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Power Estimation in Wireless Sensor Networks by Clustering Mechanism

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Abstract— Performance is one of the key factors in wireless sensor networks (WSNs). As wireless sensor networks is plays a vital role in many application which can be classified majorly as monitoring and tracking. WSNs operate with limited resource like battery, memory; processor among this power optimization is one of the main factors that affect the battery power the sensor. So there is a need of estimation of the power dissipation that affects the performance of WSNs communication. This papers aims to identify the power dissipation of the WSNs by clustering in different deployment scenarios like sparse and dense deployment, tier architecture, heterogeneous WSNs.

Index Terms— Wireless Sensor Networks, LEACH, FSCH, SEP, EBHC

1 INTRODUCTION

Wireless sensor networks (WSN) are wireless network composed of spatially distributed autonomous sensors to cooperatively monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants, at different locations. In tracking it is applied for tracking the position on wild life and in traffic management. Due to the deployment flexibility and maintenance simplicity, WSN applications have been seen in many areas

Energy is the scarcest resource of WSN nodes, and it determines the lifetime of WSNs. So energy efficiency has been known as the most important issue in research of wireless sensor networks (WSN). So it is of great importance to design an energy efficient routing protocol for WSN. In terms of routing protocol, there are two different solutions from existing works. One is flat routing [1], each sensor node plays the same role and sends their data to sink node directly which always results in excessive data redundancy and faster energy consumption. The other is hierarchical routing. In hierarchical routing, the entire network is divided into several clusters. Each cluster consists of some source nodes and a cluster head [2]. Sensor nodes, referred as source nodes, can gather information from the monitoring region and send the sensing information to their corresponding cluster head [3]. The cluster head is elected from all the sensor nodes in a cluster according to some criteria, and is responsible for collecting sensing data from source nods. After receiving data from source nodes, the cluster head also performs data aggregation to reduce the data size before sending data to the sink, which further reduces the power expended for data transfer. Clustering-based routing algorithms are more appropriate and efficient than flat routing algorithms in WSN, and the algorithm proposed in this paper is also focused on the improvement of existing clustering mechanism [4]. Currently many clustering algorithm like SEP [5], EBHC [6], HEED [7], EEHC [8] on different scenarios and concepts are developed in this area. In this paper a few of them are studied for estimation of power dissipated.

The rest of the paper is organized as follows: Section 2 presents the power estimation. Section 3and 4 gives deals with the analysis power dissipation of different algorithm in different scenarios.

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2 POWER ESTIMATION

2.1 Clustering

Clustering is the one of the best routing protocols that aims to minimize the power consumption in WSNs with data aggregation at each cluster head. The LEACH [9] protocol gives the basic idea of clustering in WSNs it was the first algorithm to focus on clustering. The clustering in WSNs can be divided into two subdivision Intra clustering and Inter Clustering. To understand the clustering concepts we considering LEACH for our study in this section.

2.1.1 Low-Energy Adaptive Clustering Hierarchy (LEACH)

It is a self-organizing and adaptive clustering protocol. The operation of LEACH is divided into rounds, where each round begins with a setup phase for cluster formation, followed by a steady-state phase, when data transfers to the sink node occur. It uses random election of cluster heads to achieve load balancing among the sensor nodes. In LEACH, a sensor node is elected as the cluster head according to a distributed probabilistic approach. Non cluster nodes decide which cluster to join based on the signal strength, that is. Based the distance of the cluster head the non sensor node select or join the cluster head which is nearer to them.

The communication among the cluster is based on TDMA [10] each node will send the data to its cluster head only within its allocated time slot.

2.1.2 Power dissipation in Intra Cluster

Intra clustering is the communication between the Cluster head and its cluster members. Basically energy dissipation in nodes will take place by two ways, Data Transmitting and Data Receiving. The energy consumed for idle listing or sleep state is negligible compared to transmitting and receiving so it is neglected.

In our study we are considering both transmitting and receiving will consume approximately equal power. The total power dissipated by the node in transmitting and receiving is given by:

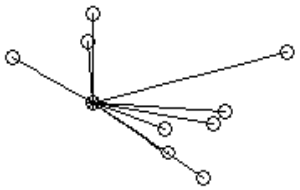
TPOWER= TENERGY*(k) +Efs*4000*(d2);

RPOWER= (RENERGY +EDA)*k;

Where,

T ENERGY = Transmitting energy
RENERGY= Receiving energy
K= Data size
D = Transmitting Distance
EDA= Data Aggregation Energy
Efs=Circuit Amplifier power

The power dissipated among a single cluster can be given in the terms of Transmission as follows: Consider a cluster as 10 nodes (9 members + 1 Cluster Head) where each node will lose TPOWER of its power



So the total power dissipated in this cluster for transmitting the data of k bits over distance d

= 9 * *TPOWER.* **(1)**

2.1.3 Power dissipation in Inter Cluster

For the same power consumption the power dissipated by the nodes is inter clustering routing process is The power dissipated in receiving the data from the same members =9*RPOWER. Where the single cluster head (CH) alone will go down by 9* RPOWER less energy. The overall energy dissipated in this cluster will be

