ENERGY PROFICIENT CLUSTER BASED ROUTING PROTOCOL FOR WSN

[1] Shriom Maurya, [2]Shish Ahmad, [3]Mohd Haroon
Dept. of Computer Sc. & Engg., Integral University Lucknow, India
[1]Shriommaurya87@gmail.com, [2]shish@iul.ac.in , [3]mharoon@iul.ac.in

Abstract— Wireless sensor networks (WSNs) have become more and more popular and have been widely used recently. WSNs usually consist of a large number of sensors for different applications of sensing that includes Military, medical, civil, disaster management, environmental, and commercial applications.
In this research we aim to design a cluster based routing approach for heterogeneous environment that increase the lifetime of wireless sensor network by reducing the energy consumption.

Keywords— Routing protocols, Energy proficient routing, WSN,MATLAB.

I. INTRODUCTION

The main aspire of energy efficient routing is to minimize the energy required to transmit or receive packets also called as active communication energy. Inactive energy is the energy which not only tries to reduce the energy consumed when a mobile node stays idle but also listens to the wireless medium for any possible communication requests from other nodes. Transmission power control method and load distribution method are the two methods which decreases active communication energy[1]. The sleep or power-down mode method decreases in- active energy. Both the protocol has specific benefits and drawbacks and therefore is applicable for certain situations. Thus it is not clear that which particular algorithm or a class of algorithms is the most excellent for all scenarios. To conserve energy, many energy efficient routing protocols have been proposed. Many re- searches are being made to carry out to develop energy aware routing protocols. Some are designed to search for the most energy efficient path from the source to the destination while some attempt to balance the remaining battery-power at each node when searching for the energy efficient path.

II. LITERATURE REVIEW

A. Energy Conservation

Energy conservative networks [2][3] are becoming extremely popular within the Ad hoc networking research. Energy preservation is presently being addressed in every layer of the protocol stack. There are two chief research topics which are almost identical: maximization of lifetime of a single battery and maximization of the lifetime of the whole network. The previous is related to commercial applications and node cooperation issues whereas the latter is more fundamental, for instance, in armed forces environments where node cooperation is assumed. The goals can be achieved either by developing better batteries, or by making the network terminals operation more energy competent. The first method is likely to give a 40% increase in batter y life in the near future (with Li-Polymer batteries). As to the device power utilization, the primary aspect are achieving energy savings through the low power hardware development using techniques such as variable clock speed CPUs, flash memory, and disk spin down. Nevertheless, from the networking point of view, our attention naturally focuses on the device's network interface, which is often the single largest consumer of power. Energy effectiveness at the network interface can be improved by developing transmission/ reception technologies on the physical layer.

B. Sensor Network Communication Architecture

According to [4], the sensor network is composed of the number of sensor devices or nodes. Each node has the capacity to gather information and then send these useful information to the sink and the end users. With the aid of multi-hop infrastructure and less architecture the information gathered is routed back to the final user through sink as shown in figure 1.

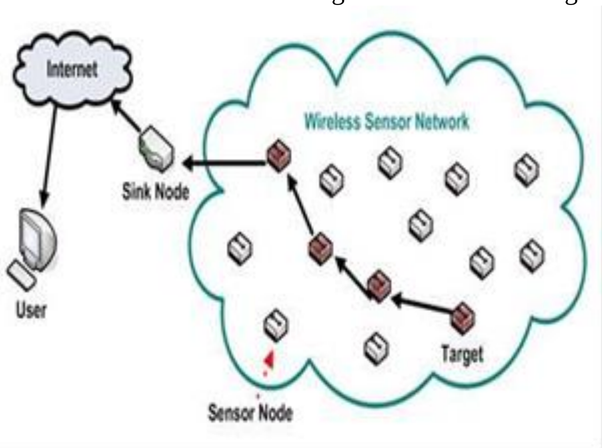

Figure 1: Wireless Sensor Network.

