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Distance-Based Energy-Aware Routing (DER) Protocol for Wireless Sensor Networks

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Abstract

Wireless sensor networks (WSNs) perform the routing functions with many routing protocols like LEACH, HPSD and so on. Still there are many unresolved issues in routing protocol in wireless sensor networks. In this work, a new algorithm named "Distance-based Energy-Aware Routing (DER) protocol has been proposed. The proposed protocol that selects a route to the base station based on the mean measure mechanism and a node, which is nearest to the base station within the range. The mean measure is calculated by adding the energy level of all nodes in the range, which can be divided by number of nodes in the range. The DER protocol will efficiently reduces the time delay and total energy consumption in wireless sensor networks. The simulation result shows that energy consumption of a node in the network is well balanced and increases survival time of the wireless sensor networks.

Keywords: DER, WSN

1. Introduction

The Distance-Based Energy-Aware Routing (DER) Protocol is the significant energy aware routing mechanism. In this scheme, the sensed data are transmitted to the base station based on assumed transmission range by the sensor nodes. In the transmission range, the energy levels of the sensor nodes are aggregated together and calculate the mean measure mechanism. The target node is finding based on the criteria such that the node which one is nearest to the base station in the range, and the energy level of the node is greater than the threshold level. This scheme effectively reduces the delay and save network energy compared to some of the previous schemes. These protocols highly useful in military based application especially in cross border terrorisms for detecting an object. The detected events are quickly send it to the base station for further actions.

2. DER Protocol Operations

The DER protocol operations are to increase the node lifetime by distributing energy load among sensor nodes using mean measure mechanism

This protocol operated on three phases:

A. Initialization Phase
B. Forwarding Phase
C. Updating Phase

2.1. Initialization Phase

Once the sensors are deployed in the field, it is not easy to re-deploy the sensor in the same field. The energy is vital for sensor node in the sensor network to survive in the environment. So the energy should conserve efficiently in the sensing field. In the Initialization phase, the node position is identified through broadcast mechanism.

2.1.1. Identification of node position

The sensor deployed in the environment randomly. To know its position at first, the base station broadcast the initialization packet to all nodes in the sensor network. On receiving such packet, it calculates the time to reach every node in the network. Each node in the network stored its reaching time. Then the node transmits its attributes (Node_ID, Time and Energy) to the base station. Finally the base station calculates distance based on time and speed. The summarized data's are broadcast it again to all nodes in the network by the base station.

Equation-1 for calculating the Distance:

$$\text{Distance} = \text{Speed} * \text{Time}$$

Where

I. Distance= Distance between the node and the base station.

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II. Speed= Speed of wave in air.

III. Time= Time elapsed of a message to reach from the base station to the node.

2.1.2. Construction of Routing Table

After identification of node position, the base station broadcast the routing information. The routing table is maintaining at each node in the sensor network for taking routing strategy. The routing table contains three fields such as Nodd_ID, Energy level of the node, Distance from the base station. The routing strategy is taken by analyzing the above fields in the routing table. The table 1 shows the routing table maintained at each node in the sensor network.

Table 1: Routing Table

Node_ID	Distance	Energy
N1	25 Meters	1 Joule
N2	37 Meters	0.97 Joule
..	..	..
..	..	..
Nn	N Meters	N Joules
BS	..	High Energy

2.2. Forwarding Phase

After the event triggered by the sensor nodes, the source node route the packet to the base station by considering the routing table.

2.2.1. Successive Transmission

In successive transmission, the energy levels of the sensor nodes are get changed in the sensor field. The source node takes the assumed transmission range of 50 meters. The target nodes are predicted based on the criteria:

I. The node that is nearest to the base station from the nodes within the range.

II. The Energy level of the node should be greater than or equal to the threshold level.

If the energy level of the node greater than or equal to the threshold level, then the data is transmitted to the node. Suppose if the energy level of the node less than threshold level, then previous least distance node in the routing table should be taken and compared with its threshold level. If the condition is met, then make transmission to that node. During the successive transmission, the energy level of nodes gets changed.

2.2.2. Procedure for forwarding phase

The procedure for forwarding phase in DER protocol is as follows.

