An Energy Efficient Cluster-Based Protocol using Mobile Sink in Wireless Sensor Network

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Abstract—Wireless sensor networks (WSNs) consist of large number of sensor nodes. These small and low cost sensor nodes are deployed in monitoring region of interest. Since sensors perform multiple functions such as data gathering and data transmission results in energy depletion, these effects the network lifetime. The nodes having tendency to fail due to energy depletion is the critical issue in WSN. Due to wide number of applications of WSN, it is required to enhance the lifetime of entire network. This paper aimed to optimize the energy dissipation by modifying the CH (Cluster Head) selection approach in LEACH (Low Energy Adaptive Clustering Hierarchy) algorithm and avoids the energy-hole problem considering mobility to the sink node, which helps to prolong the lifetime of entire network. LEACH is an example of hierarchical routing protocol Hierarchical routing is again sub divided into various approaches such as area based, grid based, tree based and cluster based. In Cluster based approach routing algorithm divides the network into different clusters. CH is elected in each cluster. CH collects data from its members, aggregates the data and sends to sink or the data collection center. LEACH algorithm gives birth to many protocols. According to this protocol, total area is divided into different clusters and one CH (cluster head) is selected for each cluster. For every round, new cluster head is elected that is there will be rotation of CH for each round of transmission In LEACH sink node will be static, in proposed method considering mobile sink results in lesser utilization of nodes energy and can avoid these disadvantages. Some nodes near to sink region dissipate energy faster than other nodes which creates energy-hole within the network. This problem can be avoided by assigning mobility to sink node.

1. INTRODUCTION

Wireless sensor networks (WSNs) use small nodes with constrained capabilities to sense, collect, and disseminate information in many types of applications. As sensor networks become widespread, security issues become a central concern, especially in mission-critical tasks. Wireless Sensor Networks (WSNs) are used in many applications in military, ecological, and health-related areas. These applications often include the monitoring of sensitive information such as enemy movement on the battlefield or the location of personnel in a building. Security is therefore important in WSNs.

However, WSNs suffer from many constraints, including low computation capability, small memory, limited energy resources, susceptibility to physical capture, and the use of insecure wireless communication channels. These constraints make security in WSNs a challenge. Many routing, power management, and data dissemination protocols have been specifically designed for WSNs where energy awareness is an essential design issue. Routing protocols in WSNs might differ depending on the application and network architecture.

Recent advances in wireless sensor networks have led to many new protocols specifically designed for sensor networks where energy awareness is an essential consideration. Most of the attention, however, has been given to the routing protocols since they might differ depending on the application and network architecture. Due to recent technological advances, the manufacturing of small and low-cost sensors has become technically and economically feasible. These sensors measure ambient conditions in the environment surrounding them and then transform these measurements into signals that can be processed to reveal some characteristics about phenomena located in the area around these sensors.

A large number of these sensors can be networked in many applications that require unattended operations, hence producing a wireless sensor network (WSN). In fact, the applications of WSNs are quite numerous. For example, WSNs have profound effects on military and civil applications such as target field imaging, intrusion detection, weather monitoring, security and tactical surveillance, distributed computing, detecting...
ambient conditions such as temperature, movement, sound, light, or the presence of certain objects, inventory control, and disaster management.

Deployment of a sensor network in these applications can be in random fashion (e.g., dropped from an airplane in a disaster management application) or manual (e.g., fire alarm sensors in a facility or sensors planted underground for precision agriculture). Creating a network of these sensors can assist rescue operations by locating survivors, identifying risky areas, and making the rescue team more aware of the overall situation in a disaster area. Typically, WSNs contain hundreds or thousands of these sensor nodes, and these sensors have the ability to communicate either among each other or directly to an external base station (BS). A greater number of sensors allows for sensing over larger geographical regions with greater accuracy. Basically, each sensor node comprises sensing, processing, transmission, mobilizer, position finding system, and power units (some of these components are optional, like the mobilizer).

Sensor nodes are usually scattered in a sensor field, which is an area where the sensor nodes are deployed. Sensor nodes coordinate among themselves to produce high-quality information about the physical environment.