Here, in this network the sink send commands or queries to other sensor nodes in sensing area, on other hand sensor node work in a group to achieve the sensing task and send sensed information to sink. In the meantime, sink act as gateway to the outer networks. Further, sink gather information from sensor nodes, and performs simple processing on these gathered information and then finally, sends appropriate data to the end user through internet. Each of the sensor nodes in the network uses single-hop long-distance transmission to send information to the sink. Both sink and nodes uses protocol stack where it combines power and routing awareness, merges information with networking protocols, communicates power efficiently by means of wireless medium and promotes joint efforts of sensor nodes.

However, this method is expensive in terms of energy consumption for long-distance transmission [5]. Therefore, from the above context it can be declared that sensor network consists of large number of small nodes with computation, sensing and wireless communication capabilities. Apart from these the network still produces high-quality data due to its coordination of sensor nodes.

C. Hierarchical State Routing (HSR)

Hierarchical State Routing (HSR) employs a multilevel clustering and logical partitioning scheme. The network is partitioned into clusters and a cluster-head is elected as in a cluster-based algorithm. Cluster heads again organize themselves into clusters up to any desired clustering level as shown in Fig 2. Within a cluster, nodes broadcast their link information to one another. A cluster head summarizes its cluster information and sends it to neighboring clusters through a gateway node. A gateway node is one, which is adjacent to one or more cluster heads. Here cluster heads are members of a higher- level cluster[7]. At each level, summarization and link information exchanges are executed. The manner in which the information is exchanged in this hierarchy is, first information is collected among the nodes forming the base level cluster, it is then passed on to the cluster head which in turn passes to its next hierarchical cluster head and from there on the information is disseminated into other cluster heads and thus the information traverses down the hierarchy. Here every node has a hierarchical address, which may be obtained by assigning numbers from the top root to the bottom node. But as a gateway can be reached from the root from more than one path, so a gateway can have more than one hierarchical address [6].

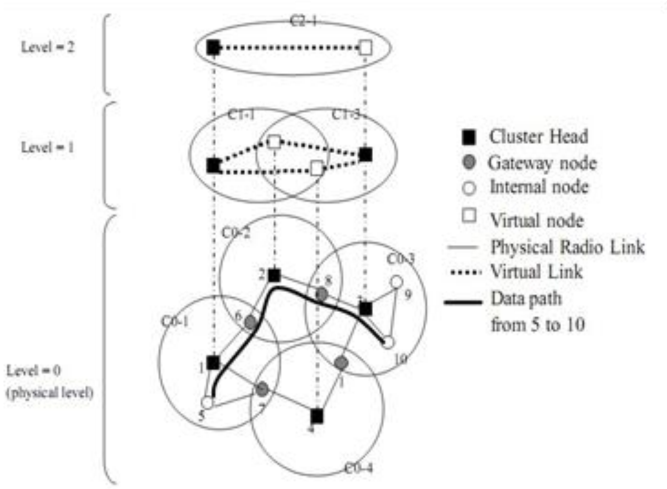

Fig 2: Clustering and Forming Hierarchies

Also, each subnet contains a location management server (LMS). All nodes in the subnet are registered with the local LMS. LMS has to inform upper levels, and upper level information comes to local LMS server. When two nodes wish to communicate, they send their initial data to the LMS, and the LMS then forwards it to the destination. But if the source and destination know each other's hierarchical addresses, they communicate directly. The protocol is highly adaptive to network changes.

The cluster head can monitor all the traffic with in the cluster and provide QoS service to real time applications simply by appending bandwidth and channel quality information to the link state information. The control traffic in HSR can be comparable to that of in on-demand protocols. The latency for access to non-frequently used destinations is low. But, the average number of hops the packets take, protocol complexity, packets dropped because of invalid routes is more in HSR when compared to that of in on-demand protocols.

