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Implementation of Energy Efficient Routing Protocol using Clustering Technique

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Abstract

The past few years have witnessed increased interest in the potential use of wireless sensor networks (WSNs) in applications such as disaster management, combat field reconnaissance, border protection and security surveillance. Sensors in these applications are expected to be remotely deployed in large numbers and to operate autonomously in unattended environments. The sensor nodes deployed in wireless sensor networks are extremely power constrained, so maximizing the lifetime of the entire networks is mainly considered in the design. In this paper, we proposed An energy efficient clustering algorithm with optimum parameters is designed for reducing the energy consumption and prolonging the system lifetime. Using a wireless sensor network, variety applications are being developed. Clustering of a sensor nodes elect to cluster head from among the sensor nodes and cluster heads to the sink node is configured a clustering. The clustering Algorithm is a kind of key technique used to reduce energy consumption. It can increase the scalability and lifetime of the network. Energy-efficient clustering protocols should be designed for the characteristic of heterogeneous wireless sensor networks.

Keywords: Wireless Sensor Network, Energy Efficiency, Clustering, Cluster Head Selection. Multihop Communication,

1. Introduction

Wireless sensor networks consist of low-cost, low power, multifunctional sensor nodes. It has been used extensively to develop various applications such as scientific, medical, military and commercial applications for the purpose of automated remote data collection. Sensor nodes operate in unattended environments, such as a battery through the use of limited energy resources.

One of the advantages of wireless sensors networks(WSNs) is their ability to operate unattended in harsh environments in which contemporary human-in-the-loop monitoring schemes are risky, inefficient and sometimes infeasible. Therefore, sensors are expected to be deployed randomly in the area of interest by a relatively uncontrolled means, e.g. dropped by a helicopter, and to collectively form a network in an ad-hoc manner. Generally, sensor nodes of WSNs are randomly scattered on specific area for satisfying user's requirements (detecting, observing and monitoring environment) and have to self organized network. It is difficult to exchange and charge node battery as the area where sensor nodes are located in is inaccessible location. So, it is important issue to design power efficient protocol method for low-power operation and prolonging the network lifetime (Akyildiz et al, 2002). In WSNs, routing methods can divide into two routing mechanisms: 'flat-routing' and 'hierarchical routing'. The 'flat-routing' technique regards the whole network as one region, enabling all nodes to participate in one region. On the other hands, the 'hierarchical-routing' technique is to execute local cluster routing scheme based on clustering. The feature of sensing data is that adjacent sensor nodes have similar or same sensing data (Ameer Ahmed Abbasi and Mohamed Younis, 2007). That is, the duplicate sensing data exist in sensor networks. To prevent duplicate sensing data, the 'hierarchical-routing' technique uses the clustering scheme. The Cluster region is a local area assigned by user's requirement. It is composed of a cluster head node and member nodes. A cluster head is for aggregating sensing data from member nodes. The number of sensing data in the 'hierarchical-routing' is lower as cluster head works. Thus, the 'hierarchical-routing' is more energy-efficient routing technique. A process of clustering is as follows. First, a sink node elects cluster heads among all scattered sensor nodes. Each cluster head makes a local cluster by using advertisement
message. Member nodes send sensing data to own cluster head. A cluster head collects sensing data from member nodes for 'data-aggregation' that prevents duplicate data. When a sink node requests user-demand, in response to user-demand, a cluster head prevents unnecessary query flooding. To communicate with sensor nodes which are outside sensing range, a sensor node is suitable for multi-hop networking(Toumpis & Goldsmith, 2003). It is important to measure the number of cluster member nodes in local cluster based on multihop clustering. If there are many member nodes in local cluster, the energy consumption in a local cluster is increased. The energy drain of a cluster head is also increased. On the other hand, if there are little member nodes in a local cluster, the energy consumption is low. The energy drain of a cluster head is also low. Thus, it is important how many member nodes are needed to set up a local cluster for energy-efficient sensor networks. This paper describes energy-efficient

cluster formation method. To achieve this, a local cluster should know the number of optimal member nodes and adjusts the position of a cluster head considering the distance between cluster heads and member nodes. That is to build balance among local clusters. Thus, this method can find low-power mechanism of sensor networks for clustering.