Each sensor node bases its decisions on its mission, the information it currently has, and its knowledge of its computing, communication, and energy resources. Each of these scattered sensor nodes has the capability to collect and route data either to other sensors or back to an external BS(s). A base station (BS) may be a fixed or mobile node capable of connecting the sensor network to an existing communications infrastructure or to the Internet where a user can have access to the reported data.

In the past few years, intensive research that addresses the potential of collaboration among sensors in data gathering and processing, and coordination and management of the sensing activity was conducted. In most applications, sensor nodes are constrained in energy supply and communication bandwidth. Thus, innovative techniques to eliminate energy inefficiencies that shorten the lifetime of the network and efficient use of the limited bandwidth are highly required. Such constraints combined with a typical deployment of large number of sensor nodes pose many challenges to the design and management of WSNs and necessitate energy-awareness at all layers of the networking protocol stack.

For example, at the network layer, it is highly desirable to find methods for energy-efficient route discovery and relaying of data from the sensor nodes to the BS so that the lifetime of the network is maximized. Routing in WSNs is very challenging due to the inherent characteristics that distinguish these networks from other wireless networks like mobile ad hoc networks or cellular networks. First, due to the relatively large number of sensor nodes, it is not possible to build a global addressing scheme for the deployment of a large number of sensor nodes as the overhead of ID maintenance is high. Thus, traditional IP-based protocols may not be applied to WSNs. In this project, the system uses Sleep scheduling algorithm.

In this thesis, Section 2 describes the literature review, Section 3 explains the proposed methodology architecture diagram, flowchart, and pseudo code. Simulation details are provided in Section 4. Performance evaluation is provided in section 5. Conclusion and future enhancements are explained in Section 6.

2. LITERATURE REVIEW

Sandra [1] et.al presented a survey of power saving and energy optimization techniques for wireless sensor networks, which enhances the ones in existence and introduces the reader to the most well-known available methods that can be used to save energy. One of the main pursued objectives of the WSN design is to prolong the network lifetime and prevent information degradation and loss. Limitation of this is that both protocols need too much processing in their nodes.

P. Raju [2] et.al has explained the problem of gathering data from a sensor network using mobile elements. In particular, he considered the case where the data are produced by measurements and need to be delivered to a predefined sink within a given time interval from the time the measurement takes place. Mobile elements travel the network in predefined paths, collect the data from the nodes, and deliver them to the sink. Each node must be visited by a mobile element that must then reach the sink within the given time constraint. The goal is to plan the paths for the mobile elements that minimize the total length travelled. He proposed an
algorithmic solution that builds node disjoint tours that always include the sink, cover the network, and optimize the total length travelled. He provided an integer linear programming formulation for the problem, and propose two novel heuristics for building the tours.

Dali Wei [3] et.al has discovered hot spots in a wireless sensor network emerge as locations under heavy traffic load. Nodes in such areas quickly deplete energy resources, leading to disruption in network services. They proposed a simple energy-efficient multihop data collection protocol to evaluate the effectiveness of EC and calculate the end-to-end energy consumption of this protocol. It is used for a higher residual energy level. In addition, UCR assumes a network-wide broadcasting, which wastes energy on unnecessary transmissions; a drawback when compared to the other two algorithms.

Shuai Peng [4] et.al has explored energy harvesting techniques have enabled the provisioning of alternative energy sources beside the conventional one which is typically provided by the batteries. Using such harvesting techniques together with proper energy management mechanisms, a Energy Neutral state can be achieved so that desired performance level can be supported perpetually.

Pengfei Zhang [5] et.al has motivated by recent developments in Wireless Sensor Networks (WSNs), he present several efficient clustering algorithms for maximizing the lifetime of WSNs, i.e., the duration till a certain percentage of the nodes die. Specifically, an optimization algorithm was proposed for maximizing the lifetime of a single-cluster network, followed by an extension to handle multi-cluster networks. Then, studied the joint problem of prolonging network lifetime by introducing energy-harvesting (EH) nodes. An algorithm is proposed for maximizing the network lifetime where EH nodes serve as dedicated relay nodes for cluster heads (CHs). It helps provide useful benchmarks for various centralized and distributed clustering scheme designs.

