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# A sink based data gathering technique by using clustering for wireless sensor networks

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**ABSTRACT**

New advance and integrated technologies have changed the traditional systems and convert these systems into more intelligent, feasible and cost effective systems. In all data communications domain, data gathering is one of the significant task performed by using any techniques, tools and devices. Wireless sensor networks (WSN) also gained popularity in various fields where the sensor node sensed the information by using sink or gateway nodes and further send to central units for decision making. With passage of time, these networks have faced complexities where most of the existing techniques have suffered with load balancing, complex processes, overhead and energy consumption issues. Firstly, this paper provides detail comparison of existing data gathering techniques adopted for WSN and then provides their performance analysis. After comparison, this paper proposes a novel data gathering techniques called a sink based data gathering techniques (ASDG) to collect the data from the sensor nodes and further send for decision making. Experimental results show that proposed techniques is better than existing techniques and provide more efficient data delivery ratio with more network lifetime. The results also indicated that when using the proposed technique, the no of dead sensor nodes are less as compared to the existing ones at different rounds.



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## 1. INTRODUCTION

Wireless sensor network (WSN) comprises of small sensors, actuators and sinks nodes which are deployed in some specific area of interest to measure specific observation about environment. The sensed data collected by these sensors and further send to the base stations (BSs) for final data manipulation [1], [2]. Sink nodes are also used to gather the data from ordinary nodes. The sink nodes can be static or dynamic in nature. Static sinks can be deployed in specific location. Energy is one of the major challenge in these networks due to sensor nodes limited capabilities in terms of battery, processing power, storage and size [3], [4]. Nodes deployment is another significant challenge in these networks where sensor nodes randomly dispersed and could not assure the coverage of region of interest and might be separated into detached sub networks. This problem may be worst especially when many obstacles exist in the network. These issues also lead to energy depletion and more energy consumption. Recharging and replacement of sensor nodes are very difficult. In WSNs, the deployed sensor nodes are different in types and capabilities and their functionalities depend on field or area specification. Mobile sensor nodes are also working with static nodes for a particular purpose; which is difficult to achieve without nodes mobility. Generally, it is assumed that sensor nodes are inexpensive, but some type of sensor are costly [5], [6].

For more efficiency, the mobile sensor nodes are working with static nodes to collect the data and further forward the data for decision making. Different type of data gathering approaches have been designed to handle the complex area monitoring such as forest, agriculture fields, deserts and hill areas [7]. However, still the existing data gathering approaches have suffered with complex processes, overhead and energy consumption issues [8], [9]. The main objective of any data gathering technique is to increase the network lifetime and improve the latency issues in WSN. In order to achieve this objective, the techniques must have some appropriate routing metrics for routing decision. The complex methods consume more energy of sensor nodes and also cause of network data load handling and management [10]. The main issue in WSN network are different obstacles where the protocols are suffered with performance degradation. The long routes selection leads to delay issues in the network. Some other studies proposed the projection node selection mechanism by using the weighted sum [11].

Cheng and Lee [12] discussed the data gathering in WSNs with uncontrolled sink mobility. As the sink is freely moving to get the specific data from sensor nodes, path towards the sink node is unpredictable. The earlier used two model trailbased forwarding random walk (TRAIL) and data-driven routing protocol (DDRP) are used to detect the mobile sink via simple approach. The main drawback of these approaches according to the authors is that, these do not ensure 100% data delivery. In TRAIL algorithm, in order to deliver the data to the mobile sink, a sensor first sends the data packet to its neighbor sensor nodes through random walk and then set the time to live (TTL) of that data packet. Until beacon packets reached to the sensor nodes, then the data packet keeps forwarded to the next sensor nodes. After it reaches to sensor nodes, data packet will be relayed to the mobile sink using TRAIL. If the packet does not reach to the mobile sink until $TTL = 0$, then the data packet would be discarded. Hence, TRAIL does not ensure 100% packet delivery. As per the authors, the second algorithm DDRP also does not assure 100% packet delivery of packets because the sensor nodes are divided into one hop neighboring sensor node (OHS), multi hop neighboring sensors node (MHS) and infinite hop neighboring sensor nodes (IHS). OHS represents that the sensor receives beacon packet from the mobile sink. MHS sensor nodes represent that sensors have path to access the OHS. IHS represents that sensor nodes do not have path to reach to mobile sink node.

