323.25 Project6: Dijkstra's Algorithm

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Algorithm Steps For Dijkstra's
S0: open inFile, SSSfile, deBugFile
S1: get numNodes from inFile
S2: create costmatrixarray[numNodes+1][numNodes+1], best[numNodes+1],
father[numNodes+1],toDo[numNodes+1]
S3: initialize everything in costmatrixarray to 999 except for diagonal, initialize all of toDo to one,
S4: loadCostMatrix(inFile)
S5: sourceNode=1, toDo[sourceNode]=0
S6: best[] = costmatrixarrat[][sourceNode]
S7: minNode = findMinNode
S8: toDo[minNode]=0
S9: debugPrint(deBugFile)
S8: currentNode=1
S9: if toDo[currentNode] > 0 {

        newCost computeCost (minNode, currentNode)

        if newCost < best [currentNode]
        best [currentNode] newCost
        father [currentNode] minNode

        debugPrint (...)

        }
S10: currentNode++
S11: repeat S9-S10 while currentNode<=numNodes
S12: repeat steps S7-S11
S13: currentNode = 1
S14: BufferedWriter writer = new BufferedWriter(new FileWriter(SSSfile,true));
                writer.write("Source node = "+sourceNode+"\n\n");
                for(; currentNode<=numNodes;currentNode++) {
                        writer.write("The path from "+ sourceNode +" to "+ currentNode+" : ");
                int cur= currentNode;
                while(cur!=sourceNode) {
                                writer.write(cur + "<-");
                        cur=father[cur];
                }
                writer.write(cur + ": cost = "+best[currentNode]+"\n");
                }
                writer.write("\n\n");
                writer.close();
S15: sourceNode++
S16: repeat steps S6-S15

S17: close files

Source Code (Alex_Baraian_Main)

```java
import java.io.*;

public class Alex_Baraian_Main {
        public static void main(String[] args) throws NumberFormatException, IOException {
                File inFile = new File(args[0]);          //Step 0
                File SSSfile = new File(args[1]);
                File deBugFile = new File(args[2]);
                Alex_Baraian_DijktraSSS thing = new Alex_Baraian_DijktraSSS();
                BufferedReader reader = new BufferedReader(new FileReader(inFile));
                BufferedWriter writer = new BufferedWriter(new FileWriter(SSSfile));

                thing.numNodes= Integer.parseInt(reader.readLine());
                thing.best= new int[thing.numNodes+1];
                thing.father = new int[thing.numNodes + 1];
                thing.costMatrix = new int[thing.numNodes+1][thing.numNodes+1];
                thing.loadCostMatrix(inFile);           //Step 1
                thing.sourceNode = 1;
                writer.write("There are "+thing.numNodes+" nodes in the input graph. Below are all pairs of the
shortest paths:\n\n");
                writer.flush();
                for(;thing.sourceNode<=thing.numNodes;thing.sourceNode++) {
                thing.setBest();     //Step 2
                thing.setFather();
                thing.setToDo();

        while(thing.doneToDo()!=true) {        //Step 8
                        thing.minNode = thing.findMinNode(); //Step 3
                        thing.toDo[thing.minNode]=0;
                        thing.debugPrint(deBugFile);
                        thing.currentNode =1;        //Step 4

                        for(;thing.currentNode<=thing.numNodes;thing.currentNode++) {          //Step 6 & 7
                                if(thing.toDo[thing.currentNode]>0) {//Step 5
                                        int newcost = thing.computCost();
                                        if(newcost<thing.best[thing.currentNode]) {
                                                thing.best[thing.currentNode]=newcost;
                                                thing.father[thing.currentNode]= thing.minNode;
                                                thing.debugPrint(deBugFile);
                                        }
                                }
                        }


                }
                thing.currentNode = 1; //Step 9
                thing.printShortestPath(SSSfile); //Step 10
                }
                writer.close();
                reader.close();

        }
```

```
}
```

Source Code (Alex_Baraian_DijktraSSS)

```java
import java.io.*;


public class Alex_Baraian_DijktraSSS {
        int numNodes;
        int sourceNode;
        int minNode;
        int currentNode;
        int newCost;
        int costMatrix[][];
        int father[];
        int toDo[];
        int best[];

        void loadCostMatrix(File inFile) throws IOException {

                for(int i=1;i<numNodes+1;i++) {
                        for(int j=1;j<numNodes+1;j++) {
                                if(i==j) {
                                        costMatrix[i][j]=0;
                                }
                                else {
                                        costMatrix[i][j]=999;
                                }
                        }
                }
                BufferedReader reader = new BufferedReader(new FileReader (inFile));
                reader.readLine();
                String line;
                int n1, n2, cost;
                while((line=reader.readLine())!=null) {
                        String words[] = line.split("\\s");
                        n1 = Integer.parseInt(words[0]);
                        n2 = Integer.parseInt(words[1]);
                        cost = Integer.parseInt(words[3]);
                        costMatrix[n1][n2]= cost;
                }
                reader.close();
        }
        void setBest() {
                for(int i = 1; i<numNodes+1;i++) {
                        best[i]= costMatrix[sourceNode][i];
                }
        }
        void setFather() {

                for(int i =1;i<numNodes+1;i++) {
                        father[i]=sourceNode;
                }
        }
        void setToDo() {
```

```java
                toDo = new int[numNodes+1];
                toDo[sourceNode]=0;
                for(int i =1; i<numNodes+1;i++) {
                        toDo[i]=1;
                }
        }
        int findMinNode() {
                int minCost = 99999;
                int index =1;
                minNode=0;
                for(;index<=numNodes;index++) {
                        if(toDo[index]>0) {
                                if(best[index]<minCost) {
                                        minCost = best[index];
                                        minNode = index;
                                }
                        }
                }
                return minNode;
        }
        int computCost() {
                return best[minNode]+costMatrix[minNode][currentNode];
        }
        void debugPrint(File deBugFile) throws IOException {
                BufferedWriter writer = new BufferedWriter(new FileWriter(deBugFile,true));
                writer.write("The Source Node Is: " + sourceNode +"\n\n");
                writer.write("The Father Array:\n");
                for(int i =0;i<=numNodes;i++) {
                        writer.write(father[i] + " ");
                }
                writer.write("\n\n");
                writer.write("The Best Array:\n");
                for(int i =0;i<=numNodes;i++) {
                        writer.write(best[i] + " ");
                }
                writer.write("\n\n");
                writer.write("The toDo Array:\n");
                for(int i =0;i<=numNodes;i++) {
                        writer.write(toDo[i] + " ");
                }
                writer.write("\n\n");
                writer.close();
        }
        boolean doneToDo() {
                for(int i = 1; i<numNodes+1;i++) {
                        if(toDo[i]==1) {
                                return false;
                        }
                }
                return true;
        }

        void printShortestPath(File SSSfile) throws IOException {
                BufferedWriter writer = new BufferedWriter(new FileWriter(SSSfile,true));
```

```
                    writer.write("Source node = "+sourceNode+"\n\n");
                    for(; currentNode<=numNodes;currentNode++) {
                            writer.write("The path from "+ sourceNode +" to "+ currentNode+" : ");
                    int cur= currentNode;
                    while(cur!=sourceNode) {
                                    writer.write(cur + "<-" );
                            cur=father[cur];
                    }
                    writer.write(cur + ": cost = "+best[currentNode]+"\n");
                    }
                    writer.write("\n\n");
                    writer.close();
            }
}
```

