A Literature Survey of Energy-Efficient Clustering in WSN Using Different Variant of LEACH Routing Protocol

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Abstract—In Recent Wireless Technology, Less Energy Consumption Design and New Wireless Technologies have Produced Very Important Applications for Wireless Devices. These Type of Application Covers Very Large Area and also Use for Real Time Transfer of Large Data from one Device to Another, Due to this Kind of Application WSN Generally Suffering from Resource Constraints. Nodes are General Battery Powered. This Makes Application with Limited Energy so it is Very Critical to Operate Sensor Network for a Long Time. Data Aggregation is a Technique in which Data are collected from multiple sources and expressed in compressed form. This Compressed form is nothing but summary of collected data. The amount of traffic will reduce due to data aggregation. Hierarchical-based Routing Protocol is efficient and absolute Solution to this Problem. LEACH is Hierarchical-based Clustering Routing Protocol that utilizes Randomized Rotation of Cluster-Heads to evenly distribute the Energy Load among the Sensors in the Network. In this paper Different Variant of LEACH routing Protocol are included which are Categorized Base on following Topics: (1) Different Method of Cluster Head Selection (2) Load Distribution (3) Reliable (4) Synchronization.

Key words: Wireless Sensor Networks (WSN), Routing protocols, Energy Efficiency, LEACH, Network Life time Different Method of Cluster Head Selection, Load Distribution; Reliability, Synchronization

I. INTRODUCTION

Wireless Sensor Networks (WSNs) is a group of specialized Sensor Device which are used to Monitor Physical conditions i.e. static or dynamic. The measurement of static events is very easy to carry out, but Dynamic events are generally non-cooperative event like movement of an unwanted vehicle in a battle field and the movement of whales in the ocean. They are not easy to monitor and they are not stable as they go up and down.

Wireless sensor network (WSN) has attracted considerable attention, since it has a wide range of applications, such as security, environment monitoring and military systems. Wireless sensor networks (WSNs) usually contain thousands or millions of sensors. Placement of a sensor network in these applications can be in arbitrary fashion (e.g., released from a helicopter) or can be fixed manually (e.g., fire alarm sensors in an office). Information about the environment is collected by the sensors and is provided to a central base station where the operator can extract the preferred data. Wireless Sensor networks (WSN) is a large network which is consist of huge number of sensor nodes and these nodes are directly interacting with their environment by sensing the physical parameters such as temperature, humidity, etc. All the sensor nodes send or receive data to/from a fixed wired station called base station (BS). The base station usually serves as a gateway to some other network. WSNs have a comprehensive range of applications in this field including; industry, medical, industry and agriculture, environmental applications, military applications, home security, Civil Structure Monitoring etc.

In Wireless Sensor Networks (WSN), Sensor nodes (Tiny Device) which are also used to monitor environmental conditions (i.e. pressure, temperature, motion and sound) and send these information to a central computing system, called the base station or sink. This kind of sensor nodes are normally batteries Powered, So Node having a very Limited Resource in terms of energy. Due to This, Routing protocols in wireless sensor network are designed in such a way that they keep the network life time for a longer period by efficiently utilizing the available resources.

A. Flat-Based [1]:

In Flat Base Routing Protocol All Node Play Same Role and coordinate to relay the sensed packets to Base Station.

B. Hierarchical-Based [1]:

In Hierarchical routing protocols, they Create clusters and an assigned head node. Head node collection and aggregation of data and transmitting data to the BS.

C. Location-Based [1]:

In Location-based protocols utilize positional information to deliver data to some desired Destination.
LEACH is Hierarchical Based Routing Protocol.

There are many survey retreated to LEACH routing protocol \cite{14}\cite{15}\cite{16}\cite{17}, but we would Like to Categorized LEACH Protocol Base On following topics: Different Method of Cluster Head Selection, Load Distribution, Reliable and Synchronization. In this Category we have also include few more Technique which are not mentation by previous reviewer \cite{4}\cite{5}\cite{6}\cite{7}\cite{9}\cite{10}\cite{11}\cite{13}.

The rest of the paper is organized as follows: Section 2 briefly reviews Different Variant of LEACH routing protocol, Open Discussion is covered in section 3. In section 4, we have conclude our work.

II. LITERATURE REVIEW

A. LEACH (Low Energy Adaptive Clustering Hierarchy):

Wendi Rabiner Heinzelman, Anantha Chandrakasan, and Hari Balakrishnan \cite{2} introduced a hierarchical clustering algorithm for sensor networks, called Low Energy Adaptive Clustering Hierarchy (LEACH) \cite{2}. LEACH arranges the nodes into small clusters and randomizes Selection of one of them as the cluster-head with a certain probability. Cluster-head Collect Data Form Non-cluster-head Node and transmits the compressed data to the base station.

