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An Energy Efficient Data Routing Protocol (Eedrp) For Wireless Sensor Networks

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Abstract

Wireless sensor networks (WSNs) perform the routing functions with many routing protocols like HPSD (High Power Short Distance) Protocol and LEACH (Low Energy Adaptive Clustering Hierarchy) Protocol and so on. Still there are many unresolved issues in routing protocol in wireless sensor networks. In this paper, a new algorithm named Distance-based "Energy Efficient Data Routing Protocol (EEDRP)" 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. This protocol will efficiently reduce the time delay and total energy consumption in wireless sensor networks. This shows that energy consumption of a node in the network is well balanced and increases survival time of the wireless sensor networks.

Keywords: WSN, Routing, Data, Energy, Protocol.

1. INTRODUCTION

WSN is a subset of Ad-hoc networks. WSN consists of specially distributed autonomous sensors to cooperatively monitor physical or environmental conditions such as temperature, sound, vibration, pressure, motion etc. This new Protocol EEDRP is the significant energy efficient routing mechanism for WSN. 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 energy. 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 sending it to the base station for further actions.

2. LITERATURE REVIEW

Al-Karaki, J.N. et al [1], proposed the energy efficient routing protocol for wireless sensor networks. The design of energy-efficient protocols for wireless sensor networks (WSNs) is a crucial problem as energy is a strict resource in these networks. They proposed an energy-aware routing protocol using a new approach. This protocol is called high power short distance protocol (HPSD). HPSD is a node-based protocol that selects the route to the base station (BS) based on the closest node that has the highest battery power relative to its surrounding neighbors. Thus, the energy load can be distributed among all sensor nodes instead of using certain path each time. So, HPSD can increase the lifetime of the network.

Xiaoxia Huang, et al [2], proposed the Robust Cooperative Routing Protocol. In wireless sensor network, path breakage occurs frequently due to node mobility, node failure and channel impairments. It is challenging to combat path breakage with minimal control overhead, while adapting to rapid topological changes. Due to the Wireless Broadcast Advantage (WBA), all nodes inside the transmission range of a single transmitting node may receive the packet; hence naturally they can serve as cooperative caching and backup nodes if the intended receiver fails to receive the packet. They present a distributed robust routing protocol in which nodes work cooperatively to enhance the robustness of routing against path breakage. They compare the energy efficiency of cooperative routing with no cooperative routing and show that the robust routing protocol can significantly improve robustness while achieving considerable energy efficiency.

Peter Kok Keong Loh, et al [3], proposed the Reliable Routing Protocols for Fixed-Power Sensor Networks. In this protocol the Fixed-power wireless sensor networks are prevalent and cost-effective. However, they face mote failures, Radio Frequency interference from environmental noise and energy constraints. Routing protocols for such networks must overcome these problems to achieve reliability, energy efficiency and scalability in message delivery. Achievement of these requirements, however, poses conflicting demands. They propose an efficient and reliable routing protocol (EAR) that achieves reliable and scalable performance with minimal compromise of energy efficiency. The routing design of EAR is based on four parameters such as path length, a weighted combination of distance traversed, energy levels and link transmission success history, to dynamically determine and maintain the best routes. Simulation experiments of EAR with four existing protocols demonstrate that a design based on a combination of routing parameters exhibits collectively better performance than protocols based on just hop-count and energy or those using flooding.

Kiran K. Rachuri et al [4], proposed the Energy Efficient and Scalable Search protocol. The proposed protocol is considering the problem of information discovery in a densely deployed Wireless Sensor Network (WSN), where the initiator of search is unaware of the location of target information. They propose two protocols: Increasing Ray Search (IRS), an energy efficient and scalable search protocol, and k-IRS, an enhanced variant of IRS. The priority of IRS is energy efficiency and sacrifices latency where as k-IRS is configurable in terms of energy-latency trade-off and this flexibility makes it applicable to varied application scenarios. The basic principle of these protocols is to route the search packet along a set of trajectories called rays that maximizes the likelihood of discovering the target information by consuming least amount of energy. The rays are organized such that if the search packet travels along all these rays, then the entire land area will be covered by its transmissions while minimizing the overlap of these transmissions. In this way, only a subset of total sensor nodes transmits the search packet to cover the entire land area while others listen. They believe that query resolution based on the principles of area coverage provides a new dimension for conquering the scale of WSN. They compare IRS and k-IRS with existing query resolution techniques for unknown target location such as Expanding Ring Search (ERS), Random walk search and variants of search. They show by analysis, simulation and implementation in test that IRS and k-IRS are highly scalable, the cost of search (total number of transmitted bytes) is independent of node density and it is much lower than that of existing proposals under high node density.

