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# EEADRT: Energy Efficient With Assured Delivery Rate and Throughput Routing Protocol For Wireless Sensor Networks

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## Abstract

In wireless sensor networks (WSN), since there are applications with various requirements, different capacity sensors are used. To design efficient, scalable routing protocol with asymmetric links and with data sinks mobility for gathering the data is a challenging task and drawn substantial interests in recent years. In this paper, EEADRT protocol is proposed. It makes use of asymmetric links to obtain assured delivery rate with less overheads and finds shortest path for data gathering with flexible mobile sinks. It does not require GPS -device or pre-defined landmarks, since it establishes logical co-ordinate reference for routing and forwarding data packets. At first reverse path for each and every asymmetric link is found and bi-directional routing is produced. Then, by using logic information it chooses forwarding nodes. Thus, the simulation result shows that it can achieve assured delivery rate with reduced control overheads and finds shortest routing path, thus improving energy efficiency.

**Index Terms:** Mobile sink, logical co-ordinates, Asymmetric links, wireless heterogeneous sensor networks, data gathering.

## Introduction

Wireless sensor networks have yield large range of applications via sensor nodes, which are low cost and consumes less power. Example: Precision agriculture, target tracking, habitat monitoring, forest fire detection, environment monitoring. Since, battery life in sensor node is limited, it is important to save battery while designing sensor network protocols. In wireless sensor networks, information about temperature, light etc., are gathered by sensors from the environment. Then the information are processed and sent to the mobile sink for further processing. Recent research says

that, in-spite of reporting data via long and multi-hop routes, it is better to use mobile sink for providing energy efficient data gathering. So, mobile sinks integrated with radio devices directly enters the area to communicate with nodes and collects information. Thus, the transmission path for data is short and energy consumption is less.

In order to minimize data gathering time, moving patterns of mobile sink is scheduled. Although Mobile Element Scheduling (MES) were used, it is an NP – hard problem to determine optimal moving path for a sink.

When moving trajectory for sink is not scheduled in prior, then the protocol allows mobile sink to frequently announce its location information throughout the network. Many Sink Oriented Data Dissemination (SODD) [12] protocol uses that approach, but produces significant control overheads. Thus, in the proposed protocol approach, mobile sinks movement can be predicated by the sensors. So, the consumption is less and it is easier to hand-off data packets.

The wireless sensor network (WSN) is nothing but the WSN generated by the heterogeneous sensors. Taking heterogeneity into account, diverse transmission ranges are considered. Routing packets efficiently to the destination in asymmetric links after completion of data collection needs a protocol which must satisfy the two requirements.

1. Must obtain assured delivery rate with less overhead and should be reliable
2. Reduction in consumption of energy by finding shortest path in asymmetric links

Here, **EEADRT** is proposed: Energy Efficient with Assured Delivery Rate and Throughput routing protocol for networks which are heterogeneous. It handles asymmetric links and uses local information to work well in areas which are distributed. It tends to produce assured delivery ratio and less overhead. It helps in finding shortest routing path thus reducing the energy consumption and control overheads.

## Related Work

There are different routing protocols which deal with sensor networks which are homogeneous [1]. From all those protocols, it is observed that the capacities of all sensors are same in case of communicating, computing, power, scalability and reliability. But in some applications like environment monitoring [11], disaster rescuing, various capability sensors are used. It is stated that if used in proper manner, the average delivery rate can be tripled by heterogeneous sensors and increases network lifetime [3].

So many routing protocols are designed in WHSNs [4],[5],[2],[3]. The sensors are classified into two parts: dominant and less dominant. Sensors are grouped with most dominant head cluster. Routing between head cluster and less dominant sensor nodes are done using intra cluster protocol and routing between head clusters are done using inter-cluster. In all these protocols each and every individual sensor does not have distinguished capability and they don’t completely utilize the asymmetric links. Thus the most challenging part is to tackle the overheads produced by sink’s movement in

an effective manner. The basic way to find sink's movement is to broadcast the current location of mobile sink to the entire network. This kind of approach is said to be sink-oriented and effect of collecting minimum quantity of data from entire network have been given from earlier efforts in the research [7][6].

