Efficient Data Collection in Wireless Sensor Network

Meet J. Vasani[1], Satish Maurya[2]
[1]PP Savani University, Surat, India
meetvasani89@gmail.com

[2]PP Savani University, Surat, India
satish.maurya@ppsu.ac.in

Corresponding Author: Meet J. Vasani.
meetvasani89@gmail.com

Abstract. There has been a steady increase in climatic and man-made disasters for the past couple of years. Due to this, numerous research on Mobile Wireless Sensor Networks (MWSN's) are attained, the sensors which are mobile and can do numerous tasks such as go to places which are dense and do not have access to the physical human body; compensation in cost, flexible, and many more which the ordinary Wireless Sensor Networks (WSN's) lack. Many ideas have been used to give the best out of the MWSN's. In every ideas so far, the Mobile Sensor (MS) collects data from the sensor and return back to the station which takes time, and this delays the data which was to be returned early in order to take actions, also the capacity of the storage in MS is quite low, so a number of laps are required to collect data from all sensors. In this paper, the Models proposed can eradicate such problems by using MS as a means of connectivity, which will connect sensors and the station.

Keywords: Mobile device collector, Mobile sensor, Clustering, Mobility, Efficiency.

1 Introduction

Natural and Man-Made disasters include Bush Fires, Earthquake, Volcanic Eruption and many more which can be controlled if actions are taken at a particular time frame but the sites of occurrences of these disasters are far away from the workers who are inspecting those particular sites. It would take a lot of time to know that something wrong has taken place and by then the time frame to control the situation had already been passed. It is when the technology of Sensor Networks come in sight where the workers sitting in their offices can know what is happening at the particular site at a particular moment and can take actions immediately as something goes wrong.

Fig. 1. Workers are unaware of the things happening at site and cannot take action on time.

Everything around is getting evolved to get the best comfortability one seeks [13], and sensors are getting in demand at a rapid rate. Sensors are elements which sense the environment [6] and store that information/data to pass it to the station, so the station can act accordingly. Wireless Sensor Networks (WSN) is said to be a communication of data between Sensor nodes placed in a particular field through wireless link [4, 14]. In single-hop transmission, data is transferred through a single sensor directly to the station in a single hop. On the contrary multi-hop transmission, data is transferred through multiple sensors that are deployed in between the sensor sending the data and the station. When the sensors come in a range of each other then and then the data can be transferred [8].

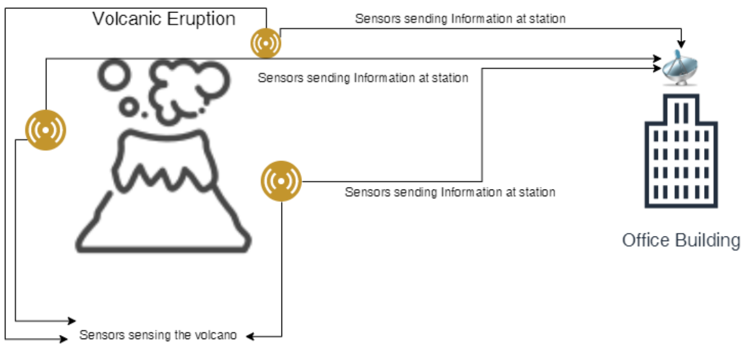

Fig. 2. Workers are aware and can take action in the particular time frame as something goes wrong.

Now to collect data from places that are out of reach, a technology called Mobility/ Mobile Wireless Sensor Networks is introduced (MWSN's). In past couple of years, there has been collaboration of robotics with the Wireless Sensor Networks which gave rise to portability [15]. In this, the sensor is able to move around in order to transfer or collect the data. When the range is too short and the distance is too long between the sensor and the station, mobility plays a vital role [7]. The sensor can be made mobile and can move towards the station until both of them are in the desired range so that the station can receive the data or vice-versa. Such different prototypes can be created based on the requirements. In single hop transmission, there can only be two possibilities (i.e. either make the sensor mobile to go the station to pass on the data or make the station move towards the sensor to collect data). In multi-hop transmission, there can be many possibilities on the passing of data to the station (i.e. various sensors can be deployed in the path of the sensor and the station which can move around to get in range and pass on the data [12] or a Cluster-based approach can be used where MS is particularly used to get data from the Cluster and come back again to the station, etc.). Multi-Hop transmissions conserve more energy than Single-Hop transmission [5]. Cluster Based Approach: Clusters are made which consists of multiple sensors and each Cluster have a Cluster Head (CH), which transmits the data further to any of the sensor in its range [3]. Instead of using multiple sensors, one can implement mobile Sensor which will move around and do all the stuff necessary. However, due to the movement of the Mobile Sensor, it will consume more power than the regular sensor [16]. Mobility can decrease the number of hops and can give better productivity by reducing the error while transmission of the data [17].

