Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 6, No.2, June : 2024

PERFORMANCE ANALYSIS OF TSPWRP FOR DIFFERENT NUMBER OF MOBILE SINKS AND VARIOUS TYPES OF DATA

S.G Packiavathy Research Scholar (Part Time- External), Register No: 12054, Department of Computer Science St.Xavier's College, Manonmanium sundaranar University, Abishekapatti, Tirunelveli,,Tamilnadu, India, Pin Code – 627012 packiavathy@shasuncollege.edu.in
P. Velmani Assistant Professor of Computer Science The M.D.T Hindu College, Pettai, Tirunelveli velmani@mdthinducollege.org
S. John Peter Head, Department of Computer Science St. Xavier's College, Tirunelveli.jaypeeyes@rediffmail.com

Abstract
One of the major challenges in wireless sensor networks (WSNs) is to prolong the network lifetime during the data transfer among the nodes. To achieve this goal, many mobile sink schemes have been presented in the literature. However, there is a lack of systematic analysis in the behaviors of the mobile sink models in terms of path selection and lifetime of the mobile sink. To overcome this problem, the TSPWRP algorithm for path selection and multiple mobile sink routing protocols using hop distance are developed. In this paper, the effect of mobile sinks and TSPWRP in the scalable architecture of WSNs is studied. The WSNs should allow a systematic deployment of sensor nodes including their mobility. The distributed data from the sensor nodes are gathered at the sink node. The data dissemination is the major source of energy consumption in WSNs. This work considers Delivery Ratio, throughput, packet drop, control overhead, generated-packet and normalized routing overhead as the evaluation parameters to evaluate the performance of TSPWRP by considering different numbers of the mobile sink and different types of data.

Keyword:
Wireless Sensor Network, TSPWRP, hop distance, energy consumption, network simulator.

1. Introduction

In a WSN, thousands of sensor nodes are deployed randomly. The sensor nodes sense the phenomenon periodically and that sensed data is sent to the sink-node. The information collected at the sink node is used to extract the relevant information. Energy can be conserved by shortening the distance taken by the packets to reach the sink node. Mobility of sensor and sink may result in the quick retrieval of data [1], [2], [3], [4], [5], [6]. Moving the Sink nodes are the most effective solutions to improve the network lifetime in WSN. In order to distribute traffic forwarding load as evenly as possible among all sensor nodes, sinks can be moved throughout the region. So that, all sensor nodes can have a nearly equal chance of being first-hop neighbors of sink nodes. To attain this objective, a lot of mobile sink schemes were developed in the past. Yet, there is a lack of systematic analysis on the behaviors of the mobile sink models in terms of both path selection and lifetime of the mobile sink. To defeat this difficulty, the TSPWRP algorithm is used.

In this work, the performance of the TSPWRP routing protocol in WSNs is investigated by considering mobile sink and sensor nodes, which move at different speeds. This analysis is done using the NS2 simulator. This work considers Delivery Ratio, throughput, packet drop, control overhead, packet-generated and normalized routing overhead as evaluation parameters to evaluate the performance of TSPWRP by considering different numbers of the mobile sink and different types of data. Node density and types of packets are considered for analysis and comparisons based on variable node density and mobility.

2. Literature Review

Velmani Ramasamy et al, (2013) suggested in this paper [12], the Velocity Energy-Efficient and Link-aware Cluster-tree (VELCT) scheme. Here, the Data Collection Tree (DCT) was constructed on the basis of the cluster head (CH) location. The Data Collection Node in the DCT transfers the data packet from cluster head to the sink but it could not sense the existing packets. This scheme also minimized the energy depletion. This simple tree structure formed by this method helped in reducing the traffic and thereby reduced the amount of energy consumed.

