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ROUTE QUALITY EVOLUTION WITH MOBILE SINK IN WIRELESS SENSOR NETWORKS USING QOS PARAMETERS

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ABSTRACT

An energy-effective routing is a fundamental task in a Wireless Sensor Network (WSN) topology. It supplies a better cost metric covering wireless route quality. Quality of Service(QoS) is behold critical design disquiet in routing protocols for WSN. Both energy and QoS parameters are used to assess network communication performance. In this study an evaluation conducted to Secure Mobile Sink Node location using Dynamic Routing Protocol (SMSNDRP) into two phases: routing generating and routing evaluation. In routing generating phase, the best path is selected based on the minimum distance between (Cluster head CH and mobile Sink Node SN) and highest CH residual energy. While in routing evaluation phase, the quality of each path is measured via creating five scenarios, one for static SN and four for mobile SN. The NS 2.35 simulator is used to implement the routing evaluation phase. The main aim of this study is proposes a technique to specify the best quality route that meets the QoS constraints for all SMSNDRP generated routes, in order to choose the best route for routing data to the SN, it must have the highest packet drop ratio, average throughput and less end to end delay that achieved better performance than other routes in the network.

Keywords: *Wireless Sensor Network (WSN), Quality of Service (QoS), Packet Drop Ratio, End to End Delay, Sink Node (SN), Cluster Head (CH)*

1. INTRODUCTION

A WSN mushroomed in various applications such as healthcare, military, weather and industry monitoring. It consisted of groups of sensor nodes that are deployed in a wide area to sense and deliver data to the clusters head CHs. Each CHs is achieved data aggregation and transmit it to SN. Which is in turn performed storing, processing on it before sending it to the client servers. The data transmission process on the route from source node to the SN affected by many things such as energy consumption on each node [1,2], distance between (CH and CH, node and SN, CH and SN) and number of hops. Thus, the route must include the nodes that have high residual energy in the network. In order to ensure successful data transmission and avoid fast node death on the path between the source and SN. Also, increase network lifetime by minimizing the distance between nodes and SN by selecting nearest node to SN that reduce number of hops.

However, finding the best route also affected by QoS parameters in a WSN such as Packet Delivery Ratio (PDR), throughput and end to end delay. The best path must maximize the (throughput and PDR) and minimize end to end delay that improved the network performance. For instance, the nodes near to SN consumed their own energy faster than the node further away from SN. Because they forward the sensory data of other nodes besides its data. In addition, the far nodes from SN need more time to deliver their data to SN. One of the solutions is to use a mobile SN to reduce the end to end lateness and balance energy consumption between the network nodes.

Another issue is the reliability of the routing path has been considered in a WSN as one of the most important QoS parameters [3]. The

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reliability is defined as the measurement of the probability in which there is at least a single route path available between the SN and nodes within cluster [4]. So, if the route link failed either due to the death of one or more nodes on the path or nodes' residual energy less than network energy threshold. In that case must be at least an alternative path in order to meet QoS requirements.

The contribution of this study is about evaluate the path quality that generated via protocol called Secure Mobile Sink Node using Dynamic Routing Protocol (SMSNDRP), which is developed by us in pervious study [5]. The evaluation process based on the QoS parameters are: PDR, Throughput, end to end delay and maximum path round numbers that prolonging network lifetime. A mobile SN is used in this study in order to reduce the end to end delay and balance energy consumption between nodes in the network. Also, an evaluation conducted on the SMSNDRP protocol in order to find the best routing paths between CHs and mobile SN. The rest of this paper is presented as follows: Section 2 review related works, Section 3 describe evaluation two phases: routing generating and routing evaluation, Section 4 is discussed simulation results for five scenarios run on NS (version 2.35) wireless simulator on WSN framework consisting of 50 nodes with static and mobile SN and finally section 5, include study conclusion.

2. RELATED WORKS

QoS is considered a defying zone to explore in WSNs for submission of QoS perceptible data to the SN. The big defy for QoS in WSN is that network resources constraints such as node buffer size, energy and sensor node transmission capacity. In study [6] researchers are measured QoS aware with energy constraints via proposed QEOR protocol. In this protocol they arranged the order of transmission delay according to the reliability of links and buffer. Bagula, suggests a traffic model in a WSN to select the fast, less delay and higher residual energy path for transmission packets route in the network [7]. The model is based on the QoS parameters (delay, reliability and energy constrained) to assess the path in a WSN. In [8] study authors proposed using multi-paths to achieve longer lifetime for the network. They balance traffic through drawing up the distance between nodes and sink node in a multipathing graph.

Moghadam et al. [9], inspected for the best routing path with minimum energy consumption using EEOR protocol. But they ignore the latency and reliability requirements in their study. In [10] they are transmitted packets via the nodes that have higher residual energy and at the same time closed to the target distance. In order to prolonging the network lifetime. Bapu and Gowd [11] use the opportunistic routing (OR) technique to distinguish and preserve from broadcast fault in a WSN. Their idea based on OR theory to form ideal path to the destination with minimum energy consumption. In Ahmed et al, proposes "Secure and QoS aware Routing Protocol (SQRP)" [12], in which they unified trust link quality with QoS parameters (link capacity, loss ratio and transmission lateness). In order to choose an optimized end-to-end path.

