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An Energy Efficient Adaptive Intracluster Routing For Wireless Sensor Network

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Abstract
Wireless sensor network (WSN) requires robust and energy efficient communication protocols to minimize the energy consumption as much as possible. However, the lifetime of sensor network reduces due to the adverse impacts caused by radio irregularity and fading in multi-hop WSN. A cluster-based scheme is proposed as a solution for this problem. The proposed scheme extends High Energy First (HEF) clustering algorithm and enables multi-hop transmissions among the clusters by incorporating the selection of cooperative sending and receiving nodes. The performance of the proposed system is evaluated in terms of energy efficiency and reliability. Simulation results show that tremendous energy savings can be achieved by adopting hard network lifetime scheme among the clusters. The proposed cooperative MIMO scheme prolongs the network lifetime with 75% of nodes remaining alive when compared to LEACH protocol. To prolong the network life, the energy consumption of the routing task is crucial. Topology control methods were given to support the energy-efficient routing, while the most of them are designed for static network. Energy consumption plays an important role in Wireless Sensor Networks.

Keywords: *Wireless sensor network, High Energy First, Multiple Input Multiple Output, Low Energy Adaptive Clustering Hierarchy*

1. Introduction

1.1 Wireless Sensor Network

A wireless sensor network (WSN) consists of sensor nodes capable of collecting information from the environment and communicating with each other via wireless transceivers. The collected data will be delivered to one or more sinks, generally via multi-hop communication. The sensor nodes are typically expected to operate with batteries and are often deployed to not-easily-accessible or hostile environment, sometimes in large quantities. It can be difficult or impossible to replace the batteries of the sensor nodes. On the other hand, the sink is typically rich in energy. Since the sensor energy is the most precious resource in the WSN, efficient utilization of the energy to prolong the network lifetime has been the focus of much of the research on the WSN.The communications in the WSN has the many-to-one property in that data from a large number of sensor nodes tend to be concentrated into a few sinks. Since multi-hop routing is generally needed for distant sensor nodes from the sinks to save energy, the nodes near a sink can be burdened with relaying a large amount of traffic from other nodes. Sensor nodes are resource constrained in term of energy, low range communication and bandwidth. Limited battery is used to operate the sensor nodes and is very difficult to replace or recharge it, when the nodes die. This will affect the network performance. Energy conservation and harvesting increase lifetime of the network. Optimize the communication range and minimize the energy usage, we need to conserve the energy of sensor nodes. Sensor nodes are deployed to gather information and desired that all the nodes works continuously and transmit information as long as possible. This address the lifetime problem in wireless sensor networks. Sensor nodes spend their energy during transmitting the data, receiving and relaying packets. Hence, designing routing algorithms that maximize the lifetime until the first battery expires is an important consideration. Designing energy aware algorithms increase the lifetime of sensor nodes. In some applications the network size is larger required scalable architectures. Energy conservation in wireless sensor networks has been the primary objective, but however, this constrain is not the only consideration for efficient working of wireless sensor networks. There are other objectives like scalable architecture, routing and latency. In most of the applications of wireless sensor networks are envisioned to handled critical scenarios where data retrieval time is critical, i.e., delivering information of each individual node as fast as possible to the base station becomes an important issue. It is important to guarantee that information can be successfully received to the base station the first time instead of being retransmitted. In wireless sensor network data gathering and routing are challenging tasks due to their dynamic and unique properties. Many routing protocols are developed, but among those protocols cluster based routing protocols are energy efficient, scalable and prolong the network lifetime .In the event detection environment nodes are idle most of the time and active at the time when the event occur. Sensor nodes periodically send the gather information to the base station. Routing is an important issue in data gathering sensor network, while on the other hand sleep-wake synchronization is the key issue for event detection sensor networks.

1.2 Existing System

Sensor nodes are resource constrained in term of energy, processor and memory and low range communication and bandwidth. Limited capacity of a battery is used to operate the sensor nodes and is very difficult to replace or recharge it, when the nodes die. This will affect the network performance. Energy conservation and harvesting increase lifetime of the network. Wireless Sensor Networks consist of battery-powered nodes that are endowed with a multitude of sensing modalities including multi-media (e.g., video, audio) and scalar data (e.g., temperature, pressure, light, magnetometer, infrared). Although there have been significant improvements in processor design and computing, advances in battery technology still lag behind, making energy resource considerations the fundamental challenge in wireless sensor networks. Consequently, there have been active research efforts on performance limits of wireless sensor networks. Those operations for a sensor to consume energy are target detection, data transmission and reception, data processing, etc. Among others data transmission consumes most of the energy, and it heavily depends on the transmission distance and the transmitted data amount.