Kebin Liu, et al, (2014) suggested [9] a series of fault detectors through which numerous nodes could coordinate with each other in a diagnosis task. Fault detectors would encode the diagnosis procedure to state transitions. Every sensor could partake in the diagnosis by transiting the detector's present state to another state based on local evidence and after that passes the detector to different nodes. Having adequate proof, the fault detector attained the Accept state and outputted the last diagnosis report. The paper inspected the performance of the suggested self-finding instrument called TinyD2 on a 100-hub indoor test bed and conducted field studies in the Green Orbs framework, which was an operational sensor system with 330 nodes outside.

Dahane Amine et al, (2014) suggested [11] an energy-efficient and safe weighted clustering algorithm (ESWCA). It was a combination of five metrics and one of them was the behavioral level metric. For checking the performance of this approach, the simulation technique was used. The ES-WCA method was used for self-organization of the mobile sensor networks. This methodology aims at creating a virtual topology and helps in reducing the re-election. It was unnecessary to reconstruct the whole network. The reduction of energy that was being consumed by the nodes was to be considered as a priority. To provide energy conservation facility, there was a chance to deplete the redundancy of the network.

YulongZou et al, (2015) recommended a study in this paper [10] that involved the analyses of WSN in the presence of eavesdropping attackers. These networks consisted of numerous sensors and sink nodes. A sensor that encompassed the highest secrecy level was included in the sensor network through the optimal sensor scheduling method, which was used for the protection of wireless transmission from the eavesdropping attacks. This node with the highest secrecy level sent the information to the sink. Closed-form expressions of the probability of occurrence of an intercept event were derived for the traditional round-robin scheduling.

Chuan Zhu et al, (2015) suggested in this paper [13] a Tree Cluster-Based Data-Gathering Algorithm (TCBDGA). This suggested approach was used for the WSNs and it was mainly concerned with the mobile sink. A tree was constructed with various tree nodes. From such tree nodes, Sub-rendezvous points (SRPs) were selected as special nodes. This selection was made to reduce the traffic load and hops that were in the root nodes. Comparisons were made with other networks and the outcomes showed that the TCBDGA could balance the complete load of the network. Through this method, the energy consumption was also reduced. Here, the hotspot problem was completely depleted and the lifetime of the network was also increased.

ZhangBing Zhou, et.al, (2015) recommended in this paper [14] the energy-efficient scheduling mobile sinks to prolong the network lifetime. For which, a three-phase energy-balanced heuristic was suggested. In particular, the network region was divided into grid cells with the same geographical size. These clusters were adjusted by (de)allocating grid cells in these clusters, while considering the energy consumption of sink movement. So, the energy to be consumed in each cluster was almost balanced considering the energy consumption of both data gathering and sink movement. Experimental evaluation demonstrated that this method could produce an optimal grid cell division within a limited time of iterations, and prolong the network lifetime.

Xie and Pan (2016) [15] introduced the mobile sink in WSNs and suggested a spanning graph-based scheduling mechanism. On the basis of this scheduling mechanism, a heuristic path planning algorithm was implemented to find a shortest path to avoid the obstacles. A mobile sink was set to walk along the path and collect data from CHs via direct transmission. The mobile sink returns to the origin after

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 6, No.2, June : 2024

data collection. Simulation results demonstrate that their proposed algorithm can extend network lifetime effectively. The scheduling mechanism they suggested approach makes a good contribution to reduce the complexity in traversing of WSNs with obstacles.
Selvakumar and Swamynathan (2017) [17] presented an efficient data aggregation algorithm called cluster-chain mobile agent routing (CCMAR). In CCMAR, the CH selection value (CHSV) is utilized to choose the optimal CHs. Cluster members form chains to transmit their data to the sink. The residual energy level, signal strength and path loss are considered to schedule an optimal routing path for the mobile agent (MA).

