Edge edge=new Edge(source,destination,weight);
            adjacencylist[source].addFirst(edge);

            edge=new Edge(destination,source,weight);
```

```

        adjacencylist[destination].addFirst(edge);
    }

    public void dijkstra_GetMinDistances(int sourceVertex,int start,int end){

        boolean[] SPT=new boolean[vertices];

        int[] distance=new int[vertices];

        for(int i=0;i<vertices;i++){
            distance[i]=Integer.MAX_VALUE;
        }

        PriorityQueue<Pair<Integer,Integer>> pq=new
PriorityQueue<>(vertices,new Comparator<Pair<Integer,Integer>>(){

            public int compare(Pair<Integer,Integer> p1,Pair<Integer,Integer>
p2){

                int key1=p1.getKey();
                int key2=p2.getKey();
                return key1-key2;
            }
        });

        distance[0]=0;
        Pair<Integer,Integer> p0=new Pair<>(distance[0],0);

        pq.offer(p0);

        while(!pq.isEmpty()){

            Pair<Integer,Integer> extractedPair=pq.poll();

            int extractedVertex=extractedPair.getValue();
            if(SPT[extractedVertex]==false){
                SPT[extractedVertex]=true;

                LinkedList<Edge> list=adjacencylist[extractedVertex];
                for(int i=0;i<list.size();i++){
                    Edge edge=list.get(i);
                    int destination=edge.destination;

                    if(SPT[destination]==false){

```

```

newKey=distance[extractedVertex]+edge.weight;

Pair<>(newKey,destination);

        int
        int currentKey=distance[destination];
        if(currentKey>newKey){
            Pair<Integer,Integer> p=new
            pq.offer(p);
            distance[destination]=newKey;
        }
    }
}

    }
}

        printDijkstra(distance,sourceVertex,start,end);
    }

    public void printDijkstra(int[] distance,int sourceVertex,int start,int end){

        System.out.println("Shortest distance from "+start+"th to "+end+"th is :
        "+distance[end-1]);

    }

    public static void main(String[] args){
        Scanner ob=new Scanner(System.in);

        int v=ob.nextInt();
        int e=ob.nextInt();
        Graph graph=new Graph(v);
        for(int i=0;i<e;i++)
        {
            int u1=ob.nextInt();
            int v1=ob.nextInt();
            int c=ob.nextInt();

