An Efficient Mobile Data Collector Based Data Aggregation Scheme for Wireless Sensor Networks

Upasana Sharma
PG Scholar
Computer Science Department
NITTTR, Chandigarh, India
pasu_upasna@yahoo.co.in

Dr. C. Rama Krishna
Professor
Computer Science Department
NITTTR, Chandigarh, India
rkc_97@yahoo.com

Dr. T.P. Sharma
Associate Professor
Computer Science Department
NIT, Hamirpur (H.P.), India
teekparval@gmail.com

***Abstract* - Recently, mobile collector or sink mobility has become an important research topic in WSNs. Data collector mobility can improve the performance of WSNs. Mobile sinks are mounted on some vehicles, animals or people moving randomly to collect information sensed by the sensor nodes where the data sink trajectories are changing or random. In the scenarios where the trajectories of the mobile collectors are fixed or predetermined, the efficient data collection problems are concerned to improve the performance of the network. Therefore, in this paper we propose an intelligent mobile data gathering scheme which dynamically changes its DGT (Data Gathering Tour) in between by utilizing information from NIT (Neighbor Information Table). Each CH (Cluster Head) learns about its neighbors whether they have data to send or not and thus creates a NIT. Based on the information in NIT at a CH, MDC (Mobile data Collector) decides its further course of action. Hence, the path travelled is dynamically pruned using this information at each cluster head. Simulation results show significant energy savings when this scheme is applied to various data collection scenarios in which different CHs are deployed as opposed to scenarios when no dynamic path pruning and data filtering is used.**

Keywords:- Wireless Sensor Networks, Neighbour Information Table (NIT), Data Filtration, Data Dissemination, Data Aggregation

I. INTRODUCTION

Wireless Sensor Network (WSN) [1] [2] is a popular technology used now-a-days in diverse scenarios. WSN has a vast application area which includes environmental monitoring, traffic control, medical applications, military applications, industrial monitoring etc. WSNs consist of large numbers of low cost and low power devices known as sensor nodes (SNs). These SNs are scattered in the region of interest to sense collectively and route the information towards a designated node known as sink or base station. Wireless SNs interact using a wireless medium to accomplish a common task. SNs sense the event for the desired data and forward the results to the sink. Sink is located close to the sensing region and it stores all the forwarded results. Besides monitoring the environment by taking temporal or spatial measurements, sensors are also responsible for collecting and routing sensing data. This may lead to non-uniform energy consumption among sensors due to the fact that sensors near the sink have to relay more packets than sensors far away from the sink. As a result, their energy is consumed much faster than others and at last depleted. Hence, how to efficiently aggregate and collect the information from the scattered sensors, generally referred to as data gathering problem, is the most challenging and an important issue in such networks. Due to the resource constraint sensor nodes and limited bandwidth of the wireless sensor network, the amount of data transmission should be minimized such as the lifetime of sensor nodes and bandwidth utilization of the network can be improved.

Hence, in present work we propose an Efficient Mobile Data Collector based Data Aggregation Scheme which works in a cluster based wireless sensor network that utilizes mobile nodes effectively for data collection.

Rest of the paper is organized as follows. Section explains related work. Section III gives complete network model and assumptions. Proposed approach is explained in section IV. In section V, different simulation scenarios with simulation parameters are given and performance of proposed approach is evaluated. Section VI concludes the work.

II. RELATED WORK

In this section, we review the related work on mobile Data collector for data collection and also review some work on data filtration/aggregation in WSNs.

T. C. Chen et al. [3] proposed a strategy for islanded partitions WSNs. In this paper the subject of acquiring sensed data in the wireless sensor network through mobile collector that possess islanded/ unexpected partitioned WSNs is investigated. Due to battery depletion of sensors, the partitioned WSNs can be created; as a result the base station does not collect the data. M. Ma et al. [5] proposed a new data gathering strategy for large scale wireless sensor networks by introducing mobility into the network. Single-Hop-Data-Gathering Problem (SHDGP) focuses on the problem of minimizing the length of each data gathering tour. The tour generally follows TSP [6] [7] path. In SHDGP M-collector is moving, it can poll nearby sensors one by one to collect data. After receiving the polling message, a sensor simply uploads the data to the M-collector directly in a single hop without relay.

M. Ma et al. [5] proposed an effective M-Collector scheme.In this data gathering scheme of multiple M-collectors, only one M-collector needs to visit the vicinity of the data sink. The entire network can be divided into some regions or sub

978-1-4799-6023-1/15 $31.00 © 2015 IEEE
DOI 10.1109/CICT.2015.78

networks. In each sub network, an M-collector is responsible to collect data from local sensors in the sub-area.

