Novel Energy Efficient Election Based Routing Algorithm for Wireless Sensor Network

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Abstract
Traffic patterns in wireless sensor networks (WSNs) usually follow a many-to-one model. Sensor nodes close to the sinks will deplete their limited energy more rapidly than other sensors, since they will have more data to forward during multihop transmission. This will cause network partition, isolated nodes and much shortened network lifetime. Thus, how to balance energy consumption for sensor nodes is an important research issue. In recent years, exploiting sink mobility technology in WSNs has attracted much research attention because it can not only improve energy efficiency, but prolong network lifetime. In this paper, a modified Election based Protocol, which employs the decision of selecting cluster heads by the sink is based on the associated additional energy and residual energy at each node. Besides, the cluster head selects the shortest path to reach the sink between the direct approach and the indirect approach with the use of the congested link. Simulation results demonstrate that our algorithm has better performance than traditional routing algorithms, such as LEACH[1] and LEACH-C.

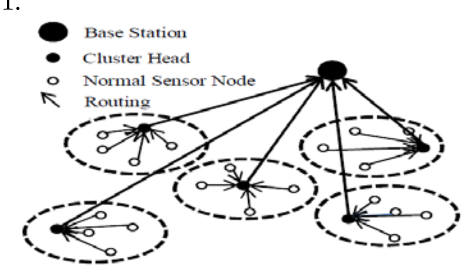
Index Terms
Wireless Sensor Networks, Multipath Routing, Packet Loss, Life time, Clustering.

I. Introduction

A. Detail Problem Definition

Many wireless sensor networks (WSNs) are deployed at the environment where the energy replenishment is very difficult but it is not impossible. In WSN there are limited resources which are not only used to satisfy QoS requirement but also they must be useful to increase system lifetime with minimum energy consumption. So our aim is to solve the problem of tradeoff between energy consumption vs. QoS requirement to provide reliability gain with the goal to maximize the WSN system lifetime. It is considered that clustering is one of the best solutions to achieve the scalability, reliability and energy conservation in wireless sensor network. If the homogeneous network is consider then the cluster head (CH) is selected among all nodes which rotate in the network. Some of the protocol like HEED[2] is used to elect cluster head among all available nodes in the network, which useful for lifetime maximization. Recent studies as given in [3][4] suggest that use of heterogeneous nodes can also enhance performance in better way and prolong the system lifetime in WSN. The nodes with highest resources like highest residual energy will perform the role of CH and they are useful to perform computationally intensive task. A routing protocol is required when a source node cannot send its packets directly to its destination node but has to rely on the assistance of intermediate nodes to forward these packets on its behalf. Since a network is characterized by its limited wireless channel bandwidth, it would be beneficial if the amount of data transmitted to the sink can be reduced. To achieve this goal, a local collaboration between the sensors in a cluster is required in order to reduce bandwidth demands. As the need for efficient use of WSNs on large regions increased in the last decade dramatically, more specific clustering protocols were developed to meet the additional requirements (increased network lifetime, reduced and evenly distributed energy consumption, scalability, etc.). The most significant and widely used representatives of these focused on WSN clustering protocols (LEACH, EEHC, and HEED) [5][6].They are all probabilistic in nature and their main objective was to reduce the energy consumption and prolong the network lifetime.

Clustering has characteristics such as scalable, energy-efficient, lower latency, etc. which make it a popular technique for WSNs. The idea is to select a set of cluster heads from the set of nodes in the network, and then cluster the remaining nodes with these heads [7][8]. The data gathered are transmitted through cluster heads to remote base stations or sink nodes. However, sink nodes are always fixed, which could result in the neighboring nodes to dying much faster and causing network partition as well as isolated sensors. A typically clustered sensor network is illustrated in Figure 1.



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In this paper, we propose a modified Election based Protocol (MEP), which employs the decision of selecting cluster heads by the sink is based on the associated additional energy and residual energy at each node In this modified algorithm, the cluster head selects the shortest path to reach the sink between the direct approach and the indirect approach with the use of the congested link.

The rest of the paper is organized as follows: Section 2 describes some related work, and our system model is provided in Section 3. In Section 4, our proposed MEP algorithm is explained in detail. Section 5 presents extensive simulation results and analysis. Section 6 gives a discussion of our work and finally Section 7 concludes this paper.