            graph.addEdge(u1-1,v1-1,c);
        }

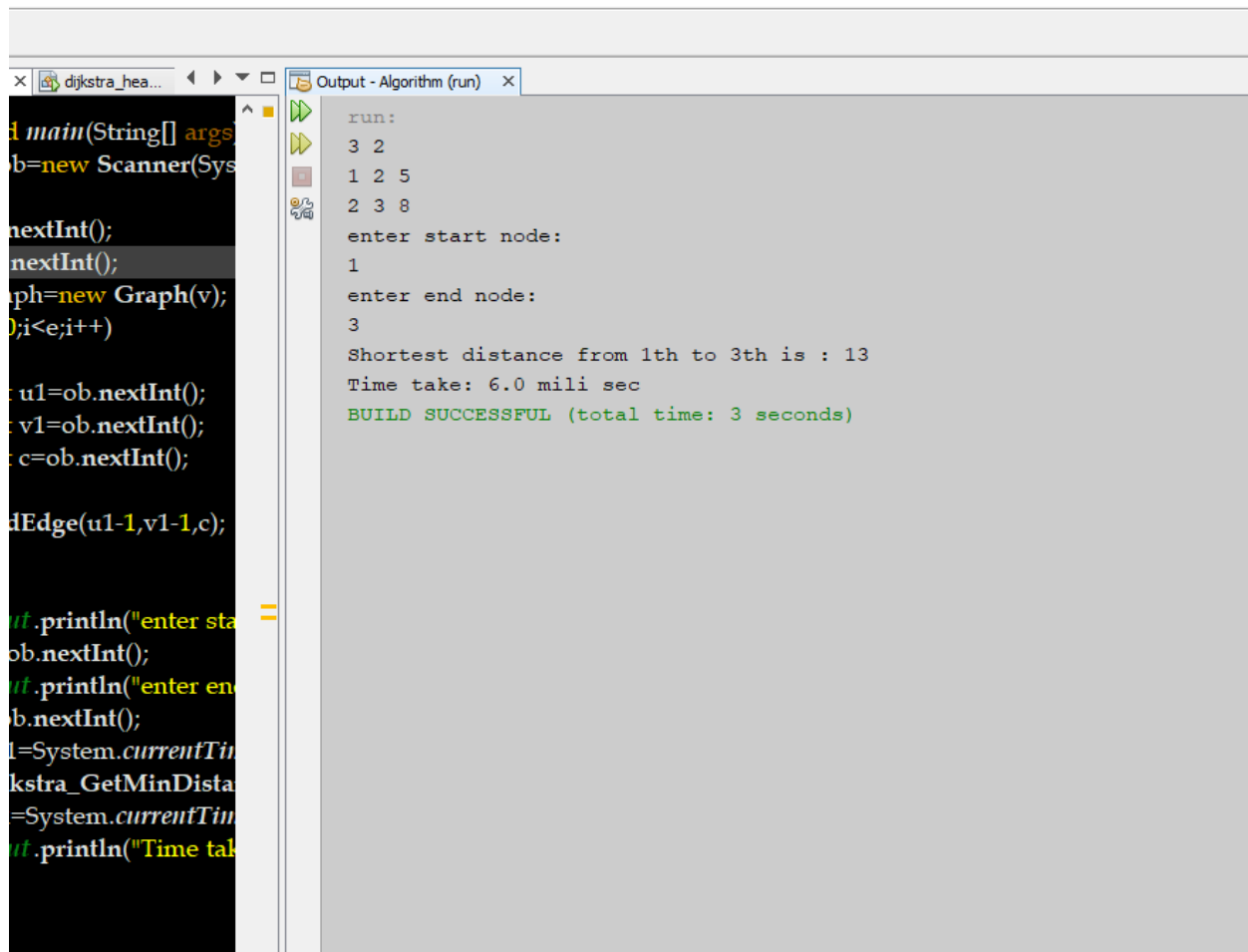
        System.out.println("enter start node:");
        int start=ob.nextInt();
        System.out.println("enter end node:");
        int end=ob.nextInt();
        double t1=System.currentTimeMillis();
        graph.dijkstra_GetMinDistances(start-1,start,end);
        double t2=System.currentTimeMillis();
        System.out.println("Time take: "+(t2-t1)+" mili sec ");

    }
}

```

```
}  
}
```

## Sample output:



The screenshot shows a Java IDE with a code editor on the left and an output window on the right. The code editor displays a snippet of Java code for a Dijkstra's algorithm implementation. The output window shows the execution results, including input data, start and end nodes, the shortest distance, and execution time.

```
1 main(String[] args,  
2 ob=new Scanner(System.  
3  
4 nextInt();  
5 nextInt();  
6 ph=new Graph(v);  
7 for(i<e;i++)  
8  
9 u1=ob.nextInt();  
10 v1=ob.nextInt();  
11 c=ob.nextInt();  
12 addEdge(u1-1,v1-1,c);  
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```

```
run:  
3 2  
1 2 5  
2 3 8  
enter start node:  
1  
enter end node:  
3  
Shortest distance from 1th to 3th is : 13  
Time take: 6.0 mili sec  
BUILD SUCCESSFUL (total time: 3 seconds)
```