This paper gives a brief perspective on reducing the delay of data at the station as much as possible. Further, the paper is divided into the following sections, Section 2 includes the main concern of proposing our Models over the previous work; Section 3 gives a brief of the idea to be implemented about using MS as a means of connectivity to transfer data instead of using it as a transporter. Section 4 contains Flow Diagrams for every model. Section 5 includes simulation results, which shows benefits obtained by the proposed Models; Section 6 states conclusion; Section 7 covers future work of the project idea.

2 Previous Work

The very crucial elements of the MWSN's are following:

i. Simple Sensors: This sensors main task is to collect the data from the surrounding [2].
ii. Sink (Station): They acquire the data collected from simple sensors sensing the surrounding and perform particular actions [2].
iii. Support Sensors: They act as an intermediate of transferring the data. They do not sense any data, but just transfers the data from one node to the other [2].

There are only 2 ways through which mobility can be applied:

i. Mobility of Sensor: Moving the sensor to the station.
ii. Mobility of Station: Moving the station to the particular sensor to collect the data.

Now, based on the kind of way chosen, there will be different ideas that can be/ has been introduced and every single idea will get a different output. Some of them are as follows:

i. A single sensor and a single station: Either of them can be made mobile and the data can be collected accordingly.
ii. Multiple sensors and a single station: Either of a sensor can be made mobile and can be sent to other sensors for collecting data and then can be sent to the station to transfer the data.
iii. Multiple sensors and a single station used as a means of mobility: The station can be made mobile and can be sent to other sensors for collecting data directly.
iv. Multiple sensors in a Cluster and a single station: In [1, 9] multiple Clusters of sensors are made. MS starts its journey from the station through its predesigned path. One by one it covers all the Clusters coming into its predesigned path. They have an algorithm set where the MS will vary its speed depending on the situation. The MS will decrease its speed while passing through any Cluster to acquire maximum data, The MS will increase its speed when it is travelling from one Cluster to the other and finally the MS will complete its journey by coming to the station. This whole journey takes place every 24 hours. By chance if there is not enough space for the MS to take data from particular Cluster, as the MS have a small amount of space, the MS will take a second lap and will have to cover all of the predesigned path just to collect data from the particular Cluster. The MS will take as many laps to collect all the data from all the Clusters. They have specified that their MS has 2 bytes of storage capacity and every 24 hours 34176 packets are generated with all the sensors sensing the environment, with each packet of 75 bytes Below Fig. 3. Is the representation of [1], they have used this same figure to illustrate their model.

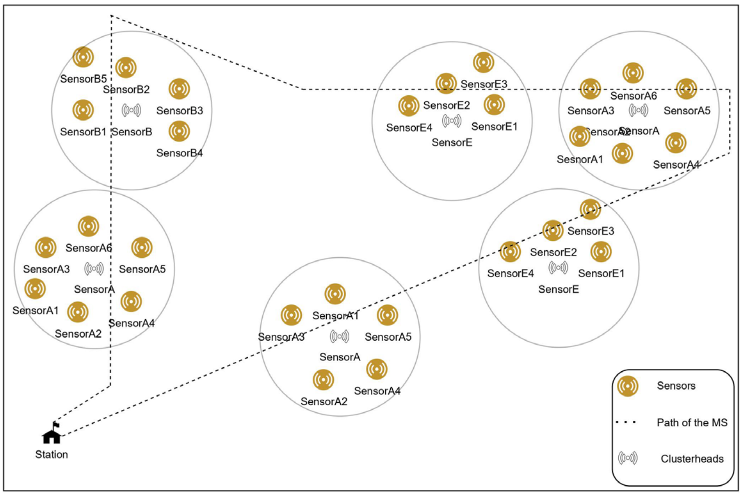

Fig. 3. Representation of [1], the complete predesigned path of the Mobile Sensor (MS).

v. In [2] they used the word Speed Control for the above given idea in Fig. 3.

vi. In [10], they are using the same idea of gathering the data through controlling the speed, but instead of using a simple MS to collect the data from all the Clusters, they have used a sink node to collect and store the data.

vii. In [11], multiple sink nodes are deployed to communicate and send the data from Clusters through a mobile sink node.

Now, we can see in all of the above ideas that MS is always used as a means of transporting the data from one place to another, the transportation between the sensors and the station delays the time of data to reach the station. Also, the capacity of MS is small, which makes it to take laps forcefully. Also in [1], if a single Cluster wants to send data still MS will have to travel the whole predesigned path which can cause more power consumption.

To overcome these problems stated above we have designed two models which can eliminate the factors of taking multiple laps and reduce the delay of data at station.

