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SINK LOAD MINIMIZATION USING HYBRID STABLE ELECTION PROTOCOL ENERGY AWARE SINK RELOCATION (SEASR) IN WIRELESS SENSOR NETWORKS

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Abstract

In this paper, we propose balanced Energy-Efficient Network Sink load minimization using hybrid stable election protocol energy aware sink relocation protocols for wireless sensor networks (WSNs). Proposed method considers energy levels of nodes and selects cluster heads (CHs) on the base of residual energy levels of nodes and average energy level of the network, whereas SEP dynamically varies the CHs selection probability in an efficient manner leading to increased network lifetime. We also present a mathematical sink mobility model and validate this model by implementing it in SEP protocols in terms of stability period, Energy consumption, and Network lifetime.

Keywords: Sink relocation, SEP, Energy consumption, Network lifetime etc.

I. INTRODUCTION

The emerging field of wireless sensor networks combines sensing, computation, and communication into a single tiny device. Through advanced mesh networking protocols, these devices form a sea of connectivity that extends the reach of cyberspace out into the physical world. As water flows to fill every room of a submerged ship, the mesh networking connectivity will seek out and exploit any possible communication path by hopping data from node to node in search of its destination. While the capabilities of any single device are minimal, the composition of hundreds of devices offers radical new technological possibilities. The power of wireless sensor networks lies in the ability to deploy large numbers of tiny nodes that assemble and configure themselves. Usage scenarios for these devices range from real-time tracking, to monitoring of environmental conditions, to ubiquitous computing environments, to in situ monitoring of the health of structures or equipment. While often referred to as wireless sensor networks, they can also control actuators that extend control from cyberspace into the physical world.

II. RELATED WORK

Many people focus on hierarchical routing methods. These methods all construct a virtual hierarchical structure and determine a multi-tier hierarchy of roles among the nodes. A successful network with a hierarchical structure can access to the high-layer nodes easily and has a corresponding strategy for the hot spot problem.

A modified stable election protocol (MSE) [8] was proposed to predetermine the sink's trajectory which is a straight line through the network. In Figure 1(a), the whole network is divided into clusters and MSE forwards the sensing data aggregated to the mobile sink via cluster-head nodes. MSE establishes a node failure maintenance mechanism for the whole network. The failed cluster-head nodes will be removed from the network automatically and MSE will select a new cluster-head node for data forwarding. However, after several node deletion operations, the network will become sparse and the distance between cluster-head nodes will be increased, which will result in significant transmission power consumption and shorten the network lifetime.

In [9], Two-Tier Data Dissemination (TTDD) is one of the hierarchical approaches which have been put forward long ago. As shown in Figure 1(b), TTDD is a virtual grid-based approach, which provides scalable and efficient data delivery to multiple mobile sinks. Each source node with the sensor data proactively constructs a rectangular grid and becomes a crossing point of this grid. Sinks receive data on the move continuously by flooding queries within a local cell only whenever needed. Location-aware sensor nodes are also needed. In general, overhead for constructing grids in TTDD is immense for periodic data reporting applications.

TTDD is not suitable for the network where events occur frequently. In order to send data to multiple mobile sinks efficiently and reduce the power consumption of sensor nodes, a grid-based energyefficient hierarchical routing protocol (GBEER) [10] is proposed, which constructs a grid structure for all the source nodes using global location information. As a mobile sink reaches a new position, data request will be sent to the closest cell-header along the grids by local flooding, and then data is sent back to the sink along the opposite direction of the original path. The approach enables high overhead to be limited in a separate cell. But nodes residing on the grid may become hot spots and drain out their battery energy in the sensor network using GBEER.

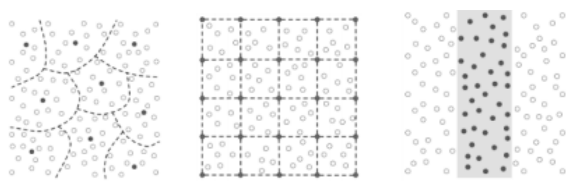

Figure 1: Various hierarchical structures: (a) Clusters (MSE [8]), (b) Rectangular grid (TTDD [9], GBEER[8], VGDRA [10]),(c)Line(LBDD [11])

Similarly with GBEER and TTDD [8, 9] a novel GridBased Dynamic Routes Adjustment Scheme is put forward in [11], aiming to reduce the routes reconstruction cost of the sensor nodes to extend the network lifetime. VGDRA adopts four propagation rules to adjust routes to copy with the routes readjustment. The scheme can realize routes readjustment by just adjusting part of routes, thereby minimizing communication consumption significantly. In addition, to prevent the energy-hole problem, the cell-header will be reselected when its energy is less than a threshold. Even though dynamic routes adjustment in VGDRA shows good performance in prolonging the network lifetime, cell-headers adjacent to the sink deplete energy quicker than others and the network still might appear energy-hole phenomenon. Apart from rectangular structures and cluster-based structure, the line-based network structure is also adopted in [12], but it has the same defect that local nodes will consume more energy and die earlier than other nodes. This will decrease network connectivity.

