International Journal of Electrical and Computer Engineering (IJECE)
Vol. 5, No. 6, December 2015, pp. 1417~1423
ISSN: 2088-8708

Performance Comparison of Routing Protocols in Bipartite Wireless Sensor Network

Devashish Gosain, Itu Snigdh
Department of Computer Science, Birla Institute of Technology, Ranchi, India

Article Info

Article history:

Received Apr 12, 2015
Revised Jul 20, 2015
Accepted Aug 16, 2015

Keyword:

Average Delay
Bipartite
Carried Load
Energy Consumed

ABSTRACT

This paper evaluates and ranks the suitability of routing algorithms for bipartite wireless sensor network topology. The network considered in this paper, consists of an irregular combination of fixed and mobile nodes, which leads to construction of a bipartite graph among them. A wireless sensor network is usually constrained by the energy limitations and processing capabilities. We therefore, consider the important metrics for analysis namely, carried load, energy consumption and the average delay incurred. We present the possibilities of employing the routing algorithms subject to the quality of service required by the wireless sensor networks applications.

Corresponding Author:

Devashish Gosain,
Department of Computer Science,
Birla Institute of Technology,
Ranchi, India
Email: gosain.devashish@gmail.com

1. INTRODUCTION

WSN's are now all pervasive in world. From home automation system to critical boiler monitoring, from X-Box to military surveillance, they are ubiquitous. Recently, considerable amounts of research efforts have enabled the actual implementation and placement of sensor networks tailored to the unique requirements of certain sensing and monitoring applications [1].

An established well-functioning sensor network has a foundation, built on, two factors, a good communication protocol and a robust network topology. Extensive review of existing communication protocols can be found in [2], [3] and for Sensor placement (or network topology) [4] can be referred.

Objective of any sensor topology is to increase the coverage with minimizing the cost. To increase the coverage various schemes have been proposed, which includes bifurcated network of fixed and mobile nodes, like grid deployment method [5], where the region is divided into grids. Number of deployed static nodes, obstacles and boundaries collectively decides the weight of each grid. The grid with least weight is the destination of a mobile sensor. In [6] Voronoi polygon is exploited to find the number of coverage holes (with their positions) using a coverage enhancing algorithm. Similar to this, in [7] authors propose an algorithm which uses Delaunay triangulation to determine holes with the help of mobile and static sensor nodes.

Since variegated network of such kind has many practical applications; we focus on the topology which is partially static and partially dynamic in our research. The wireless sensor networks that constitute mobile and fixed sensors usually compromise between cost and coverage. Also, in order to achieve high coverage, mobile sensors may require to move from dense areas to sparse areas. The background strength of our analysis lies in incorporating bipartite graphs into such kind of topology. There has been a lot of research by employing such graphs in target tracking applications. The network is incorporated as a set Si consist of i

sensors and set Tj consist of j targets; with the objective to assign sensors to targets optimally (maximizing utility and/or minimizing cost), subject to the imposed constraints. Authors view this as a bipartite graph, where an edge e(Si, Tj) corresponds to a pairing of sensor Si with target Tj with the objective of assigning sensors to targets optimally (maximizing utility and/or minimizing cost), subject to the imposed constraints [8]-[10].

Our work is different from the previous work, because here we are partitioning sensors into two disjoint sets of mobile and stationary sensors.

2. MOTIVATION

The motivation behind the idea is that, sometimes it becomes impossible to manually deploy sensors in sites like rough mountain terrain, dense forests, cave, battlefields, and areas affected by poisonous gases. The solution is scattering the sensors randomly, with obvious drawback of not having the desired placement and coverage. In the recent times, researchers have encouraged on mixed sensor networks, in which the stationary nodes and mobile nodes work in coherence to perform placement task. Such placements give more coverage and robustness with reduced number of nodes.

