CS542 Link State Routing Protocol Simulator

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Overview:

- Finding the shortest path between two nodes/routers in a computer network is a common problem. In computer network, the packets should be transferred to the destination through a shortest path.
- There are mainly two techniques used to find a shortest path between two nodes/routers in a network: 1) Link State Routing 2) Distance Vector Routing.

Link State Routing:

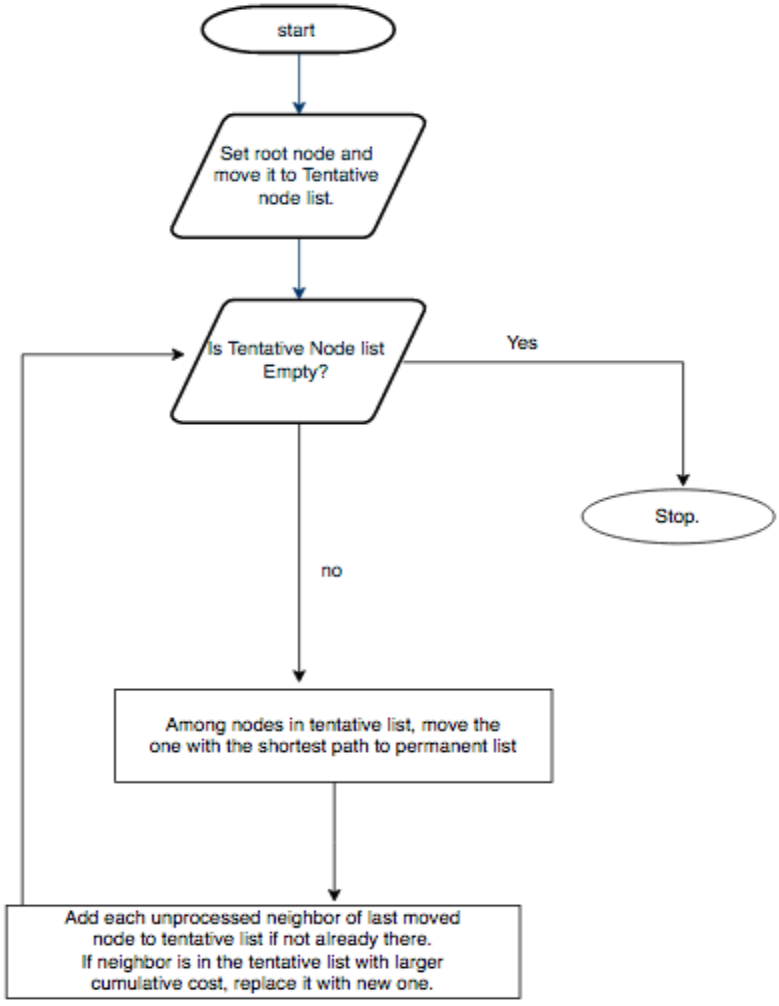
- Link State Routing protocol is one of the main protocols in routing protocols. It is used in packet switching techniques for data communications. The other protocol that is being used is distance vector routing protocol.
- The Link State Routing is different than a Distance Vector Routing, in Link State Routing each node in the network domain has the entire topology of the domain, it includes list of nodes and links, and how they are connected to each other, including cost/weights and condition of the links.
- The node in a domain can use the Dijkstra's algorithm to build a routing table using this information. Each node uses the same network topology to build a routing table, but the routing table for each node is unique.
- Link State Routing has an assumption, that each node doesn't have a global knowledge of the topology, but each of them has a partial knowledge of it. So, the whole topology can be deduced from this partial knowledge of each node.

Phases of Link State Routing:

1. Creation of the Link State Packet by each node, which contains the states of the links created by each node.
2. Spreading of Link State Packets to every other nodes/routers in an efficient and reliable way. It is called flooding.
3. Creation of shortest path tree for each routers/nodes.
4. Calculate the routing table based on the shortest path tree.

Dijkstra' Algorithm:

- After dissemination of the LSPs, each node in a network will have a knowledge of the whole a topology. However, this knowledge is not sufficient to compute the shortest path to each node. A Shortest Path tree is needed to compute the shortest path to each nodes.
- The Dijkstra's algorithm creates a shortest path tree using the whole topology knowledge.
- The algorithm divided the nodes into two groups. Tentative and Permanent. It finds the neighbours of a current node, and make them tentative, after that it examines them, if they pass the criteria, it makes them permanent. The algorithm can be defined using the below flow-chart.



Implementation of Dijkstra's Algorithm:

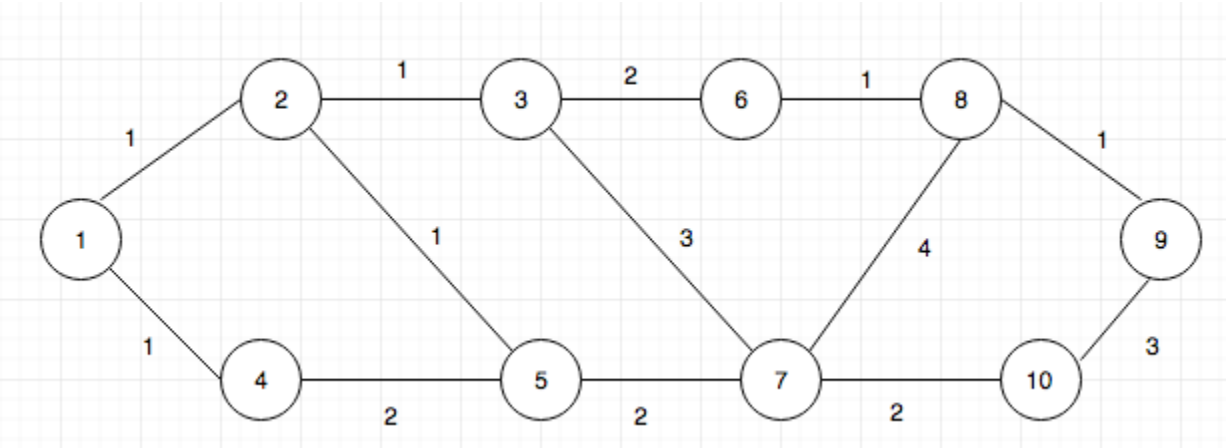
- Below is the pseudo code implementation of Dijkstra's Algorithm.

- Pseudo Code of Dijkstra's Algorithm:

```
For each router set myDistance[router] = MAX
unvisitedNodes = empty
visitedNodes = empty

Add sourceNode to unvisitedNodes
myDistance[sourceNode]= 0


repeat untill unvisitedNodes has up-router{
nearestRouter = findNearestReachableNode to visitedNodes from unvisitedNodes
remove nearestRouter from unvisitedNodes
        add nearestRouter to visitedNodes
        findReachableNodeOfNewlyAddedNode of nearestRouter
}

findNearestReachableNode(unvisitedNodes){
        find the router with the lowest myDistance in unvisitedNodes and return it
}

findReachableNodeOfNewlyAddedNode(currentNode){
For each destinationNode which can be reached via an edge from currentNode AND
which is not    visited before {
   edgeDistance = getDistance(edge(currentNode, destinationNode))
   newDistance =  edgeDistance + myDistance[currentNode]
   if (myDistance[destinationNode]  > newDistance ) {
        myDistance[destinationNode]  = newDistance
        add destinationNode to unvisitedNodes
                                        }
                }}
```

Example of Dijkstra's Algorithm:

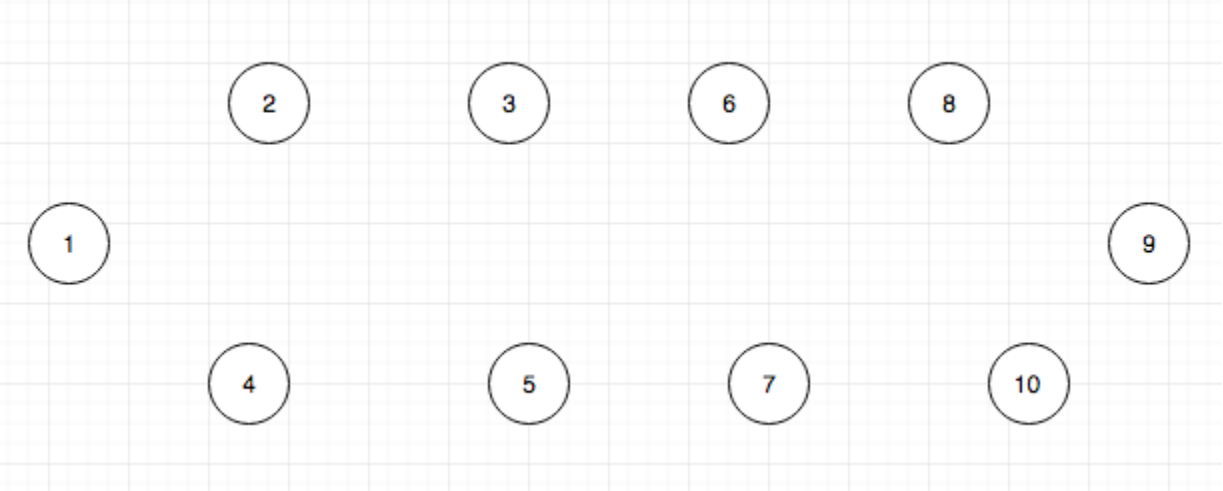
Network Topology:



Example:

- Now, we will use router 1 and built shortest path tree for it, using Dijkstra's Algorithm.