In study [13] used Ant Colony algorithm to discover the best path from multi-path that meet QoS parameters to reform local route, in case a current path between the source and destining is failed. They take into account lateness time, numbers of hops, bandwidth and residual energy while maintaining the path. Bhuyan, and Sarma [14] used a delay aware routing protocol that delivered the high time event information through multi-paths from the source node to SN within specified transmission time. In their protocol they maintained forward routing table that contain information collected from node neighbors. So, based on this information (location, node id, residual energy and distance to SN) they calculate the end to end lateness. Thus, the path with less routing lateness is the best path for sending packets to SN. Another study about mobile WSN [15], the researchers also used location information with routing table on each node, to find the node that closed to the target with minimum number of hops. Consequently, they reduce lateness time in that way in the network.

However, specified the best route in WSN with mobile SN consider a challenge because the destination is not static. Beside the routing process affected by QoS constraints. The [16] study presented a routing protocol in WSN with two mobile SN considering end to end lateness parameters. The protocol provides a reliability via forming multi-paths between the source node and mobile SN. Also, it minimized the energy consumption. The protocol chose the best path based on link estimate lateness between the nodes. Link estimate lateness is the time taken to send a packet from node (x) to (y) pulse the time to get acknowledgment from node (y) to (x). Beside its considered a distance from SN and residual energy.

In this study an evaluation technique proposed on hierarchical structure network. That used SMSNDRP routing protocol to form clusters and generated many routes for routing data between CHs and mobile SN. The best route quality between CHs and mobile SN is selected from many routes, based on QoS parameters and CHs' residual energy consumption. Also, the proposed method provides reliability in case the selected route is failed, due to the condition of reaming energy threshold is not satisfied, then an alternative best quality route will be selected instead of it.

3. STUDAY METHOD

In this study a mobile SN is used to reduce the end to end lateness and balance energy consumption between nodes in the network. The SMSNDRP was used to generate paths between CHs and Mobile SN. Thereafter, an evaluation conducted on these paths based on the QoS parameters are: PDR, Throughput, end to end delay. So, the study method divided into two phases, see Figure 1:

- Route Generating
- Route Evaluation.

2.1 Route Generation

In this phase, four routes are generated using SMSNDRP protocol that developed in our pervious study [5]. The protocol applied on a WSN structure is hierarchal clustering. The objective of using a SMSNDRP is to increase mobile SN location anonymity in the network. In order to secure it from traffic analysis attack. The basic foundation of this protocol is updating the location of mobile SN according to the locations of all new elected CHs. The new location coordination point of SN is calculating through computed mean function of the all selected CHs position coordination points. Although, the route designed is dependant on the CHs' remaining energy. In a way that a CH with maximum remaining energy than other CHs become the closest one to mobile SN in a WSN, see Figure 1. Therefore, only it's permitted to transmit data packets to the SN directly.

However, the route is automatically updated when one or more CHs' residual energy become less than or equal to the network energy threshold. Consequently, the new route is reconstruction again from the step of elected new clusters head in the new round and mobile SN new position computation. Furthermore, reliability is performed in that way though generating more one paths in the network using the same technique that described above. So, when one of the paths is failed or not meet the network energy threshold, then one of the generated paths is selected as alternative path. This the alternative path must have total remaining energy of all the CHs that constructed it, greater than other generating paths in the network.

2.2 Route Evaluation

In this phase an evaluation conducted on result routes from routing generating phase. The evaluation is based on the following QoS parameters:

1. Send packets: which is the count number of the packets that send successfully from the source
2. Received packets: which is the count number of the packets that received successfully in the destination
3. Packet Delivery Ratio (PDR): is the summation of the received packets divided by the summation of the sent packets. Highest value of PDR means better performance [17], see mathematical Eq. (1) that is used to calculate PDR.

$$PDR = \frac{\sum received\ packets}{\sum send\ packets} \quad (1)$$

4. Total Drop Packets: is the difference between number of sent packets and received packets.
5. Average Throughput: is the effective number of transmission packets during specific period of time. So, when throughput is high that means a good network performance and low throughput means poor performance, see mathematical Eq. (2) that is used to calculate Average Throughput

$$Average\ Throughput = \frac{the\ size\ of\ transmission\ packet}{Round\ Time\ Trap} \quad (2)$$

6. End to End Delay (EED): is the elapsed time that data packet takes it when leave the source node and received at destination node. This cover propagation delay, queueing delay and all possible delay rise by temporary storing during path discovery latency. So, when get a small value for end to end delay this means a better performance [18]. See mathematical Eq. (3) that is used to calculate average End to End Delay (EED).

$$Average\ EED = \frac{\sum Time\ required\ to\ deliver\ packets\ to\ destination}{number\ of\ received\ packets\ at\ destination} \quad (3)$$

So, the best path in the network is the one that meet the following QoS requirements [18,19]:

1. The path that routing data must have lowest end to end delay
2. The path must be at the same time generate the highest PDR than other paths
3. Although, it must give the maximum average throughput

Thus, the best path is selected based on the above criteria in this phase, but must be after selecting the best path in the generation phase. In which, the path constructed from the CHs that have the highest remaining energy. In order to produce highest number of rounds that extending the network lifetime. However, in this phase, the first step is arranging the paths that generated in generation phase, according to the maximum number of rounds in descending order. In other words, select the path that prolongs network lifetime more than other paths. The next 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 CHs' residual energy is less than energy threshold then moves to next path in the order. That has highest number of rounds, PDR, Average throughput and lowest end to end delay.