Aparna Gurjar [6] et.al had implementing source location privacy makes it possible to hide the location information of the transmitting node. Classified as a contextual privacy protection technique, the source location privacy is an essential feature of those real life sensor networks which have been deployed for monitoring events happening at particular locations. Designed a source location privacy scheme using cluster based anonymization and random routing. The privacy measure index is then evaluated in order to estimate the overall privacy achieved by the SLP scheme.

Yun Li [7] et.al has explored the message authentication is one of the most effective ways to thwart unauthorized and corrupted traffic from being forwarded in wireless sensor networks (WSNs). To provide this service, a polynomial-based scheme was recently introduced. However, this scheme and its extensions all have the weakness of a built-in threshold determined by the degree of the polynomial: when the number of messages transmitted is larger than this threshold, the adversary can fully recover the polynomial. He proposed a scalable authentication scheme based on elliptic curve cryptography (ECC). While enabling intermediate node authentication, our proposed scheme allows any node to transmit an unlimited number of messages without suffering the threshold problem. Message complexity and security resilience since public-key-based approaches have simple. It has a key management problem.

Jian Meng [8] proposed an Adaptive Energy Harvesting Aware Clustering (AEHAC) routing protocol for EH-WSNs, which takes node energy state into cluster head election algorithm and can adjust its parameter according to the network deploying environment. He analyzed and evaluated the routing performance in terms of two metrics available node number and network throughput.

Junfeng Wang [9] et.al has performed a multipath routing in wireless multimedia sensor network makes it possible to transfer data simultaneously so as to reduce delay and congestion and it is worth researching. In this paper, they propose a pair-wise directional geographical routing (PWDGR) strategy to solve the energy bottleneck problem. First, the source node can send the data to the pair-wise node around the sink node in accordance with certain algorithm and then it will send the data to the sink node. Reliability and fault tolerance is an advantage. To take other nodes into consideration unless the energy of the nearest neighbor nodes is used up and it is easy to form energy hole.

X.Wang [10] proposed a cluster-based dynamic energy management mechanism. Dijkstra’s algorithm is utilized to obtain optimal intra-cluster routing. Target position is predicted by particle
filter. The predicted target position is adopted to estimate the idle interval of sensor nodes. Hence, dynamic awakening approach is exploited to prolong sleep time of sensor nodes so that the operation energy consumption of wireless sensor network can be reduced. The sensor nodes around the target wake up on time and act as sensing candidates. With the candidate sensor nodes and predicted target position, the optimal sensor node selection is considered. Binary particle swarm optimization is proposed to minimize the total energy consumption during collaborative sensing and data reporting. Experimental results verify that the proposed clustering approach establishes a low-energy communication structure while the energy efficiency of wireless sensor networks is enhanced by cluster-based dynamic energy management.

H.L. Fu [11] has explored a rapid emergence of Wireless Sensor and Robot Networks (WSRNs) contributes to the deployment of an environmental monitoring system. Can Tunca [12] has explained the concentration of data traffic towards the sink in a wireless sensor network causes the nearby nodes to deplete their batteries quicker than other nodes, which leaves the sink stranded and disrupts the sensor data reporting. To mitigate this problem the usage of mobile sinks is proposed. Mobile sinks implicitly provide load-balancing and help achieving uniform energy-consumption across the network. However, the mechanisms to support the sink mobility (e.g., advertising the location of the mobile sink to the network) introduce an overhead in terms of energy consumption and packet delays. With these properties mobile sink routing constitutes an interesting research field with unique requirements. He present a survey of the existing distributed mobile sink routing protocols. In order to provide an insight to the rationale and the concerns of a mobile sink routing protocol, design requirements and challenges associated with the problem of mobile sink routing are determined and explained. A definitive and detailed categorization is made and the protocols’ advantages and drawbacks are determined with respect to their target applications.

Yuan Gao [13] has proposed method. Firstly, a number of collection points are selected according to the sensor distribution. Secondly, the optimal path across the points for the mobile sink is performed by using a quantum genetic algorithm. The sink will travel along this path periodically, and collect data at each point. Simulation results show that the scheme has better performance and collects more data.

3. **PROPOSED SYSTEM**

The proposed system is an ENERGY-BALANCED LEACH protocol. The CH nodes act as gateways between the sensor nodes and the BS. The function of each CH, 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. Figure 1 shows the system architecture.