DDRP is different from TRAIL in the sense of mechanism of overhearing. In this mechanism, a sensor which is without the beacon packet can hear about the route because of neighboring sensor nodes which have beacon packet to transmit the data. Thus, the status of IHS sensors would be altered from IHS to MHS. Whereas, MHS and OHS can send the data to the mobile sink using beacon packet. As IHS cannot deliver data packet, these have to depend on random walk for finding MHS or OHS. Hence, assurance of 100% delivery cannot be confirmed. In this paper, a technique i.e. Trail based algorithm with guide lines (TAG) is suggested. In which virtual guide lines are used to ensure the data delivery from each sensor to mobile sink. Area of interest is divided into virtual vertical guidelines. When mobile sink passes near to the sensor, then it sends guide packet to nearest sensor and then it first saves this guide packet into its guide table and relay the guide packet to its neighboring sensors upward and downward. Neighboring sensor receives the guide packet and repeats the same and forward the guide packet to next sensors until no sensor left for relaying. Using guidelines when a sensor need to relay data to mobile sink, it has to send that packet in horizontal directions to be delivered to the sink. Query packet sent from the sensor in right and left directions. All the sensors which receives query packet are return the route update back to that sensor. Sensor excerpt the information regarding guide and beacon from its guide table and beacon table simultaneously. Data packet sends on the basis of latest route information. Based on the TAG algorithm, data delivery ratio is maximum as compared to DDRP and TRAIL. Whereas, total forwarding hop counts in the proposed TAG algorithm shows the minimum value as compared to DDRP and TRAIL.

Yang *et al.* [13] proposed a scheduling method for collecting the data in WSNs with mobile sink node. In order to extend the network life time, scheduling of mobile sink is proposed for less energy consumption during data transmission. Proposed method termed as heuristic algorithm. Heuristic algorithm consists of two steps. Finding the root for data aggregation is the first step in heuristic algorithm where the distance between nodes to the root is minimum. Secondly, it selects the sensors as anchor nodes for data collection by mobile sink. It is assumed in the model, that transmitted data would be forwarded by the sensors until it reaches to the destination. The generated data is forwarded to the parent nodes from the sensors repeatedly until it reaches to the root via the tree structure. Gathered data thus can be forwarded to specific sensors known as anchor nodes when mobile sink is used. Anchor nodes receives the forwarded data and then sends that data to mobile sink. The data forwarded by the anchor points consume less energy as the data is not all the times relayed by the root hence increasing the network lifetime. Sensors with higher outstanding energies are selected as anchor nodes. Heuristic algorithm results are compared with weighted rendezvous planning (WRP) technique. It is compared that network life time using heuristic algorithm is higher than WRP because, root location and remaining energy of sensors equally took into consideration while evaluating anchor nodes.

Saravanan and SrinivasaRangachar [14] proposed data gathering method with multiple mobile sinks using particle swarm optimization (PSO) method. First of all, mobile sinks travel around the network to gather the data from the rendezvous points (RPs). Optimal trajectory path is found from sub-trees using PSO technique. After that, global optimal trajectory is obtained by using splitting tree technique. Adaptive stop time technique is used for mobile sinks to wait and collect the data from the sensors, as all the data could not be stored in single session. Mobile sinks stop for some time at rendezvous points to gather the data. The time of stopping of mobile sinks depends upon the sensor's density, data collection rate and distance between the RPs. At the end, by simulation results it is shown that the proposed particle swarm optimization mobile sink based big data gathering (PSOMSDG) as compared to the biased sink mobility with adaptive stop times (BSMASD) gives better results in packet delivery ratio, packet drop, energy consumption and delay. Results are calculated on the basis of number of nodes and data rate separately. The 44% higher delivery ratio is observed as compared to BSMASD. Similarly, packet drop ratio w.r.t. different number of nodes scenario is 75% less as compared to BSMASD technique. Energy consumption using proposed PSOMSDG algorithm is 8% less as compared to BSMASD approach.

