Modification of Clustering based LEACH and LCM Protocols of Wireless Sensor Networks (WSNs)

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Abstract: Energy reduction is the major problem for routing protocols. In this paper we extended two cluster based routing protocols for the sake of improve in system life time of wireless sensor network. The two protocols studied here are: Low-Energy Adaptive Clustering Hierarchy (LEACH) and Link Aware Clustering Mechanism (LCM). LEACH does not consider the remaining energy of nodes when selecting cluster head (CH). When this node dies causes to operate, the entire cluster becomes inoperative. That is why we consider the node remaining energy when we selecting the CH. We set a pre-determined threshold when we select the CH, this is threshold concerned about node remaining energy. From our simulation results it is clear that the Extended-LEACH life time is better than that of LEACH. Its nodes are alive 100 times round rather than LEACH protocol. In this paper we try to improve the LCM method. In our work, we strive for implementing different nodes in different places. Our simulations demonstrate that the nodes which are far apart from the base station (BS) consume more power and the nodes which are near to the BS consume less power. We strive to find a path for selecting the cluster CH. An equation is proposed for choosing the CH. This CH directly communicates with the BS. In this paper we found a path to select the CH which is mostly near to the desired nodes. So we can get the information without wasting more power.

Keywords: Clustering Hierarchy, Sensor node, Ad-hoc network, Autonomous, WSN

1. Introduction

A. Sensor Node
A sensor node is a device which is capable of sensing information (sensing mean the perception that something has occurred or some state exists) around its surrounding environment; this information may be temperature, pressure, humidity and the like and convert this physical phenomenon into an electrical signal. The main component of a sensor node is sensing unit, power unit, storage unit, processing unit, transceiver unit.

B. WSN
A wireless sensor network (WSN) is one kind of wireless network which consists of a number of small, low energy consumed, self-sustaining and adaptive sensor node. Sensor nodes are capable of performed the specific job it has given. Sensor nodes are the live of a wireless sensor network. A WSN is a far distributed, autonomous, self-organizing network. It has needed no fixed infrastructure. It is one kinds of ad-hoc network. A WSN system incorporates a gateway that provides wireless connectivity back to the wired network and distributed nodes. A topical wireless sensor network architecture shown in Figure 1.

Figure 1: Wireless sensor network architecture

II. Reviews

A. Related Work
Heinzelman et al. [1]. Proposed the most popular clustering-based routing protocol named Low-Energy Adaptive Clustering Hierarchy (LEACH), then the proposed routing protocol is compared with minimum-transmission-energy (MTE) and direct transmission routing protocol. In this paper an energy analysis of routing protocols were done and finally the operation of (LEACH) were given.

Younis et al. [2]. Proposed an iterative clustering protocol named HEED, it employ probabilistic fashion. Both electing...
cluster heads (CHs) and joining clusters are performed based on the hybrid combination of two parameters. The primary parameter depends on the node’s residual energy. The alternative parameter is the intra-cluster communication cost.

Gupta et al. [3], introduced a CH election method using fuzzy logic to overcome the drawbacks of LEACH. The authors stated that by using three fuzzy variables (node degree, node residual energy and node centrality), the network lifetime can be efficiently increased. There are 27 fuzzy if-then rules which are defined at the BS. The BS elects the CHs according to these fuzzy rules.

Arboleda et al. [4] presented a comparison survey between different clustering protocols. The authors of the survey discussed some basic concepts related to the clustering process, such as cluster structure, cluster types, clustering advantages, and briefly analyzed LEACH-based protocols as well as proactive and reactive algorithms in WSNs. The main characteristics of these protocols were compared and the evidences where they can be used currently were outlined.

Kumarawadu et al. [5] surveyed the clustering algorithms available for WSNs and classified them based on the cluster formation parameters and CH election criteria. The authors of the survey also studied the key design challenges and discussed the performance issues related clustering protocols based on the classification of identity-based clustering algorithms, neighborhood information based clustering algorithms, probabilistic clustering algorithms and biologically inspired clustering algorithms.

Maimour et al. [6] considered clustering routing protocols to achieve energy efficiency in WSNs and presented a review on clustering algorithms from the perspective of data routing. A simple classification of clustering routing protocols is proposed in the review.

B. Energy Dissipation Model

Energy dissipation models are very important in WSNs. From the energy point of view energy dissipation model can be utilized to compare the performance of different routing protocols. A very simple and commonly used energy dissipation model is the first order radio model. The model is shown in Figure 2 assumed that to transmit a k-bit packet from sender to receiver over a distance d, the system spends [1]:

\[ E_{Tx}(k,d) = E_{Tx-elec}(k) + E_{Tx-amp}(k,d) \quad (3.1) \]

\[ E_{Rx}(k,d) = E_{elec} \times k + \varepsilon_{amp} \times k \times d^2 \quad (3.2) \]

Where \( E_{Tx}(k,d) \) the energy is consumed by the transmitter to send a k-bit long packet over distance d. \( E_{Tx-elec}(k) \) is the energy used by the electronics of the transmitter, and \( E_{Tx-amp}(k,d) \) is the energy expended by the amplifier.

