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Energy Efficient Data Dissemination in WSN with Mobile Sink

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Abstract — With the advancements in the MEMS technology, wireless communication, there has been a growing need for the development of techniques and design methodologies that result in the efficient communication. In WSN the sensor nodes are typically energy constrained and most of the energy expenditure is attributed to communication and the nodes that are closer to the mobile sink, generally get depleted of their energy, resulting in the dead nodes and hence the network connectivity is affected causing the throughput to be reduced. We discuss in this paper a network infrastructure, based on the mobility of the sink, building an unequal cluster structure along with data dissemination nodes introduced. The proposed protocol aims at enhancing the efficient energy consumption and prolonging the network lifetime of the WSN. The simulation results confirm the effectiveness of our proposed approach against as well as its performance gain over alternative methods.

Keywords— Wireless sensor networks, Mobile sink, Source Node, Dissemination Node, Data dissemination unequal cluster structure, energy efficiency, network lifetime.

I. INTRODUCTION

Energy has always been a key concern in the wireless sensor network design, as once the sensor nodes that have been deployed the sensing field, where human intervention is not possible, it became impossible to recharge or replace those batteries. The major cause for the consumption of energy in WSN has been the communication phase, where sensory nodes send their data to the base station. During the communication phase, the nodes which are closer to the base station or the sink, consume the batteries much faster then the nodes that are far away from the base station and hence resulting in the depletion of energy non-uniformly in the network [1], which causes disconnected network as the nodes which are exhausted in energy, are considered dead.

In order to enhance the network lifetime of the WSN, the energy consumed in the communication of the data has to be saved. The energy expenditure of the source nodes which are static can be reduced by introducing the concept of mobility of the sink. Because if the sink is mobile , the static source nodes will not be requiring long-hop relaying and hence less energy will be consumed as the source nodes will be requiring single-hop or limited hop transfers, in relaying the data to the MS, when it comes in radio range of SNs, hence conserving energy and prolonging the network lifetime. Another benefit of using a mobile sink is that it can deal with the disconnected network, as the mobile sink can collect data from the disconnected elements of the network also. Further the mobility of the mobile sink can be used with other network functionalities such as energy replenishment [6], [7], coverage repair [8] [9], localization [10].

But the major issue with the mobile sink performance is the increased latency in collecting the data and this design constraint is related to the low speed of the mobile sink. In order to overcome this design issues the concept of unequal clustering has been introduced in WSN, where the SNs are clustered into small groups and a head is selected among all the SNs in each cluster. These CHs are responsible for the data aggregation and communication with the base station. The basic idea behind the introduction of unequal cluster structure is that the clusters which are close to the MS are small in size, as the CHs of these clusters consume more energy, as compared to clusters which are far away from the MS and hence are large in size. The CHs which are close to the MS are overburdened with the task of data collection, filtering and data relaying and hence they get depleted of their energy sooner, resulting in 'energy-hole' problem.

To overcome this problem of energy-depleted CHs, the concept of Rendezvous Based data collection has been used [2008]. Here a subset of static nodes is used which are called Rendezvous Points (RPs), these nodes are very close to the mobile sink. Their role is to collect the data from the CHs, hence reliving the nearby CHs of the overload of data collection and data relaying, resulting in the conservation of energy and hence the lifetime elongation of the nodes. The MS can periodically visit these RPs and can collect the data from them. The criterion for the selection of these RPs is very important. The no. of RPs should be neither too small nor too large, should be equivalent to the deployment density of the source nodes [1].

Now it is seen that during intra-cluster communication, the appointed CH is responsible for all the data collection from all the member nodes and relaying that data to the MS. But during inter-cluster communication the clusters which are larger in size and far-away from the MS have to communicate through the CHs of small size and hence the CHs of small clusters that are closer to the MS get overloaded and consume energy much faster then CHs of larger clusters, hence in order to relive these CHs from the extra load coming from the other clusters, we introduced the concept of data dissemination, where dissemination nodes (DNs) are selected and these DNs are forward the aggregated data to the RNs which then communicate with the MS. The simulation results show that the proposed algorithm outperforms the previous algorithms. The rest of the paper is organized as follows, section-2 reviews related work, section-3 introduction to the D-Mobilcluster protocol, section-4 represents the simulation results and section-5 concludes the paper.