3. Proposed Method

3.1 Finding Distance and Hop Count

In WSN, the accurate estimation of the distance between sensor nodes is essential. The hop count is used to find the shortest path between the nodes. Each router forms a hop with moving data from one source to another to reach the data sink. Hop count is used to estimate the position of nodes based on calculation of hop count distance is done by using equation1.

$$\text{hop distance}_{RN_i} = \frac{\sum_{RN_{i,j\varepsilon\, RN}}^{n} \text{distance}(RN_i, RN_j)}{\sum_{RN_{i,j\varepsilon\, RN}}^{n} \text{hopcount}(RN_i, RN_j)}$$

Equation 1
Where, RN is the reference node, distance (RNi , RNj) is the distance from the reference node (RNi to RNj) , and hopcount(RNi , RNj) shows the minimum number of hops from RNi to RNj .

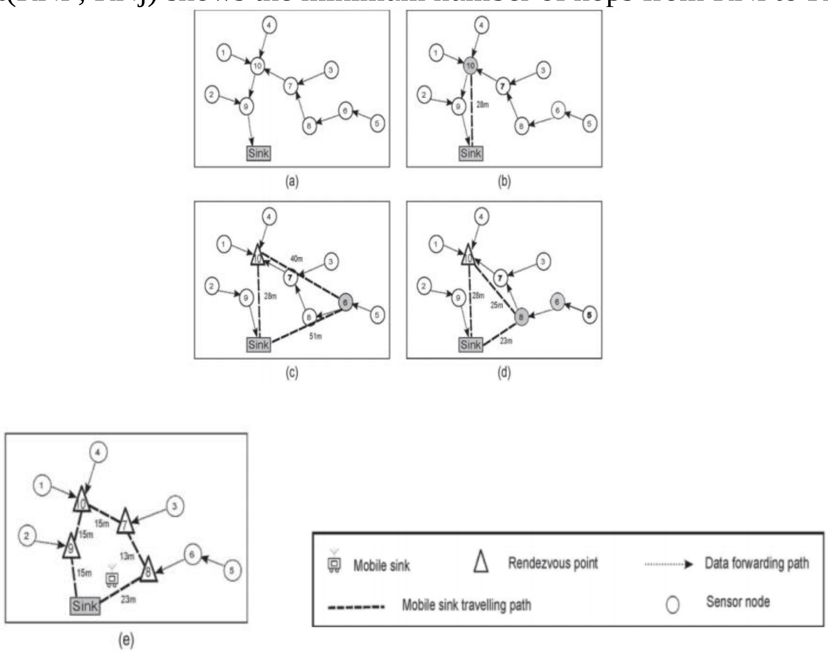


Fig 1 Example of TSPWRP operating in a WSN with ten nodes

Fig. 1 shows an example of how TSPWRP finds a traveling tour for a mobile sink. The maximum tour length is lmax = 90m. TSPWRP starts from the sink node and adds it to the tour, i.e., M = [Sink]. Then, an SPT rooted at the sink node is constructed [Fig. 1(a)]. In the first iteration, TSPWRP adds node 10 to the tour because it has the highest weight, yielding M = [Sink, 10]. As Fig. 1(b) shows, the tour length of M is smaller than the required tour length (56 < 90), meaning node 10 stays in the final tour (lines 22–32). In the second iteration, TSPWRP recalculates the weight of sensor nodes because node 10 is now part of the tour. In this iteration, TSPWRP selects node 6 as the next RP, which has the highest weight. As Fig. 1(c) shows, the tour length of M = [Sink, 10, 6] is larger than the required tour length (119 > 90). Consequently, TSPWRP removes node 6 from the tour M = [Sink, 10] (lines 33–37). TSPWRP selects node 8 because it has the highest weight and is not marked. The TSP function returns 76 m for M = [Sink, 10, 8], which is less than 90 m. Therefore, node 8 is added to the tour. As shown in Fig. 1, the final tour computed by TSPWRP always includes sensor nodes that have more data packets to forward than other nodes as RPs. This ensures uniform energy consumption and moderates the energy-hole problem.