Raj S and Jose [15] proposed a modified clustering algorithm in order to collect the big data from sensors in WSN. With the advent of new technologies, big data contribution is increasing. It represents the high volume of data with high veracity and velocity. Proposed algorithm deals with the transmission of big data within WSNs using two mobile sinks. The main problem of big data collection is limited energy of WSNs. A comparison between the number of sensor nodes and number of mobile sinks required is made in this paper. According to the authors, using less mobile sinks than the required count would be time and energy consuming approaches. Whereas, using more mobile sinks than the required count would be underutilization of resources. In the proposed algorithm, node which has more residual energy is elected as cluster head which is then notified from all the sensor nodes. Sensor nodes sense and store the data in their buffer. Static sink known as cluster head which gathers the data from all the sensor nodes and save it in buffer. When the buffer reaches to its full capacity, mobile sink can be notified. Thus the mobile sink gathers all the data from the static sink which would be further forwarded to the base station (BS). Performance simulation has done by using the eight topologies which ranges from one to eight mobile sinks. In each topology, modified clustering and (MS) based data gathering algorithms have executed. Each topology has the same number of sensor nodes i.e. 50 with on BS. Results tested against the different parameters e.g. packet delivery ratio, dropped packets, residual energy and packet send and receive counts. Upon compiling results from all the eight topologies, it is interpreted that the topology with two mobile sinks have the better results in terms of above mentioned parameters. The projected system mitigates the load for calculation of number of mobile sink which increases the performance and cost would be reduced.

Vijayalakshmi and Manickam [16] proposed mobile data collection using PSO and space division multiple access (SDMA) techniques. In order to overcome the issues of latency, energy inefficiency and overflow of buffer cluster-based data gathering technique using SDMA has used. Mobile data collectors (MDCs) are used to collect the data from the clusters. In order to schedule the visit locations of MDCs, anchor points are selected through PSO technique. SDMA technique is used to collect the data from all the sensor nodes where the delay in data gathering could be minimized. Different receive antennas are used in SDMA in uplink transmission. Mobile data collectors are having two antennas for sensing and one antenna for data transmission. In the simulation evaluation, proposed particle swarm optimization cluster based mobile data gathering (PSOCMDG) algorithm is compared with SenCars and MDG-MS. Performance metrics like delay, average energy consumed and packet delivery ratio have taken into consideration. Results are evaluated on the basis of Transmission range and on the basis of speed of MDG separately. When compared to mobile data gathering mobile station (MDGMS), proposed PSOCMDG shows 29% less delay, 19% increase in packet delivery ratio and 17% increase in system life time.

Sivakumar and Sowmya [17] proposed a technique for data gathering using mobile sensor node called energy efficient clustering with delay reduction (EE-CDRDG). This proposed technique uses multiple SenCar with delay reduction clustering techniques. Proposed algorithm collects the data through multiple sensor nodes which reduces the latency. Use of two antennae for collecting the data from cluster heads simultaneously reduces the time for data transmission for data efficiently. During cluster formation, two nodes with the same residual energy can be elected as cluster heads. Proposed algorithm first selects the cluster head and then cluster formation took place which resultantly saves the energy. In the given technique, every sensor has been given a time slot (TS) to send the sensed data to the cluster head, because sending of data to the cluster head (CH) at the same time may result data loss. However, the node outside the cluster can send the data directly to the base station. Simulation results shows that the proposed technique EE-CDRDG has less delay, less dropping ratio, highest throughput, highest network life time and highest residual energy as compared to static element based technique (SEBT), mobile element based technique (MEBT) and efficient clustering with delay reduction approach in data gathering (EE-CRDG-I) techniques. There are some other traditional simple methods for data collection such as [18], in which authors used survey.

The survey is and data analysis is based on simple descriptive statistics and inferential statistics. In another study [19], the machine learning has adopted to measure cosin-angle with target and non targeted classes.

The existing work has adopted different parameters and methods for data gathering in WSN networks. The main objective of existing solutions is to improve the network perfoemnce and provide higher data delivery, maximizing the enrgy, and reduce the delay time and overhead. On the basis of above mentioned research papers following parameters of techniques have been evaluated in Table 1. Table 1 shows the comparison of discussed studies in terms of used techniques, and other significant routing decision parameters such as energy, network lifetime, delay, no of hops, packet drop ratio, and network life time.

Table 1. Analysis of mobile data gathering techniques w.r.t. different performance metrics

| S. No. | Technique | Used technique | Energy efficient/network lifetime | Higher packet delivery ratio | Reduced delay/less forwarding hop counts | Less packet drop ratio/buffer overflow tackled | Efficient network traffic |
|---|---|---|---|---|---|---|---|
| 1 | TAG [12] | – Uses virtual guidelines<br>– Using beacon and guide tables information | × | √ | √ | × | √ |
| 2 | Heuristic algorithm [14] | – Using tree structure through anchor nodes | √ | × | × | × | × |
| 3 | PSO-MSDG [15] | – Using PSO technique | √ | √ | √ | √ | × |
| 4 | Modified clustering algorithm | – Using modified clustering algorithm<br>– Using two mobile sinks | √ | √ | × | √ | × |
| 5 | PSOCMDG [16] | – Using PSO and SDMA techniques | √ | √ | √ | × | × |
| 6 | EE-CDRDG [17] | – Using clustering with delay reduction | √ | × | √ | √ | × |