3. SIMULATION RESULTS

The NS version 2.35 simulator is used to implement the routing evaluation phase. In this study five scenarios are created: one for static SN and four for mobile SN. See Table 1, which shows the four routes to the mobile SN that result from routing generating phase in our pervious study [5]. Each scenario conducted on a WSN framework consist of 50 nodes with one SN deployed in 1000x1000 meters, see Table 2, which demonstrates the simulation parameters.

Table 1: Mobile Sink Node routes details

Number	Route to the Sink Node	Number of Rounds
1	CH23->CH10->CH7->CH12->CH1->CH41->CH2->CH12->CH25->CH4->CH14->CH37->CH20->CH9->CH43->CH46->CH30->CH11->CH36->CH38->CH13->CH44->CH49->CH26->CH28->CH48->CH32->CH31->CH40->CH6->CH24->CH22->CH47->CH19->CH8->SN	14
2	CH12->CH7->CH2->CH41->CH4->CH14->CH37->CH21->CH20->CH9->CH30->CH46->CH36->CH8->CH31->CH6->CH47->CH28->CH26->CH44->CH38->CH13->CH19->CH11->SN	78
3	CH7->CH41->CH4->CH14->CH37->CH21->CH8->CH6->CH47->CH9->CH20->CH38->CH44->CH11->CH46->CH26->CH19->CH28->CH13->SN	24
4	CH7->CH41->CH4->CH37->CH21->CH8->CH6->CH20->CH9->CH38->CH29->CH26->CH28->CH11->CH19->SN	32

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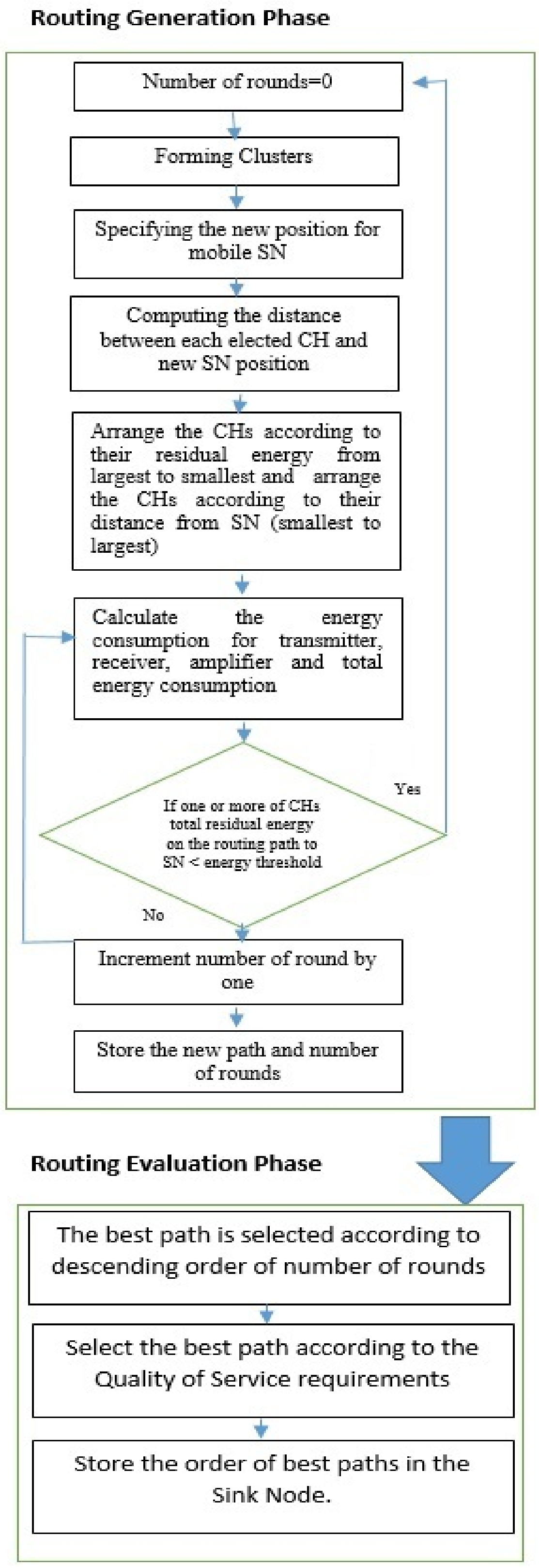

