

Adaptive and Dynamic Routing Protocol for Mobile Wireless Sensor Network

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Abstract

Wireless sensor networks have a vast verity of day to day life real-time applications due its low cost, self-computing, powerful, autonomous tiny sensors which are having small storage, limited non-removable non-rechargeable battery and low computational power. In mobile wireless sensor networks, the topology of the network changes continuously, this has a great impact on the performance of the network. In order to improve the reliability and performance of the network having mobile nodes, a cluster based Adaptive and Dynamic Routing for Mobile Wireless Sensor Networks (ADRM) protocol is proposed which uses the acknowledgment signal to carry out the routing of data from source node to destination instead of the signal strength. The proposed method has the advantages of clustered approach and it reconfirms the availability, aliveness and responsiveness of the node and bypasses the failed, busy, unresponsive nodes

to improve the reliability and performance of the network. It deals with nodes which go out of a cluster, nodes which are entering in a different cluster while moving around. In addition, it overcomes the problem of path failure, node failure situations to improve the overall performance of the network.

Key Words : WSN, Mobile Nodes, Cluster Based, Acknowledgment based

1 Introduction

In recent years the Wireless Sensor Networks (WSNs) [1-7] are become more popular, growing and one of the hottest research topic because of its wide variety of application areas. Such type of networks is basically composed of tiny, low powered, low cost, non-rechargeable battery driven, autonomous, cooperative, spatially distributed sensors that are designed for a specific task. The sensors are deployed densely in hundreds to thousands in number in a region of interest shown in Fig. 1.1, from where the information is to be collected and transferred to the sink which is located away from this region. The collected data can be further processed. In such systems, there is no network infrastructure, so nodes must cooperate to accomplish communication, global control and information aggregation.

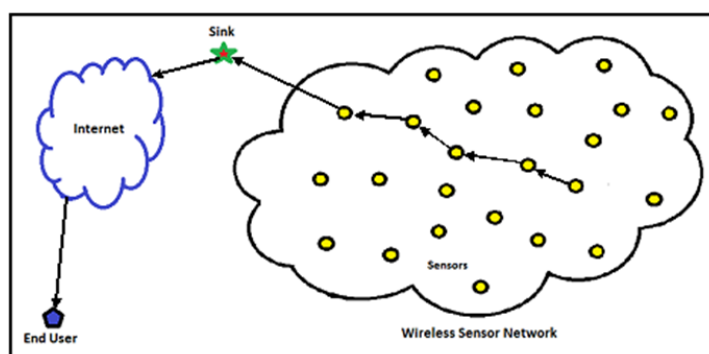


Fig. 1.1: Sample structures of Wireless Sensor Networks

Sensor nodes that are deployed in the wireless sensor networks can be static or mobile in nature according to need of the application. The static sensors are rigid, fixed type of sensors that cannot move from one geographic location to other, once they are deployed in the network. Mobile Wireless Sensor Networks (MWSN) [8-10, 11] is more versatile than static sensor networks as the nodes have the ability to move from one location to other. They can be deployed in any scenario and have ability to cope with rapid change in topology. As the nodes are mobile in nature the topology of the network changes rapidly, they produce new challenges in MWSN, which must be handled properly.

2 Related Work

Cluster Based Routing (CBR) [12-15] is the most common routing schemes used in mobile WSN, where the sensor nodes are grouped into different clusters. One of the node in each cluster works as a Cluster Head (CH), whose duty is to collect data from each of the member nodes in its cluster and send the collected data to the sink node or the base station. Usually CHs collect data from sensors periodically using TDMA scheduling scheme. Fig. 2.1 shows structure of cluster based MWSN. The reason of popularity of Cluster based routing protocols is it has a variety of advantages over other non-clustered routing protocols [13-16]. Some of the major advantages are load balancing, low energy consumption, high degree of scalability, Data Aggregation, Data Fusion, robustness, Collision Avoidance, Maximizing the lifetime of the Network etc.

