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Improved Cluster Head Determination in Heterogeneous Wireless Network

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Abstract

Wireless sensor network (WSN) can be used in diverse applications that require sensing of critical data. Such applications include military, medical, civil, disaster management, environmental, and commercial applications.

In this paper, we intend to propose a cluster based routing approach to boost the existence of heterogeneous wireless sensor network by plummeting the energy burning-up.

Keywords: Routing protocols, WSN, Clustering, Network Lifetime

1. INTRODUCTION

Wireless sensor network is composed of diminutive, low-cost and elegant sensors. It is usually deployed arbitrarily inside or on the brink of events to be monitored. These networks are advantageous as they are self-configuring. They can be deployed erratically without the requirement for human intervention on a battleground, in a debacle region or in unapproachable areas.

1.1 Energy Preservation

The two chief research topics concerned with energy preservation are maximization of life span of a single battery and maximization of life span of the entire network[2][3]. The maximization of life span of a battery is concerned with business applications and hitches of collaboration of sensors while maximization of life-span of the network is concerned with rudimentary applications like in armed forces milieu where node cooperation is expected. We have simple option to attain previous goals either by manufacturing superior batteries or by preserving energy burning in communication. With Li-Polymer batteries first method is expected to give a 40% raise in life of battery. Also by using techniques such as variable clock speed CPUs, flash memory, and disk spin down, low power consuming hardware were developed to preserve the energy in communication. However, as we are aware that prevalent consumption of power takes place at device's network interface, thus our concentration unsurprisingly focuses on it. So to diminish energy consumption and augment effectiveness, network interfaces are expected to be modified by enhanced transmission/ reception technologies on the physical layer.

1.2 Sensor Network Communication Architecture

According to Mooi Choo et. al. [4], the sensor network is composed of the various sensor devices or nodes. Each node has the capacity to gather information and then send this useful information to the sink and the end users. As shown in figure 1, the information gathered is routed back to the final user through sink with the support of multi-hop infrastructure.

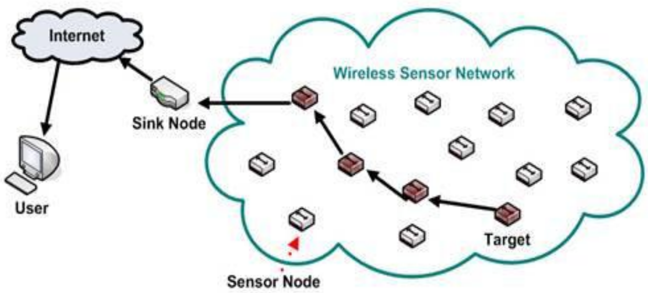

Figure 1: Wireless Sensor Network.

As shown in figure 1, sink node send commands or queries to other sensor nodes in sensing area, conversely sensor node work in a group to accomplish the sensing task and send sensed information to sink node. In the meantime, sink node 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 as well as nodes use protocol stack where they coalesce power and routing awareness, amalgamate information with networking protocols, communicate power efficiently by means of wireless medium and encourage joint efforts of sensor nodes.

Nevertheless, this method is pricey in terms of energy utilization for long-distance transmission[5]. Hence, from the above context it can be declared that sensor network consists of hefty 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[6].

2. LITERATURE REVIEW

2.1 Hierarchical State Routing (HSR)

Hierarchical State Routing (HSR) approach is as in a cluster-based algorithm. HSR partitions network into clusters and a cluster-head(CH). Cluster-head again organizes themselves into clusters up to any preferred clustering level as revealed in Fig 2.There are three kinds of nodes, cluster head, Gateway node and Internal node. The nodes which are flanking to one or more cluster heads are called gateway node. Within a cluster, every node is instructed to relay their link information. The CH has responsibility to recapitulate this link information and sends it through a gateway node to adjoining clusters.