The main issue in discussed techniques is randomization of projected nodes. There is also no guarantee of node probability. In this paper, firstly' we analyzed different existing data gathering approaches using mobile sink nodes and evaluate these techniques in term of energy efficiency, data delay, packet delivery ratio, network life time and packet drop ratio. In addition, these techniques are also evaluated on basis of their principles, advantages and drawbacks. Then, we proposed a mobile data gathering technique for WSN. In order to achieve this objective, the other sub objectives are:

- Comparison of existing data gathering techniques in terms of their limitations and issues.
- Determine the performance of existing data gathering techniques.
- Proposed a data gathering technique with more feasible metrics to enhance the network lifetime and increase the data delivery.
- Evaluate the performance of proposed techniques with existing techniques in terms of network lifetime, data delivery and no of alive or dead nodes in the network.

The rest of the paper is organized: section 2 presents the related work and their advantages and limitations in WSN. Section 3 presents the comparison section of existing techniques. Section 4 presents the proposed data gathering technique. In section 5, the experimental results are discussed. In last, paper concludes with future direction.

## 2. COMPARATIVE ANALYSIS

Different techniques for mobile sink based data gathering in WSNs have been evaluated on few performance metrics. This section compared the few characteristics of these updated techniques in the domain of WSNs like energy efficiency, packet delivery ratio, delay, packet drop ratio and network traffic. These techniques include TAG, heuristic algorithm, PSO-MSDG, modified clustering algorithm, PSOCMDG and EE-CDRDG. TAG algorithm works on the virtual guidelines to sense the movement of mobile sink using guide and beacon tables information. In heuristic algorithm, data have been forwarded through root and anchor nodes jointly so that cluster head would have less energy consumption during relaying. Particle swarm optimization-mobile sink data gathering (PSO-MSDG) uses the splitting tree technique through PSO to find the optimal path trajectory. It further uses the adaptive stop time technique for mobile sink to wait and take the data from sensor nodes. Modified clustering algorithm uses the eight topologies to compared the performance of WSNs depending upon the usage of different number of mobile sinks. PSOCMDG uses both the PSO and SDMA techniques for mobile sink based data gathering and has better results compared to other techniques. EE-CDRDG used the energy efficient clustering technique with delay reduction while gathering the data in WSNs. The comparison of these technologies shows in Figure 1.

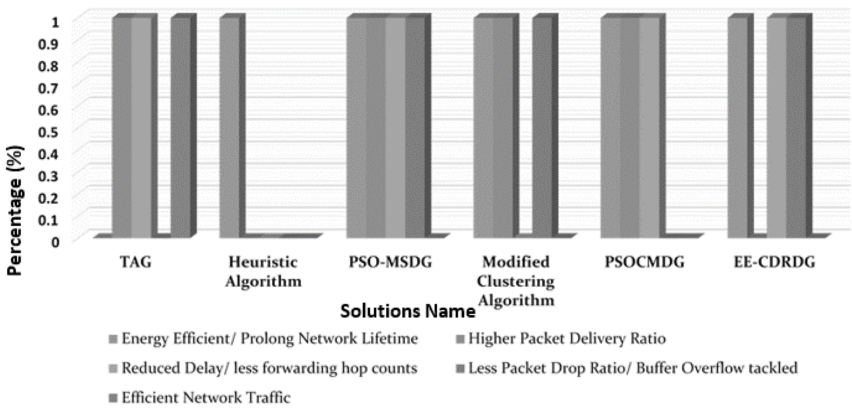


Figure 1. Analysis of mobile sink based data gathering techniques

## 3. PROPOSED SINK BASED DATA GATHERING TECHNIQUE

We adopted clustering technique in WSN where the sensor nodes are divided into separate groups called clusters [20]. Every cluster has one CH and cluster members (CM). For the selection of CH and CMs in the networks, the all nodes are performing a CH selection and election process. After this all election, the CH are assigned for every cluster which is responsible to apply the data gathering techniques and then send the data to other CHs. Figure 2 shows the network model and its process.