## Source Code (Using Unsorted + Adjacency Matrix ) :

```
package algorithm;

import java.util.Scanner;

public class Dijkstra{

    public static void dijkstra(int[][] graph,int source,int start_node,int end_node){
        int count=graph.length;
        boolean[] visitedVertex=new boolean[count+1+1];
        int[] distance=new int[count];
        for(int i=1;i<count;i++){
            visitedVertex[i]=false;
            distance[i]=Integer.MAX_VALUE;
        }

        distance[source]=0;
        for(int i=1;i<count;i++){
            int u=findMinDistance(distance,visitedVertex);
            visitedVertex[u]=true;
            for(int v=1;v<count;v++){

                if(!visitedVertex[v]&&graph[u][v]!=0&&(distance[u]+graph[u][v]<distance[v])){
                    distance[v]=distance[u]+graph[u][v];
                }
            }
        }
        System.out.println("Shortest distance from node "+start_node+"th to node "+
end_node+"th is : "+distance[end_node]);
    }

    private static int findMinDistance(int[] distance,boolean[] visitedVertex){
        int minDistance=Integer.MAX_VALUE;
        int minDistanceVertex=-1;
        for(int i=1;i<distance.length;i++){
            if(!visitedVertex[i]&&distance[i]<minDistance){
                minDistance=distance[i];
                minDistanceVertex=i;
            }
        }
        return minDistanceVertex;
    }
}
```

```

    }

    public static void main(String[] args){
        Scanner ob=new Scanner (System.in);
        int v=ob.nextInt();
        int e=ob.nextInt();
        int graph[][]=new int[v+1][v+1];

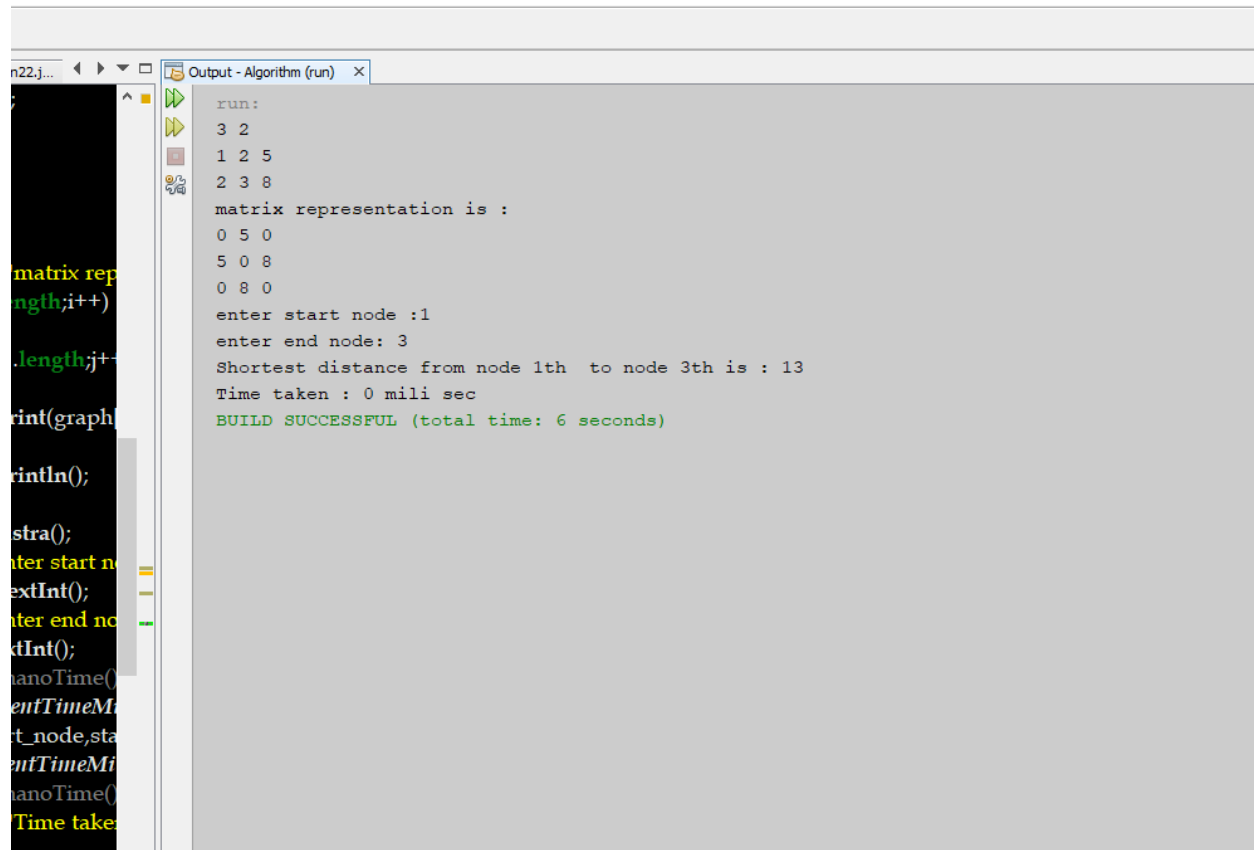
        for(int j=0;j<e;j++)
        {
            int v1=ob.nextInt();
            int v2=ob.nextInt();
            int cost=ob.nextInt();
            graph[v1][v2]=cost;
            graph[v2][v1]=cost;
        }

        System.out.println("matrix representation is : ");
        for(int i=1;i<graph.length;i++)
        {
            for(int j=1;j<graph[0].length;j++)
            {
                System.out.print(graph[i][j]+" ");
            }
            System.out.println();
        }
        Dijkstra T=new Dijkstra();
        System.out.print("enter start node :");
        int start_node =ob.nextInt();
        System.out.print("enter end node: ");
        int end_node=ob.nextInt();
        //long t11=System.nanoTime();
        long t1=System.currentTimeMillis();
        T.dijkstra(graph,start_node,start_node,end_node);
        long t2=System.currentTimeMillis();
        //long t22=System.nanoTime();
        System.out.println("Time taken : "+(t2-t1)+" mili sec");
    }
}