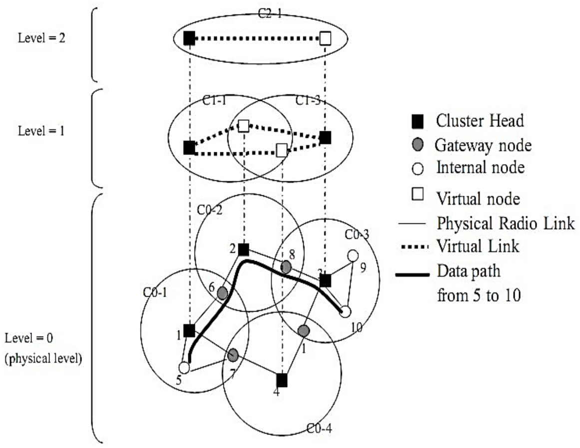

Figure 2: Clustering and Forming Hierarchies

2.2 Clustered Gateway Switch Routing protocol (CGSR)

As shown in Figure 3, this protocol utilizes a disseminated algorithm that elects cluster head and all nodes are aggregated[8].
By exploiting the conception of clustering we can build scaffold for the development of significant facets such as effectual channel allotment, code severance among clusters, spatial reuse, bandwidth and routing allocation. However one important fact is that if CH is selected wrongly, it may cause intricacy and overhead, thus performance may be mortified.

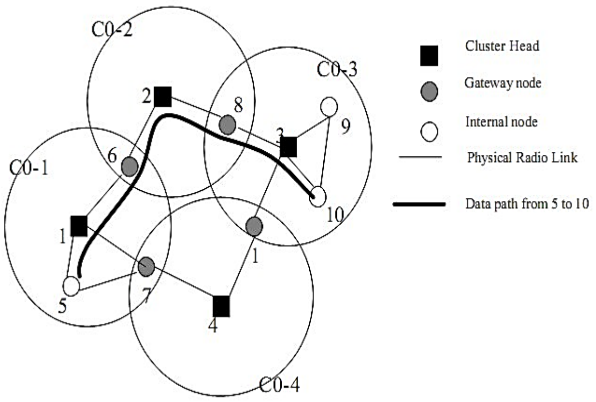

Figure 3: Clustering

2.3 Low-Energy Adaptive Clustering Hierarchy(LEACH)

W. Heinzelman et. al. [9] proposed a proactive routing protocol named LEACH. This protocol was designed for special kind of network which is composed of copious sensors dispersed haphazardly. These sensors are capable to sense data and communicate it to CHs. The responsibility of CHs is to gather this data, aggregate the data received from other sensors and then transmit it to BS.

3. PROPOSED METHODOLOGY

We divide all the sensors of WSN in three categories on the basis of their power.

- Ordinary node
- Middle Nodes
- Superior Node

As the name refers superior nodes have large amount of energy while ordinary nodes have normal energy. Middle nodes have energy that less than superior node and greater that ordinary node. Let us consider the following notations:

N : Total number of nodes
E_{ord} : Energy for ordinary nodes
E_{mid} : Energy for middle nodes
E_{sup} : Energy for superior nodes
F_{mid} : Fraction of middle nodes to total number of nodes
F_{sup} : Fraction of superior nodes to total number of nodes
EF_{mid} : Energy factor for middle nodes i.e. middle nodes have EF_{mid} times more energy than ordinary nodes
EF_{sup} : Energy factor for superior nodes i.e. energy of superior nodes is EF_{sup} times more than that of ordinary nodes
Relationship between EF_{sup} and EF_{mid} :

$$EF_{mid} = EF_{sup} / 2$$

Considering above notations, following mathematical representations can be derived:

Energy for superior nodes
$$E_{sup} = E_{ord}\,(1 + EF_{sup})$$

Energy for middle nodes
$$E_{mid} = E_{ord}\,(1 + EF_{mid}),$$

Thus if we know the total number of ordinary, superior and middle nodes and their energy requirements, we can simply calculate total energy of each kinds of nodes as follows:

$$TE_{ord} = N \times E_{ord} \times (1 - F_{mid} - F_{sup})$$
$$TE_{mid} = N \times F_{mid} \times E_{ord} \times (1 + EF_{mid})$$
$$TE_{sup} = N \times F_{sup} \times E_{ord} \times (1 + EF_{sup})$$

$$\text{Total Energy} = TE_{ord} + TE_{mid} + TE_{sup}$$
$$= N \times E_{ord} \times (1 + F_{mid} \times EF_{mid} + F_{sup} \times EF_{sup})$$