B. Need of Proposed System

The problem we are addressing in this paper is effective energy management of a clustered WSN to maximize system lifetime operation in the presence of unreliable nodes which are responsible for packet loss. We are addressing the tradeoff issue between energy consumption and QoS requirement to gain in reliability and timeliness so that we can maximize the lifetime of a clustered WSN, it will also be a satisfying application for QoS requirements in case of multipath routing.

More specifically, we are analyzing the optimal amount of redundancy in WSN through which data are routed to a remote sink in the presence of unreliable nodes, so that the probability to answer users query must be maximized while maximizing the system lifetime through multipath routing, there are two major problems to solve first is how many paths to use and second is what paths to use. We are focusing on to address the how many paths to use to reach to the sink problem we are employing a algorithm for congested node so that there must be less energy conservation by the nodes in the network. The congested nodes are detected and the path through that node is ignored from the heterogeneous WSN. In this paper we decide how many paths to use in order to tolerate residual compromised nodes, so as to increase system useful lifetime of the HWSN.

II. Related Work

A. Study of Existing techniques

Low-Energy Adaptive Clustering Hierarchy (LEACH) is a classic clustering algorithm for WSNs. It is a clustering-based protocol that utilizes randomized rotation of local cluster heads to evenly distribute the energy load among the sensors in the network. As the authors claimed, LEACH reduces communication energy by as much as 8 times compared with direct transmission and minimum-transmission-energy routing [9]. Its advantages can be summarized as follows: first, it can prolong the network lifetime compared to the original plane routing protocol and static clustering algorithms. Second, the cluster heads fuse the data collected from the corresponding areas, and transfer it to the sink node, which could effectively raise the energy use ratio. Finally, LEACH distributes the task among every sensor node, reducing the overload of individual nodes. LEACH-C was proposed in [10] to cope with the disadvantages of LEACH. It uses a central control algorithm to form clusters, which distributes cluster heads more evenly throughout the network. To make sure the energy load is evenly distributed among all nodes, the base station computes the average node energy. Nodes with energy below the average cannot be used as cluster heads for the current round [10].

However, LEACH-type protocols have some disadvantages. First, the algorithm offers no guarantee about the placement and number of cluster head nodes. Second, if the cluster head dies in round n, the whole cluster is unable to transfer its data to the base station until the next round. This intermittent failure of clusters could be a disaster when monitoring a region in real-time. Third, the individual sensor nodes transfer their data to the cluster head through single-hops, which is not suitable for large-scale networks. Therefore, further research has been undertaken into some of these issues.

The main idea in Power-Efficient Gathering in Sensor Information System (PEGASIS) is to make the energy load distribution more even among sensors for WSNs. Each node will receive from and transmit to close neighbors and take turns being the leader for transmissions to the base station [11]. It assumes that all nodes have global knowledge of the network; the base station is fixed at a far distance from the sensor nodes; the sensor nodes are homogeneous and energy constrained with uniform energy; and the energy cost for transmitting a packet depends on the distance of transmission. PEGASIS builds a chain to ensure that all nodes have close neighbors. When a node dies, the chain is reconstructed to bypass the dead node.

The Hybrid Energy-Efficient Distributed (HEED) [12] algorithm selects cluster heads according to a hybrid of node residual energy and a secondary parameter, such as node proximity or node degree. There is a tradeoff between extending the time until the first node dies (FND) and the time until the last node dies (LND). In [13], an evolutionary-based routing protocol has been proposed to obtain a better compromise between stability and network lifetime. It can guarantee a better tradeoff between the lifespan and the stability period of the network with efficient energy utilization. As the tradeoff that exists between network lifetimes and sensing coverage is the major problem in fixed sink networks, the authors in [13] proposed an energy-aware coverage-preserving hierarchical (ECHR) algorithm which accommodates energy-balance and coverage-preservation.

In [14], a distance aware intelligent clustering (DAIC) was proposed. The key concept is dividing the network into tiers and selecting the high energy CHs at the nearest distance from the base station. In [15], an Energy-Efficient Unequal Clustering (EEUC) mechanism for periodical data gathering in WSNs is proposed to address the hot spots problem. It partitions the nodes into clusters of unequal size, and clusters closer to the base station have smaller sizes than those farther away from the base station. In [16], an energy-aware clustering algorithm (EADC) was proposed using competition range to construct clusters of even sizes. The routing algorithm of EADC increases forwarding tasks of the nodes in scarcely covered areas by forcing cluster heads to choose nodes with higher energy.