The operation of LEACH is broken up into rounds, where each round Starts with a set-up phase when Selection of cluster-head and clusters are organized, followed by steady state phase in which actually data transfers between cluster head to the base station Happen. There is no Collision Due To CSMA code which is generated by cluster-head and cluster head allocate TDMA slot for each and every Node in Cluster. In LEACH CH selection is random process and LEACH does not work well with the applications that require large area.

This protocol is divided into rounds; each round consists of two phases;

1) Set-Up Phase:
- Advertisement Phase
- Cluster Set-up Phase

2) Steady Phase:
- Schedule Creation
- Data Transmission

B. Setup Phase

Each node decides independent of other nodes if it will become a CH or not. This decision takes into account when the node served as a CH for the last time (the node that hasn’t been a CH for long time is more likely to elect itself than nodes that have been a CH recently).
\[ T(n) = \begin{cases} \frac{P}{1-P^{r \bmod \frac{1}{p}}} & \text{if } n \in G \\ 0 & \text{otherwise} \end{cases} \]

- Where,
- \( P \) is the desired percentage of cluster heads,
- \( r \) is the current round and
- \( G \) represents the set of nodes that have not been selected as CHs in last \( 1/P \) rounds.

In the following advertisement phase, the CHs inform their neighborhood with an advertisement packet that they become CHs. Non-CH nodes pick the advertisement packet with the strongest received signal strength.

In the next cluster setup phase, the member nodes inform the CH that they become a member to that cluster with "join packet" contains their IDs using CSMA. After the cluster-setup sub phase, the CH knows the number of member nodes and their IDs. Based on all messages received within the cluster, the CH creates a TDMA schedule, pick a CSMA code randomly, and broadcast the TDMA table to cluster members. After that steady-state phase begins.

- Based on \( T(n) \), threshold, CHs are selected
- All CHs broadcast ADV message to all non-CH nodes
- All non-CH nodes select their CHs, based on RSSI of ADV message
- After selecting cluster, it (non-CH node) sends Join-REQ back to CH Now, CHs create TDMA schedule & send it to the all non-CH nodes

C. Steady-State Phase:

Data transmission begins; Nodes send their data during their allocated TDMA slot to the CH. This transmission uses a minimal amount of energy (chosen based on the received strength of the CH advertisement). The radio of each non-CH node can be turned off until the nodes allocated TDMA slot, thus minimizing energy dissipation in these nodes.

When all the data has been received, the CH aggregate these data and send it to the BS. LEACH is able to perform local aggregation of data in each cluster to reduce the amount of data that transmitted to the base station.

- Sensor nodes begin sensing & transmitting data to CHs as per their TDMA Schedule
- After receiving data, CHs aggregates data to the BS in one-hop manner, thus reducing the no. of transmissions & hence saving energy
- After certain time, NW goes back to set-up phase again & enters another round
- Each cluster communication, using different CDMA codes to reduce the interference from other cluster nodes

D. Improved CH Selection Methods:

1) AI. K-LEACH:

K-LEACH \[3\] is divided into many rounds, and each round contains cluster formation phase and Steady state phase. In cluster formation phase clusters are Create using K-medoids cluster formation algorithm and cluster heads are selected as a node which lies at the center or nearer to the center of cluster using Euclidian distance. In remaining rounds nodes nearest to the cluster head of the previous round selection is chosen as cluster head. In Steady state phase actually data transfers between cluster-head to the base station happen during it’s allocated time slot which Was Broadcast By CH.

The stability period of the K-LEACH is higher than LEACH but selection of CH based on Only Euclidian distance, So Lower Energy Node Become CH due to Euclidian distance.

2) En-LEACH (Enhanced LEACH protocol):

The operation of En-LEACH \[4\] protocol is broken into rounds, where each round exclude Cluster Set-up Phase, Schedule Creation Phase and Steady-state Phase (Data Transmission Phase).

In Set-up phase, for First round (i.e. round zero) Selection Method of CH are same as Used in LEACH Protocol. In this if the threshold value is greater than the random number chosen then the node becomes the cluster-head for this round.

Hence the probability of becoming cluster-head in round zero is given as,

\[ P(n) = p' (1-p^*(r \mod 1/p)) \]

But during other round the cluster-head is selected based on the residual energy left in node. Hence the probability of becoming cluster-head in other round is given as,

\[ P(n) = \frac{\text{Energy of node}}{\text{Total energy of the cluster}} \]

Working of Remaining Schedule Creation Phase and Steady State Start
state Phase (Data Transmission Phase) are same as Classic LEACH Protocol.

3) New Method for CH Selection [5]

In this paper, Author propose a modified model for CH selection which improves threshold values and also elects an optimal number of CHs in each round. Author presented schemes to improve the lifetime of LEACH protocol by including current energy level of the nodes in Threshold Equation T(n).

