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ADAPTIVE ENERGY EFFICIENT DECENTRALIZED HIERARCHICAL DYNAMIC CLUSTER BASED ROUTING PROTOCOL IN WSN

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Abstract

Clustering is one of the common remarkable approaches in Wireless Sensor Networks for organizing efficient communication on over resource constrained devices. There is enormous clustering routing protocols were proposed to ensure load balancing on hierarchical networks. The selection of cluster heads will be based on the energy and distance levels. In this paper the wireless network uses dynamic switching between clusters for transferring of messages over a large scale network and the idea is to reduce the energy consumption and to increase the network life time by making the nodes in the cluster to be in sleep mode when they are not involving in data transferring. The simulation results are done for LEACH protocol through Matlab Simulator which shows only the cluster which is in active mode while data transferring.

1. Introduction

In recent technologies WSN plays a prominent role which contains a organized network that comprises of huge number of sensor devices called sensor nodes which is of low cost. WSN can perform the task of observing, processing and decision will be depending on the observations. The battery powered devices are sensor devices which are used collect the environmental data like temperature, humidity etc. from remote locations with better

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accuracy. Typically, a sensor node consists of three main subsystems which are sensing element, processing element and a communication. WSN are used in military application, surveillance and environment monitoring etc. which are usually redundant. The Data which is collected from different sensors will be aggregated at node called as aggregator then it transfers the data which is only aggregated values to the Base Station. Due to constraints in power and energy resources of sensor nodes the data will be aggregated to great degree by using basic algorithms such as averaging. Robust data aggregation is a serious concern in WSNs and huge numbers of researchers are researching various cluster based routing ideas for achieving energy efficiency. Cluster is the collection of the same type of the data. The idea behind grouping of data is to minimize energy consumption, delay, fault tolerance and increase in QOS. Clustering helps in minimizing the overload of huge number of nodes to takes part in data transmission and within individual cluster, one node will be elected as Cluster Head (CH) which is used to separate the data from the other nodes. CH straight forwardly sends data Base Station in one hop but energy consumed will be more. In Order to solve this problem multi-hop routing algorithm is preferred. However CH maintains the information about sensor nodes in a cluster and includes list of path information to every node [1] and CH is responsible to communicate with other nodes within its own cluster. Selection of CH's plays an important aspect due to the low constrained environment in WSN, in-order to select efficient dynamic cluster head in WSN, there are enormous techniques were presented for electing cluster head, but most of the existing were based on different factors such as node interaction history, energy, of the node [2], need of reclustering [3], and execution [4]. The designed system exhibits dynamic Cluster election which is based on node residual energy and node degree. The developed protocol helps in reduction of energy consumption by choosing dynamic switching between each cluster which helps in reducing the load balancing, energy utilized and increase in network life time.

2. Related Work

Bajaber [5] developed a network with even sizes of Clusters consists of set of sensor nodes and cluster head. Cluster head will be elected depending on the gathered information from sensor nodes and residual energy. BS will

helps in splitting the network into clusters. Later eligible candidates for CH depending on the residual energy which are having above threshold will be elected as CH for the successive round which may lead to more power consumption in sensor nodes. Whereas Kumar [6] developed an algorithm EEHC used for heterogeneous networks which is based on probability to elect the eligible CH'S in shared manner in presence of heterogeneous hierarchical WSNs results in acceptable simulations. The discussed protocols states base station will receive data from CHs nodes through single hop and while data is transferring to the base station the power dissipation will be more and it results to an issue of premature nodes death. Multihop clustering is one of the best solutions for energy saving methods. PEGASIS protocol is one of the extensions for LEACH protocol which forms a chain by collecting set of nodes. Selecting the leader in the chain task is shifted within the nodes for each round in order to achieve proper energy balancing between the sensor nodes but it leads to delay in data transferring which is not chosen for large networks. The author Bandyopadhyay [7] gave detailed information about distributed randomized algorithm for clustering which helps for generating a high level of CH's. The protocol in [7] leads to energy saving as the number of levels in the network increases the nodes energy will be increased which leads to higher delay in the algorithmic procedure. So, HEED approach which is also a distributed network for clustering generally chosen for long lived adhoc networks is preferred. In this protocol CHs will be selected depending on energy and the adjustment degree which is a secondary parameter while choosing. In HEED protocol it can exclude in O(1) iteration , which helps in reducing the overhead of messages on the network and results in assured link between the cluster networks with effective raise in network lifetime. The author Z. Liu [8] gave a detailed explanation regarding DEECIC protocol which selects the minimum number of nodes which are undertaking Cluster Head task, results in covering the entire network and depending on the each nodes local information a unique identity will be developed. Wang [9] gave detailed information of keeping the assumed number of Cluster Heads stable and sliding window technique helps in adjusting the electing probability. This developed protocol utilizes the information of initial energy of nodes which is preferred as effective parameter and secondary parameter as average energy of nodes which are not involved in CH network will helps in attaining assured uniformity in the energy utilization of network cycle. Chang [10] idea is to