```



## Sample output:



```
n22.j...
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.length;j+
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Time take

run:
3 2
1 2 5
2 3 8
matrix representation is :
0 5 0
5 0 8
0 8 0
enter start node :1
enter end node: 3
Shortest distance from node 1th  to node 3th is : 13
Time taken : 0 mili sec
BUILD SUCCESSFUL (total time: 6 seconds)
```

**Performance table:(for vertex=100)**

<b>Priority Queue Data Structure</b>	<b>Adjacency list</b>	<b>Adjacency matrix</b>
<b>Binary Heap</b>	<b>0.12 mili sec</b>	<b>2.103 mili sec</b>
<b>Unsorted Array</b>	<b>1.001 mili sec</b>	<b>2.989 mili sec</b>

## Problem : Kruskals Algorithm

### Source Code:

```
package algorithm;

import java.util.*;
import java.lang.*;

import java.io.*;

class Graph{

    class Edge implements Comparable<Edge>{

        int src, dest, weight;

        public int compareTo(Edge compareEdge){
            return this.weight-compareEdge.weight;
        }
    };

    class subset{

        int parent, rank;
    };
    int V, E;
    Edge edge[];

    Graph(int v,int e){
        V=v;
        E=e;
        edge=new Edge[E];
        for(int i=0;i<e;++i){
            edge[i]=new Edge();
        }
    }

    int find(subset subsets[],int i){

        if(subsets[i].parent!=i){
            subsets[i].parent=find(subsets,subsets[i].parent);
        }
    }
}
```

```

    }
    return subsets[i].parent;
}

void Union(subset subsets[],int x,int y){
    int xroot=find(subsets,x);
    int yroot=find(subsets,y);

    if(subsets[xroot].rank<subsets[yroot].rank){
        subsets[xroot].parent=yroot;
    } else if(subsets[xroot].rank>subsets[yroot].rank){
        subsets[yroot].parent=xroot;
    } else{
        subsets[yroot].parent=xroot;
        subsets[xroot].rank++;
    }
}

void KruskalMST(){
    Edge result[]=new Edge[V];
    int e=0;
    int i=0;
    for(i=0;i<V;++i){
        result[i]=new Edge();
    }

    Arrays.sort(edge);

    subset subsets[]=new subset[V];
    for(i=0;i<V;++i){
        subsets[i]=new subset();
    }

    for(int v=0;v<V;++v){
        subsets[v].parent=v;
        subsets[v].rank=0;
    }
    i=0;
    while(e<V-1){

        Edge next_edge=new Edge();
        next_edge=edge[i++];
        int x=find(subsets,next_edge.src);
        int y=find(subsets,next_edge.dest);

        if(x!=y){
            result[e++]=next_edge;
            Union(subsets,x,y);