III. Radio Energy and Network Model

a) Radio energy model

Radio Energy Model used is based on [4, 13]. Energy model for the radio hardware energy dissipation where the transmitter dissipates energy to run the radio electronics and the power amplifier, and the receiver dissipates energy to run the radio electronics. Here both the free space (d2 power loss) and the multipath fading (d4 power loss) channel models have been used, depending on the distance between the transmitter and receiver. Power control can be used to invert this loss by appropriately setting the power amplifier—if the distance is less than a threshold does, the free space model is used; otherwise, the multipath model is used. Thus, to transmit an *I*-bit message a distance, the radio expends

$$E_{Tx}(l,d) = \begin{cases} l.E_{elec}^{Tx} + l.\varepsilon_{amp}.d^{n} & if\ d < do \\ l.E_{elec}^{Tx} + l.\varepsilon_{amp}.d^{n} & if\ d \geq do \end{cases} \quad (1)$$

And to receive and *I* -bit message, radio expands

$$E_{Rx}(l,d) = l.E_{elec}^{Rx} \quad (2)$$

Where *I* is the length of the transmitted/received message in bits, d represents the distance over which the data is communicated and d_o is the distance threshold for swapping amplification models, which can be calculated as $d_o = \sqrt{\varepsilon_{fs}/\varepsilon_{mp}}$ .As it can be seen, the transmitter expends energy to run the radio electronics and power amplifier, while the receiver only expends energy to run the radio electronics. We consider both free space (n = 2, $\varepsilon_{amp} = \varepsilon_{fs}$) and two-ray multipath (n = 4, $\varepsilon_{amp} = \varepsilon_{mp}$) models to approximate signal attenuation as a function of the distance between transmitters and receivers.

b) Network Model

Our network model is composed of three types of nodes deployed uniformly in a square region, including normal nodes, advanced nodes, and a few super nodes (Figure 2). The selection probability of each node to become a CH is weighted by the initial energy of a node relative to that of the normal node in the network. We assume each sensor node transmits sensing data to the BS through a selected CH by using multihop communication approach. All the CHs are selected periodically by different weighted probability. If CH is farther from the sink it sends the data to another CH which is nearer to the sink. Similarly each member node sends data directly to sink if they are nearer to the sink compared to its associated CH.

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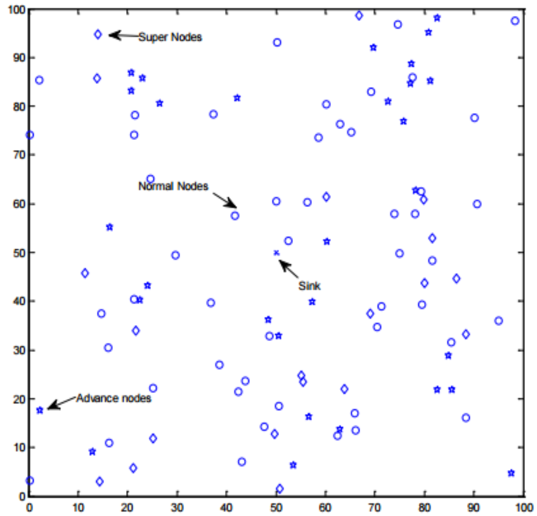

Figure 2: Heterogeneous WSN model

Assumptions:

• All the sensor nodes uniformly dispersed within a square field

• All sensor nodes and sink are stationary after the deployment.

• Multihop communication towards sink.

• A WSN consists of heterogeneous nodes in terms of node energy.

• All the sensor nodes are of equal significance.

• CHs perform data aggregation.

• The sink has enough energy in comparison with the other nodes in the network.