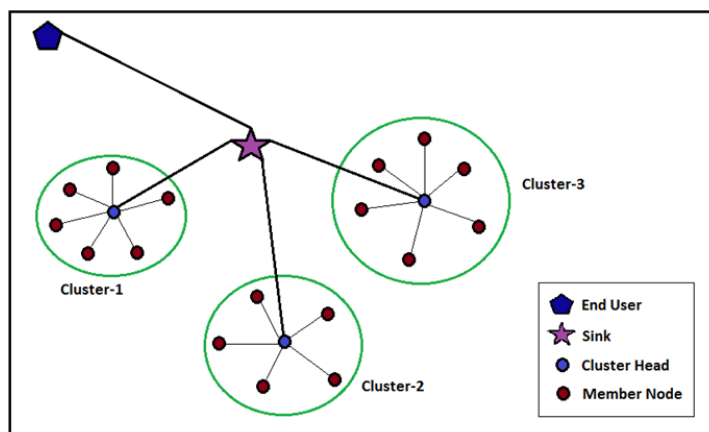


Fig. 2.1: Cluster Based Routing in Wireless Sensor Networks

2.1 LEACH-Mobile

LEACH-Mobile discussed in [15, 19-21] is an extend version of basic LEACH protocol, that works on the same principle of LEACH but with some additional features incorporated. This protocol is mainly designed to support the mobile sensor nodes in the networks, which is sometimes required, as needed in some specific applications. The network may consist of static as well as mobile sensor nodes depending on the applications. In LEACH-Mobile protocol, some or all sensor nodes are mobile in nature, so this protocol announces the membership of a cluster to confirm whether the member nodes can communicate with the cluster head or not, as the member node may move from one location to other.

2.1.1 Operations in LEACH-Mobile

LEACH-Mobile protocol also consists of two phases i.e. setup phase and steady state phase, like the basic LEACH protocol; it also considers the mobility factor of the sensor nodes.

1. Set-up phase: clusters are formed and cluster heads are selected base on the residual energy of the sensor nodes, considering mobility of the nodes.

2. Steady phase: Using TDMA the nodes send data to their CH during time slots allocated to them, considering the physical movement of the nodes.

The clustering in LEACH-Mobile consists of static nodes as well as mobile nodes in the network. The cluster heads are selected and the clusters are formed using the predefined strategy and the communication takes place using the TDMA scheduling. The static as well as mobile nodes transmit data to their respective CHs and after that the CHs send data to the Sink node.

2.1.2 Working of LEACH-Mobile

The physical movement of the sensor nodes drastically and dynamically changes the topology of the network at run time, which is the key feature of this protocol. In the setup phase of LEACH-Mobile, the cluster heads are selected and clusters are formed like the basic LEACH protocol. Here, every sensor node chooses the most appropriate cluster head by sending the join message to the cluster head, using the signal strength. The cluster head creates the TDMA schedule as soon as it receives a join signal from any of the sensor nodes and shares it with all the cluster members.

In the Steady state phase, the phase is broken down into different frames, where, based on the TDMA scheduling, a timeslot is assigned to each member node to send data to the cluster head. Here, the node wakes up at the beginning of its timeslot assignment and waits for a data request message from its cluster head, based on TDMA scheduling. If the sensor node receives the data request from its cluster head, it will send back the data to the cluster head. The node will go to sleep mode until the next time slot, if it does not receive the data request from its cluster head, in the time slot assigned to it. The next time slot will arrive at the next frame. If in the next frame also it does not get any data request message from the cluster head, the node sends a join-ack-msg i.e. the join request message to available CHs nearest to it.

Similar criterion is also applicable at the cluster head level. If in two consecutive frames a cluster head does not receive any data from member sensor nodes, it is considered that the node is moved out of the cluster head range and the member node will be removed from the schedule. Similarly, depending on receiving a new join request

for new nodes just entered in the new cluster, the cluster head sends announcement-message known as advertisement message at end of each frame.

3 Proposed ADRPM routing protocol

The clustering mechanisms in most of the clustering based routing protocols are working on the principle of the signal strength and/or distance between the pair nodes to form the clusters. These parameters are considered as the key factor for forming the clusters. In real time scenarios, it may possible that though the signal strength between the pair of nodes is good or the distance between pair of nodes is shortest i.e. radio of the node is working properly then also the node may not take part into communication because of some reasons.

There can be many reasons which may make these nodes compulsory to not to take participation in the communication in the network. The reasons may be like, the node is busy in some other activity, or the node is not ready to take part in the communication due to some problem or error, or the node facing some malfunctioning, node unable to sense the desired data, or node unable to take part in routing of the data, or the node has some manufacturing defect, etc. In such cases these nodes may be called as faulty nodes.

For the clustering protocols which only consider the signal strength and/or the distance between the pair of nodes to form the clusters, may not work properly, if there is presence of faulty nodes in the network. Because these faulty nodes may be considered actively while selecting the cluster heads, creating the TDMA scheduling and in communications which take place in rounds considering rotation of cluster heads, etc. If such faulty nodes are present in the network they will be very risky, surely create problems and degrades performance of the overall network.

Hence a novel energy efficient, balanced, reliable and acknowledgement based adaptive and dynamic routing for mobile wireless sensor networks (ADRPM) protocol based on the very well-known LEACH and its variant protocols [17, 18, 22] is proposed, which will work for static as well as mobile nodes in wireless sensor networks. The key concept of the proposed routing protocol is, rather

than considering the signal strength and/or distance between pair of nodes as the key parameters to form clusters, it uses the concept of acknowledgment to confirm the readiness of the pair of nodes to take participation in formation of clustering, selecting the cluster head and making the communication, which make the network more steady, stable, better and reliable.