```

```

    }

    }
    int minimumCost=0;
    System.out.println("The constructed MST contains edges : ");
    for(i=0;i<e;++i){
        System.out.println((result[i].src+1)+" -- "+(result[i].dest+1)+" ==
"+result[i].weight);
        minimumCost+=result[i].weight;
    }
    System.out.println("Total Minimum Cost : "+minimumCost);
}

public static void main(String[] args){

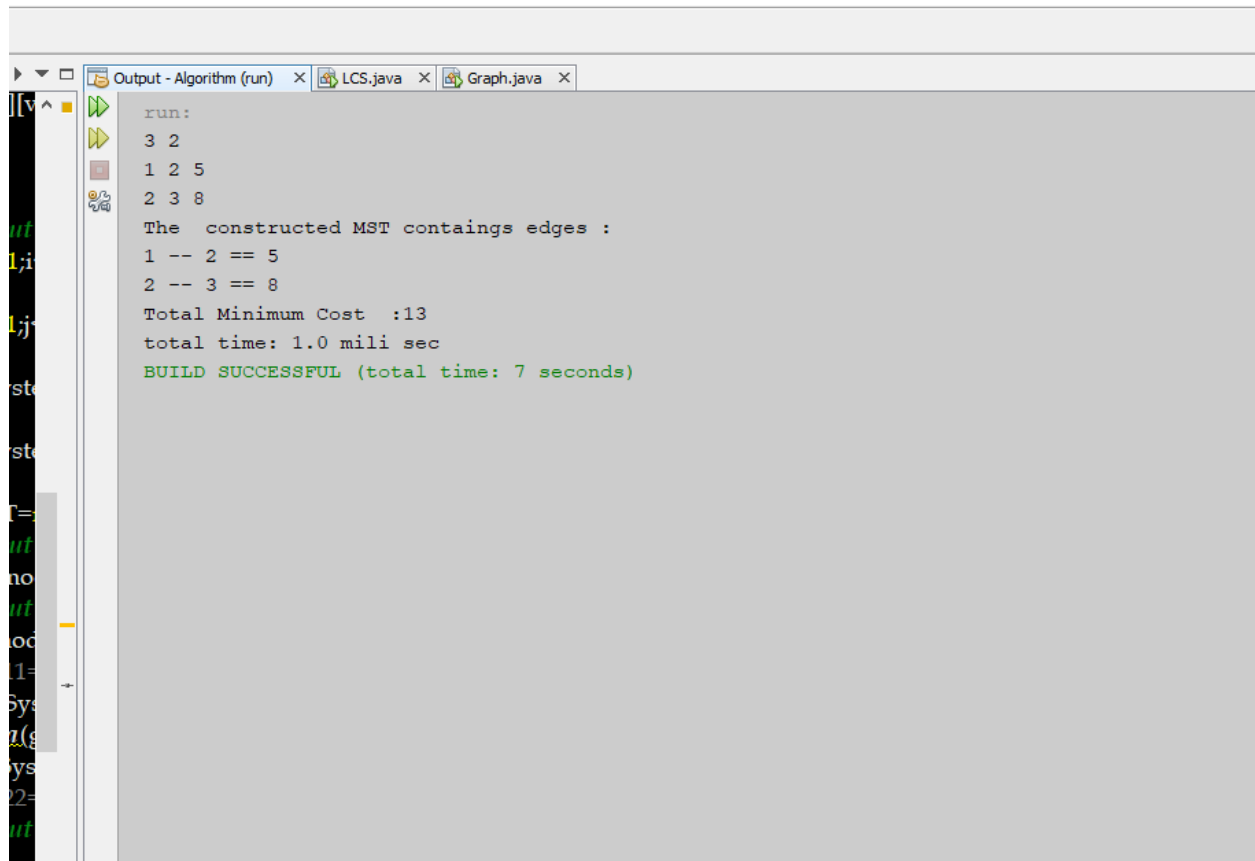
    Scanner ob=new Scanner(System.in);
    int V=ob.nextInt();
    int E=ob.nextInt();
    Graph graph=new Graph(V,E);
    for(int i=0;i<E;i++){
        int u1=ob.nextInt();
        int v1=ob.nextInt();
        int c=ob.nextInt();
        graph.edge[i].src=u1-1;
        graph.edge[i].dest=v1-1;
        graph.edge[i].weight=c;

    }

    double t1=System.currentTimeMillis();
    graph.KruskalMST();
    double t2=System.currentTimeMillis();
    System.out.println("total time: "+(t2-t1)+" mili sec");
}
}

```

## Output:



The screenshot shows an IDE with three tabs: "Output - Algorithm (run)", "LCS.java", and "Graph.java". The "Output - Algorithm (run)" tab is active and displays the following text:

```
run:
3 2
1 2 5
2 3 8
The constructed MST contains edges :
1 -- 2 == 5
2 -- 3 == 8
Total Minimum Cost :13
total time: 1.0 mili sec
BUILD SUCCESSFUL (total time: 7 seconds)
```

The output indicates that the algorithm successfully constructed an MST with a total minimum cost of 13. The edges included in the MST are (1, 2) with a weight of 5 and (2, 3) with a weight of 8. The total execution time was 1.0 milliseconds.