Recently, several applications which introduce sink mobility into the wireless sensor networks have appeared. In some applications, mobile elements have been taken forward to attach network node for data collection. It is very promising to use mobile sink to improve network lifetime without causing negative impacts to the network. This is because the role of hot spot node will rotate among most sensors, which will basically balance the traffic load throughout the whole sensor network.

In [17], a mobility-based clustering (MBC) protocol for WSNs with mobile nodes is proposed. The authors consider residual energy together with the current speed of each sensor node. A threshold value is multiplied by the factors representing the residual energy and the current speed of a node. Using this threshold, the nodes with more residual energy and lower speed may have more probability to be selected as cluster heads. MBC used a heuristic mechanism in which each sensor wakes itself up one timeslot before its scheduled timeslot according to the TDMA schedule and goes back to sleep mode after its timeslot.

A network infrastructure based on the use of controllably mobile elements was discussed in [18], with the essential of reducing the communication energy consumption at the energy constrained nodes and, thus, increasing useful network lifetime. The controllable mobile infrastructure can reduce energy consumption at the energy constrained nodes and, thus, increase useful network lifetime. In particular, the infrastructure focuses on network protocols and motion control strategies. The significant issue to be noticed is that the controllably mobile infrastructure tests using a practical system and do not assume idealistic radio range models or operation in unobstructed environments. Provided in the timeliness domain by guaranteeing multiple packet delivery speed options. In the reliability domain, various reliability requirements are supported by probabilistic multipath forwarding.

B Analysis of Existing System

Many wireless sensor networks (WSNs) are deployed in an unattended environment in which energy replenishment is difficult if not impossible. Due to limited resources, a WSN must not only satisfy the application specific QoS requirements such as reliability, timeliness, but also minimize energy consumption to prolong the system useful lifetime. The tradeoff between energy consumption vs. reliability gain with the goal to maximize the WSN system lifetime has been well explored in the literature. However, no prior work exists to consider the tradeoff in the presence of malicious node.

In Existing systems:-

- In existing works no consideration was given to redundancy management.
- In existing works no consideration was given to Energy Consumption & detection of hot spot.
- In existing works no consideration wa s g i v e n to Packet dropping & Energy Consumption & Maximization of WSN lifetime.

C. Comparison of existing systems with proposed system

In Existing System, effective redundancy management of a clustered HWSN is used to prolong its lifetime operation in the presence of unreliable nodes. We address the tradeoff between energy consumption vs. QoS gain in reliability, timeliness with the goal to maximize the lifetime of a clustered HWSN while satisfying application QoS requirements in the context of multipath routing. More specifically, we analyze the optimal amount of redundancy through which data are routed to a remote sink in the presence of unreliable nodes, so that the query success probability is maximized while maximizing the HWSN lifetime.

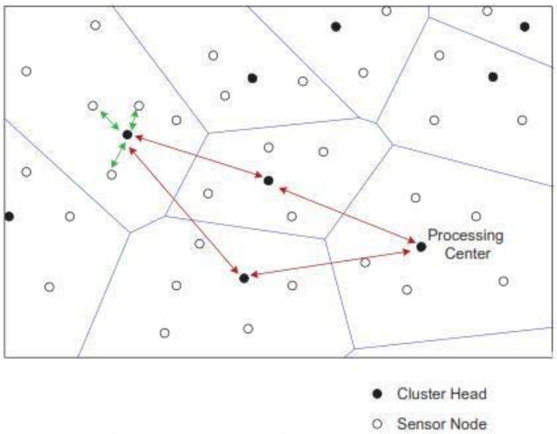
III. System Model

A. Basic Assumption

We make the following basic assumptions
1 All sensor nodes are fixed after deployment
2 Each sensor nodes has unique Id
3.Sensor nodes adjust power based on distance

As per above assumption network is not assume to be homogeneous .It can be heterogeneous with various types of sensor and sink nodes.

