A New Shortest Routing Path Algorithm using Spanning Trees – A Technical Research

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Abstract

In the contemporary systems of communication, Wireless Sensor Networks (WSNs) have become one of the most up-and-coming trends. In the design of WSNs, routing is of utmost importance. Several commonly used routing metrics include the minimum hop, minimum energy consumed per packet, maximum energy capacity, maximum minimum energy capacity, maximum time required to partition the network, minimum variance in the power level of the node, the quality of service(QoS) and the robustness.
Keywords- Shortest Path Routing, Sensor Node

I. INTRODUCTION

Routing in wireless sensor networks should be light weight due to the limitations of processing storage, bandwidth and energy capacities. Dynamic changes in WSNs like the change in the topology, failure of node require that routing solution should be very flexible and adaptive.

WSNs have wide applications in varied fields, their main functionality is to assemble any scalar, audio, still image or video information from the vicinity of the sensors and deliver the collected information to the base station. The energy processing power & communication functionality of the wireless sensors is limited owing to their cost, size & weight.

Thus the conservation of energy is of utmost importance in extending the lifespan of WSNs. Numbers of nodes that participate in forwarding the information do affect the energy efficiency.

If a large number of nodes are involved in broadcasting the same messages, it will surely result in draining out the energy of the network rapidly. Thus, a routing algorithm should carefully consider the selection of minimum number of nodes required to participate in WSN message transmission.

An efficient routing path would reflect the nodes with high energy level to improve the probability of message delivery to the base station.

II. OVERVIEW OF THE PROPOSED WORK

A. The Proposed Algorithm

1) Initialize minimum paths between the source node and all other nodes
2) Find MST of the graph.
3) Find paths between the source-node and all other nodes using the MST.
4) Update minimum paths based on the newly generated paths. (ie. If there exists a shorter path between one of the network node and the source-node, save this path as the minimum path)
5) Find all the bridges in the graph.
6) Remove the lowest cost edge, which is not a bridge.
7) Repeat steps 2 to 6 until Number of edges < Number of vertices.

The above algorithm makes use of the Prim's algorithm to construct the minimum spanning tree.

The minimum cost paths from single source to all other nodes of network, obtained using the above algorithm can be validated by comparing them with the paths obtained using any of the established single-source shortest path algorithms (for example Dijkstra's algorithm).

III. IMPLEMENTATION

For the implementation of the proposed algorithm and to check its validity, I have used the following:

1) Visual C++, for the simulation and implementation of the algorithm.
2) Prim's Algorithm to find the minimum spanning tree of an undirected, connected graph.
3) A generic bridge finding algorithm to find the bridges in the graph to avoid disconnection.
4) Depth-First-Search (DFS) to compute the paths between each pair of nodes in the spanning Tree.
5) Dijkstra's Algorithm, to compute the shortest paths from a single-source to all other nodes and to validate the results of the proposed algorithm.

In the implementation of algorithm, the application takes as input, the number of nodes, required for the graph. Then it constructs a graph with nodes placed at random locations and constructs a full-mesh topology (each node is connected with every other node in the graph) to generate a connected undirected graph. The weights assigned to the edges are selected randomly between 0 to 50.