3 Proposed Models

3.1 Model A

For Model A, we designed an idea which mainly focused on reduction of the path for MS. In [1], they have set a pre-designed path which is to be travelled by MS every time a Cluster wants to send the data. Even if a single Cluster has to send the data, then also MS has to travel an excess path to reach that particular Cluster. This causes excess path to travel. To overcome this issue, we made a single Mega Cluster consisting of 3 to 4 Mini Clusters, such that the Clusters will send the data to the Mega Cluster and from that Mega Cluster MS can fetch the data and go back to the desired station.

In Fig. 4, the single Mega Cluster with one Cluster Head Sensor C which consists of all the 4 Mini Cluster (i.e. Cluster with Cluster Head A, Cluster with Cluster Head B, Cluster with Cluster Head E, and Cluster with Cluster Head F). Sensors sensing the environment are (Sensor A1, A2, B1, B2, E1, E2, F1, and F2), station is the sink. All the Mini Cluster Head (i.e. Cluster with Cluster Head A, Cluster with Cluster Head B, Cluster with Cluster Head E, and Cluster with Cluster Head F) are support sensors, which will not store any data, it will just act as a passer of information/data. If any of the Mini Clusters have any data, they will share directly to the Mega Cluster with one Cluster Head Sensor C and from that sensor C, MS can fetch the data and go back to the station. Here MS works both as a sink and sender. It will act as a storage when getting data from the single Mega Cluster with one Cluster Head Sensor C and a sender when giving data to the Station.

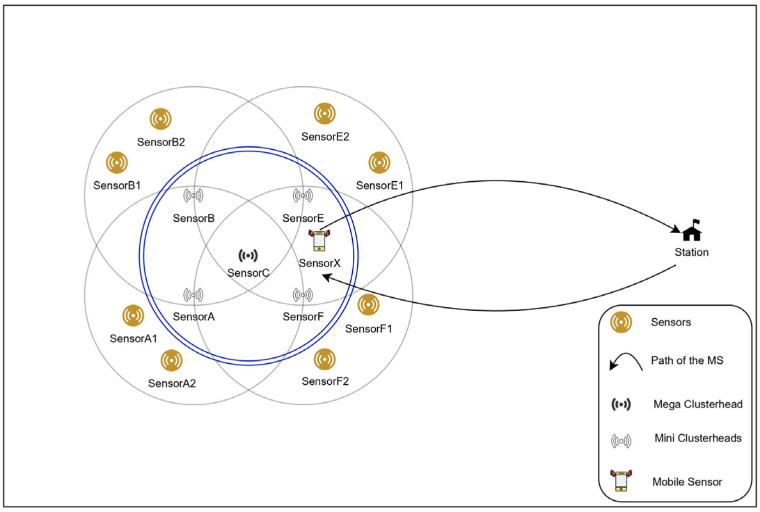

Fig. 4. Representation of Model A on how the Mobile Sensor (MS) will collect data from the Mega Cluster.

Now, Suppose a single Mini Cluster with Cluster Head A wants to send the data out of all the 4 Mini Clusters, it will send the data to Mega Cluster with Cluster Head Sensor C, then MS can go to Mega Cluster directly to fetch the data, instead of going to all the Mini Clusters and return back to the station as of in [1]. So, we have made Cluster of Clusters in order to remove the excess path even if a single Mini Cluster wants to send the data. We have eliminated the problem of the excess path covered, but still there will be a delay of data at the station as MS has to travel all the way back to the station to dump the data and as MS still has a small memory, indirectly, it will take a number of laps to collect all the data from all the sensors. To deal with these, Model B can be considered.

3.2 Model B

We have used the same concept from the above Model A, but instead of making MS travel all the way to the Mega Cluster and back to the station, we deployed some more sensors in the way between the station and the Mega Cluster and a gap was left in between, whenever the Mega Cluster wants to send the data, MS will come and fill that gap and will pass whatever data any of the Clusters have to pass. In Fig. 5, single Mega Cluster with one Cluster Head Sensor C which consists of all the 4 Mini Cluster (i.e. Cluster with Cluster Head A, Cluster with Cluster Head B, Cluster with Cluster Head E, and Cluster with Cluster Head F), Sensor P and Sensor Q are support sensors which will transfer data to the Station. Sensors sensing the environment are (Sensor A1, A2, B1, B2, E1, E2, F1, and F2), station is the sink.

Now, here we have kept a gap between sensor Q and Mega Cluster with Cluster Head Sensor C, we made MS (sensor X) go and fill that gap so that Mega Cluster with Cluster Head Sensor C can transfer all the data directly to the Station. Here MS works as a support sensor, it will just pass the information, instead of storing.