1.3 Proposed System

Cluster heads are selected according to the probability of optimal cluster heads determined by the networks. After the selection of cluster heads, the clusters are constructed and the cluster heads communicate data with base station. Because LEACH is only depend on probability model, some cluster heads may be very close to each other and can be located in the edge of the WSN. These disorganized cluster heads could not maximize energy efficiency. To overcome the defects of LEACH methodology, a cluster head election method HEF algorithm has been introduced. This method proved that the network lifetime can be efficiently prolonged by using fuzzy variables (concentration, energy and density). Providing a trustworthy system behavior with a guaranteed hard network lifetime is a challenging task to safety-critical and highly-reliable WSN applications. For mission critical WSN applications, it is important to be aware of whether all sensors can meet their mandatory network lifetime requirements. The High Energy First (HEF) algorithm is proven to be an optimal cluster head selection algorithm that maximizes a hard N-to-N lifetime for HC-WSNs under the ICOH condition. Then, we provide theoretical bounds on the feasibility test for the hard network lifetime for the HEF algorithm. Our experiment results show that the HEF algorithm performs improvement over LEACH, and HEF's lifetime can be bounded.

2. Module

2.1 Cluster Head Selection

The cluster heads may be special nodes with higher energy or normal node depending on the algorithm and application. Here base station is a cluster head performs computational functions such as data aggregation and data compression in order to reduce the number of transmission to the base station (or sink) there by saving energy. One of the basic advantages of clustering is that the latency is minimized compared to flat base routing and also in flat based routing nodes that are far from the base station lacks the power to reach it. Cluster based algorithms are believed to be the most efficient routing algorithm for the WSNs. Clustering along with reduction in energy consumption improves bandwidth utilization by reducing collision. Work is currently underway on the energy efficiency in WSNs which will result from the selection of cluster heads.

2.2 Energy Consumption

Transmission in WSNs is more energy consuming compared to sensing, therefore the cluster heads which performs the function of transmitting the data to the base station consume more energy compared to the rest of the nodes. Clustering schemes should ensure that energy dissipation across the network should be balanced and the cluster head should be rotated in order to balance the network energy consumption. The communication model that wireless sensor network uses is either single hop or multi hop. Since energy consumption in wireless systems is directly proportional to the square of the distance, single hop communication is expensive in terms of energy consumption.

2.3 Energy Efficient Routing

In contrast to simply establishing correct and efficient routes between pair of nodes, one important goal of a routing protocol is to keep the network functioning as long as possible. The goal can be accomplished by minimizing mobile nodes energy not only during active communication but also when they are inactive. Transmission power control and load distribution are two approaches to minimize the active communication energy, and sleep/power-down mode is used to minimize energy during inactivity. The method is useful to provide the min-power path through which the overall energy consumption for delivering a packet is minimized. Each wireless link is annotated with the link cost in terms of transmission energy over the link and the min-power path is the one that minimizes the sum of the link costs along the path. However, a routing algorithm using this metric may result in unbalanced energy spending among mobile nodes. When some particular mobile nodes are unfairly burdened to support many packet-relaying functions, they consume more battery energy and stop running earlier than other nodes disrupting the overall functionality of the ad hoc network. Maximizing the network lifetime (the second metric shown above) is a more fundamental goal of an energy efficient routing algorithm: Given alternative routing paths, select the one that will result in the longest network operation time.

3. High-Energy First Algorithm

The most important property of the WSN network lifetime is not longevity, but predictability. Schedulability tests are essential for the time-critical system because it provides predictability to complement online scheduling. Cluster head selection algorithms produced by empirical techniques often result in highly unpredictable network lifetimes. Although an algorithm can work very well to prolong the network lifetime for a period of time, a possible failure can be catastrophic, resulting in the failure of a mission, or the loss of human life. A reliable guarantee of the system behaviors is hence a requirement for systems to be safe and reliable. However, there are currently no known analytical studies on the network lifetime predictability for cluster head selection algorithms. Apply the worst-case energy consumption analysis to derive the predictability of HEF.Wireless Sensor Networks it is often required to deploy a large number of sensors in a random fashion to monitor a set of targets. The sensors have limited battery life and it is necessary to efficiently utilize the energy while monitoring all targets for maximum duration. With the available technology sensors are battery powered and that is rarely replaced or renewed. Therefore, energy conservation is a critical issue which affects the application life time. As large-scale sensor networks may be overly deployed, a subset of sensors can be active at any given time to monitor all targets. Such over-deployment can be exploited to obtain a longer lifetime of battery-powered sensor network.

