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Energy Efficient Routing and Data Collection in Wireless Sensor Network

Sivadurga K*, Sona G**
*(PG Scholar, Dept. of Computer Science and Engineering, Government College of Engineering, Tirunelveli)
** (Assistant Professor, Dept of Computer Science and Engineering, Government College of Engineering, Tirunelveli)

Abstract
The Wireless Sensor Network (WSN) plays a vital role in different fields ranging from industry to military. WSN is an infrastructure less network which is structured in ad-hoc manner. In WSN nodes are self-configurable and works autonomously. The nodes are deployed in the area where it senses the environment and sends data packets to the base station via the cluster head. The nodes are partitioned into clusters and cluster heads are selected for each cluster which is mobile. Routing the data packets from sensor nodes to the base station in an optimized energy efficient manner is the major challenge. Researchers today are working on the wireless network and suggesting solutions. Considering the network lifetime, energy consumption, delay and throughput, this proposes an energy efficient routing protocol that optimizes the routing of the data packet. This will provide a better improvement in the above given metrices when compared to the existing system.

Keywords — **Routing, energy efficient, clustering, WSN, ad-hoc network.**

I. INTRODUCTION

Advancement in wireless communication technology has led to the development of WSNs. WSNs are formed by sets of distributed autonomous devices with several distinct characteristics to sense, process, transmit and receive observed or measured condition. Due to its smart sensing capability, inexpensive and small size, it is easily deployed in the area of scalable network environment. In simple, sensor nodes are made up of sensor components that will sense the physical surroundings and measure the observed situation while the microprocessor component intelligently compute the sensed information. The communication between the neighbouring nodes takes place with the help of wireless radio embedded in the nodes. A large number of sensor nodes are deployed to cover the network area as single node can give only a limited amount of information.

WSN has been distributed in the network field widely for various purposes such as monitoring the environment by remote, health care monitoring and monitoring the air quality. By deploying large number of heterogenous low powered sensors, WSN can collects the information it needed from the distributed environment. This key features of WSN helps to realize the Internet of Things (IOT) and green communication era. By the battery capacity of the sensor nodes, the network lifetime is greatly restrained in WSN. In recent years many efforts have been made to reduce the energy expenditure by focusing on exploiting energy to diversify energy supply. Among this, energy harvesting method in WSN has received the attention as it has the ability to extend the lifetime of WSN. Each sensor nodes in the network field of Wireless sensor network can harvest energy such as solar and wind power from the environment and thereby providing unlimited energy supply to every node in the network. This is achieved by the use of energy harvesting unit and energy buffer. This type of network is referred as Energy Harvesting Wireless Sensor Network (EH-WSN). In hyper cellular network, Sustainable energy supply techniques have also been suggested. Wireless energy transfer and energy cooperation can be used in various applications.

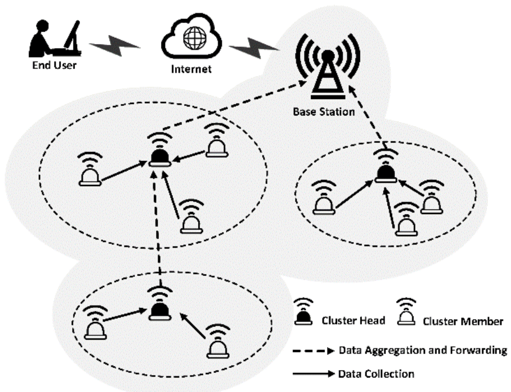

Fig 1: WSN cluster formation

A WSN is a network consisting of sensor nodes that are spatially distributed, self-configurable autonomous devices. These nodes cooperatively monitor physical environmental conditions such as moisture, temperature, pressure, sounds and vibrations, motions at different locations. Initially wireless sensor network was developed for military applications such as battlefield surveillance. Later it has its uses including health care, environment monitoring, fire detection, home automation and traffic control.

II. LITERATURE SURVEY

A. S. Alshawi, et al, "lifetime enhancement in wireless sensor networks using fuzzy approach and a-star algorithm".

Wireless sensor networks are used in various applications for gathering the sensitive information and forward that to the base station for the purpose analysis. Limitation in resources have to be considered while designing the sensor network. The unbalanced energy distribution in the node is the major issue characterized by the multi-hop routing. This unbalanced energy distribution will lower the lifetime of the network.

