International Journal of Engineering & Technology, 7 (4) (2018) 3810-3815

SPC

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET
doi: 10.14419/ijet. v7i4.16525
Research paper

Designing efficient paths between base station and multi mobile sink nodes to transfer data in wireless sensor networks based on anchor nodes

Mahmood Z. Abdullah [1], Nadia A. Shiltagh [2], Ahmed R. Zarzoor [3] *

[1] *Assist. Prof. Dr. Mahmood Z. Abdullah, Mustansiriyah University, College of Engineering, Baghdad – Iraq*
[2] *Assist. Prof. Dr. Nadia A. Shiltagh, University of Baghdad, College of Engineering, Baghdad – Iraq*
[3] *Ahmed R. Zarzoor, Institute for Post-graduation Studies Iraqi Commission for Computer & informatics, Baghdad - Iraq*
**Corresponding author E-mail: Ahmed.Arjabi@gmail.com*

Abstract

A Wireless Sensor Networks (WSNs) has been implemented in a lot of applications such as smart homes, military, healthcare, etc. Thus, integrated all WSNs in a single large geographical network, which poses major challenge for designing efficient paths to transfer data between all these WSNs. This study proposes a technique to design best short paths between multi-mobile sink nodes (SN) and single Base Station (BS) based on Anchor nodes (AN). The ANs are used to specify the BS location, with one Reference node that used to specify a mobile SN location in each WSN. Although, the best path is selected based on a number of hops, the distance between each SN and the B S. Furthermore, the path quality is measured by using Quality of Service (QoS) parameters. In this study, two scenarios are implemented using NS software (version 2.30) on the network framework consisted of four WSNs, with four static or mobile SNs, connected to six ANs around a single BS and four reference nodes. The simulation results show that the dynamic paths with mobile SNs improved overall network performance, because they give higher throughput and minimum delay and dropped packets in comparison to static paths with static SNs.

***Keywords**: Anchor Nodes; Base station (BS); Quality of Service (QOS); Reference Node; Mobile Sink Node; Wireless Sensor Networks (WSNs).*

1. Introduction

A WSN composed of a lot of sensor nodes that collected data form sense environment and send it report to the Sink Node (SN) [1]. The SN performs processing on the sensory data in order to be ready for sending to the Base Station (BS). Thus, the data needs to pass through many sensor nodes until SN or BS is reached. So, a more data transmutation between sensor nodes means more network energy consumption, which in turn reduces the network lifetime. Another issue is, sensor node that close to the static SN consumed its energy faster and die than the sensor nodes that located a far away from SN. Therefore, this will cause hotspot or energy hole [2] problem in the network and increase the traffic around the SN. To overcome this problem, researchers [3-5] used a mobile sink node to balance energy consumption, prolong network lifetime and reduce traffic around the SN. Although, SN mobility help in protection against traffic analysis attack via increasing SN location anonymity [6].

However, in large-scale network, when there is more than one WSN, each of it has a mobile SN connected to the BS. Designing the routing path to transmit and receive data between mobile SN and BS is a considerable issue. Because it affects the network performance and energy usage. For instance, if the routing path is used there will be many hops to transmit data between the mobile SN and BS which it then maximizes end to end latency and consumes more energy. Also, since the mobile SN position on the path to the BS needs to be changed dynamically. Thus, BS needs to keep track of SNs location, otherwise the transmitted data between them will be lost. One of the solutions is to used anchor node that specified unknown nodes location based on its known location [7]. But to locate the unknown node location in large scale network required a lot of anchor nodes to be deployed in the network. Which increased the cost and energy consumption due to sending the anchor nodes location to all the nodes in the network.

In this study six anchor nodes will be used to specify the BS location and choose the short path between the mobile sink and BS. Although, they constructed a routing table for each WSN that composed of WSN ID, Mobile SN position, number of hops and distance between SN current location and BS position. The paper is organized as follows: Section 2 explore related works that designing routing path with mobile SN via anchor nodes, Section 3 described study method which consisted of three phases: designing the routing path between Cluster Heads (CHs) and mobile SN, designing routing path between mobile SN and BS and path quality evaluation using QoS constraints. Section 4, discussed the results of two scenarios are implemented using NS software (version 2.30) on the network framework consisted of four WSNs, with four static or mobile sink nodes, connected to six anchor nodes around single BS and four reference nodes. Finally, section 5 includes study conclusion.