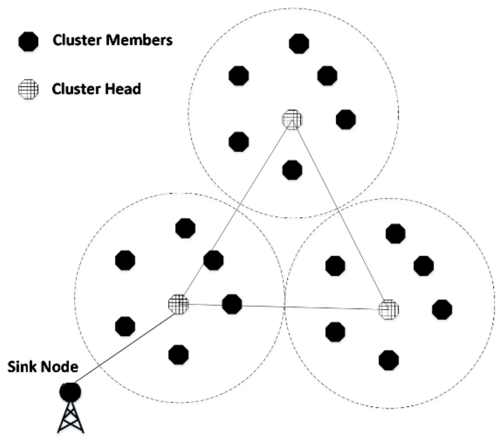


Figure 2. Network model and data gathering process

Before explaining the all phases of proposed techniques, we have some assumption which are:
- The distribution of sensor nodes is random.
- All sensor nodes have same radio range for data transmission.
- Localization algorithm is enable in sensor nodes for update the location information with neighbor nodes.
- Security is not taking into account.

### 3.1. Clustering

For clustering, the sensor nodes are divided into groups where each sensor nodes becomes a leader called CH. CH acts as an intermediate node between other nodes CM. The CH is selected based on all sensor nodes energy level because CH need more capabilities than other CM nodes in the network. In cluster based routing protocols, the different phases are initiated where the CH election carried out to select the best preferable node as a CH. If there is any changing in networks, then again the CH process is started until select a new CH. In this proposed protocol, we used CH, identification (ID) strategy to maintain the routes in cluster. CH, ID has reduced the processes to calculate the route every time. By using CH, ID the energy of nodes increases. If there is any change in the networks, then the CH, ID is again calculated and update for the whole network. After CH selection, the next phase is communication between CH to other CH. Then CH forward the data to the BS.

#### 3.1.1. Cluster head selection

The proposed a sink based data gathering techniques (ASDG) technique computes the energy level at every node and the more energy nodes add one identifier in its beacon header and disseminated to all nodes in the networks. By receiving the unique identifier messages, every node compares it with its own energy level and if threshold is increased then that identifier node becomes a CH for node. If the energy level identifier is less than node level, then slimily the nodes discard the beacon. After calculating the energy level and CH election, the all other nodes declared itself as a CM. This process initiate at the beginning until a CH is selected for every cluster. Then, all CH broadcast the advertisement messages to other CH and make a route and forward the data to the selected path. Every node broadcast the beacon messages to add the energy level identifier. The CH election process shows in Algorithm 1.

Algorithm 1. CH selection

Input: nodes location and initial energy level
Output: CH selection
1. IDM (Identifier messages broadcasting)
2. For all nodes j € do
3. If energy value is increased then
4. Select CH
5. Else
6. Discard
7. End if

### 3.2. Data aggregation process at sink node

In this phase, the chain based data gathering strategy is adopted for data collection which is better than tree based compressed data structure. Every CH is loaded with projection vector for CM. This coefficient is generated to identified the CM in the network. After receiving the projection sum, the next CH calculates the new projection sum. Data compression process is start by using compressed sensing theory as discussed in [21]-[23]. The data compression is started where the $D$ shows the original data and by measurement matrix $\Phi$ utilized as used in [24]. The (1) shows the compression steps.

$$D = \Phi\, M \tag{1}$$

Where $D$ denoted the original data and $M$ denotes the measurement data and $\Phi$ is measurement matrix.

## 4. EXPERIMENTS AND RESULTS

First all experiments, we used NS-2 [25] to setup the network. In simulation, the 100 nodes are set in several scenarios. The all nodes are randomly deployed in the network and set their radio range. The total network size is 100 m × 100 m to form the network. Other all setting of simulation are showing in Table 2.

Table 2. Simulation parameters

| Simulation parameters | Values |
|---|---|
| Network size | 100 m × 100 m |
| Number of sensor nodes | 100 |
| Initial node energy | 2 J |
| Data packet size | 512 bytes |
| BS | 1 |

In first experiment, we test the network lifetime where we calculate the first node dies and last nodes dies ratio with alive nodes in the network. Figure 3 shows the greater performance of ASDG compared to existing techniques PSO MSDG and modified cooperative access (MCA). The results indicated that the first node dead with PSO-MSDG is after 3112 rounds whereas the first node dead with MCA after 2650 rounds. As compared with both existing techniques, the proposed ASDG show the dead node at 3506 rounds. This result indicated that the proposed technique is better compared than existing techniques.