D. Clustered Gateway Switch Routing protocol (CGSR)

In this protocol, nodes are aggregated into clusters controlled by a cluster head elected using a distributed algorithm as shown in Fig 3. All nodes within the transmission range of the cluster-head belong to this cluster [8]

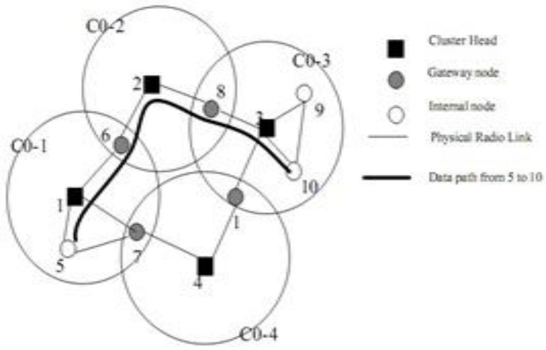

Fig 3: Clustering

Clustering provides framework for the development of important features such as code separation (among clusters), effective channel allocation and spatial reuse, routing and bandwidth allocation. But the selection of the cluster heads may cause complexity and overhead, thus degrading performance. Also, there are traffic bottleneck and single point failures at the cluster heads and gateways.

III. Proposed Methodology

It is cluster based routing protocol, in which cluster head is elected randomly according to the election probability.

We divide all the nodes of WSN in two categories on the basis of their energy.

- Normal node
- Advanced Node

Advance nodes have high energy than normal nodes. We do not form cluster of normal nodes as energy of normal node is less than advance node, and cluster head consumes more energy than cluster members in receiving data from cluster members. If we allow normal nodes to become cluster head they die soon resulting in the shortening of stability period.

A. Proposed Precinct-Based Steady Choice Protocol [PSCP*]*

In most routing protocols, nodes are deployed randomly in network field and energy of nodes in network is not utilized efficiently. We modified this theme: network field is divided in three precincts: precinct 0, chief precinct 1 and chief precinct 2, on the basis of energy levels and Y co-ordinate of network field. We assume that a fraction of the total nodes are equipped with more energy. Let m be fraction of the total nodes n, which are equipped with α time more energy than the other nodes. We refer these nodes as advance nodes, (1-m)×n are normal nodes.

- Precinct 0: Normal nodes are deployed randomly in Precinct 0, lying between 20<Y<=80.
- Chief Precinct 1: Half of advance nodes are deployed randomly in this region, lying between 0<Y<=20.
- Chief Precinct 2: Half of advance nodes are deployed randomly in Chief Precinct 2, lying between 80<Y<=100.

The reason behind this type of deployment is that advance nodes have high energy than normal nodes. As corners are most distant places in the field, so if a node is at corner then it requires more energy to communicate with base station so we have deployed high energy nodes (advance nodes) in Chief Precinct 1 and Chief Precinct 2.

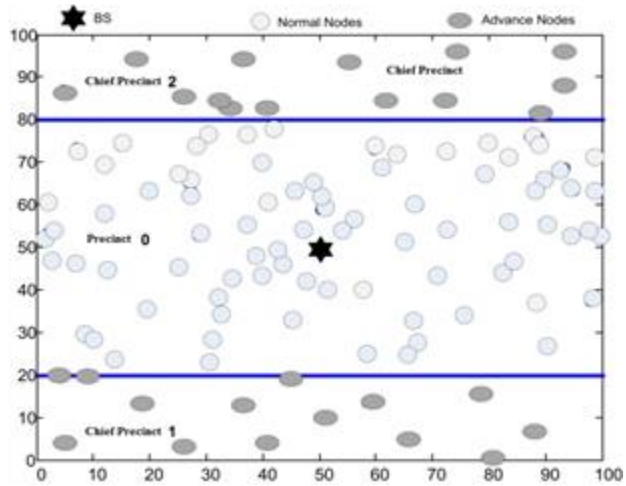

Fig.4 Network Architecture

1) PSCP Operation

PSCP uses two techniques to transmit data to base station. Techniques are:

- Direct communication.
- Transmission via Cluster head.