M. Zhao et al. [8] proposed multiple mobile collectors and Spatial Division Multiple Access (SDMA) technique for data gathering. Its main focus is to optimize the data gathering tour by using special sencar equipped with two sensors. S. Chowdhury et al [9] proposed an approach in which a large number of low cost static sensor nodes distributed randomly in large region associated with a static data sink located at the centre of the field. A mobile collector (*MC*) is used to collect data packets from each sensor nodes within a single hop data transmission and mobile relay based [10] approach is used. S. Guo et al. [11] proposed data gathering cost minimization (DaGCM) framework with concurrent data uploading, which is constrained by flow conservation, energy consumption, link capacity, compatibility among sensors. It allows concurrent data uploading from sensors to the mobile collector to sharply shorten data gathering latency and significantly reduce energy consumption due to the use of multiple antennas and space-division multiple access technique.

M. Arshad et. al. [12] proposed a Mobile Data Collector (MDC) based routing protocol for data aggregation, which is based on multi-hop routing strategy. This approach is better than LEACH in terms of energy consumption and enhances the network lifetime during data transmission. S. Guo et. al. [13] proposed a framework of joint Wireless Energy Replenishment and anchor-point based Mobile Data Gathering (WerMDG) in WSNs by considering various sources of energy consumption and time-varying nature of energy replenishment. They determine the anchor point selection strategy and the sequence to visit the anchor points.

R. W. N. Pazzi et. al. [14] proposed a design of a protocol for wireless sensor networks using mobile data collector that offers low latency event delivery for emergency preparedness applications. In this scheme, the sinks broadcast beacon messages periodically and also employ both static and mobile sinks. It also uses propagation trees rooted at the sinks.

T.P. Sharma et al. [15] proposed energy efficient Data filtering scheme which uses simple static clustering strategy where some of nodes from sensor region are randomly selected as cluster head nodes (CHNs). The proposed approach uses a filtering window at a node which binds maximum permissible and minimum required variation in data report from previously disseminated report to make it eligible for dissemination.

In this way various issues have been investigated in the above schemes. Most of the schemes have proposed routing strategy for static WSNs having stationary nodes. Most of the techniques proposed above require prior information for the movement of the MDC. Most of the schemes work on pre-specified static tour. Most techniques that employ MDCs deal with the problem of collecting data in non-delay sensitive scenarios. Hence, to address some of the issues we have proposed an efficient mobile data collector scheme which employs clustering and data filtering.

III. SYSTEM MODEL & ASSUMPTIONS

A. Network Model

We assume that the network contains tens or hundreds of SNs randomly deployed in the area of observation. All nodes are of similar type and thus form a homogeneous network. Each SN knows its geographical coordinates, which are assigned to it during deployment phase. These coordinates act as node's identity and thus enables it to be identified on the network. There also exists a sink or Base Station (BS) in the network. BS acts as a gateway between sensor field and outside world. We use simple static clustering strategy, where some of nodes from sensor field are randomly selected as cluster heads (CHs). Each CH broadcasts its presence in its transmission range using special packet containing its identity (*i.e.* coordinates). Each SN in the range hears these broadcasts during setup time and forms a group *G* comprising of coordinates of CHs from which it hears these broadcasts. Each SN with coordinates *(x,y)* then calculates minimum distance as follows:

$$d((x,y), G) = \min\{ \sqrt{(x - x_i)^2 + (y - y_i)^2} \ : (xi, yi) \in G\}$$

Accordingly, the coordinates in *G* which gives minimum distance to *(x,y)* are selected and corresponding CH is chosen as cluster head for that SN. SN sends its selection result to this CH and CH enters SN's coordinates in its child list. Mobile data collector is aware about the location of the sink. The data is collected through MDC and CHs can disseminate data directly to it when MDC visits in its range. In this way, MDC completes its DGT and at last handovers the data to Base Station. Fig. 1 shown simple mobile data collection strategy in WSN

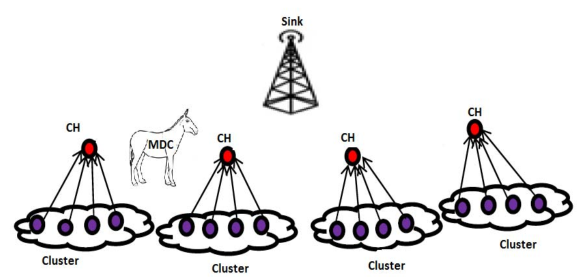

Fig. 1 Mobile Data Collection

B. Assumptions

- Flat two dimensional sensor field
- Homogeneous sensor nodes with symmetric communication
- Single sink which is overall data collector
- Single mobile data collector with richer resources than sensor nodes with locomotive capability
- Mobile data collector is aware about the location of the sink
- Static sensor nodes and know their geographical location