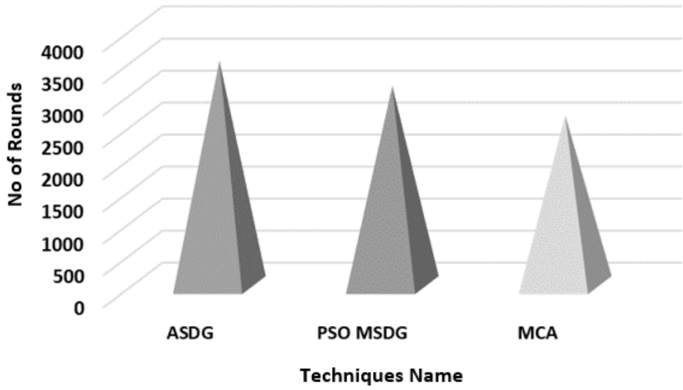


Figure 3. Network lifetime analysis with first and last node die

In second experiment, we tested the network lifetime for 100 m × 100 m network with 100 nodes. It is noted that the performance of proposed techniques has better results compared to PSOMSDG and MCA. The results indicated that the no of dead nodes by using proposed technique is less compared to existing ones. As compared with both existing techniques, the proposed ASDG show the dead node at 3506 rounds. In Figure 4, the result indicated that the proposed technique is better compared than existing techniques in term sof network lifetime with total no of alive nodes.

In third experiment, we test the data delivery ratio of proposed technique with state of the art technique. The average data delivery of proposed technique is better than existing techniques due to its sink selection and data gathering strategies where it performs better than previous. This average is evaluated with total number of packets that have reached to the destination. ASDG is better in data delivery and best option of cluster based networks. Figure 5 shows the packet delivery ratio.

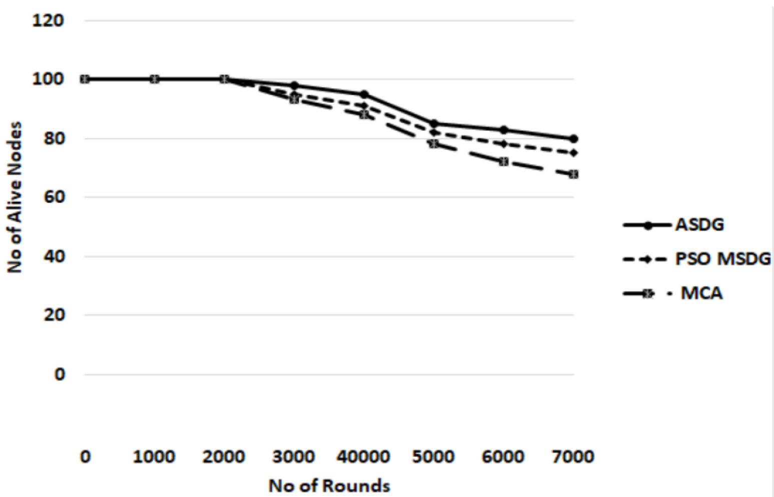


Figure 4. Network lifetime with total no of alive nodes

The all simulations are performed to check the best and worst performance of proposed and existing solutions in terms of network lifetime, data delivery ratio and alive node probability in the network. The simulation run multiple times with different parameters to evaluate the propsoed existing solutions.

After implementing the existing solutions, the proposed solution is evaluated with different parameters like network lifetime, alive nodes, data gathering ratio and overall network services. The following findings are concluded after all simulations and results and linked with proposed technique:

– The proposed technique achieves the better network lifetime in the presence of first node dies and last nodes dies ratio with alive nodes in the network by using different simulation rounds. This results achieves the energy efficiency results by enhancing the network lifetime as compared with existing techniques.
– The second result showed the better average of alive no of nodes where proposed techniques achieves better performance.
– The packet delivery ratio is also indicated that the proposed technique is best option for data gathering especially for WSN networks.