Step 1:



Visited Node:

Unvisited Node:

1									

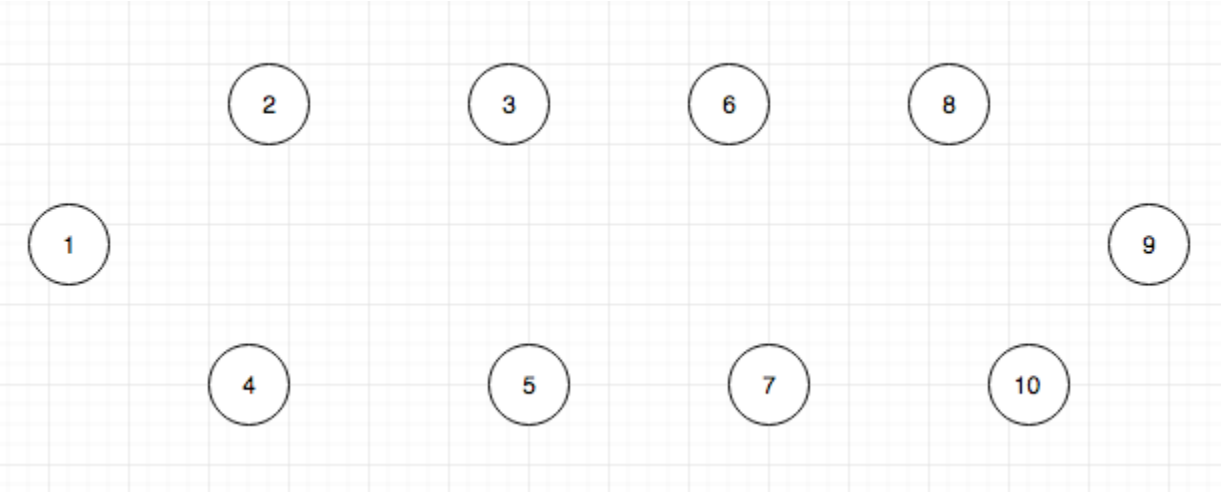
Last Visited

V2	V1

Distance

V	DIST
1	0

Step 2:



Visited Node:

1									

Unvisited Node:

2	4								

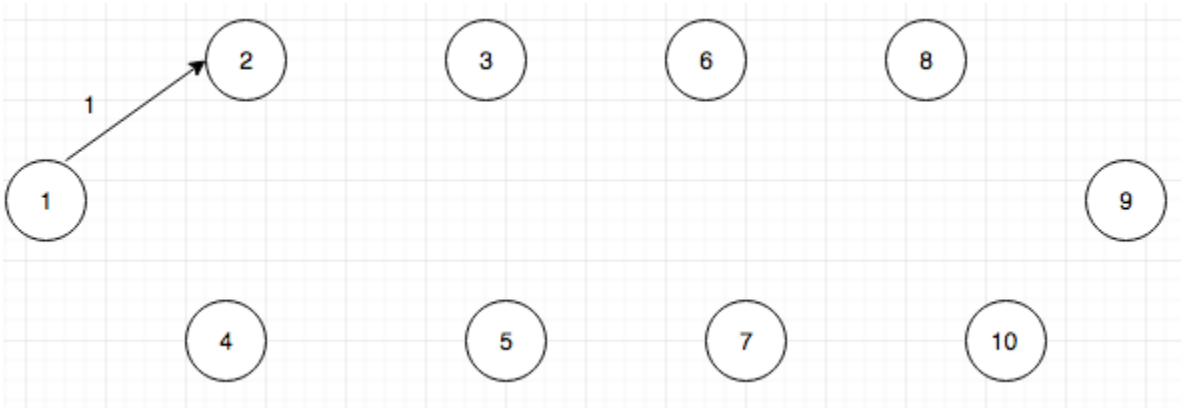
Last Visited

V2	V1

Distance

V	DIST
1	0
2	1
4	1

Step 3:



Visited Node:

1	2								

Unvisited Node:

4	3	5							

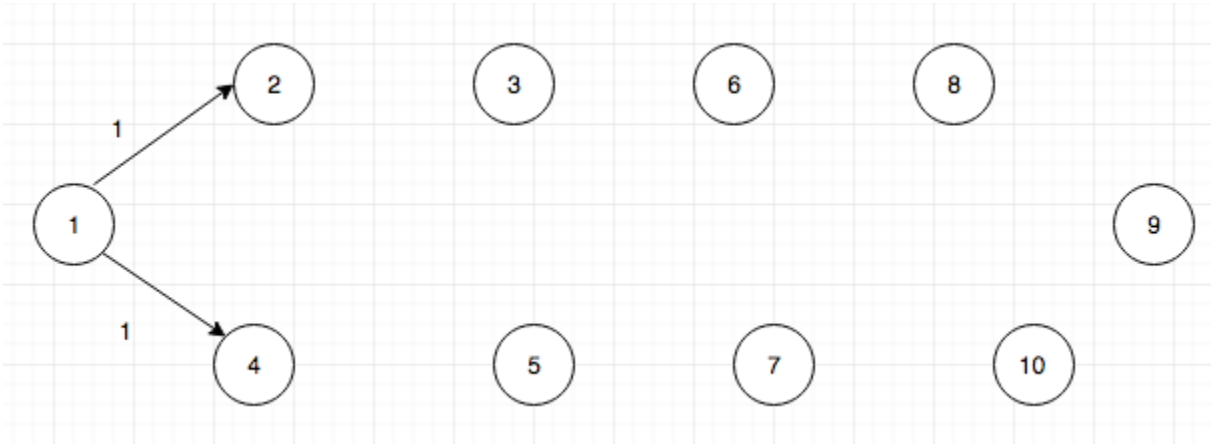
Last Visited

V2	V1
2	1

Distance

V	DIST
1	0
2	1
4	1
3	2
5	2

Step 4:



Visited Node:

1	2	4							

Unvisited Node:

3	5								

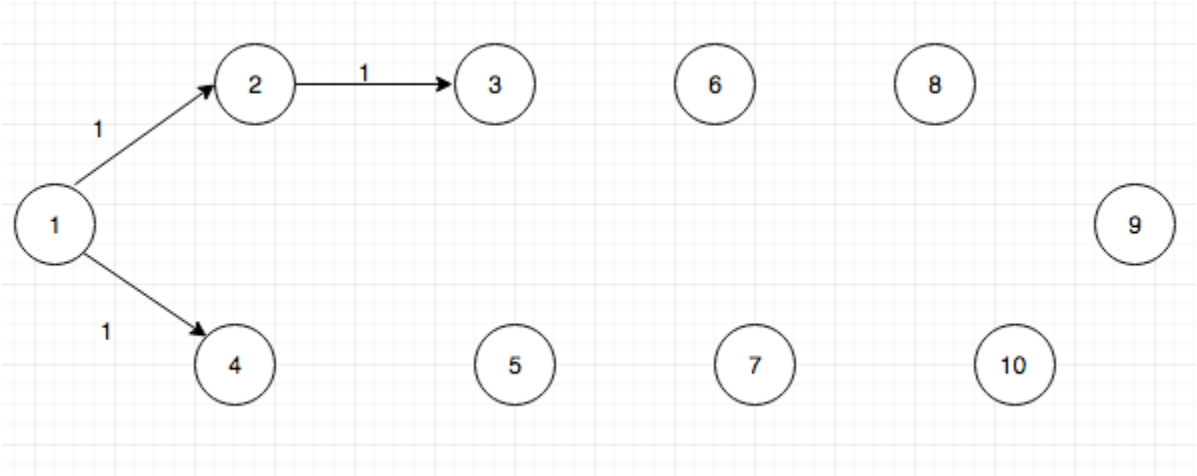
Last Visited

V2	V1
2	1
4	1

Distance

V	DIST
1	0
2	1
4	1
3	2
5	2

Step 5:



Visited Node:

1	2	4	3						

Unvisited Node:

5	6	7							

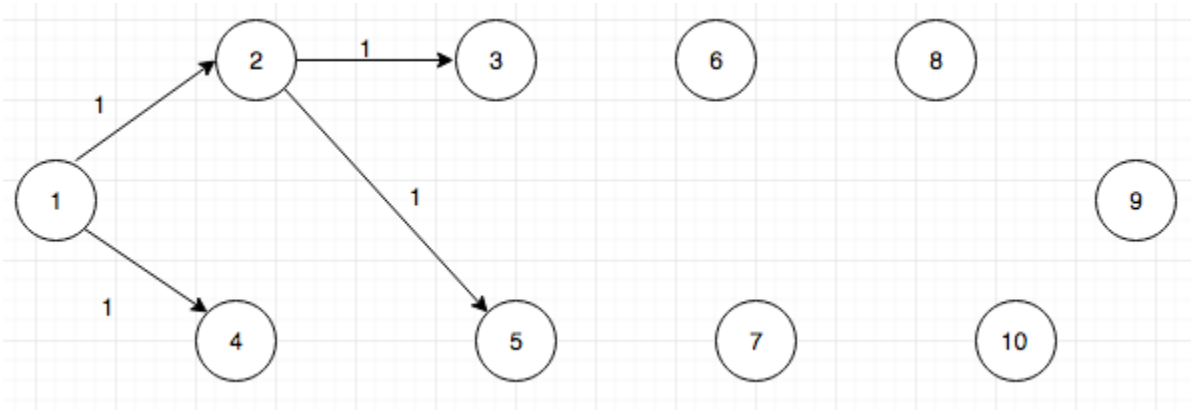
Last Visited

V2	V1
2	1
4	1
3	2

Distance

V	DIST
1	0
2	1
4	1
3	2
5	2
6	4
7	5

Step 6:



Visited Node:

1	2	4	3	5					

Unvisited Node:

6	7								

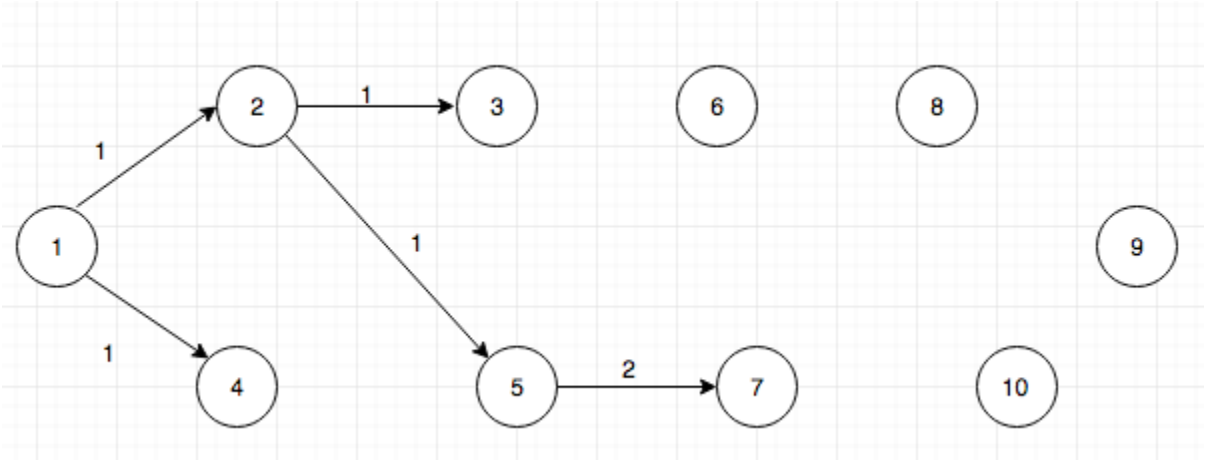
Last Visited

V2	V1
2	1
4	1
3	2
5	2

Distance

V	DIST
1	0
2	1
4	1
3	2
5	2
6	4
7	4

Step 7:



Visited Node:

1	2	4	3	5	7				

Unvisited Node:

6	8	10							

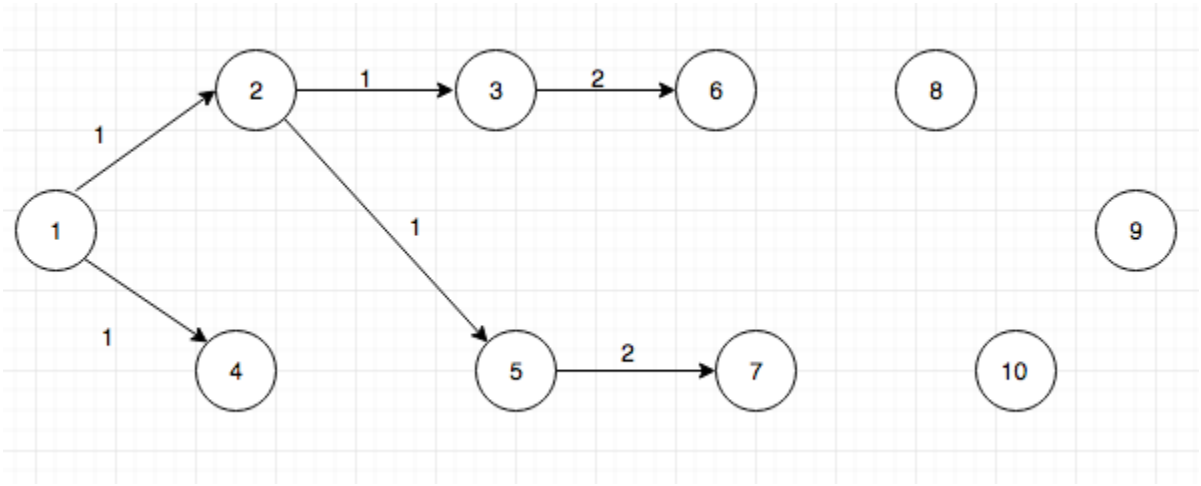
Last Visited

V2	V1
2	1
4	1
3	2
5	2
7	5

Distance

V	DIST
1	0
2	1
4	1
3	2
5	2
6	4
7	4
8	8
10	6

Step 8:



Visited Node:

1	2	4	3	5	7	6			

Unvisited Node:

8	10								

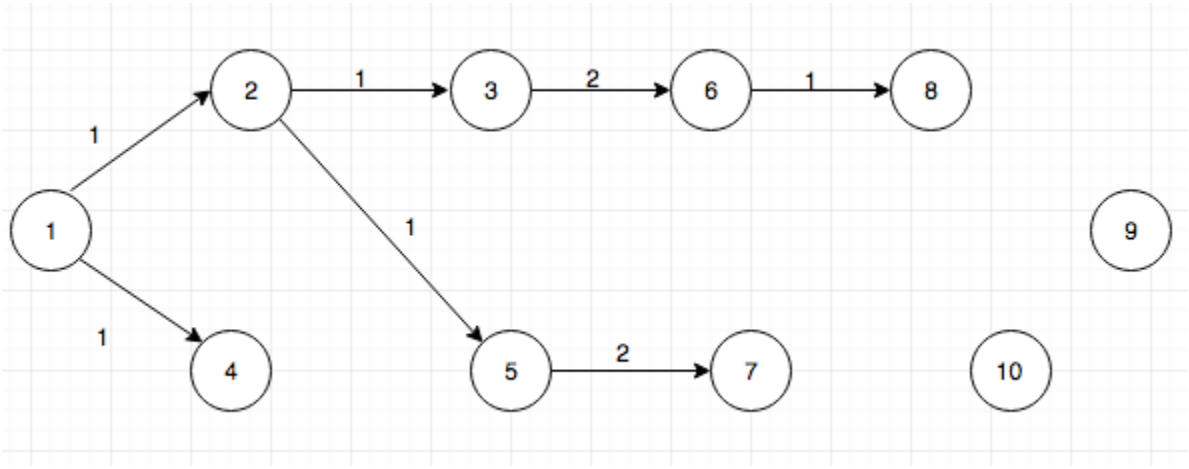
Last Visited

V2	V1
2	1
4	1
3	2
5	2
7	5
6	3

Distance

V	DIST
1	0
2	1
4	1
3	2
5	2
7	4
6	4
8	5
10	6

Step 9:



Visited Node:

1	2	4	3	5	7	6	8		

Unvisited Node:

10	9								

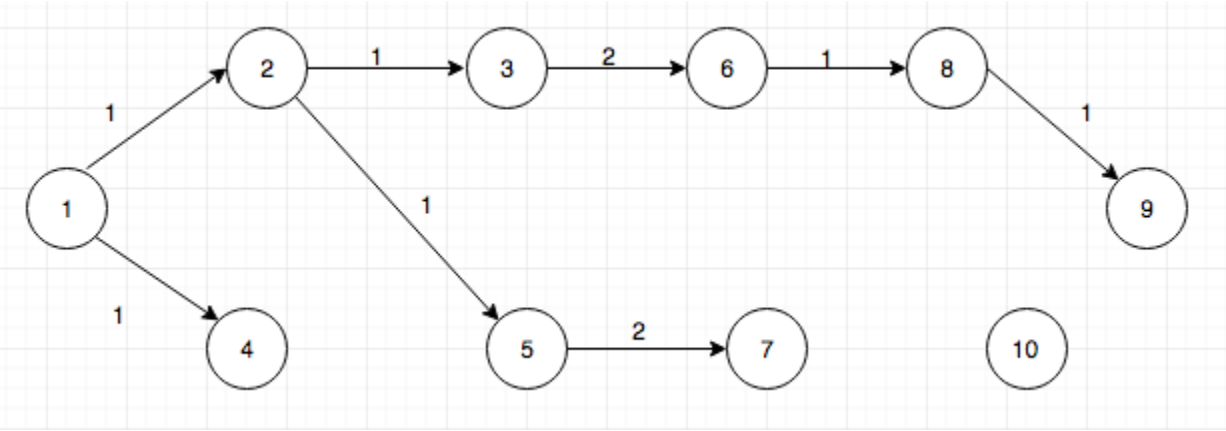
Last Visited

V2	V1
2	1
4	1
3	2
5	2
7	5
6	3
8	6

Distance

V	DIST
1	0
2	1
4	1
3	2
5	2
7	4
6	4
8	5
9	6
10	6

Step 10:



Visited Node:

1	2	4	3	5	7	6	8	9	

Unvisited Node:

10									

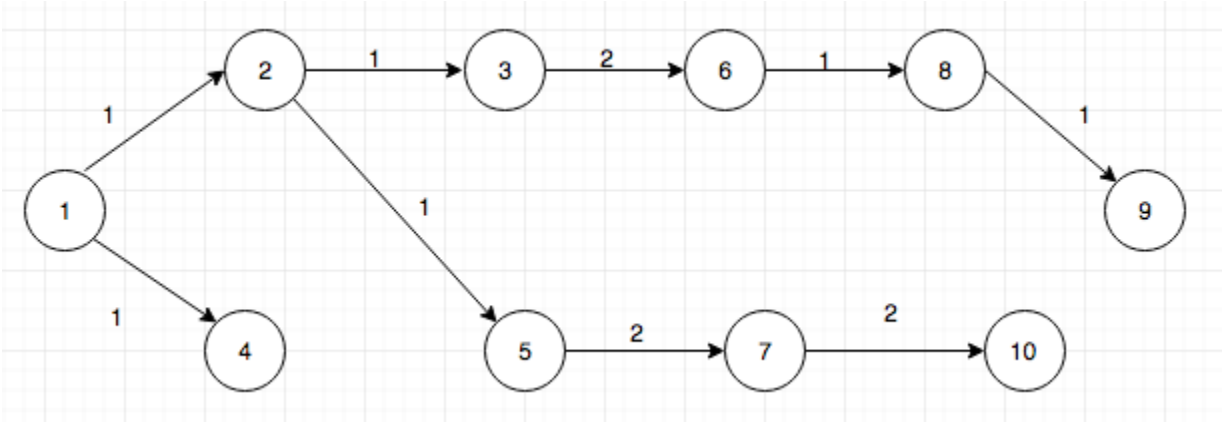
Last Visited

V2	V1
2	1
4	1
3	2
5	2
7	5
6	3
8	6
9	8

Distance

V	DIST
1	0
2	1
4	1
3	2
5	2
7	4
6	4
8	5
9	6
10	6

Step 11:



Visited Node:

1	2	4	3	5	7	6	8	9	10

Unvisited Node:

Last Visited

V2	V1
2	1
4	1
3	2
5	2
7	5
6	3
8	6
9	8
10	7

Distance

V	DIST
1	0
2	1
4	1
3	2
5	2
7	4
6	4
8	5
9	6
10	6

Additional Features:

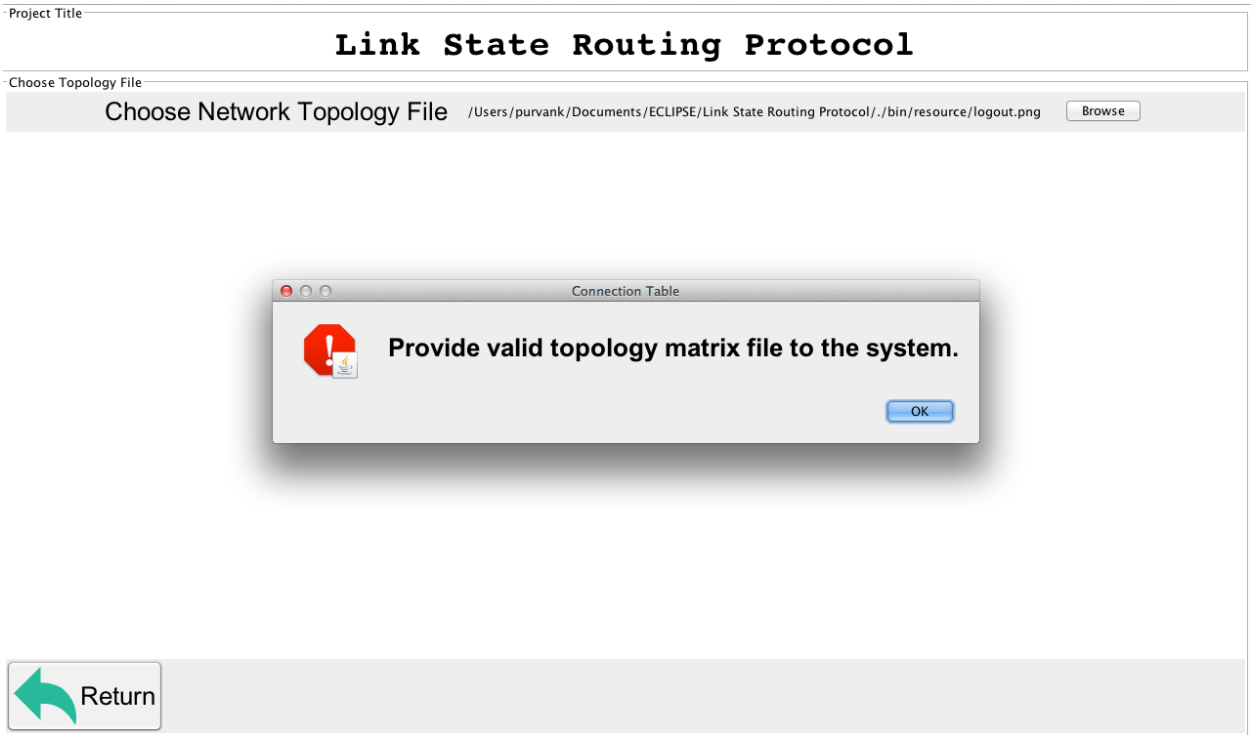
- We have implemented some additional features in the Link State Routing Protocol, which are as below:
- Add Edge: A user can edge a new edge in a network topology.
- Add Router: A user can add a new router in a network topology.
- Modify a Topology: A user can modify the network topology, he/she can remove a router or can modify the weights of an existing edge.
- If there are multiple shortest path available between source and destination with the same cost, the algorithm will find all of them.

Testing and Results:

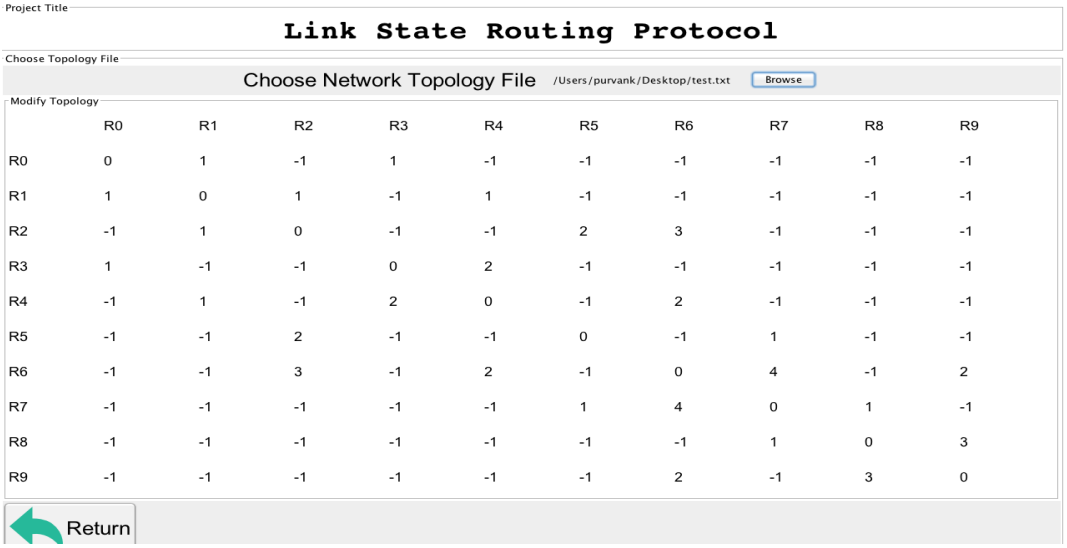
- Topology used for testing.

```
0 1 -1 1 -1 -1 -1 -1 -1 -1
1 0 1 -1 1 -1 -1 -1 -1 -1
-1 1 0 -1 -1 2 3 -1 -1 -1
1 -1 -1 0 2 -1 -1 -1 -1 -1
-1 1 -1 2 0 -1 2 -1 -1 -1
-1 -1 2 -1 -1 0 -1 1 -1 -1
-1 -1 3 -1 2 -1 0 4 -1 2
-1 -1 -1 -1 -1 1 4 0 1 -1
-1 -1 -1 -1 -1 -1 -1 1 0 3
-1 -1 -1 -1 -1 -1 2 -1 3 0
```

1) Checking whether the file and topology format is valid or not:

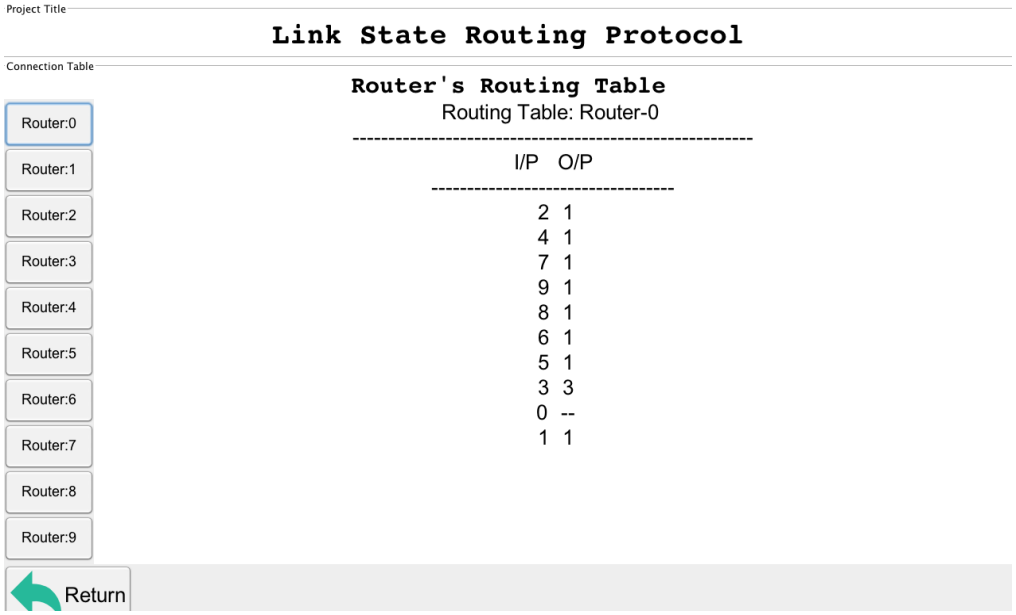


- If the file format and network topology is valid it will show the topology matrix as below:

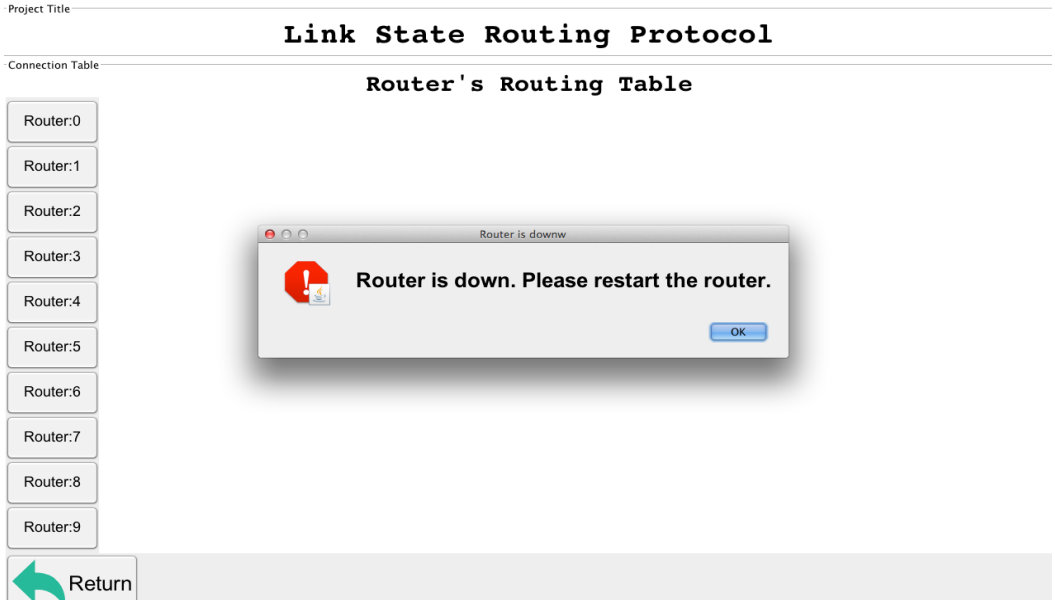


	R0	R1	R2	R3	R4	R5	R6	R7	R8	R9
R0	0	1	-1	1	-1	-1	-1	-1	-1	-1
R1	1	0	1	-1	1	-1	-1	-1	-1	-1
R2	-1	1	0	-1	-1	2	3	-1	-1	-1
R3	1	-1	-1	0	2	-1	-1	-1	-1	-1
R4	-1	1	-1	2	0	-1	2	-1	-1	-1
R5	-1	-1	2	-1	-1	0	-1	1	-1	-1
R6	-1	-1	3	-1	2	-1	0	4	-1	2
R7	-1	-1	-1	-1	-1	1	4	0	1	-1
R8	-1	-1	-1	-1	-1	-1	-1	1	0	3
R9	-1	-1	-1	-1	-1	-1	2	-1	3	0

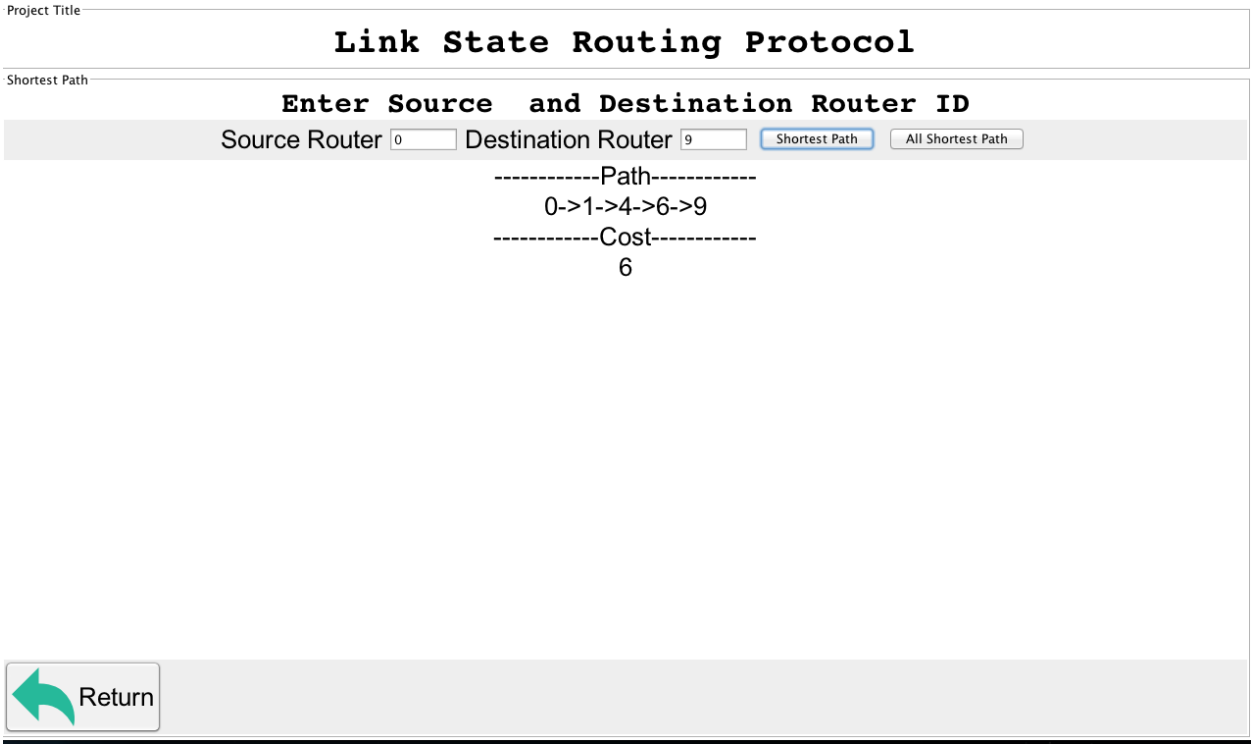
2) Check the routing table of each router according to the network topology.

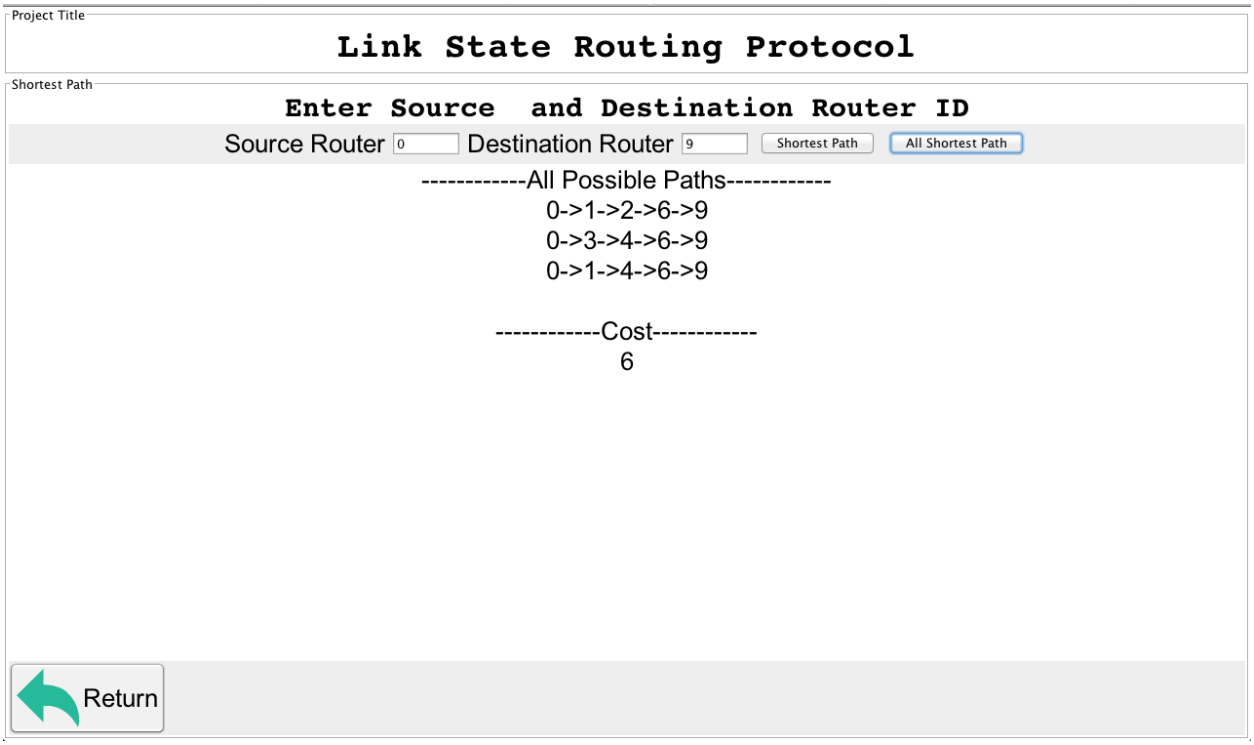


- As we can see from the network topology the output interface of router 3 is different, other than that the output interface is same for all other routers, which is shown by the above picture.
- Here if the router is down, it will show an error of “Router is down”.

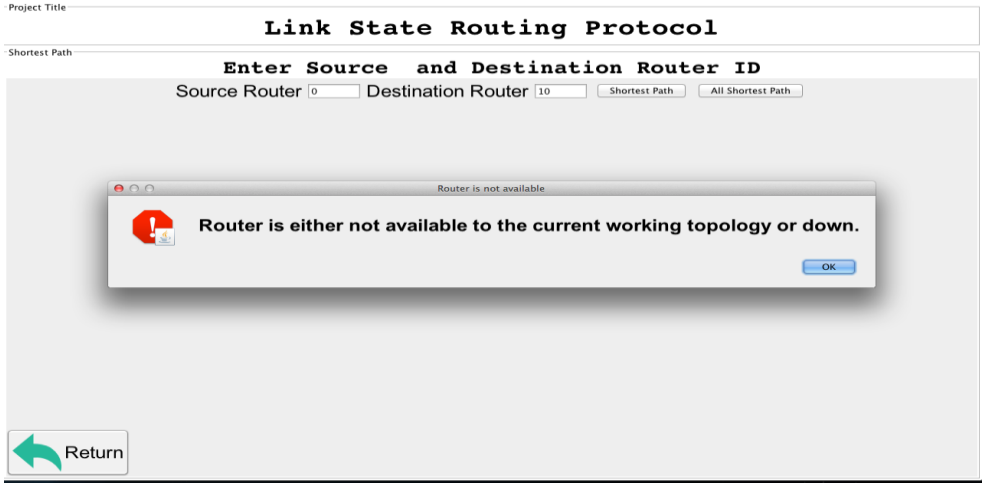


3) Now, we will find shortest path between router 0 and router 10. If we click the shortest path It will show the shortest path between router 0 and router 10 as below. If the user wanna see all the shortest path available between source and destination. By clicking the all shortest path button, it will show all the shortest path available between source and destination router.