2. Related works

In order to enhance the network lifetime by the period of a particular mission, many routing protocols have been devised. One of these is network clustering, in which network is partitioned into small clusters and each cluster is monitored and controlled by a node, called Cluster Head (CH). These cluster heads can communicate directly with the base station (BS). Other nodes send the data, sensed from the environment to these CHs. CHs first aggregate the data from the multiple sensor nodes, and then finally send it directly to the BS. Hence the CH should be powerful, closer to the cluster-centroid a less vulnerable . Heinzelman et al. proposed LEACH [4] a protocol based on network clustering. Each cluster has a cluster-head that aggregates all the data received from the near nodes and send them to the base station. The cluster-head are selected following a distributed algorithm for each round. The [6] proposed an algorithm called TB-LEACH which is an improvement of the LEACH one. This algorithm permits to dominate the number of clusters heads to have at any transmission round, the optimal cluster-heads amount that modifies the cluster-head selection algorithm to improve the partition of cluster. This algorithm assumes that all nodes receive the messages broadcasted by the nodes selected as cluster heads. PEGASIS [7] is an improvement of the LEACH protocol. Rather than forming multiple clusters, PEGASIS forms chains from sensor nodes so that each node transmits and receives from a neighbour and only one node is selected from that chain to transmit to the base station (sink). Gathered data moves from node to node, aggregated and eventually sent to the base station.

This method [3] is for energy distribution as all sensor nodes would be selected as a cluster head after 1/p round. And it helps efficient-energy saving of nodes since the nodes which has high remaining energy are elected as a cluster head. However, it does not consider unequal energy consumption of nodes by unequal clusters. The elected cluster head is not again selected as a cluster head during 1/p rounds although the node has the most energy than others.

In [1] Using a wireless sensor network applied look at the U.S.military in the field monitoring the movements of the enemy and reconnaissance systems that are deployed during the operation.Northop Gruman's UGS (Unattend Ground Sensor)systems[3], L-3 Communications Corp. Rembass system[4] and BAE Systems[5] has been developing a sensor network surveillance and reconnaissance system.

Saab is under development a surveillance and reconnaissance systems that the attacker based on sensor networks that consist of various complex sensor nodes. Network topology of SRSN is configured hierarchically clustering[5] for efficient operation of networks. SRSN (Surveillance Reconnaissance Sensor Networks) that detects and tracks the enemy's attack using a wireless sensor network.

In SRSN Clustering limit to certain area nodes which is physical proximity position and grant a specific node (Cluster Head) in area(Cluster) of role of head and it is node configuration method for information of in area collect or transmit. Cluster Head(CH) collect sensing information of sensor nodes and it can be transmit to other CH or sink information.SRSN has a 2-Tier network configuration. 1st-Tier network configure between the CH as gateway to sink node and 2nd- Tier network configure between CH to sensor node as CH to sink node. Event occurs, the information detected by the sensor node is transmitted to CH, CH transmit a information to the gateway. Gateway transmits event data to Task Manager of management of data and networks using a military tactical communication network.

In this paper we propose a new Energy –Efficient Routing Protocol which uses the clustering technique i.e. Cluster Head election and Data transmission with the help of Cluster Head.

3. Assumptions

1. All the sensor nodes are static, i.e. mobility is not supported in our proposed protocol. In many applications of WSN, the mobility is not mandatory. Thus this assumption is feasible to these applications.

2. Energy consumption for each task is known for specific application. Usually, energy consumption can be divided into three domains: sensing, communication, and data processing. Of the three domains, a sensor node expends maximum energy in data communication. This involves both data transmission and reception for example. Whenever the base station receives a packet from a sensor node, it is aware of the energy consumption of each node on the routing path.

3. All nodes have the same amount of energy available at the beginning of the Data Transmission phase, though it is the case that those nodes within one or two hops of the base station consume more energy during Initialization phase.

4. Each node consumes the same level of energy for transmitting and receiving one packet.

5. The sensor node select a cluster head for clustering and clustering is done mainly cluster head.

6.Sensor nodes communicate to cluster heads through multihop and cluster head configure a network with gateway through multi-hop between cluster heads.