3.1 Operations in ADRPM in WSNs

The operations of ADRPM in Wireless Sensor Networks are based on the LEACH and its variants [17, 18, 22], but unlike LEACH and LEACH-Mobile, it has 5 phases to work with. The phases in proposed ADRPM are as follows:

1. Set-up Phase: In this phase, the cluster head selection, cluster formation and member registration part is done, based on the residual energy of the sensor nodes and acknowledge time between the CH and sensor nodes in the network.
2. Stand-by Phase: In this phase, the nodes which do not get registered to any of the CH in phase-1 are considered and they get registered to TEMP-CH, a newly created CH in an existing cluster.
3. Steady-state phase: Actual communication between member nodes to CHs and TEMP-CHs to CHs takes place using the TDMA schedule created earlier.
4. Hold-On Phase: In this phase, if any of the member node moves out of its CH range, or any new node enters into a new cluster during communication, the particular clusters will enter in Hold-On phase.
5. Final-State phase: Communication between the CHs to sink takes place in this phase, which is the last phase of operation of ADRPM.

3.2 Structure of ADRPM in WSNs

The clustering in ADRPM in wireless sensor network is described in the Fig. 3.1. The cluster heads are selected and the clusters are

created using the strategy described in the previous section. Here, the network consists of the static nodes and mobile nodes. The static or mobile sensor nodes and the nodes which are not in the range of clusters, CH and TEMP-CH are shown by different colors in the network, as shown in Fig 3.1. The ADRPM in wireless sensor network handles the situation where, the nodes are not in the range of the cluster, by using the concept of TEMP-CH and the mobile nodes moving out of its cluster.

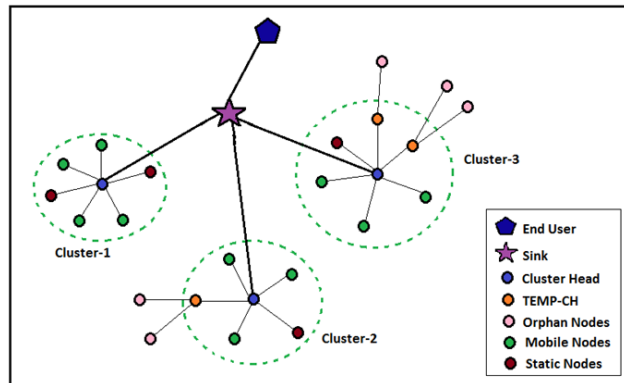


Fig. 3.1: Clustering in ADRPM in WSNs

4 Experimental setup

One of the most popular network simulators, i.e. NS-2 (Network Simulator-2) is used to check the working of the proposed protocols on different scenarios in detail. NS-2 provides real-time environment and platform to check the working of various networking protocols for wired as well as wireless networks. NS-2 has many benefits that make it a very useful tool to work with, like it supports for multiple protocols, which has the capability of graphically detailing network traffic etc. In addition, it supports several routing and queuing algorithms. The basic network parameters for ADRPM algorithm on NS-2 is discussed in the following table 4.1.

SN	Attribute	Value
1	Channel Type	WirelessChannel
2	Radio Propagation Model	TwoRayGround
3	Antenna Model	Omni-Antenna
4	Maximum Packet in ifq	50
5	Number of Nodes	30
6	Routing Protocol	ADR
7	X Dimension of Topography	200
8	Y Dimension of Topography	200
9	Initial Energy at Node	10000
10	Node Deployment Type	Random
11	Type of Sensor Nodes	Mobile

Table 4.1: Network parameters for ADRPM

5 Results and Discussion

The simulation on the network parameters discussed in table 4.1 was carried out on 30 mobile nodes using the ADRPM algorithm, up to 6 rounds and the results were generated, tested, evaluated and compared with existing routing protocols LEACH-Mobile discussed in section 2, on various evaluation parameters like mean delay, mean energy consumption and mean PDR. The comparative analysis of the results is discussed in following sections.

5.1 Comparative Analysis of Mean Delay

The mean delay in the network should be less, to be an efficient routing. In this section, the mean delay using ADRPM algorithm on 30 mobile nodes are compared with MLEACH. The comparison of the results is shown in Fig. 5.1. On the x-axis the number of round is considered, whereas, delay in m-second is taken on y-axis. From the results, it is observed that the mean delay of ADRPM is comparatively less than MLEACH.

