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LIFETIME AND STABILITY ENHANCEMENT OF WIRELESS SENSOR NETWORK USING CLUSTERING PROTOCOL

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***Abstract*— Energy hole problem is a critical issue for data gathering in wireless sensor networks. Sensors near the static sink act as relays for far sensors and thus will deplete their energy very quickly, resulting energy holes in the sensor field. This project proposed a mobile sink-based adaptive immune energy-efficient clustering protocol (MSIEEP) to alleviate the energy holes. A MSIEEP uses the adaptive immune algorithm (AIA) to find the optimum number of cluster heads (CHs) to improve the lifetime and stability period of the network. The performance of MSIEEP is compared with the previous protocols; namely, low-energy adaptive clustering hierarchy (LEACH), rendezvous, and mobile sink improved energy-efficient PEGASIS-based routing protocol using Network Simulator (NS2). Simulation results show that MSIEEP is more reliable and eliminates the energy hole problem and improves the lifetime and the stability of the wireless sensor network.**

Index Terms*— Wireless sensor networks, immune algorithm, clustering protocols, mobile sink, energy hole problem.

I. INTRODUCTION

Wireless Sensor Network (WSN) typically consists of a large number of low-cost in the surrounding environment such as heat, pressure, vibration, presence of objects, etc. The concept of wireless sensor networks is based on a simple equation:

Sensing + Processing + Communication = Thousands of potential applications

The measurements and monitored events are then forwarded towards a static sensors of the network. Thus, many clustering protocols have been specifically designed for WSNs to improve data aggregation mechanisms. These protocols widely vary depending on the nodes deployment, the network and radio models, and the network architecture.

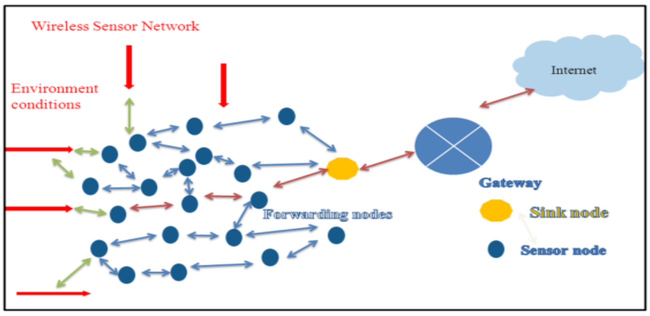

Fig. 1 An example of wireless sensor network

The problem of these protocols is using static sinks. Direct transmission to sink does not guarantee well balanced distribution of the energy load among distribution of the energy load among sensors in WSN and thus increase the network lifetime. The effectiveness of the WSNs lie in their sensing quality, flexibility, coverage, etc., they can offer. WSNs naturally become the first choice when it comes to deployment in remote and hazardous environment. The ultimate goal of such WSNs deployed in the above crucial environments is often to deliver the sensing data from sensor nodes to sink node and then conduct further analysis at the sink node. Data collection becomes an important factor in determining the performance of such WSNs.

II. RELATED WORK

Many clustering protocols for typical WSNs, which composed of static sensor nodes and a static sink, have appeared in the literature. Low-Energy Adaptive Clustering Hierarchy (LEACH) is the first clustering protocol has been developed . In LEACH, CH collects and aggregates data from the sensors in its own cluster and passes the data to the sink directly. The problem of LEACH protocol is the randomly selection of CHs. LEACH requires the user to specify the desired probability of CHs that uses in determining whether a node becomes a CH or not. . Mobile Sink based Routing Protocol (MSRP) for prolonging the network lifetime in clustered WSN has been addressed. In MSRP, the sink moves to CHs having higher energy in the clustered network to collect sensed data from them. A new optimizing LEACH clustering algorithm with mobile sink and rendezvous nodes was introduced. This algorithm combines the use of the LEACH algorithm, mobile sink and rendezvous points to preserve the benefits of the LEACH algorithm and improve the CH selection process.

Moreover, it decreases energy consumption in WSNs further than in traditional LEACH, particularly when the network is large. Mobile sink Improved Energy-Efficient PEGASIS-Based routing protocol (MIEEPB) has been presented. MIEEPB introduces the sink mobility in the multi-chain model and divides the sensor field into four regions, therefore achieving smaller chains and decreasing load on the leader nodes. The sink moves along its trajectory and stays for a time at fixed location in each region to guarantee data collection. The mobile sink in the existing routing protocols always follows a certain trajectory and stops at fixed sojourn locations.