3.2 Simulation Method

The proposed system is implemented by using network simulator (NS2). The NS2 is an event-out tool for networking. There are 2 languages in NS2, C++ and Otcl. At the back-end, c++ determines the internal mechanics of the experimental object and at the front-end, otcl creates a simulation by installing and configuring the object. At the end of each experiment, it creates two types of files one is tracing file(.tr) used for static analysis and the other is nam(.nam) used for animation.

To analyze the energy consumption, various evaluation parameters like Delivery Ratio, Delay, throughput, control overhead,and normalized routing overhead which impact wireless Networks are used. The energy consumption can cause an unfortunate effect on these performance metrics. A brief discussion of the parameters is given below

1. Packet Delivery Ratio

It is defined as the ratio of packets received by the destinations to those sent by the sources. i.e., ∑ Number of packets received/∑ Number of packet sends. The energy consumption increases when the packet delivery ratio decreases. The packet delivery ratio may decrease packets drop occurs.

2. Delay

It is the average time taken by a data packet to reach the destination node. It includes the delay in the path finding process and the queue. The energy consumption is increased when the end to end delay decreases. End to end delay may decrease as the node replies immediately without checking the routing table.

3. Throughput

Throughput is the amount of data transferred from source to destination in a given amount of time. It is measured in kbps. The energy consumption is increased when the throughput of the network considerably decreases.

4. Control Overhead

It is the ratio of the control packets to the total number of the received data packets. The energy consumption is increased when the control overhead is decreased.

5. Normalized Routing

It is the average ratio of total routing control packets transmitted to the total data packets received at the destination. It should be lower for efficient network and it increases energy consumption.

4 Analysis of the Performance of proposed work by Varying the Network Size

The size of the network is varied by changing the number of nodes from 1 to 2000. From all nodes, 50 nodes are allotted as mobile sink nodes and the remaining nodes are fixed. Experiments show that throughput, PDR and control overhead reduces the size of the network due to congestion. Also, average delay and energy consumption diminishes without exploring the path between mobile sink and nodes in the existing approach. Normal network load has also increased for these reasons. But, the proposed approach solves these drawbacks. This is shown in the below graph. & table.

Table1: Packet Delivery Ratio of WR and WR + Energy

No of Nodes	WR	WR + Energy
10	81.9900	90
20	83.9900	91
30	86.9900	93
40	88.9900	94
50	90.9900	96

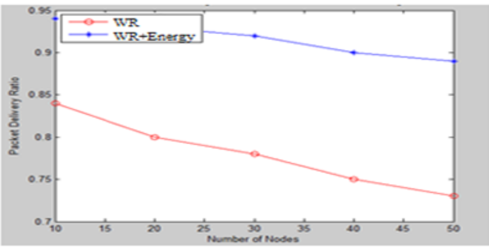


Figure 1: Packet Delivery Ratio of WR and WR + Energy

No of Nodes	WR	WR + Energy
10	165	185
20	170	194
30	175	200
40	179	209
50	185	225

Table2: Delay of WR and WR + Energy

Figure2: Delay of WR and WR + Energy

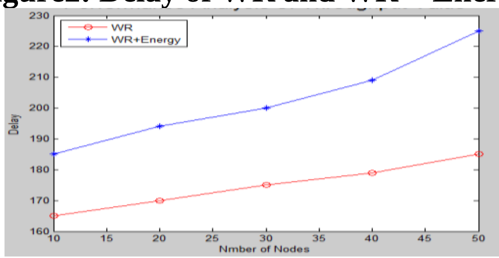


Table 3: Throughput of WR and WR + Energy

No of Nodes	WR	WR + Energy
10	140	170
20	145	179
30	150	185
40	154	194
50	160	210