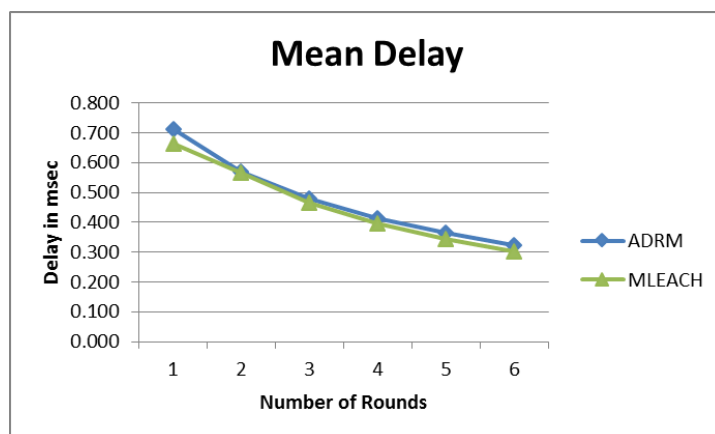


Fig. 5.1: Comparative Analysis of Mean Delay for 30 Nodes

5.2 Comparative Analysis of Mean Energy

Energy optimization is one of the main challenges in mobile WSN, energy dissipation should be less to prolong the lifetime of the network. Here, the Mean Energy on 30 mobile nodes using ADRPM up to 6 rounds is observed and the results are generated and compared with MLEACH. The comparison of the results on Mean Energy is shown in Fig. 5.2. On the x-axis the number of round is considered, whereas, energy dissipation in Jules is taken on y-axis. From the results and comparison, it is observed that ADRPM also works efficiently in terms of energy optimization, by dissipating less energy as compared to MLEACH.

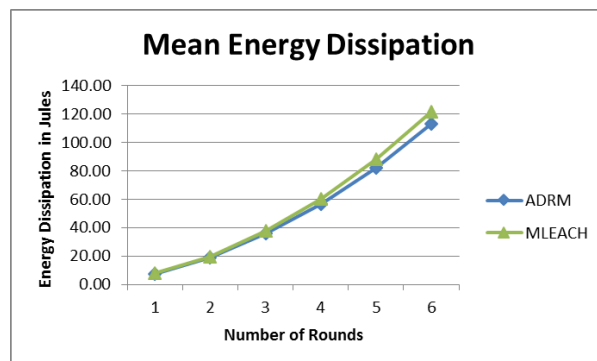


Fig. 5.2: Comparative Analysis of Mean Energy for 30 Nodes

5.3 Comparative Analysis of Mean PDR

Packet Delivery Ratio (PDR) signifies the successful delivery of packets at the destination, initiated by the source. To be an efficient routing protocol, the PDR must be high. Here, the Mean PDR is calculated and compared for 30 mobile nodes using ADRPM up to 6 rounds with MLEACH. The comparison of the results on Mean PDR is shown in Fig. 5.3.

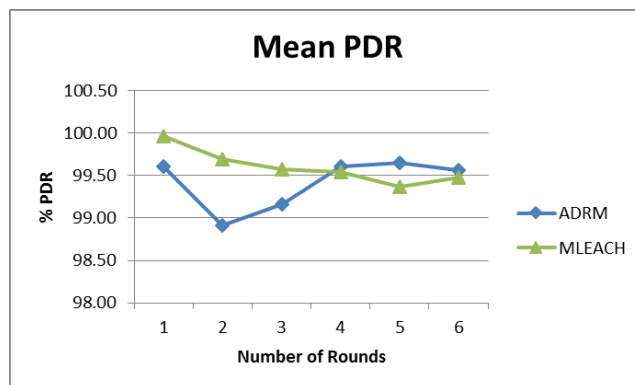


Fig. 5.3: Comparative Analysis of Mean PDR for 30 Nodes One the x-axis the number of round is considered, whereas, % PDR is taken on y-axis. From the results and comparison with MLEACH, it is observed that, the % PDR is slightly less for first three rounds, but later it matches with desired levels.

6 Conclusion and Future Scope

Routing in Mobile Wireless Sensor Network is really a challenging task, as the topology of the network changes rapidly and continuously which directly affects the performance of the network. To improve the performance and reliability of the network, the proposed Adaptive and Dynamic Routing Protocol for mobile wireless sensor networks (ADRPM) works perfectly on the network parameters. From the results, it is observed that, the ADRPM outperforms on the evaluation parameters like, mean delay, energy optimization, and PDR, in comparison with the existing routing protocols for mobile nodes, LEACH-Mobile.

In future, the proposed ADRPM will be tested on more number of nodes, rounds and scenarios. It will also be compared with more number of existing routing protocols on mobile wireless sensor networks and try to optimize the working of ADRPM for handling critical situations like, path recover, optimizing the paths, handling malicious nodes, and providing security to the network.

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