Figure. 1: Study method two phases functional

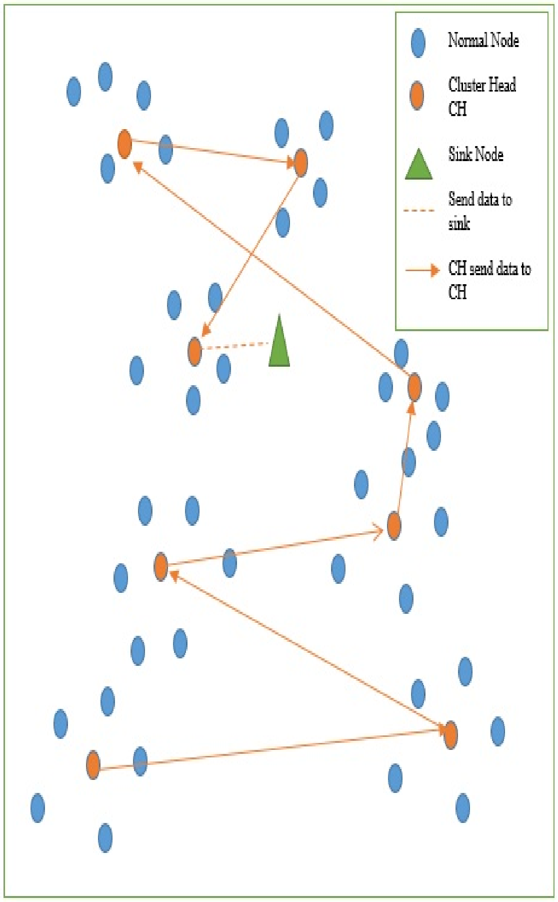

Figure 2: The SMSNDRP generate path between CHs and mobile SN

Table 2: Simulation parameters details

Parameters	Values
Time of simulation end	60 s
Number of nodes	50
Channel type	Channel/WirelessChannel
Network interface type	Phy/WirelessPhy
Area	1000x1000 meters
MAC type	Mac/802_11
Traffic Model	FTP

In scenario 1, the path to the mobile SN begin with CH 23 and terminate with CH8. Simulator duration time is 60s and each CH take 2 seconds to transmit the data packets to the next CH. To illustrate, the CH23 start send packets from time 0s to 2s and then CH10 received packets from CH23 and from time 2s to 4s send packets to the CH7 on the path and so on, see Figure. 3. Posteriorly, calculation of the QoS parameters for routing path number one has been done and the results are: send packets= 1251 packets, received packet= 1213 packets, PDR= 96.96%, Total Drop Packets= 38 packets, Average throughput= 121.45 kbps, End to End Delay= 421.125 milliseconds.

In scenario 2, the path to the mobile SN start with CH 12 and terminate with CH 11. Simulator duration time is 60s and each CH required 2 second to transmit data packet to the next CH on the path. Subsequently, calculation of the QoS parameters for routing path number two has been done and the results are: send packets=354 packets, received packet=1344 packets, PDR=99.26%, Total Drop Packets=10 packets, Average throughput=134.55 kbps, End to End Delay= 328 milliseconds.

In scenario 3, the path to the mobile SN start with CH 7 and terminate with CH 13. Simulator duration time is 60s and each CH required 2 second to transmit data packet to the next CH on the path. Subsequently, calculation of the QoS parameters for routing path number three has been done and the results are: send packets= 803 packets, received packet = 796 packets, PDR= 99.128%, Total Drop Packets= 7 packets, Average throughput= 78.64 kbps, End to End Delay= 582.95 milliseconds.

In scenario 4, the path to the mobile SN start with CH 7 and terminate with CH 19. Simulator duration time is 60s and each CH required 2 second to transmit data packet to the next CH on the path. Subsequently, calculation of the QoS parameters for routing path number four has been done and the results are: send packets= 533 packets, received packet= 524 packets, PDR= 98.311%, Total Drop Packets= 9 packets, Average throughput= 52.43 kbps, End to End Delay= 296.24 milliseconds.

In scenario 5 the path to the static SN begin with all CH 5, 35, 17, 8, 32, 24, 15, 30, 29, 23, 27, 28, 25, 33, 4, 22 ,26,14 ,21, 31, 34, 18, 13, 10, 1,9, 7, 12, 20,16, 3, 19, 2,11, 6 and terminate with the static SN. Simulator duration time is 60s and each CH required 2 second to transmit data packet to the static CH on the path. To illustrate CH5 begin send packets from time 0s to 2s to the static SN and then CH35 begin send packets to the static SN, from time 2s to 4s and so on. Subsequently, calculation of the QoS parameters for routing static path has been done and the results are: send packets = 1015 packets, received packet = 983 packets, PDR= 96.8, %, Total Drop Packets= 32 packets, Average throughput= 97.89 kbps, End to End Delay= 666.192 milliseconds.

However, from all above the dynamic path is 1,2,3 and 4 are produced form routing generating level. Based on the round number that produced in that level the best path is selected. So, SN perform descending order process on round number. Consequently, the best paths that achieved the highest extending of the network lifetime will be in the following sequence order: path 2, 3 ,4 and 1. In another word, the route that prolongs the network lifetime is the one that has the highest round number.