SSSfile for Data1

There are 5 nodes in the input graph. Below are all pairs of the shortest paths:

Source node = 1

The path from 1 to 1 : 1: cost = 0
The path from 1 to 2 : 2<-1: cost = 10
The path from 1 to 3 : 3<-4<-1: cost = 50
The path from 1 to 4 : 4<-1: cost = 30
The path from 1 to 5 : 5<-3<-4<-1: cost = 60

Source node = 2

The path from 2 to 1 : 1<-5<-3<-2: cost = 100
The path from 2 to 2 : 2: cost = 0
The path from 2 to 3 : 3<-2: cost = 50
The path from 2 to 4 : 4<-1<-5<-3<-2: cost = 130
The path from 2 to 5 : 5<-3<-2: cost = 60

Source node = 3

The path from 3 to 1 : 1<-5<-3: cost = 50
The path from 3 to 2 : 2<-1<-5<-3: cost = 60
The path from 3 to 3 : 3: cost = 0
The path from 3 to 4 : 4<-1<-5<-3: cost = 80
The path from 3 to 5 : 5<-3: cost = 10

Source node = 4

The path from 4 to 1 : 1<-5<-3<-4: cost = 70
The path from 4 to 2 : 2<-1<-5<-3<-4: cost = 80
The path from 4 to 3 : 3<-4: cost = 20
The path from 4 to 4 : 4: cost = 0
The path from 4 to 5 : 5<-3<-4: cost = 30

Source node = 5

The path from 5 to 1 : 1<-5: cost = 40
The path from 5 to 2 : 2<-1<-5: cost = 50

The path from 5 to 3 : 3<-4<-1<-5: cost = 90
The path from 5 to 4 : 4<-1<-5: cost = 70
The path from 5 to 5 : 5: cost = 0

deBugFile for Data1

The Source Node Is: 1

The Father Array:
0 1 1 1 1 1

The Best Array:
0 0 10 70 30 999

The toDo Array:
0 0 1 1 1 1

The Source Node Is: 1

The Father Array:
0 1 1 1 1 1

The Best Array:
0 0 10 70 30 999

The toDo Array:
0 0 0 1 1 1

The Source Node Is: 1

The Father Array:
0 1 1 2 1 1

The Best Array:
0 0 10 60 30 999

The toDo Array:
0 0 0 1 1 1

The Source Node Is: 1

The Father Array:
0 1 1 2 1 1

The Best Array:
0 0 10 60 30 999

The toDo Array:
0 0 0 1 0 1

The Source Node Is: 1

The Father Array:
0 1 1 4 1 1

The Best Array:
0 0 10 50 30 999

The toDo Array:
0 0 0 1 0 1

The Source Node Is: 1

The Father Array:
0 1 1 4 1 4

The Best Array:
0 0 10 50 30 90

The toDo Array:
0 0 0 1 0 1

The Source Node Is: 1

The Father Array:
0 1 1 4 1 4

The Best Array:
0 0 10 50 30 90

The toDo Array:
0 0 0 0 0 1

The Source Node Is: 1

The Father Array:
0 1 1 4 1 3

The Best Array:
0 0 10 50 30 60

The toDo Array:
0 0 0 0 0 1

The Source Node Is: 1

The Father Array:
0 1 1 4 1 3

The Best Array:
0 0 10 50 30 60

The toDo Array:
0 0 0 0 0 0

The Source Node Is: 2

The Father Array:
0 2 2 2 2 2

The Best Array:
0 999 0 50 999 999

The toDo Array:
0 1 0 1 1 1

The Source Node Is: 2

The Father Array:

0 2 2 2 2 2

The Best Array:
0 999 0 50 999 999

The toDo Array:
0 1 0 0 1 1

The Source Node Is: 2

The Father Array:
0 2 2 2 2 3

The Best Array:
0 999 0 50 999 60

The toDo Array:
0 1 0 0 1 1

The Source Node Is: 2

The Father Array:
0 2 2 2 2 3

The Best Array:
0 999 0 50 999 60

The toDo Array:
0 1 0 0 1 0

The Source Node Is: 2

The Father Array:
0 5 2 2 2 3

The Best Array:
0 100 0 50 999 60

The toDo Array:
0 1 0 0 1 0

The Source Node Is: 2

The Father Array:
0 5 2 2 2 3

The Best Array:
0 100 0 50 999 60

The toDo Array:
0 0 0 0 1 0

The Source Node Is: 2

The Father Array:
0 5 2 2 1 3

The Best Array:
0 100 0 50 130 60

The toDo Array:

0 0 0 0 1 0

The Source Node Is: 2

The Father Array:
0 5 2 2 1 3

The Best Array:
0 100 0 50 130 60

The toDo Array:
0 0 0 0 0 0

The Source Node Is: 3

The Father Array:
0 3 3 3 3 3

The Best Array:
0 999 999 0 999 10

The toDo Array:
0 1 1 0 1 1

The Source Node Is: 3

The Father Array:
0 3 3 3 3 3

The Best Array:
0 999 999 0 999 10

The toDo Array:
0 1 1 0 1 0

The Source Node Is: 3

The Father Array:
0 5 3 3 3 3

The Best Array:
0 50 999 0 999 10

The toDo Array:
0 1 1 0 1 0

The Source Node Is: 3

The Father Array:
0 5 3 3 3 3

The Best Array:
0 50 999 0 999 10

The toDo Array:
0 0 1 0 1 0

The Source Node Is: 3

The Father Array:
0 5 1 3 3 3

The Best Array:
0 50 60 0 999 10

The toDo Array:
0 0 1 0 1 0

The Source Node Is: 3

The Father Array:
0 5 1 3 1 3

The Best Array:
0 50 60 0 80 10

The toDo Array:
0 0 1 0 1 0

The Source Node Is: 3

The Father Array:
0 5 1 3 1 3

The Best Array:
0 50 60 0 80 10

The toDo Array:
0 0 0 0 1 0

The Source Node Is: 3

The Father Array:
0 5 1 3 1 3

The Best Array:
0 50 60 0 80 10

The toDo Array:
0 0 0 0 0 0

The Source Node Is: 4

The Father Array:
0 4 4 4 4 4

The Best Array:
0 999 999 20 0 60

The toDo Array:
0 1 1 1 0 1

The Source Node Is: 4

The Father Array:
0 4 4 4 4 4

The Best Array:
0 999 999 20 0 60

The toDo Array:
0 1 1 0 0 1

The Source Node Is: 4

The Father Array:
0 4 4 4 4 3

The Best Array:
0 999 999 20 0 30

The toDo Array:
0 1 1 0 0 1

The Source Node Is: 4

The Father Array:
0 4 4 4 4 3

The Best Array:
0 999 999 20 0 30

The toDo Array:
0 1 1 0 0 0

The Source Node Is: 4

The Father Array:
0 5 4 4 4 3

The Best Array:
0 70 999 20 0 30

The toDo Array:
0 1 1 0 0 0

The Source Node Is: 4

The Father Array:
0 5 4 4 4 3

The Best Array:
0 70 999 20 0 30

The toDo Array:
0 0 1 0 0 0

The Source Node Is: 4

The Father Array:
0 5 1 4 4 3

The Best Array:
0 70 80 20 0 30

The toDo Array:
0 0 1 0 0 0

The Source Node Is: 4

The Father Array:
0 5 1 4 4 3

The Best Array:
0 70 80 20 0 30

The toDo Array:
0 0 0 0 0 0

The Source Node Is: 5

The Father Array:
0 5 5 5 5 5

The Best Array:
0 40 999 999 999 0

The toDo Array:
0 1 1 1 1 0

The Source Node Is: 5

The Father Array:
0 5 5 5 5 5

The Best Array:
0 40 999 999 999 0

The toDo Array:
0 0 1 1 1 0

The Source Node Is: 5

The Father Array:
0 5 1 5 5 5

The Best Array:
0 40 50 999 999 0

The toDo Array:
0 0 1 1 1 0

The Source Node Is: 5

The Father Array:
0 5 1 1 5 5

The Best Array:
0 40 50 110 999 0

The toDo Array:
0 0 1 1 1 0

The Source Node Is: 5

The Father Array:
0 5 1 1 1 5

The Best Array:
0 40 50 110 70 0

The toDo Array:
0 0 1 1 1 0

The Source Node Is: 5

The Father Array:
0 5 1 1 1 5

The Best Array:
0 40 50 110 70 0

The toDo Array:
0 0 0 1 1 0

The Source Node Is: 5

The Father Array:
0 5 1 2 1 5

The Best Array:
0 40 50 100 70 0

The toDo Array:
0 0 0 1 1 0

The Source Node Is: 5

The Father Array:
0 5 1 2 1 5

The Best Array:
0 40 50 100 70 0

The toDo Array:
0 0 0 1 0 0

The Source Node Is: 5

The Father Array:
0 5 1 4 1 5

The Best Array:
0 40 50 90 70 0

The toDo Array:
0 0 0 1 0 0

The Source Node Is: 5

The Father Array:
0 5 1 4 1 5

The Best Array:
0 40 50 90 70 0

The toDo Array:
0 0 0 0 0 0

SSSfile for Data2

There are 8 nodes in the input graph. Below are all pairs of the shortest paths:

Source node = 1

The path from 1 to 1 : 1: cost = 0
The path from 1 to 2 : 2<-1: cost = 9
The path from 1 to 3 : 3<-1: cost = 5
The path from 1 to 4 : 4<-3<-1: cost = 10
The path from 1 to 5 : 5<-4<-3<-1: cost = 18
The path from 1 to 6 : 6<-4<-3<-1: cost = 13
The path from 1 to 7 : 7<-8<-2<-1: cost = 13
The path from 1 to 8 : 8<-2<-1: cost = 11

