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An Efficient Multi-hop Energy Efficient Clustering Protocol for WSN System to Increasing Life Time

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ABSTRACT - The clustering-based protocols are believed to be the best for heterogeneous wireless sensor networks (WSNs). The evaluation is based on two new clustering-based protocols, which are called single-hop energy-efficient clustering protocol (S-EECP) and multi-hop energy-efficient clustering protocol (M-EECP). In S-EECP, the cluster heads (CHs) are elected by a weighted probability based on the ratio between residual energy of each node and average energy of the network. The nodes with high initial energy and residual energy will have more chances to be elected as CHs than nodes with low energy whereas in M-EECP, the elected CHs communicate the data packets to the base station via multi-hop communication approach. To analyze the network lifetime three types of sensor nodes equipped with different battery energy are assumed. By analyzing these parameters, M-EECP gives prolong network lifetime, and achieve load balance among the CHs better than the existing clustering protocols. Here the simulation is based on ns-2 simulator.

Keyword: heterogeneous, clustering, weighted probability, residual energy network lifetime.

1. INTRODUCTION

1.1 WIRELESS SENSOR NETWORKS

A wireless sensor network (WSN) consists of spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, pressure, etc. and to cooperatively pass their data through the network to another node in the network. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance, today such networks are used in many industrial and consumer applications, such as industrial process monitoring and control, machine health monitoring. The WSN is built of nodes from a few to several hundreds or even thousands, where each node is connected to a sensor. The topology of the WSNs can vary from a simple star network to an advanced multi-hop wireless mesh networks. The propagation technique between the hops of the network can be routing or flooding. The main characteristics of a WSN include:

- Power consumption constrains for nodes using batteries or energy harvesting
- Ability to cope up with node failures
- Mobility of nodes
- Communication failures
- Heterogeneity of nodes
- Ability to withstand harsh environmental conditions

1.2 OBJECTIVE

The main objective is

- To provide prolong network lifetime and energy efficient network based on different clustering protocol schemes.
- To make a comparative study between different clustering protocol schemes.
- To investigate the throughput and delay for clustering protocol schemes.

2. EXISTING SYSTEM

There are two types of energy efficient clustering schemes for WSNs are

- homogeneous clustering scheme
- heterogeneous clustering scheme

2.1 LEACH

Low energy adaptive clustering hierarchy (LEACH) is one of the first clustering schemes which play a great role in reducing energy consumption of the nodes and enhancing the network lifetime. LEACH provides a balance of energy consumption through a random rotation of CHs. However, a CH expends more energy while transmitting the data to the BS, which consume high energy. LEACH performs well under homogeneous network, but it fails in heterogeneous WSN because the low-energy nodes will die more rapidly than high-energy nodes.

2.2 EEHCA

Energy Efficient Hierarchical Clustering Algorithm (EEHCA) adopts a new method for CH selection along with the concept of backup CHs in order to improve the performance of the WSNs. Furthermore, when the CHs have finished the data aggregation, the head clusters transmit aggregated data to the BS node by a multi-hop communication approach. Therefore, EEHCA achieves a good performance in terms of network lifetime by minimizing energy consumption for communication and balancing the energy load among all the nodes.

2.3 MLCRA

Multi-Layer Clustering Routing Algorithm (MLCRA) is proposed for moving vehicles to mitigate the hotspot problem in WSN and achieves much improvement in network lifetime and load balance compared with the old algorithms which are direct, LEACH and deterministic cluster-head selection (DCHS). In MLCRA, non-top-level data transfer within the cluster uses direct means of communication, and the top-level CHs use multi-hop communications.

2.4 EECT

A novel energy-efficient clustering technique (EECT) applied for periodical data gathering is recently published for WSNs. The clustering technique adopts a new method for CH selection, which can avoid frequent selection of CHs. In the determination of CH, the EECT produced a new method to balance energy consumption among all the nodes.

3. PROPOSED PROTOCOLS: S-EECP AND M-EECP

When considering a general sensor network which may be deployed over a large region, the energy spent in the power amplifier related to distance may dominate to such an extent that using multi-hop mode may be more energy-efficient than single-hop mode. Our heterogeneous network model consists of three types of sensor nodes deployed uniformly in a square region, that is, normal nodes and a few super and advanced nodes. Note E_0 is the initial energy of normal nodes. Let m be the fraction of N normal nodes, which own α times more energy than the normal ones, we refer to these nodes as advanced nodes.