In the route evaluation level, the path quality is measured based on calculation of QoS parameters as following:

1. The best path quality for total drop packets is the path that produced lowest number of drop packs value. Thus, based on the demonstrated values on the graphic chart in Figure 4, the order of best paths that achieved minimum number of drop data packets will be in the following sequence order of paths: 3,4,2 and 1.

2. For PDR the better path quality is the path that produced maximum PDR. Therefore, according to the shown values on the graphic chart in Figure 5, the order of best paths that achieved maximum number of PDR will be in the following sequence order of paths: 2,3,4 and 1.

3. The better path quality that generated the highest average throughput in the network. Consequently, based to the demonstrated values on the graphic chart in the Figure 6, the order of best paths that achieved highest average throughput will be in the following sequence order of paths: 2,1,3 and 4.

4. The End to End latency best performance path is the path that produced minimum End to End latency values. based to the demonstrated values on the graphic chart in the Figure 7, the order of best paths that achieved lowest End to End latency will be in the following sequence order of paths:2,4,1 and 3.

In scenario 5, based on the network simulation results, one or more CHs on the static path that conveyed data packets to the static SN, are stop satisfying the condition 1of network energy threshold after 12 rounds. While in the situation of utilizing mobile SN the lowest rounds number is 14. Consequently, utilizing mobile SN with SMSNDRP protocol is extending the network lifetime in contrast with static SN.

Moreover, the route quality is evaluated via meeting the QoS determinations. It discovered that a static path produced minimum data drop packets (value=32) in contrast with the first dynamic path number one (where values=38). But remain paths number 2, 3 and 4 generated less data drop packets value than static path. For other parameters: average throughput and packet delivery ratio still the static path produced the minimum value among the other routes. Also, static path generated the maximum end to end latency (value=666.192) in contrast with other routes values. At the end the quality of static path with static SN gives low quality to improve a WSN performance, in compare with all the dynamic routes that produced by SMSNDRP protocol with mobile SN.

4. DISCUSSION

In scenario 5, based on the simulation results, when one or more CHs that constructed static

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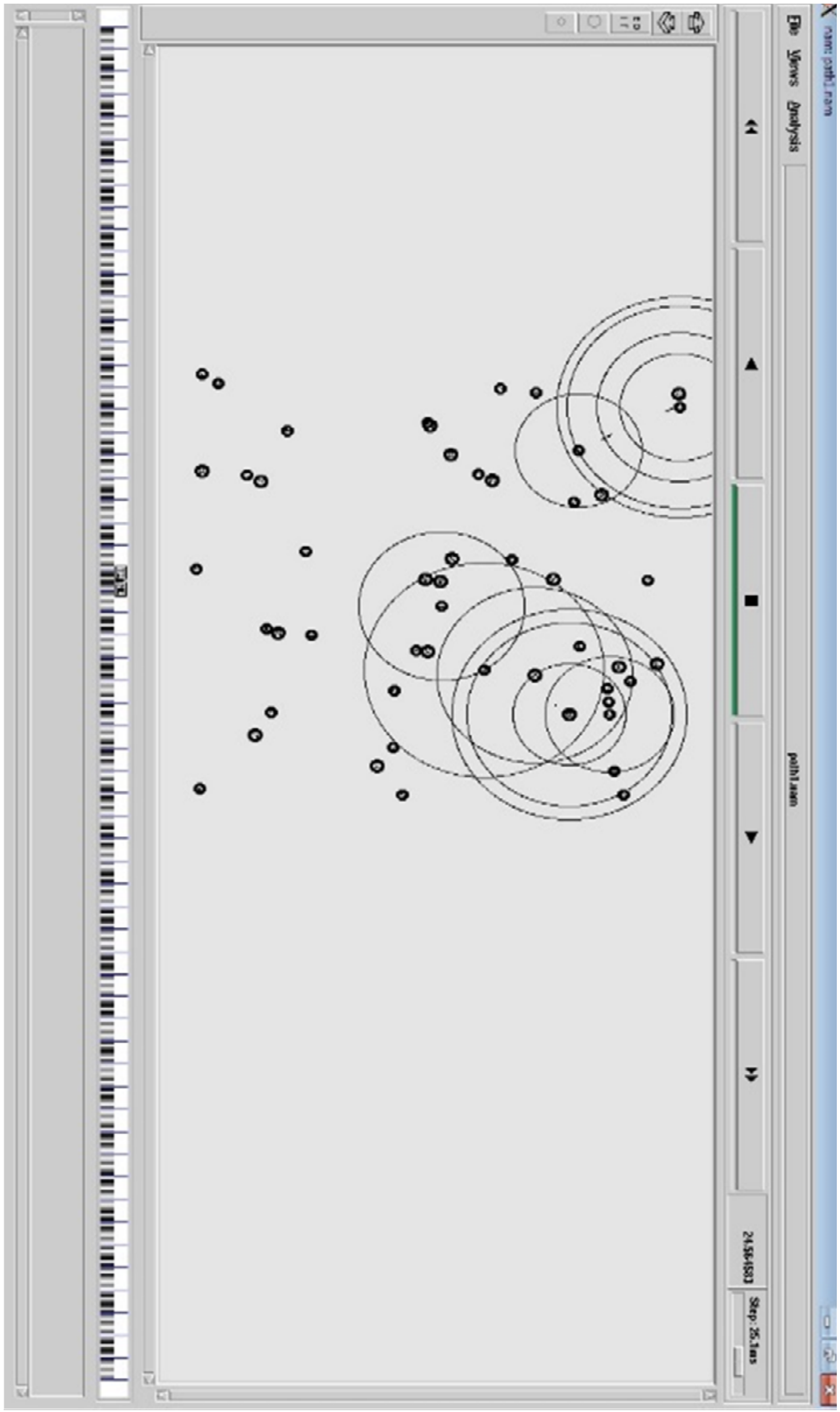