- Clustering is done through some energy efficient schemes such as LEACH or its improved versions
- Sink possesses information (ids and coordinates) of all CHs in the field which it gathers during initial topology setup phase

IV. Proposed Mobile Data Collector Based Data Aggregation Scheme for Wireless Sensor Networks

Proposed scheme uses cluster based wireless sensor network in which sensor nodes are arranged into clusters. One of the node is selected as a cluster head which serves as an aggregator. Cluster head aggregates the data received from its children and send to the base station through MDC after filtration. The MDC performs its job so intelligently by using NIT (Neighbor Information Table) that it only approaches those CHs which have data to send. It creates a dynamic path and needs not to go uselessly to other CHs that do not have any data. When data filtering and dynamic mobile path is used together, it results in as energy and time saver.

A. Mobile Data Collector Scheme

Initially mobile data collector (MDC) collects cluster heads (CHs) information (ids and coordinates) from the sink. MDC generates a complete path covering all CHs using Travelling Salesman Problem (TSP).Initially MDC follows TSP path to move across the entire field visiting each CH whether it has data or not and collects data from CH which has data to send. In subsequent rounds, the path travelled is dynamically pruned using information available at each CH. The information is built as follows:

Table 1 List of Notations used in the Proposed Approach

SN_{VAL}	Value of Sensor Node
SN_{Buffer}	Buffer of Sensor Node
T_{ob}	Observation Period
N_{UB}	Upper Bound for Spurious Data Filtering
N_{LB}	Lower Bound for Spurious Data filtering
β_{ASV}	± Max. and Min. variation allowed for Spurious Data Filtering
δ_{ASV}	± Max. and Min. variation allowed for Redundant Data Filtering
CH_{AVG}	New Average Calculated from Buffered Values
CH_{MEAN}	Mean of Filtering Bounds
CH_{Buffer}	Buffer of Cluster Head
H_{UBS} / H_{LBS}	Upper/Lower bound for Spurious Data Filtering
H_{UBR}/ H_{LBR}	Upper/Lower bound for Redundant Data Filtering

- Each CH sends a beacon message periodically to its neighbor having its id and informing that it has data to send
- CHs which do not have data to send during a period do not send beacon during that period
- Thus, each CH learns about its neighbors whether they have data to send or not and thus creates a neighbor information table (NIT)

Based on the information in NIT at a CH, MDC decides its further course of action as follows:

- If all neighbors of CH have data to send, follow normal next move as per TSP path calculated initially and explore its NIT to take next move
- If few of the neighbors have data to send and others not, then move towards the next CH according to TSP but to that which has data to send *i.e.* leave the CH on TSP path that does not have data
- If none of the neighbors have data to send, follow TSP to move to next CH bypassing CHs that are neighbors of current CH
- If by now MDC comes to know information about all CHs (from initial TSP stored in MDC), it calculates new partial TSP there onwards and uses it for further traversal towards sink only in present round

When MDC completes that journey, it hands over the data collected to the sink and frees its buffer and becomes ready for the next round data collection.

Before moving on next round, MDC checks with sink for any further instruction regarding creation of the fresh TSP path if any.

Sink decides to instruct the MDC to calculate the fresh TSP on following bases:

- Sink keeps on remembering the recent specific numbers of actual paths (say *P*) traversed by the MDC
- By finding the common CHs and left out CHs in subsequent traversals over *P*, sink can predict the approximate region of the event and thus divide the entire sensor field in to some smaller regions so that new modified TSP can be built with in the region where the chances of event detection are high. Sink hands this information to MDC and instructs to form new TSP

Now MDC traverses according to this new TSP and repeats the same action till observation period is over.

B. Data Filtration Approach

The proposed approach uses a filtering algorithm at a node which binds maximum permissible and minimum required variation in data readings from previously disseminated reading to make it eligible for dissemination. Filtering is Multi-way since it suppresses data reading which varies either insignificantly or beyond maximum permissible limit from previously disseminated reading. In present work, we consider lossy dissemination at CHs because aggregated values are disseminated and losseless dissemination at SNs as entire readings are disseminated. However, at CHs average of all samples in a report is calculated to set mean and bounds for data filtering. However, different deployment scenarios will use different correlation function values to set filtering bounds. Filtration is applied before transmission of sensor node readings to the base station through MDC. It can be done in two phase:

- Sensor node to CH dissemination
- CH to MDC dissemination

β_{ASV} can be set using general heuristics on historical data patterns available about the application in hand. Algorithm 1 gives detailed filtering strategy at SN. SN senses phenomenon after small interval and is determined by application requirements. If event is detected, sensed data reading is pushed into SN_{buffer}, otherwise nothing is done. If dissemination is first time, the filtering check is bypassed and CN disseminates buffered values to its CH and bound of filtering algorithm is set to SN_{VAL}.