The probability of nodes to be designated as a CH on energy basis can be determined by using blueprint which is as follows:

$$p_{ord} = \frac{p_{opt}}{(1 + \mathrm{F}_{\mathrm{mid}} \times \mathrm{EF}_{\mathrm{mid}} + \mathrm{F}_{\mathrm{sup}} \times \mathrm{EF}_{\mathrm{sup}})}$$

$$p_{mid} = \frac{p_{opt}.(1 + \mathrm{F}_{\mathrm{mid}})}{(1 + \mathrm{F}_{\mathrm{mid}} \times \mathrm{EF}_{\mathrm{mid}} + \mathrm{F}_{\mathrm{sup}} \times \mathrm{EF}_{\mathrm{sup}})}$$

$$p_{\mathrm{sup}} = \frac{p_{opt}.(1 + \mathrm{F}_{\mathrm{sup}})}{(1 + \mathrm{F}_{\mathrm{mid}} \times \mathrm{EF}_{\mathrm{mid}} + \mathrm{F}_{\mathrm{sup}} \times \mathrm{EF}_{\mathrm{sup}})}$$

Now to guarantee that cluster head assortment is done in the analogous manner, we consider threshold level of each kind of node. As every node produces arbitrarily a number between 0 to 1 (both inclusive), if produced value is below brink value then this node is designated as CH.
On the basis of probabilities to become CH, the threshold can be computed as follows:

$$T_{ord} = \begin{cases} \dfrac{p_{ord}}{1 - p_{ord}\left[r.\mathrm{mod}\dfrac{1}{p_{ord}}\right]} & if \quad n_{ord} \in S' \\ 0 & otherwise \end{cases}$$

$$T_{m} = \begin{cases} \dfrac{p_{m}}{1 - p_{m}\left[r.\mathrm{mod}\dfrac{1}{p_{m}}\right]} & if \quad n_{m} \in S'' \\ 0 & otherwise \end{cases}$$

$$T_{\mathrm{sup}} = \begin{cases} \dfrac{p_{\mathrm{sup}}}{1 - p_{\mathrm{sup}}\left[r.\mathrm{mod}\dfrac{1}{p_{\mathrm{sup}}}\right]} & if \quad n_{\mathrm{sup}} \in S''' \\ 0 & otherwise \end{cases}$$

S′, S″ and S‴ are the set of ordinary, middle and superior nodes that have not get the chance to be designated as CH in the past respectively.

3.1 Proposed Protocol

At the beginning of every round, the phenomenon of cluster change occurs. When the cluster change occurs, the CH broadcasts the Reporting Time (RT), physical parameters (P), Inflexible brink (IB), Flexible brink (FB). Inflexible brink is a value of sensed parameter beyond which node will convey data to CH. If the value which has been sensed turn out to be identical or larger than this brink value, the node immediately turns on its transmitter and conveys that information to CH.

In this way in our approach, we keep all nodes in sensing modes. The sensed value (SV) is stored in an inner variable of node. When SV reaches inflexible brink value or if divergence between current SV and the value hoarded in SV variable is either equal or greater to flexible brink, transmitter gets activated and data is sent out to CH. Thus we can simply diminish number of data transmissions by maintaining these both brink values.

Followings are some imperative features concerned with proposed approach:
1) Data that is very critical, reaches the user almost instantaneously.
2) Nodes continuously sense data, but sensed data is not sent out instantly, as a result much power can be saved as compared to proactive networks.
3) When cluster changes, values of FB, RT and P are transmitted afresh and so, user can decide the frequency and parameters to be sensed according to the criticality of sensed attribute and application.
4) Depending on necessity, the client can amend the parameters, as parameters are broadcasted at the cluster change time.

4 EXPERIMENTATION EVALUATION

4.1 Simulations

We have used simulation parameters as by [11]. Simulation parameters shown in table 1.