Figure 3: Scenario 1 screenshot from NS2 simulator software that demonstrated the implementation of path1 that generated by SMSNDRP protocol in the network. the path to the mobile SN begin with CH 23 and terminate with CH8.

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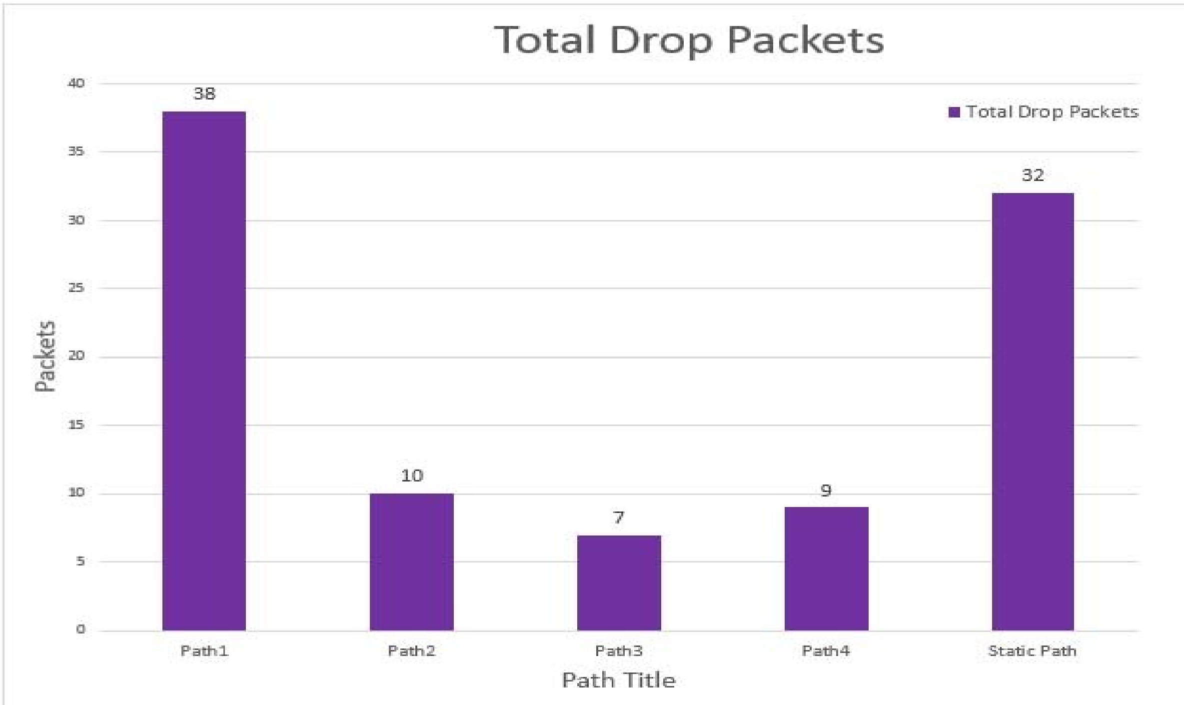

Figure 4: For mobile SN the best path among (1,2,3 and 4) is path3 that has minimum drop packets (value =7). For static SN, only one static path (value=32)