Algorithm 1: SN Filtration

1) Set application specific value for β_{ASV}
2) *Until* Tob (observation period) is not over
3) Set $SN_{VAL = 0.0.}$
4) Sensor node senses environment.
5) *If* (event is detected)
6) Push sensed reading to $SN_{Buffer.}$
7) *If* (Dissemination is not first time)
8) *// Bounds already set*
9) If ($SN_{VAL} > N_{UB}$ || $SN_{VAL} < N_{LB}$) *// SDF Filtering*
10) Detected Event is blocked for Dissemination to CH
11) GO TO 14
12) Disseminate Data to CH
13) *// First Sensed Reading // Filtration Criteria Selected*
14) $N_{UB} = SN_{VAL} + \beta_{ASV}$, $N_{LB}=SN_{VAL} + \beta_{ASV}$
15) Clear SN_{Buffer}
16) *End Until*

Algorithm 2 is used to set filtering bound on CH. β_{ASV} is same as previous algorithm 1. At the other end, δ_{ASV} defines bounds for minimum variation required for new data to become eligible for dissemination, therefore is purely defined by application requirements. Algorithm 2 gives detailed filtering strategy at CH. CH senses phenomenon or event from all its children. If event is detected, sensed data reading is pushed into CH_{buffer}, otherwise nothing is done. CH_{buffer} is then processed to calculate the average (i.e. CH_{Avg}) of data values stored in it. If dissemination is first time, the filtering check is bypassed and CH disseminates buffered values to MDC and CH_{Mean} of the filtering is set to CH_{Avg}. In case CH_{buffer} is empty, there is no need for further processing and dissemination is immediately blocked. Contents of CH_{buffer} are immediately cleared after dissemination to MDC, so that CH readies itself for accumulating fresh data. However, CH_{Mean} and filtering bound values (i.e. β_{ASV} and δ_{ASV}) are retained. In subsequent disseminations CH_{Avg} is calculated from buffered values and undergoes through filtering checks prior to dissemination. If it qualifies filtering criteria, dissemination to MDC is allowed, otherwise dissemination is blocked. This cycle continues till the end of the observation period (*i.e.* Tob). In case, dissemination is blocked, the recipient treats previously received data as the current data from source.

V. Performance Evaluation

A. Simulation Scenarios and Metrics

We used network simulator NS-2 for validating proposed approach.

Algorithm 2: Multi-Way Data Fitration

1) Set application specific value for β_{ASV} and δ_{ASV}
2) Set $CH_{AVG} = CH_{MEAN} = 0.0$
3) *Until Tob* observation period is over
4) SN Disseminate the Data to CHs
5) *If* (CH_{Buffer} is empty) *// NO Reading*
6) Block Data Dissemination to MDC
7) *GO TO* 18
8) *else* Calculate CH_{AVG} from Readings in CH_{Buffer}
9) *If* (Dissemination is not first time)
10) *// Bounds Already Set*
11) *If* ($CH_{AVG} > H_{UBS}$) || ($CH_{AVG} < H_{LBS}$) *// SDF Filtration*
12) || (($CH_{AVG} < H_{UBR}$) &&($CH_{AVG} < H_{UBR}$)) *// RDF Filtration*
13) Block Data Dissemination to MDC
14) *GO TO* 19
15) Disseminate Data to MDC *// First time dissemination*
16) *// Filtration Criteria Set*
17) $H_{UBS} = CH_{MEAN} + \beta_{ASV}$, $H_{LBS} = CH_{MEAN} - \beta_{ASV}$, $H_{UBR} = CH_{MEAN} + \delta_{ASV}$, $H_{LBR} = CH_{MEAN} - \delta_{ASV}$
18) Clear CH_{Buffer}
19) End Until

For simulation purposes different parameters are set as per Table 2. We created different network scenarios and evaluated energy savings achieved for each scenario with respect to no filtering case and varying number of CHs. In proposed approach, two scenarios have been discussed. These scenarios depend on the type of CH selection and deployment. The scenarios are as follow:-

- Scenario 1:Random Selection
- Scenario 2:Uniform Selection

Scenario 1: A sensor field of size 1000x1000m^2, SNs is varied from 10 to 100 and CHs are varied from 2 to 12. This scenario is created to observe the effect of mobility and filtering on energy savings with varying CH and SNs density. In random selection and deployment CHs are randomly generated at any position. Each SN is connected with its corresponding CHs on the basis of minimum distance with in single hop. All SNs sense the environment and disseminate the data to CHs using data filtration before handed over this to MDC. In this way MDC only visits those CHs which have data. Snapshot Scenario 1 from network animator of simulator NS-2 is shown in Fig. 2.