In this a novel routing method was proposed using the combination of fuzzy approach and star algorithm to extend the network lifetime. This determines the optimal routing path from source node to destination node by considering the minimum number of hops, minimum traffic loads and highest remaining battery power. To demonstrate this, two different topographical areas is chosen and the same routing criteria is used.

B. C. Cassandras, et al, "optimal routing and energy allocation for lifetime maximization of wireless sensor networks with nonideal batteries".

The major goal in sensor network is to maximize the network lifetime. The problem in routing is solved by an optimal control approach. The analysis provides that the batteries in the sensor nodes are not assumed to be in ideal rather it behaves according to the dynamic energy consumption model. In fixed topology case, there exists an optimal policy. It has time invariant routing probability that may be obtained by solving nonlinear programming problems. This optimal policy is robust with respect to the battery model used, under very mild conditions. Further, joint routing and initial energy allocation problem over the network nodes is considered. The solution is given by the policy that depletes all node energy at the same time and the corresponding energy allocation and routing probabilities are obtained by solving an NLP problem.

III. EXISTING SYSTEM

One of the major issues in IoT devices is the cost of servicing and maintenance of the large numbers of sensor nodes that are deployed in the network area. Replacing the batteries of the sensors is a tedious job. For instance, a sensor that to be deployed on the animals or species for the purpose of monitoring, is achievable by placing the battery that outlive for years.

LEACH protocol has been intensively modified by many researchers for improving the network performance. It is the combination of clustering architecture and provide multi-hop routing. Researchers today are concentrating to provide enhancement in the existing algorithms for the betterment of the IoT system. An energy-efficient method was discussed for WSN based IoT networks which uses risk strategy analysis to reduce network overhead.

- The existing LEACH clustering algorithm involves two stages:
  - Set-up phase
  - Steady-state phase
- The set-up phase is where the node is deployed and clustering of nodes takes place by dynamic clustering schemes, then CH is selected per clusters which is responsible for collecting the data from the sensing node.
- The steady-state is where the actual data routing occurs. The collected data is forwarded to the BS via CH of the network.

IV. PROPOSED SYSTEM

A. Overview

The main phases of the proposed framework consist of initial network deployment with nodes, cluster management and data routing between node and BS. In the first phase, initial routing procedure is carried out in order to obtain the neighbour nodes information and this can be stored in the local table of every node. The aim of this phase is to perform energy-efficient clustering scheme using mobile cluster head and also presented a paradigm to retains the near optimal paths for data forwarding towards the existing position of the mobile CHs.

The proposed scheme mainly focuses on the relay node (CH) that will be triggered to perform the relocation process. Besides this, the operation of the WSN's environment monitoring needs to incorporate the routing procedure for reporting the sensed data to the sink node from the source node in an energy consumption model. In phase I, the energy consumption model for message relaying is described. Then, maximum capacity path (MCP) is adopted in MH-LEACH and it is illustrated using a routing example.

- The dynamic routing protocol known as maximum capacity path (MCP) is the underlying routing protocol of the proposed MH-LEACH.
- The MCP mainly consists of three steps. They are,
  - Layering graph G into layered network N;
  - Determining the MCP for sensor nodes;
  - Performs routing and updates residual energy.
- The MCP will performs these steps iteratively for each round in message reporting.

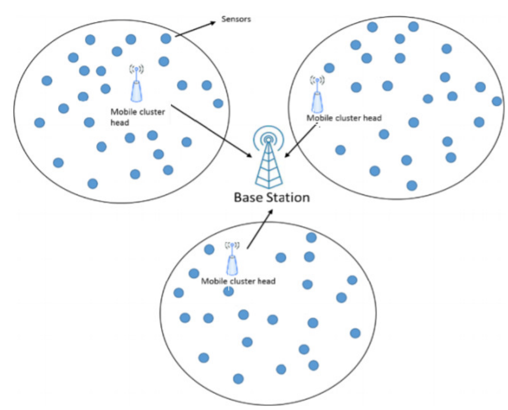

Fig 2: Sensor network using MH-LEACH protocol

B. Advantages

- The data is fused in order to reduce the data traffic.
- Energy balancing performance is improved.

- More number of resources can be sent at a time.
- The range of transmission is high.
- It provides improvement in network performance such as residual energy, network lifetime and throughput.