This makes the sensors near the fixed sojourn location to dissipate their energy faster than other nodes. So in this paper, we use a control mobile sink guided based on minimizing the dissipated energy of all sensor nodes. In this case, the sensors surrounding the sink change over time, giving the chance to all sensors in the network to act as data relays to the mobile sink and thus balancing the load among all nodes.

III. MOBILE SINK

The energy hole problem leads to a premature disconnection of the network and thus sink gets isolated from the rest of the network due to the death of its neighbours, while most of the sensor nodes are still alive and fully operational. Exploiting the mobility of the sink has been widely accepted as an efficient way to alleviate the energy hole problem in WSNs and further prolong the network lifetime by avoiding excessive transmission overhead at nodes that are close to the sink. Clustering algorithms can effectively organize the sensor nodes in the network and using a controlled mobile sink can solve the energy hole problem. However, finding the optimum number of CHs and the optimal moving trajectory for the mobile sink are Non-deterministic Polynomial –time hard (NP-hard) problems. Sink represents an important component of a WSN as it acts as a gateway between the sensor nodes and the end-user.

Mobile sink has many advantages such as increasing the security of WSNs. Since the location of the mobile sink changes over time, the malicious users hard to know its location and damage it. So, the mobile sink may be useful for secure applications such as medical care, target tracking and intrusion detection in battlefield. Moreover, the mobile sink improves the network lifetime and the packet drop rate. When a static sink is far from the sensor field or the sensor field is so large that most nodes need numerous hops to reach the sink, considerable retransmitting energy is consumed during transmission, thereby significantly accelerating node depletion. However, the mobile sink conserve energy since data is transmitted over fewer hops. Thus, the number of dropped packets is reduced due to the movement of the mobile sink closer to the sensor nodes in the sensor field. Furthermore, the mobile sink improves the network connectivity and eliminates the energy holes by balancing the load of data routing among sensors.

IV. CLUSTERING

Naturally, grouping sensor nodes into clusters has been widely adopted by the research community to satisfy the above scalability objective and generally achieve high energy efficiency and prolong network lifetime in large-scale WSN environments. The corresponding hierarchical routing and data gathering protocols imply cluster-based organization of the sensor nodes in order that data fusion and aggregation are possible, thus leading to significant energy savings. In the hierarchical network structure each cluster has a leader, which is also called the cluster head (CH) and usually performs the special tasks referred above (fusion and aggregation), and several common sensor nodes (SN) as members. The cluster formation process leads to a two-level hierarchy where the CH nodes form the higher level and the cluster-member nodes form the lower level. The sensor nodes periodically transmit their data to the corresponding CH nodes. The CH nodes aggregate the data (thus decreasing the total number of relayed packets) and transmit them to the base station (BS) either directly or through the intermediate communication with other CH nodes. However, because the CH nodes send all the time data to higher distances than the common (member) nodes, they naturally spend energy at higher rates. A common solution in order balance the energy consumption among all the network nodes, is to periodically re-elect new CHs (thus rotating the CH role among all the nodes over time) in each cluster. The BS is the data processing point for the data received from the sensor nodes, and where the data is accessed by the end user. It is generally considered fixed and at a far distance from the sensor nodes. The CH nodes actually act as gateways between the sensor nodes and the BS. The function of each CH, as already mentioned, is to perform common functions for all the nodes in the cluster, like aggregating the data before sending it to the BS.

In some way, the CH is the sink for the cluster nodes, and the BS is the sink for the CHs. Moreover, this structure formed between the sensor nodes, the sink (CH), and the BS can be replicated as many times as it is needed, creating (if desired) multiple layers of the hierarchical WSN (multi-level cluster hierarchy). In clustering, the sensor nodes are partitioned into different clusters. Each cluster is managed by a node referred as cluster head (CH) and other nodes are referred as cluster nodes. Cluster nodes do not communicate directly with the sink node. They have to pass the collected data to the cluster head. Cluster head will aggregate the data, received from cluster nodes and transmits it to the base station. Thus minimizes the energy consumption and number of messages communicated to base station. Ultimate result of clustering the sensor nodes is prolonged network lifetime network. It is the bridge (via communication link) between the sensor network and the end user. Normally this node is considered as a node with no power constraints. Cluster: It is the organizational unit of the network, created to simplify the communication in the sensor network. There are many types in clustering techniques used in wireless sensor network. After these techniques wireless sensor networks emerged as a best network for communication field