2. Related works

The sink node is playing a significant role in all WSN applications, because its storing, processing and aggregating all the network sensory data. In Catalina Aranzazu-Suescun and Mihaela Cardei study, they proposed two distribution algorithms "Grid Flooding and Grid Sink-based Routing" [8], to transmit a request from sink node to all sensor nodes in the network. On the sensor nodes side, they checked the event condition of request. So, if the condition is satisfied then sensory data is started by them. For example, the event (20/7/2018, location coordinate (x, y), Temperature >90° C) means sensor nodes on date 20/7/2018 at location x, y satisfies the condition where Temperature is greater than 90° C. Thus, only nodes that satisfied the event condition can then sensor data and send it to the SN. Therefore, they reduced the energy consumption and prolonging the network lifetime.

Since, the BS is always located outside the WSN area. Consequently, the aggregated data requires a multi-hop in order to reach the BS. This decreases the intermediate sensor nodes lifetime. In [9] the researchers suggested a method to balance energy consumption via dividing the large scale network into subarea. They measured the mean remain energy of all sensor nodes in each subarea. Thus, based on that they select the best sub area to move a data collector to it, to gather data and send it to the SN. While in study [10] proposed method to select best BS position that reduces end to end latency and minimizes energy usage, dependent on the optimal number of elected cluster heads location. Also, they select a node from each cluster and called it "delegated node" that act as a communicator in the network between CH and BS. The main idea is to minimize the distance between CHs and BS to achieve high network performance. In another study, Yuvaraj and Manimozhi analyzed the effectiveness of BS position on the network sensor nodes energy usage [11]. They compared four different locations for BS on a WSN using ESSCA protocol [12] in order to elect CHs. In ESSCA protocol they divided the network area into four regions using x, y coordination. The nodes that locate in the center of cluster and has highest average remain energy is elected as CH. They compare their protocol's ESSCA performance with LEACH protocol in electing CHs process. Also, they measured the effectiveness of BS position on all nodes in the WSN. They found more improvement on sensor node energy when using ESSCA protocol in compare with LEACH protocol. Although, in study [13] they proposed changing the BS location dynamically, based on the residual energy and location of the elected CHs in the network. They found that extended the network lifetime in compare with fixed BS location.

On the other hand, a researcher [14] suggests to use multiple BS to render a WSNs. Thus, the BS that closed to the sensor nodes in the specific area of the network will turn on during specific period of times, while the other BS will in result turn off. This will save energy usage but using more than one BS is considered an expensive solution. In Cayirpunar et. al, study inspected the using of "optimal mobility patterns" [15] such as spiral, grid and random patterns to move multiple mobile BS on it, in order to avoid energy holes in the network and extending the network lifetime. In another study, [16] the researchers use multiple mobile BS that movies in static path and stop in some locations in the network. Thus, they can be able to collect data from sensor nodes. While Faheem and Gungor study [17], proposed using multiple mobile sink nodes that move first in static schemes pattern and later according to self-learning, they improve region coverage and minimize end to end latency and avoid memory overflow. So, they designed a new scheme pattern. The new scheme must satisfy the QoS requirements (such as maximize throughput and minimizes latency) on the link that used to gather data from sensor nodes and transmitted to the sink node.

In study [18], the researchers used reactive protocol to collect data periodically from the sensor nodes and send it to the sink node based on the event. So, there is no need to collect all the data from all sensor nodes and send it to the sink node every time. They used anchor nodes to create the short path between the sensor nodes and SN. For example, if the event request at location x, y with condition (humidity<60) near first anchor node A1 known location. Subsequently, unknown sensor node location is specified based on known location A1 where number of hops=0. Otherwise, check second anchor node A2 (where number of hops=1) and so on. In Tunca et. al study, proposed a "ring routing protocol" [19] in which, a WSN consisted of three kind of nodes: normal node, anchor and ring nodes. The anchor node is located near to the SN, in order to specify its location and send it to the ring node. The normal nodes request the locations of SN from the ring nodes, when they want to send collected data to it. The ring nodes are placed around the network with the same distance from the network center location. They store all sensor nodes location information that send to them from the anchor node. Although, in [20] they use the same idea but with mobile SN in order to minimize delivered data delay to SN and reduced sensor nodes energy usage.