4. Functionality and algorithm

The proposed protocol has two phases:
[i]Initialization phase(Cluster Head Election)
[ii]Data Transmission(Communicating Node selection)

4.1. Initialization Phase

- Every neighbour node broadcasts a Neighbour Discovery message throughout the whole network.
- After receiving this message , each node records the address from which the node receives the message and stores it in the neighbours list.

  Eventually, the data being sensed by the nodes in the network must be transmitted to a control centre or base station, where the end-user can access the data. There are many possible models for these microsensor networks. In this work, we consider microsensor networks where:
  - The base station is fixed and located far from the sensors.
  - All nodes in the network are homogeneous and energy constrained

4.2. Cluster Head Election

Initially, when clusters are being created, each node decides whether or not to become a cluster-head for the current round. This decision is based on the suggested percentage of cluster heads for the network (determined a priori) and the number of times the node has been a cluster-head so far. This decision is made by the node n choosing a random number between 0 and 1. If the number is less than a threshold T(n) then the node becomes a cluster-head for the current round.

$$T(n) = \begin{cases} \frac{p}{1-p*\left(r \bmod \frac{1}{p}\right)} & if\ \ n \in G \\ 0 & otherwise \end{cases}$$

Where T(n) – Threshold value of node
P --Desired Percentage of nodes to become CH
G --set of nodes which is not CH in last 1/P rounds
r- Current round
n :- node index checked for CH
If T (n) > value i.e. rand (0,1) , n is CH

Where P = = the desired percentage of cluster heads (e.g. 0.05), r = the current round, and G is the set of nodes that have not been cluster-heads in the last 1/p rounds. Using this threshold, each node will be a cluster-head at some point within 1/p rounds. During round 0(r = 0), each node has a probability P of becoming a cluster-head. The nodes that are cluster-heads in round 0 cannot be cluster-heads for the next 1/P rounds.

Thus the probability that the remaining nodes are cluster-heads must be increased, since there are fewer nodes that are eligible to become cluster-heads. After 1/p-1 rounds T = 1 for any nodes that have not yet been cluster-heads, and after 1/p rounds, all nodes are once again eligible to become cluster-heads. Future versions of this work will include an energy-based threshold to account for non-uniform energy nodes.

In this case, we are assuming that all nodes begin with the same amount of energy and being a cluster-head removes approximately the same amount of energy for each node. Each node that has elected itself a cluster-head for the current round broadcasts an advertisement message to the rest of the nodes. For this “cluster-head-advertisement” phase, the cluster-heads use a CSMAMAC protocol, and all cluster-heads transmit their advertisement using the same transmit energy. The non-cluster-head nodes must keep their receivers on during this phase of set-up to hear the advertisements of all the cluster-head nodes. After this phase is complete, each non-cluster-head node decides the cluster to which it will belong for this round. This decision is based on the received signal strength of the advertisement. Assuming symmetric propagation channels, the cluster-head advertisement heard with the largest signal strength is the cluster-head to whom the minimum amount of transmitted energy is needed for communication. In the case of ties, a random cluster-head is chosen. After each node has decided to which cluster it belongs, it must inform the cluster-head node that it will be a member of the cluster. Each node transmits this information back to the cluster-head again using a CSMA MAC protocol. During this phase, all cluster-head nodes must keep their receivers on. If two of the cluster head is elected at the same time then both the cluster head has to broadcast a CHD message with the energy information and ID.

The sensor nodes, those are elected as cluster head will broadcast Cluster Head Declaration (CHD) message to their neighbour node which includes the complete cluster head information. Sensor nodes those have received the CHD message are considered as child node or derived node of the cluster head node. Once the child nodes are elected, the selection process of cluster head does not proceed for next round. If two of the cluster head is elected at the same time then both the cluster head has to broadcast a CHD message with the energy information and ID. Cluster head is received CHD message of other cluster head.After receiving of CHD message, the cluster head will go for compare the energy information of receiving CHD to it’s own energy information.

