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Optimal Path Selection Using Dijkstra's Algorithm in Cluster-based LEACH Protocol

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ABSTRACT

Wireless Sensor Networks (WSNs) consists of thousands of sensing nodes, also known as motes, which are powered by battery to communicate with one another. They are deployed at remote location for continuously checking the environment to collect data. WSNs are used in many areas, i.e. surveillance, forest fire monitoring, healthcare and industrial automation. These nodes sense the environment for data and send to a sink node, also known as base station. In these networks, optimal paths need to be determined for efficient flow of data. Power optimization based on optimal path selection is a major concern/ issues in WSNs. In this paper, we present optimal path selection based on Dijkstra's algorithm. Furthermore, we calculate the load experienced by Cluster Heads (CHs.) We proposed a hybrid algorithm/ technique, which is the combination of load of CH's and optimal path selection using Dijkstra's algorithm.
KEYWORDS*:* Wireless Sensor Network, Cluster Head*,* Dijkstra's algorithm, Optimal Path Selection

I. INTRODUCTION

In the last decades, wireless sensor networks (WSNs)have been evolved due to the rapid development of wireless technologies. The WSNs consist of a number of sensing nodes that can continuously check a specific region based on phenomena of interest, also known as events. A sensor node is a small hardware device with a processing unit, communication, sensing and power unit, used for information processing. These small nodes sense data and forward it to the head node, known as Cluster Head (CH). A Cluster Head transmit information to the sink node. Many clustering algorithms have been proposed in literature for efficient communication and scalability. A node which has a higher energy, also known as sink node, can be used to send data, whereas, a node that is low energy, also known as member node, which are used for sensing of data. Some of the widely known protocols are LEACH [1], LEACH-C [2], PEGASIS [3] and APTEEN [4].

In order to improve/ increase the life span of wireless sensor nodes [5], cost-efficient paths need to be detected using Dijkstra's algorithm. The Dijkstra's algorithm determines the shortest distance between different nodes, i.e., least cost associated paths, between a source node and its neighbor [6]. In this paper, we apply Dijkstra's algorithm for finding the shortest/ efficient path from CH to the base station to reduce power, i.e., more energy utilization, of the sensor devices, and also find the load experienced by each CH.

This paper is organized as follows. In Section II, we demonstrate a concise overview of related work. In Section III, we present our proposed algorithm for optimal path selection in wireless sensor network. Finally, we conclude our work and provide future directions in Section IV.

II. RELATED WORK

Energy or power is a scarce resource of wireless sensor network's nodes. The limited energy/ power of the sensing nodes is one of the major problem, faced by the design of wireless sensor network. The power consumption problem in WSN's is addressed by several researches.

In[3], individually sensor nodes uses the signal strength to menstruate the distance/ space to all members' nodes so that only one node can be heard. They have proposed a protocol known as "PEGASIS" (Power-Efficient Gathering in Sensor Information System). This protocol constitutes a chain, which is made of those sensing nodes, which are closest to each other and form an efficient route to the sink node. It eliminate the overhead caused by dynamic cluster formation in LEACH. However, the single leader can create bottleneck problem.

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Preserving energy is a major issue in WSNs. In LEACH protocol, the probability consistent to number of cluster heads. LEACH consist of different/ many rounds, each round has two phases, i.e., a set-up phase and a steady phase. In set-up phase, selection of cluster heads, and in steady phase, the cluster head transmits data from sensor nodes to a base station. Clusters heads are used to perform data aggregation before forwarding data to the base station or sink node. Clusters formation is the job of CH, which are then responsible for data transmitted, as shown in Fig (1).

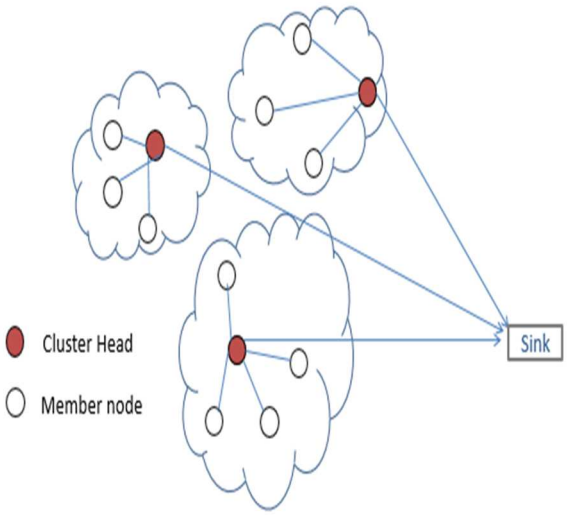

Fig 1. Clustering in LEACH [1]

In [7], optimal path selection algorithm is represented. It is based on Chandy-Misra's distributed structure/ model regarding node weight and edge weight. They use the concept of minimum spanning tree (MST) with some percentage value of weights. Also, keep/ hold the criticality of the sensor node if its energy/ battery power is below/ low a certain level. They proposed a formula, which is effective up to some extent because of its real-time conditions and re-execution of algorithms if the energy/ power level become decreases or low. As a result, the proposed scheme generates energy efficient path always.