IV. Proposed method

SEP [7] protocol is an enhancement and improvement of LEACH [6] protocol which uses clustering based routing approach based on the node heterogeneity of the sensor node in the networks. In this protocol and method, some of the sensor nodes have high energy they are mentioned to as the progressive nodes and the probability of the advanced nodes to become CHs is more as associated to the normal nodes and the normal nodes have lower energy as compared to the advanced nodes in the network. SEP strategy uses a dispersed technique to select a CH in WSNs. It is heterogeneity-aware protocol and CH selection probabilities of nodes are weighted by initial energy of each node associated to the other nodes in WSN. So essentially, SEP protocol is based on two levels of node heterogeneity as normal nodes and advanced nodes.

- Let, miss the fraction of total number of nodes n, which are organized with α times more energy than the others nodes.
- These controlling nodes are as advanced nodes.
- The remaining $(1 - m) \times n$ nodes are as normal nodes.
- Probability of normal nodes to become CHs is calculated as

$$\text{Pnor} = \frac{Popt}{1 + m.\propto} \quad (3)$$

- Probability of progressive nodes to become CHs is calculated as

$$\text{Padv} = \frac{Popt}{1+m.\propto}(1+\alpha). \quad (4)$$

Poptis the optimal probability of each node to become CH in the network. In SEP [7][8]approach, selection of CH is done arbitrarily on probability basis for each node. Sensor nodes unceasingly sense data and communicate it to their associated CH and CH transmit that data it to the sink or base station (BS). This scheme can be more improved by increasing the value of mor Padv.Due to advance nodes with two level of node heterogeneity SEP [7] strategy results in high stable time period, high network lifetime and high throughput.

Clustering ensures scalability and load balancing in the WSNs and increases the system capacity by facilitating the spatial reuse of resources. Also, it elects a cluster head for the enhanced coordination of the transmission activities. This reduces the transmission collision of mobile nodes, to ensure the energy saving and reduced resource consumption. Generation and spreading of the routing information are controlled by forming a virtual backbone for inter-cluster routing including cluster heads and cluster gateways. Therefore, each node stores and processes a fraction of the total network routing information, thus saving a lot of resources. Energy aware clustering is adopted to enhance the energy efficiency of the network. Generally, the mobile nodes are deployed randomly in a specific region. The distance from a node to the corresponding cluster head or sink is less than or equal to d0. Energy dissipation in the cluster head during a single round is specified by the Eq. (5):

$$E_{CH} = (\frac{n}{k} - 1) \times B \cdot E_{elec} + \frac{n}{k} B \cdot E_{DA} + B \cdot E_{elec} + B \cdot \varepsilon_{fs} \cdot D_{AVG} \quad (5)$$

where, B is the number of bits in the message, D_{AVG} is the average distance between the cluster head and base station and E_{DA} is the required energy for data fusion or aggregation in a single round. Energy consumed in the non-cluster head is given by Eq. (6):

$$E_{NCH} = B \times (E_{elec} + \varepsilon_{fs} \times D_{CH}) \quad (6)$$

where, DCH represents the average distance of the node from the cluster head. The total amount of energy consumed in the cluster is given by Eq. (7):

$$E_{Cluster} = E_{CH} + (\frac{n}{k} - 1) E_{NCH} \approx E_{CH} + (\frac{n}{k}) E_{NCH} \quad (7)$$

The total energy dissipation level of the network is given by Eq. (8):

$$E_{Total} = B \times (2nE_{elec} + nE_{DA} + k\varepsilon_{fs} D_{AVG}^2 + n\varepsilon_{fs} D_{CH}^2) \quad (8)$$

the optimal number of the clusters can be computed by finding the derivative of E_{Total} with respect to k and equating it to zero:

$$k_{opt} = \frac{\sqrt{n}}{\sqrt{2\pi}} \sqrt{\frac{\varepsilon_{fs}}{\varepsilon_{mp}}} \frac{M}{D_{AVG}} \quad (9)$$

$$R = \frac{E_N}{D.E_{round}} \quad (10)$$

$$D_{AVG} = 0.765 \frac{M}{2} \quad (11)$$

The optimal probability of a node to become as a cluster head is specified by the Eq. (12):

$$P_{opt} = \frac{k_{opt}}{n} \quad (12)$$

Election of the cluster heads for normal nodes is performed using a probability scheme, based on the average energy and residual energy of the normal nodes. Let, n be the number of nodes and m be the fraction of the number of the nodes with β times more energy than normal nodes. Powerful nodes are known as advanced nodes and the rest (1-m) ×n as normal nodes. The initial energy of each normal node is E_{init} and advanced node has $E_{init} \times (1+\beta)$. Intuitively, advanced nodes have to become CHs more often than normal nodes, since the energy of the advanced nodes is greater than the energy of the normal nodes. The value of P_{opt} does not change, but the total energy of the network is changed. The total initial energy of the heterogeneous network is given by (12):

$$T.E = N \cdot (1-m) E_{init} + N \cdot mE_{init}(1+\beta) = N \cdot E_{init}(1+\beta m) \quad (13)$$

E_R and E_{NAVG}denote the residual energy and the average energy of a normal node. Since the threshold calculation depends upon the average energy of normal sensor nodes in a round r, therefore it should be calculated.