Carlos F. García-Hernández at el. [5], specifies that the refinement of energy harvesting techniques that can be gather useful energy from vibrations, blasts of radio energy, and self power circuitry is a very real possibility with networks of millions of nodes, deployed through paint brushes, injections and aircraft. Also the introduction of an additional type of sensor nodes allows the network to self-organize and learn by embedding smart and adaptive algorithm. On the other hand, the use of adoptive power control in IP networks that utilizes reactive routing protocols and sleep-mode operation, more powerful mobile agents, QoS (Quality of Service) to guarantee delivery, security mechanisms, robustness and fault-tolerance.

Mohammad Hossein Anisi at el. [6], Propose the EDR (Energy Data Routing) Algorithm. In this algorithm, instead of broadcasting the packets, the algorithm considers the residual energy of the nodes and the time of packet delivery. Hence, data packets are sent directly toward the Base Station (BS). Additionally the algorithm takes into account the type of request data and it is able to meet the satisfy QoS requirements of incoming data such as fast data deliver for real-time applications. Also, by comparing data in each node, we limit the number of redundant and unnecessary responses from the sensor nodes. Hence the total number of messages sent is reduced which results in high packet delivery ratio. This allows the solution to ensure optimal energy consumption and extend the network lifetime.

It is a data-centric routing algorithm. The aim is to achieve an energy-efficient solution for data routing in wireless sensor networks. In this mechanism, each sensor node sends its data only to one neighbor and this neighbor is selected according to some criteria such as remaining energy of the node and the time of data delivery. The nodes with redundant data do not send any response. The main contribution of this algorithm are: ability to use in both event-driven and query-driven applications, ensuring taking the shortest routing path, transmitting very less number of packets, simplifying the implementation, maintaining the routs, high probability of completeness of responses while realizing significant power savings and increasing the network lifetime.

Aamir Shaikh and Siraj Pathan [7] specified that Zigbee is a new wireless communication technology with short distance, low complexity, low energy consumption, slow data rate and low cost. It is based on IEEE 802.15.4 Standard with the capacity of coordinating mutual communication among thousands of tiny sensors. Through the radio waves, these sensors can transmit the data from one sensor to another with small energy cost and high efficiency. Compared with various existing wireless communication technology, Zigbee technology has the lowest energy consumption and cost. Because of the slow data rate and the small range of communication, Zigbee technology is extremely suitable for agriculture field which has small amount of data flows. Zigbee has self-organizing features that one node can sense other ones without any human interventions and connect with each other automatically to create a completed network. It also obtains self-recovery function that the network can repair itself when a node is added or deleted, the position of a node is changed, or a breakdown occurred. It has also the topology structure to ensure that the whole system can work normally without any human interventions.

Aamir Shaikh and Siraj Pathan [7] specified that RFID (Radio Frequency Identification) is a non-contact automatic identification technology that uses radio frequency signals which automatic recognizes target and access to relevant data. The identification work does not require human interference and can work in variety of harsh environments. But if there is no network to transmit data, it will be difficult to play its advantage.

Reshma I. Tandel [8] specified that LEACH is a Low Energy Adaptive Clustering Hierarchy protocol. The main goal of cluster based sensor networks is to decrease system delay and reduce energy consumption. Leach is a cluster based protocol for micro sensor networks which achieves energy efficient, scalable routing and fair media access for sensor nodes.

LEACH protocol is the first protocol of hierarchical routing which proposed data fusion. It is milestone significance in clustering routing protocol. Hierarchical protocols are defined to reduce energy consumption by aggregating data and to reduce the transmissions to the base station. LEACH is a TDMA based MAC protocol. The main aim of this protocol is to improve the life time of wireless sensor networks by lowering the energy. Leach protocol is a typically representation of hierarchical routing protocol. It is self-adaptive and self-organized. Operations of Leach protocol consists of several rounds with two phases in each round. Leach protocol uses round as unit, each round is made up of cluster set-up phase and steady phase for the purpose of reducing unnecessary energy costs.