B. Network Model:



We are assuming that geographic routing which is a well known routing protocol for WSNs, is used to route the data from CH to the base station or sink along with multipath routing; thus, in this case there is no need to maintain path information of the network. We must know the location of the destination node so that we can correctly send the packet towards it. So the CH are responsible to get the location of all SN and vice versa in its cluster and it is the part of clustering. A CH are also aware with the location of neighbor CHs along with the direction towards the base station or sink.

The network is clustered into group of cluster. Sensors are selected as cluster head based on Threshold Which will be discussed in section 5.The sensor will transmit their sensed data to the sink through cluster heads via single of multi hop transmission. The network model can be described as an undirected connectivity graph G(S,E) where S is the set of all sensor nodes and P(i,j) is the set of wireless link between node i and j.

Let E be a energy efficient algorithm which saves the energy such that [19][20]

E={Wn,C,CH,P,N ¦ Φ s } where
Wn represent web network Wn={wno¦ Φwn }
C represent cluster C={co,c1,c2..cn¦ Φc }
CH represent cluster head CH={ch0,ch2,ch2..chn¦ Φch}
P represent path P= {p0,p1,p2…pn¦ Φp}
N represent no of nopdes N={n0,n1,n2..nn¦ Φn }

C. Energy model :

We use radio energy model in equation to transmit an l bit length message through a distance d, the energy consumption by the radio is given by

For multi-hop communication, the calculation of energy consumption model is

$$\varepsilon(n) = c(n) \times h(n) \times e(n) \text{ ------------ (1)}$$

Where $c(n) \rightarrow$ Number of transmitted bit.

$h(n) \rightarrow$ Average number of hops for the transmission.

$e(n) \rightarrow$ Energy consumption to transmit single bit.

Every node sends data only to cluster node (i.e. if $h(n)=1$) so energy consumption by individual node n_i in time t is given by,

$$\varepsilon(n_i) = c(n_i) \times 1 \times e(n_i) \times sr_i \times t \text{ ------------ (2)}$$

Where $sr_i \rightarrow$ Sampling rate of node n_i in samples per second, $\boldsymbol{t} \rightarrow$ time in seconds

Cluster head is responsible for forwarding all data in cluster. Hence energy consumption of cluster head is given by

$$\varepsilon(\text{ch}) = h(ch) \times \sum_{i=0}^{n} (\varepsilon(\text{ni})) \text{ ----------- (3)}$$

Where $h(ch)$ is number of hops for transmission from cluster head to sink node and $\boldsymbol{n}$ is number of nodes in cluster.

In existing approach node is selected as cluster head based on hop count values, same node is selected as cluster head throughout network life time.

Energy consumption of cluster node in time t is

$$\varepsilon_t(\text{ch}) = t \times h(ch) \times \sum_{i=0}^{n} (\varepsilon(n_i)) \text{ ------------- (4)}$$

In this proposed approach cluster head is selected periodically based on remaining energy of node, every node get chance to be cluster head for some period, i.e. in period t every node is cluster head for time $\frac{t}{n} or \left(t - \frac{t}{n}\right)$ time as normal node .energy consumption by each node in time t is

$$\varepsilon(n_i) = c(n_i) \times 1 \times e(n_i) \times sr_i \times \left(t - \frac{t}{n}\right) + \frac{t}{n} \times h(ch) \times \sum_{i=0}^{n} (\varepsilon(n_i))$$

--- (5)

Where P is a ratio of cluster heads among all sensors. 1/p is the expected number of nodes in one cluster, r is the index of current round and g is the set of nodes that have not been cluster heads in the last r mod(1/P) rounds.

In each round sensor node generates a random number between 0 and 1. If the random number is < than the T(n), it will be selected as a cluster head. After sensor node is selected as cluster head, its corresponding T(n) will be set to be 0. Hence every random number between 0 and 1 will not be smaller than the corresponding T(n), which ensure that the cluster head will not be selected twice within 1/P round. Sensor node which have not selected as cluster head will continue the selection with threshold T(n) which will increase as round increases. After the (1/P-1) round, T(n) = 1. Thus the remaining nodes which have not been cluster heads will be cluster heads in the last round.

In our proposed algorithm we consider network to be heterogeneous, where there are m percentage advanced nodes which have the additional energy factor (alfa) in itslf compared with normal nodes. We assume the inial energy to be E0. The energy of advanced node in our proposed sensor network is E0.(1+ α).