I. An event occur it triggered by the sensor nodes.

II. The node takes the transmission range of 50 meters.

III. If it is successive transmission, the energy levels of the sensor nodes are get changed in the sensor field. The target nodes are predicted based on the criteria:

A. The node, which one is nearest to the base station from the nodes with in the range.

B. The energy level of the node should greater than the threshold level.

IV. Calculation of Mean Measure or Threshold level

The Mean Measure or Threshold level are calculated based on the energy level of all the nodes in the range and divided by number of nodes in the range.

$$Th = \sum_{(i=1 \text{ to } n)} ((EN_{(i)} + EN_{(i+1)} + \ldots\ldots..EN_{(n)})/\text{No. Of nodes in the range}$$

Where, EN(i) is the Energy level of node i

Th is the Threshold level

V. The node, which is nearest to the base station,

A. If Threshold <= Energy level, Then take next far distance node in the range and compare it until the energy level is greater than the threshold. Then take that node as target node.

B. If Threshold >= Energy level, Then take that node as target node.

VI. The above step 4 and 5 is repeated until it reaches the base station.

2.3. Updating Phase

After every transmission of information from source to base station, the energy leve of the node in the sensor

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fields get changed. So it is essential for updating routing information at each node after every transmission of packets. Here the energy required for updating the routing information at each node lies on the hands of the base station.

A. During transmission, the target nodes in every range not only send the sensed data in addition to that it sends energy level and Node-ID to the base station.

B. The base station broadcast the messages to all nodes in the network.

C. After receiving such message the nodes update its routing information.

The above process is repeated after every transmission to update the routing table at every node in the sensor network. The maximum size of the packet is 53 bytes. The size of the packet is variable in nature, because the numbers of target nodes get vary depend upon the location of the event occurred.

3. Algorithm for DER Protocol

The proposed algorithm for DER Protocol is:

```
1. Const Tr = 50;
2. For each (Node n in Transmission range)
3. Loop beginning
4.      if (Energy level of n is not same)
        // Node energy level is not uniform with in the range
            Get_least_distance_node();
5.      End if
6. Loop End.
7. Get_least_distance_node()      //If the node is least distance to the base station
8. Begin
9.      For each (Node n in Transmission range)
10.     Loop Beginneing
11.         Nn = Minimum_dist();
12.         Get_target_node(Nn);
13.     Lood End
14. End
        //If the Mean Threshold greater than basic threshold and
        //Energy level of node greater than the Mean threshold
15. Get_target_node(Nn)
16. Begin
17.     For each(Node n in Transmission range)
18.     Loop Beginning
19.         EN = EN1 + EN2 + ……+ ENn;
20.         MTh = EN/n;
21.         Const BTh = 0.002Joule;
22.     Loop End
23.     If((MTh >= BTh) && (ENn >= MTh))
24.         target_node = Nn;
                //Route to target node
25      Else
26.         Get_next_minimum_dist();
27.         If(target.BS == true)
28.             //Route to base station
29.         End If
30.     End If
31. End
32. Minimum_dist()          //Finding the Minimum Distance Node
33. Begin
34.     For each (Node n in Transmission range)
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35.     For each (Node m in Transmission range)
36.     Loop Beginning
37.         If (N[n] < M[n])
38.             t = N[n]
39.             N[n] = M[n]
40.             M[n] = t
41.         End If
42.     Loop End
43. End
44. Get_next_minimum_dist()
45. Begin
46.     For each (Node m in Transmission range)
47.     Loop Beginning
48.         Nn = M[n--]
49.         Get_target_node(Nn)
50.     Loop End
51. End
```

Table: 2 Notations used in the DER Algorithm

Name	Meaning
Tr	Transmission Range
Nn	Minimum Distance node
EN1…ENn	Energy Level of nodes in the range
EN	Total Energy of the nodes in the range
BTh	Base Threshold
MTh	Mean Threshold
BS	Base Station

4. Conclusion

The proposed protocol DER selects routes based on energy aware of the nodes in the network by mean measure approach. The distance based energy aware routing efficiently reduces the time and energy in WSN. The energy consumption of the node in the network is well balanced and prolonging the survival time of the WSN. The performance of DER is analyzed through simulation, the results show that in DER the time delay was reduced, the energy consumption by the nodes in the network were low and it increased the lifetime of the network compared to other conventional protocols like LEACH and HPSD.

5. Future Work

For future work the transmission range will dynamically read. The dynamic read mechanism can optimize the energy consumption of the nodes in the sensor networks.

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