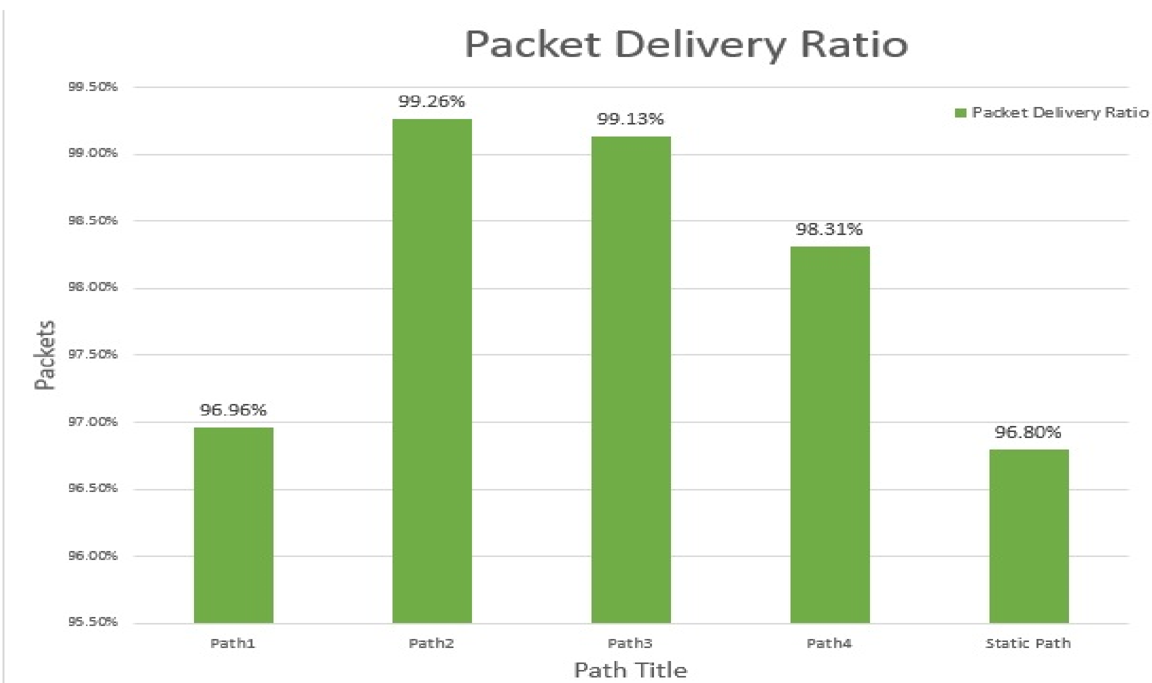

Figure.5: For mobile SN the best path between (1,2,3,4) is path2 that has maximum packet delivery ratio (value =99.26%). For static SN only one static path (value=96.8%)

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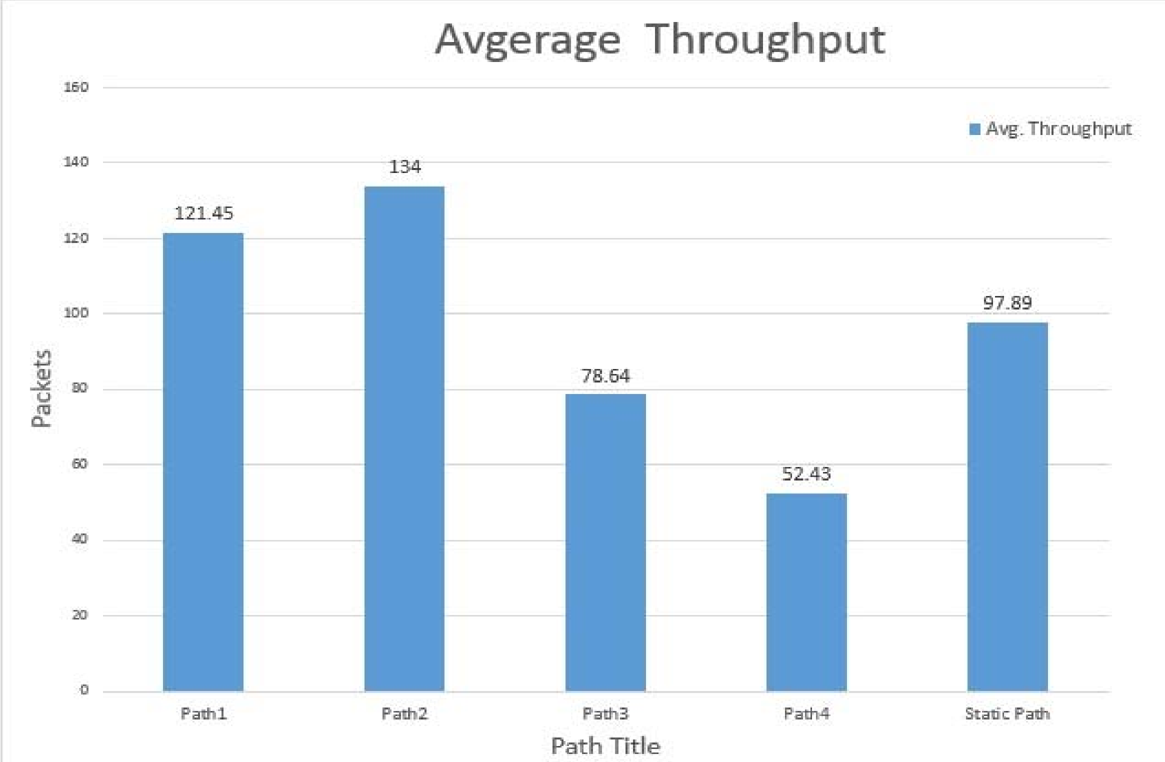
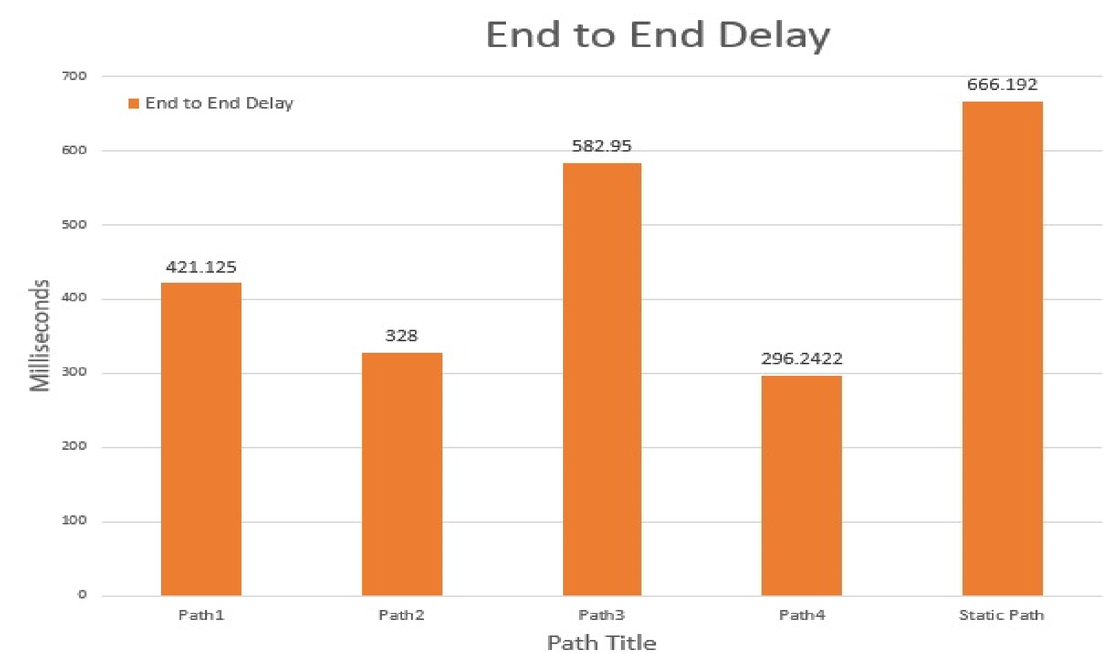