Figure 3: Throughput of WR and WR + Energy

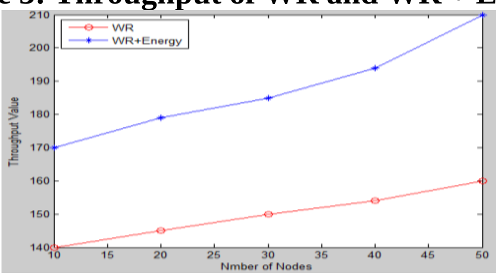


Table 4: Control overhead of WR and WR + Energy

No of Nodes	WR	WR + Energy
10	81.9880	89.9910
20	83.9880	90.9910
30	86.9880	92.9910

40	88.9880	93.9910
50	90.9880	95.9910

Figure 4: Control overhead of WR and WR + Energy

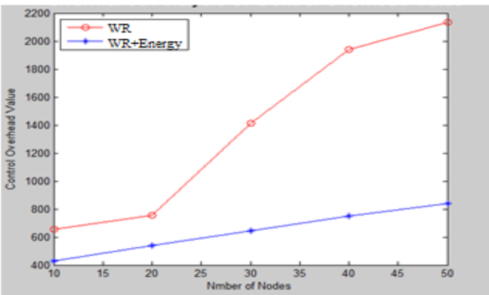
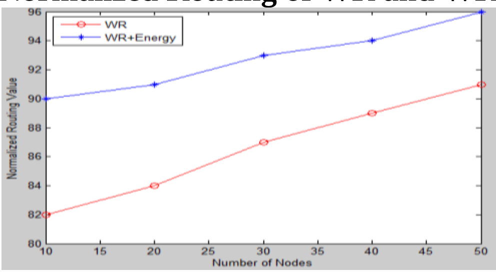


Table 5: Normalized Routing of WR and WR + Energy

No of Nodes	WR	WR + Energy
10	790	590
20	1000	800
30	1990	1790
40	2300	2100
50	2500	2300

Figure 5: Normalized Routing of WR and WR + Energy



5 Analysis of the Performance of ENERGY CONSUMPTION

5.1 Analysis of the Performance of proposed work by Varying the Network Size (With Numerical Packet)

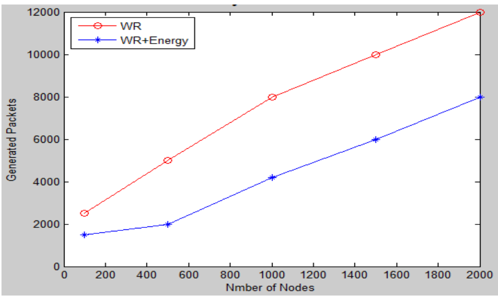
Generated Packet:

Several packages are created while testing each scenario with different number of nodes. It can be seen that the number of generated packets is proportional to the number of mobile nodes. For minimum number of nodes, only a few packets are created. But for maximum number of nodes, more number of packets is created. It can be seen that networks affected by energy consumption create more network packets. In this way, generated packets affect energy consumption in the network. This is shown in Table 6.

Table 6: Generated Packets of WR and WR + Energy

No of Nodes	WR	WR + Energy
100	2500	1500
500	5000	2000
1000	8000	4200
1500	10000	6000
2000	12000	8000

Figure 6: Generated Packets of WR and WR + Energy



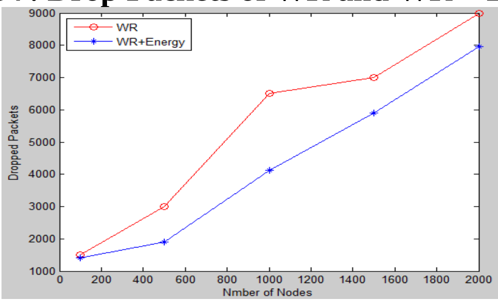
Drop Packet:

Several packages are created while testing each scenario with different number of nodes. It reduces the number of packets and it blocks traffic, networks, and packets including management packets and acknowledgment packets. In this way, the total numbers of network packets created in the network affect energy consumption. This is shown in table 7.