= 9*RPOWER **(2)**

And the CH have to transmit the data to the base station so the energy dissipated in transmitting the k bits of data over short and long distance is given by

CH POWER= TENERGY*(k)+Efs*4000*(d2);
-For shorter distance **(3)**

Or

CH POWER= T ENERGY*(k) +Efs*4000*(d4);
- For long distance **(3)**

So the Total Power dissipated by the one cluster is

= (1) + (2) + (3)

$$= 9(T_{POWER} + R_{POWER}) + CH_{POWER} \quad (4)$$

The overall power dissipated in these two types of clustering depends on the number of cluster present in the network with corresponding transmitting distance and data size.
The total power dissipation in a network for a one round of clustering is given as

=number of Cluster *(TPOWER + RPOWER) + CH POWER **(5)**

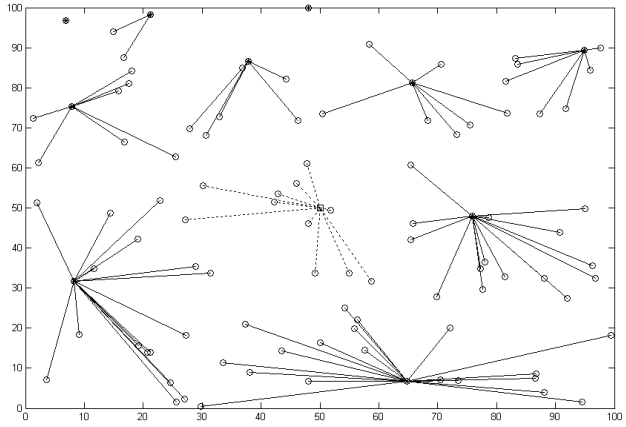


FIGURE 1: CLUSTERING

In this section we discussed the major process of power dissipation in the WSNs the next section focus on the algorithm which aims to optimize the power consumption with different scenarios that comes under this major power dissipation of WSNs.

3. POWER OPTIMIZATION BY EFFICIENT INTER CLUSTERING ROUTING

3.1 Favorable Selection of a Cluster Head in a Sensor Network [11]

This algorithm aims to increase the efficiency of the WSNs by using better way of routing algorithm. The working of this algorithm is classified in to 2 phase as shown below.

A. Criteria for becoming a Cluster Head

For a node to become a Cluster head it must have some minimum amount of energy so that it can transmit the packet successfully to the base station. The reason is that the node may aggregate all its member data but cant able to reach the destination successfully resulting in failure to transmit. By this the small amounts of energy in the node get wasted, and it could have been a member node for some period of time, with resulting in data lost.

So they are calculating a threshold distance and the threshold energy for the node to become Cluster head. Only the node satisfying this threshold energy distance condition will become a cluster head. Equation below gives the threshold distance and energy:
Equation below gives the threshold distance and energy:

Where, = Threshold distance Where a= area of a Square network = Transmitting energy. = Data Aggregation Energy =Packet size

$$\mathbf{M}_{\varepsilon} = (\boldsymbol{\varepsilon}_{tx} * \boldsymbol{\varepsilon}_{da}) * \mathbf{k} + \boldsymbol{\varepsilon}_{fs} * \mathbf{k}(\mathbf{T}_{d} * \mathbf{T}_{d})$$

Where,

$\mathbf{T}_{d=}\sqrt{\mathrm{Md}^2 + \mathrm{Md}^2}$ = Threshold distance

$\mathbf{M}_{d=}\frac{a}{400}$ Where a= area of a Square network

$\boldsymbol{\varepsilon}_{t\,x}$= Transmitting energy.
$\boldsymbol{\varepsilon}_{da}$= Data Aggregation Energy
$\mathbf{k}$ =Packet size

B. Phase of Selection of Cluster Head

If the node satisfies the first condition then it is eligible to become a cluster head. The main concept of inter cluster routing is to increase the cluster head in the network this is decided by the following steps:

Step-1: Find the residual energy (RE) of all the node the is currently acting as cluster head

Step-2: Calculate SCH (condition to select CH) which is given By the below equation SCH= (CHtotal/p)*RE

Step-3: if (SCH/p>I⊚/SCH)
End of Selecting CH
Else Select other CH from non CH group

By this way of cluster the energy dissipated in the intra clustering can be reduced because the cluster is not congested with more number of nodes so that only small amount of energy is dissipated from the CH as part of receiving energy

4. Power Optimization In Sparse Sensor Network

The network area in which only few nodes are deployed is considered as sparse [12]. In this situation the nodes may be deployed far from one another. So the formation of Inter and Intra clustering will consume more power.

4.1 Clustering in Tier Architectures for a Sparse Sensor Networks [13]

In this a tiered architecture is defined for WSNs which is well suitable for under water sensor networks.

The architecture plays an important role in the wireless sensor network. So selection of architecture is also an important task along with the selection an efficient protocol for communication across the nodes.

Figure below shows the comparison of performance of a sensor networks in different with different number of tiers. This graph is a result of analysis of LEACH in different tiers as we can see that the numbers of failure nodes are decreased in two and three tier for sparse WSNs.