Similarly, at the receiving node,

\[ E_{Rx}(k) = E_{Rx-elec}(k) \quad (3.3) \]

\[ E_{Rx}(k) = E_{elec} \times k \quad (3.4) \]

Where \( E_{Rx}(k) \) is the energy consumed by the receiver in receiving a k-bit long packet, which is given by the energy used by the electronics of the receiver \( E_{Rx-elec}(k) \). We consider \( E_{elec} = 50 \text{ nJ/bit} \) is the energy consumed by both the transmitter and receiver circuitry, \( \varepsilon_{amp} = 100 \text{ pJ/bit/m}^2 \) is the energy consumed by the amplifier, and a path loss exponent \( \alpha = 2 \).

\[ T(n) = \begin{cases} \frac{p}{1 - p \times (r \mod \frac{1}{p})} \times \frac{E_{elec}}{E_{in}} \times K & \text{if } n \in G \\ 0 & \text{otherwise} \end{cases} \quad (3.5) \]

![Figure 2: First order radio model [1]](http://ijmes.info)

C. Extended Low-Energy Adaptive Clustering Hierarchy (Extended-LEACH)

In our work we extended the LEACH’s probabilistic CH selection algorithm. We adjusted the threshold \( T(n) \) in relative to the nodes residual energy. Through applying this threshold each node decides whether to become a CH in a round or not.
Here, $E_{re}$ is the nodes remaining energy and $E_{in}$ is the nodes initial energy before transmission. In order to determining the minimum number of clusters for the network, we use

$$K = N \times \frac{M}{d_{BS}} \quad (3.6)$$

where, $K$ is the whole number of sensor nodes, $M$ is the length of nodes distributing fields and $d_{BS}$ is the distance between nodes and the BS.

D. Extended-LEACH Operation

Such as LEACH protocol the total operation divides into rounds and each round consists of two phases, they are

- cluster formation phase (Set up phase)
- cluster steady phase

**Cluster Formation Phase (Set up phase)**

In cluster formation phase, each node decides whether to turn into cluster head or not by comparing with residual energy. The nodes with more residual energy turn into cluster heads and declare as cluster head to other nodes. The other nodes with less residual energy turn into common nodes and join to cluster node.

**Cluster Steady Phase**

In cluster steady phase, nodes in a cluster send data according to TDMA table, and cluster heads receive, fuse and send data to sink. After a period of time, the network reforms the cluster head selection procedure in a new round.

E. LCM Method

The LCM always consumes less energy than the PC (passive clustering) [9], PC-LQ, and PC-RE. This is mostly because the node that the PC-RE selects is associated with a high value of ETX. In the LCM mechanism can use two counter named as, Predicted Transmission Count (PTX) and Expected Transmission Count (ETX) [10]. PTX is used for power calculations. ETX is used to evaluate the level of link quality. This PC proposes a link aware clustering mechanism (LCM) to maintain the energy efficient routing in Wireless Sensor Networks. The most important goal of the LCM is to set up a reliable and persistent routing path by determining appropriate nodes to become Cluster Heads (CH) and Gateways (GW). In the LCM the Cluster Head and Gateway nodes use the link condition and node status to determine PTX. The PTX provides the level of effective report quality of nodes can support and also provides high transmit power consumption and link quality. In wireless sensor networks the LCM can be works in uncasing only.

F. Cluster formation

Clustering is a process that divides network in to interconnected substructures called clusters [11]. Each cluster has a cluster head (CH) as coordinator within the substructure. Cluster formation is based on contact probability of each node in cluster based routing the optimized flooding scheme makes use of broadcasting the information only within the cluster.

G. Cluster state transition

When an IN node receives messages from either a CH node or a GW node it changes its cluster identity. Because they are belongs to the same cluster. If the sender is a CH node, the IN node then transits its state to GW node. Otherwise the IN nodes transits to CH node if the sender is a GW node. There is a distributed gateway nodes in LCM. GW nodes receive messages from the GW_R nodes and sends back to the initial nodes when the cluster is formed. Meanwhile, the initial node enters the contention procedure to calculate its priority and determine its ultimate state. If the node becomes a CH or GW node, it then forwards the received message [12].

H. Extended-LCM Method

The LCM primarily considers node status and link condition, and uses a clustering metric called the predicted transmission count PTX evaluate the qualification of nodes for cluster heads. Each cluster head or gateway nodes depends on the PTX to derive its priority and the nodes with the highest priority become the cluster head or gateway node. In LCM method, this is sequentially assigning the cluster head & power consumption for each node. In this approach, when the cluster head is selected then some results have been taken out from some simple calculations over the individual power consumption by following the equation given below.

$$W_i = \left( P_{e_i} + \sum_{j=1}^{n} P_{e_j} + n \right) \quad \text{Here} \ i = 1to n, \ where \ P_{e_j} = 0, i = j.$$
Cluster head will be selected with the help of the result. That will be reverse order of power consumption. The node at larger distance will be cluster head for lesser number of times rather than a node at a shorter distance. Because the node at larger distance consumes more power & the node at shorter distance consumes less power.