CLUSTERING PARAMETERS

There are many parameters of clustering on which the network performance is based. Some important parameters with regard to the whole clustering procedure in Wireless sensor networks are as follows,

- Number of clusters (cluster count)
- Number of nodes in a cluster
- Nodes and CH mobility
- Nodes types and roles:
- Cluster formation methodology
- Cluster-head selection
- Algorithm complexity

ADVANTAGES OF CLUSTERING

- Transmit aggregated data to the data sink
- Reducing number of nodes in a transmission
- Useful Energy consumption
- Scalability for large number of nodes
- Reduces communication overhead
- Efficient use of resources in WSNs

V. PROPOSED SYSTEM

We propose a mobile sink-based adaptive immune energy-efficient clustering protocol (MSIEEP) to alleviate the energy holes. MSIEEP uses the Adaptive Immune Algorithm (AIA) to find the sojourn locations of the mobile sink and the optimum number of CHs and their locations based on minimizing the total dissipated energy in communication process and overhead control packets of all sensor nodes within the network. In our protocol, we use a controlled mobile sink that guided based on minimizing the dissipated energy of all sensor nodes. The sensor field is divided into *R* equal size regions to conserve energy since data is transmitted over fewer hops. This reduces the number of dropped packets and delay that packet needs to reach to the sink because the mobile sink moves along the sojourn path and stops at the sojourn location closer to the sensor nodes in each region in the sensor field.

A.PREPARE PHASE

In this phase, the sink initializes the network by defining the number of nodes , the data packet size, the control packet size, the size of sensor field and the parameters of the radio model. Then the sink divides the sensor field into *R* equal size regions; where *N/R* nodes are deployed randomly in each region. After that, the sink initially moves to center of each region and requests the ID, position and *Eo* of all sensors in each region. The connectivity between nodes and the sink is always satisfied, because the communication radius for each node is assumed to be larger than the coverage radius.

B.SET-UP PHASE

After initialization, the mobile sink goes to center of r^{th} region ($r = 1, 2, \dots, R$) and uses AIA to find its sojourn location and locations of the optimum CHs based on the minimization of the total dissipated energy in communication. Then the mobile sink assigns the members nodes of each CH. If a sensor is close to the sink than any CH in this region, this node will communicate directly to the sink. Once CHs are selected and members of each CH are assigned, the sink broadcasts two short messages. The first one is sent to the selected CHs to inform each one by IDs of its members. While the second message that contains CH’s ID and logic 0 is sent to member nodes to inform each one where will join. Based on the received messages from the sink, each CH in r^{th} region creates the TDMA schedule by assigning slots to its member nodes and informs these nodes by the schedule. The TDMA schedule is used to avoid intra-cluster collisions and reduce energy consumption between data messages in the cluster and enable each member of the radio equipment off when not in use.

C.STEADY STATE PHASE

After finding the locations of the CHs and the sojourn location of the mobile sink in a region *r*, the sink moves to its sojourn location and wakes up the sensor nodes in this region, while the rest nodes in other (*R-1*) regions are sleep. The nodes start sensing the data; then each sensor sends its data to its CHs or the sink if it is close to the sink than CH according to the TDMA schedule. Each cluster communicates using different CDMA codes in order to reduce interference from nodes belonging to other clusters. Once each CH received the sensed data from its member nodes, it performs signal processing functions to aggregate the data into a single packet. Then, CHs send their packets to the sink. After certain time called sojourn time, the sink moves at a certain speed along the mobility path to the next region (*r+1*) to perform clustering and collects data from the sensors in this region. This process is repeated until the sink visits all *R* regions in the sensor field to guarantee complete data collection. When the sink finishes its round, it again goes back to first region to begin a new round.