Here we are using MS as a connector instead of a transporter, this way we will able to reduce the number of laps. Furthermore, the storage issue will also be fixed as MS will only work as a passer of information instead of storing it. There will be no delay in data as there is minor to no transportation done in the process. A Cluster wants to send the data, MS will fill the gap and the data can be fetched directly by the station. Also, the network is made static, and so is the path of where to get connected for MS is also pre designed and for a particular time period, the Station will be getting data from a single Mega Cluster to which MS has connected to, after finishing of all the data the particular Mega Cluster wants to send, then MS will go to another Mega Cluster to collect data. So, there will be collision between Mini Clusters when sending the data and that can be controlled by applying different networking protocols, but there would be no chance of getting collision between Mega Clusters.

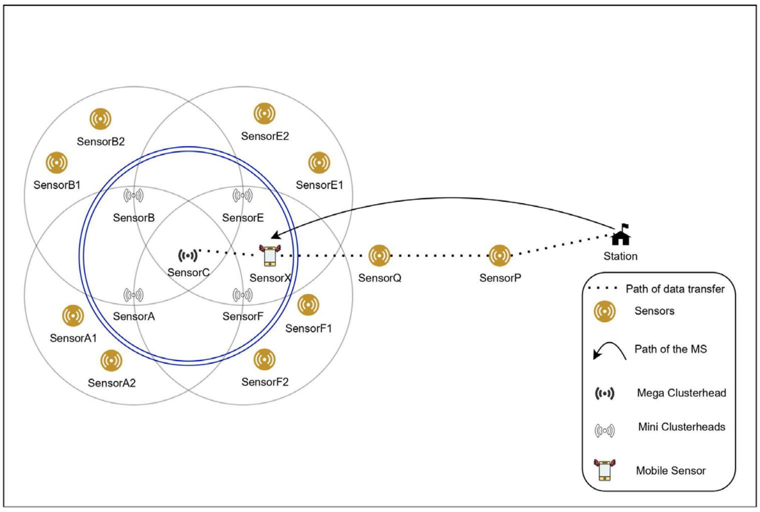

Fig. 5. Representation of Model B on how MS will collect data from the Mega Cluster.

We could have used a sensor instead of using MS to fill the gap, but let's say if we have multiple Mega Clusters with Cluster Head (C1, C2, ... , C_n), then we can use a single MS to fill gaps between multiple Mega Clusters and station, also the sensors which are deployed in between the station and the Mega Cluster can be used by different Mega Clusters (C2, C3, ... C_n) as well if they are in range, this will also reduce the number of sensors used for making the path.

In Fig. 6, MS goes to Mega Cluster with Cluster Head (C1), connects and transfers the data to the station, then goes to Mega Cluster with Cluster Head (C2), connects and transfers the data to the station, then goes to Mega Cluster with Cluster Head (C3), connects and transfers the data to the station. Here, in the Mega Cluster with Cluster Head (C3), we used the same deployed sensors of the Mega Cluster with Cluster Head (C2) and transfer the data, no additional sensors are used. This way the number of sensors can be reduced for cost conservation.

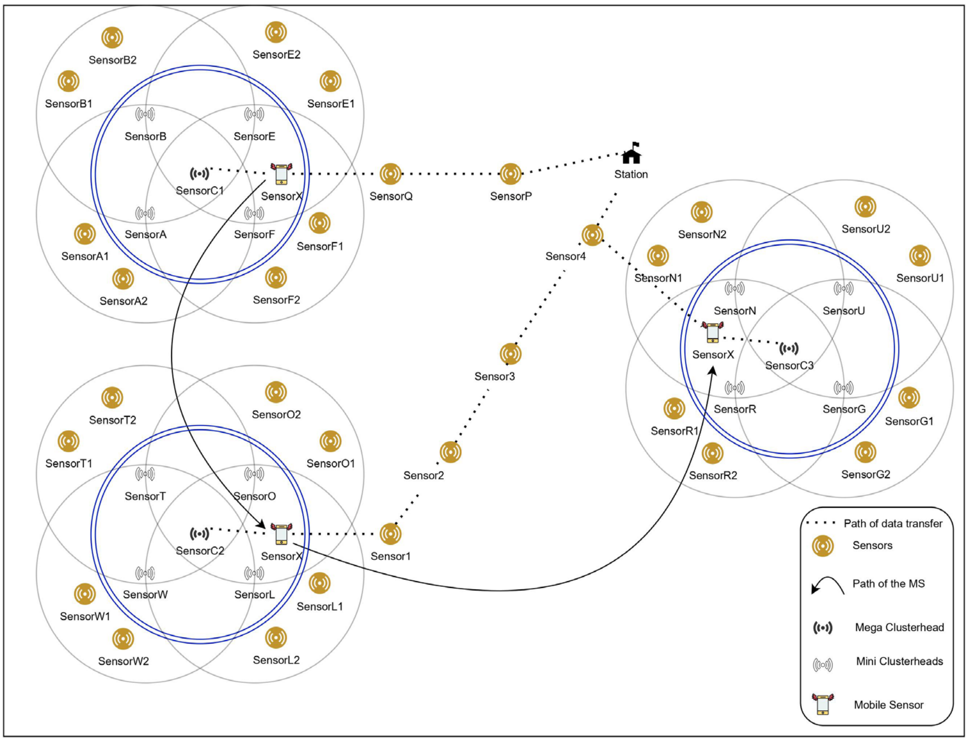

Fig. 6. Representation of Model B on how MS will collect data from the multiple Mega Cluster.