Thus, there are m × N advanced nodes equipped with initial energy $E_0(1 + \alpha)$. The proportion mo of super nodes among advanced nodes are equipped with β times more energy than the normal nodes. Thus, there are m × mo super nodes equipped with initial energy $E_0(1 + \beta)$. Hence, the total initial energy of the new heterogeneous network setting is given by the following equation

$$E_{total} = N \times E_0 \times (1 + m + S) - - - (3.1)$$

where $S = (\alpha - m_o \times (\alpha - \beta))$. All the CHs are elected periodically by different weighted probability. Each member node communicates with their respective CHs by using single-hop communication (i.e. intra-cluster communication). Then CHs collect the data from the member nodes in their respective clusters, aggregate it and transmit it to the BS using multi-hop communication (i.e. inter-cluster communication).

3.1 CLUSTER HEAD ELECTION MECHANISM

In LEACH, during the set-up phase, each node generates a random number between 0 and 1. If this random number is less than the threshold value, T(s) then the node becomes a CH for the current round. During each round, new CHs are elected and as a result balanced load energy is distributed among the CHs and other nodes of the network.

$$T(s) = \begin{cases} \dfrac{p_{opt}}{1 - p_{opt} \times \left(r \bmod \left(\frac{1}{p_{opt}}\right)\right)}, & \text{if } s \in G \\ 0, & \text{otherwise} \end{cases} \quad (3.2)$$

where p_{opt} is the desired percentage of CHs, r is the count of current round; G is the set of sensor nodes that have not been elected as CHs in the last $1/p_{opt}$ rounds.

. Therefore the estimation of the average energy E_{avg} of the network at r^{th} round by the following equation

$$E_{avg}(r) = \frac{1}{N} E\left(1 - \frac{r}{R}\right) - - - - - (3.3)$$

where R denotes the total number of rounds of the network lifetime, which means that every node consumes the same amount of energy in each round. Let us assume that all the nodes die at the same time. Let E_{round} denote the energy consumed by the WSN in each round. Thus, R can be calculated by the following equation

$$R = \frac{E_{total}}{E_{round}} - - - - - - - - - - (3.4)$$

This above modification of the threshold equation has a drawback. Further modification has been done in threshold to solve the above problem. It is expanded by a factor which increases the threshold for any node that has not been elected as CH for the last $1/p_i$ rounds. Hence, the new modified threshold value is given by the following equation

$$T(s_i) = \begin{cases} \dfrac{p}{1 - p_i \times \left(r \bmod \left(\frac{1}{p_i}\right)\right)} \left[\dfrac{E_i}{E_{avg}} + \left(r_s \operatorname{div} \dfrac{1}{p_i}\right)\left(1 - \dfrac{E_i}{E_{avg}}\right)\right], & \text{if } s \in G \\ 0, & \text{otherwise} \end{cases} \quad (3.5)$$

where r_s are the number of consecutive rounds in which a node has not become CH. Hence, the chance of each type of node to become a CH increases because of a higher threshold value.

3.2 CLUSTER FORMATION PHASE

During this phase, each non-CH node decides to join the closest CH node based on the received signal strength of the advertisement message. After this, the sensor node must inform the CH node that it will be a member of the cluster by sending a short join message. Each sensor node transmits this information back to the CH again using a CSMA MAC protocol. During this phase, all CH nodes must keep their receivers unit on. The CH node receives all the messages from its member nodes. Based on the member nodes in the cluster, the CH creates a TDMA schedule telling each node when it can transmit.

3.2 DATA COMMUNICATION PHASE

Once the clusters are formed and the TDMA schedule is fixed, the data communication phase can begin. The active sensor nodes periodically collect the data and transmit it during their allocated transmission time to the CH. The radio of each non-CH or member node can be turned off until the node's allocated transmission time which minimizes energy consumption in these nodes. The CH node must keep its receiver on to receive all the data from the member nodes in the cluster. When all the data have been received, the CH nodes aggregate the data and route the aggregated data packets to the BS via multi-hop communication approach.

4. DESIGN AND SIMULATION

Simulation is done by NS2. SEECP and MEECP methods are developed in NS2.In this implementation used to measure Residual Energy, Energy consumption, Transmitted and Received packets. Fig 4.1 shows that wireless sensor nodes are randomly deployed according to the environment.