Energy efficient target coverage problem deals with scheduling the sensor's active/sleep durations such that he total if the time of the network is maximized while all the targets are continuously monitored. The battery life of individual sensors is the constraint that prevents the network to have arbitrarily large lifetime.

3.1 Energy-Efficient Target Coverage

Sensors can monitor a disk centered at the sensor's location, whose radius equals the sensing range. Target coverage problem presented in attempts to maximize the total network lifetime by grouping sensors into non-disjoint sensor covers and then activating them one after another. A greedy heuristic to solve target coverage problem where heuristic gives priority to that sensor which covers critical target (target covered by least number of sensors) and maximum number of uncovered targets while generating sensor covers. Maximize the lifetime for target coverage problem by organizing the sensors into maximum disjoint set covers and these are activated successively.

3.2 Energy-Efficient Connected Coverage

An important issue in WSN is connectivity. A network is connected if any active node can communicate with any other active node, possibly using intermediate nodes as relays. Once the sensors are deployed, they organize into a network that must be connected so that the information collected by sensor nodes can be relayed back to data sinks or controllers. An important, frequently addressed objective is to determine a minimal number of working sensors required to maintain the initial coverage area as well as connectivity. Selecting a minimal set of working nodes reduces power consumption and prolongs network lifetime. The research work discuss a variant of target coverage problem known as target connected coverage where all the sensors in generated sensor cover must be connected to some designated base station (BS) with the help of some relay nodes.

3.3 High-Energy-First (HEF) heuristic

It is based on above observations a new heuristic is used to solve the target coverage problem. A new heuristic to solve the target coverage problem. The granularity parameter *w* plays an important role in getting a better approximation of optimal solution. Hence prioritizing the sensors in terms of residual battery provides us better opportunity of using the sensors.

- **Generate a cover-** The HEF heuristic generates sensor cover S by selecting a sensor with highest residual battery life and which covers at least one uncovered target.

Ideally, some sort of priority (weight) is associated with each sensor.
The sensor cover is constructed by iteratively selecting sensors of high priorities till all the targets are covered.

- **Assign lifetime to a cover-**The temptation is to assign maximum allowable lifetime. Instead, the algorithm requires a user-specified constant and whenever a cover is generated, w¢ = Min (w, max_lifetime(S)) is added to its lifetime.
  By this process, we do not consume the total energy of sensors and make these sensors available for other covers.
- **Change the priorities of the sensors-** In order to avoid the repeated generation of the same sensor cover in consecutive iterations, the priority of a sensor reduces once it is used in a sensor cover and as a result the greedy construction of sensor cover in the next iteration tries to avoid such a sensor.

4. Software Equipments

4.1 Overview of the Ns-2 Environment

NS-2 stands for Network Simulator Version 2.It is discrete event simulators for networking research work at packet level provide substantial support to simulate branch of protocols like TCP, UDP, FTP, HTTP and DSR. Simulate wired and wireless network.

Is primarily UNIX based Use TCL as its scripting language.NS-2 is a standard experiment environment in research community.NS-2 is a packet-level simulator and essentially a centric discrete event scheduler to schedule the events such packet & timer expiration.

5. Simulation Results

The simulation results shows that the transmission of packets in 0th level. It contains 15 nodes. The data is transmitted from one cluster to another via base station as illustrated in Figure 1.

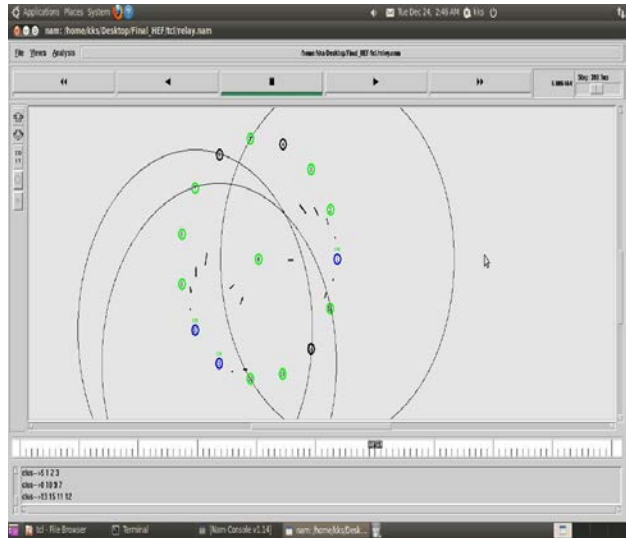

Fig 1 NAM window shows the transmission in level 0

This shows the transmission of packets in level 1. It contains 37 nodes. The data is transmitted among clusters in the network as illustrated in Figure 2.