Table 1: Simulation parameters

Parameters	Value
No. of Nodes(N)	100
Preliminary energy (Eo)	0.5 J
Transmitting and receiving energy (Eelec)	50nJ/bit/message
Energy for data aggregation (EDA)	5 nJ/bit/signal
Amplification energy for long distance (Eamp)	0.013 pJ/bit/m^4
Amplification energy for short distance (Efs)	10 Pj/bit/m^2
k	6000
Probability (Popt)	0.1
F_{sup}	0.1
EF_{sup}	1

Following performance metrics have been exploited the simulations:

1) Permanence time: It is time interval between the events beginning of the network operation and the demise of first sensor.
2) Unsteadiness period: It is time interval between the demise of first sensor and last sensor.
3) Throughput: It is the number of packets CH transmits to BS.
4) Number of sensors that lost entire energy (lifeless sensors) per round.
5) Number of nodes that still have some energy (alive sensors) per round.

4.2 Result and Discussion

The snapshots of generated results are as follows:

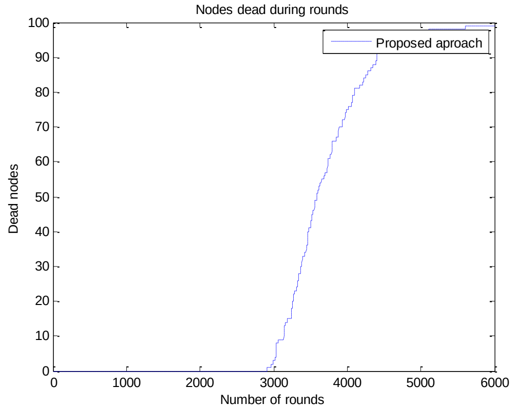

Figure 4: Dead nodes per round

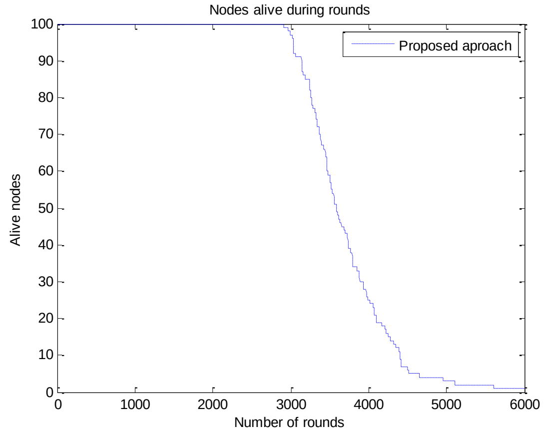

Figure 5: Alive nodes per round

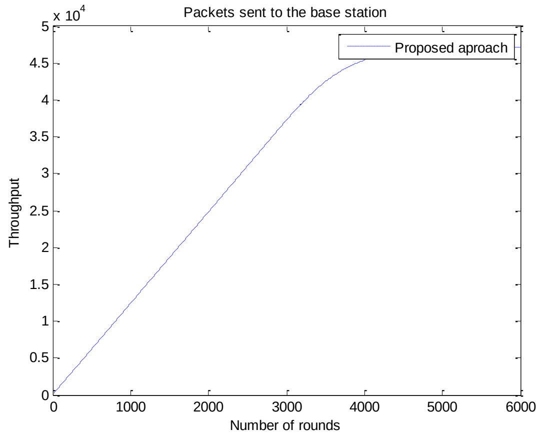

Figure 6: Packets sent from CHs to BS

When the results were compared with different variants of LEACH[10], it is observed that:

- Our proposed approach has improved steadiness period than all other protocols.
- The network life-span has been enlarged as compared to other protocols.
- Boosted number of alive nodes and lessened lifeless nodes per round respectively.

5 CONCLUSION

In this paper, we propose a novel reactive routing protocol for sensor network, where we divide all the nodes of WSN in three categories on the basis of their energy.
To guarantee that cluster head selection is done in the analogous manner, we have taken a different parameter into contemplation. The proposed approach causes boost in stability period as well as network life.

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