Our article analyses this topology construction in context to a bipartite graph. Essentially a bipartite graph, also called a bigraph, is a set of graph vertices decomposed into two disjoint sets such that no two graph vertices within the same set are adjacent [11]. Our bipartite sensor network involves partitioning sensors into two disjoint sets of mobile and stationary sensors. In this article, we analyze the performance of bipartite network under three classes of routing algorithms, namely DSR (on demand) [12], OLSR (distance vector based , static) [13], and FISHEYE (link state based) [14] on different kinds of bipartite sensor networks that has not been addressed in previous literatures till date.

3. SYSTEM MODEL

We constructed a bipartite graph B(V, E), where V = S ∪ M, where S denotes the set of static nodes and M denotes the set of mobile nodes. We have taken the distance as a cost metric in the construction of the bipartite graph.

3.1. Assumptions

1) Sensors are location aware either obtained from Global Positioning System (GPS) or through location discovery algorithms.
2) It is assumed that mobile sensors are Full Functional Device and Stationary Sensors are reduced functional devices.
3) The mobile/dynamic sensors can easily move and can reach the desired location efficiently and accurately using the mobility algorithm for dynamic sensors.

3.2. Mobility Algorithm

1) For each mobile node
2) For each static sensor node
3) Calculate Euclidian distance from itself
4) Update node table entry
5) End For
6) From node table select the node with min. distance
7) Move towards the node selected in step 5
8) Latch with node selected in step 5 and to all other static nodes which are in its communication range
9) Delete node entries from its node table (of latched nodes from step 7)
10) Repeat step 6 to 9 until its node table gets empty
11) End For
12) Repeat steps 1 to 11 multiple times

3.3. Steps of Construction

1) Add all the movable nodes into set M.
2) Add all the stationary nodes into set S.
3) $\forall m \in M$and $\forall s \in S$ if mobile node m can reach static node s, (the distance between m and s is less than maximum prescribed distance and the remaining energy of m is above a certain threshold E_T) then

add an edge e(m,s) into the bipartite graph; the weight of the edge e(m,s) is represented as w(m,s), denotes the distance between mobile node m and fixed node s, otherwise, w(m,s) = NULL.

3.4. Model Generated

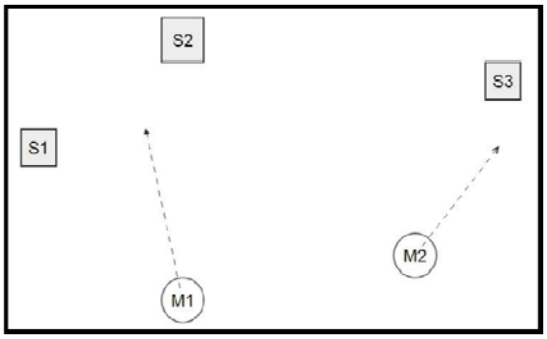

Figure 1. An initial deployment of $B_{3,2}$ sensors in a particular field

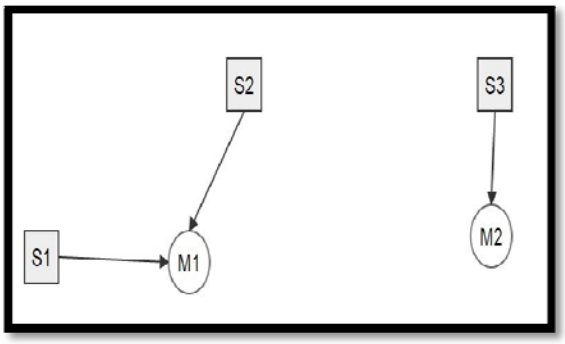

Figure 2. Final deployment of $B_{3,2}$ sensors

Figure 1 depicts two classes of sensors; static and mobile where, S1, S2 and S3 represent static sensors (none of them is in range of each other, communication is not possible). M1 and M2 represent mobile sensors. The dashed arrows represent the trajectories of M1 and M2 (mobile sensors) at a particular instance of time. (Note: both the sensors are completely free to move around inside the periphery, these arrows represent, onlyone particular possibility of their direction).