4 Flow Diagrams

In [1], the MS starts from the station and as it has its predesigned path set, it will travel from one Cluster to the other. Also, the MS has a capability of varying its speed, when MS is inside the range of Cluster, it will reduce its speed for maximum collection of data and while travelling from one Cluster to the other it will maximize /increase its speed. This process takes place every 24 hours. Also, the MS takes multiple laps to collect all the data as MS has small memory. The Flow Diagram of [1] is given below Fig. 7.

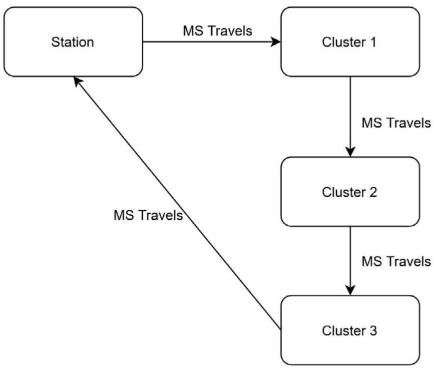

Fig. 7. Flow diagram of how [1] will use its MS to collect data.

In Model A, we have a Mega Cluster which consists of multiple Clusters named Mini Clusters, these Mini Clusters consists of sensors which sense the environment and send data to their respective Mini Cluster. This Mini Clusters will send data to the Mega Cluster. Now, in order to collect data from the Mega Cluster, MS will travel from station to the Mega Cluster, will collect the data from the Mega Cluster and will return back. The main purpose of this Model was to reduce the path which MS has to travel in [1] if a single Cluster have any data. Here all the Mini Cluster will transfer data to the Mega Cluster itself. So, no excess path will be covered, but still the number of laps will be taken by MS to collect all the data as it has a small memory. Flow Diagram of Model A is given below Fig. 8.

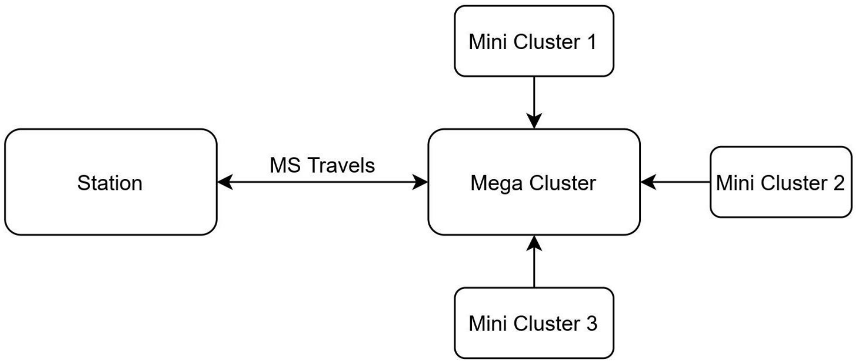

Fig. 8. Flow Diagram of how Model A will use MS to collect data.

In Model B, we have a Mega Cluster which consists of multiple Clusters named Mini Clusters, these Mini Clusters consists of sensors which sense the environment and send data to their respective Mini Cluster. This Mini Clusters will send data to the Mega Cluster. Now, the main difference between Model A and Model B, is that we have made a path between Mega Cluster and station consisting of regular support sensors and have kept a gap between them in order to connect the MS at the gap to transfer data directly to the station. The MS will travel from the station and will connect at the gap, acting as a support sensor instead of storage. By this, the transportation is eliminated and all the data will be collected in one go with elimination of multiple number of laps taken by the MS. Flow Diagram of Model B is given below Fig. 9.

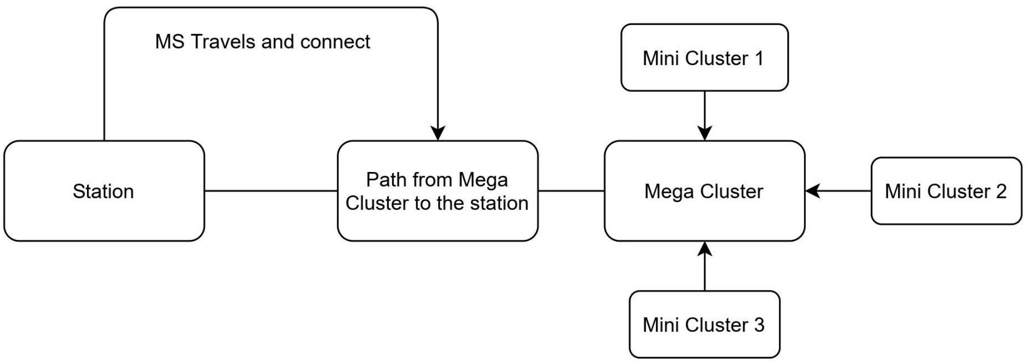

Fig. 9. Flow Diagram of how Model B will use MS to collect data.