Hierarchical clustering in WSNs can greatly contribute to overall system scalability, lifetime, and energy efficiency. Hierarchical routing is an efficient way to lower energy consumption within a cluster, performing data aggregation and fusion in order decrease the number of transmitted messages to the BS. There is a need to change the cluster heads at every round considering residual energy so that CH selected should have high energy. Hence an efficient cluster head replacement algorithm is needed to conserve energy within the network and load balancing among all the clusters is required to increase the network life time. The modified version of LEACH requires lesser maintenance of routing tables because for a normal node, it will maintain local topology information and for CH node it will maintain global limited topology. The algorithm will also find the route which will have reduced number of hops, route discovery time and energy computation. Further the proposed method reduces the problem of energy hole by providing mobility to the sink node. Sink node moves to different clusters to collect the information so location of the sink needs to be known at each iteration. From each cluster a special node called agent node is selected to update the location of sink. Based on different tiers for data transmission nodes are classified as normal node, cluster head, agent node and one movable sink node.

Cluster formation is performed based on the Euclidean distance. In the first round, centroid of the cluster is selected as the cluster head as all the nodes in the network has equal amount of energy. In further rounds, the node with maximum energy is elected as the cluster head in the cluster.
3.1 MOBILE SINK

Wireless sensor networks (WSNs) are formed from sensor nodes with limited resources that are deployed to detect physical phenomena. These nodes generate data and operate in a multi-hop fashion to relay data from other nodes. In our case, we consider relaying data to a base station (static data sink) in buildings during a fire as could be used for monitoring the spread of the fire, locating people in the building, and providing real time information to firefighters, etc. This needs robust and rapid communication, yet the sensor field may become unreliable as nodes are consumed by the fire. We envisage firefighters entering the building each with a small powered node attached to them as part of their equipment pack. These nodes can act as mobile sink nodes which are able to relay data to the base station in a single hop, using for example IEEE 802.11. The main question we consider is how to make best use of these mobile sinks in order to improve the efficacy of network delivery. This raises several key research questions. When should sensor nodes relay data via the mobile sink? How does the mobile sink make its presence known to the sensor nodes? How can we use the mobile sink to re-connect disconnected regions of the field? Note that the movement of the mobile sink is not under the control of the WSN. We do not assume that we can direct the firefighter, and so from the point of view of the WSN, the mobility is uncontrolled. An opportunistic routing scheme for taking advantage of these uncontrolled mobile sinks in fire systems in buildings: the mobile sinks can collect data locally, or can act as connectors to the disconnected areas. We evaluate the performance using simulation and show that use of the mobile sink can increase the message delivery rate by up to 50%.

Sink mobility in conventional sensor networks has been extensively studied in the past few year and demonstrated that it can significantly improve various network performance including reducing the energy consumption of sensors, balancing the workload among the sensors, reducing the data delivery delays, and prolonging the network lifetimes. Most existing studies focused on minimizing the energy consumption so as to prolong the network lifetime since sensors are powered by energy-limited batteries. The use of a path-constrained mobile sink for data collection in conventional sensor networks. Figure 2 depicts the flowchart of proposed system.

3.2 ADVANTAGES:

- It provides energy efficient transmission.
- It achieves the optimal solution.
- High throughput
- It reduce end to end delay.
- It is flexible. Increasing the packet delivery ratio

3.2.1 ALGORITHM FOR L-LEACH PROTOCOL:

STEP 1: START
STEP 2: for (i = 0; i <= 99; i++)
    loop
deploy sensor nodes
end loop
STEP 3: for (i = 0; i <= 3; i++)
    loop
for(j = 0; j <= 24; j++)
    loop
form cluster
end loop
end loop
STEP 4: calculate the energy-levels
for the first time all the nodes have equal energy. Centroid will be selected as cluster head
After round 1, the node with maximum energy will be elected as cluster head and is will be repeated until complete data is collected
STEP 5: Data from the cluster head is collected by mobile sink and after completion of data gathering, mobile sink goes to its original position
STEP 6: Sleep mode
STEP 7: STOP

3.3 ARCHITECTURE DIAGRAM

Figure 1. Architecture of the proposed system
3.3.1 FLOWCHART:

**Figure 2. Flowchart for the proposed system**

3.3.3 PSEUDO CODE for proposed system:

**STEP 1:** Randomly deploy the nodes with mobile sink in the sensor network

**STEP 2:** Applying L-LEACH protocol to make clusters (Based on energy levels of each node)

**STEP 3:** Sensing data and sending to cluster head from the nodes in the cluster

**STEP 4:** Transmission of data from cluster head to mobile sink

**STEP 5:** Calculating energy levels, if YES goto step-2, else goto step-6

**STEP 6:** Node is set to sleep mode

**STEP 7:** If user wants to continue the process of data gathering and data transmitting in the network goto step-2, else step-8

**STEP 8:** Stop the process

4. SIMULATION

NS2 is an open-source event-driven simulator designed specifically for research in computer communication networks. NS2 has continuously gained tremendous interest from industry, academia, and government. Having been under constant investigation and enhancement for years, NS2 now contains modules for numerous network components such as routing, transport layer protocol, application, etc. To investigate network performance, researchers can simply use an easy-to-use scripting language to configure a network, and observe results generated by NS2. Undoubtedly, NS2 has become the most widely used open source network simulator, and one of the most widely used network simulators. Table 2 shows the simulation parameters used.

### 4.1 SIMULATION PARAMETERS

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel</td>
<td>Wireless Channel</td>
</tr>
<tr>
<td>Model</td>
<td>Propagation/Two Ray Model</td>
</tr>
<tr>
<td>Network Interface</td>
<td>Wireless Physical Interface</td>
</tr>
<tr>
<td>MAC</td>
<td>IEEE 802.11</td>
</tr>
<tr>
<td>Interface Queue</td>
<td>Queue/ Drop Tail/ Pre-Queue</td>
</tr>
<tr>
<td>Layer</td>
<td>Link Layer</td>
</tr>
<tr>
<td>Antenna Model</td>
<td>Antenna/ Omni Antenna</td>
</tr>
<tr>
<td>Routing protocol</td>
<td>L-LEACH</td>
</tr>
<tr>
<td>Number of sensor nodes</td>
<td>100</td>
</tr>
<tr>
<td>Maximum packet in ifq</td>
<td>50</td>
</tr>
<tr>
<td>X dimension of topography</td>
<td>1000</td>
</tr>
<tr>
<td>Y dimension of topography</td>
<td>1000</td>
</tr>
<tr>
<td>Time of simulation end</td>
<td>30</td>
</tr>
<tr>
<td>Initial energy</td>
<td>100</td>
</tr>
</tbody>
</table>

**Table 2. Simulation Parameters**

**Figure 3. Random Network Deployment**
5. PERFORMANCE EVALUATION

Performance Metrics:

Performance metrics are used to evaluate the simulation results. The purpose of each metric is described here.

<table>
<thead>
<tr>
<th>METRIC</th>
<th>DESCRIPTION</th>
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<tbody>
<tr>
<td>Throughput</td>
<td>The rate of messages transferred successfully in the network</td>
</tr>
<tr>
<td>Delay</td>
<td>The time difference between packets received and packets sent</td>
</tr>
<tr>
<td>Packet Delivery Ratio</td>
<td>It is the performance measure used to know the ratio between number of packets received and number of packets sent</td>
</tr>
<tr>
<td>Energy Consumption</td>
<td>It is the measure used to know how much energy is consumed by the network in data transmission, sensing, data processing</td>
</tr>
</tbody>
</table>

Table 3. Performance Metrics

Table 3 gives the description of performance metrics.

Figure 7 to Figure 10 shows the Graphs of various performance metrics.
6. CONCLUSION AND FUTURE ENHANCEMENT

We implemented L-LEACH protocol with mobile sink and compared L-LEACH with static sink with four parameters Energy, Throughput, Delay and Packet Delivery Ratio. Energy consumption is reduced, delay is decreased, packet delivery ratio is high and throughput is increased by implementing the mobility for sink node. Thus, proved the performance of L-LEACH with mobile sink is much better when compared to L-LEACH with static sink.

The mobile sink concept can be applied further for various routing protocols in WSN.

REFERENCES