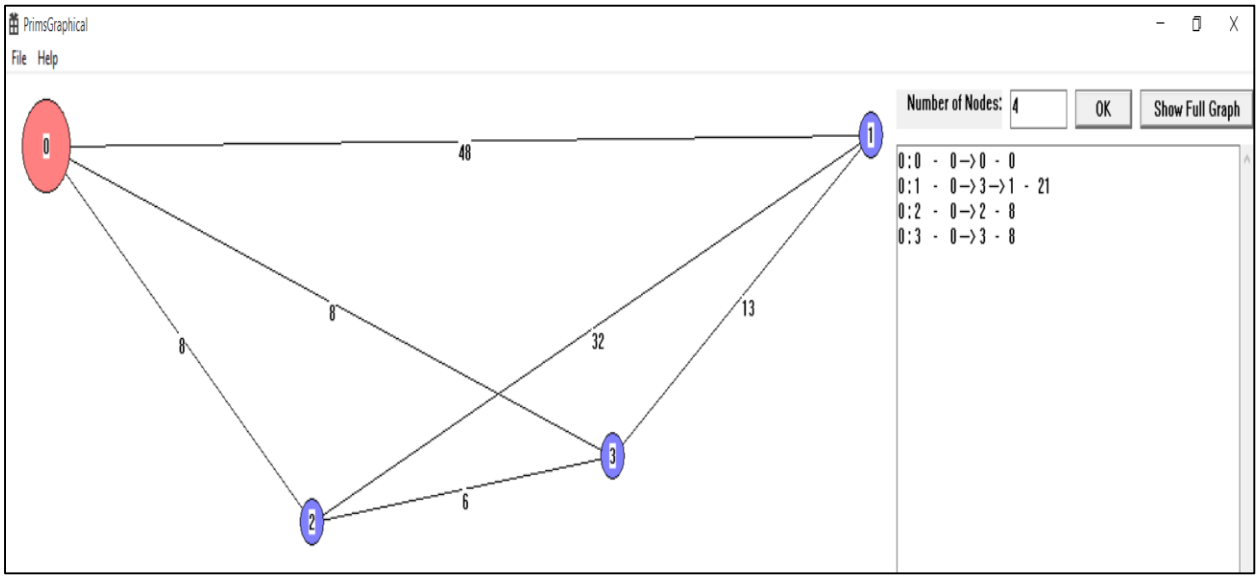


Fig. 1: A Graph and the computed single source shortest path from Node-0 to each node in the graph

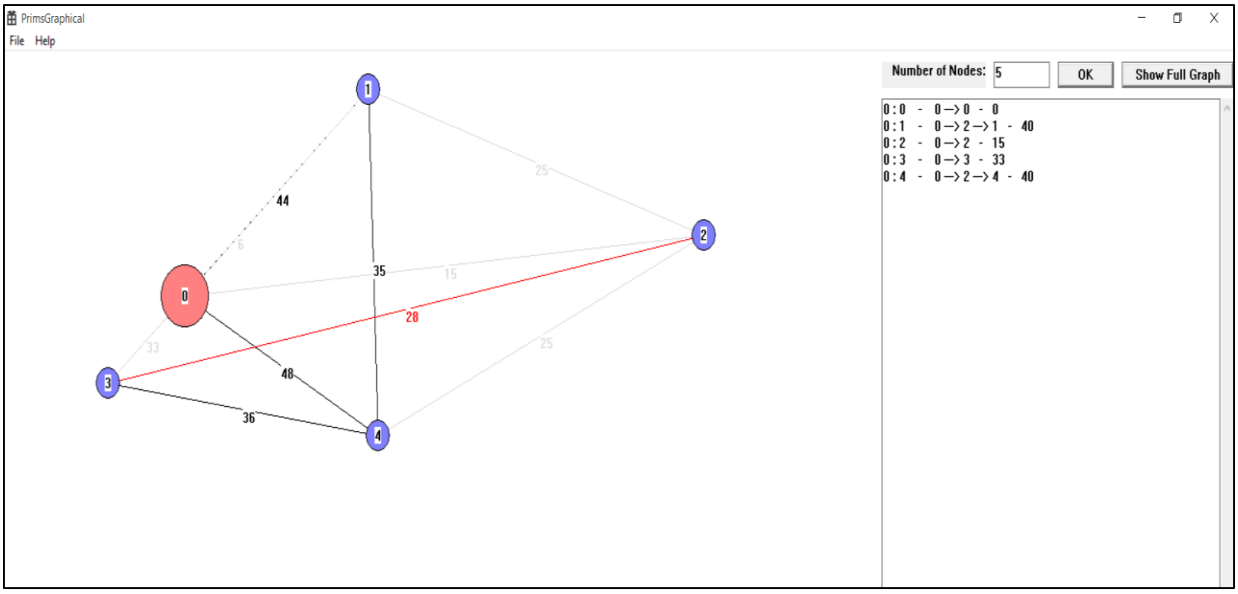


Fig. 2: An intermediate step of the proposed algorithm. The light-gray have been removed from the graph during subsequent executions of the algorithm