5 Result Evaluation

(NOTE – All the evaluations were done on the OMNET++ Simulator. All the sensors including MS, use a radio model 802.15.4.). Below given data is obtained by implementing both the models in the OMNET++ Simulator. All the data and figures given below were fully derived from the OMNET++ simulator and no theoretical assumptions were used.

We will compare the above Model A and Model B to find out which one results out the maximum efficiency.

Table 1 states the comparison between the numbers of Packets collected per second by the MS in both the models.

Table 2 states the comparison between the numbers of Laps taken by both the models in order to gather particular data.

Table 3 states the comparison between the total numbers of time it takes to get the data to the station for both the models.

5.1 Packets Collected Per Second

As per the speed of MS, there is a variation in the number of packets collected. The below graph Fig. 10, shows the comparison of packets collected in Model A and Model B whilst changing the speed of MS. In Model A, linear mobility was applied to MS for back and forth movement from the station whereas in Model B, circular mobility was applied as it has to stay connected at one place until all the data gets connected. We can see from the below Table 1, that packets collected per second is higher in Model B than in Model A.

Table 1. Difference of data collection with respect to the MDC speed in both Model A and Model B.

MS Speed	Packets collected per second in (Model A)	Packets collected per second in (Model B)
0.5ms	131	236
1ms	131	223
1.5ms	131	221
2ms	131	229
2.5ms	131	229
3ms	131	230
3.5ms	131	230
4ms	131	221
5ms	131	221
6ms	131	221
7ms	131	221
8ms	131	221
9ms	131	221
10ms	132	221
50ms	136	230
60ms	114	229
100ms	74	233

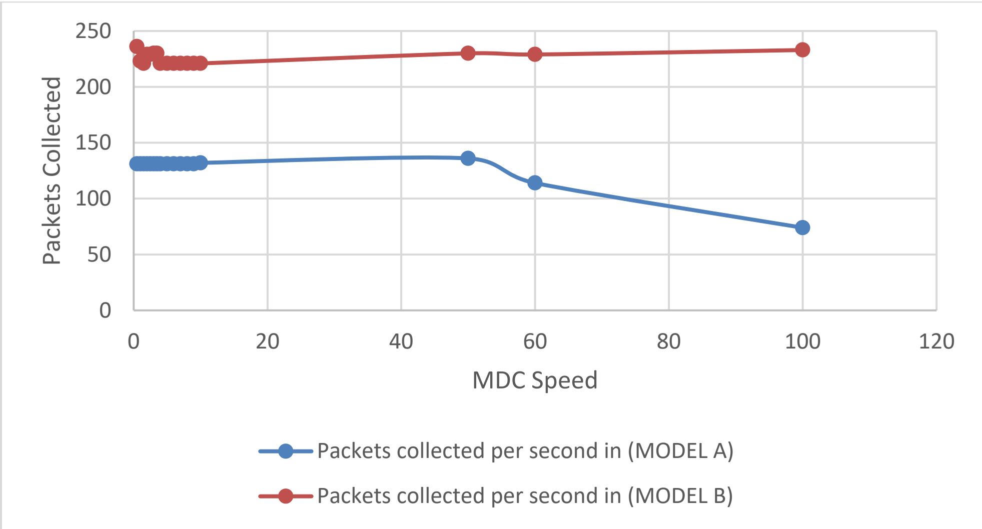

Fig. 10. Packets collected in Model A vs. Model B.

5.2 Number of Laps taken by the MS

In Model A, MS has to travel all the way to the Mega Cluster and back to the station in order to provide data to the station. Also MS has a low capacity of storing the data, so it has to take a number of laps to collect all the data from the particular Mega Cluster. On the other hand, in Model B, MS just has to go and connect in the path in order to transfer the data to the station. MS will not store any data so it will take as many as 1 lap to collect all the data from the particular Mega Cluster. In the below Fig. 11, we can see that in Model A, MS takes 8 rounds in order to collect 27757 packets, on the other hand in Model B, MS takes only one round to collect 27757 packets. So, Model A is taking 8 rounds to collect 27757 packets because the MS has a small capacity, so it will not be able to collect all the data from the Clusters in one go, it will have to take multiple laps to collect all the data, on the other hand in Model B it is taking only 1 round to collect 27757 packets as we have used the MS as a means of communicator and not transporter of data so it will just connect and pass the data directly to the station.