In the equation the power consumption for each cluster head is \( W_i \). If we take the LCM of all the individual powers a common power term & the number of cluster head can be selected. If \( i^{th} \) node is cluster head for \( k^i \) times then after all the iterations over the cluster of \( n \) nodes, each node will have same power. Now take LCM of all the powers as 

\[
C = LCM\, W_1, W_2, W_3, \ldots, W_n
\]

This LCM power \( C \) implies that when \( i^{th} \) is cluster head for \( k^i \) times then it will transmit power equal to \( C \). Since LCM is taken it is named LCM method.

The total powers consumed by all nodes are 

\[
W_{total} = nC
\]

So the number of times each node will be cluster head is 

\[
K_i = \frac{C}{W_i}
\]

Then the total number of iterations then can be mentioned as 

\[
K = \sum_i k_i
\]

III. RESULT

Simulation parameter of LEACH protocol are shown in a tabular form in Table 1

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensor nodes</td>
<td>100</td>
</tr>
<tr>
<td>Bit per messages</td>
<td>2000</td>
</tr>
<tr>
<td>Radio dissipation to run the transmitter or receive, ( E_{tar} )</td>
<td>( 50, \text{nJ/bit} )</td>
</tr>
<tr>
<td>Radio dissipation for transmit amplifier, ( E_{amp} )</td>
<td>( 1000, \text{pJ/bm}^2/\text{m}^2 )</td>
</tr>
<tr>
<td>Initial energy, ( E_i )</td>
<td>0.5 J</td>
</tr>
<tr>
<td>Node field diameter</td>
<td>(100m×100m)</td>
</tr>
</tbody>
</table>

Table 1: Simulation parameter of LEACH protocol

Figure 3 the system lifetime is simulated. In this Figure we saw that after 600 rounds the sensor node gradually began to die. Approximately after 700 rounds all nodes are died. So, from this simulation result we can say that LEACH protocol maintain uniform energy consumption.

Simulation parameter of Extended- LEACH protocol are shown in a tabular form in Table 2

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensor nodes</td>
<td>100</td>
</tr>
<tr>
<td>Bit per messages</td>
<td>2000</td>
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<tr>
<td>Radio dissipation to run the transmitter or receive, ( E_{tar} )</td>
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<td>( 1000, \text{pJ/bm}^2/\text{m}^2 )</td>
</tr>
<tr>
<td>Initial energy, ( E_i )</td>
<td>0.5 J</td>
</tr>
<tr>
<td>Node field diameter</td>
<td>(100m×100m)</td>
</tr>
<tr>
<td>Location of base station</td>
<td>75m&lt;( d &lt;185,\text{m} )</td>
</tr>
</tbody>
</table>

Table 2: Simulation parameter of Extended- LEACH protocol

In Figure 4 the system lifetime of Extended-LEACH is shown. From this simulation result we saw that After 700 rounds the sensor node gradually began to die. Approximately after 800 rounds all nodes are died. So, from this simulation result we
can say that Extended-LEACH protocol is more energy efficient than LEACH protocol because it support more round than conventional LEACH protocol. After 770 rounds the sensor field is shown in Figure 4. In this figure we saw that few of the sensor nodes are alive and almost all are dead. So, Extended-LEACH is also deal with uniform energy.

Figure 5: Power consumption of LCM method in mW
In Figure 5 we see that the node which is near to the BS consumes less power than the nodes which is far away from the BS. If a node is CH for several times then after all iterations over the cluster of n nodes, each node will have the same amount of power. It is helpful for the networks which have to cover a large area.

IV. CONCLUSION
Energy consumption is the main critical problem in WSNs. So designing an energy aware routing protocol is challenging issues in WSNs. Research are being conducted for designing energy aware routing protocol. LEACH is design for this purpose but it has some limitation. Our work is done based on one of the limitations. Although our Extended-LEACH cannot solve all the limitation of LEACH but simulation show that Extended-LEACH has better performance than the LEACH protocol. In LCM method the CH is randomly chosen. In our modified LCM we trying to choose the CH on the base on distance, but it also have limitations also. After all we may conclude that our modification performs better than the LCM method.

V. FUTURE WORK
In this paper, we propose a modification of the LEACH’s stochastic cluster-head selection algorithm by considering the additional parameters, the residual energy of a node relative to the residual energy of the network. Energy plays an important role for WSNs and also energy efficiency and load balancing are the significant challenges of clustering algorithm for energy sensor networks. Simulation results show that our proposed model consumes the energy fairly and reduce the energy difference between the sensor nodes and thus prolong the network lifetime.

REFERENCES