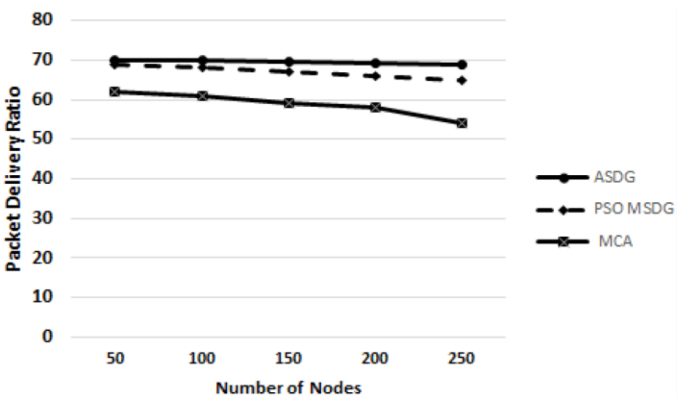


Figure 5. Packet delivery ratio

## 5. CONCLUSION

In this paper, we proposed a sink based data gathering techniques (ASDG) to collect the data from the sensor nodes and further send for decision making by using sink nodes. In proposed techniques, first the CH election is initiated by broadcasting the energy level information identifier in beacons. Every node calculates its own energy with provided energy and select CH for every cluster. After CH selection, the network process is creating the route and send route ID to all CHs. Then CH have adopted data compression techniques to forward the compressed data. By using this strategies, the proposed protocol performance is better compared with existing techniques. The different simulation experiments have conducted to evaluate the proposed technique ASDG performance with existing PSO-MSDG and MCA techniques. The proposed technique achieves the better network lifetime in the presence of first node dies and last nodes dies ratio with alive nodes in the network by using different simulation rounds and enhance the energy efficiency results by enhancing the network lifetime as compared with existing techniques. In future, we add some mobility in the network to evaluate the proposed technique performance. In addition, the quality of services parameters will consider for CH selection in future.

## REFERENCES

[1] L. A. Grieco, G. Boggia, S. Sicari, and P. Colombo, "Secure Wireless Multimedia Sensor Networks: A Survey," *2009 Third International Conference on Mobile Ubiquitous Computing, Systems, Services and Technologies*, 2009, pp. 194-201, doi: 10.1109/UBICOMM.2009.27.
[2] C. Kanimozhi, M. M. Musthafa, and M. Tech, "Mobile sink based data gathering and forwarding in WSN," *International Journal of Innovative Research in Computer and Communication Engineering*, vol. 2, no. 1, pp. 3701-3706, 2014. [Online]. Available: https://www.researchgate.net/profile/mohamed-m-m/publication/332672551_icgict'14_organized_by_department_of_cse/links/5cc2f1744585156cd7b21bea/icgict14-organized-by-department-of-cse.pdf
[3] Y. -C. Wang, F. -J. Wu, and Y. -C. Tseng, "Mobility management algorithms and applications for mobile sensor networks," *Wireless Communications and Mobile Computing*, vol. 12, pp. 7-21, Jan. 2012, doi: 10.1002/wcm.886.
[4] R. A. Nazib and S. Moh, "Sink-type-dependent data-gathering frameworks in wireless sensor networks: A comparative study," *Sensors*, vol. 21, no. 8, p. 2829, 2021, doi: 10.3390/s21082829.
[5] K. N. Qureshi and A. H. Abdullah, "Localization-based system challenges in vehicular ad hoc networks: survey," *Smart Computing Review*, vol. 4, no. 6, pp. 515-528, Dec. 2014. [Online]. Available: https://www.researchgate.net/publication/270897134_Localization-Based_System_Challenges_in_Vehicular_Ad_Hoc_Networks_Survey
[6] K. N. Qureshi, A. H. Abdullah, O. Kaiwartya, F. Ullah, S. Iqbal, and A. Altameem, "Weighted link quality and forward progress coupled with modified RTS/CTS for beaconless packet forwarding protocol (B-PFP) in VANETs," *Telecommunication Systems*, vol. 75, pp. 145-160, doi: 10.1007/s11235-016-0207-x.

[7] K. Maraiya, K. Kant, and N. Gupta, "Wireless sensor network: a review on data aggregation," *International Journal of Scientific Engineering Research*, vol. 2, no. 4, pp. 1-6, 2011. [Online]. Available: https://www.researchgate.net/publication/265242700_Wireless_Sensor_Network_A_Review_on_Data_Aggregation

[8] K. N. Qureshi, A. H. Abdullah, and J. Lloret, "Road perception based geographical routing protocol for vehicular ad hoc networks," *International Journal of Distributed Sensor Networks*, vol. 2016, pp. 1-16, 2016, doi: 10.1155/2016/2617480.

[9] P. V. P. Raj, A. M. Khedr, and Z. A. Aghbari, "Data gathering via mobile sink in WSNs using game theory and enhanced ant colony optimization," *Wireless Networks*, vol. 26, pp. 2983-2998, 2020, doi: 10.1007/s11276-020-02254-x.

[10] H. Wan, M. David, and W. Derigent, "Energy-efficient chain-based data gathering applied to communicating concrete," *International Journal of Distributed Sensor Networks*, vol. 16, no. 8, 2020, doi: 10.1177/1550147720939028.