form uniform clusters concepts in the network which helps in reducing the distance for data transmission for the nodes. Choosing a cluster head in the network will be depended on average distance between sensor nodes and residual energy. Cluster Head will sends data to base station through relay nodes which acts as intermediate node while data transferring. The author of Chang-ri [11] described about segmenting monitoring region into hexagon cells which requires nodes geographical location information. The cluster formation requires at least seven hexagon cells which includes the nodes with same cluster identity. Cluster head will be placed at centre cell of individual cluster which uses the transmission power management technology for reducing packets collision rate and results in reuse of channel enhancement and energy efficiency. Author Zhang [12] explained about the algorithm which helps in finding an optimal area in a cluster for Cluster head which minimizes the maximum energy consumption within the network. Opting the best location of EH nodes will validate the near optimality performance.

3. Multipath Routing Protocols Based On Energy

Considering restricted battery power for nodes to perform their operation is a major problem while designing the wireless sensor network. For this reason battery potter is an important resource which must be used efficiently for not occurring of early termination of node and also energy management plays a key role within the WSN which maintains the information of controlling helps in managing the energy resources efficiently and also increases life time of an ad-hoc WSN. The three important ways of increasing the node life time: Efficient battery management, Transmission power management, and system power management. If any termination occurs due to mobile sensor node it will lead to packet loss as it cannot forward the data, which affects the node itself and results in reduction of network life time which is a major drawback. So, in WSN energy efficient based routing is the most prominent design criteria in networks as it will be powered through batteries which is having limited capacity. Keeping this design issue many researchers are working behind this for developing different routing protocols for minimizing the energy consumption and increasing the reliability of the network.

4. Network Model

A network generally consists of Sensor nodes and base station which are arranged in a target region. For developing an algorithm these assumptions must be considered:

1. Consider N nodes in a network which are arranged in a $M \times M$ square field.

2. Energy limitations are not considered for BS which is placed at longer distance from the sensing node.

3. After arranging the sensor nodes and BS in the network they will be stationary.

4. Nodes in the network can be heterogeneous.

5. Unique identity is present for each node.

6. Each node knows the information of neighboring node.

Cluster Formation

The Cluster formation can be detailed by selecting a circle with stationary radius either by self-assertively or with largest collaborating neighbor density within range and selecting a node as centre and radius with small distance randomly. New circle centre will be calculated as average of the points present within the circle but the radius will be increased by distance of two successive centers. The nodes present inside the Cluster will be formed as group and from the Clusters the Cluster Heads (CH) are formed depending on the parameter of residual energy and distance from the BS.

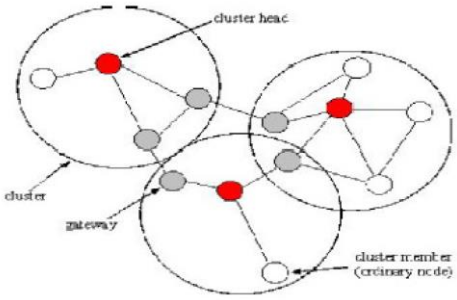

Figure (a). Cluster formation.

Energy is the major concern in wireless sensor networks. In general Single link failure (fault) may occur because of maintaining of one cluster head for a long time, so we are choosing energy efficient cluster head selection process and also developing a protocol which helps in dynamically electing the Cluster which communicates with BS will be in active mode and making the remaining clusters to be in sleep modes which helps in reducing the energy consumption reliability and increases network life time.

Residual Energy: The RE (Residual Energy) of individual N (Node) following one data communication is evaluated using following technique

$$RE_i = E_{ini} - (E_{tx} + E_{rx})$$

where E_i = Initial energy of the node, E_{tx} & E_{rx} = energy used at the time of data transmission and reception.

Leach Routing Protocol

Heinzelman et al. detailed about a distributed algorithm for clustering which is known as Low-Energy Adaptive Clustering Hierarchy i.e., LEACH protocol utilized for routing homogeneous sensor networks. LEACH protocol chooses the CH randomly and also avail Round Robin management policy to different nodes while assigning Cluster Heads which helps in acquiring reduction of energy dissipation between the nodes. For minimizing the amount of data that is transmitted to the BS, the CHs will aggregate the data captured by the node members who belong to their individual cluster and they start sending an aggregated packet to the BS. The entire protocol operations are separated into numerous rounds **Cluster-route setup** specified as primary stage, which includes two phases.