Direct Communication:

Nodes in Precinct 0 send their data directly to base station. Normal nodes sense environment, gathers data of interest and send it data directly to base station.

Transmission via Cluster head:

Nodes in Chief Precinct 1 and Chief Precinct 2 transmit data to base station through clustering algorithm. Cluster head is selected among nodes in Chief Precinct 1 and Head zone 2. Cluster head collect data from member nodes, aggregate it and transmit it to base station. Cluster head selection is most important. As shown in Fig.4 advance nodes are deployed randomly in Chief Precinct 1 and Chief Precinct 2. Cluster is formed only in advance nodes. Assume an optimal number of clusters Kopt and n is the number of advance nodes.

Every node decides whether to become cluster head in current round or not. Every node has optimal probability (Popt) to be cluster head which is calculated as follows.

$$P_{opt} = \frac{K_{opt}}{n} \tag{1}$$

A random number between 0 and 1 is generated for node. If this random number is less than or equal threshold T(n) for node then it is selected as cluster head. Threshold T(n) is given by as follows.

$$T(n) = \begin{cases} \dfrac{Popt}{1 - Popt\left(r \times \ mod \dfrac{1}{Popt}\right)} & if\ n \in G \\ 0 & otherwise \end{cases} \tag{2}$$

Where G is the set of nodes which have not been cluster heads in the last 1/Popt rounds.

Probability for advance nodes to become cluster head is proposed as

$$Padv = \frac{Popt}{1 + (\alpha . m)} \times (1 + \alpha) \tag{3}$$

Accordingly the threshold for advance nodes is

$$T(adv) = \begin{cases} \dfrac{Padv}{1 - Padv\left(r \times \ mod \dfrac{1}{Padv}\right)} & if\ adv \in G' \\ 0 & otherwise \end{cases} \tag{4}$$

G' is the set of advance nodes that have not been cluster head in the last 1/Padv rounds.

Once the cluster head is selected then the cluster head broadcasts an advertisement message to the nodes. The nodes receive the message and decide to which cluster head it will belong for the current round. This phase is called as cluster configuration phase.

On the basis of received signal strength, nodes respond to cluster head and become member of cluster head. Cluster head then assign a TDMA schedule for the nodes during which nodes can send data to cluster head. After the clusters configuration, every node data and sends it to the cluster head in the time slot allocated by the cluster head to the node. This phase is shown in Fig. 5.

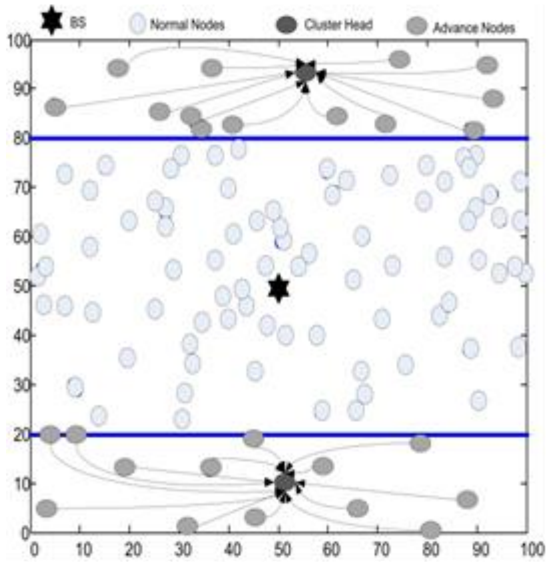

Fig.5 Nodes sending data to cluster head

When data is received from nodes, Cluster head then aggregates this data and send it to the base station this phase is called as transmission phase. Fig.6 illustrates this phase.