Hence, the above Equation of T(n), modified to LEACH CURRENT [5] and is given below:

\[
T(n)_{\text{Current}} = \begin{cases} 
\frac{E_{\text{current}}}{E_{\text{max}}} & n \in G \\
0 & \text{otherwise}
\end{cases}
\]

Here, \( E_{\text{current}} \) is the current energy of the node in a specific round and \( E_{\text{max}} \) is its initial energy at the time of network deployment. When residual energy level of the nodes decreases and threshold value become too low. At that time, it becomes a challenging task for the nodes to be elected as CHs due to lower threshold value.

4) Improve Algorithm of Cluster Head Election:

In Classic LEACH protocol for cluster head election threshold formula are used but formula ignore the residual energy and density of node. So Author Proposed a paper “The improve algorithm of cluster head election based on LEACH” [6] in this paper they Include density factor and energy factor in Threshold Formula. Nodes have large density and Much More Residual Energy, that node will Select as Cluster Head.

Hence, New Equation of T(n) is given below:

\[
T(n) = \begin{cases} 
\frac{p}{1 - p \cdot (r \mod \frac{1}{p})} \cdot \frac{E_i}{E_{\text{avg}}} + \mu D(n), & n \in D \\
0, & \text{otherwise}
\end{cases}
\]

Node Density D(i) is the total Number in Neighborhood Of Node Nneighbour(n) accounts for the entire network number of nodes Nall. The energy factor Ei(n) is the ratio of the residual energy Erc of the node, with the initial energy Estra.

5) I-LEACH (Improved LEACH):

Most of LEACH algorithms do not consider properties of sensor nodes e.g., energy, location, distance to BS, and the number of neighbour in the selection of CH nodes. In order to select the appropriate CH nodes in the Set-up Phase, the Improved LEACH (I-LEACH) [7] algorithm takes important factors such as the amount of residual energy of each sensor node, position of the sensor node relative to the BS and the number of neighbours of each sensor node into account. Cluster Formation Phase and Data transmission Phase are Same as Classic LEACH.

Hence, New Equation of T(n) is given below:

\[
T(n) = \begin{cases} 
\frac{p}{Nbr_n \cdot d_{t0BSavg}} \cdot x \frac{\text{Esum}}{\text{Eavg}} \cdot \frac{Nbr_n}{Nbravg} \cdot \frac{d_{t0BSavg}}{d_{t0BSn}}, & S \in G \\
0, & \text{otherwise}
\end{cases}
\]

Ecur is current Energy of node, Eavg is the average energy whole network; Nbrn is the number of neighbours, Nbravg is average number of neighbor nodes in the network; d_{t0BSavg} is the average distance between sensor nodes to the BS, d_{t0BSn} is distance between sensor nodes to BS.

E. Load Distribution:

1) Enhanced LEACH:

Enhanced LEACH routing Protocol which are use to improves the energy distribution between sensor nodes. Enhanced LEACH [8] work as rounds and each round contains Setup phase, Pre-Steady phase and Steady State phase. Setup Phase and is same as Classic LEACH routing protocol.

The main Idea of Pre-Steady phase is to elect cluster member node that can handle the aggregation processes in the round. If not exist such a node then cluster head will handle the aggregation process itself. CH has responsibility to determine which node work as aggregator node. In Steady State phase cluster member nodes send their data to the aggregator node according to their time slots. When all the data has been received, the aggregator node sends it to the base station after performs data aggregation.

2) EEE LEACH (Energy Efficient Extended LEACH):

EEE LEACH [9] is multilevel clustering technique. Instead of using single layer of clusters formation between the nodes and Base station like LEACH, EEE LEACH Include two layers of clusters formation. In the first layer CHs are formed where the normal nodes transmit their own data to their respective CH and by using the data aggregation energy technique, CHs aggregate the received data. Again in the second layer Master Cluster Heads (MCH) are formed. After the formation of MCHs, CH transmit their aggregate data to the respective MCHs. MCH perform aggregation, transform them into a compress format and forward them to the base station (BS).

F. Synchronization:

1) OP LEACH (Optimized LEACH):

Every sensor node does not have data all the time. The data is available in random fashion. OP-LEACH [10] is utilizing the slots belonging to the node having no data to send. This method turns free slots into useful slots without making any changes in the TDMA schedule.

If it has data to transmit, it transmits to the cluster head during its time slot. If sensor node does not have any data to transmit it donates its slot to next node in the TDMA schedule and enters in to the sleep mode. If that node doesn’t have any data either, this slot and slot for that next node as well are allotted to the next node and so on until the TDMA frame is completed. OP-LEACH is utilizing allocated time slots but Required More Synchronization between Non CH and also required More Energy.