Several techniques are proposed for reducing control overheads. The protocol named Two-Tier Data Dissemination (TTDD) discussed in [13] creates a structure which enables quick data forwarding. Moreover, in all these works it is assumed that sinks moves with velocity which are fixed and in prescribed direction. The proposed approach is with suppression of control message and therefore it aims at minimizing the flooding effect of messages, which does not confine the movement of sink. This in the real time application, it is considered to be the most attractive approach. The other method called Mobile Element Scheduling (MES) [9][13] considers sink mobility and its track movement. From the previous works it is clear that movement of mobile is controlled and it queries each sensor node and gathers data. This reduces data gathering time and length. In case of heterogeneous sink movement scheduling becomes more helpful. Although, MES methods reduced the cost of transmitting data, sink needs to cover each node in field. This delays data gathering and finds difficult for large scale networks. Thus it is an NP-hard problem to determine the accurate technique for data gathering [8],[10].

## The Proposed EEADRT Protocol

This section deals with the work of proposed protocol EEADRT. This protocol consist of two parts,

1. Logic co-ordinates representation, which includes tracking of neighbor's relationship and sinks without the help of GPS. Finding reverse path for an asymmetric link is also done in this part
2. Dynamic Routing part, which includes gathering of data with mobile sink, reduces route length, forwarding messages and sending acknowledgment. Thus, it reduces total energy consumption.

This paper is organized in such a way to assure delivery rate in WSNs and to use asymmetric communication links. The energy consumption is drastically reduced if the movement of mobile sink can be predicted by the sensors. With the help of Temporary References (Temp Ref) data are reported without knowing the velocity and current location of mobile sink.

**Algorithm: EEADR Strategy**

1. //Initializing data sequence and hop count
2. data.seqN ← 0;
3. data.hopC← 0;
4. //Movement Strategies
5. **While** largest no. of nodes have not been covered **do**
6. Shift to next temp point;
7. data.seqN← data.seqN+1;
8. broadcast temp msg;

9. checks for data reporting packets;
10. **end while**
11. End the procedure and exit;
12. //Temp Ref Updating
13. **if** data gathering is not over
14. **and if** data seq N > latest data seq number then
15. shift Temp Ref of node i to left by one position;
16. increment data.hopC & move it to kth element of node ith Temp Ref(α);
17. move data.hopC + 1 → data.hopC
18. Rebroadcast msg;
19. **else if** data.seqN = latest data.seqN then
20. Compare it with α;
21. **if** α > data.hopC + 1;
22. Repeat step 16 and 17;
23. **else**
24. discard the msg;
25. **end if**;
26. **end if**;
27. **else if** data.seqN < latest data.seqN then
28. discard the msg;
29. **end if**;
30. **end if**
31. //forwarding
32. Current forwarding node broadcast the packets and msgs to be transferred to sink
33. Forwarding node number is increased by 1
34. Temp Ref are exchanged with neighbors after all its elements are updated
35. **if** sink is within coverage range, send data directly to it
36. **else**, choose next hop neighbor node closest to the destination
37. Forward data to next hop
38. **end if**
39. //Acknowledgement
40. When packet *P* reaches sink, acknowledgement $P_{ack}$ is sent to all forwarding nodes
41. When forwarding node receives $P_{ack,}$ it increases its delivery number by 1
42. **if** forwarding node m has its reverse path to its previous node n, then it sends acknowledgement to n via reverse path of asymmetric link
43. **else** it drops $P_{ack}$
44. **end if**

Consider large, evenly distributed sensor network. Nodes in network communicate via radio link. Whole sensor network is assumed to be connected. Normally, two hop neighbor information models helps in routing in WSN by knowing the information about the neighbors. But due to asymmetric links, neighbors are denoted by one hop receivers and sensor node knows the information about these one hop receivers through exchange of "Hello" message. To gather data from network, mobile sinks are

sent to the fields. They have processors for communicating with nodes, gather information and process them. The supply of mobile sink is easy to recharge or replace so they have no limitations in power.