In this study, six anchor nodes are used to form a ring around a single BS. These anchor nodes are used to specify the unknown BS location for four WSNs. Each of the WSN has one mobile SN. In addition to one reference node that is used to specify the new mobile SN location and send it to the six anchor nodes. See Figure 1.

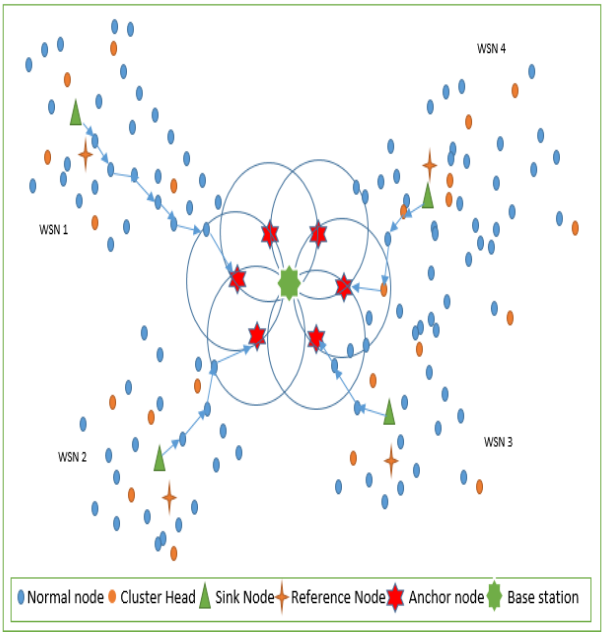

Fig. 1: The Network Framework Consisted of Four WSN with Four Mobile Sink Nodes connected to six Anchor Nodes around Single BS, Four Reference Nodes Specified the Mobile Sink Node Location. Blue Arrows Represented the Designing Path.

3. Study method

This paper proposed, a technique to design best short path that satisfy QoS requirements. The path is used to send collected data from each mobile SN in different hierarchical structure networks to the single BS, see Figure 1. The study method conducted in three phases as follows:

1) Designing Path from Cluster Head to the Mobile Sink Node
2) Designing Path from Mobile Sink Node to the Base Station Node
3) Path Quality Evaluation.

3.1. Designing path from cluster head to the mobile sink node

In each WSN there is one mobile SN moved using "Secure Mobile Sink Node using Dynamic Routing Protocol" (SMSNDRP) that developed in our previous study [21]. The protocol implemented on a hierarchical clustering network. The purpose of using a SMSNDRP is to increase the mobile SN location anonymity in the network and provide protection against a traffic analysis attack. The basic idea of this protocol is moving the mobile SN to new position based on the new elected CHs locations. The new SN location coordination point is computing through calculating the mean of the CHs location coordination points. Also, the path constructed is dependent on the CHs' residual energy and their distance from SN. Thus, the CHs on the path are sorted in a way that CH with highest residual energy and minimum distance from SN, become the last one in the path to mobile SN location in the network. So, only it's permitted to transmit data packets to the SN directly.

3.2. Designing path from mobile sink node to the base station node

In this phase designing a path between each unknown mobile SN location and single unknown BS location. So, the first step is to calculate the BS location based on the six anchor nodes known location that constructs a ring around BS see Figure. 1. Two node types are used to design the path: anchor and reference node. The anchor node is used to store and route information such as mobile SN location, distance between BS and Mobile SN, number of hops, BS location, WSN ID and the routing path. In another word, it constructs a routing table (see Table 1). According to its information, the best path is selected to transmit the data between mobile SN and BS. The reference nodes are used to store information about mobile SN position and send it to the anchor nodes.
However, each anchor node is placed on the same distance from center area, where the BS position can be estimated. Subsequently, all of them will send a beacon signal to this area. Thus, based on the beacon signal's strength received by unknown BS, the location can be specified. On the contrary, a Trilateration technique is used to specified location of BS based on known distance of three anchor nodes around it. In this study, six anchor nodes are used in order to increase anonymity of BS position and protect its location against a traffic analysis attack. To illustrate, it is supposed that an unknown BS coordinate is x, y and the coordinate of six anchor nodes A, B, C, D, E and F are: (x_a, y_a), (x_b, y_b), (x_b, y_b), (x_c, y_c), (x_d, y_d), (x_e, y_e) and (x_f, y_f). Thus, the distance d_a, d_b, d_c, d_d, d_e and d_f is calculated using Eq. (1) [7]. Consequently, based on the received strength signal indicator (RSSI) technique [22], the location of BS can be specified according to the signal strength, which depends on the distance between the sender and receiver side. Therefore, the receiver measure signal strength based on the distance from sender.