Suzan Shukry [9] proposed the Efficient Node Stable Routing (ENSR) protocol. It is introduced to guarantee the stability of transmission data between the source and destination nodes in a dynamic WSN conditions. The stability of the node is defined in both the global and local aspects of stability. The stable node is explored by introducing the stable between centrality and switching packets based on the locality dependency energy degree to guarantee the global and local stability of the node, respectively. The packet retransmission times is taken into account, where the accurate calculated packet retransmission times decrease the extra overhead of the network. This routing algorithm guarantees the energy conversing factor and mitigates “hot-spots” by changing the stable over time.

2.1 Algorithm Paradigms for Wireless Sensor Networks

Luis Javier Garcia Villalba [10] specifies that Sensor applications demand the communication of nodes to execute certain procedures or algorithms. In fact, three kinds of algorithms can be executed on wireless sensor networks:

- Centralized Algorithms: They are executed in a Base node that posses the knowledge of the whole network. These algorithms are quite rare because of the cost of transmitting the data to make the node know the status of the complete network.
- Distributed Algorithms: The nodes are communicated with each other. The communication is supported by message-passing.
- Localized Algorithms: The nodes use restricted data acquired from a close area. With this local information, the algorithm is executed in one node.

The algorithm paradigm is an important factor to take into account when deciding about the routing protocol to employ in the network. If localized algorithms are used, the routing protocol should reinforce and optimize the communication between neighbors. On the other hand, for centralized algorithms, combining the messages that simultaneously go to the central node (even when they are generated by different sources) could be an advantage. The distributed algorithms should efficiently support the communication between any two pairs of nodes. Finally, Local based algorithms depend on some solution that provides geographic coordinates, like GPS, making the solution more expensive.

3. PROPOSED PROTOCOL OPERATIONS

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

This protocol operates on three phases:

- Initialization Phase
- Forwarding Phase
- Updating Phase

3.1. 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.

3.1.1. Identification of node position

The figure 1 describes the 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.

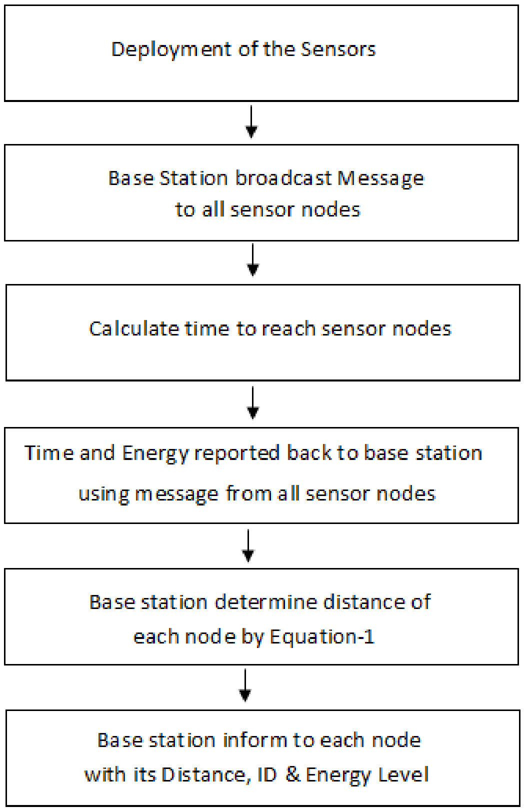

Figure 1: Identification of Node Position

Equation-1 for calculating the Distance:

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

Where

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

II. Speed= Speed of wave in air.

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

3.1.2. 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 Node_ID, Distance from the base station, and Energy level of the node. 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.

Node_ID	Distance	Energy
N1	25 Meters	1 Joule
N2	37 Meters	0.97 Joule
..	..	..
..	..	..
Nn	N Meters	N Joules
BS	0 Meter	High Energy

Table 1: Routing Table

3.2. Forwarding Phase

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

3.2.1. Successive Transmission

In successive transmission, the energy levels of the sensor nodes are get changed in the sensor field. In figure 2, 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.