Figure 2 depicts the same network but aase when the mobile node moves in the communication range of a particular static sensor node thereby initiating data transfer. We see that M1 has moved along his trajectory and is in the transmitting range of both S1 and S2 (represented by solid arrows). Also, M2 has moved along his trajectory and is in the transmitting range of S3 (represented by solid arrows).In this scenario, S1, S2 and S3 are sensing their neighborhoods. M1 and M2 comes in proximity with Stationary sensors and collect the data from them. Later on, they will be moving towards sink and will transfer the data (sensed by themselves and collected from static sensors). Same process is iterated multiple times.

3.5. Snapshot of Actual Simulation of B3,2

Figure 3 shows that initially mobile sensors 4 and 5 are not in range of any static sensor 1, 2 or 3. The red flags are random waypoints which indicate the next location of mobile sensors.

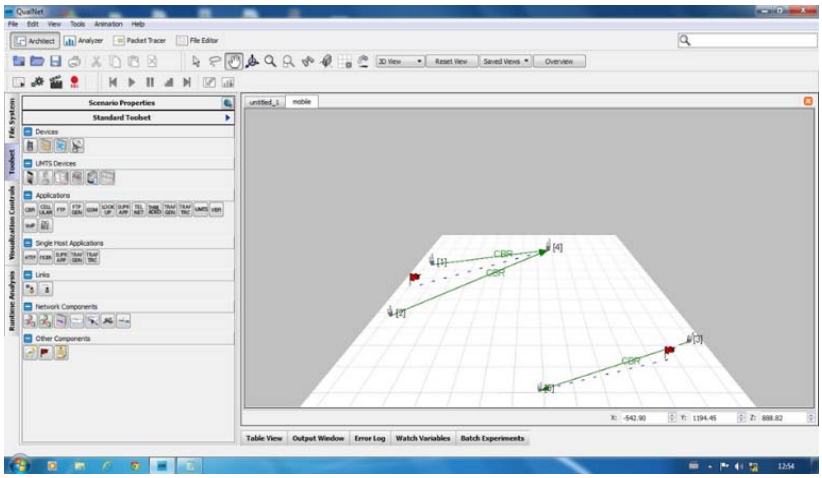

Figure 3. Initial deployment setup

From Figure 4 we observe that finally, mobile nodes have travelled and now they are in range of static nodes. Node 4 (mobile) is communicating with nodes 1 and 2 (static). Similarly Node 5 (mobile) is communicating with node 3 (static)

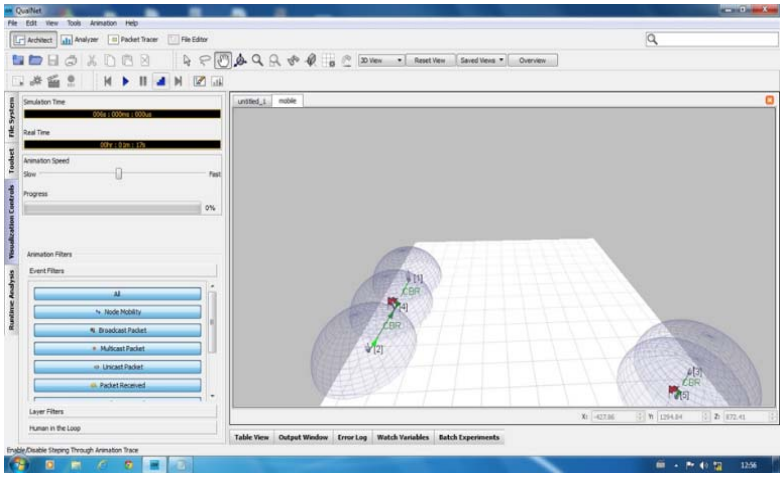

Figure 4. After movement of mobile nodes

3.6. Notations Used

Assembly of S1, S2 and M1 is named as $B_{2,1}$,acronym of Bipartite Graph consisting two set of nodes static (S1 and S2) and mobile (M1).

1) Assembly of S3 and M2 is named as $B_{1,1}$,acronym of Bipartite Graph consisting two set of nodes static (S2) and mobile (M2).