$$\begin{Bmatrix} d_a &= \sqrt{(x-x_a)^2+(y-y_a)^2} \\ d_b &= \sqrt{(x-x_b)^2+(y-y_b)^2} \\ d_c &= \sqrt{(x-x_c)^2+(y-y_c)^2} \\ d_d &= \sqrt{(x-x_d)^2+(y-y_d)^2} \\ d_e &= \sqrt{(x-x_e)^2+(y-y_e)^2} \\ d_f &= \sqrt{\left(x-x_f\right)^2+\left(y-y_f\right)^2} \end{Bmatrix} \tag{1}$$

The second step, is to allocate the mobile SN position. Since its location changes dynamically when the path from CHs to SN is changed. The reference node located near the SN area is used to store the new SN x, y coordination point. Also, the reference node changes its location based on the known new SN location. Besides that, it sends the new location to the anchor nodes. So, depending on a new SN location information, the anchor nodes are maintained by the routing table by replacing the old SN location by the new location, recalculated the distance between the new SN location and BS location, counting the number of hops and replacing the old path by the new one.

3.3. Path quality evaluation

In this phase an evaluation is conducted on the result paths from designing path between mobile SN and BS phase. The evaluation is dependent on the following QoS parameters: Packet Delivery Ratio (PDR), End to End Latency, Total Drop Packets and Average Throughput. Subsequently, the best path in the network is the one that meet the QoS requirements. In which the path must have a higher PDR, Average Throughput and Less End to End Delay, in order to get a better network performance. In this phase, the first step is arranging all the paths according to the number of hops and distance for each WSN in descending order. For instance, the best path for WSN1 in Table 1 is SN1->N30->N35->N40->AN1->BS, where number of hop is [4] and the distance is 500 Meters.
The second step, is calculating QoS parameters for each path and again arranging the paths, in descending order according to PDR and average throughput. Also, arrange them again in ascending order according to end to end delay. In order to discover the best path quality in the network. In case the path is changing due to mobile SN location changed. Consequently, the routing table information is updating and a new path is designed between the new mobile SN position and BS. That has the lowest number of hops and minimum distance from BS location, higher PDR, maximum average throughput and lowest end to end delay, see Figure 2.

4. Simulation results

The NS software (version 2.35) simulator is used to implement the study method. In this study, two scenarios are created: one with four static SN and other one with four mobile SN. The network framework consisted of four WSNs with four static or mobile sink nodes, connected to 6 anchor nodes around a single BS, four reference nodes are used to specify the mobile sink node location. The sensor nodes are deployed in 1000x1000 meters, see Table 2, which demonstrates the simulation parameters. In scenario one, the best paths are static as shown in Table 3. Four paths are selected based on the minimum distance (between the static SN position and the BS location) and the less number of hops count on the

Table 1: Routing Table Details Constructed by Anchor Node (AN)

WSN ID	Mobile SN Location X,Y coordination	No. of hops	Distance between SN and BS in Meters	BS Location X,Y coordination	Path
1	50,100	5	602.0797	500,500	SN1->N1->N5->N7->N8->AN1->BS
1	100,200	4	500	500,500	SN1->N30->N35->N40->AN1->BS
2	30,80	4	630.3174	500,500	SN2->N90->N95->N99->AN2->BS
2	100,100	5	565.6854	500,500	SN2->N92->N97->N95->N99->AN2->BS
3	200,80	5	516.1395	500,500	SN3->N110->N145->N120->N140->AN3->BS
3	250,100	3	471.6991	500,500	SN3->N120->N142->AN3->BS
4	200,350	4	335.4102	500,500	SN4->N155->N165->N190->AN4->BS
4	200,200	3	424.2641	500,500	SN4->N160->N190->AN4->BS
4	250,300	5	320.1562	500,500	SN4->N151->N155->N165->N190->AN4->BS
4	250,320	6	308.0584	500,500	SN4->N166->N167->N170->N160->N192->AN4->BS