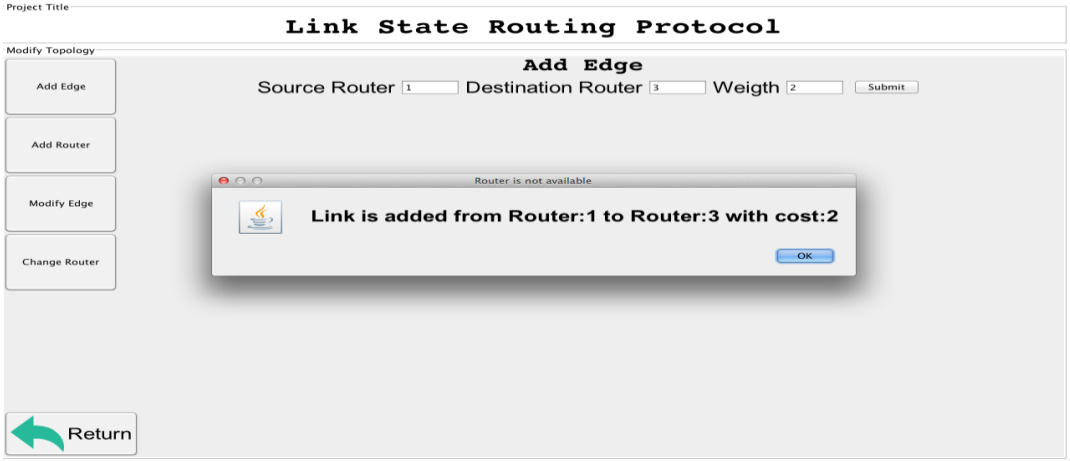




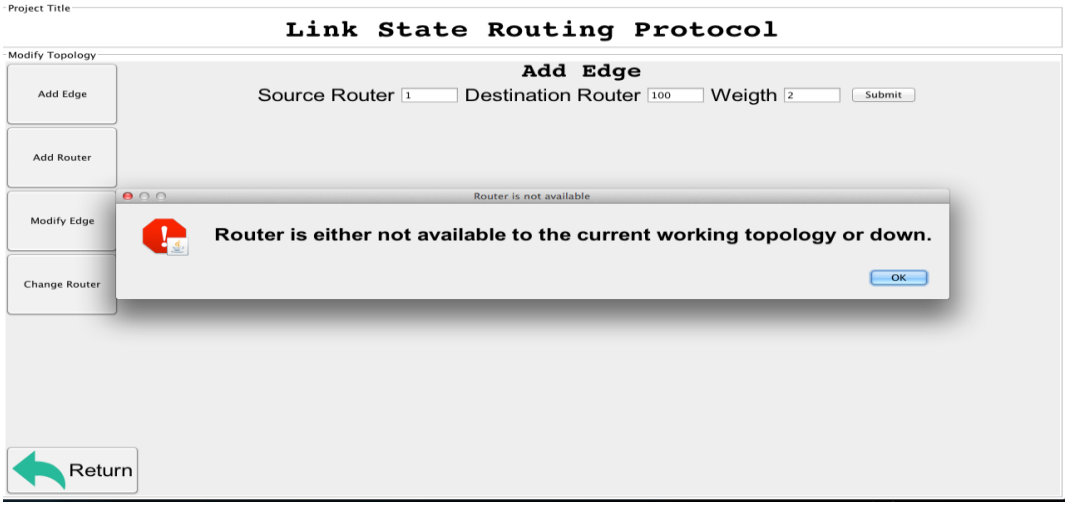
- If the source or destination router is down in the shortest path, or the router isn't present in the network topology, it will show the error as below that "Router is either not available or it is down", here I made router 0 down, so it is showing this error.



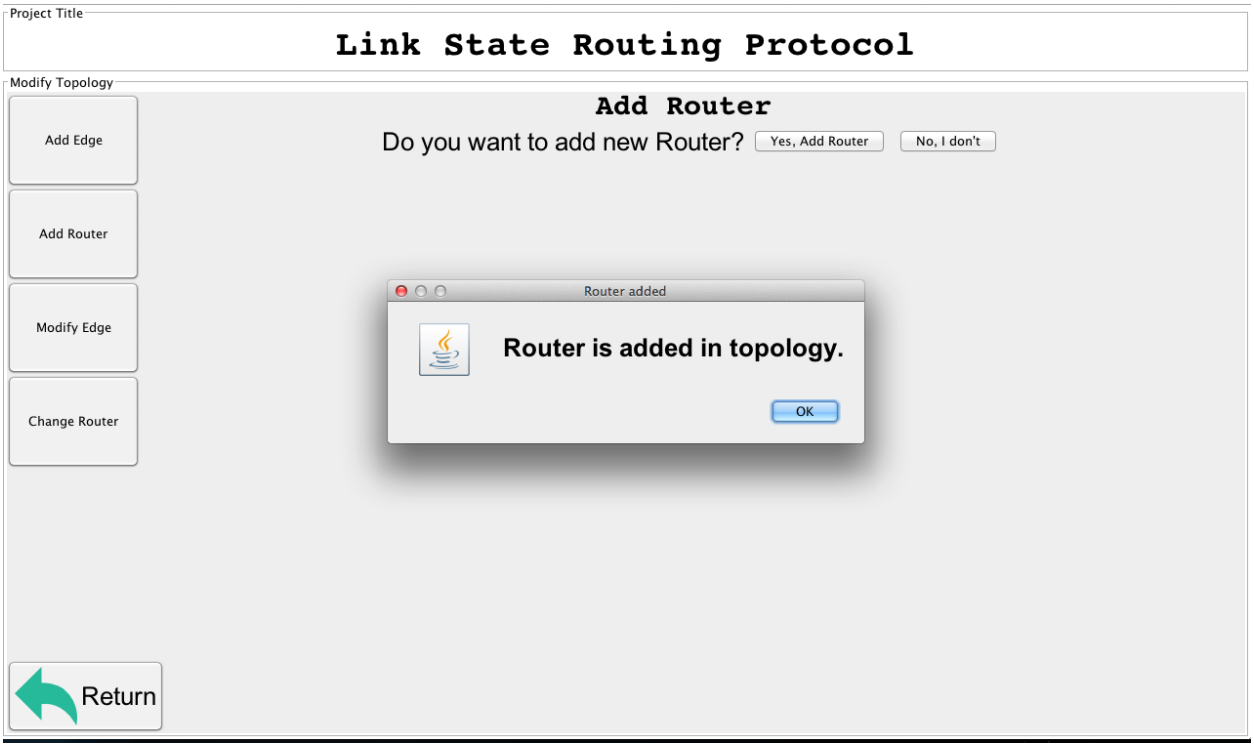
4) I added an edge between router 1 and router 3 with a cost of 2. I used modify topology's add edge button.