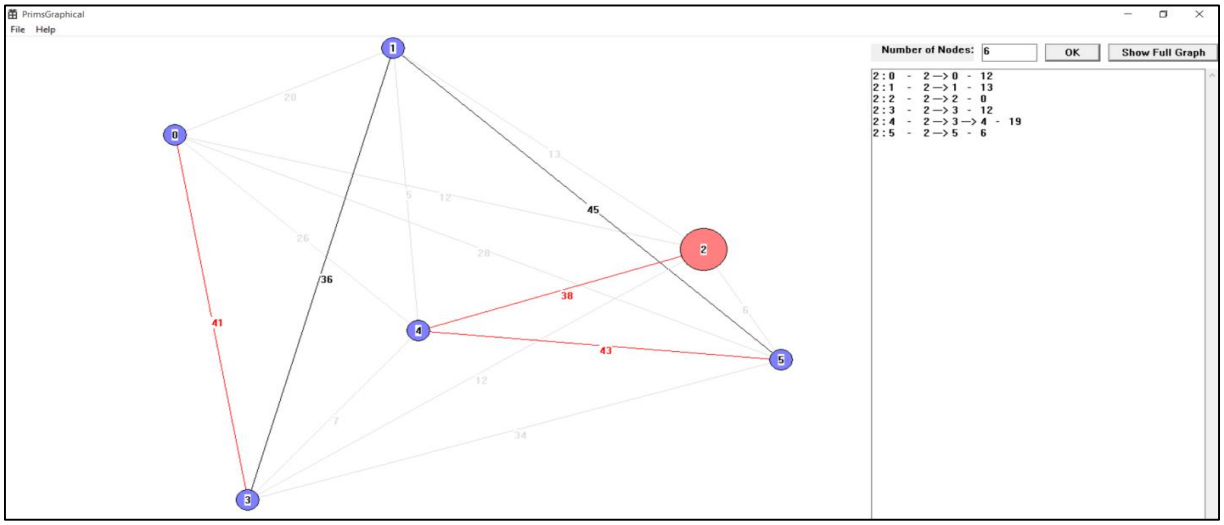


Fig. 3: An intermediate step of the proposed algorithm. The red edges are bridges disconnecting which will result in the graph to become disconnected