Source node = 2

The path from 2 to 1 : 1<-8<-2: cost = 8
The path from 2 to 2 : 2: cost = 0
The path from 2 to 3 : 3<-1<-8<-2: cost = 13
The path from 2 to 4 : 4<-7<-8<-2: cost = 8
The path from 2 to 5 : 5<-4<-7<-8<-2: cost = 16
The path from 2 to 6 : 6<-7<-8<-2: cost = 7
The path from 2 to 7 : 7<-8<-2: cost = 4
The path from 2 to 8 : 8<-2: cost = 2

Source node = 3

The path from 3 to 1 : 1<-6<-4<-3: cost = 14
The path from 3 to 2 : 2<-3: cost = 7
The path from 3 to 3 : 3: cost = 0
The path from 3 to 4 : 4<-3: cost = 5
The path from 3 to 5 : 5<-4<-3: cost = 13
The path from 3 to 6 : 6<-4<-3: cost = 8
The path from 3 to 7 : 7<-8<-3: cost = 11
The path from 3 to 8 : 8<-3: cost = 9

Source node = 4

The path from 4 to 1 : 1<-6<-4: cost = 9
The path from 4 to 2 : 2<-1<-6<-4: cost = 18
The path from 4 to 3 : 3<-1<-6<-4: cost = 14
The path from 4 to 4 : 4: cost = 0
The path from 4 to 5 : 5<-4: cost = 8
The path from 4 to 6 : 6<-4: cost = 3
The path from 4 to 7 : 7<-6<-4: cost = 7
The path from 4 to 8 : 8<-2<-1<-6<-4: cost = 20

Source node = 5

The path from 5 to 1 : 1<-6<-5: cost = 20
The path from 5 to 2 : 2<-1<-6<-5: cost = 29
The path from 5 to 3 : 3<-1<-6<-5: cost = 25
The path from 5 to 4 : 4<-7<-6<-5: cost = 22
The path from 5 to 5 : 5: cost = 0
The path from 5 to 6 : 6<-5: cost = 14
The path from 5 to 7 : 7<-6<-5: cost = 18
The path from 5 to 8 : 8<-2<-1<-6<-5: cost = 31

Source node = 6

The path from 6 to 1 : 1<-6: cost = 6
The path from 6 to 2 : 2<-1<-6: cost = 15
The path from 6 to 3 : 3<-1<-6: cost = 11
The path from 6 to 4 : 4<-7<-6: cost = 8
The path from 6 to 5 : 5<-4<-7<-6: cost = 16
The path from 6 to 6 : 6: cost = 0
The path from 6 to 7 : 7<-6: cost = 4
The path from 6 to 8 : 8<-2<-1<-6: cost = 17

Source node = 7

The path from 7 to 1 : 1<-6<-7: cost = 9
The path from 7 to 2 : 2<-1<-6<-7: cost = 18
The path from 7 to 3 : 3<-1<-6<-7: cost = 14
The path from 7 to 4 : 4<-7: cost = 4
The path from 7 to 5 : 5<-4<-7: cost = 12
The path from 7 to 6 : 6<-7: cost = 3
The path from 7 to 7 : 7: cost = 0
The path from 7 to 8 : 8<-2<-1<-6<-7: cost = 20

Source node = 8

The path from 8 to 1 : 1<-8: cost = 6
The path from 8 to 2 : 2<-1<-8: cost = 15
The path from 8 to 3 : 3<-1<-8: cost = 11
The path from 8 to 4 : 4<-7<-8: cost = 6
The path from 8 to 5 : 5<-4<-7<-8: cost = 14
The path from 8 to 6 : 6<-7<-8: cost = 5
The path from 8 to 7 : 7<-8: cost = 2
The path from 8 to 8 : 8: cost = 0