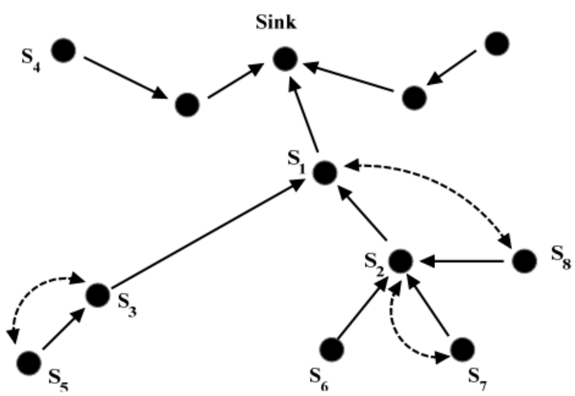

Fig. 3: Mobile node rotation process

The average energy of normal nodes is estimated as:

$$E_{NAVG} = \frac{1}{N} E_N (1 - \frac{r}{R}) \quad (14)$$

Here R represents the total round of the network lifetime and R can be estimated as:

$$R = \frac{E_N}{D.E_{round}} \quad (15)$$

$D.E_{round}$ denotes the total energy dissipated in a round of the network and EN is the total energy of normal nodes in the network. Cluster head threshold for the normal nodes are multiplied by the ratio of the residual energy and average energy of the normal nodes in a round, since the energy of the normal nodes is less when compared to advanced nodes. Hence, the normal nodes will become a cluster head, only when it has sufficient energy.

Parameters	Value
No of nodes, n	100
N/w size X × Y	100 × 100
Receiver Energy, ERX	50nJ
Transmitter Energy, ETX	50nJ
Free space Energy Consumption, E_{fs}	.01nJ
Multipath Energy Consumption, E_{mp}	.0013pJ
Initial Energy, E_0	0.5J
Data Aggregation Energy, EDA	5nJ
Percentage of advanced nodes, m	0.1, 0.2& 0.3
Multiple of normal node energy, a	1, 2, 3

V. RESULT

Simulation of the algorithm is performed using MATLAB 2014a. The nodes are placed in a grid structure in the given area. The results obtained for different performance measures of SEP-EASR are compared with EASR. A network is considered with diameter of 1000 x 1000 meters with 100 nodes (including the Sink node), initial energy of nodes is 100 J and simulation time 39.535236 seconds .The network lifetime increased as the transmission range increased for the SEP-EASR method. Since a transmission range is setting to be larger, the routing path length will be decreased and the number of neighbors with respect to the sink will also be increased. The amount of residual battery energy in the hot spots for performing the message relaying task to the sink will be increased, which might then increase the network lifetime of a WSN. The performance appraisal is done on the basis of following performance parameters:

(i) Energy consumption
(ii) Network life Time

The capability to receive a packet during an impact can provide a number of significant assistances for wireless networking, with higher throughput, lower end to end delay and improved spatial reuse.