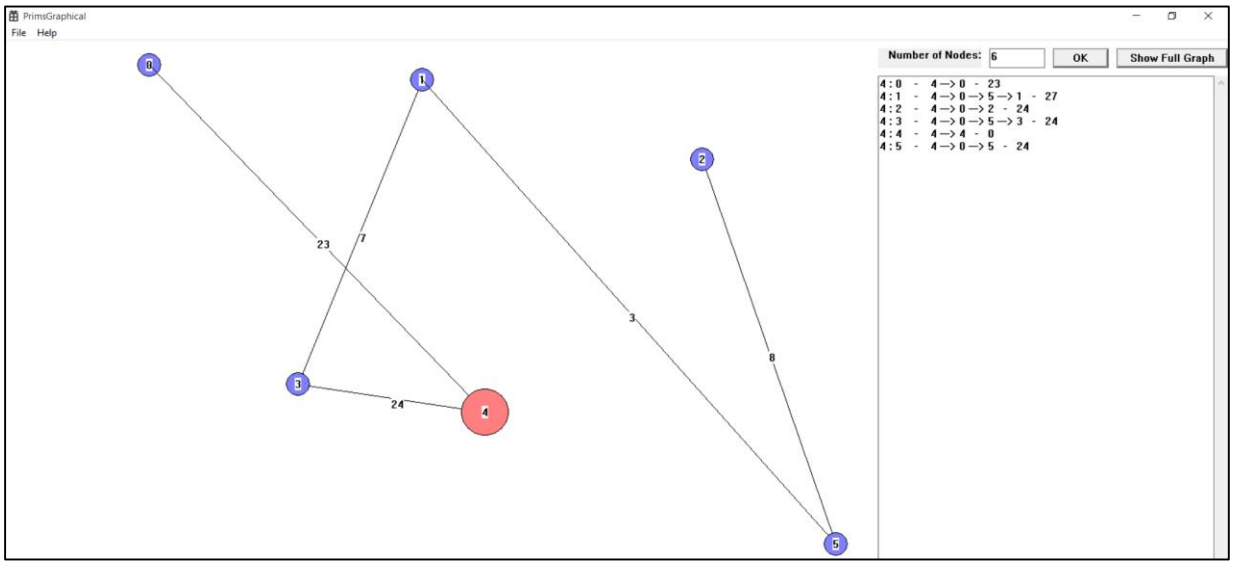


Fig. 4: Intermediate step of the proposed algorithm

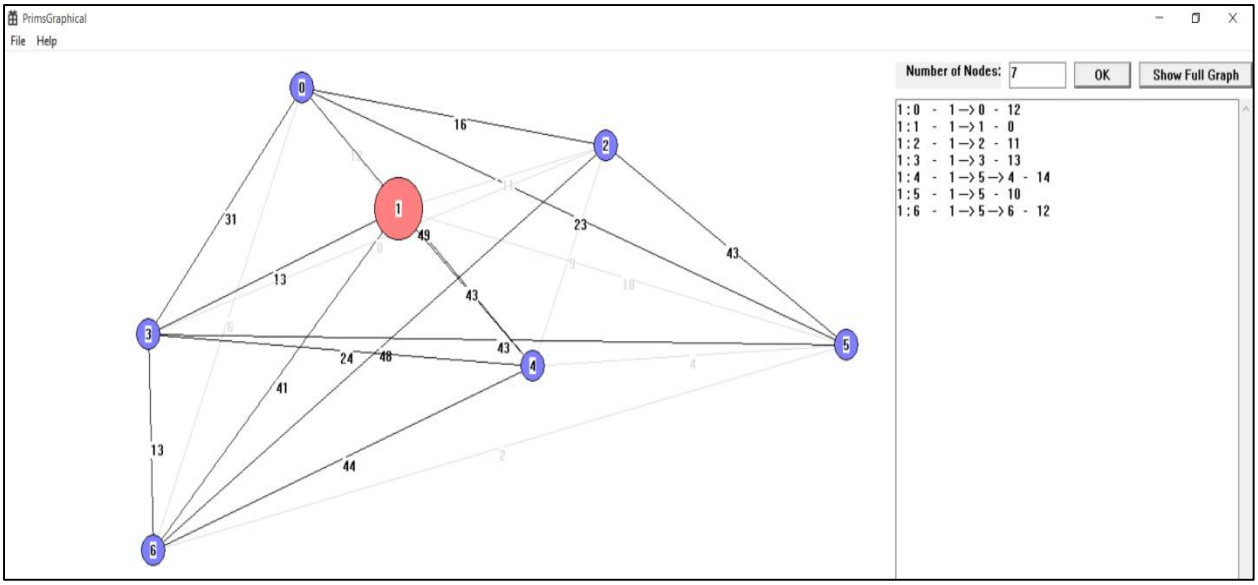


Fig. 5: Intermediate step of the proposed algorithm