II. RELATED WORK

The recent works have exploited a no of approaches for data collection using mobile sink [1]. Accordingly the data collection can be accomplished by either collection of data from SNs, by visiting each and every SNs by the MS [11] [12] [13] [14] [15] [16] or the MS follows a fixed track and the data is send by the SNs to the MS whenever the MS is in their range [17] [18] [19]. In both the approaches there are some pros and cons, in first approach energy consumption is less but the delay is large and in the second approach delay is less, but energy consumption is fast , also there is an extra overload of maintaining a location update table to know the exact position of the MS in the field. In order to overcome these limitations we need to introduce the concept of Rendezvous-Points (RPs), these nodes lie in between the SNs and MS. These RPs are responsible for the data collection from SNs and sending them to MS. In this regard the work proposed by [3] and [2] are rendezvous based solutions which assume the mobility of the sink.

In [3] Somasundara uses MS that is used to collect data from a group of SNs. In this all the SNs that lie within the range of MS are selected as RNs and these RNs are used to collect data from SNs and buffer them and then relaying it to the MS, when it comes in range of RNs. But the problem is that there is no fixed strategy for the selection of RNs and the RNs which are selected are associated with uneven no of SNs.

In [2], Xing proposed a rendezvous-based solution for variable & fixed MS trajectories. The algorithm assumes full aggregation, which is practically not possible, there RPs are used for data collection and relaying. Hence in this algorithm the knowledge of network topology is a must. The path that is built to transfer data from SNs to MS through RPs is fixed & this path is used as such without any chances throughout the lifetime of the WSN.

In the above algorithm [2] [3], there is no proper criterion for the selection of RNs. Also, there is no knowledge about the contact time the RNs would be with the MS and how much data the RNs can receive from the SNs. Hence this results in buffer overflow and hence very long delivery delays, also there is no other provision given if in case the appointed RNs run out of energy. So, to deal with all these issues Konstantopoulos [1] proposed Mobilcluster protocol which deal with all the above issues and aims at enhancing the network lifetime and minimizing the energy consumption and overall network overhead. This is done by building an unequal cluster structure, in which clusters of unequal sizes are build and among the clusters CHs are selected which perform all the data filtering and forwarding the data to the appointed RNs. but here also, since the clusters are unequal in size depending on their distance, the CHs which are close to the RNs get overburdened with the load of performing data collection, data filtering and relaying the data along with the data coming from the previous clusters to the RNs.

So, in order to overcome these limitations we have proposed a protocol called D-Mobicluster, This proposed protocol aims at minimizing the overall energy consumption and hence ensuring balanced energy consumption among the SNs and prolonging the network lifetime. These objectives are achieved by introducing the concept of data dissemination nodes used during inter-cluster communication.

III. D-MOBICLUSTER PROPOSED PROTOCOL

In the proposed protocol the mobile sink is placed on some public transportation say a bus, which follows a fixed route and follows a fixed route and follows that path on a periodic schedule i e. after fixed interval of time. The assumption that are made for the proposed D-Mobicluster protocol are;

- The sensor nodes are deployed in urban areas in proximity to public transportation vehicle routes.
- These sensor nodes have a fixed level of transmission power.
- These sensor nodes are not position aware.
- A unit disk model is assumed for the sensor network model.

The operation of the proposed D-Mobicluster has been divided into the following two phases;

- Setup phase
- Data transmission phase

The setup phase further consists of three sub-phases:

- Clustering
- Selection of RNs
- Selection of DNs

The data transmission phase consists of the following sub-phases:

- Data aggregation and data forwarding
- Communication between RNs and MS

Phase 1: CLUSTERING

Clustering is used to organize the network in such a way, so as to balance the load among the nodes and hence enhance the network lifetime, it also helps in reducing the channel contention and the collision of data packets which results in improved network throughput. Here we have used the idea of unequal clustering structure [20]. In this the cluster sizes are different depending on their distance from the MS. The clusters which are close to MS are small in size while the clusters which are far-away from the MS are large in size. In this algorithm we firstly need to find the cluster centres of all the clusters from the MS and the SNs which are having the same probability are selected as tentative CHs, the final CHs selection is done based on weighted sum method where w1 and w2 are the weights of the distance of the SNs from the MS and the battery of the SNs respectively. The tentative CHs with the highest values are selected as final CHs of the clusters.

Phase 2: SELECTION OF RNs

The selection of RNs is very important as it is related to the network lifetime. The SNs which are in direct communication with the MS are selected as the tentative RNs based on the competence value which considers the residual energy of SNs , the distance of the SNs from MS and the no of beacon message packets received. The SN with the highest competence values are selected as tentative RNs and the tentative RNs which have a distance zero from all other CHs are the elected RNs which are used from buffering the data coming from the CHs and relaying that data to the MS.