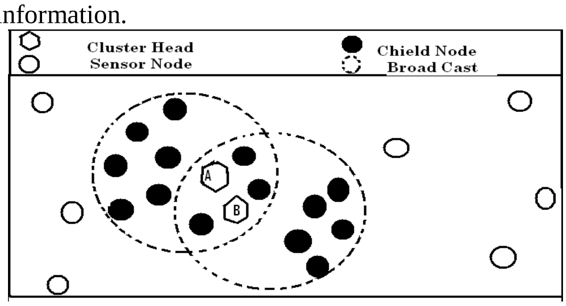

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Fig. 4.2.1 (A and B Broadcasts CHD message)

When energy is the same then determine the priority to compare the ID. As shown in Figure 1.2, lower priority cluster head broadcasts Cluster head Cancel (CHC) message to the child node.

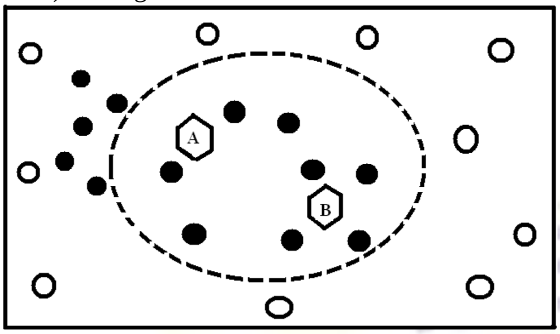

Fig. 4.2.2 (B Broadcasts CHC message)

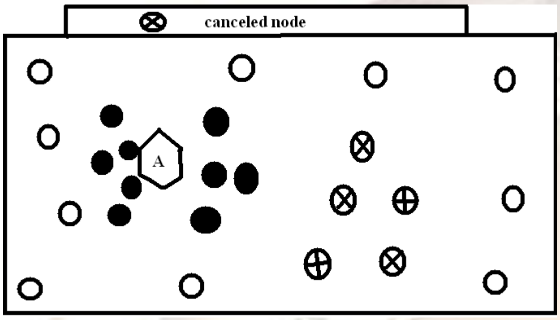

Fig. 4.2.3(Completion of Cluster Head Selection)

In above fig. sensor node transmits a CHC message is child node of high priority cluster head.

4.3 Communicating node selection

After cluster head election, the other cluster head does not exist in communication range of cluster head. So in order to communicate with other cluster head and need a communicating node to connection between the cluster nodes.

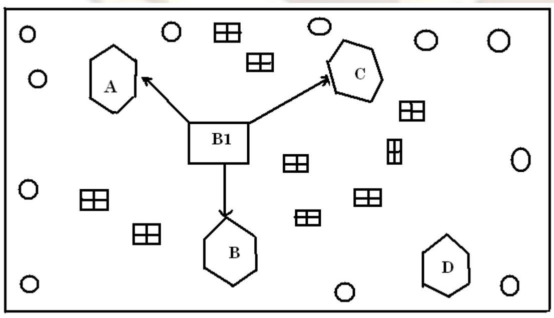

Fig.4.3.1 (Unicast of Bridge Declaration message to Cluster Head)

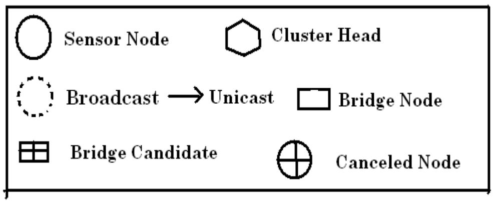

Fig.4.3.2

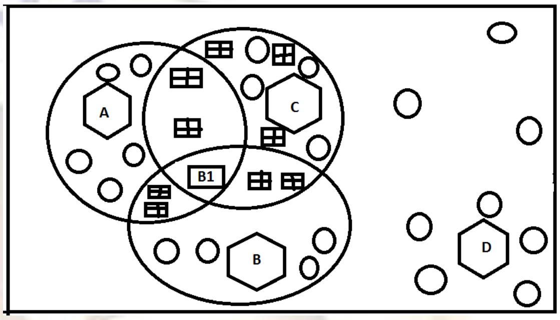

Fig.4.3.3 (Cluster Head broadcasts BS message)

Sensor nodes which can be elected a communicating node or a bridge node that must have more than two cluster head information.