Table 2. Number of Mobile Sensor (MS) rounds taken to collect the particular amount of packets.

MS Rounds	Packets collected in (Model A)	Packets collected in (Model B)
1	1167	27757
2	4132	30722
3	7097	33687
4	11229	36652
5	15361	39617
6	19493	42582
7	23625	45547
8	27757	48512

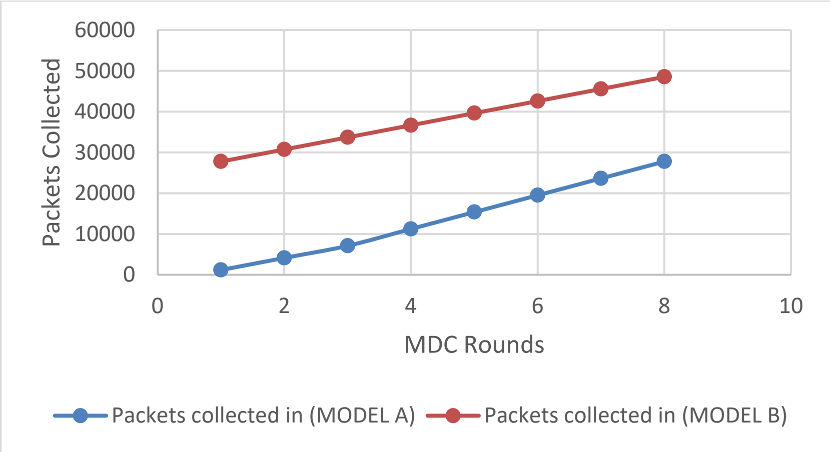

Fig. 11. Number of rounds taken by Model A vs. Model B.

5.3 Time taken to collect the Packets

In Model A, as MS has to travel from station to the particular Mega Cluster and from that particular Mega Cluster to the station again. Due to the travelling of MS to the sensor, it will make a delay and the data will reach late at the station. On the other hand in Model B, the data will be directly transferred to the station and there will be no delay of data at station. In the Fig. 12 given below, we can see that Model A has not collected any data at 0 seconds and at 100 seconds it has collected 1167 packets, on the other hand we can see that Model B collects 1167 packets in 0 seconds and at 100 seconds it has collected 7 times more packets than Model A. As Model A will travel from Cluster to the station which will delay the data to be reached at the station and it will deliver 1167 packets at 100th second to the station on the other hand Model B will deliver 1167 packets at the 5th second to the station because we have eliminated the transportation process in order to reduce the delay of data.

Table 3. Time taken to collect particular amount of packets in Model A and Model B.

Time	Packets collected in (Model A)	Packets collected in (Model B)
5s	0	1167
18s	0	4132
100s	1167	7097
150s	0	11229
200s	0	15361
285s	4132	19493

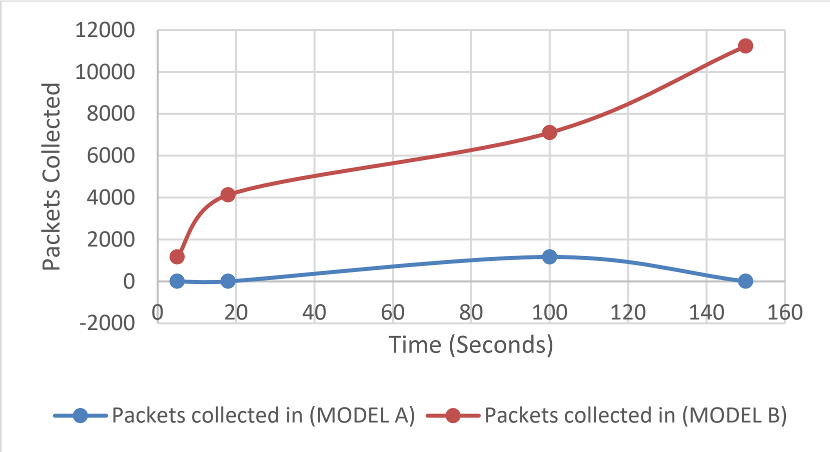

Fig. 12. Time taken to collect particular amount of packets in Model A vs. Model B.

6 Conclusion

We can see from the above results that the number of packets collected in Model A is less than the packets collected in Model B. If we keep MS intact at one place, instead of making it travel from station to the particular Mega Cluster, we can see from the above results that the number of laps for collecting all the data is less in Model B than in Model A. As in Model A, MS stores the data, and at any instance the storage might get full and it will have to forcefully go back to the station to dump the data and clear its storage and again go back to the particular Mega Cluster to collect the remaining data. In Model B, MS is used only to transfer the data by completing the incomplete path instead of storing the data, which on the other hand will reduce the number of laps to be taken by MS. In Model A as MS will have to travel all the way to the station in order to transfer the data to the station which it has collected from the particular Mega Cluster, due to this transportation there will be a delay of data to reach the station. On the other hand in Model B, when we kept our MS intact, then the packets will directly reach the station without any delay.