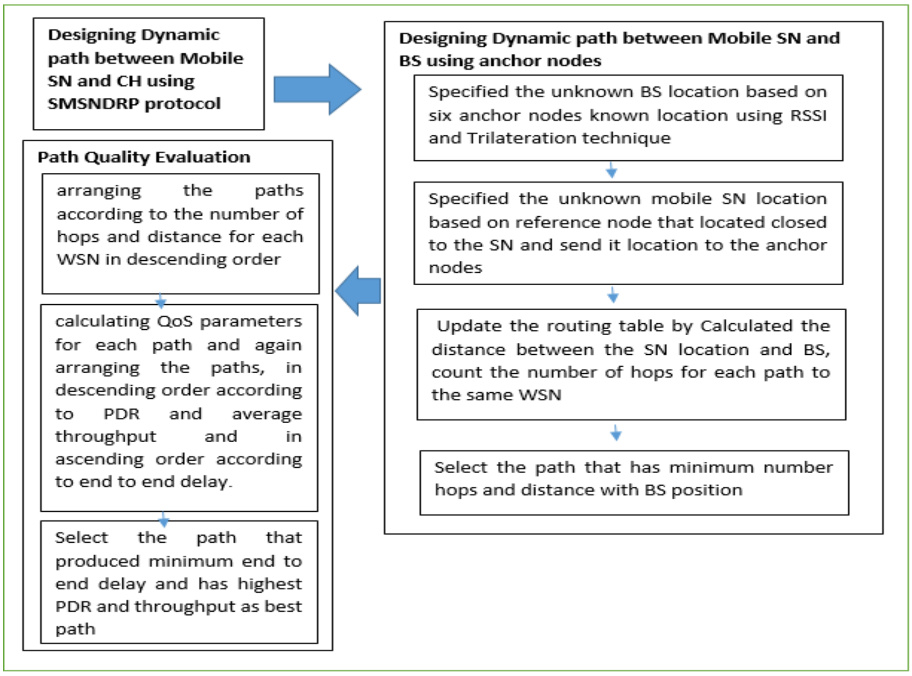

Fig. 2: Illustrate Study Method Functional Diagram.

Selected path. The QoS parameters are measured for the four static path that are used to transmit packets between four WSNs and single BS, see Figure 3. In scenario 2, the mobile SN are used instead of the static one in the four WSNs. It starts with the same four paths that shown in Table 3.

The paths are dynamically changed when the mobile SN changes it location, due to the dynamic changing on the path from CHs to mobile SN in each WSN that done by SMSNDRP [21]

Table 2: Simulation Parameters Details

Parameters	Values
Time of simulation end	60 s
Number of nodes	207
Channel type	Channel/WirelessChannel
Network interface type	Phy/WirelessPhy
Area	1000x1000
MAC type	Mac/802_11
Traffic Model	FTP

Table 3: Static Sink Node Routes Details

WSN ID	Route to the BS from Static Sink Node	Number of hops
1	SN->N85->N99->N71->N80->N70->AN201->BS	6
2	SN->N48->N19->N43->N42->N17->AN202->BS	6
3	SN->N196->N176->N183->N182->AN204->BS	5
4	SN->N137->N121->N132->N109->N101->AN205->BS	6

In the first scenario, the first route information is: WSN ID=1, start with static SN -> Node number=85 (N) N85-> N85->N99->N71->N80->N70->Anchor Node number= 201(AN201)-> BS and number of hops=6, the second route start with SN->N48 and end with AN202->BS, WSN ID=2 and number of hops =6, thrird route start with SN->N196 and end with AN204->BS, WSN ID=3 and number of hops =5 and last route start with SN->N196 and end with AN205->BS, WSN ID=4 and number of hops=6. The QoS parameters for all static routing paths in scenario 1 with time duration=60s are measured and the results are: Generated packets=26292, Send Packets= 21531, Received Packet= 21212, Packet Delivery Ratio (PDR)= 98.96%, Total Dropped Packets= 319, Average Throughput= 2188.8 Kbps, End to End Delay= 250.1616 milliseconds.