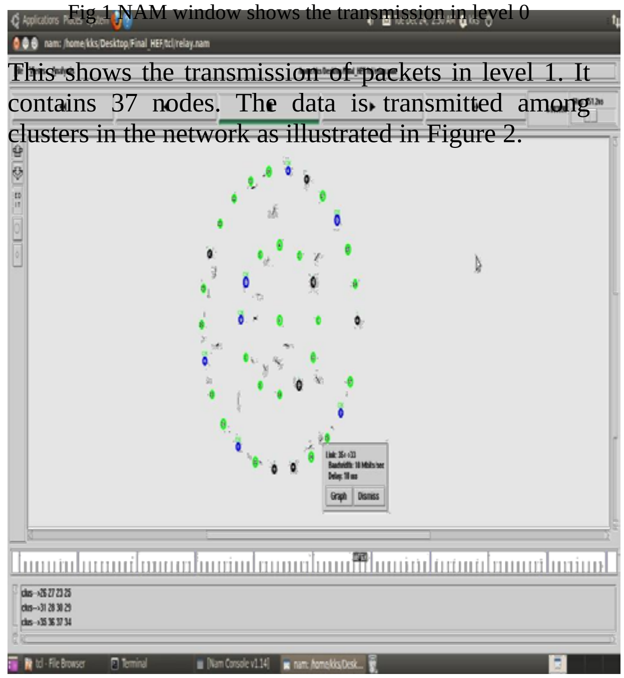

Fig 2 NAM window shows the transmission of packets in level 1

The transmission of packets in level 2. It contains 55 nodes. The data is transmitted among clusters in the network as illustrated in Figure 3.

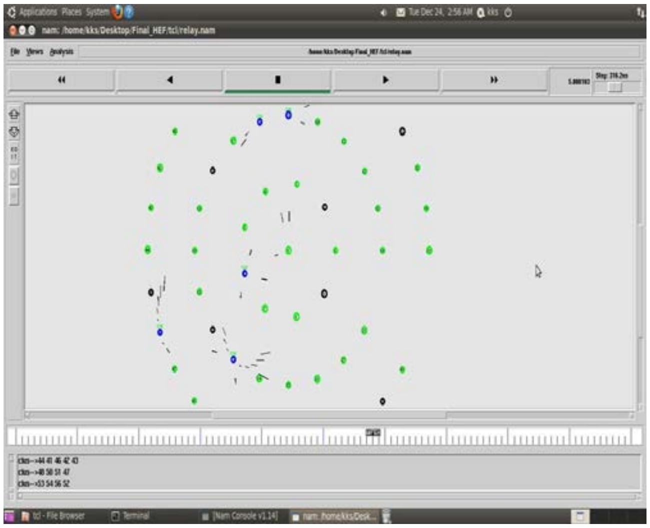

Fig 3 NAM window shows the transmission in level 2

Figure 4 shows that the changes in the interest cluster. The nodes which indicates black colour are the nodes which are already acts as a cluster head.

The node which indicates blue colour is the nodes are acts as a cluster head. The green colour nodes are remaining nodes. The plot shows the comparison of energy levels in both LEACH protocol and HEF algorithm.

The plot clearly denotes that 95%of energy is saved in HEF whereas in LEACH protocol only 70% of the energy is saved as illustrated in Figure 5.