deBugFile for Data2
The Source Node Is: 1

The Father Array:
0 1 1 1 1 1 1 1

The Best Array:
0 0 9 5 19 29 999 999 999

The toDo Array:
0 0 1 1 1 1 1 1

The Source Node Is: 1

The Father Array:
0 1 1 1 1 1 1 1

The Best Array:
0 0 9 5 19 29 999 999 999

The toDo Array:
0 0 1 0 1 1 1 1

The Source Node Is: 1

The Father Array:
0 1 1 1 3 1 1 1 1

The Best Array:
0 0 9 5 10 29 999 999 999

The toDo Array:
0 0 1 0 1 1 1 1 1

The Source Node Is: 1

The Father Array:
0 1 1 1 3 1 1 3 1

The Best Array:
0 0 9 5 10 29 999 33 999

The toDo Array:
0 0 1 0 1 1 1 1 1

The Source Node Is: 1

The Father Array:
0 1 1 1 3 1 1 3 3

The Best Array:
0 0 9 5 10 29 999 33 14

The toDo Array:
0 0 1 0 1 1 1 1 1

The Source Node Is: 1

The Father Array:
0 1 1 1 3 1 1 3 3

The Best Array:
0 0 9 5 10 29 999 33 14

The toDo Array:
0 0 0 0 1 1 1 1 1

The Source Node Is: 1

The Father Array:
0 1 1 1 3 1 1 3 2

The Best Array:
0 0 9 5 10 29 999 33 11

The toDo Array:
0 0 0 0 1 1 1 1 1

The Source Node Is: 1

The Father Array:
0 1 1 1 3 1 1 3 2

The Best Array:
0 0 9 5 10 29 999 33 11

The toDo Array:
0 0 0 0 0 1 1 1 1

The Source Node Is: 1

The Father Array:
0 1 1 1 3 4 1 3 2

The Best Array:
0 0 9 5 10 18 999 33 11

The toDo Array:
0 0 0 0 0 1 1 1 1

The Source Node Is: 1

The Father Array:
0 1 1 1 3 4 4 3 2

The Best Array:
0 0 9 5 10 18 13 33 11

The toDo Array:
0 0 0 0 0 1 1 1 1

The Source Node Is: 1

The Father Array:
0 1 1 1 3 4 4 3 2

The Best Array:
0 0 9 5 10 18 13 33 11

The toDo Array:
0 0 0 0 0 1 1 1 0

The Source Node Is: 1

The Father Array:
0 1 1 1 3 4 4 8 2

The Best Array:
0 0 9 5 10 18 13 13 11

The toDo Array:
0 0 0 0 0 1 1 1 0

The Source Node Is: 1

The Father Array:
0 1 1 1 3 4 4 8 2

The Best Array:
0 0 9 5 10 18 13 13 11

The toDo Array:
0 0 0 0 0 1 0 1 0

The Source Node Is: 1

The Father Array:
0 1 1 1 3 4 4 8 2

The Best Array:
0 0 9 5 10 18 13 13 11

The toDo Array:
0 0 0 0 0 1 0 0 0

The Source Node Is: 1

The Father Array:
0 1 1 1 3 4 4 8 2

The Best Array:
0 0 9 5 10 18 13 13 11

The toDo Array:
0 0 0 0 0 0 0 0 0

The Source Node Is: 2

The Father Array:
0 2 2 2 2 2 2 2 2

The Best Array:
0 999 0 999 999 999 999 999 2

The toDo Array:
0 1 0 1 1 1 1 1 1

The Source Node Is: 2

The Father Array:
0 2 2 2 2 2 2 2 2

The Best Array:
0 999 0 999 999 999 999 999 2

The toDo Array:
0 1 0 1 1 1 1 1 0

The Source Node Is: 2

The Father Array:
0 8 2 2 2 2 2 2 2

The Best Array:
0 8 0 999 999 999 999 999 2

The toDo Array:
0 1 0 1 1 1 1 1 0

The Source Node Is: 2

The Father Array:
0 8 2 2 2 2 8 2 2

The Best Array:
0 8 0 999 999 999 9 999 2

The toDo Array:
0 1 0 1 1 1 1 0

The Source Node Is: 2

The Father Array:
0 8 2 2 2 2 8 8 2

The Best Array:
0 8 0 999 999 999 9 4 2

The toDo Array:
0 1 0 1 1 1 1 1 0

The Source Node Is: 2

The Father Array:
0 8 2 2 2 2 8 8 2

The Best Array:
0 8 0 999 999 999 9 4 2

The toDo Array:
0 1 0 1 1 1 1 0 0

The Source Node Is: 2

The Father Array:
0 8 2 2 2 7 2 8 8 2

The Best Array:
0 8 0 999 8 999 9 4 2

The toDo Array:
0 1 0 1 1 1 1 0 0

The Source Node Is: 2

The Father Array:
0 8 2 2 7 2 7 8 2

The Best Array:
0 8 0 999 8 999 7 4 2

The toDo Array:
0 1 0 1 1 1 1 0 0

The Source Node Is: 2

The Father Array:
0 8 2 2 7 2 7 8 2

The Best Array:
0 8 0 999 8 999 7 4 2

The toDo Array:
0 1 0 1 1 1 0 0 0

The Source Node Is: 2

The Father Array:

0 8 2 2 7 2 7 8 2

The Best Array:
0 8 0 999 8 999 7 4 2

The toDo Array:
0 0 0 1 1 1 0 0 0

The Source Node Is: 2

The Father Array:
0 8 2 1 7 2 7 8 2

The Best Array:
0 8 0 13 8 999 7 4 2

The toDo Array:
0 0 0 1 1 1 0 0 0

The Source Node Is: 2

The Father Array:
0 8 2 1 7 1 7 8 2

The Best Array:
0 8 0 13 8 37 7 4 2

The toDo Array:
0 0 0 1 1 1 0 0 0

The Source Node Is: 2

The Father Array:
0 8 2 1 7 1 7 8 2

The Best Array:
0 8 0 13 8 37 7 4 2

The toDo Array:
0 0 0 1 0 1 0 0 0

The Source Node Is: 2

The Father Array:
0 8 2 1 7 4 7 8 2

The Best Array:
0 8 0 13 8 16 7 4 2

The toDo Array:
0 0 0 1 0 1 0 0 0

The Source Node Is: 2

The Father Array:
0 8 2 1 7 4 7 8 2

The Best Array:
0 8 0 13 8 16 7 4 2

The toDo Array:

0 0 0 0 0 1 0 0 0

The Source Node Is: 2

The Father Array:
0 8 2 1 7 4 7 8 2

The Best Array:
0 8 0 13 8 16 7 4 2

The toDo Array:
0 0 0 0 0 0 0 0 0

The Source Node Is: 3

The Father Array:
0 3 3 3 3 3 3 3 3

The Best Array:
0 999 7 0 5 999 999 28 9

The toDo Array:
0 1 1 0 1 1 1 1 1

The Source Node Is: 3

The Father Array:
0 3 3 3 3 3 3 3 3

The Best Array:
0 999 7 0 5 999 999 28 9

The toDo Array:
0 1 1 0 0 1 1 1 1

The Source Node Is: 3

The Father Array:
0 3 3 3 3 4 3 3 3

The Best Array:
0 999 7 0 5 13 999 28 9

The toDo Array:
0 1 1 0 0 1 1 1 1

The Source Node Is: 3

The Father Array:
0 3 3 3 3 4 4 3 3

The Best Array:
0 999 7 0 5 13 8 28 9

The toDo Array:
0 1 1 0 0 1 1 1 1

The Source Node Is: 3

The Father Array:
0 3 3 3 3 4 4 3 3

The Best Array:
0 999 7 0 5 13 8 28 9

The toDo Array:
0 1 0 0 0 1 1 1 1

The Source Node Is: 3

The Father Array:
0 3 3 3 3 4 4 3 3

The Best Array:
0 999 7 0 5 13 8 28 9

The toDo Array:
0 1 0 0 0 1 0 1 1

The Source Node Is: 3

The Father Array:
0 6 3 3 3 4 4 3 3

The Best Array:
0 14 7 0 5 13 8 28 9

The toDo Array:
0 1 0 0 0 1 0 1 1

The Source Node Is: 3

The Father Array:
0 6 3 3 3 4 4 6 3

The Best Array:
0 14 7 0 5 13 8 12 9

The toDo Array:
0 1 0 0 0 1 0 1 1

The Source Node Is: 3

The Father Array:
0 6 3 3 3 4 4 6 3

The Best Array:
0 14 7 0 5 13 8 12 9

The toDo Array:
0 1 0 0 0 1 0 1 0

The Source Node Is: 3

The Father Array:
0 6 3 3 3 4 4 8 3

The Best Array:
0 14 7 0 5 13 8 11 9

The toDo Array:
0 1 0 0 0 1 0 1 0

The Source Node Is: 3

The Father Array:
0 6 3 3 3 4 4 8 3

The Best Array:
0 14 7 0 5 13 8 11 9

The toDo Array:
0 1 0 0 0 1 0 0 0

The Source Node Is: 3

The Father Array:
0 6 3 3 3 4 4 8 3

The Best Array:
0 14 7 0 5 13 8 11 9

The toDo Array:
0 1 0 0 0 0 0 0 0

The Source Node Is: 3

The Father Array:
0 6 3 3 3 4 4 8 3

The Best Array:
0 14 7 0 5 13 8 11 9

The toDo Array:
0 0 0 0 0 0 0 0 0

The Source Node Is: 4

The Father Array:
0 4 4 4 4 4 4 4 4

The Best Array:
0 999 999 999 0 8 3 999 999

The toDo Array:
0 1 1 1 0 1 1 1 1

The Source Node Is: 4

The Father Array:
0 4 4 4 4 4 4 4 4

The Best Array:
0 999 999 999 0 8 3 999 999

The toDo Array:
0 1 1 1 0 1 0 1 1

The Source Node Is: 4

The Father Array:
0 6 4 4 4 4 4 4 4

The Best Array:
0 9 999 999 0 8 3 999 999

The toDo Array:
0 1 1 1 0 1 0 1 1

The Source Node Is: 4

The Father Array:
0 6 4 4 4 4 4 6 4

The Best Array:
0 9 999 999 0 8 3 7 999

The toDo Array:
0 1 1 1 0 1 0 1 1

The Source Node Is: 4

The Father Array:
0 6 4 4 4 4 4 6 4

The Best Array:
0 9 999 999 0 8 3 7 999

The toDo Array:
0 1 1 1 0 1 0 0 1

The Source Node Is: 4

The Father Array:
0 6 4 4 4 4 4 6 4

The Best Array:
0 9 999 999 0 8 3 7 999

The toDo Array:
0 1 1 1 0 0 0 0 1

The Source Node Is: 4

The Father Array:
0 6 4 4 4 4 4 6 4

The Best Array:
0 9 999 999 0 8 3 7 999

The toDo Array:
0 0 1 1 0 0 0 0 1

The Source Node Is: 4

The Father Array:
0 6 1 4 4 4 4 6 4

The Best Array:
0 9 18 999 0 8 3 7 999

The toDo Array:
0 0 1 1 0 0 0 0 1

The Source Node Is: 4

The Father Array:
0 6 1 1 4 4 4 6 4

The Best Array:
0 9 18 14 0 8 3 7 999

The toDo Array:
0 0 1 1 0 0 0 0 1

The Source Node Is: 4

The Father Array:
0 6 1 1 4 4 4 6 4

The Best Array:
0 9 18 14 0 8 3 7 999

The toDo Array:
0 0 1 0 0 0 0 0 1

The Source Node Is: 4

The Father Array:
0 6 1 1 4 4 4 6 3

The Best Array:
0 9 18 14 0 8 3 7 23

The toDo Array:
0 0 1 0 0 0 0 0 1

The Source Node Is: 4

The Father Array:
0 6 1 1 4 4 4 6 3

The Best Array:
0 9 18 14 0 8 3 7 23

The toDo Array:
0 0 0 0 0 0 0 0 1

The Source Node Is: 4

The Father Array:
0 6 1 1 4 4 4 6 2

The Best Array:
0 9 18 14 0 8 3 7 20

The toDo Array:
0 0 0 0 0 0 0 0 1

The Source Node Is: 4

The Father Array:
0 6 1 1 4 4 4 6 2

The Best Array:

0 9 18 14 0 8 3 7 20

The toDo Array:
0 0 0 0 0 0 0 0 0

The Source Node Is: 5

The Father Array:
0 5 5 5 5 5 5 5 5

The Best Array:
0 999 999 999 999 0 14 999 999

The toDo Array:
0 1 1 1 1 0 1 1 1

The Source Node Is: 5

The Father Array:
0 5 5 5 5 5 5 5 5

The Best Array:
0 999 999 999 999 0 14 999 999

The toDo Array:
0 1 1 1 1 0 0 1 1

The Source Node Is: 5

The Father Array:
0 6 5 5 5 5 5 5 5

The Best Array:
0 20 999 999 999 0 14 999 999

The toDo Array:
0 1 1 1 1 0 0 1 1

The Source Node Is: 5

The Father Array:
0 6 5 5 5 5 5 6 5

The Best Array:
0 20 999 999 999 0 14 18 999

The toDo Array:
0 1 1 1 1 0 0 1 1

The Source Node Is: 5

The Father Array:
0 6 5 5 5 5 5 6 5

The Best Array:
0 20 999 999 999 0 14 18 999

The toDo Array:
0 1 1 1 1 0 0 0 1

The Source Node Is: 5

The Father Array:
0 6 5 5 7 5 5 6 5

The Best Array:
0 20 999 999 22 0 14 18 999

The toDo Array:
0 1 1 1 1 0 0 0 1

The Source Node Is: 5

The Father Array:
0 6 5 5 7 5 5 6 5

The Best Array:
0 20 999 999 22 0 14 18 999

The toDo Array:
0 0 1 1 1 0 0 0 1

The Source Node Is: 5

The Father Array:
0 6 1 5 7 5 5 6 5

The Best Array:
0 20 29 999 22 0 14 18 999

The toDo Array:
0 0 1 1 1 0 0 0 1

The Source Node Is: 5

The Father Array:
0 6 1 1 7 5 5 6 5

The Best Array:
0 20 29 25 22 0 14 18 999

The toDo Array:
0 0 1 1 1 0 0 0 1

The Source Node Is: 5

The Father Array:
0 6 1 1 7 5 5 6 5

The Best Array:
0 20 29 25 22 0 14 18 999

The toDo Array:
0 0 1 1 0 0 0 0 1

The Source Node Is: 5

The Father Array:
0 6 1 1 7 5 5 6 5

The Best Array:
0 20 29 25 22 0 14 18 999

The toDo Array:
0 0 1 0 0 0 0 0 1

The Source Node Is: 5

The Father Array:
0 6 1 1 7 5 5 6 3

The Best Array:
0 20 29 25 22 0 14 18 34

The toDo Array:
0 0 1 0 0 0 0 0 1

The Source Node Is: 5

The Father Array:
0 6 1 1 7 5 5 6 3

The Best Array:
0 20 29 25 22 0 14 18 34

The toDo Array:
0 0 0 0 0 0 0 0 1

The Source Node Is: 5

The Father Array:
0 6 1 1 7 5 5 6 2

The Best Array:
0 20 29 25 22 0 14 18 31

The toDo Array:
0 0 0 0 0 0 0 0 1

The Source Node Is: 5

The Father Array:
0 6 1 1 7 5 5 6 2

The Best Array:
0 20 29 25 22 0 14 18 31

The toDo Array:
0 0 0 0 0 0 0 0 0

The Source Node Is: 6

The Father Array:
0 6 6 6 6 6 6 6 6

The Best Array:
0 6 999 999 999 999 0 4 999

The toDo Array:
0 1 1 1 1 1 0 1 1

The Source Node Is: 6

The Father Array:
0 6 6 6 6 6 6 6 6

The Best Array:
0 6 999 999 999 999 0 4 999

The toDo Array:
0 1 1 1 1 1 0 0 1

The Source Node Is: 6

The Father Array:
0 6 6 6 7 6 6 6 6

The Best Array:
0 6 999 999 8 999 0 4 999

The toDo Array:
0 1 1 1 1 1 0 0 1

The Source Node Is: 6

The Father Array:
0 6 6 6 7 6 6 6 6

The Best Array:
0 6 999 999 8 999 0 4 999

The toDo Array:
0 0 1 1 1 1 0 0 1

The Source Node Is: 6

The Father Array:
0 6 1 6 7 6 6 6 6

The Best Array:
0 6 15 999 8 999 0 4 999

The toDo Array:
0 0 1 1 1 1 0 0 1

The Source Node Is: 6

The Father Array:
0 6 1 1 7 6 6 6 6

The Best Array:
0 6 15 11 8 999 0 4 999

The toDo Array:
0 0 1 1 1 1 0 0 1

The Source Node Is: 6

The Father Array:
0 6 1 1 7 1 6 6 6

The Best Array:
0 6 15 11 8 35 0 4 999

The toDo Array:
0 0 1 1 1 1 0 0 1

The Source Node Is: 6

The Father Array:
0 6 1 1 7 1 6 6 6

The Best Array:
0 6 15 11 8 35 0 4 999

The toDo Array:
0 0 1 1 1 0 1 0 0 1

The Source Node Is: 6

The Father Array:
0 6 1 1 7 4 6 6 6

The Best Array:
0 6 15 11 8 16 0 4 999

The toDo Array:
0 0 1 1 1 0 1 0 0 1

The Source Node Is: 6

The Father Array:
0 6 1 1 7 4 6 6 6

The Best Array:
0 6 15 11 8 16 0 4 999

The toDo Array:
0 0 1 0 0 1 0 0 1

The Source Node Is: 6

The Father Array:
0 6 1 1 7 4 6 6 3

The Best Array:
0 6 15 11 8 16 0 4 20

The toDo Array:
0 0 1 0 0 1 0 0 1

The Source Node Is: 6

The Father Array:
0 6 1 1 7 4 6 6 3

The Best Array:
0 6 15 11 8 16 0 4 20

The toDo Array:
0 0 0 0 0 1 0 0 1

The Source Node Is: 6

The Father Array:

0 6 1 1 7 4 6 6 2

The Best Array:
0 6 15 11 8 16 0 4 17

The toDo Array:
0 0 0 0 0 1 0 0 1

The Source Node Is: 6

The Father Array:
0 6 1 1 7 4 6 6 2

The Best Array:
0 6 15 11 8 16 0 4 17

The toDo Array:
0 0 0 0 0 0 0 0 1

The Source Node Is: 6

The Father Array:
0 6 1 1 7 4 6 6 2

The Best Array:
0 6 15 11 8 16 0 4 17

The toDo Array:
0 0 0 0 0 0 0 0 0

The Source Node Is: 7

The Father Array:
0 7 7 7 7 7 7 7 7

The Best Array:
0 999 999 999 4 999 3 0 999

The toDo Array:
0 1 1 1 1 1 1 0 1

The Source Node Is: 7

The Father Array:
0 7 7 7 7 7 7 7 7

The Best Array:
0 999 999 999 4 999 3 0 999

The toDo Array:
0 1 1 1 1 1 0 0 1

The Source Node Is: 7

The Father Array:
0 6 7 7 7 7 7 7 7

The Best Array:
0 9 999 999 4 999 3 0 999

The toDo Array:

0 1 1 1 1 1 0 0 1

The Source Node Is: 7

The Father Array:
0 6 7 7 7 7 7 7 7

The Best Array:
0 9 999 999 4 999 3 0 999

The toDo Array:
0 1 1 1 0 1 0 0 1

The Source Node Is: 7

The Father Array:
0 6 7 7 7 4 7 7 7

The Best Array:
0 9 999 999 4 12 3 0 999

The toDo Array:
0 1 1 1 0 1 0 0 1

The Source Node Is: 7

The Father Array:
0 6 7 7 7 4 7 7 7

The Best Array:
0 9 999 999 4 12 3 0 999

The toDo Array:
0 0 1 1 0 1 0 0 1

The Source Node Is: 7

The Father Array:
0 6 1 7 7 4 7 7 7

The Best Array:
0 9 18 999 4 12 3 0 999

The toDo Array:
0 0 1 1 0 1 0 0 1

The Source Node Is: 7

The Father Array:
0 6 1 1 7 4 7 7 7

The Best Array:
0 9 18 14 4 12 3 0 999

The toDo Array:
0 0 1 1 0 1 0 0 1

The Source Node Is: 7

The Father Array:
0 6 1 1 7 4 7 7 7

The Best Array:
0 9 18 14 4 12 3 0 999

The toDo Array:
0 0 1 1 0 0 0 0 1

The Source Node Is: 7

The Father Array:
0 6 1 1 7 4 7 7 7

The Best Array:
0 9 18 14 4 12 3 0 999

The toDo Array:
0 0 1 0 0 0 0 0 1

The Source Node Is: 7

The Father Array:
0 6 1 1 7 4 7 7 3

The Best Array:
0 9 18 14 4 12 3 0 23

The toDo Array:
0 0 1 0 0 0 0 0 1

The Source Node Is: 7

The Father Array:
0 6 1 1 7 4 7 7 3

The Best Array:
0 9 18 14 4 12 3 0 23

The toDo Array:
0 0 0 0 0 0 0 0 1

The Source Node Is: 7

The Father Array:
0 6 1 1 7 4 7 7 2

The Best Array:
0 9 18 14 4 12 3 0 20

The toDo Array:
0 0 0 0 0 0 0 0 1

The Source Node Is: 7

The Father Array:
0 6 1 1 7 4 7 7 2

The Best Array:
0 9 18 14 4 12 3 0 20

The toDo Array:
0 0 0 0 0 0 0 0 0

The Source Node Is: 8

The Father Array:
0 8 8 8 8 8 8 8

The Best Array:
0 6 999 999 999 999 7 2 0

The toDo Array:
0 1 1 1 1 1 1 0

The Source Node Is: 8

The Father Array:
0 8 8 8 8 8 8 8

The Best Array:
0 6 999 999 999 999 7 2 0

The toDo Array:
0 1 1 1 1 1 1 0 0

The Source Node Is: 8

The Father Array:
0 8 8 8 7 8 8 8

The Best Array:
0 6 999 999 6 999 7 2 0

The toDo Array:
0 1 1 1 1 1 1 0 0

The Source Node Is: 8

The Father Array:
0 8 8 8 7 8 7 8 8

The Best Array:
0 6 999 999 6 999 5 2 0

The toDo Array:
0 1 1 1 1 1 1 0 0

The Source Node Is: 8

The Father Array:
0 8 8 8 7 8 7 8 8

The Best Array:
0 6 999 999 6 999 5 2 0

The toDo Array:
0 1 1 1 1 1 0 0 0

The Source Node Is: 8

The Father Array:
0 8 8 8 7 8 7 8 8

The Best Array:
0 6 999 999 6 999 5 2 0

The toDo Array:
0 0 1 1 1 1 0 0 0

The Source Node Is: 8

The Father Array:
0 8 1 8 7 8 7 8 8

The Best Array:
0 6 15 999 6 999 5 2 0

The toDo Array:
0 0 1 1 1 1 0 0 0

The Source Node Is: 8

The Father Array:
0 8 1 1 7 8 7 8 8

The Best Array:
0 6 15 11 6 999 5 2 0

The toDo Array:
0 0 1 1 1 1 0 0 0

The Source Node Is: 8

The Father Array:
0 8 1 1 7 1 7 8 8

The Best Array:
0 6 15 11 6 35 5 2 0

The toDo Array:
0 0 1 1 1 1 0 0 0

The Source Node Is: 8

The Father Array:
0 8 1 1 7 1 7 8 8

The Best Array:
0 6 15 11 6 35 5 2 0

The toDo Array:
0 0 1 1 0 1 0 0 0

The Source Node Is: 8

The Father Array:
0 8 1 1 7 4 7 8 8

The Best Array:
0 6 15 11 6 14 5 2 0

The toDo Array:
0 0 1 1 0 1 0 0 0

The Source Node Is: 8

The Father Array:
0 8 1 1 7 4 7 8 8

The Best Array:
0 6 15 11 6 14 5 2 0

The toDo Array:
0 0 1 0 0 1 0 0 0

The Source Node Is: 8

The Father Array:
0 8 1 1 7 4 7 8 8

The Best Array:
0 6 15 11 6 14 5 2 0

The toDo Array:
0 0 1 0 0 0 0 0 0

The Source Node Is: 8

The Father Array:
0 8 1 1 7 4 7 8 8

The Best Array:
0 6 15 11 6 14 5 2 0

The toDo Array:
0 0 0 0 0 0 0 0 0