(a) Depending on individual node local information and consistent specifications, Cluster Heads will be decided and the routing path will be developed between the selected Cluster Heads.

(b) Nodes which are common will be linked to most appropriate Cluster Head between multiple choices.

Data transmission titled as secondary stage, involves transmission of individual node's data to Base Station along the developed routing path. For balancing the energy consumption in individual Cluster Head, the cluster head's role will change depending on the energy and the cluster will be

dynamically elected which helps in reduction of load overhead on the network. During the first stage, selecting CHs is initialized to choose future Figure (a). Cluster Formation CHs. If the threshold Ts is greater than random number then the node will be elected as CH in the present round, otherwise the node is assumed to merge to the nearest CH in its neighborhood. The equation for threshold is as follows

$$T_a = T/\left(1 - p\left(r \bmod \left(\frac{1}{p}\right)\right)\right) \text{ if } a \in S$$

$$= 0 \quad \text{Otherwise.}$$

Here

r = present number of the round

p = probability of individual node to elect as a Cluster

Head

S = from the last $1/p$ round the set of nodes which are not elected as cluster heads

Energy equations

For evaluating the energy consumption and the expended radio energy for transferring n-bit information is given in following equation

$$E_{t(n,\,d)} = n \times E_{elec} + n \times Efs \times d^2 \quad d < d_0$$

$$= n \times E_{elec} + n \times Empf \times d^4 \quad d \geq d_0$$

where

d = transferring distance.

Efs = free space amplifier energy.

$Empf$ = multipath fading channel amplifier energy

d_0 = threshold distance will depend on the environment.

Depending on the distance between transmitter and receiver we are assuming

if $d < d_0$ the model selected is free space

else $(d < d_0)$ the model is multi-path fading.

Energy dissipation when receiving data by individual sensor node is

$$E_{r(l)} = l \times E_{elec}.$$

Depending on the short range between transmission and reception in individual cluster, the energy dissipation occurred due to non CHs will follow model of Friss free space. Mainly Cluster Head energy consumption consists of three parts:

1. While receiving information from cluster nodes, energy will be consumed.

2. Data aggregation also involves energy consumption.

3. For transmission of aggregated data to the Base Station through multi-hop routing also requires energy.

Due to larger distance between Cluster Heads we presume the energy dissipation will follows the multipath fading model.

$$E(CH_m) = N_m \times l \times E_{elec} + (N_m + 1) \times l \times E_{DA} + l \times (E_{elec} + \epsilon mpd^4).$$

Where

Nm = quantity of non-CH nodes in cluster m

EDA = aggregated energy data

5. Designed Protocol

Designing a protocol mainly involves electing Cluster head, dividing nodes among clusters for forming groups and checking whether the node is dead node or not. Keeping all these points in view we are developing a Leach protocol by collecting the nodes which are to be placed in the network as shown in figure (b) and dividing the network into Clusters depending on their energy levels. Input: set of nodes: $S_1, S_2, S_3, S_4, S_5, \ldots, S_n$, clusters $C_1, C_2, C_3, \ldots, C_n$.

1. Nodes in the network will be separated among themselves to form different groups to join into clusters using

$$S1[i] \cdot G = 0.$$

2. Compute neighbors of each node

$$\text{for } i : 0\, t \text{ on } -1$$

$$dis : \sum_{i=0}^{n-1} \sqrt{(X_{i+2} - X_{i-1})^2 + (Y_{i+2} - Y_{i-1})^2} \ldots. \quad (1)$$

Compare: if : dis $\leq R$

$$NL_i \leftarrow x \text{ where } x \in S_i$$

for : end

3. Cluster selection process will be started and send the packet to the nodes.

4. Depending on the probability of the energy levels they will be categorized in the following way.

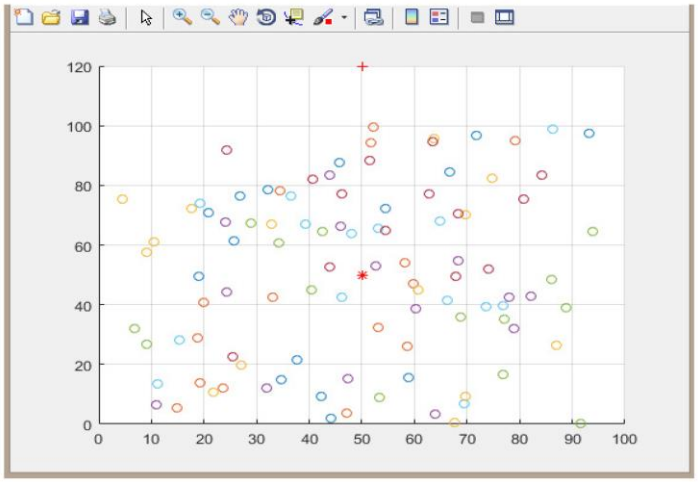

Figure (b). Nodes placed in the network.