In the second scenario, the implementation is started with same four paths that are used in the first scenario with time duration 60s. During that time the four paths are changing dynamically based on the changing of mobile SN position in each WSN. Therefore, the path from mobile SN to the BS is changed in the four WSNs. The QoS parameters for all dynamic routing paths in the entire network are: Generated Packets=26292, Send Packets= 22583, Received Packet= 22358, Packet Delivery Ratio (PDR)= 99.003%, Total Dropped Packets= 225, Average Throughput= 2301.95 Kbps, End to End Delay= 187 milliseconds.

However, based on the results of the two scenarios, it found that network performance gives a better average throughput (value =2301.95 Kbps) when using mobile SN in compare with static SN, where throughput (value=2188.8 Kbps) as shown in Figure 4. Although, for end to end delay (value=250.1616) and total drop packet (value=319) higher than the second scenario values, where (end to end delay value=187, and total drop packet value=225), for PDR is slightly higher with dynamic paths (value=99.00%) in contrast with static paths (value=98.96%) as demonstrated in Figure 5.

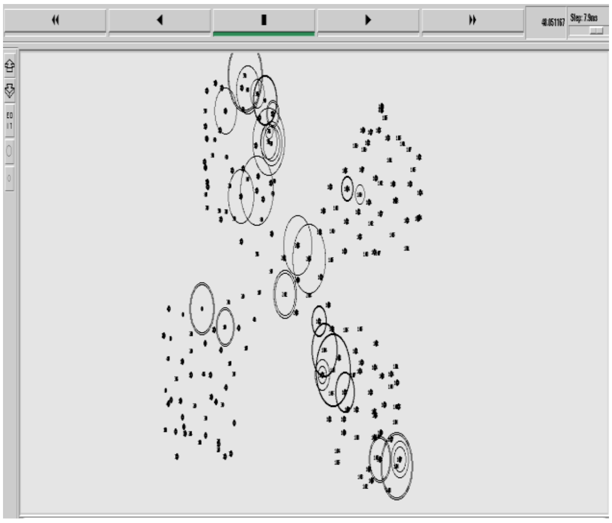

Fig. 3: Screenshot from (NS2.30 Simulator) for Network Consisted 207 Nodes Divided into Four WSN with Four Static Paths from SN to the BS.

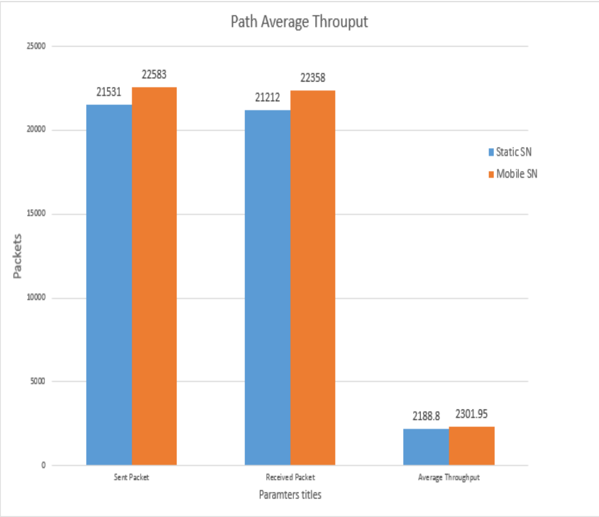

Fig. 4: The Network Performance Is Improved when Using Mobile SN because it Gives Higher Throughput Value in Compare with Using Static SN.