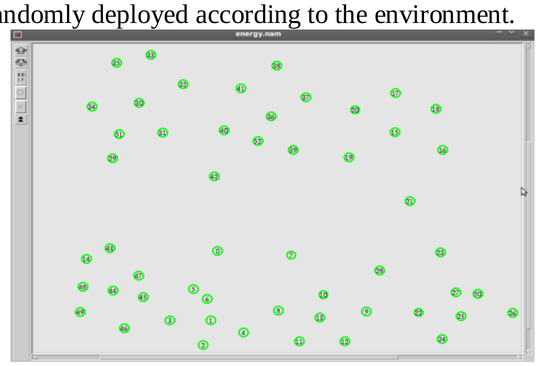

Fig. 4.1 Random Deployment of nodes

Fig 4.2 shows that the CH election process is based on the ratio

$$\text{Weighted Probability} = \frac{\text{Residual Energy of a node}}{\text{Average Energy of the Network}} \quad (4.1)$$

The Weighted Probability is combined with Threshold Value (0-1).

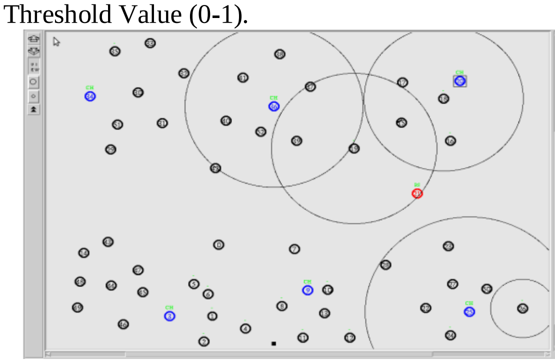

Fig. 4.2 CH Selection

Fig 4.3 shows that the Single hop communication b/w CHs to BS. It adopts single hop transmission in Intra-cluster and Inter- cluster communication. The node which has high energy can elect as CHs.

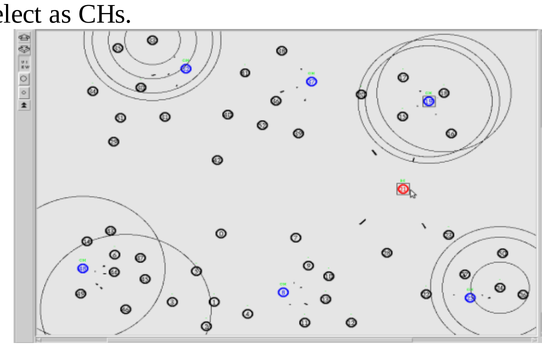

Fig. 4.3 Single Hop Communication

Fig 4.4 shows that the cluster head selection is same as SEECP. It adopts Multi-hop communication b/w CHs to BS by considering shortest path. Three types of sensor nodes with different energy are normal nodes, advanced nodes and super nodes.

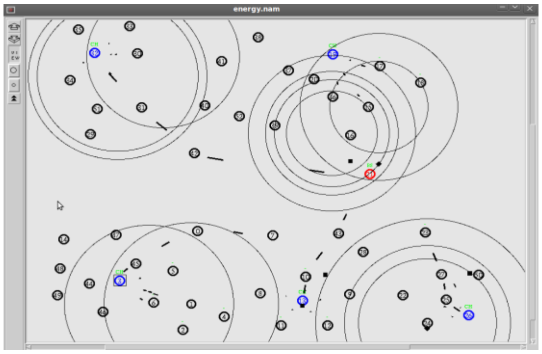

Fig. 4.4 Multi Hop Communication

5. RESULTS AND DISCUSSION

Fig 5.1 shows that the Graphical Representation of Energy Consumption for SEECP and MEECP. This indicates that the single hop communication consumes more energy compare to multi hop communication.