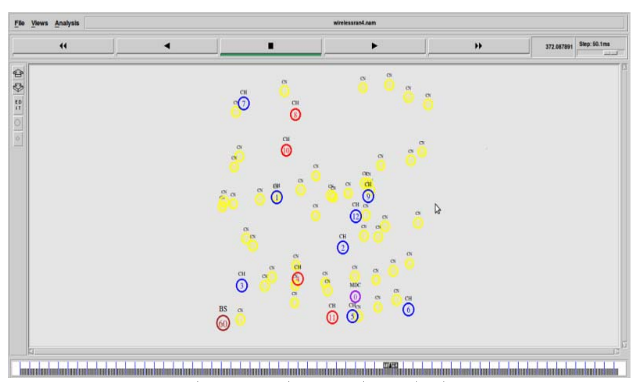

Fig. 2 Scenario 1: Random Selection

Scenario 2: In uniform selection and deployment CHs are uniformly placed at fixed position where as the number of nodes are randomly generated. Rest of the simulation parameters is same as Scenario 1. The Scenario 2 is described by snapshot in Fig. 3

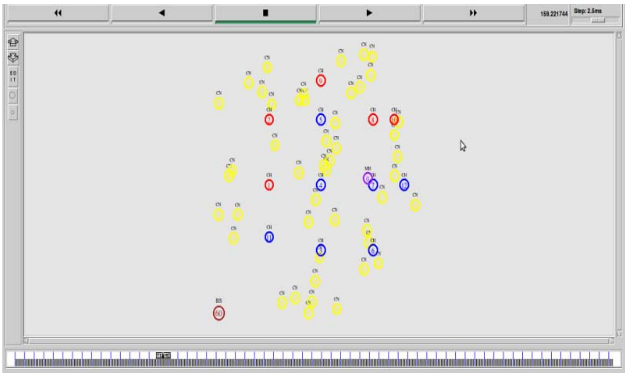

Fig. 3 Scenario 2: Uniform Selection

Rest of simulation parameters for both scenarios are shown in the Table 2.

In order to check the performance of our proposed approach we have taken five metrics:

- Overall Network Energy Consumed : It is defined as the energy which is consumed by the MDC to complete its DGT and the energy which is consumed by all nodes for transmission and reception
- Energy Consumption by MDC: It can be defined as the energy consumed by MDC to complete its Data Gathering Tour (DGT)
- Average Packet Delay: It is defined as the average time taken by the packet to reach at Base Station after its generation at CHs.
- Energy Consumption by SN and CH: It can be defined as the sum of total energy consumed by each node during transmission and each CH during reception.
- Total Time Taken: It can be defined as the overall time taken by MDC to complete its DGT in all rounds.

Table 2 Simulation Parameters

Parameters	**Values**
Antenna	Omni Antenna
Initial Energy of node	2 J (standard)
Transmission range	60 m
Channel Type	Wireless
Packet Size	512 bits
Max. Packets	500
Network Size	1000 m * 1000m
Number of nodes	10-100
Cluster	2-12
Number of MDC	1
MDCs velocity	5 m/s

B. Results

The proposed mobile data collector based data aggregation scheme has been simulated using NS-2 simulator and compared with MDC/PEQ algorithm [14]. The comparative analysis has been shown below on various performance metrics.

Fig. 4(a) and 4(b) show effect of CHs/polling points density on over all percentage energy savings achieved by entire network with varying SNs when proposed MDC strategy and data filtering is used. The overall energy of network is the sum of total energy consumed by MDC and the total energy consumed by sensor nodes, CHs for transmission and reception. When we run the simulation for different numbers of CHs for 10 rounds the overall energy consumed by proposed scheme in both the scenarios is less than the MDC/PEQ due to data filtration. In MDC/PEQ no data filtration is applied on SNs and MDC moves to each and every polling points to gather data. In our proposed approach, Multi-way data filtration is applied on CHs and SNs which eliminates number of dissemination (between SNs and CHs and further among CHs and MDC) as well as MDC moves to those CHs only which have data and does not move to other CHs.Trends clearly indicate that the energy consumed by MDC in proposed scheme in both the scenarios is less than the energy consumed by MDC/PEQ. So our proposed scheme shows an improvement in overall energy consumption over MDC/PEQ at different standard deviations. For example, when numbers of CHs are 8 then proposed scheme shows 47.82% improvement in scenario 1 and 41.74% improvement in scenario 2 in terms of overall energy consumption.