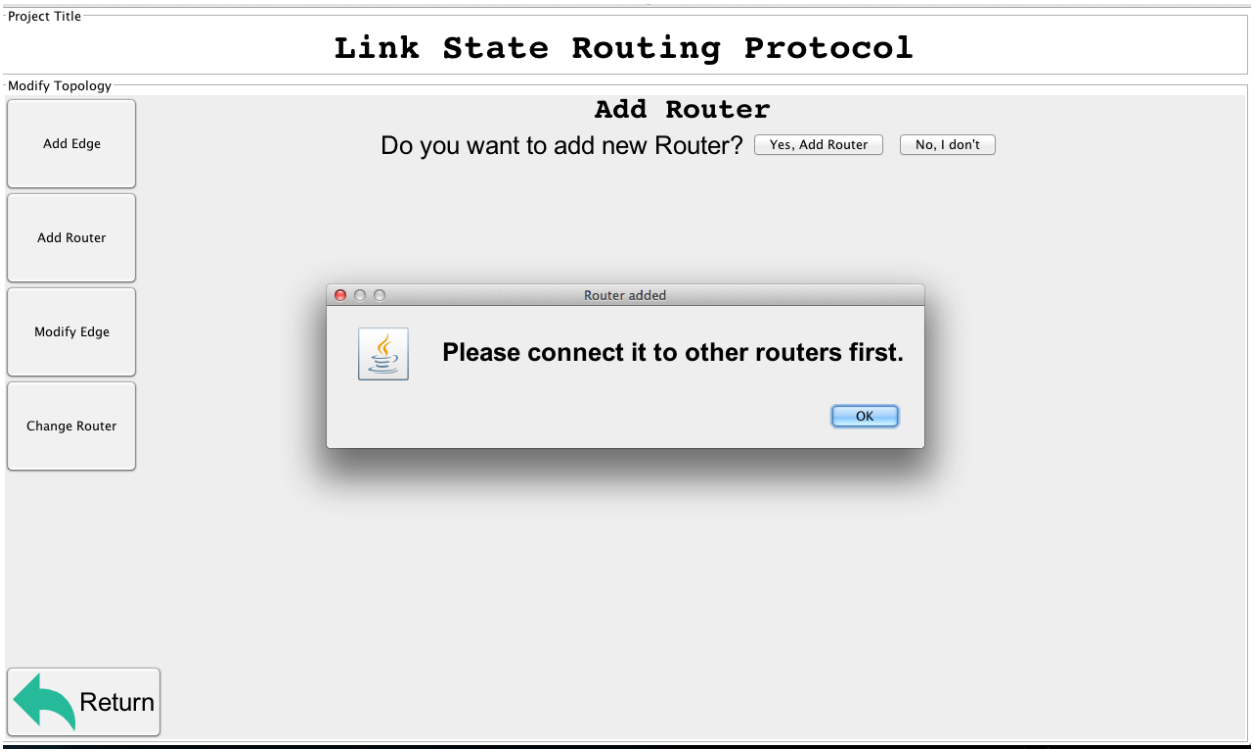


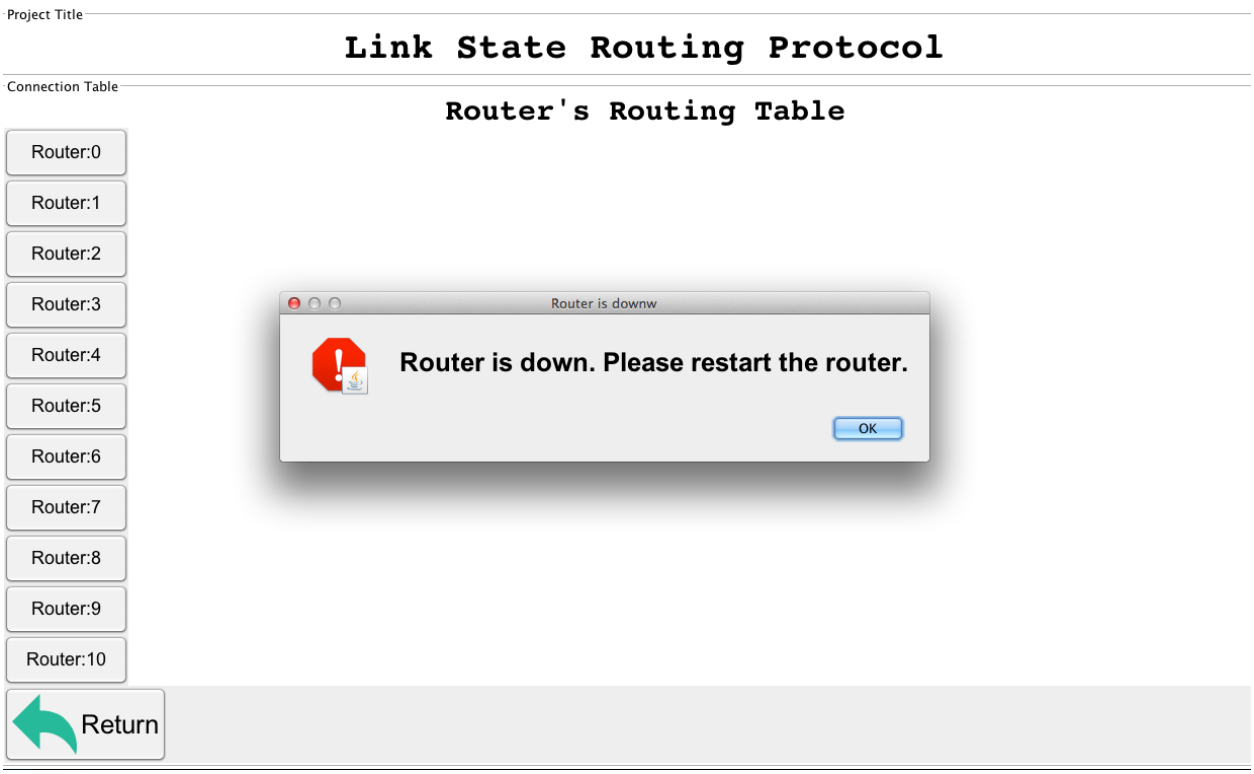
- If I mention to add an edge between a routers/router that is not present in a topology, it will throw me an error.
- I tried to add an edge between a router 1 and router 100. As the router 100 is not present in the topology, it will throw me a below error that "router is either not available or down".



5) We can use modify topology's add router button, to add a new router in a topology. It will add a new router in a topology. But the new router will not have a connection with other router. So, it will show a message to connect the new routers with the existing ones. We can check whether the router is added or not by looking at the connection table. In this case, it shows the new added router 10 in the connection table, but when we open the connection table of router 10, it will throw a router down error, as the new router hasn't been connected in the topology.

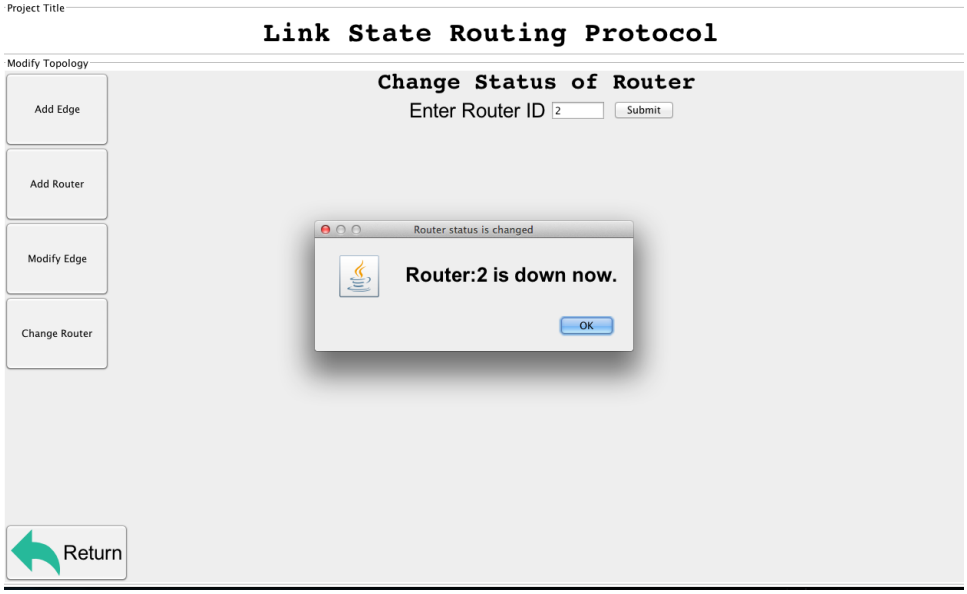


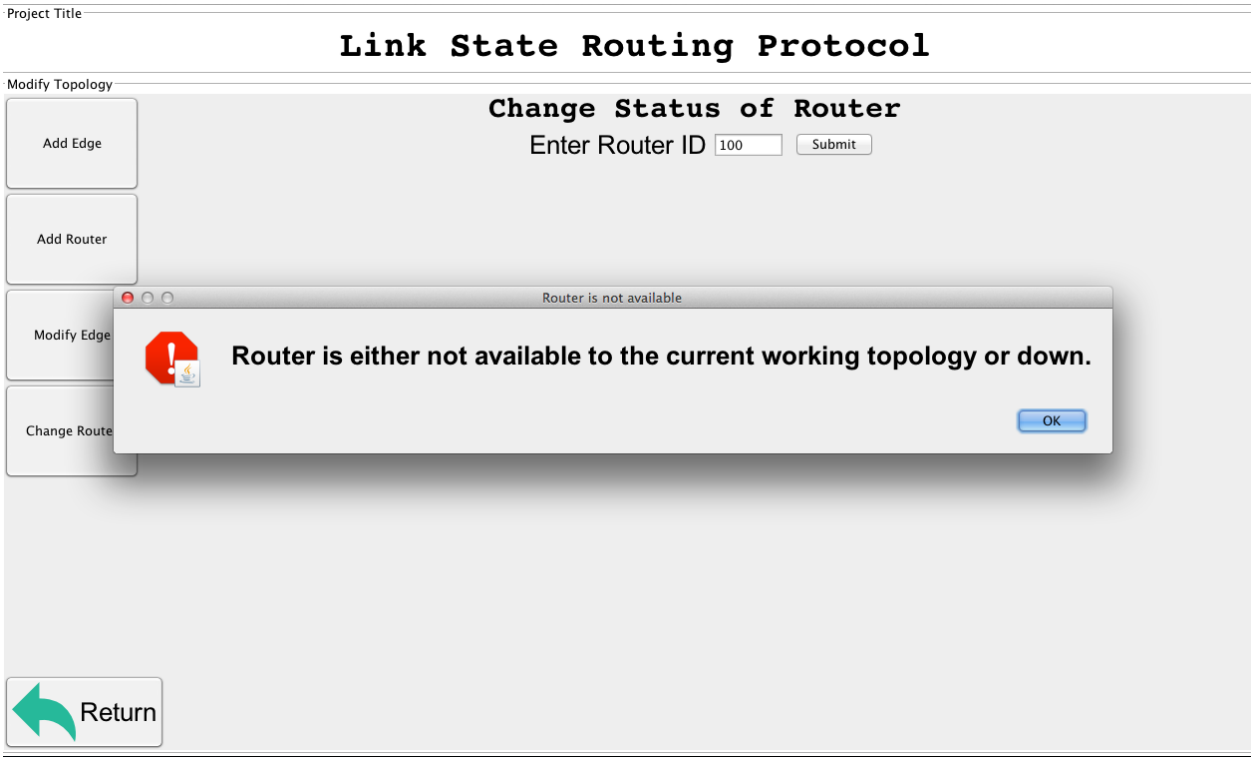

Project Title
Link State Routing Protocol
Modify Topology
Add Edge
Add Router
Modify Edge
Change Router
Return
Add Router
Do you want to add new Router?
Yes, Add Router
No, I don't
Router added
Please connect it to other routers first.
OK