Table 7: Drop Packets of WR and WR + Energy

No of Nodes	WR	WR + Energy
100	1500	1400
500	3000	1900
1000	6500	4120
1500	7000	5912
2000	9000	7970

Figure 7: Drop Packets of WR and WR + Energy



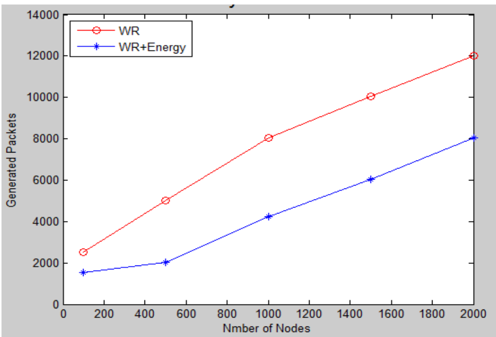
5.2 Analysis of the Performance of proposed work by Varying the Network Size (With Numerical Packet)

Several packages are created while testing each scenario with different number of nodes. It can be seen that the number of generated packets is proportional to the number of mobile nodes. For minimum number of nodes, only a few packets are created. But for maximum number of nodes, more number of packets is created. It can be seen that networks affected by energy consumption create more network packets. In this way, generated packets affect energy consumption in the network. This is shown in below table 8.

Table 8: Generated Packets of WR and WR + Energy

No of Nodes	WR	WR + Energy
100	2530	1530
500	5030	2030
1000	8030	4230
1500	10030	6030
2000	12030	8030

Figure 8: Generated Packets of WR and WR + Energy



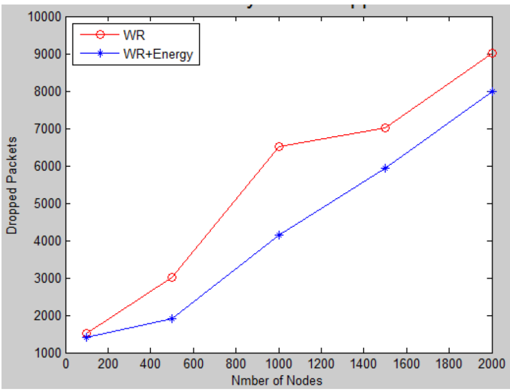
Drop Packet: (With Numerical Packet)

Several packages are created while testing each scenario with different number of nodes. It reduces the number of packets and it blocks traffic, networks, and packets including management packets and acknowledgment packets. In this way, the total numbers of network packets created in the network affect energy consumption. This is shown in below table 9.

Table 9: Delivered Packets of WR and WR + Energy

No of Nodes	WR	WR + Energy
100	1520	1420
500	3020	1920
1000	6520	4140
1500	7020	5932
2000	9020	7990

Figure 9: Delivered Packets of WR and WR + Energy



6. Conclusion

This paper presented a simulation system and discussed the simulation results of a TSPWRP with various numbers of mobile sensor nodes and a mobile sink by considering various speeds of mobile sinks and different data. This paper used Delivery Ratio, throughput, packet drop, control overhead, generated packets and normalized routing overhead to measure TSPWRP performance.

From the simulation results, this work shows,

• Higher throughput for higher mobility speed.
• Higher Control overhead for higher speeds of movement.
• Lower Packet Drop for lower mobility speed of the sink and sensor nodes
• Lower routing overhead for lower mobility speed of the sink and sensor nodes
• Higher Delivery Ratio for lower mobility speed of the sink and sensor nodes

References

[1] S. Giordano and C. Rosenberg, ”Topics in Ad Hoc and Sensor Networks”, IEEE Communication Magazine, Vol. 44, No. 4, pp. 97-97, 2006.