The total energy of new heterogeneous network is calculated as follows.

$$N.(1-m)E0+n.m.E0(1+\alpha)=N.E0.(1+\alpha . m) \quad \text{--- (6)}$$

Hence total energy increses by (1+alfa.m) times. Based on quation of probabilities for advanced and normal node we improved selection method with the residual energy of certain sensor nodes. As shown in equation probability of normal node is:

$$P_{nrm}=Popt/1+\alpha .m * E_{resiu}/E0 \quad \text{--- (7)}$$

Popt is optimal percentage of cluster head, α is factor of additional energy,m is the percentage of advanced node,Eresi is energy left after certain rounds,and E0 is the initial energy of any nodes. Similarly probability of advanced node is

$$P_{adv}=Popt/1+\alpha .m * (1+\alpha)* E_{resi}/E0 \quad \text{--- (8)}$$

Define threshold for normal and advanced node.

$$T(P_{nrm}) = P_{nrm} /1- P_{nrm} [r \bmod(1/ P_{nrm})] \quad \text{--- (9)}$$

$$T(P_{adv})= P_{adv} /1- P_{adv} [r \bmod(1/ P_{adv})] \quad \text{--- (10)}$$

Where Where P is a ratio of cluster heads among all sensors. 1/p is the expected number of nodes in one cluster, r is the index of current round and g is the set of nodes that have not been cluster heads in the last r mod(1/P) rounds.

IV. Our propose MEBR Algorithm :

In our work, we consider redundancy management of multipath routes, based on energy values to maximize the system lifetime of a HWSN in the presence of unreliable nodes. Also we considered congested node for maximizing throughput.

More specifically, we are analyzing the optimal amount of redundancy in WSN through which data are routed to a remote sink in the presence of unreliable and congested nodes, so that the probability to answer users query must be maximized while maximizing the system lifetime

To congestion through multipath routing, there are two major problems to solve first is how many paths to use and second is what paths to use. We are focusing on to address the how many paths to use to reach to the sink problem. Our approach is different from existing for the, what paths to use problem, in that we consider specific routing protocols to solve the problem. . The congested nodes are detected and the path through that node is ignored from the heterogeneous WSN. In this paper we decide how many paths to use in order to tolerate residual congested nodes so as to increase system useful lifetime of the HWSN.Also We used multiple mobile sink in order to reduced burden on single sink node.

A. Cluster head selection:

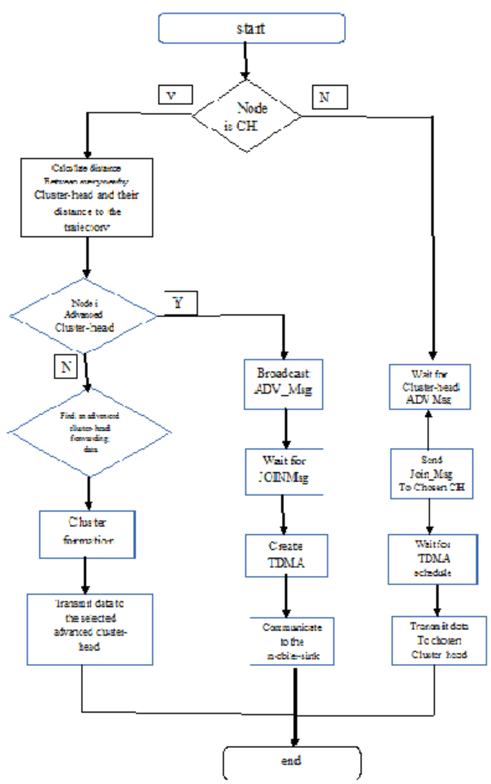
Cluster head S selected by sink node using election approach based on residual energy and future energy required. Equation for cluster head selection is as follows.

$$T(n) = \begin{cases} \frac{P}{1-P*(r \bmod \frac{1}{P})} & \text{if } n \in G \\ 0 & \text{otherwise} \end{cases} \quad *Eo/E_{resu} \quad \text{--- (11)}$$