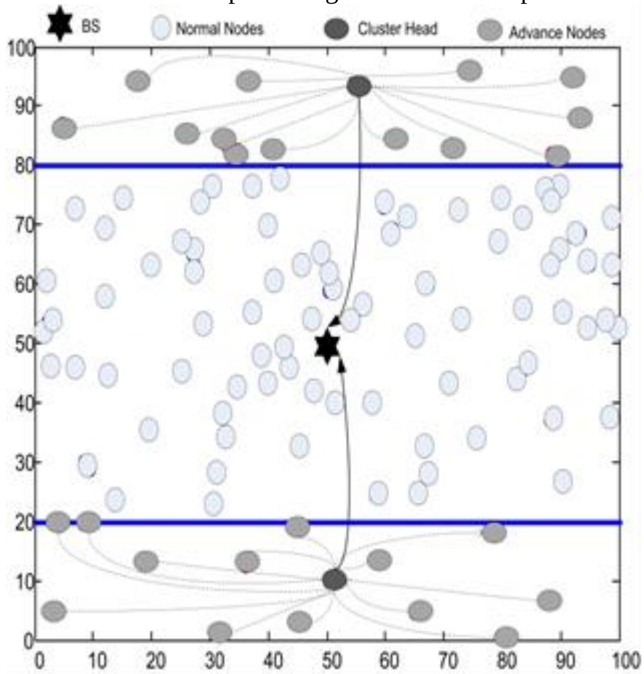

Fig.6 Cluster head transmitting data to base station

IV. Experimentation Evaluation

A. Simulations

We simulate our proposed protocol in a field with dimensions 100m×100m and 100 nodes deployed in specific zones with respect to their energy. Base station is placed in the center of the network field. We are using the first order radio model as used in SEP. MATLAB is used to implement the simulations.

Specifically, we have following settings.

Let 20% of nodes are advance nodes and half of them are deployed in Chief Precinct 1 and half in Chief Precinct 2. Since Popt is 0.1 so we have 2 cluster heads per round. One cluster head in Chief Precinct 1 and one in Chief Precinct 2 per round.

Other simulation parameters are shown in Table 1.

Table 1: Simulation parameters

Parameters	Value
Initial energy Eo	0.5 J
Initial energy of advance nodes	Eo(1+α) α Denoted by a In Graph
Energy for data aggregation EDA	5 nJ/bit/signal
Transmitting and receiving energy Eelec	5 nJ/bit
Amplification energy for short distance Efs	10 Pj/bit/m2
Amplification energy for long distance Eamp	0.013 pJ/bit/m4
Probability Popt	0.1

B. Result and Discussion

Here, we compare the results of our protocol with SEP and LEACH. We have introduced heterogeneity in LEACH, with the same setting as in our proposed protocol, so as to access the performance of all the protocol in presence of heterogeneity. Our goals in conducting simulation are

- To examine the stability period of LEACH, SEP and PSCP.
- We also examine the throughput of LEACH, SEP and PSCP.

Fig.7 and Fig.8 shows result for the case when m=0.1 and α=1.This means that there are 100 advance nodes out of total nodes which are 100. According to our proposed protocol 5 advance nodes will be deployed randomly in Chief Precinct 1 and 5 advance nodes will be placed in Chief Precinct 2.

Fig.7 shows the number of alive nodes against rounds. Fig.7 clearly shows that our protocol is enhanced from SEP and LEACH in terms of steadiness. As LEACH is very sensitive to heterogeneity so nodes die at a faster rate. SEP performs better than LEACH in two level heterogeneity, because SEP has weighted probability for selection of cluster head for both normal nodes and advance nodes. PSCP performs better than LEACH and SEP, because nodes in Precinct 0 (normal nodes) communicates directly to base station while nodes in Chief Precinct 1 and Chief Precinct 2 communicates via cluster head to base station: As in clustering technique, cluster head consumes energy in the form of data aggregation and also by receiving data from nodes in the cluster. So this energy is conserved in normal nodes as they do not have to aggregate data and receive data from other nodes, so energy is not dissipated as that of cluster head, resulting the increase of stability period. In Fig.7, we can see that network lifetime is also increased because of the advance node. Advance nodes have α time more energy than normal nodes so advance nodes die later than normal nodes. So this increases the instability period.