[2] W. Hu, N. Bulusu, and S. Jha, ”Overload Traffic Management for Sensor Networks”, ACM Transactions on Sensor Networks, Vol. 3, No. 4, pp. 18-38, October 2007.
[3] A. A. Somasundara, A. Kansal, D.D. Jea, Jea, D.Estrin, and M. B. Srivastava, ”Controllably Mobile Infrastructure for Low Energy Embedded Networks”, IEEE Transactions on Mobile Computing, Vol. 5, No. 8, pp. 958-973, August 2006.
[4] O. Younis, S. Fahmy, ”HEED: A Hybrid, Energy-efficient, Distributed Clustering Approach for Ad-hoc Sensor Networks”, IEEE Transactions on Mobile Computing, Vol. 3, No. 4, pp. 366-379, 2004.
[5] S. S., Kulkarni, “TDMA Services for Sensor Networks”, Proceedings of 24th International Conference on Distributed Computing Systems Workshops, pp. 604-609, 23-24 March 2004.
[6] W. Ye, J. Heidemann, D. Estrin, “Medium Access Control with Coordinated Adaptive Sleeping for Wireless Sensor Networks”, IEEE/ACM Transactions on Networking, Vol. 12, No. 3, pp. 493-506, June 2004.
[7] Wendi RabinerHeinzelman, AnanthaChandrakasan,andHariBalakrishnan,”Energy Efficient Communication Protocol for Wireless Micro sensor Networks”, Proceeding HICSS '00 Proceedings of the 33rd Hawaii International Conference on System Sciences-Volume 8 - Volume 8.
[8] P. Baruah, R. Urgaonkar and B. Krishnamachari, ”LearningEnforced Time Domain Routing to Mobile Sinks in Wireless Sensor Fields”, Proc. of 29th Annual IEEE International Conference on Local Computer Networks (LCN-2004), Tampa, FL, USA, pp. 525-532, November 2004.
[9] Kebin Liu, Qiang Ma, Wei Gong, Xin Miao, and Yunhao Liu,” Self-Diagnosis for Detecting System Failures in Large-Scale Wireless Sensor Networks”, 2014, IEEE Transaction on Wireless Communications, Vol. 13, Issue 10 [10] YulongZou, and Gongpu Wang,” Intercept Behavior Analysis of Industrial Wireless Sensor Networks in the Presence of Eavesdropping Attack”, 2015, IEEE Transaction on industrial informatics, Volume 12, Issue 2, pp 780-787 [11] Dahane Amine, BerrachedNassreddine, KecharBouabdellah,” Energy Efficient and Safe Weighted Clustering Algorithm for Mobile Wireless Sensor Networks”, 2015, Elsevier International conference on Ambient system, networks and technologies, international conference on sustainable energy information technology, Volume 52, pp 641-646.
[12] VelmaniRamasamy, KaarthickBalakrishnan,” An Efficient Cluster-Tree based Data Collection Scheme for Large Mobile Wireless Sensor Networks”, 2015, IEEE Sensor Journal, Volume 15, Issue 4, pp 2377- 2390.
[13] Chuan Zhu, Shuai Wu, Guangjie Han, Lei Shu and Hongyi WU,” A Tree-Cluster-Based Data-Gathering Algorithm for Industrial WSNs with a Mobile Sink”, 2015, IEEE Access, volume 3, pp 381-396.
[14] ZhangBing Zhou, Chu Du, Lei Shu, Gerhard Hancke, JianweiNiu, and HuanshengNing, “An EnergyBalanced Heuristic for Mobile Sink Scheduling in Hybrid WSNs”, 2015, IEEE.
[15]Xie G., Pan F. Cluster-Based Routing for the Mobile Sink in Wireless Sensor Networks with Obstacles. IEEE Access. 2016;4:2019–2028. doi: 10.1109/ACCESS.2016.2558196.
[16] Sasirekha S., Swamynathan S. Cluster-chain mobile agent routing algorithm for efficient data aggregation in wireless sensor network. J. Commun. Netw. 2017;19:392–401.