ADVANTAGES

- Reduce the dropped packets
- Decrease the time delay
- Provide the efficient packet delivery
- Reduce energy consumption

VI. RESULT AND DISCUSSION

The proposed protocol extends the stability period and improves the network lifetime as compared to MIEEPB protocol and rendezvous protocol for the three mobility path patterns respectively. This means that the proposed protocol is more energy-efficient than the other protocols, because it allows for nodes to work with full functionality for long time due to the higher residual energy of the sensor nodes in the network. Furthermore, the residual energy of all nodes in the network for the proposed protocol decreases more slowly than other protocols when the number of rounds of the nodes increases. Using the mobile sink with AIA(Adaptive Immune Algorithm) eliminates the energy holes and outperforms the other protocols in terms of the stability period ,throughput, packet delivery ratio and in the lifetime.

PERFORMANCE METRICS

The following metrics are used to evaluate the performance of the proposed protocol

- NUMBER OF ALIVE NODES PER ROUND: The number of nodes that have not yet expended all of their energies.
- NETWORK LIFETIME: The time interval from the start of network operation until the death of the last alive sensor.

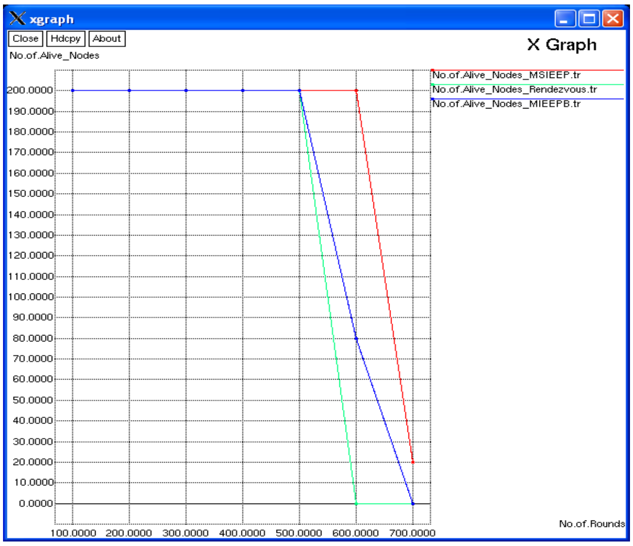

Fig 2. Network Lifetime

- STABILITY PERIOD**:** The time interval from the start of network operation until the death of the first sensor.
- THROUGHPUT: It measures the total rate of data sent over the network, including the rate of data sent from CHs to the sink and the rate of data sent from the nodes to their CHs.
- PACKET DELIVERY RATIO: It measures the ability of a protocol to deliver packets to the destination. It is the ratio of the number of packets that are successfully delivered to the destination to the total number of packets that are sent.

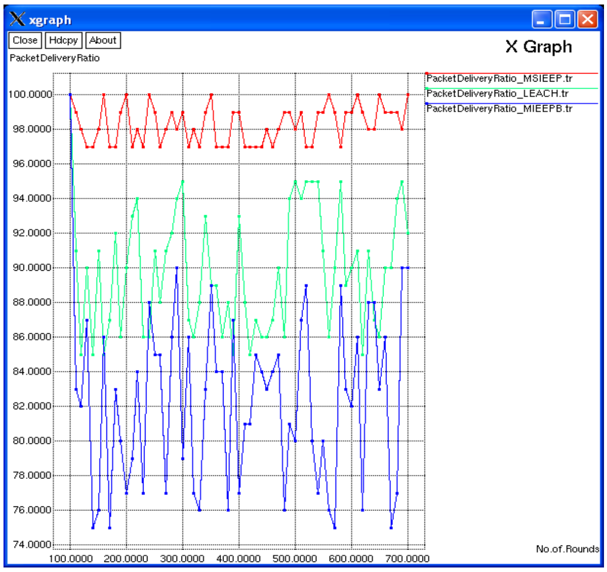

Fig 3. Packet Delivery Ratio

- PACKET DROP RATIO: It measures the robustness of protocol and is calculated by dividing the total number of dropped packets by the total number of transmitted packets.