2) Together these assemblies are known as $B_{3,2}$,acronym of Bipartite Graph consisting two set of nodes static (S1, S2 and S3) and mobile (M1 and M2).

3) In general, $B_{m,n}$represents a Bipartite graph of two set of nodes, one consisting of *m* fixed nodes and other consisting of n mobile nodes.

4. SIMULATION RESULT

Construction of the various bipartite network scenarios is implemented in Qualnet under the set of given experiments with following parameters.

1) $B_{m,1}$graphs which consist of m static nodes and only 1 moving node.
2) $B_{m,2}$ graphs which consist of m static nodes and 2 moving node.
3) $B_{m,3}$graphs which consist of m static nodes and only 3 moving node.

Table 1. Parameter Specifications

PARAMETERS	VALUES
Area	1500 x 1500 m
Data Rate	2 Mbps
Radio Type	802.11b
Packet Reception Model	PHY802.11b
Battery Model	Residual Life Estimator
Energy Model	Mica Motes
MAC Propagation Delay	1 s
Application	Constant Bit Rate

The main interest lies in observing how the routing protocol performs with increasing number of mobile nodes as they will require extra power source for motion.The three important parameters of WSN, Carried Load, Energy and Delay have been observed for DSR, OLSR and FISHEYE. The graphs are analysed for the results obtained after simulation.

4.1. Carried Load

From Figure 5(a), 5(b) and 5(c it is evident that carried load in the network is minimum for DSR followed by OLSR and FISHEYE. Performance of DSR can be attributed to its ad-hoc nature. It is an on-demand protocol designed to minimize the bandwidth consumed by control packets in ad hoc wireless networks by eliminating the periodic table-update messages required in the table-driven approach (like OLSR and FISHEYE) [15].