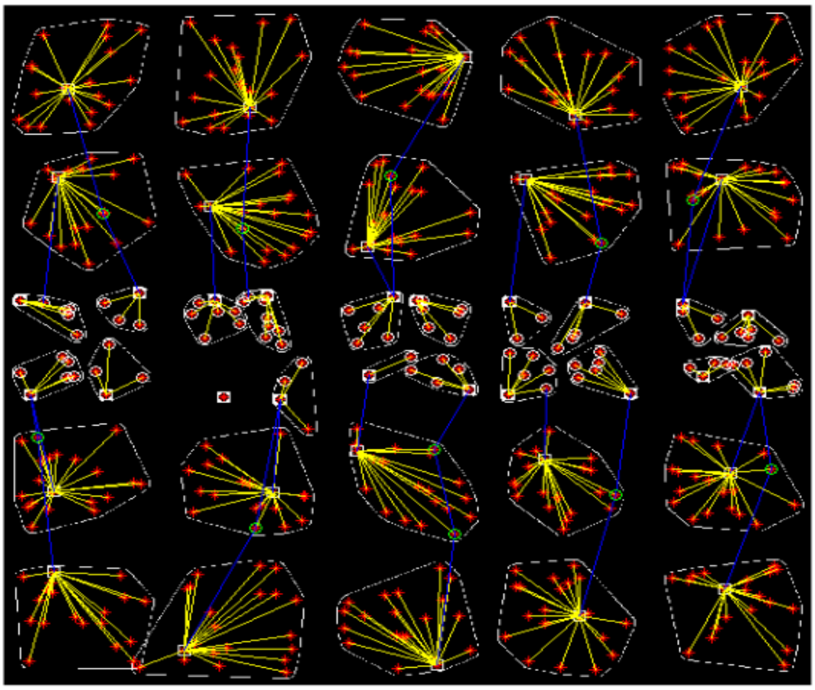

Fig. 1 The fig. showing Inter-cluster and Intra-cluster communication

Phase 3: SELECTION OF DNs

The dissemination node are those nodes which are used in between the CHs and the RNs for inter-cluster communication, in order to reduce the load of the CHs of the clusters which are close to the MS. The DNs can be a general SN or it can be CHs.

Phase 4: DATA COLLECTION AND DATA FORWARDING

The data transmission phase of D-Mobicluster starts with the data collection done by the sensor nodes. The data that is sensed by each SN is then sent to their respective CHs (intra-cluster communication). In fig. 1 the intra cluster communication between cluster members SNs and their respective CH is shown by 'yellow' lines. The CHs perform data aggregation, data filtering and removes the redundancy in the data and sends that data to the DNs attached with these CHs (inter-cluster communication) which is shown by 'blue' line. The DNs then send the data to the RNs.

Phase 5: COMMUNICATION BETWEEN RNs AND MS

The last phase Of D-Mobicluster protocol involves the delivery of data that is buffered at RNs to MS, whenever the MS comes in range with the RNs.

IV. SIMULATION RESULTS

The simulation results of the D-Mobicluster shows that the proposed protocol out-performs the other three protocols in terms of average residua energy and the network lifetime.

Average Residual Energy: The D-Mobicluster achieves reduced average residual energy consumption as compared to the other three protocols. This is been made possible through the use of unequal clustering structure and the introduction of Dissemination node (DNs) for inter-cluster communication between different clusters hence resulting in efficient energy consumption and balance in terms of energy consumption among the nodes.