At the moment the sink enters the field, the process of data gathering starts and stops when sufficient data are collected. All the data are reported to the mobile sink. At time of data gathering, sink moves around the network slowly and checks for packets which reports data. It broadcasts messages by stopping at particular place, to the whole network for short duration and moves on to the other point. These points are called "Temp Points" and messages are called "Temp Messages". The mobile sinks movement is tracked by Temp points.

The algorithm describes the working of the protocol to find the shortest path in asymmetric link and to report data to mobile sinks assuring delivery. It initializes data.seqN and data.hopC to 0. Then, moves the temp point until sufficient data are collected and broadcast temp messages while concurrently listen for data report packets. In logic co-ordinate representation part < data.seqN and data.hopC > are set to 1 and 0 respectively. If data gathering process is not yet over, then update temp ref by comparing data sequence number with most latest data sequence number recorded by a node. Three types of comparison is done and messages are broadcast and discarded accordingly. Then data are forwarded in the dynamic routing part if temp ref is updated and if sink is within radio range. Acknowledgement is sent back from mobile sink to the forwarding node m. If forwarding node m has reverse path to previous node n, then $P_{ack}$ is send via reverse path of asymmetric link. Thus, the algorithm is designed to assure delivery rate and provides energy efficiency.

## Simulations

In this section, two metrics are used for validating proposed protocol.

1. Delivery ratio
2. Total Energy Consumption

To show the improvement in delivery ratio, proposed protocol EEADRT is compared with AODV protocol. Both protocols are similar in design aspects and make use of reverse path in routing in spite of having several differences. EEADRT deals with asymmetric links in heterogeneous network and AODV uses symmetric link for ad-hoc wireless network.

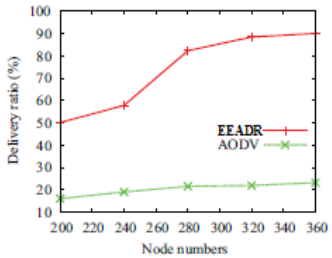


**Figure 1:** Comparison of delivery ratio between EEADRT and AODV

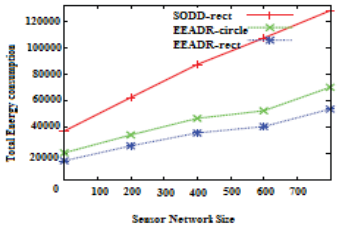


**Figure 2:** Comparison of EEADRT with SODD in Energy consumption

From the simulation, EEADRT obtains assured delivery ratio of about 90% with increased number of nodes and connections. EEADRT outperforms SODD protocol. In case of total energy consumption, the data gathering threshold is set to 98%. The proposed EEADR is compared with SODD in both rectangular and circular motion pattern of the sink and the simulation result shows that EEADR outperforms SODD. The savings in energy consumption is about 38%. Thus, the proposed protocol is superior than other two and outperforms them in case of energy efficiency and assured delivery rate.

## Conclusion

In this paper, EEADRT routing protocol is proposed which deals with asymmetric links, consistency and scalability issues in WSN and it is a low complexity, energy efficient data gathering protocol. It uses logic co-ordinate references for establishing data reporting routes and forwarding the packets through shortest path to destination reference. It does not require GPS or extra land marks to be installed. Thus the proposed protocol ensures shortest path in asymmetric links and assures delivery rate thereby reducing energy consumption and control overheads. The efficiency of EEADRT is evaluated by the simulation result. In future, more efficient routing protocol in WSN will be designed.

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