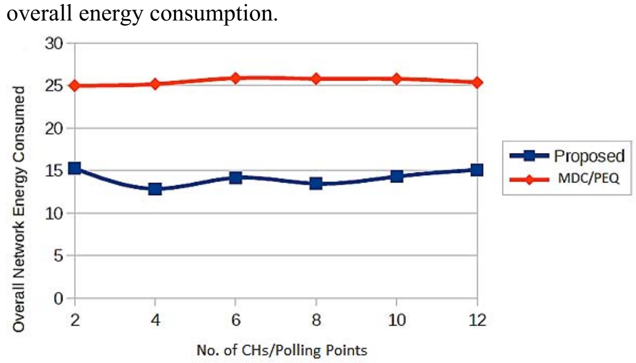

Figure 4(a) Overall Network Energy Consumption (joules) v/s No. of CHs/Polling points in Scenario 1

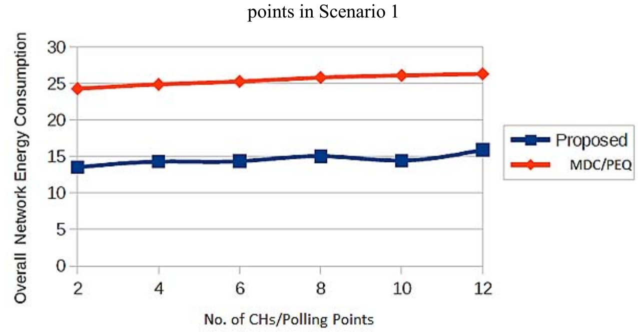

Figure 4(b) Overall Network Energy Consumption (joules) v/s No. of CHs/Polling Points in Scenario 2

Fig. 5 shows the energy consumed by MDC during DGT in proposed scheme in both the scenarios is less than the energy consumed by MDC/PEQ. This is due to the reason that when data filtration is applied on the CHs then only few of them generate data. MDC moves to those CHs only which have data and does not move to other CHs. Therefore it uses dynamic path selection which prunes the DGT length. Hence, it saves energy consumed by MDC to visit each CHs. In MDC/PEQ MDC moves to each polling point to collects data which consumes more energy for MDC movement and consistently follows the same TSP path.

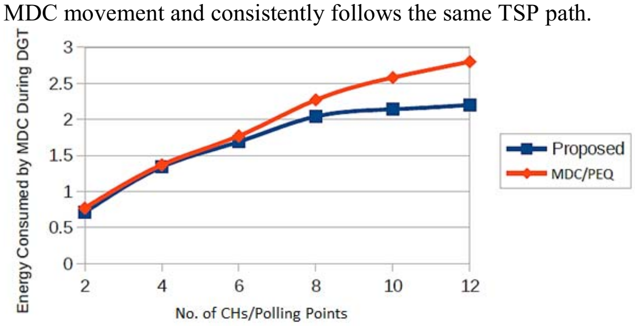

Fig. 5 Energy Consumed (joules) by MDC during DGT v/s No. of CHs/Polling Points

From Fig. 5, it is clear that, our proposed scheme performs better than MDC/PEQ in terms of energy consumption by MDC. For example, when numbers of CHs are 10 then the proposed scheme shows 17.05% improvement in terms of energy consumption by MDC over MDC/PEQ.

Fig. 6 shows the time taken by MDC to complete DGT by proposed approach is less than the MDC/PEQ due to dynamic path selection. It is the time taken by MDC to complete DGT in each round during specified CHs. In MDC/PEQ MDC have to move each and every polling points to collect data but in proposed approach MDC moves to those CHs which have data and follows dynamic path selection. The dynamic path selection prunes the DGT length which consumes less time to complete its tour. But the analysis also shows that as number of CHs/polling point's increase, the total time taken also increase in both the schemes. Trend shows that the time taken by MDC to complete DGT in our proposed approach is less than the MDC/PEQ. For example, when number of CHs are 6 than the proposed scheme has resulted in 28.02% saving of time comparatively to MDC/PEQ.

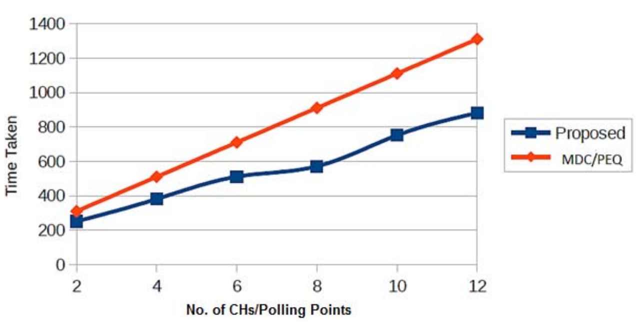

Fig. 6 Time Taken (seconds) v/s No. of CHs/Polling Points

Fig. 7(a) and 7(b) shows the average time taken by the packet to reach at destination from CHs during DGT. The analysis shows that when number of CHs/polling points increase, the average packet delay also increases. But the comparative analysis shows that the delay caused by proposed scheme is less than the MDC/PEQ due to dynamic path selection. The dynamic path selection prunes the DGT length which consumes less time to complete its tour and handovers the data to Base Station. From Fig. 7(a) and 7(b), it is clear that, the proposed scheme performs better than MDC/PEQ in terms of average packet delay. For example, when numbers of CHs are 4, it shows 25% improvement in scenario 1 and 5.88% improvement in scenario 2 in terms of average packet delay.