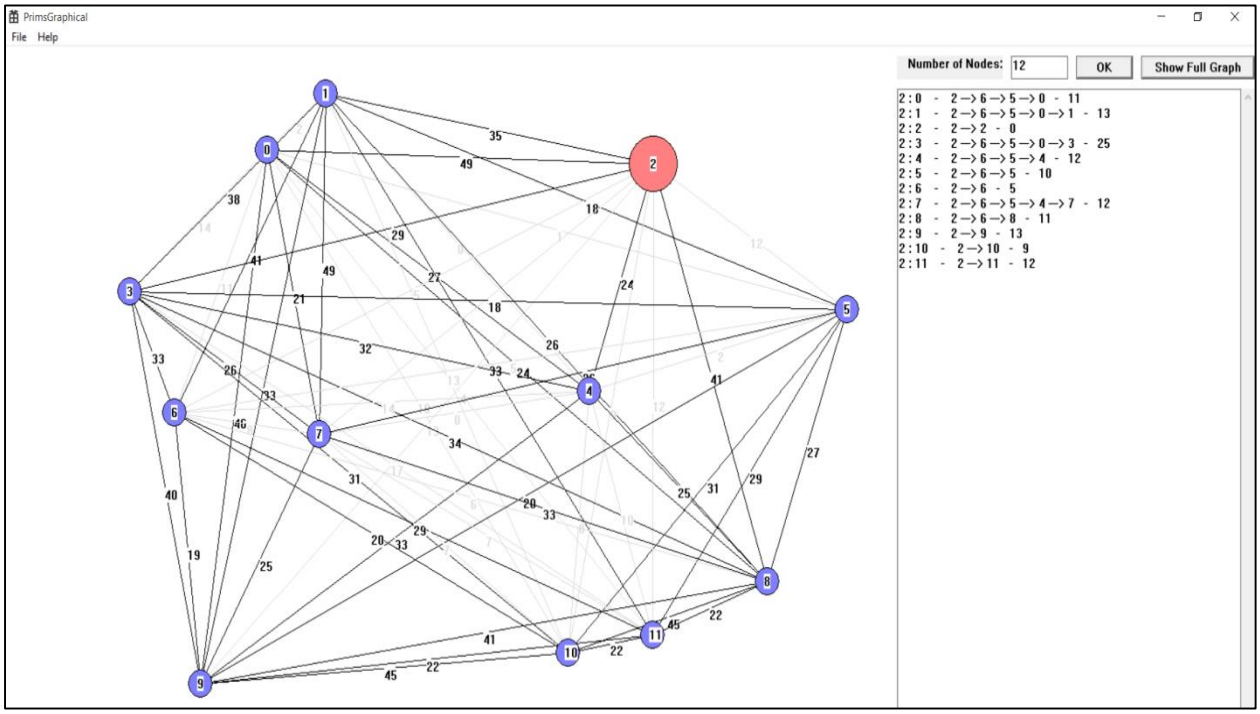


Fig. 6: Intermediate step of the proposed algorithm

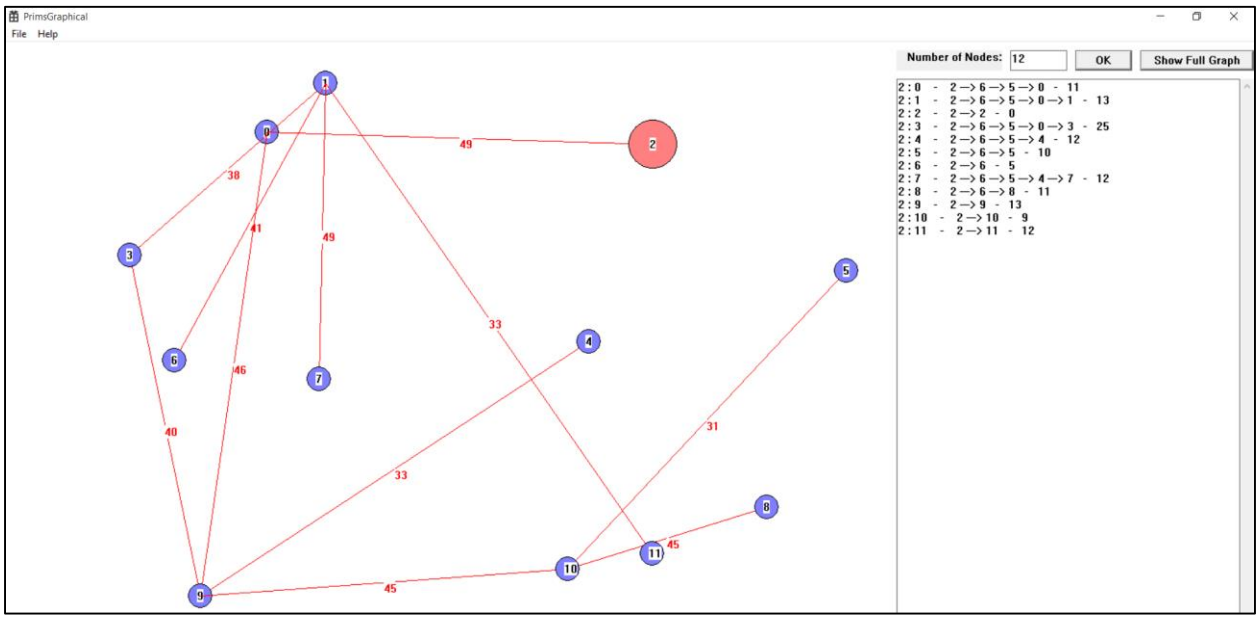
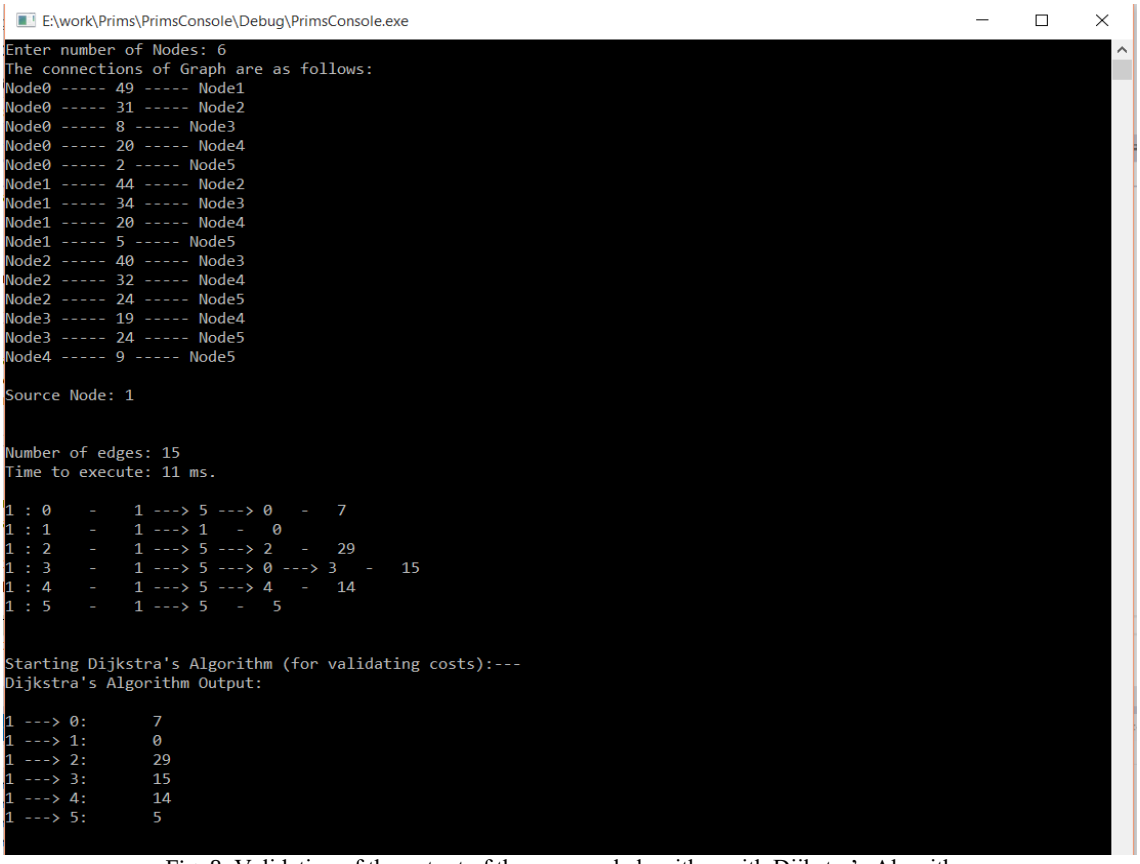


Fig. 7: Final step of the proposed algorithm. The algorithm is complete when all the edges of reduced graph become bridges OR the resulting graph is the MST of itself