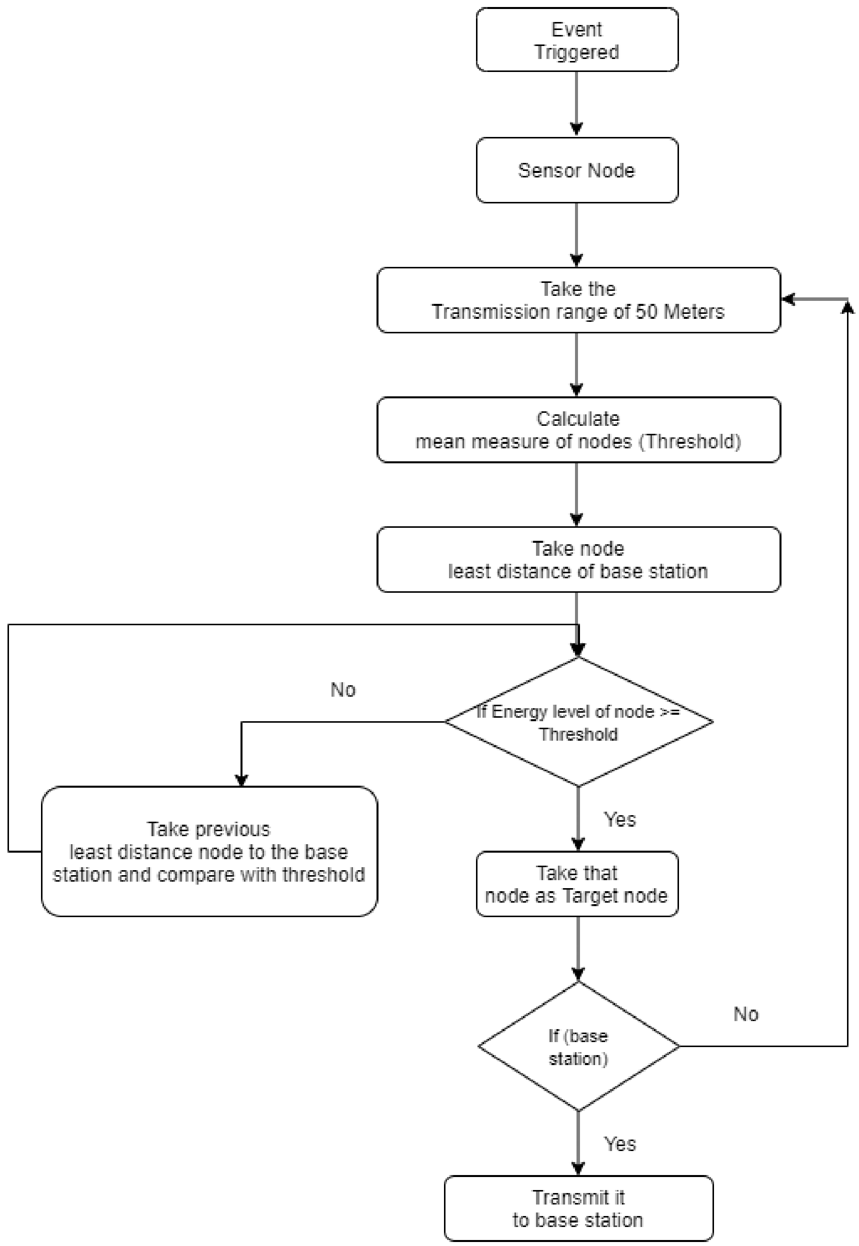

Figure 2: Flow Chart of Forwarding Phase for Data Transmission

3.2.2. Procedure for forwarding phase

The procedure for forwarding phase in this 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 within 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 Energy level <= Threshold, 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 Energy level >= Threshold, Then take that node as target node.

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

3.3. Updating Phase

After every transmission of information from source to base station, the energy level of the node in the sensor 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, but also 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 64 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.

4. PROPOSED PROTOCOL METHOD

The proposed algorithm is Distance based “Energy efficient data Routing protocol”. The procedure for forwarding phase is after the event triggered the source node takes the assumed transmission range of 50 meters.