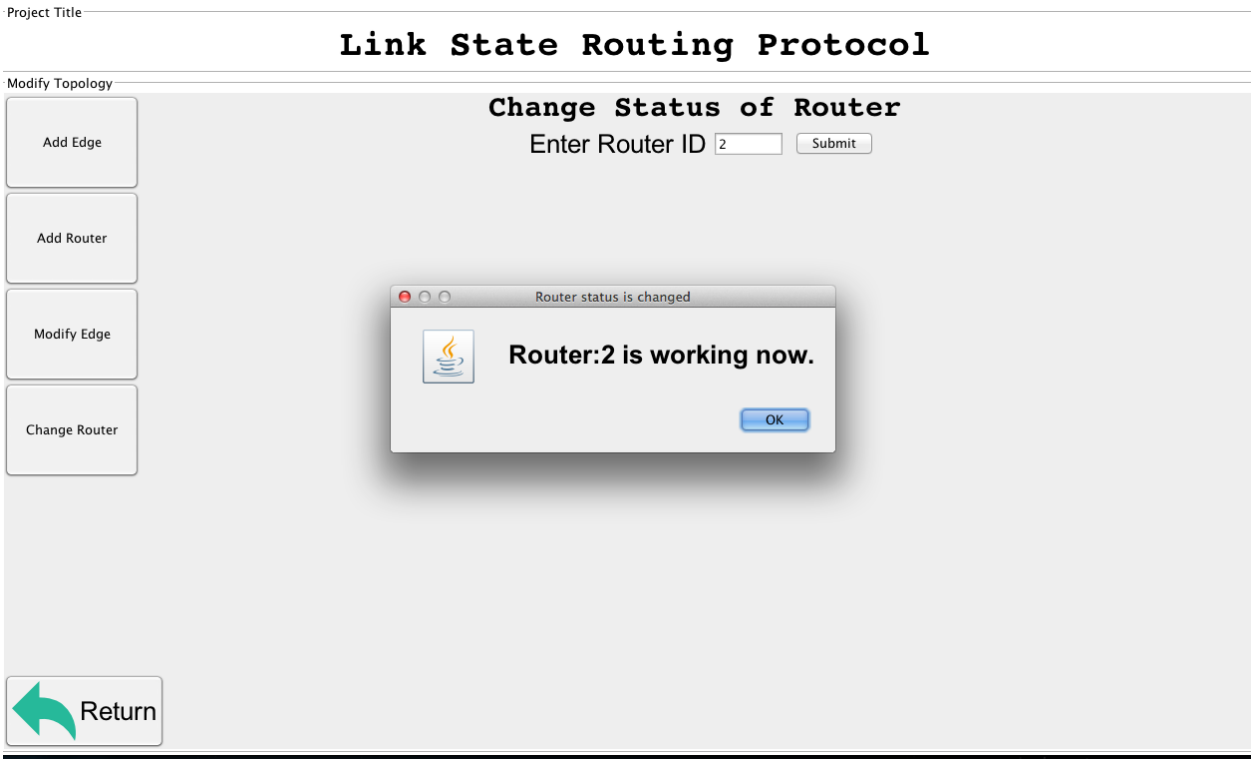

Project Title
Link State Routing Protocol
Connection Table
Router's Routing Table
Router:0
Router:1
Router:2
Router:3
Router:4
Router:5
Router:6
Router:7
Router:8
Router:9
Router:10
Return
Router is downw
Router is down. Please restart the router.
OK

6) To modify the weight of an edge, we can use modify edge button. We have to provide the source and destination routers of the edge as well as the new weight of the link. If both the router are present in the topology and are up, it will change the cost between them. If the one of the router is down, or isn't present in the topology it will throw a "router down or not available" error.

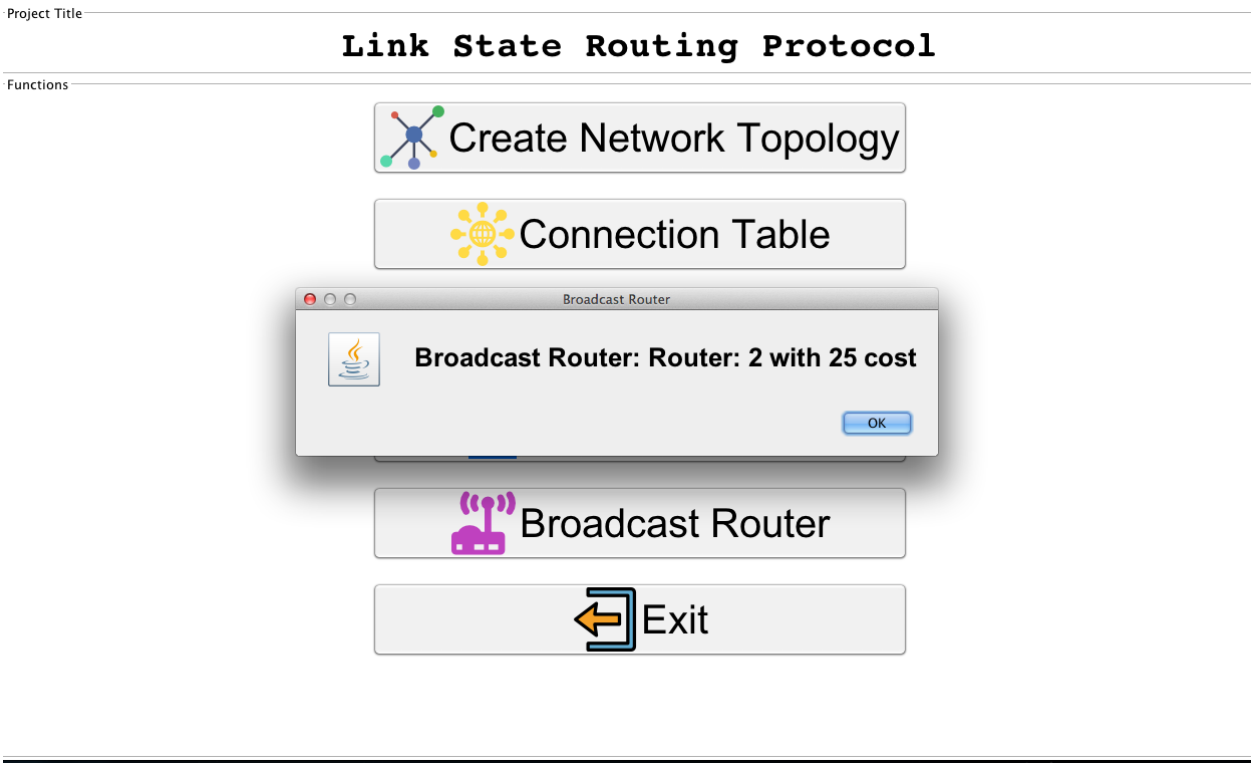
7) We can change the router status using change router button in modify topology. If the router will not be present in a topology, it will throw an error of “router not available or down”, or else if the router is present in the topology if it is down it will make it up/recover, and if it is down it will make it down/remove.



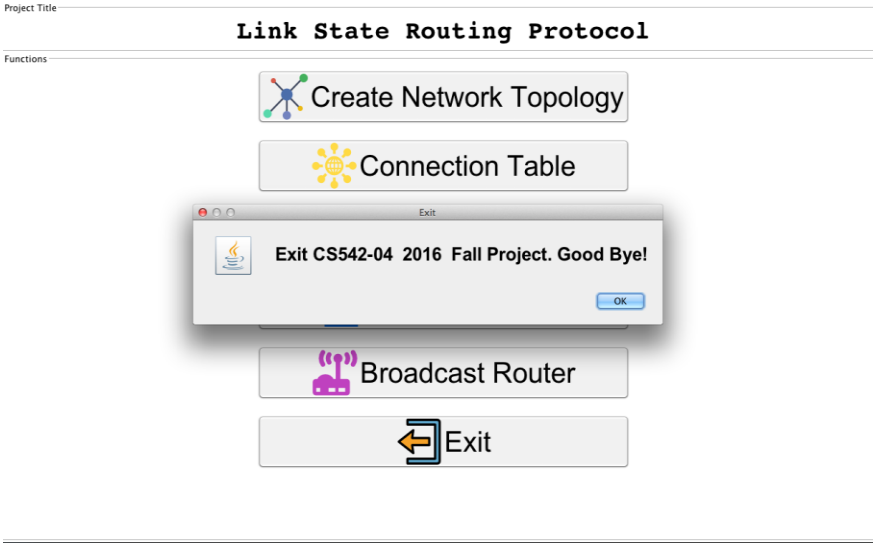

Project Title
Link State Routing Protocol
Modify Topology
Add Edge
Add Router
Modify Edge
Change Route
Change Status of Router
Enter Router ID
100
Submit
Router is not available
Router is either not available to the current working topology or down.
OK
Return


Project Title
Link State Routing Protocol
Modify Topology
Add Edge
Add Router
Modify Edge
Change Router
Change Status of Router
Enter Router ID 2
Submit
Router status is changed
Router:2 is working now.
OK
Return

8) To find the broadcast router, we can click broadcast router button. It will show the best router for broadcasting with it's overall cost. As we can see from our topology that router 2 is the best router for broadcasting with a cost of 25, and the output is the same too.



9) By pressing the exit button, it will close the GUI.



References:

- Data Communication and Networking 4th Edition by Behrouz A. Forouzan
- Wikipedia: Link State Routing Protocol