(a) Highest Probability (LEVEL 1)… will be elected as Cluster Head and it is having highest energy when compared to remaining nodes.

(b) Medium Probability (LEVEL 2) … will be elected as normal node.

(c) Lowest Probability (LEVEL 3) … will be a dead node whose information will communicate directly to sink and Gateway node.

5. The node states keep on change during the process of data distribution.

6. Check whether any loss of packet or packet drop is present.

$$r \leq Pn, \text{ packet received}$$

$$r \geq Pn, \text{ packet lost}$$

7. Calculate throughput

$$Theoretical = \frac{Pn}{Pn + rn}$$

$$Actual = (r \times packet)/total\ packet.$$

8. Cluster head will be elected depending on both probability and threshold as follows

$$\text{Probability} = P/(1 - P^* \bmod (r, \text{round}(1/P))).$$

9. Calculate

$$\sqrt{(Efs/Emp)} \ldots\ldots\ldots \quad (2)$$

Compare equation (1) and equation (2) in order to know whether the path is free space path or multipath.

10. Depending on the distance, each node which is present in the Cluster and their energy will be calculated depending on following equations.

If $eq(1) > eq(2)$

$$S(i) \cdot E = S(i) \cdot ES0(i) \cdot E((ETX)^*(4000) + (Emp)^* 4000^*$$

$$(dist0^* dist0^* dist0^* dist0));$$

else

$$S(i) \cdot E = S(i) \cdot ES0(i) \cdot E((ETX)^*(4000) + (Emp)^* 4000^* (dist0^* dist0));$$

11. Check the packet count which are arriving at base station (BS) to know whether the packets are received without any path loss.

6. Simulation Results

The simulation results show the performance of the designed protocol system using Matlab simulator. Here we are arranging 100 nodes which are

divides over a 100mx100m network area which is shown in figure (c). Individual Cluster shown in figure (d) and figure (e) will be in active when it involves in packet transferring but remaining clusters will be sleep mode which does not consume energy which results in increase in network lifetime.

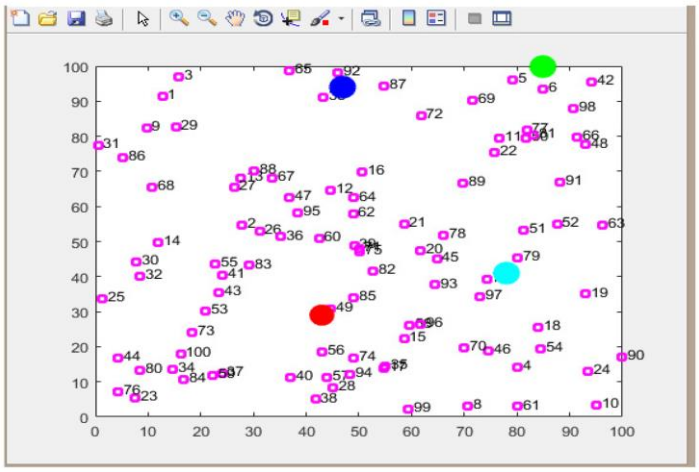

Figure (c). Nodes arranged in network (100mX100m).

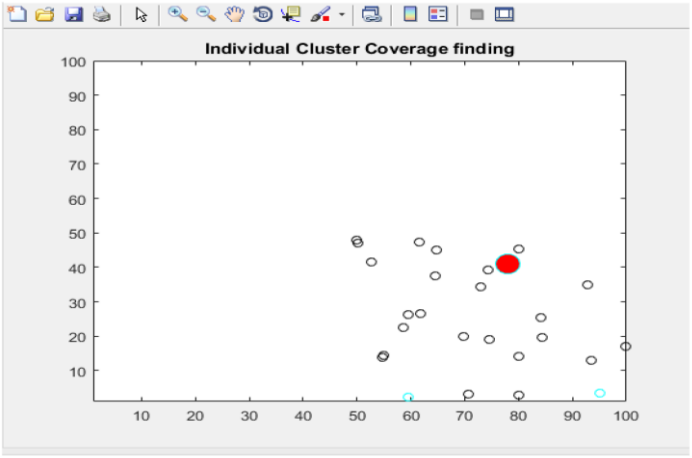

Figure (d). Individual Cluster 1.