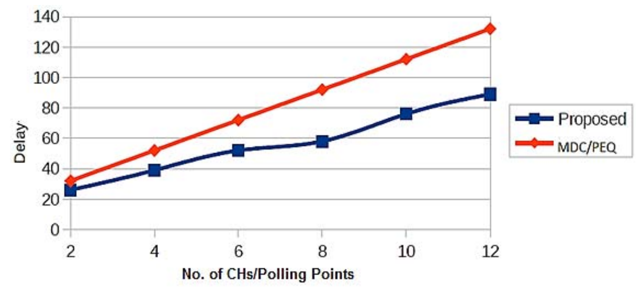

Fig. 7(a) Delay (seconds) v/s No of CHs/Polling Points in Scenario 1

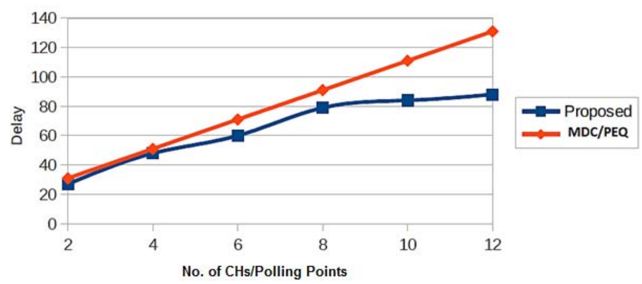

Fig. 7(b) Delay (seconds) v/s No. of CHs/Polling Points in Scenario 2

Figure 8(a) and 8(b) show the energy consumed by SNs during transmission and CHs during reception in both the scenarios. The comparative analysis for 12 CHs shows that the energy consumed by SNs and CHs in proposed scheme is less than the MDC/PEQ. In MDC/PEQ MDC itself acts as a CH for each SNs during polling process and does not apply data filtration/aggregation technique. But the proposed scheme shows deviation in the graph in different rounds due to data filtration because some of the SNs produce data and some do not. Trend shows that the proposed approach performs better than MDC/PEQ. For example, when number of rounds are 6, proposed approach shows 44.44% improvement in scenario 1 and 48.72% improvement in scenario 2 in terms of energy consumption by SNs and CHs.

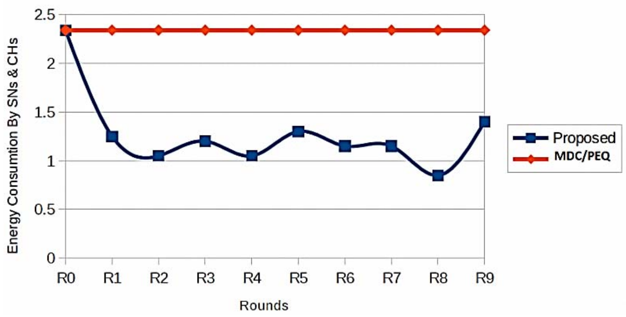

Figure 8(a) Energy Consumption (joules) by SNs and CHs v/s Rounds in Scenario 1: (i) No. of CHs/Polling Points are 12

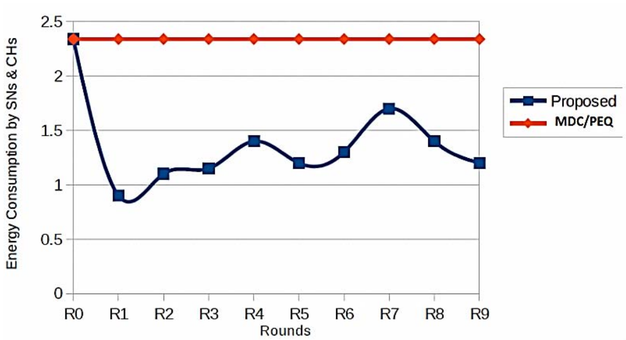

Figure 8(b) Energy Consumption (joules) by SNs & CHs v/s Rounds in Scenario 2: (i) No. of CHs/Polling Points are 12

VI. CONCLUSIONS

Data collection is a vital process and MDC is more effective in collecting data as compared to static data collector. Hence, there is a need to improve these schemes in order to make it more energy efficient and to reduce the transmission of data among MDC and base station. Our proposed approach has used the cluster based wireless sensor network in which sensor nodes are arranged into clusters. One of the node is selected as a cluster head which serves as an aggregator. Cluster head aggregates the data received from its children and send to the base station through MDC after filtration. The MDC performs its job so intelligently that it only approaches those CHs which have data to send. It creates a dynamic path and need not to go uselessly to other CHs that do not have any data.