Figure.6: For mobile SN the best path among (1,2,3 and 4) is path2 that has maximum Average throughput (value =134.55 kbps). For static SN only one static path (value=97.89 kbps)



Figyre7. For mobile SN the best path among (1,2,3 and 4) is path4 that has minimum End to End Delay (value =296.24422 Milliseconds). For static SN only one static path (value=666.92 Milliseconds)

path to the static SN are stop meeting the condition of energy threshold value after 12 rounds. While in the case of using mobile SN scenario (1,2,3 and 4) in Table 1, the minimum rounds number is 14.

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Thus, using mobile SN with SMSNDRP protocol is prolonging the network lifetime in compare with static SN. Also, when measured the path quality via satisfying the QoS constraints. It found that a static path gives less data drop packets (value=32) in compare to the first dynamic path1 (values=38). But still path2, path3 and path4 produced less data drop packets value than it. For packet delivery ratio and average throughput, the static path gives the lowest value among the other paths. Although, it gives the highest end to end delay (value=666.192 Milliseconds) in compare with other paths values. Which make the quality of static path with static SN not good in contrast with dynamic path that generated by SMSNDRP protocol with mobile SN.

However, in compare with [19] study that used mobile sink node to reduce end to end delay and energy consumption via moving the SN to the area where there is more data need to be conveyed. They used queue weight in CH. Thus, according to the highest CHs' queue weight value the SN is moved toward it in order to reduce latency. While in SMSNDRP protocol the location of the SN is specified based on the position of elected CHs. Beside only the closed CHs position with highest residual is allowed to send the aggregate data to the new mobile SN position. So, there is only one hop to send data to the SN. Which reduce the end to end delay for data transmutation to the SN.

On other side, in the case of large scale network that distributed in wide geographical area, using one mobile sink node based on the proposed technique in this study is considered challenge issue. Due to large number of elected CHs in the network, which make the routing path to the SN consisted of large number of CHs that consumed more energy. Beside it increased the latency. which make the technique of using more than one mobile sink node [16] an appropriate solution for large scale network, in order to minimize the latency and balance the energy exhaustion in the whole network. Nevertheless, our future work will consider this issue via using group of mobile sink node on hierarchical structure network that used SMSNDRP protocol for routing protocol data.

5. CONCLUSION

In conclusion, this study proposed an evaluation technique based on QoS constrains, to find the best quality routing path between CHs and mobile SN. The best path is the one that achieved minimum CHs' remaining energy consumption, produced highest (throughput and PDR) and lowest (end to end delay) than other paths. The proposed technique is implemented on all the routing paths that are generated via SMSNDRP routing protocol. The evaluation has been achieved in two phases: routing generating and routing evaluation. In routing generating phase, the best routing path is selected based on the minimum distance between CH and mobile SN and highest CHs' residual energy. In routing evaluation phase, the best path in the network is the one that meets the QoS requirements. So, it must have higher PDR, average throughput and less end to end delay value in order to improve the network performance.

The quality of each path is measured via creating five scenarios, one for static SN and four for mobile SN. The NS 2.35 simulator is used to implement the routing evaluation phase. However, it found that the all the routing paths with mobile SN produced higher (PDR, average throughput) and minimum (end to end delay) with lowest CHs' energy consumption in compare to the routing path with static SN.

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