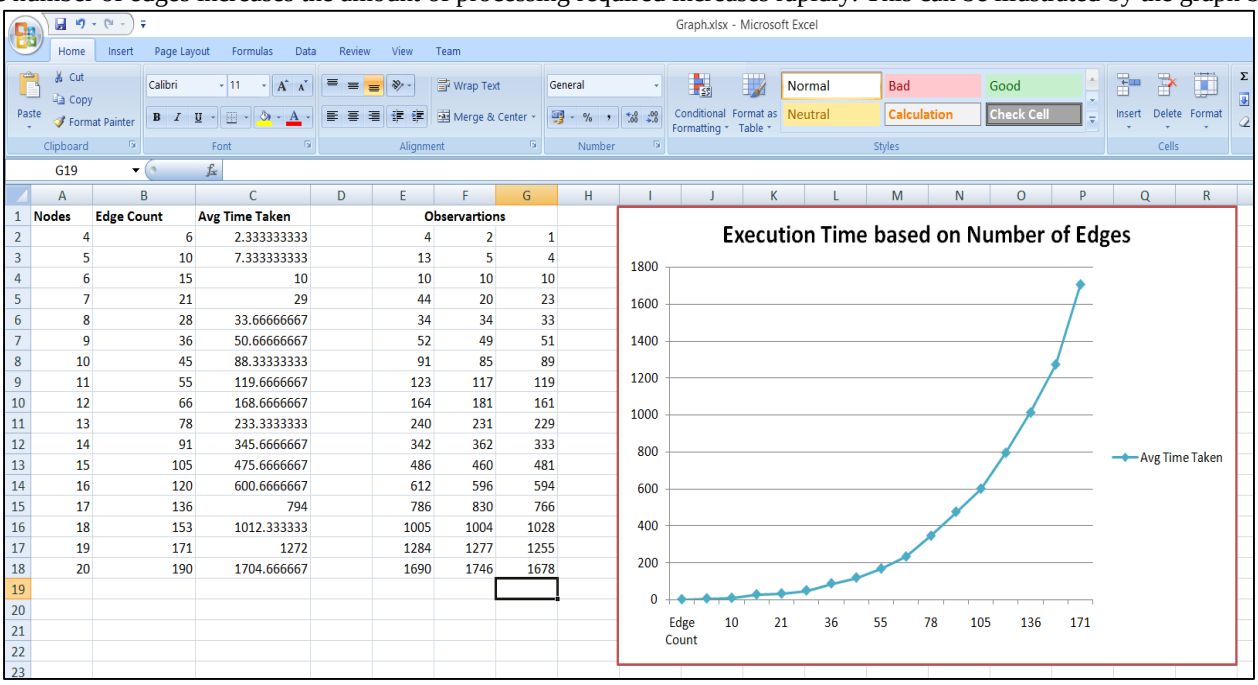
```
E:\work\Prims\PrimsConsole\Debug\PrimsConsole.exe
Enter number of Nodes: 6
The connections of Graph are as follows:
Node0 ----- 49 ----- Node1
Node0 ----- 31 ----- Node2
Node0 ----- 8 ----- Node3
Node0 ----- 20 ----- Node4
Node0 ----- 2 ----- Node5
Node1 ----- 44 ----- Node2
Node1 ----- 34 ----- Node3
Node1 ----- 20 ----- Node4
Node1 ----- 5 ----- Node5
Node2 ----- 40 ----- Node3
Node2 ----- 32 ----- Node4
Node2 ----- 24 ----- Node5
Node3 ----- 19 ----- Node4
Node3 ----- 24 ----- Node5
Node4 ----- 9 ----- Node5

Source Node: 1


Number of edges: 15
Time to execute: 11 ms.

1 : 0    -    1 ---> 5 ---> 0    -    7
1 : 1    -    1 ---> 1    -    0
1 : 2    -    1 ---> 5 ---> 2    -    29
1 : 3    -    1 ---> 5 ---> 0 ---> 3    -    15
1 : 4    -    1 ---> 5 ---> 4    -    14
1 : 5    -    1 ---> 5    -    5


Starting Dijkstra's Algorithm (for validating costs):---
Dijkstra's Algorithm Output:

1 ---> 0:       7
1 ---> 1:       0
1 ---> 2:       29
1 ---> 3:       15
1 ---> 4:       14
1 ---> 5:       5
```

Fig. 8: Validation of the output of the proposed algorithm with Dijkstra's Algorithm

IV. EXPERIMENTAL RESULTS

It is observed that – In most scenarios, the proposed algorithm accurately computes and constructs the minimum cost paths from a single source to all other nodes of a connected un-directed graph. In very rare scenarios, some of paths computed by Dijkstra's algorithm are shorter than those computed by the proposed algorithm. This is one limitation of the proposed algorithm for which identifying an exact pattern requires further experimental analysis.