Candidates of communicating node are elected bridge node using a timer which uses two types of conditions i.e.

[1]Number of cluster head information

[2]Energy information of its own.

If candidate s have many cluster head information, then timer is short and nodes will have priority.

A candidate which terminate a timer, that node will unicast Bridge Declaration(BD) message that includes bridge node and cluster head information of own to cluster head of own.

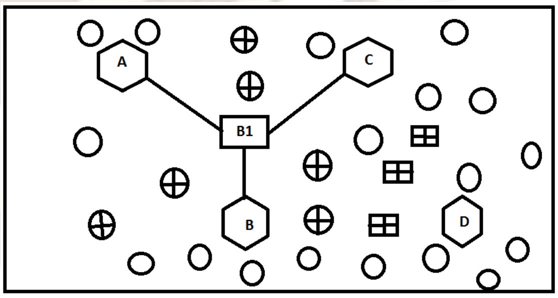

Fig.4.3.4 (B1 is selected as Bridge Node)

Cluster head which received BD message broadcast Bridge Selection (BS) message that include bridge node is election and around cluster head of elected bridge node.

Two or more nodes of the bridge is elected at the same time, the cluster head receives the BD message at the same time. Received the BD message cluster head determines bridge node among candidates of elected bridge nodes and broadcast BS message.

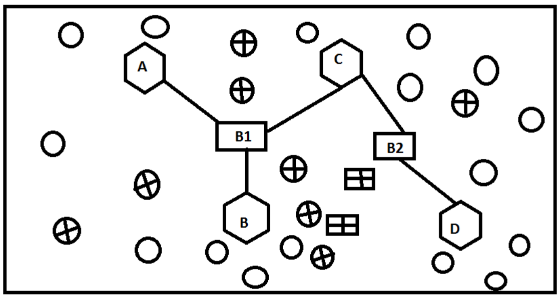

Fig.4.3.5 (Another Bridge node B2 is selected)

In some cases if the bridge node is having same cluster head information, then the node is selected as bridge node .which is having more information. There fore cluster head information of node which transmits BD message is same, then compare the energy information and the higher node is selected as the bridge node or communicating node.So when Bridge node will accept a BS message from cluster head then it configures a backbone network to connect between the cluster head. If some of the candidates are receiving BS message but not elected by bridge node, then they compare their cluster head information and message information and after that they may change a status to candidate of bridge node or general sensor node

.

5. Implementation and Result Analysis

We have implemented this protocol on mat lab 7.5.0 having 100 random sensor node distributed randomly over 100 × 100 area and the maximum round is 625. The base station is assumed to be present at the origin. The position of all the nodes is randomly generated. All the co-ordinates of the node are known to the base station. Cluster formation is done according to the LEACH algorithm and the received signal strength of a node is measured by the Euclidian distance between the nodes. The initial energy of each sensor node is 1 joule. The whole network is divided into n no of clusters. The clusters are changed dynamically. Cluster members joined in a particular cluster depending upon the distance from the cluster head.

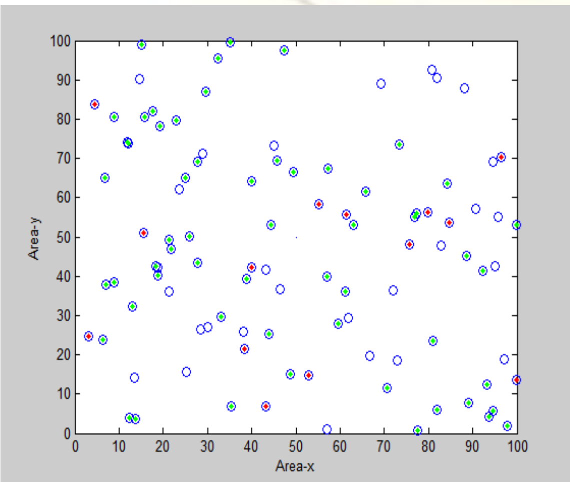

Fig 5.1(100 node random Sensor Network)

The clusters are changed dynamically .Cluster members are joining in a particular cluster depending upon the distance from the cluster head and according to the signal strength. After selection of cluster head, Bridge candidates are chosen and out of those Candidates Bridge nodes are selected.