We have evaluated the performance of our proposed approach on NS-2.29 simulator. We have considered five metrics i.e. overall network energy consumption, energy consumption by MDC, total time taken, average packet delay and energy consumption by SNs and CHs. From simulation, it is clear that our proposed scheme performs better in terms of energy consumption, time taken by MDC during DGT and average packet delay.

REFERENCES

[1] I.F. Akyildiz, W. Su, Y. Sankarasubramaniam and E. Cayirci, "A Survey on Sensor Networks," *Proceedings of IEEE Communication Magazine, Vol. 40, No. 8, pages 102-114, 2002*.

[2] G. Anastasi, M. Conti, M. D. Francesco and A. Passarella, "Energy Conservation in Wireless Sensor Networks: a Survey*," Proceedings of ELSEVIER Journal of Ad Hoc Networks, Vol. 7, No. 3, pages 537- 568, 2009.*

[3] T. C. Chen, T. S. Chen and P. W. Wu, "Data Collection in Wireless Sensor Networks Assisted by Mobile Collector," *Proceedings of 1st IEEE National Conference on Wireless Days, pages 1-5, 2008.*

[4] Y. Gu, D. Bozdag, E. Ekici, F. Ozguner and C. Lee, "Partitioning Based Mobile Element Scheduling in Wireless Sensor Networks," *Proceedings of 2nd IEEE Annual Communications Society Conference on Sensor and Ad Hoc Communications and Networks, pages 386-395, 2005.*

[5] M. Ma and Y. Yang, "Data Gathering in Wireless Sensor Networks with Mobile Collectors," *Proceedings of IEEE International Symposium on Parallel and Distributed Processing (IPDPS), pages 1-9, 2008.*

[6] D. S. Johnson, "Approximation Algorithms for Combinatorial Problems," *Proceedings of J. Computer System Sciences, Vol. 9, pages 256-278, 1974.*

[7] S. S. Skiena, "Traveling Salesman Problem*," Proceedings of SPRINGER Conference on The Algorithm Design Manual, pages 319-322, 1997.*

[8] M. Zhao and Y. Yang, "Data Gathering in Wireless Sensor Networks with Multiple Mobile Collectors and SDMA Technique Sensor Networks," *Proceedings of IEEE Wireless Communication and Networking Conference(WCNC), pages 1-6, 2010.*

[9] S. Chowdhury and C. Giri, "Data Collection Point Based Mobile Data Gathering Scheme Relay Hop Constraint," *Proceedings of IEEE International Conference on Advances in Computing, Communications and Informatics (ICACCI), pages 282-287, 2013.*

[10] M. Zhao and Y. Yang, "Bounded Relay Hop Mobile Dat Gathering in Wireless Sensor Networks," *Proceedings of IEEE Transactions on Computers, Vol. 61, No. 2, pages 265 –277, 2012.*

[11] S. Guo and Y. Yang, "A Distributed Optimal Framework for Mobile Data Gathering with Concurrent Data Uploading in Wireless Sensor Networks," *Proceedings of IEEE Conference on Computer Communications (INFOCOM), pages 1305-1313, 2012.*

[12] M. Arshad, M. Alsalem, F. A. Siddqui, N. Kamel and N. M. Saad, "Efficient Cluster Head Selection Scheme in Mobile Data Collector Based Routing Protocol," *Proceedings of 4th IEEE International Conference on Intelligence and Advance Systems(ICIAS), Vol. 1, pages 280-284, 2012.*

[13] S. Guo, C. Wang and Y. Yang, "Joint Mobile Data Gathering and Energy Provisioning in Wireless Rechargeable Sensor Networks," *Proceedings of IEEE Transactions on Parallel Computing, Vol. 1, No. 99, pages 1, 2014.*

[14] R. W. N. Pazzi and A. Boukerche, "Mobile Data Collector Strategy for Delay-Sensitive Applications over Wireless Sensor Networks," *Proceedings of ELSEVIER Computer Communications, Vol. 31, pages 1028–1039, 2008.*

[15] T. P. Sharma, R.C. Joshi and M. Mishra, "Tuning Data Reporting and Sensing for Continuous Monitoring in Wireless Sensor Networks," *Proceedings of IEEE International Conference on Performance, Computing and Communication, pages 412-417, 2008.*