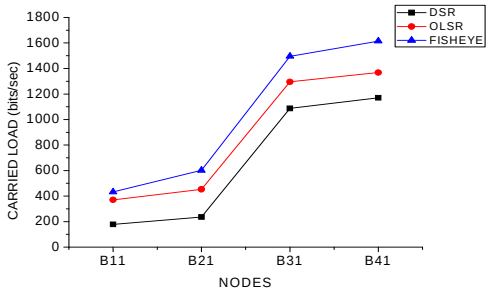

Figure 5(a). $B_{m,1}$ graph

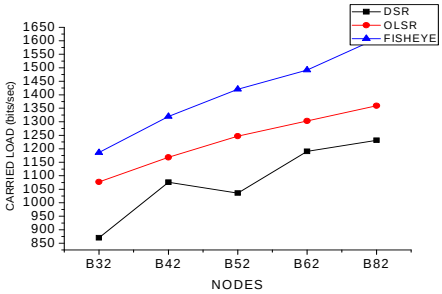

Figure 5(b). $B_{m,2}$ graph

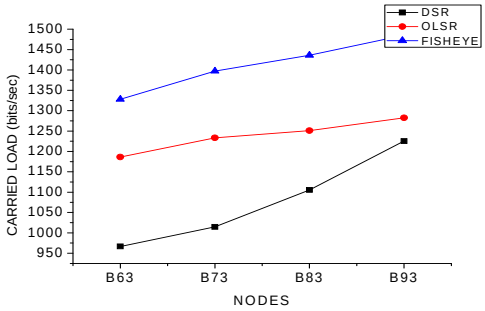

Figure 5(c). $B_{m,3}$ graph

4.2. Energy Consumed

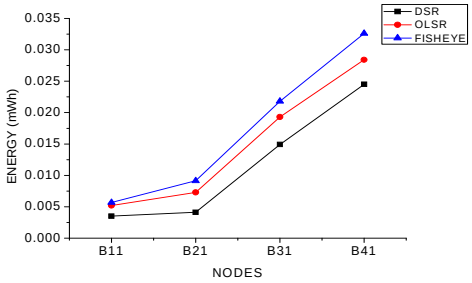

Figure 6(a). $B_{m,1}$ graph

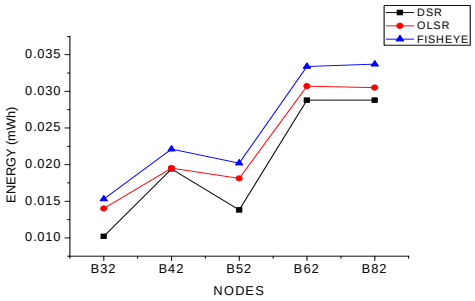

Figure 6(b). $B_{m,2}$ graph

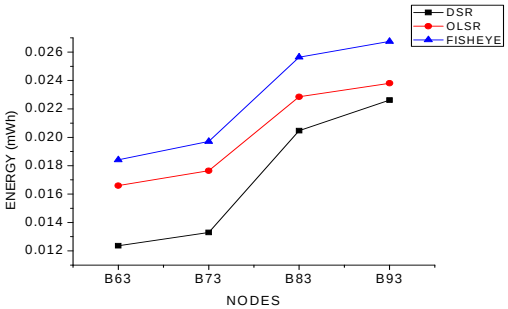

Figure 6(c). $B_{m,3}$ graph

On observing Figure 6(a), 6(b) and 6(c) it is clear that DSR has minimum energy requirement whereas FISHEYE has maximum. Carried load of a sensor node is directly proportional to its energy consumed. From previous findings it is established that for DSR routing scheme carried load is minimum, which implies energy consumption will also be minimum for the same. Since, FISHEYE and OLSR are proactive protocols, significant amount of energy will be required in transmitting and receiving control packets to maintain the link state routing table by each node, this leads to their high energy requirement.

4.3. Average Delay

Figures 7(a), 7(b) and 7(c) depicts that DSR routing scheme produces long delays in network. This can be attributed to the fact that, in link state routing algorithms (OLSR and FISHEYE), before transmission of data, neighbor tables of all the nodes are updated at the beginning only. Next hop selection takes trivial amount of time. But, in DSR every time the data packet is received by the node, it is forwarded to the next node, if a route to the destination is known by the present node. Else, route discovery mechanism is initiated by that node. This consumes considerable amount of time. This factor can be attributed to DSR's poor performance withrespectto the average delay parameter.

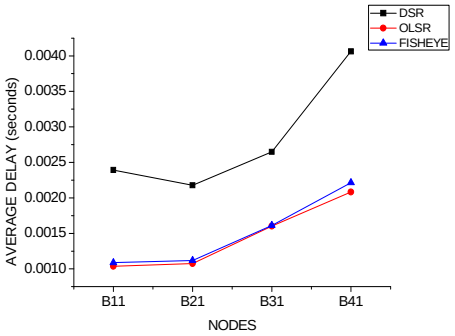

Figure 7(a). $B_{m,3}$ graph

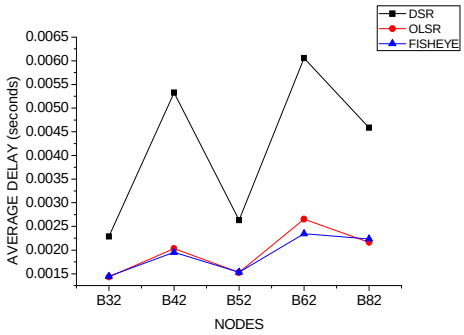

Figure 7(b). $B_{m,3}$ graph

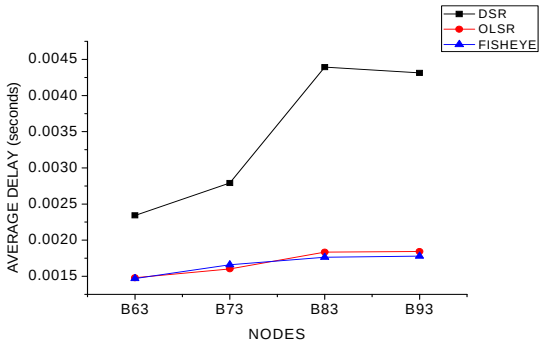

Figure 7(c). $B_{m,3}$ graph

Table 2. Rank Table

PERFORMANCE PARAMETERS	RANK 1	RANK 2	RANK 3
Carried Load (bits/sec)	DSR	OLSR	FISHEYE
Energy Consumed (mWh)	DSR	OLSR	FISHEYE
Average Delay (sec)	FISHEYE	OLSR	DSR