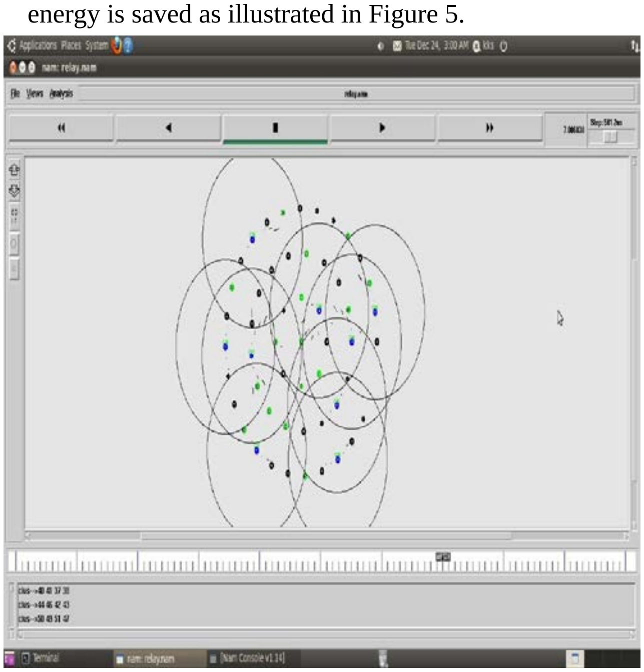

Fig 4 NAM window shows the changes in cluster formation

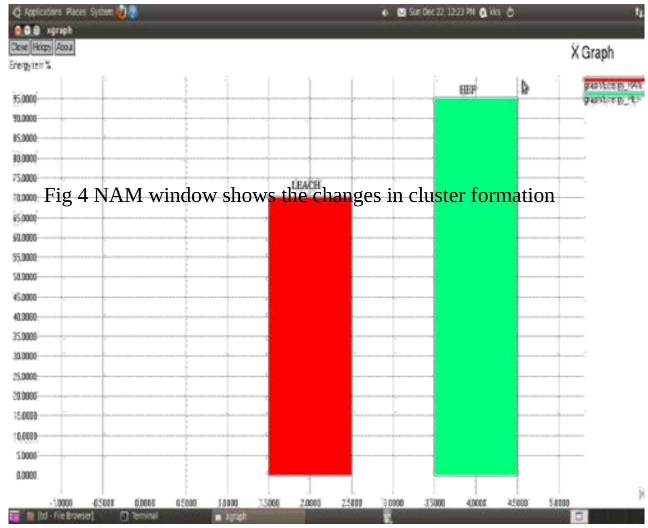

Fig 5 Bar chart representations of energy levels in LEACH and HEF algorithm

The graph shows the representation of energy levels in both LEACH protocol and HEF algorithm. The clearly shows that 99.9000J energy is saved in HEF whereas only 99.8000J energy is saved in LEACH. The more number of energy levels are saved in HEF algorithm than LEACH protocol as illustrated in Figure 6.

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Fig 6 Plot shows the graph representation of energy levels in LEACH and HEF algorithm.

The plot gives the comparison of the network parameter such as the delay for the LEACH and the HEF.The plot clearly shows that the delay in HEF is 1.32ms whereas in LEACH, the delay is 1.35ms.

The delay is slightly less in HEF.The plot shows the packet delivery ratio for both LEACH and HEF algorithm. The packet delivery ratio of HEF is slightly more than the LEACH as illustrated in Figure 7.

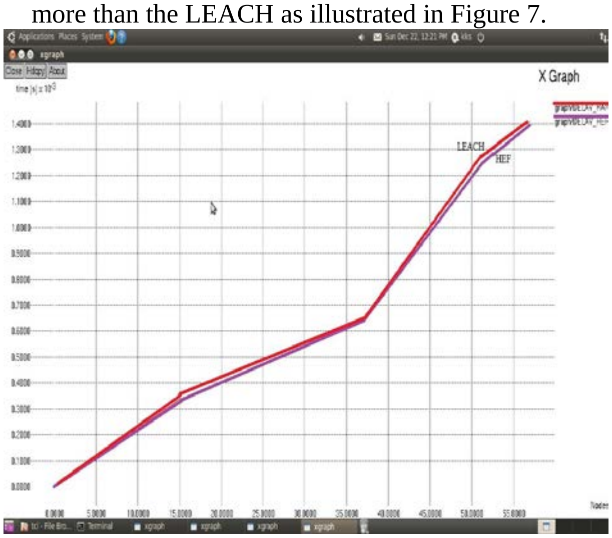

Fig 7 Plot shows the packet delivery ratio in LEACH and HEF

Thus, the simulation result shows that the HEF algorithm is efficient for energy consumption in Wireless Sensor Networks. The parameters such as energy, delay and packet delivery ratio were obtained.

6. Conclusion

6.1 Conclusion

The issues of the predictability are addressed as collective timeliness for WSNs of interests. The sensor nodes are typically expected to operate with batteries and are often deployed to not-easily-accessible or hostile environment, sometimes in large quantities. It can be difficult or impossible to replace the batteries of the sensor nodes.

The sensor energy is the most precious resource in the WSN; efficient utilization of the energy to prolong the network lifetime has been the focus of much of the research on the WSN. So to avoid the replacement of batteries and to increase the network lifetime, the High Energy First algorithm is used.

The High Energy First (HEF) algorithm is proven to be an optimal cluster head selection algorithm that maximizes a hard N-to-N lifetime for HC-WSNs. The comparison results of various network parameters such as delay, packet delivery ratio were obtained.

The experimental result shows that the HEF algorithm achieves significant performance improvement over LEACH.

6.2 Future Work

With the use of HEF algorithm, the energy can be efficiently used and the lifespan of the network can be increased. The number of cluster groups will increase in the future. The cluster group gives choice for source and destination.

So it will select cluster according to the user choice of source and destination code for selecting gateway near to source cluster groups and it will be implemented in the monitoring of forest and planets.

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