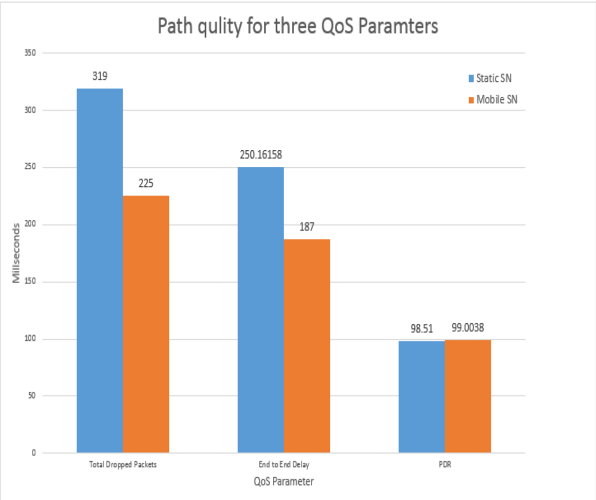

Fig. 5: The Network Performance is Improved when Using Mobile SN Because It Gives Lowest Delay Value and Total Dropped Packets in Compare with Using Static SN.

5. Conclusion

This study is proposed a method to design an efficient path to send data between multi mobile SN and BS. The path quality is measured according to QoS requirements. The path designed using six anchor nodes that form a ring around BS, in order to determine the BS position on the path. The mobile SN position on the path is specified via using a reference node in each WSN. Thus, depend on the SN and BS position, less number of hops on the path and minimum distance between SN and BS the best path is selected.
The quality of all designed paths between BS and multi mobile SN is evaluated via QoS parameters: End-to-End Delay, PDR, Throughput and Total Dropped Packets. Therefore, two scenarios are conducting using NS software (version 2.30): one with four static SNs and other one with four mobile SNs, in the network framework consisted of four WSN, with four static or mobile sink nodes. The two scenarios results have shown that dynamic paths with multi mobile SN improved network performance, because it gives higher throughput and less latency and dropped packets in compare with static paths SN.

Acknowledgement

We would like to appreciate all the excellent suggestions of anonymous reviewers to enhance the quality of this paper.