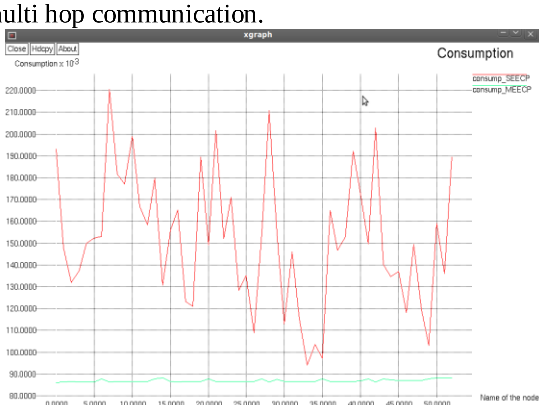

Fig. 5.1 Graphical Representation of Energy Consumption

Fig 5.2 shows that the Graphical Representation of Residual Energy for SEECP and MEECP. This indicates that the single hop communication has low remaining energy compare to multi hop communication.

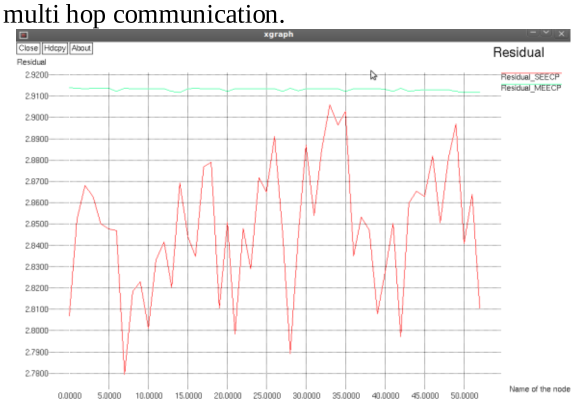

Fig. 5.2 Graphical Representation of Residual Energy

Fig 5.3 and Fig 5.4 shows that the Transmitted and Received Packets of SEECP and MEECP. SEECP has High Packet Loss compare to MEECP. This shows that MEECP is better for data communication.

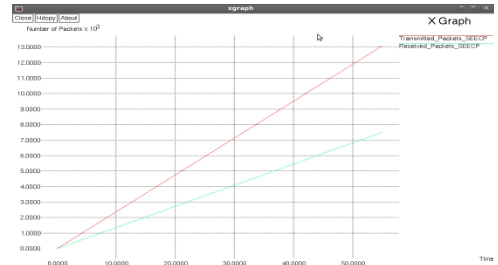

Fig. 5.3 Transmitted Vs Received Packets in SEECP

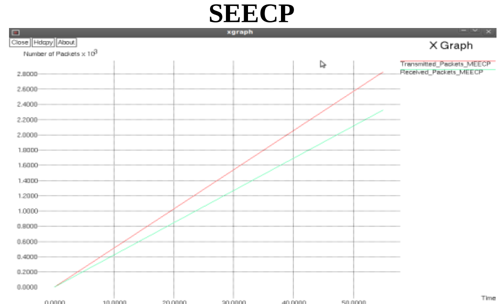

Fig. 5.4 Transmitted Vs Received Packets in MEECP

6. COMPARISON

Table 6.1 Comparison of S-EECP and M-EECP

S-EECP	M-EECP
Direct link to BS	Link with different level of clusters to find a shortest path for data transmission
It consumes more energy	It consumes less energy compare to SEECP
High Packet Loss Ratio	Compare to SEECP, here it is less
High Secure	Less Secure because of intermediate nodes
It does not suites for long distance communication	It suites for long distance communication
Residual energy is low	Residual energy is high
There is no such situation	There is a chance of hacking data while pass through multi-hop
No hidden terminal problem	There is a hidden terminal problem but it s avoided by hand shaking mechanism
Generated and Transmitted packets = 12846	Generated and Transmitted packets = 2835

Received packets = 4714	Received packets = 2335

7. FUTURE WORK

EDDEEC- Enhanced Developed Distributed Energy Efficient Clustering and HEED- Hybrid Energy Efficient Distribution Protocol are going too analyzed along with SEECP and MEECP with sink mobility.

8. CONCLUSION

In heterogeneous WSNs, S-EECP and M-EECP are the two protocols. Consider three types of nodes with different battery energy which is a source of heterogeneity. The election process of CHs is more stable in S-EECP than EECT and EEHC. In S-EECP, we adopt single-hop approach for data transmission in intra-cluster and inter-cluster communications. M-EECP adopts single-hop approach in intra-cluster communication and multi-hop approach in inter-cluster communication. Simulation results indicate that M-EECP gives prolong network lifetime, and balance energy consumption up to 94% among the CHs better than SEECP, EECT and EEHC protocols.

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