C. Block diagram

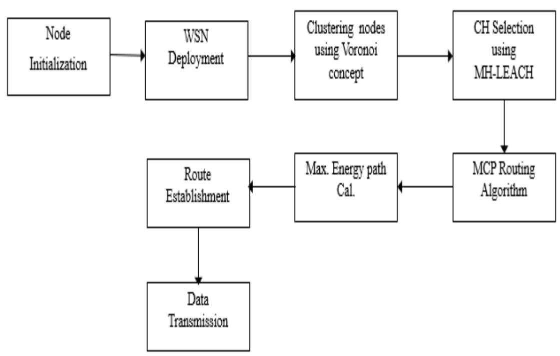

Fig 3: Block diagram

The energy saving is the design issues in improving the network lifetime of WSN. Routing protocol for message reporting to the sink in WSN can generally be classified into two categories: static routing and dynamic routing. The static routing protocol routes the data in a predetermined message reporting path to the sink at any time whereas the dynamic routing protocol routes the data by altering the routing path for each round according to the current state of the sensor node's residual energy of the battery. Due to this fact, dynamic routing protocols can balance the load on each sensor node and prolongs the network lifetime than static routing protocols.

In the proposed work, dynamic routing protocol called Maximum Capacity Path (MCP) is used which is the underlying protocol of MH-LEACH protocol. The MCP works well in prolonging the network lifetime in WSN. The following are the procedures that illustrates the MCP routing algorithm.

A WSN and sensor node's current residual battery energy state can be modelled by a graph G = (V, E), where set V denotes the sensor nodes and E denotes the direct communication between the sensor nodes. Let r: $V \rightarrow R^{+}$ be the residual battery energy function that represent each sensor's residual battery energy.

For example, consider node 's' which is a sink node has infinity energy. It may plug into the power line or equipped with an extremely large capacity battery when compared to other sensor nodes. There is a node 'a' which has current residual battery energy of value equal to 50.

The detailed operations of the MCP are,

- Let level number Lv with respect to each sensor node v ∈ V denotes the shortest path length from v to the sink s.

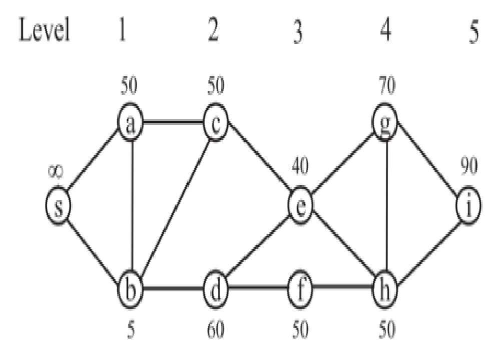

Fig 4 Initial node deployment

- For the example in Fig. 4, since the shortest path length from nodes g and h to node s are both 4, Lg = Lh = 4. The layered network *N* can be obtained from graph *G* by deleting the edges (u,v) ∈ E such that Lu = Lv.
- For example, as shown in Fig. 3.4, since La = Lb = 1 and Lg = Lh = 4, then edges (a, b) and (g, h) will be deleted from G. Then the layered network N obtained from G is a directed graph, such that for all of the remaining edges (u,v) ∈ E after the deleting operation, the directed edge (u,v) from node u to node v, if Lu = Lv + 1.

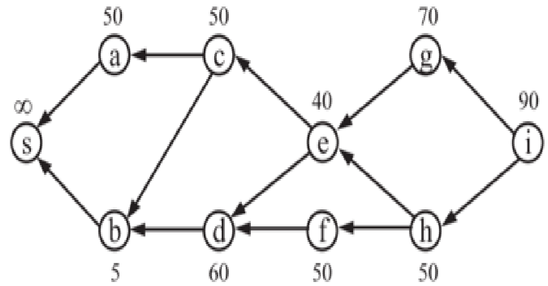

Fig 5 Removing the links between nodes

- Fig. 5 shows the resulting network obtained from *G* in Fig. 4. Let Pus = u, u1, u2, ..., ul, s be a path from node *u* to the sink s in N. And we let the capacity c(Pus) of path Pus be the minimum value of residual battery energy in path Pus; that is, c(Pus) = min {r(u), r(u1), r(u2), . . ., r (ul)}. Let P * us be the maximum capacity path with the maximum capacity value among every path from node *u* to *s*. The resulting graph of the union of each maximum capacity path P * us, ∀u ∈ V will be the routing paths for message reporting.