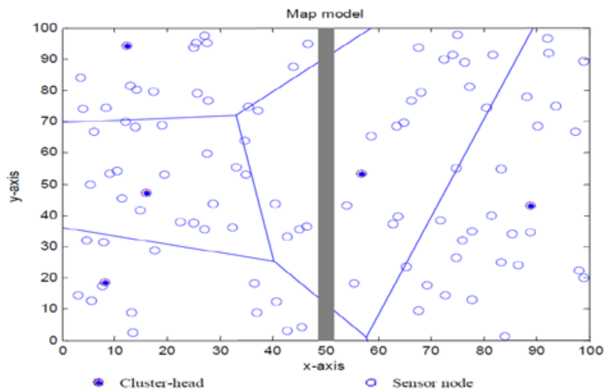
Where P is a ratio of cluster heads among all sensors. 1/p is the expected number of nodes in one cluster, r is the index of current round and g is the set of nodes that have not been cluster heads in the last r mod(1/P) rounds.

In each round sensor node generates a random number between 0 and 1. If the random number is < than the T(n), it will be selected as a cluster head. After sensor node is selected as cluster head, its corresponding T(n) will be set to be 0. Hence every random number between 0 and 1 will not be smaller than the corresponding T(n), which ensure that the cluster head will not be selected twice within 1/P round. Sensor node which have not selected as cluster head will continue the selection with threshold T(n) which will increase as round increases. After the (1/P-1) round, T(n) = 1. Thus the remaining nodes which have not been cluster heads will be cluster heads in the last round.

Cluster formation flowchart



During the broadcasting phase each cluster head broadcasts an advertisement message and location among all members and depends on strongest signal strength members send join message to cluster head. After cluster head receives JOIN message from members, it setup TDMA schedule and transmit this schedule among all members. By using TDMA schedule collision can be avoided. This effectively reduces energy consumptions for sensor node and prolong lifetime of the network. Assume sink nodes are moving at the center of network area. Calculate distance between advanced nodes to the nearest sink node depends on location. Finally cluster head wil transmit message to sink node. Then data is forwarded to main sink node.



V. Performance Evaluation and discussion:

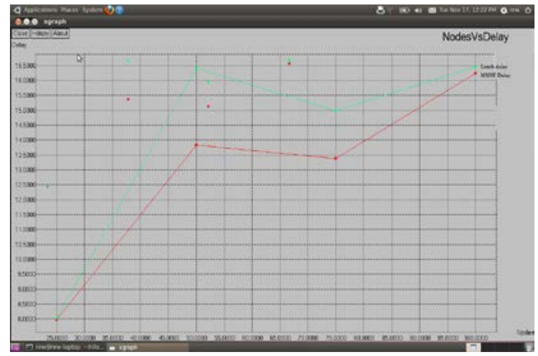
We used NS2 simulator to evaluate the performance of our proposed MMSE algorithm. Simulation parameters are listed as follows.

Simulation parameters:
Simulation Parameter Representation Unit

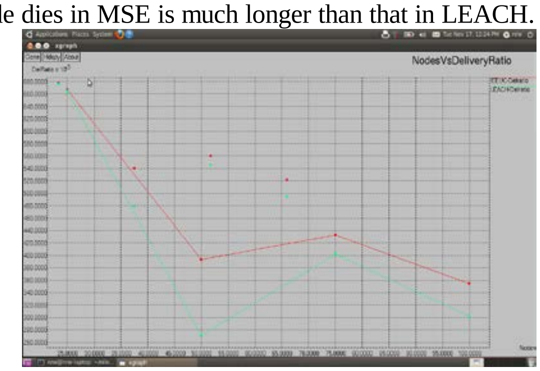
N No of sensor Nodes 100
E0 Initial energy of nodes 0.2 J
E_{DA} data aggregation 5 nJ/bit/signal
E_{elec} Energy dissipation to run the radia device 50 nJ/bit
L packet length 4000 bits

VI. Performance Evaluation:

Figure 5 shows that the energy consumption increases as delay in LEACH is more as compared to MMSC algorithm



In Fig 6 shows the good delivery ratio as compared to LEACH protocol. We can find that the time when the first node dies in MSE is much longer than that in LEACH.



VII. Conclusion:

In this paper we described a election based modified MSE method for energy efficient routing in WSN. Our algorithm forms a hierarchical routing protocol by dividing the network into cluster and selecting CH base on election using remaining energy and location The m modified algorithm shows good performance in balancing the energy and prolonging network lifetime.

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