7 Future Scope

The above Model A and Model B can be implemented both in small whereas in the large sensor networks. Modifications can be done on the final proposed solution by using power conservation techniques and to reduce the delay of data at the station even more, so that the actions can be taken soon from the particular station. There should be some modifications on how to reduce the number of sensors used in making the pre designed path between the Mega Clusters and station.

REFERENCES

1. Sayyed A., deAraujo, G.M. and Becker, L.B., **(2016)**. *Smart data collection in large scale sparse WSNs*. 9th IFIP Wireless and Mobile Networking Conference, July. pp. 1-8.

2. Di Francesco, M., Das, S.K. and Anastasi, G., **(2011)**. *Data collection in wireless sensor networks with mobile elements: A survey*. ACM Transactions on Sensor Networks (TOSN), 8(1), pp.1-31.

3. Dhand, G. and Tyagi, S.S., **(2016)**. *Data aggregation techniques in WSN: Survey*. Procedia Computer Science, 92, pp.378-384.

4. Rawat, P., Singh, K.D., Chaouchi, H. and Bonnin, J.M., **(2014)**. *Wireless sensor networks: a survey on recent developments and potential synergies*. The Journal of supercomputing, 68(1), pp.1-48.

5. Al-Karaki, J.N. and Kamal, A.E., **(2004)**. *Routing techniques in wireless sensor networks: a survey*. IEEE wireless communications, 11(6), pp.6-28.

6. Amundson, I. and Koutsoukos, X.D., **(2009)**, September. *A survey on localization for mobile wireless sensor networks*. In International Workshop on Mobile Entity Localization and Tracking in GPS-less Environments (pp. 235-254). Springer, Berlin, Heidelberg.

7. D. Culler, D. Estrin, and M. Srivastava., **(2004)**, *Guest editors introduction: Overview of sensor networks*, Computer, vol. 37, no. 8, pp.4149.

8. Abdul-Salaam, G., Abdullah, A.H., Anisi, M.H., Gani, A. and Alelaiwi, A., **(2016)**. *A comparative analysis of energy conservation approaches in hybrid wireless sensor networks data collection protocols*. Telecommunication Systems, 61(1), pp.159-179.

9. Sayyed, A. and Becker, L.B., **(2015)**, December. *Optimizing speed of mobile data collector in wireless sensor network*. In 2015 International Conference on Emerging Technologies (ICET) (pp. 1-6). IEEE.

10. Kumar, N. and Dash, D., **(2017)**, December. *Maximum data gathering through speed control of path-constrained mobile sink in WSN*. In 2017 7th International Symposium on Embedded Computing and System Design (ISED) (pp. 1-4). IEEE.

11. Konstantopoulos, C., Vathis, N., Pantziou, G. and Gavalas, D., **(2015)**, October. *Efficient delay-constrained data collection in wireless sensor networks using mobile sinks*. In 2015 8th IFIP Wireless and Mobile Networking Conference (WMNC) (pp. 1-8). IEEE.

12. Gandham, S.R., Dawande, M., Prakash, R. and Venkatesan, S., **(2003)**, December. *Energy efficient schemes for wireless sensor networks with multiple mobile base stations*. In GLOBECOM'03. IEEE Global Telecommunications Conference (IEEE Cat. No. 03CH37489) (Vol. 1, pp. 377-381). IEEE.

13. Dantu, K., Rahimi, M., Shah, H., Babel, S., Dhariwal, A. and Sukhatme, G.S., **(2005)**, April. *Robomote: enabling mobility in sensor networks*. In IPSN 2005. Fourth International Symposium on Information Processing in Sensor Networks, 2005. (pp. 404-409).IEEE.

14. Anastasi, G., Conti, M. and Di Francesco, M., **(2009)**. *Reliable and energy-efficient data collection in sparse sensor networks with mobile elements*. Performance Evaluation, 66(12), pp.791-810.

15. Guangming Song, Yaoxin Zhou, Fei Ding and Aiguo Song, **(2008).** *A Mobile Sensor Network System for Monitoring of Unfriendly Environments.* Sensors, 8(11), pp.7259-7274.

16. Shuangjuan Li, Hong Shen, Qiong Huang and Longkun Guo, **(2019)**. *Optimizing the Sensor Movement for Barrier Coverage in a Sink-Based Deployed Mobile Sensor Network*. IEEE,

pp.2169-3536

17. Chunsheng Zhu, Lei Shu, Takahiro Hara, Lei Wang, Shojiro Nishio, **(2010).** *Research Issues on Mobile Sensor Networks*. Research Gate.