From the source node, the assumed transmission range of 50 meters should be taken. Within that range, find the node, which is nearest to the base station and compare that node’s energy level with the threshold level. Suppose if energy of the node is less than the threshold level, then the previous least distance node from the routing table is taken and compared with the threshold level until the node energy is greater the threshold level. If the energy of the node is greater than the threshold level, then take that node as target node. The process is repeated until the information reached at the base station.

5. ABBREVIATIONS USED IN ALGORITHM

Name	Meaning
TR	Transmission Range
Dn	Minimum Distance of node n
Dm	Minimum Distance of node m
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

Table 2: Notations used in the Algorithm

6. ALGORITHM FOR PROPOSED PROTOCOL EEDRP

The proposed algorithm for new Protocol is:

1. Const TR = 50;// Transmission Range TR = 50
2. For each (Node n in TR)
3. Loop Begin
4. If (Energy level of n)
// Node energy level is not uniform within the range
Get_least_distance_node();
5. End If
6. Loop End.
//If the node is least distance to the base station

7. **Get_least_distance_node()**
8. Begin
9. For each (Node n in TR)
10.Loop Begin
11.Dn = Minimum_dist();// Dn is the Distance of node n
12.Get_target_node(n);
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(n)**
16. Begin
17.For each (Node n in TR)
18.Loop Begin
19.EN = EN1 + EN2 + ………+ ENn;// En is the total Energy level of nodes

20. MTh = EN/n;// MTh is the Mean Threshold
21. Const BTh = 0.002 Joule; // BTh is the Base Threshold
22.Loop End
23. If ((MTh >= BTh) && (ENn>= MTh))
24. target-node = n;
Route to target-node;
25Else
26.Get_next_minimum_dist();
27.If (target-node == BS)// BS is the Base Station
28.Route to BS (Base Station)
29.End If
30.End If
31. End
//Finding the Minimum Distance Node
32. **Minimum_dist()**
33. Begin
34.For each (Node n in TR)
35.For each (Node m in TR)
36.Loop Begin
37.If (Dm<Dn)
38.t = Dn
39.Dn = Dm
40.Dm = t
41.End If
42.Loop End
43. End
44. **Get_next_minimum_dist()**
45. Begin
46.For each (Node m in TR)
47.Loop Begin
48.Dn = Dm
49.Get_target_node(n)
50. Loop End
51. End

7. IMPLEMENTATION

The proposed algorithm is implemented in following points.

7.1. Initial Node Deployment

The initial nodes are deployed in the network randomly in the network. In the proposed approach the nodes in the environment is 50 Numbers and the size of the network is 50*50 m^2.

7.2. Broadcasting of packets for Node Identification

The Base station broadcast the Hello packet in the network. After receiving the packet, it calculates the time to reach the node from the base station.

7.3. Calculated Time transmit to Base Station

The nodes in the network send the acknowledgement to the base station. In this acknowledge packet, it holds the information related to the Node-ID, Energy and Time and sends it to the base station. After receiving such packet it calculates the distance based on the time and speed. The routing information is constructed based on the information received from the nodes in the network.

7.4. Broad Casting of Routing Information

The constructed routing information is broadcasted to all the nodes in the network. After receiving the information, every node updates its Routing table. The routing strategy is taken based on the routing information in the routing table.

7.5. Detected Event Forwarded to the Base Station

Once the event detected by the sensor nodes, it may act as source node. It transmits the sensed data to the base station based on the Mean Measure Mechanism. Here the packets are delivered to the base station. In that it holds not only the sensed information, it also holds the energy level of the target node and Node_ID.

7.6. Update the Routing Information by Broadcasting

The change in energy level of the node in the network is updated by broadcasting the update information by the base station. The base station broadcasts the update routing information packets to all nodes in the network.

8. CONCLUSION

The proposed protocol EEDRP selects routes based on energy efficiency of the nodes in the network by mean measure approach. The distance based energy efficient routing reduces the time and energy in WSN. The energy consumption of the node in the network is well balanced and extending the survival time of the WSN. In this protocol, the time delay was reduced, the energy consumption by the nodes in the network is low and it increases the lifetime of the network compared to other conventional protocols like HPSD (High Power Short Distance) Protocol and LEACH (Low Energy Adaptive Clustering Hierarchy) Protocol.

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