In [8], using directed diffusion, the authors proposed a potential path from data sources (member node) to the base (sink node). However, network endure is important metric of the approach. Therefore, the distance based on cost of each path is measure and keep in the routing table. At every point of time, path is selected based on routing table with relating cost on each path. The greater the cost/ distance path have less the probability/ chances of selection. The proposed scheme increases network lifetime by 44%.

In [9], the authors designed a shortest path for ad-hoc network using LEACH for energy-efficient routes. They developed an algorithm for mobile node, in the role of CH. The path design using a technique called “AMR” (Adjacency Matrix Reduction). Simulation result shown that the proposed algorithm is suitable for ad-hoc networks. The major problem associated with their proposed scheme is the energy consumption.

In [10], the authors proposed a new scheme called “EBGR” (Energy Beaconless Geographic Routing WSN’s), which are completely stateless, loop free and efficient power utilization sensors to sink node, routing at a low communication overhead without the help of neighborhood knowledge. So, no packet loss and no failure in greedy forwarding.

In [11], the authors proposed a novel strategy named as “OPEAS” (Optimal Path and Energy Efficient Aware Sensor) which can use different parameters to minimize the number of broadcasting messages. These two main design features of OPEAS leads to reduce power consumption compare to the ARPEES and related algorithm of similar category. Their simulation results show that the OPEAS achieve better packet loss rate than ARPESS and other similar protocols. Therefore, it reduces broadcasting messages during the relay sensor node selection. It achieves better energy consumption but the problem is the packet loss rate is higher than the other.

In [12], proposed O-LEACH protocol which is more efficient than LEACH protocol and it uses static deployment technique. They evaluate three protocols AODV, LEACH and O-LEACH. These protocols has been tested by using four fraction energy/ power utilization of end-to-end delay, throughput, rate of packet delivery ratio, and consider that O-LEACH is energy efficient than LEACH. Cluster formation has been decided by knowing the

position of node so least power is required for cluster formation. In this protocol overhead is increases by finding the suitable position for cluster head.

III. PROPOSED WORK

In this paper, we present an efficient novel concept to minimize power consumption or energy utilization for the transmission of data in WSN's. Proposed concept is the combination of optimal path selection/ finding using a well-known algorithm called Dijkstra's and also calculating the load of CH's. The flowchart of our proposed concept of clustering algorithm is shown in fig (2).

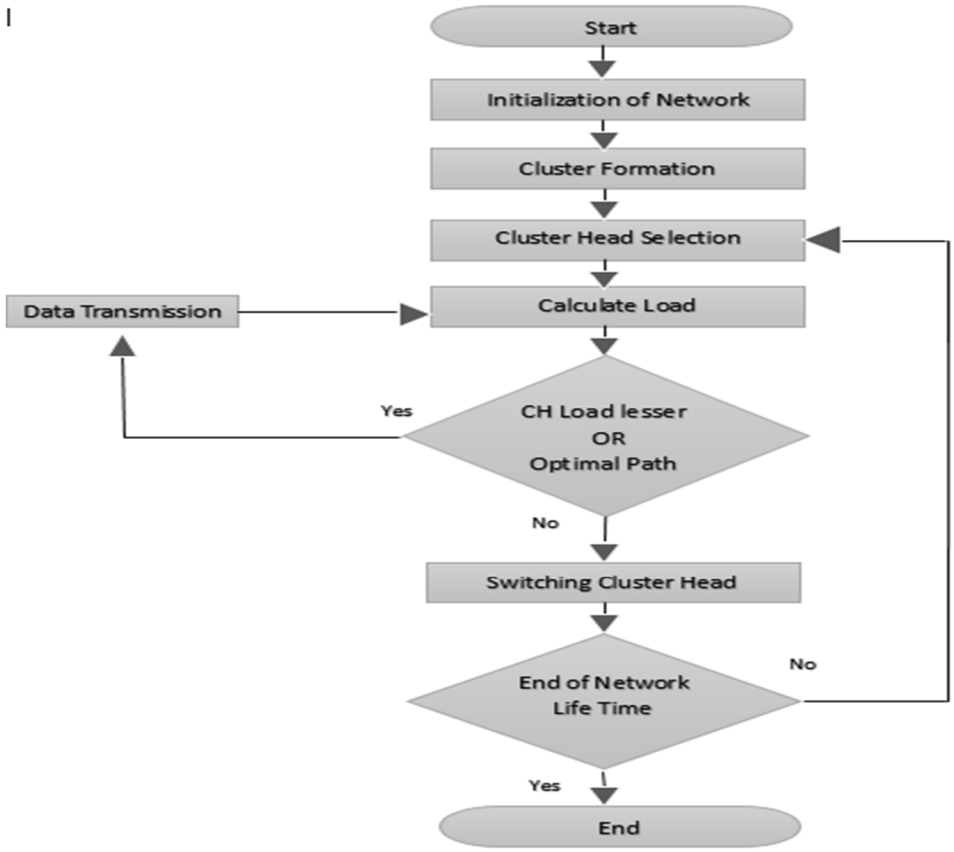

Fig 2. Flowchart of Proposed Concept.