5. CONCLUSION

Energy and delay are two paraphernalia's for any WSN. If the bi-partite network is established in difficult-to-access terrains, where human intervention is infeasible, to prolong the network lifetime, DSR is the only option because of least energy requirement. However, in surveillance applications and disaster management system, where delivery time is of foremost importance, FISHEYE/OLSR can be employed but certainly DSR does not prove to be efficient. In situations where WSN is restricted to be operated on low bandwidth DSR routing scheme is a better option and must be employed for enforcing least carried load

REFERENCES

[1] Akyildiz, Ian F., and Mehmet Can Vuran, "Wireless sensor networks", Vol. 4, John Wiley & Sons, 2010.

[2] De Morais Cordeiro, Carlos, and Dharma Prakash Agrawal, "Ad hoc and sensor networks: theory and applications", 2nd edition, World Scientific, 2011.

[3] Royer, Elizabeth M., and Chai-Keong Toh, "A review of current routing protocols for ad hoc mobile wireless networks", *Personal Communications, IEEE*, Vol. 6, No. 2, pp. 46-55, 1999.

[4] P. Santi, "Topology Control in Wireless Ad Hoc and Sensor Network", John Wiley & Sons, 2005

[5] R. C. Luo and O. Chen, "Mobile sensor node deployment and asynchronous power management for wireless sensor networks", *IEEE Transactions on Industrial Electronics*, Vol. 59, No. 5, pp. 2377–2385, 2012.

[6] A. Ghosh, "Estimating coverage holes and enhancing coverage in mixed sensor networks", *In Proceedings of the 29th Annual IEEE International Conference on Local Computer Networks (LCN '04)*, pp. 68–76, 2004.

[7] Z. J. Zhang, J. S. Fu, and H. C. Chao, "An energy-efficientmotion strategy for mobile sensors in mixed wireless sensor networks", *International Journal of Distributed Sensor Networks*, Vol. 2013, pp. 12, 2013.

[8] Rowaihy, Hosam, *et al*., "A survey of sensor selection schemes in wireless sensor networks", *Defense and Security Symposium. International Society for Optics and Photonics*, 2007.

[9] Deshpande, Amol, Samir Khuller, Azarakhsh Malekian, and Mohammed Toossi. "Energy efficient monitoring in sensor networks", *Springer Algorithmica*, Vol. 59, No. 1, pp. 94-114, 2011.

[10] Khan, Usman A., and José MF Moura, "Distributed Kalman filters in sensor networks: Bipartite fusion graphs", *Statistical Signal Processing, 2007. SSP'07. IEEE/SP 14th Workshop on. IEEE*, 2007.

[11] http://mathworld.wolfram.com/BipartiteGraph.html.

[12] Johnson, D., Y. Hu, and D. Maltz, "The dynamic source routing protocol (DSR) for mobile ad hoc networks for IPv4", *The Internet Engineering Taskforce*, Vol. 260, pp. 4728, 2007.

[13] Jacquet, Philippe, Paul Muhlethaler, Thomas Clausen, Anis Laouiti, Amir Qayyum, and Laurent Viennot, "Optimized link state routing protocol for ad hoc networks", *In Multi Topic Conference, 2001. IEEE INMIC 2001. Technology for the 21st Century. Proceedings. IEEE International*, pp. 62-68, 2001.

[14] Pei, Guangyu, Mario Gerla, and Tsu-Wei Chen, "Fisheye state routing: A routing scheme for ad hoc wireless networks", *In Communications, 2000. ICC 2000. 2000 IEEE International Conference on*, Vol. 1, pp. 70-74, 2000.

[15] http://en.wikipedia.org/wiki/Dynamic_Source_Routing.