[11] J. Qiao and X. Zhang, "Compressive Data Gathering Based on Even Clustering for Wireless Sensor Networks," in *IEEE Access*, vol. 6, pp. 24391-24410, 2018, doi: 10.1109/ACCESS.2018.2832626.

[12] C. Cheng and H. Lee, "Data Gathering in Wireless Sensor Networks with Uncontrolled Sink Mobility," *2016 IEEE 83rd Vehicular Technology Conference (VTC Spring)*, 2016, pp. 1-5, doi: 10.1109/VTCSpring.2016.7504183.

[13] Y. -H. Yang, T. Lin, B. -H. Liu, S. -I. Chu, C. -Y. Lien, and V. -T. Pham, "An efficient mobile sink scheduling method for data collection in wireless sensor networks," *2017 International Conference on System Science and Engineering (ICSSE)*, 2017, pp. 554-557, doi: 10.1109/ICSSE.2017.8030936.

[14] G. Saravanan and M. J. SrinivasaRangachar, "Mobile Sink Data Gathering Technique for Wireless Sensor Networks using PSO," *International Journal of Intelligent Engineering and Systems*, vol. 9, no. 3, pp. 101-109, 2016, doi: 10.22266/ijies2016.0930.10.

[15] Antu Raj S and S. Jose, "Analysis of mobile sink based Big Data gathering in dynamic wireless sensor networks," *2016 International Conference on Automatic Control and Dynamic Optimization Techniques (ICACDOT)*, 2016, pp. 875-880, doi: 10.1109/ICACDOT.2016.7877712.

[16] K. Vijayalakshmi and J. M. L. Manickam, "A cluster based mobile data gathering using SDMA and PSO techniques in WSN," *Cluster Computing*, vol. 22, pp. 12727–12736, doi: 10.1007/s10586-018-1748-4.

[17] B. Sivakumar and B. Sowmya, "An energy efficient clustering with delay reduction in data gathering (EE-CDRDG) using mobile sensor node," *Wireless Personal Communications*, vol. 90, pp. 793-806, 2016, doi: 10.1007/s11277-016-3214-z.

[18] O. N. Ezirim and C. U. Okpoechi, "Community-driven Development Strategy for Sustainable Infrastructure," *Journal of Human, Earth, and Future*, vol. 1, no. 2, pp. 48-59, Jun. 2020, doi: 10.28991/HEF-2020-01-02-01.

[19] M. Kowsher, I. Hossen, A. Tahabilder, N. J. Prottasha, K. Habib, and Z. R. M. Azmi, "Support Directional Shifting Vector: A Direction Based Machine Learning Classifier," *Emerging Science Journal*, vol. 5, no. 5, pp. 700-713, 2021, doi: 10.28991/esj-2021-01306.

[20] K. M. Awan, A. Ali, F. Aadil, and K. N. Qureshi, "Energy efficient cluster based routing algorithm for wireless sensors networks," *2018 International Conference on Advancements in Computational Sciences (ICACS)*, 2018, pp. 1-7, doi: 10.1109/ICACS.2018.8333486.

[21] E. J. Candes and M. B. Wakin, "An Introduction To Compressive Sampling," in *IEEE Signal Processing Magazine*, vol. 25, no. 2, pp. 21-30, March 2008, doi: 10.1109/MSP.2007.914731.

[22] D. L. Donoho, "Compressed sensing," in *IEEE Transactions on Information Theory*, vol. 52, no. 4, pp. 1289-1306, 2006, doi: 10.1109/TIT.2006.871582.

[23] K. N. Qureshi, A. H. Abdullah, F. Bashir, S. Iqbal, and K. M. Awan, "Cluster-based data dissemination, cluster head formation under sparse, and dense traffic conditions for vehicular ad hoc networks," *International Journal of Communication Systems*, vol. 31, no. 8, 2018, doi: 10.1002/dac.3533.

[24] S. Qaisar, R. M. Bilal, W. Iqbal, M. Naureen, and S. Lee, "Compressive sensing: From theory to applications, a survey," in *Journal of Communications and Networks*, vol. 15, no. 5, pp. 443-456, Oct. 2013, doi: 10.1109/JCN.2013.000083.

[25] S. N. Abdulwahid, "Development of an efficient mechanism for rapid protocols using NS-2 simulator," *APTIKOM Journal on Computer and Science and Information Technologies*, vol. 3, no. 1, pp. 13-20, 2018, doi: 10.11591/APTIKOM.J.CSIT.81.


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