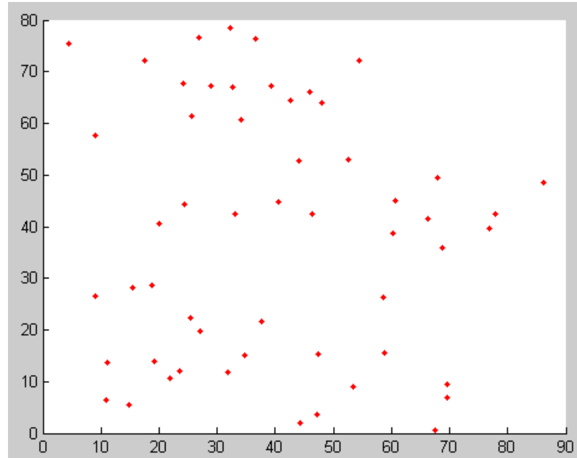

Figure 4: Network simulation

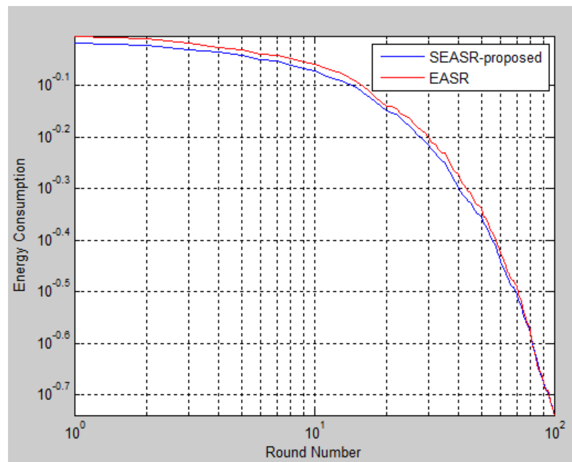

Figure 5:Energy consumption of EASR and SEP-EASR

Fig 5 shows the Energy Consumption varying the sensor nodes. The sensor node consumes power for sensing, communicating and data processing. More energy is required for data communication than any other process. Power is stored either in batteries or capacitors. More the sensor nodes save energy more will be the lifetime of the WSN. Upon comparing the existing system (EASR) the energy is saved more in our proposed system (SEP-EASR).

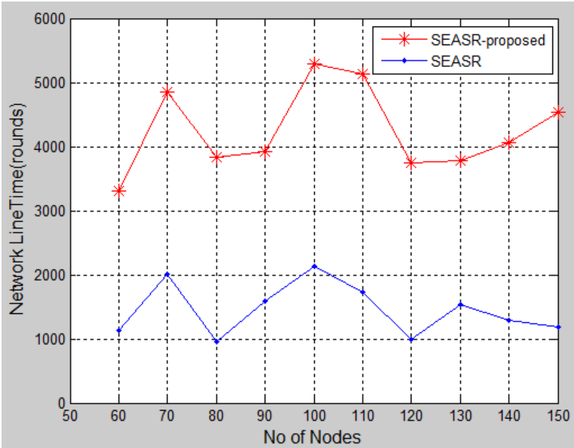

Figure 6:Network line time of SEASR and proposed SEASR over no of nodes

Fig. 6 shows the Network line time comparison by varying the number of sensor nodes. Network line time refers to the number of packets delivered to the base station by the sink node at any instance of time. When compared to the SEASR the Network line time is high in the proposed SEASR. It traverses through the shortest path inside the sensing field and collects updated data on time and hence delivers more number of packets at any instance of time to the base station.

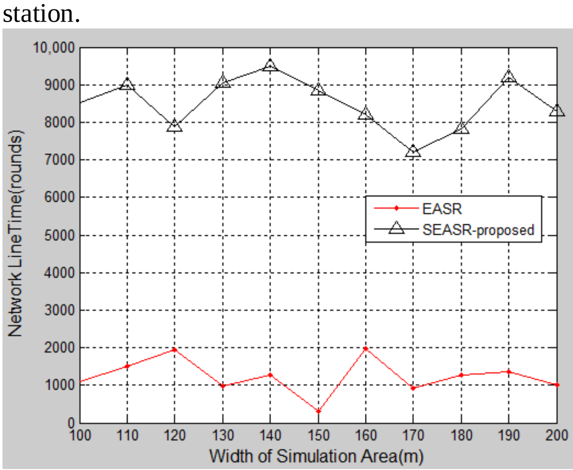

Figure 7:Network line time of EASR and proposed SEASR over width of simulation area (m)

Fig.7 shows the Network line time over width of simulation area. This figure shows the proposed method is get as compare to existing work.

VI. Conclusion

In this research, Stable election protocol aware sink relocation with Sink Relocation (SEP- ASR) protocol is proposed to enhance the energy efficiency of the WSN. The access control mechanism of the network is improved, by the energy aware clustering process. Rotation of the mobile nodes and relocation of the sink are performed, to balance the energy consumption in the network, during the data transmission process. Henceforth, the energy loss occurred due to the continuous multi-hopping concept is mitigated and energy consumption due to the cluster communication is also comparatively reduced. From the simulation results, it is clearly evident that the proposed SEP-ASR protocol achieves reduction in the energy consumption and improvement in the network lifetime. The proposed protocol achieves better performance than the existing EASR protocols.

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