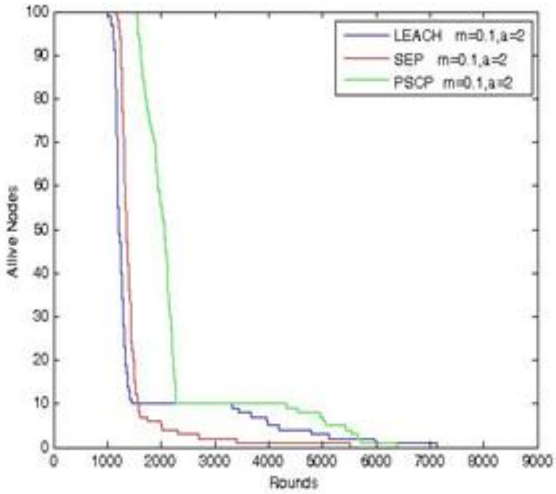

Fig.7 Alive nodes in LEACH, SEP and PSCP

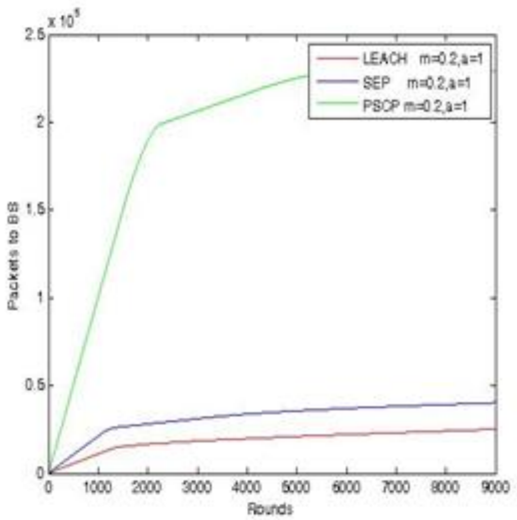

Fig.8 Throughput in LEACH, SEP and PSCP

Fig. 8 shows the throughput of LEACH, SEP and PSCP. Throughput of PSCP is greater than LEACH and SEP.

CONCLUSION

In this research we proposed we proposed a approach for heterogeneous environment of wireless sensor network. We divide all the nodes of WSN in two categories Normal node and Advanced Node.

Advance nodes have high energy than normal nodes. We do not form cluster of normal nodes as energy of normal node is less than advance node, and cluster head consumes more energy than cluster members in receiving data from cluster members. We divided in three precincts: precinct 0, chief precinct 1 and chief precinct 2, on the basis of energy levels and Y co-ordinate of network field. Nodes in Precinct 0 send their data directly to base station. Nodes in Chief Precinct 1 and Chief Precinct 2 transmit data to base station through clustering algorithm. Cluster head is selected among nodes in Chief Precinct 1 and Head zone 2. Cluster head collect data from member nodes, aggregate it and transmit it to base station.

We simulate our proposed protocol in a field with dimensions 100m×100m and 100 nodes deployed in specific zones with respect to their energy. Base station is placed in the center of the network field. We are using the first order radio model as used in SEP. MATLAB is used to implement the simulations.

We have compared the average results for LEACH, SEP and our proposed approach PSCP. Approximately 100% stability period of our proposed protocol is increased from LEACH and SEP, however network lifetime is increased little bit when compared with LEACH. When compared with SEP, PSCP network life time is increased due to advance nodes which die slower than normal nodes. Network lifetime of SEP is short because of the weighted probability for normal and advance nodes in the field. .

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