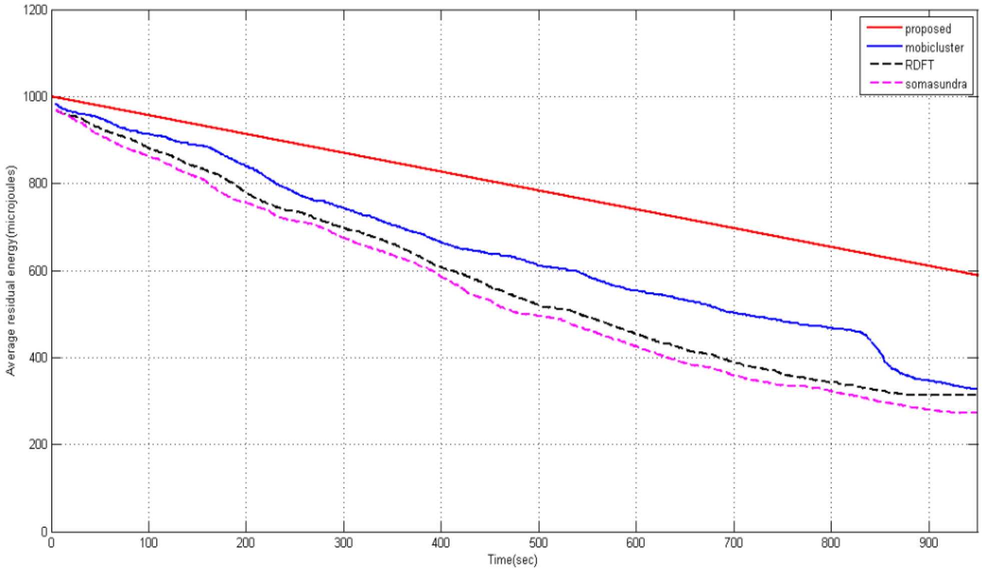

Fig. 2 The Average Residual Energy vs Time

Table 1. Comparison of D-Mobicluster and other three protocols in terms of their average residual energy

Time	Somasundara	RD-FT	Mobicluster	D-Mobicluster
1st time	970	972	981	1000
25% time	718	739	790	956
50% time	504	540	627	790
75%time	350	379	497	700
100%time	271	313	327	580

Network Lifetime: The D-Mobicluster out performs the other three protocols in term of Network lifetime also. Network lifetime of the node is defined as the time of the first SNs energy gets depleted. The D-Mobicluster involves the RNs, which are used to deliver the pre-processed data to the sink, saving much of the energy of the SNs. The re-clustering and the change of role of RNs when this RN gets exhausted of energy saves a lot of energy, the use of data dissemination nodes DNs which also relieves the CHs from the extra load of data aggregation, data filtering and data forwarding during inter-cluster communication saves a lot of energy and hence prolonging the network lifetime of the nodes.

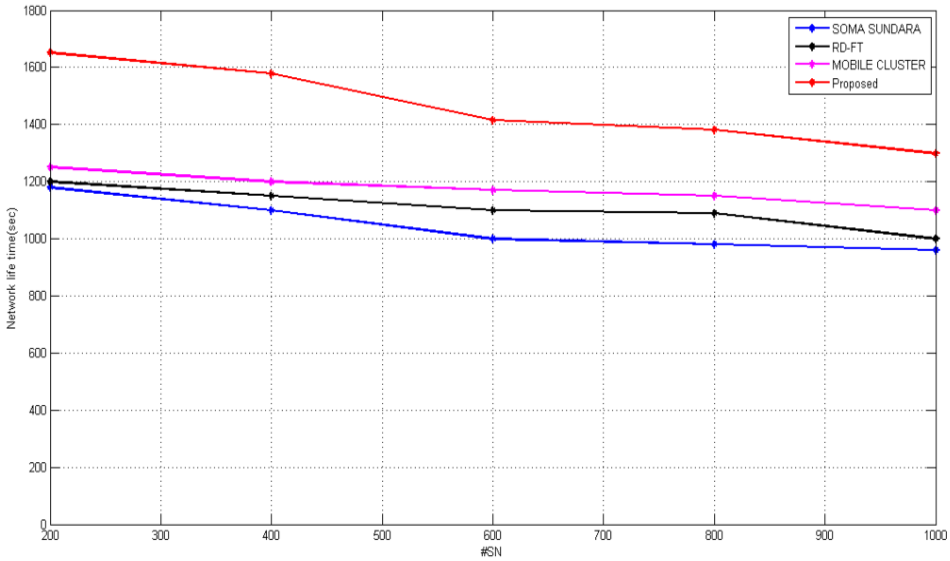

Fig. 3 Network lifetime vs #SNs

Table 2. Comparison of all the protocols in terms of Network lifetime

#SNs	**Somasundara**	**RD-FT**	**Mobicluster**	**D-Mobicluster**
200	1180	1200	1250	1652
400	1100	1150	1200	1579
600	1000	1100	1170	1416
800	980	1090	1150	1381
1000	960	1000	1100	1298

V. CONCLUSTION

This paper introduced D-Mobicluster protocol that aims at minimizing the energy consumption of the network in terms of average residual energy and prolonging the network lifetime of the nodes, by introducing the data dissemination node in between the CHs and the RNs for the inter-cluster communication. The DNs introduced are used to relieve the CHs of the clusters which are close to the MS from the task of data collection and data filtering and relaying the data to the MS, so, a lot of energy saving is done by the introduction of DNs In the network.

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