References

[1] Constrained node-weighted steiner tree based algorithms for constructing a wireless sensor network to cover maximum weighted critical square grids," Computer Communications, vol. 81, pp. 52- 60. https://doi.org/10.1016/j.comcom.2015.07.027.
[2] Y Gu, F. Ren, Y. Ji, J. Li, (2016), "The evaluation of sink mobility management in wireless sensor networks: A survey", IEEE Communications Surveys Tutorials, vol. 18, pp. 507-524 https://doi.org/10.1109/COMST.2015.2388779.
[3] N. T. Nguyen, B. H. Liu, V T. Pham, and C. Y Huang, (2016), "Network under limited mobile devices: A new technique for mobile charging scheduling with multiple sinks," IEEE Systems Journal, pp 1-11
[4] Y. Yim, K. Hoon Kim, M. Aldwairi and Ki-II Kim, (2018), "Energy-Efficient Region Shift Scheme to Support Mobile Sink Group in Wireless Sensor Networks", Sensors, Vol. 18(1), pp. 679-706
[5] Zhong, Peijun and Ruan, Feng (2018), "An Energy efficient multiple mobile sinks based routing algorithm wireless sensor networks" IOP Conference Series: Materials. Science and Engineering, Vol. 323, pp. 012029-012032 https://doi.org/10.1088/1757-899X/323/1/012029.
[6] Vicky Kumer and Ashok Kumer, (2017), "A Novel Approach for boosting Base Station Anonymity in a WSN", International Journal of Advanced Computer Science and Applications (IJACSA), vol. 8, issue nine.
[7] G. Han, J. Jiang, C. Zhang, T. Duong, M. Guizani, and G. Karagiannidis, (2016), "A Survey on Mobile Anchor Node Assisted Localization in Wireless Sensor Networks", IEEE COMMUNICATIONS SURVEYS & TUTORIALS, VOL. 18, NO. Three, pp. 2220-2243 https://doi.org/10.1109/COMST.2016.2544751.
[8] Catalina Aranzazu-Suescun and Mihaela Cardei, (2017), "Distributed Algorithms for Event Reporting in Mobile-Sink WSNs for Internet of Things", TSINGHUA SCIENCE AND TECHNOLOGY, Vol. 22, No. 4, pp. 413–426 https://doi.org/10.23919/TST.2017.7986944.
[9] Kamarei, M., Patooghy, A., Shahsavari, Z., Javad Salehi, M., (2018), "Lifetime Expansion in WSNs Using Mobile Data Collector" A Learning Automata Approach, Journal of King Saud University - Computer and Information Sciences, pp. 1-14
[10] O.M. Alia, (2017), "Dynamic relocation of mobile base station in wireless sensor networks using a cluster-based harmony search algorithm", Information Sciences, pp.76–95 https://doi.org/10.1016/j.ins.2016.12.046.
[11] Yuvaraj. P and Manimozhi. M, (2017), "Impact of base station location in clustering schemes of WSN", International Conference on Microelectronic Devices, Circuits and Systems (ICMDCS), pp. 1-5
[12] P. Yuvaraj, and K. V. L. Narayana, (2016), "EESCA: Energy efficient structured clustering algorithm for wireless sensor networks," International Conference on Computing, Analytics and Security Trends (CAST), pp. 523–527. https://doi.org/10.1109/CAST.2016.7915024.
[13] Tohma Yakup, Kadir Kutlu and I. Abasikeles-Turgut Ipek, (2017), "A New Cluster Head Based Dynamic Base Station Positioning for Wireless Sensor Network", ELECTRONICS, pp. 1-6
[14] T. Chin and K. Xiong, (2016), "MPBSD: A Moving Target Defense Approach for Base Station Security in Wireless Sensor Networks", International Conference on Wireless Algorithms, Systems, and Applications, pp. 487-498 https://doi.org/10.1007/978-3-319-42836-9_43.
[15] O. Cayirpunar, B. Tavli, E. Kadioglu-Urtis and S. Uludag, (2017), "Optimal Mobility Patterns of Multiple Base Stations for Wireless Sensor Network Lifetime Maximization", IEEE SENSORS JOURNAL, Vol. 17, No. 21, pp.7177-7188. https://doi.org/10.1109/JSEN.2017.2747499.
[16] J. Wang, L. Zuo, J. Shen, B. Li, and S. Lee, (2015), "Multiple mobile sink-based routing algorithm for data dissemination in wireless sensor networks," Concurrency Comput., Pract. Exper vol. 27, no. 10, pp. 2656–2667. https://doi.org/10.1002/cpe.3313.
[17] M. Faheem and V.C. Gungor, (2018), "MQRP: Mobile sinks-based QoS-aware data gathering protocol for wireless sensor networks-based smart grid applications in the context of industry 4.0-based on internet of things", Future Generation Computer Systems, Vol. 82, Pages 358-374. https://doi.org/10.1016/j.future.2017.10.009.
[18] Aranzazu-Suescun C., Cardei M., (2017), "Reactive Routing Protocol for Event Reporting in Mobile-Sink Wireless Sensor Networks", Q2SWinet'17, ACM, pp 43-50. https://doi.org/10.1145/3132114.3132116.
[19] C. Tunca, S. Isik, M. Y. Donmez, and C. Ersoy. (2015). "Ring routing: an energy-e_cient routing protocol for wireless sensor networks

with a mobile sink. IEEE Transactions on Mobile Computing, Vol. 14, No.9, pp. 1947-1960. https://doi.org/10.1109/TMC.2014.2366776.

[20] Anisha P A and K Raghuveer, (2016), "Load Balanced Data Delivery Using Mobile Sink in Wireless Sensor Network", International Journal of Advanced Research in Computer Science & Technology (IJARCST), Vol. 4, Issue 2, pp. 88-91

[21] Mohmood Z. Abdullah, Nadia A. Shiltagh and Ahmed R. Zarzoor, (2018), "Secure Mobile Sink Node location in Wireless Sensor Network using Dynamic Routing Protocol", Association of Arab Universities Journal of Engineering Sciences, accepted published date 25/6/2018

[22] H. P. Mistry and N. H. Mistry, (2015), "RSSI based localization scheme in wireless sensor networks: A survey," in Proc. 5th Int. Conf. Adv. Comput. Commun. Technol. (ACCT), pp. 647–652.Fauci AS, Braunwald E, Kasper DL & Hauser SL (2008), Principles of Harrison's Internal Medicine, Vol. 9, 17thedn. *McGraw-Hill*, New York, NY, pp.2275–2304.