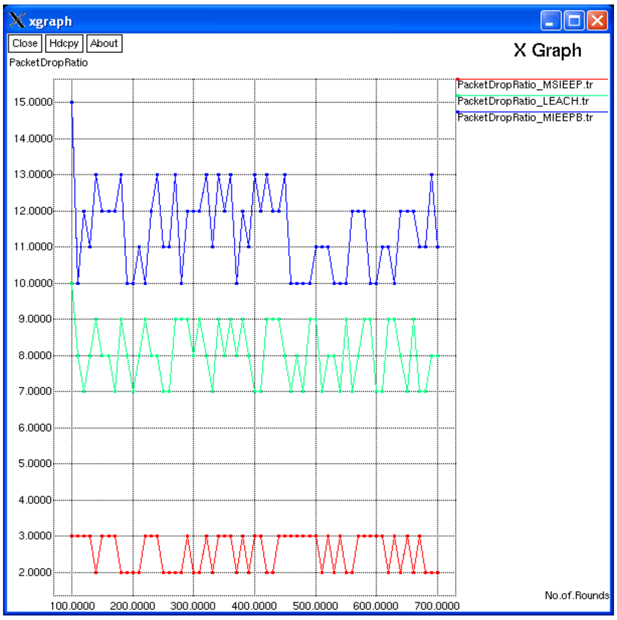

Fig 4. Packet Drop Ratio

- PACKET DELAY: The time required by a packet to reach from source to destination. It is calculated by dividing the distance from source to destination by the speed of light.

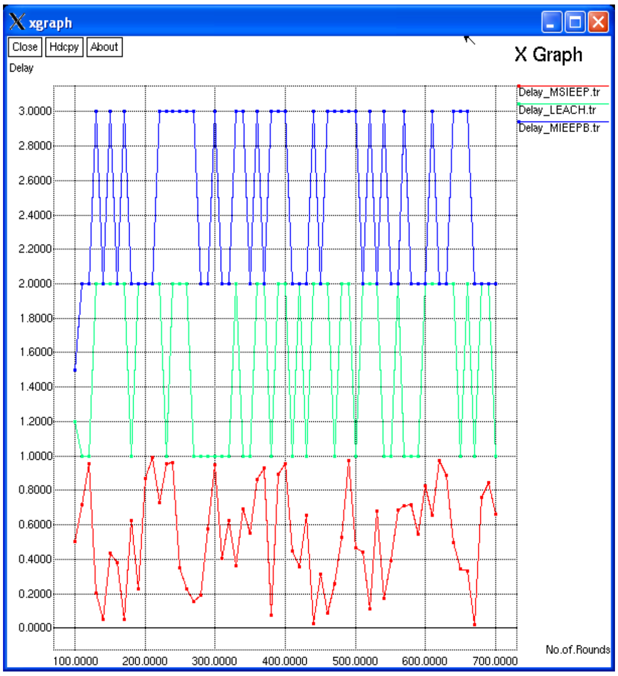

Fig 5. Packet Delay

SIMULATION RESULTS

Parameters	LEACH and rendezvous Protocol	MSIEEP Protocol	Percentage of Improvement (%)
Packet drop ratio(%)	11.42	0.57	95
Packet delay(μ sec)	11.76	8.45	28
Packet delivery ratio (%)	75.06	98.06	23

Table 1. Simulation Results

From these results, it is noticed that the packet drop ratio and the packet delay increase as the number of nodes increases for all protocols. Sending more packets for high node degree cases increases the chances of more dropped packets due to increased congestion at the receiver end which causes buffer overflow and thus leading to dropped packets and higher packet delay. Introducing mobility to sink and dividing the sensor field into small size regions in the proposed protocol improve the probability of packet drop and packet delay compared to the other protocols. Moreover, this increases the robustness and the ability of the proposed protocol to deliver packets to the destination.

VII. CONCLUSION

A clustering protocol called Mobile Sink based adaptive Immune Energy-Efficient clustering Protocol (MSIEEP) has been presented to eliminate the energy hole problem and further improves the lifetime and the stability period of WSNs. Moreover, this protocol utilizes the adaptive immune algorithm also the optimum number of cluster heads and their locations based on minimizing the dissipated energy in communication and overhead control packets of all sensor nodes in the sensor field. Simulation results showed that the proposed protocol is more reliable and energy efficient as compared to other protocols; namely LEACH, LEACH-GA, A-LEACH, rendezvous and MIEEPB protocols. Moreover, it outperforms the previous protocols in terms of the lifetime, the stability period, the packet drop ratio and the packet delay. The future work can be done by using path planning algorithm for the mobile sink. In which, The delay will get reduced and further improve packet delivery ratio of the wireless sensor network

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