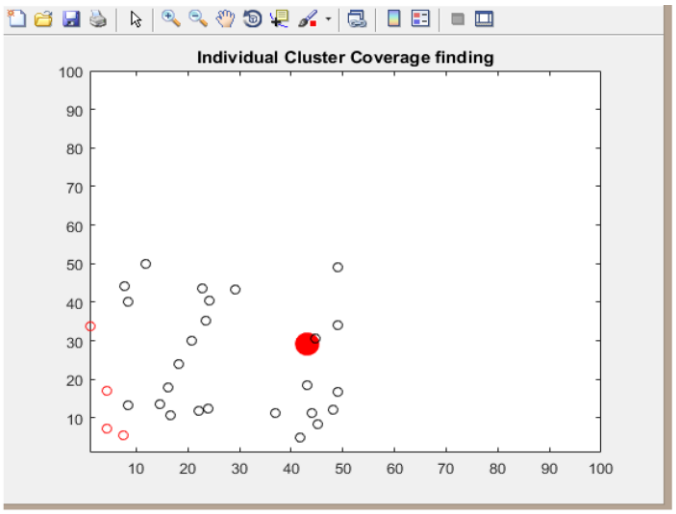

Figure (e). Individual Cluster 2.

The figure (f) shows the energy consumption of the developed system which consumes very low power when equated with other approaches. In this system Cluster which is actively participating will be in active mode and remaining Clusters will be in sleep mode which results in reduction of energy consumption. The throughput of the designed system is better as it consumes very low energy when compared with other approaches shown in figure (g)

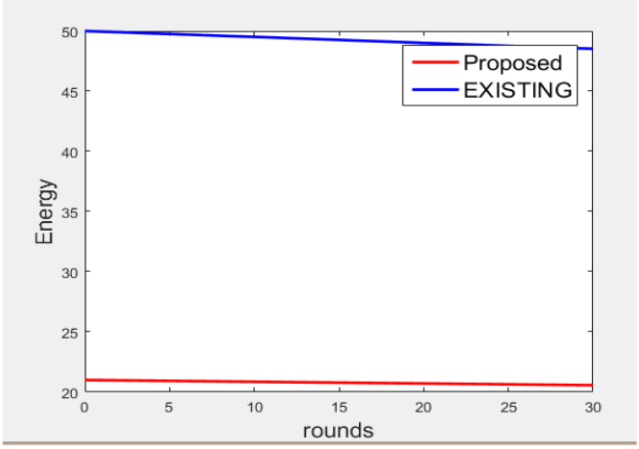

Figure (f). Energy Consumption.

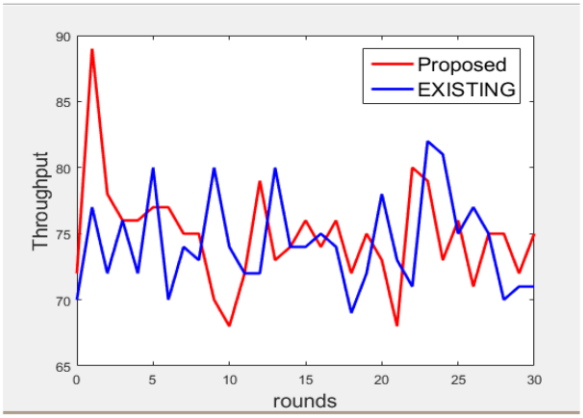

Figure (g). Throughput of designed system.

7. Conclusion

The paper describes about designed protocol system which helps in reducing the energy utilization and enhancement in network life time by electing Cluster dynamically. Simultaneously, with the Cluster Head selection a hierarchy tree is constructed with a BS as its root and also a Cluster Head is located at individual edge and cluster member node as its leaves. Depending on the parameters such as distance and residual energy the Cluster Heads will be elected which helps in packet transferring from sensor nodes to the base station (BS). Clusters will be organized with uniform sizes to equalize energy usage among cluster nodes. Deploying of sensor nodes randomly will lead to load unbalance between Clusters. To solve this problem, we developed a protocol in which Cluster will be elected dynamically depending on the above calculated parameters will be in active mode and remaining Clusters will be in sleep mode which helps in reducing load balancing on single Cluster while data transferring. The simulation results shows the developed protocol which provides more energy efficiency, reliability, low load overhead and increase in network life time when compared with the other algorithms.

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