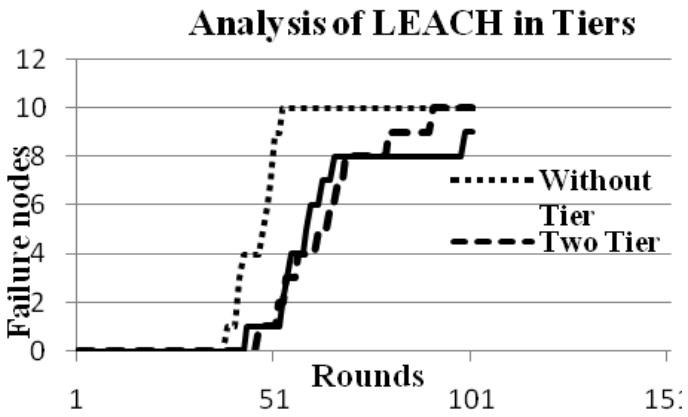


Figure 2: Clustering with tier architecture

5. Power Optimization In Dense Sensor Network

In this section we discuss on the process of power dissipation in dense sensor networks as INTRA Cluster Routing. This case can be lead to Intra Clustering routing, as there is more number of nodes are deployed one can select the cluster head in well equally distributed manner. By this way there will be more number of members in each cluster and the cluster heads have to receive suitable mechanism in order to choose cluster head uniformly by avoiding rapid failure of the

cluster head.

6. Power Optimization In Energy Heterogeneous Sensor Network

In this case we study the heterogeneous concept of WSNs as our aim is to power estimation in WSNs, so we are concentrating on energy heterogeneity sensor network. This also faces the same problem as in normal WSNs, but due to heterogeneity it can overcome the problem facing by normal WSNs. The main aim here is to selecting cluster head more often from the group of advance nodes so we can maintain energy balance between advance and normal nodes.

6.1 Energy Balancing Clustering for Heterogeneous Sensor Network [6]

This algorithm proposes a new Energy-balancing Clustering protocol for heterogeneous WSN where only the advance nodes with more energy than normal nodes are made as Cluster Heads and normal nodes act as members, until some percent of advance nodes dies. By this we can balance the energy in network and to utilize the energy of advance node efficiently. This mechanism is an improved solution for the problem identified in SEP (Stable Election Protocol). And this mechanism utilize the energy of advance nodes efficiently in order to increase the lifetime of a WSNs

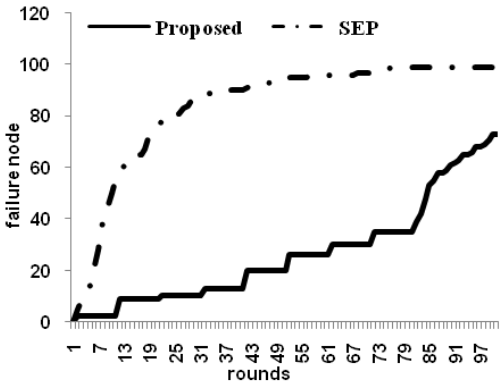


Fig-3 Energy Balancing Clustering for Heterogeneous vs. SEP for m=0.1 & a=1

In Fig-3 we can compare the results of these 2 heterogeneous WSNs. In this EBCH has 70 failure node and SEP has as 99 Failure nodes when the percentage of advance node m=-0.1, which is 29% more failure nodes than SEP.

7. CONCLUSION

In this section we are comparing the different clustering algorithms in a Matlab based simulator. We focused only on the Lifetime of a sensor network

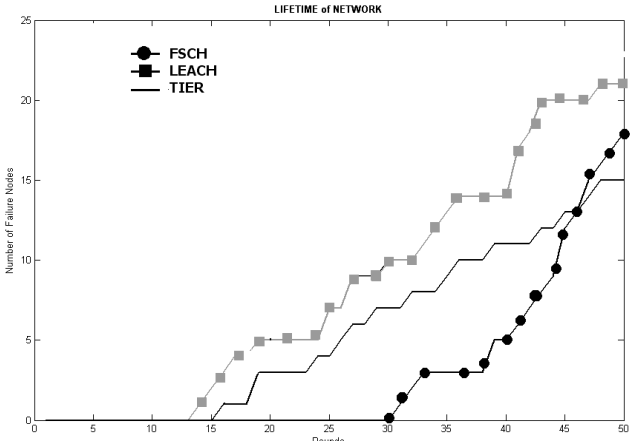


Figure 3: Lifetime of a Network

The above graph show is simulated for a 50 nodes deployed in a 100 Sqm area for 50 rounds. Where X axis is number of rounds and Y axis is number of failure nodes. As we can see that the number of failure nodes in FSCH is less than LEACH and number of failure nodes in Tiered Clustering is less than that of FSCH by this we can say that Tier Architecture can increase the efficiency of clustering.

This paper aims to study the power dissipation by different clustering mechanism in WSNs by considering the basic power dissipation in WSNs one can develop an better algorithm which can increase the performance of the WSNs by optimizing the power in this process.

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