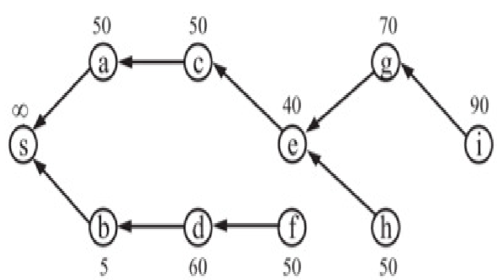

Fig 6 Selected Maximum Capacity Path

- For example, Fig.6 Shows the resulting maximum capacity paths obtained from the layered graph N of Fig.5 the above operations are the second procedure steps of the MCP.
- Now, as a sensor node u detects an abnormal event or has sensed data to report to the sink node *s*, and then the message will be relayed along the maximum capacity path P * us to s. For example, the maximum capacity path P * gs = *g*, *e*, *c*, *a*, *s*. After the message relaying from node *g* to s along path P * gs, the residual battery energy of each sensor node in the path is updated accordingly. The above three procedure steps will be repeated for each transmission round until one of the nodes drains out its battery energy.

V.IMPLEMENTATION AND RESULTS

A. Implementation of wsn

The wireless sensor network is created with multiple heterogeneous nodes. All the 40 nodes are configured and are deployed randomly in the square shaped network area of 1400 X 1400 units. As it is a WSN, every node in the network is assigned with initial energy, transmission energy and receiving energy. The communication protocol is implemented. Sender and receiver nodes are selected randomly and the communication between them is initiated.

All the nodes in the network is configured to exchange the location information and the initial energy information among the nodes. The base station is configured with highest communication range and it has the energy which is higher than every other node in the network. As it is the central controller of the network, it may connect to the power line or given energy which outlive for years. Data transmission is established between nodes using UDP agent and CBR traffic.

To enable all the nodes in the network in order to get the global energy model, MCP algorithm is proposed under the dynamic battery model. There exists an optimal policy consisting of time-invariant routing probabilities in a fixed network topology and this policy can be obtained by solving a set of problems.

In this dynamic routing protocol MCP is used to find the optimal energy efficient path in order to provide the efficient the data transmission. The MCP is adapted to the MH-LEACH to perform dynamic routing based on the current energy level of the node in the sensor network.

Table 1: Simulation parameters

PARAMETER	VALUE
Simulator	NS2
Simulation time	10s
Area	1400X1400
Number of nodes	40
Physical Layer	IEEE 802.11
Routing protocol	AODV / MH-LEACH
Mobility model	Random way point
Radio type	802.11a/g
Transmission rate	10 packets/s
Packet Size	512/ 1024
Pause time	0s

The cluster formation is based on the dynamic clustering technique in MH-LEACH. The nodes in the network is clustered together based on the location. There is CH which is mobile that will move around the clusters. The CH selection is based in the initial energy, transmission energy and residual energy of the node. As CH is mobile it can be recharged when the energy of the CH battery drains out.

B. Performance Analysis

The performance of the proposed work is analyzed based on the graph. The X-graphs are plotted with basics parameters. Throughput, delay and energy consumption of the node are the parameters considered here. This is compared with previous results and final result is concluded.

VI. CONCLUSION AND FUTURE WORK

A. Conclusion

Many researches have been done in designing the routing protocol for wireless sensor network based on the energy of the node and network lifetime constraints. Choosing an energy efficient routing algorithm that evenly distributes the load in the network is a big deal. Keeping a mobile cluster node is another approach for improving the network lifetime that would not remain in the same place for longer period. This approach can also integrate the LEACH routing to enhance the network lifetime performance. The CH relocation method was proposed, which adopts multi-hop low energy adaptive clustering hierarchy routing method for message relaying. Experimental analysis given in this demonstrate that MH-LEACH can extend the network lifetime in WSN. It improves network performance metrics such as energy consumption, end-to-end delay and throughput.

B. Future Work

In future this work will be extended by considering the security constraints for wireless sensor networks and designing the routing protocol that can achieve secure trade-off between the nodes in multi-hop sensor networks.

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[16] Figure 1 source: communication pattern for clustered wireless sensor networks<https://www.mdpi.com/sensors/sensors-1700998/article_deploy/html/images/sensors-17-00998-g001.png>.

[17] Figure 2 source: Haseeb 2019, wireless sensor network with mobile cluster head and BS, < https://www.google.com/url/www.semanticscholar.orgFIntrusion-Prevention-Framework-for-Secure-Routing>.

[18] Figure 4,5,6 source: Multiple capacity path procedures < https://www.ijert.org/research/sink-relocation-for-lifetime-elongation-in-wireless-sensor-network>.