2) PR-LEACH (Percentage LEACH):

PR-LEACH [11] is divided into Round. In first round, Cluster Heads are selected randomly same as in Classic LEACH and then data transmission is performed. At the start of the second round each member node transmits its residual energy to it’s own cluster-head. Cluster-head Perform aggregation on residual energy of the respective members and transmits it with its residual energy to the nearest cluster-head. All clusterheads perform same Activity and residual energy reach to Base Station. The base-station
calculates the Network Energy Range (NER) from the minimum and the maximum energies and transmits it back to the cluster-heads, and cluster heads transmit to their member nodes. After Receiving NER value Node Can calculate the threshold cluster value (ThreValue). If the residual energy of node $\geq$ ThreValue, the node will be candidate to be cluster-head else it will be a normal node.

Hence, New Equation of ThreValue is given below:

$$\text{Thre value} = \text{Minimum energy} + (\text{PR} \times \text{NER})$$

Where, \text{PR} is Random Number Between 0 to 1

G. Reliability:

1) V LEACH (Vice-CH LEACH):

V LEACH [12] uses the concept of alternate Cluster Head called Vice Cluster Head. As a Cluster Head dies it is replaced by the Vice Cluster Head. In V-LEACH protocol, there is a vice-CH that takes the role of the CH when the CH dies because of its operation of receiving, sending and overhearing. Due to This cluster node data will always reach the BS; no need to elect a new CH each time the CH dies. This will extend the overall network life time. But in case of Vice Cluster Head Dies, it does not provide solution for that and the network start reducing the energy very fast and finally the network dies completely.

2) A CLUSTER BASED RELIABLE ROUTING PROTOCOL[13]

Initially a cluster is formed and the cluster head is selected based upon the cost value, CV calculated based on residual energy, and distance to coordinator node. Node with High CV selected as CH. The nodes in the cluster maintain a Neighbour information table (NIT) which containing Node id, Distance and Cost. This NIT information is sent to the cluster head. Each cluster selects a coordinator node (CN) randomly in the network which is closer to the cluster and monitors the operations of the sensor nodes and commands them for specific operations. Cluster-Head Node Perform Data Aggregation and sends aggregated Data to the Coordinator Node. The CN calculates the loss ratio which is the ratio of number of packets dropped and total packets broadcast from the Node. Based upon the loss ratio, the cluster size can be modified. CN send Data to BS.

III. DISCUSSION

We discussed Different variant of LEACH routing Protocol in this paper. There are already lots of papers which were published as improvement in LEACH routing protocol. Researcher had already done Good research in Different method of CH selection, Load distribution and etc. All variant of LEACH routing Protocol Perform as well as Compare to Classic LEACH routing protocol, but after surveying lots Of paper related to LEACH routing protocol we have identified that few work which was done base on reliability. There was not acknowledgement message for every communication which is happen between Non CH to CH, due to some environmental condition, message might be lost which was send by non CH. You can use acknowledgement message for every communication which is happen between Non CH to CH but these method required more number of message and more energy. These kinds of scenario become open Issue for Researcher. Every node in Cluster which is inside the coverage area of Head node can easily listen what is going on between CH to BS. If you modify Header of aggregated message which will indicate absent and present of non CH’s message than non-CH could easily listen Header format. If frame Header flag indicate absence of message than non CH have to retransmit their previous lost message in next frame. In this way you can improve your LEACH routing Protocol toward RELIABILITY.

IV. CONCLUSION

In this survey paper we have discussed LEACH and Different variant of LEACH routing which were categories Based on Different method of CH selection, Load Distribution, Reliable and Synchronization. In Different method Of CH selection consider properties of sensor nodes e.g., energy, location, distance to BS, and the number of neighbour in the selection of Cluster Head. The main Concept of Load Distribution is to reduce amount of load on Cluster-head. Node to have synchronization internally is for high Performance, which was discuss in synchronization. In last Section, some failure handling mechanism was included in LEACH to make it more reliable.

In 21st century there has been a growing interest in wireless sensor networks applications. One of the major challenges in wireless sensor network is to develop an energy-efficient routing protocol in order to increase network lifetime. The Low Energy Adaptive Clustering Hierarchy (LEACH) protocol and analyzed the protocol based on network lifetime, stability period and the network throughput. We have put in our survey period we studied briefly about LEACH protocols and we able to distinguish various disadvantages of this protocol along with its advantages. During our survey we also studied various improved version of LEACH protocol which gives various advantageous result in many ways which we are able to learn when we do the comparative study of various improve version of LEACH with the fundamental one. Finally, it can be concluded from the given survey that for an energy-efficient and prolonged wireless sensor networks, still it is needed to find more efficient, scalable and robust clustering scheme for better result.

V. ACKNOWLEDGMENT

I would like to thanks the faculty member of the Information Technology Department of L.J. Institute of Engineering & Technology, Ahmedabad and My Family, My friends.

REFERENCES