In this proposed methodology, first we creating/ initialization of the network means here we will form a network by dropping several nodes regardless of their position. Second we select random nodes as a source and to act as a CH in order to begin transmission of data, and cluster formation according to OPEASRP methodology, to calculate load on each sensor node using LEACH algorithm [13][11]. Third, selection of cluster heads (CH). Fourth, Load calculation means a load on each node is taken in WSN's can be defined as number of transmitted packets are counted with respect to total number of packets submitted during a period of time. Mathematically,

Load = no. of packets released / total no. of packets

In OPEASRP, load is a onetime task, which is done when network is starting or a new node is added to a network [11]. Fifth, check the load of any CH if the load of the selected cluster head is lesser they selected to be in the path to BS [13], or if a node find optimal path using, Dijkstra's algorithm if they find optimal path transmit the data either use the optimal path or by using the load. In this paper, we combine the load and Dijkstra's algorithm for path finding if any one of these two condition is true start data transmission, which is energy efficient and effective. Which is better than the other previous implemented algorithm for LEACH protocol.

Our proposed algorithm, will calculate load of each cluster head (no. of packet released / total no. of packets) and find optimal route using well-known algorithm called Dijkstra's. For the selection of cost lowest path between sensor nodes Dijkstra's is one of the best solution. It gives single-source shortest paths problem when all links/

nodes have non-negative weights. Algorithm begins at source vertex S. Q is the queue is initially contains all vertices, loop until the queue is not empty, if the distance become minimum or low then select one of the element from the Q. If new optimal/ shortest path is found set new value of shortest path [14].

Algorithm of Modified LEACH

Set-Up State

```
r = rand(0,1);//generate random number between 0 and 1
 If(InitialEnergy> 0 && r mod(1/p) ≠ 0) then
CalculateT(S)
      If ( r < T(S)) then
   CH{s} == True; // then select s be a CH
     else
CH{s} == False;// otherwise, s not be a CH
endif
endif
 If (CH{s} == True ) then
Broadcast Message (Advertisement);// broadcast message to neighbor sensor nodes
Join(IDi); // receive the broadcast message to all the member nodes with strongest signal and join their id and send back to CH
Cluster Form(c)
endif
```

Steady-State Phase (Modified/ Enhanced)

```
If( CH{s} == True) then
Calculate( load of cluster heads );
If(load of cluster heads is lesser OR find shortest path using Dijkstra's algorithm ) then
    Start data Transmission until condition is true
else
   Switching the Cluster Heads
If( end of network life time == True) then
    end/ stop the network
else
Start next round
endif
```

In this proposed algorithm each rounds is consist of two states/ phases. Set-up phase and a Steady state phase. In a set-up phase node decides that it will become a CH on not. This decision is based on the node served as a CH for a last time (node that has not been CH for long time is more likely elect to become a CH). If a CH is made it generate an advertisement message/ signal/ packet to all the neighbors nodes that they selected as a CH. All nodes that are not CH pick/ receive the advertisement packet with the strongest signal strength. In the next to set-up phase, the member nodes informs the CH that they are the member of that Cluster (CH) with their ID join with packet.

In Steady state phase, if CH is selected then calculate the load on each cluster heads (load can be calculated by number of packets released divided by total number of packets). Checks if the load in each cluster heads is less so they can be selected in path to base station (BS) or find the optimal path/ route using well-known algorithm called Dijkstra's algorithm. In this algorithm, we use both (load and Dijkstra's) to find the best route to BS, which is energy efficient. If anyone of these two conditions is true, optimal path will be found which gives better result in terms of energy/ power or performance of wireless sensor node.

IV. CONCLUSION

LEACH protocol gives better solution for clustering in WSN's. The paper focused on the problems of energy as well as optimal path selection to decrease the power/energy consumption of sensor nodes of LEACH protocol. We proposed an algorithm for selection of optimal path and for checking the load on each sensor node, which gives better results related to power and performance using this hybrid technique.

V. FUTURE WORK

In the future, we implement this algorithm practically to prolong the network lifespan and to reduce the power consumption among the sensor nodes in wireless sensor networks.

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