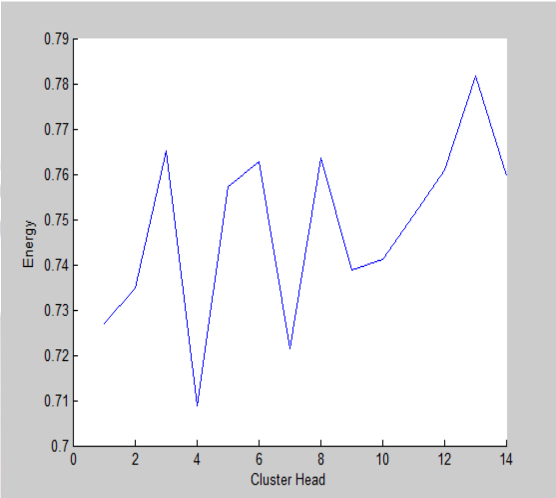

Fig.5.2 (Energy Dissipated by Cluster Head)

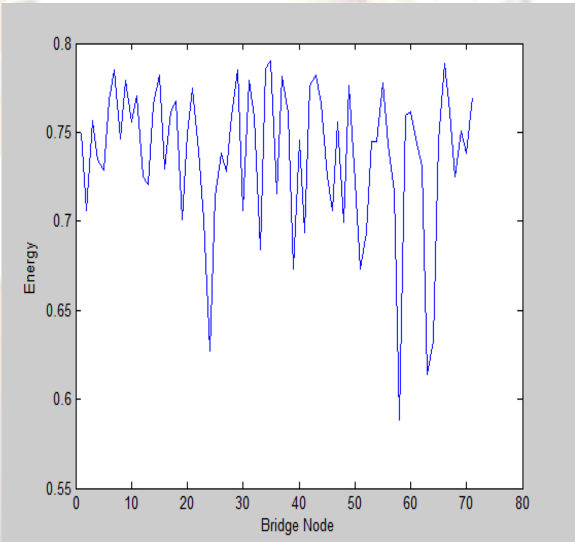

Fig. 5.3 (Energy Dissipated by Bridge Node)

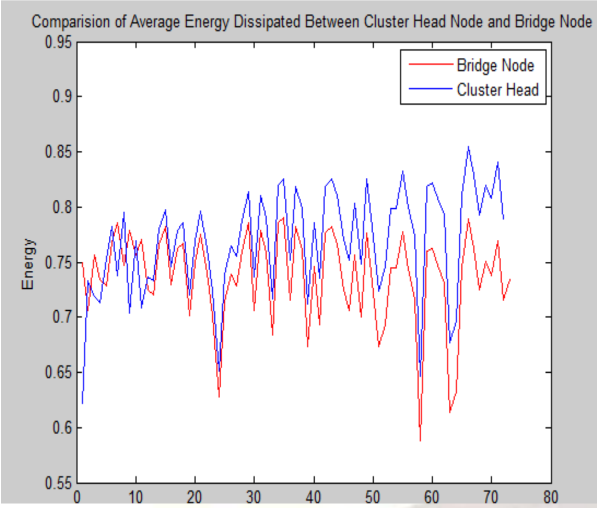

Fig. 5.4 (Comparison of Average Energy Dissipation between Cluster Head and Bridge Node)

In Fig. 5.4, we compare the average energy dissipation of our proposed scheme (i.e.) in between Cluster Head and Bridge Node. Fig. 5.4 shows that the Bridge nodes in our proposed protocol achieve significant energy savings over LEACH, in which data transmission was possible through the cluster head. For various values of rounds, Bridge node consumes less energy over previous one.

6. Conclusion

Clustering techniques applied in this paper is configured for a broad range of application for wireless sensor network. By applying clustering more efficient network configuration and data management will be enabled and here also we have defined a clustering technique which will consume less energy and reduce no. of transmission. It's an energy efficient routing protocol that is using an efficient cluster technique considering to elect cluster heads and elected bridge node algorithm design for network connection.

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