**Performance table:(For Vertex  $\geq 100$ )**

<b>V</b>	<b>E</b>	<b>Time (path compression)</b>	<b>Time(Without path compression )</b>	<b>Solution(total cost)</b>
<b>100</b>	<b>100</b>	<b>3.580</b>	<b>2.106</b>	<b>4430</b>
<b>100</b>	<b>80</b>	<b>7.604</b>	<b>3.341</b>	<b>3589</b>
<b>100</b>	<b>50</b>	<b>6.616</b>	<b>5.565</b>	<b>2711</b>

## Problem: Longest Common Subsequence (Dynamic programming)

### Source Code:

```
package algorithm;

import java.util.Scanner;

public class LCS_1803078 {
    public static void main(String[] args){
        Scanner ob=new Scanner(System.in);
        String A=ob.next();
        String B=ob.next();
        int m=A.length(), n=B.length();
        int[][] ans=new int[m+1][n+1];
        for(int i=0;i<m;i++){
            ans[i][0]=0;

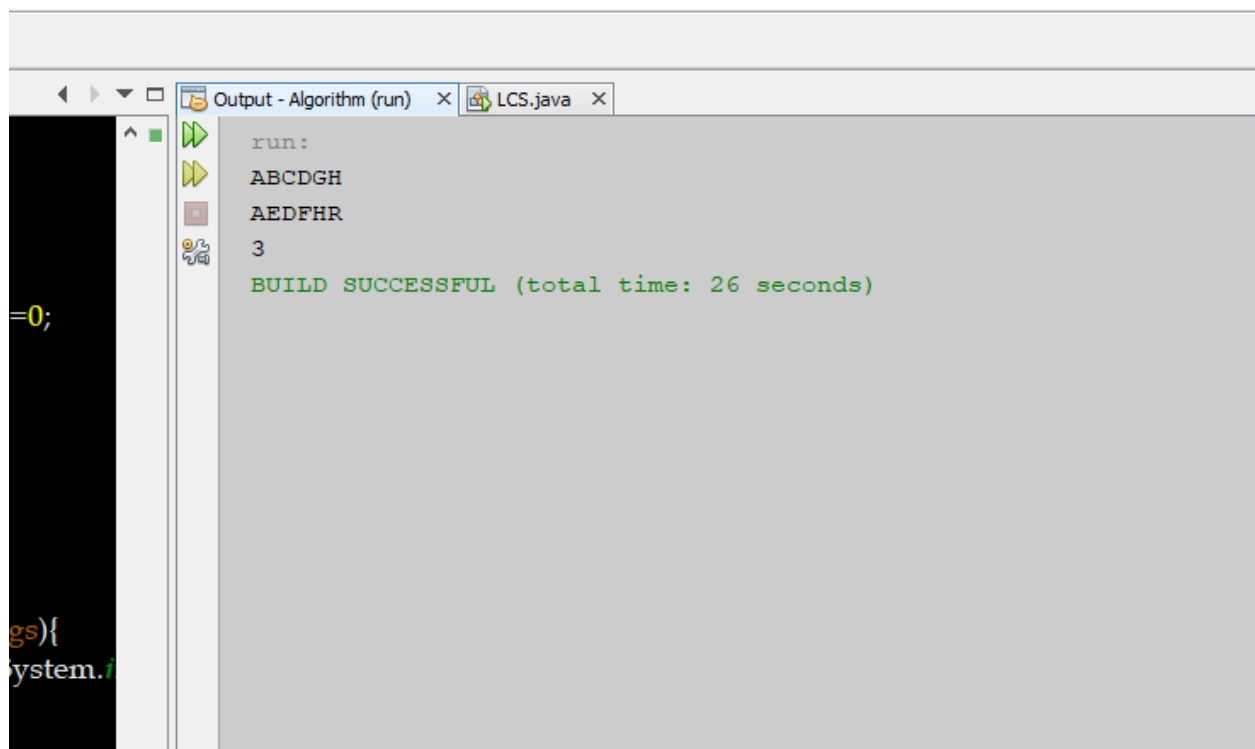
        }
        for(int j=0;j<n;j++){
            ans[0][j]=0;

        }
        for(int i=1;i<=m;i++){
            for(int j=1;j<=n;j++){
                if(A.charAt(i-1)==B.charAt(j-1)){
                    ans[i][j]=ans[i-1][j-1]+1;
                }else{
                    ans[i][j]=Math.max(ans[i-1][j],ans[i][j-1]);
                }
            }
        }
    }
}
```



```
        System.out.println(ans[m][n]);  
    }  
}
```

## Output:



```
run:  
ABCDGH  
AEDFHR  
3  
BUILD SUCCESSFUL (total time: 26 seconds)
```

```
gs){  
system.i
```