As the number of edges increases the amount of processing required increases rapidly. This can be illustrated by the graph below:



Nodes	Edge Count	Avg Time Taken	Observartions		
4	6	2.333333333	4	2	1
5	10	7.333333333	13	5	4
6	15	10	10	10	10
7	21	29	44	20	23
8	28	33.66666667	34	34	33
9	36	50.66666667	52	49	51
10	45	88.33333333	91	85	89
11	55	119.6666667	123	117	119
12	66	168.6666667	164	181	161
13	78	233.3333333	240	231	229
14	91	345.6666667	342	362	333
15	105	475.6666667	486	460	481
16	120	600.6666667	612	596	594
17	136	794	786	830	766
18	153	1012.333333	1005	1004	1028
19	171	1272	1284	1277	1255
20	190	1704.666667	1690	1746	1678

Fig. 9: Simulation Results and Graph showing execution time of the proposed algorithm

V. CONCLUSION & FUTURE ENHANCEMENTS

In very rare scenarios, length of some paths computed by Dijkstra's algorithm is smaller than those computed by the proposed algorithm.

The execution time of the proposed algorithm increases rapidly with the increase in the number of edges. One of the most time consuming operations is that of computing the bridges during every iteration.

The Depth First Search used during each iteration, to compute and construct the paths between source and each node of graph in the spanning tree, also adds major time-complexity to the overall performance of the proposed algorithm.

I will need to identify the exact scenarios when Dijkstra's algorithm finds shorter paths than the proposed algorithm and then, modify the algorithm to solve the issue.

I would try to optimize the algorithm, by finding some alternative method for bridge finding operation and thus reduce the time complexity involved in the operation.

REFERENCES

[1] Pritam Khan, Gargi Konar, Niladri Chakraborty, "Modification of Floyd-Warshall's Algorithm for Shortest Path Routing in Wireless Sensor Networks,", In the proceedings of IEEE 2014 Annual IEEE India Conference (INDICON)
[2] Sami Alwakeel, Agung Prasetijo, and Najla Alnabhan, "An Adaptive Energy-Saving Routing Algorithm for Mobile Wireless Sensor Networks", In the proceedings of IEEE 1st International Conference on Electrical and Information Technologies ICEIT'2015
[3] Nandkumar Kulkarni, Neeli Rashrni Prasad, Ramjee Prasad, "G-MOHRA: Green Multi-Objective Hybrid Routing Algorithm for Wireless Sensor Networks", 2014 IEEE
[4] Zhi Hu 1,2, Ying-you Wen 1,2, Hong Zhao 1,2, "A Secure Routing Algorithm in Wireless Sensor Networks", In the proceedings of IEEE Workshop on Advanced Research and Technology in Industry Applications (WARTIA) 2014
[5] K S Shivaprakasha, Muralidhar Kulkarni," Energy Efficient Shortest Path Routing Protocol for Wireless Sensor Networks",In the proceedings of 2011 International Conference on Computational Intelligence and Communication Systems.
[6] Kamil Samara, Hossein Hosseini, "A Routing Protocol for Wireless Sensor Networks with Reliable Delivery of Data", In the proceeding of 2015 IEEE International Conference on Data Science and Data Intensive Systems
[7] Prantik Biswas, Abhisek Paul, Paritosh Bhattacharya, "Generating Spanning Tree of Non-Regular Graphic Sequences Through a Variant of Prim's Algorithm", 2015 IEEE International Conference on Circuit, Power and Computing Technologies [ICCPCT]
[8] Akinniyi Ojo, Ngok-Wa Ma, Isaac Woungang, "Modified Floyd-Warshall Algorithm for Equal Cost Multipath in Software-Defined Data Center", In the proceedings of IEEE ICC 2015 - Workshop on Advances in Software Defined and Context Aware Cognitive Networks 2015 (IEEE SCAN-2015)
[9] Monjur Ahmed, "Handshaking Problem Associated with Addressing Scheme for the nodes in Wireless Sensor Network", In the proceedings of International Journal of Advancements in Research and Technology 2012.
[10] Pritam Khan, Gargi Konar, Niladri Chakraborty, Arnab Ghosh "Temperature and Humidity Monitoring through Wireless Sensor Network using Shortest Path Algorithm" In the proceedings of IEEE 2014 International Conference on Control, Instrumentation, Energy & Communication(CIEC)
[11] Nitika Vats Doohan, Durgesh Kumar Mishra, Sanjiv Tokekat, "Shortest Path Routing Protocol (Sprp) For Highly Data Centric Wireless Sensor Networks" 2011 IEEE.