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Improving Energy Efficiency by Using Tree-Based Routing Protocol for Wireless Sensor Network

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Abstract- Wireless Sensor Network (WSN) collects large amount of information and sends them to the Base Station (BS). WSN contains low-cost nodes with limited battery power and battery replacement is not easy for WSN with thousands of physically embedded nodes, which means energy efficient routing protocol should be employed to offer a long-life work time. To achieve this minimizing total energy consumption and balancing WSN load is required. So, in the existing system, a Tree-Based Energy-Balance routing protocol (TBEB) is presented which builds a routing tree using a process where, for each round, BS assigns a root node and broadcasts this selection to all sensor nodes. Subsequently, each node selects its parent by considering only itself and its neighbours information, thus making TEB a dynamic protocol. But in this method the parent node selection is based on only the residual energy level.

The drawback in this method is if the parent node has less communication capacity, high interference and congestion there is less network performance in terms of packet delivery ratio, delay, throughput etc. So, an innovative technique is introduced which is named as Tree Based QoS Balanced Routing Protocol (TQR) in order to improve the performance. Communication capacity deals with the data handling capacity of the nodes. The communication capacity is computed based on the utilization factor. For the interference level, the signal to interference noise ratio is computed for computing the interference level of the node. Since congestion significantly reduces the effective bandwidth of a link, the effective link data-rate depends on the congestion level. So, based on this the parent node is selected. An experimental result shows that the proposed system achieves high data rate, throughput and less end-to-end delay.

Keywords- Energy-Balance, Network Lifetime, Routing Protocol, Tree Balanced, Wireless Sensor Network

1. INTRODUCTION

A Wireless sensor network is a group of special transducers with communications infrastructure intended to monitor and record conditions at diverse locations. Commonly monitored parameters are temperature, humidity, pressure, wind direction and speed, illumination intensity, vibration intensity, sound intensity, power-line voltage, chemical concentrations, pollutant levels and vital body functions.WSN has a wide range of potential applications [7], including military surveillance, disaster prediction, environment monitoring, area monitoring, air quality monitoring, Machine health monitoring

In this paper, we propose a Tree based Energy Balance routing protocol (TBEB).We consider a situation in which the network collects information periodically from a terrain where each node continually senses the environment and sends the data back to BS [8]. Normally there are two definitions for network lifetime:

a) The time from the start of the network operation to the death of the first node in the network [9].
b) The time from the start of the network operation to the death of the last node in the network.

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1.1 Overview of the project

A sensor network consists of multiple detection stations called sensor nodes. The nodes are small, lightweight and portable [1],[12][13]. Every sensor node is equipped with a transducer, microcomputer, transceiver and power source. The transducer generates electrical signals based on sensed physical effects and phenomena. The microcomputer processes and stores the sensor output. The transceiver, which can be hard-wired or wireless, receive command from a central computer and transmits data to that computer. The power for each sensor node is derived from the electric utility or from a battery. A sensor node in a wireless sensor network that is capable of performing some processing, gathering sensory information and communicating with other connected nodes in the network.

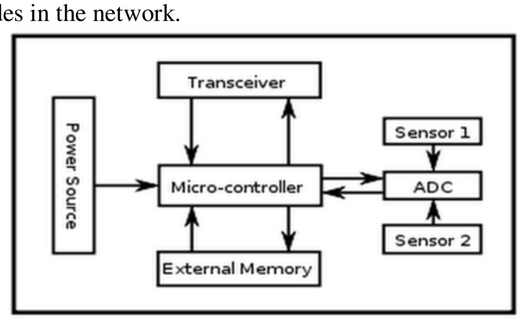

Figure1. 1. The typical architecture of the sensor node

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The main components of a sensor node are a microcontroller, transceiver,external memory, power source and one or more sensors. The controller performs tasks, processes data and controls the functionality of other components in the sensor node.The functionality of both transmitter and receiver are combined into a single device known as a transceiver. The operational states are transmitted, receive, idle, and sleep. Most transceivers operating in idle mode have a power consumption almost equal to the power consumed in receive mode. External memory used for storing application related or personal data, and program memory used for programming the device. An important aspect in the development of a wireless sensor node is ensuring that there is always adequate energy available to power the system. The sensor node consumes power for sensing, communicating and data processing. More energy is required for data communication than any other process. Sensors are hardware devices that produce a measurable response to a change in a physical condition like temperature or pressure. Sensors measure physical data of the parameter to be monitored. The continual analog signal produced by the sensors is digitized by an analog-to-digital converter and sent to controllers for further processing.

The WSN is built of "nodes" – from a few to several hundreds or even thousands, where each node is connected to one or several sensors. A sensor node might vary in size from that of a shoebox down to the size of a grain of dust, although functioning "motes" of genuine microscopic dimensions have yet to be created. The topology of the WSNs can vary from a simple star network to an advanced multi-hop wireless mesh network. Size and cost constraints on sensor nodes result in corresponding constraints on resources such as energy, memory, computational speed and communications bandwidth.

1.2 Significance of Wireless Sensor Network

Wireless sensor network refers to a group of spatially dispersed and dedicated sensors for monitoring and recording the physical conditions of the environment and organizing the collected data at a central location.

- Data Fusion and Dynamic Inference of Network Information
- Integration of Sensor Networks and Web-Based Services
- Location and Time Services
- New Applications of Sensor Network: Environmental Monitoring, Healthcare, Home Automation
- QoS Issues in WSN-Based Integrated Networks
- Reliability of Sensor Network and Failure Analysis
- Routing Protocols for Cross Networks
- Sensor Tasking, Control and Actuation
- Network and Transport Layer Protocols for Cross Networks
-

1.3 Need for the study

In the existing system, in order to improve the energy efficiency various energy efficient routing protocols are suggested.

In Low Energy Adaptive Clustering Hierarchy (LEACH), for the entire network, nodes selected according to a fraction p from all sensor nodes are chosen to serve as cluster heads (CHs), where p is a design parameter. The operations of LEACH are divided into several rounds. Each round includes a setup phase and a steady-state phase. During the setup phase, each node will decide whether to become a CH or not according to a predefined criterion. After selection of CHs , each of other nodes will select its own CH and join the cluster according to the power of many received broadcast messages. Each node will choose the nearest CH. During the steady-state phase, CHs fuse the data received from their cluster members and send the fused data to BS by single-hop communication. LEACH uses and randomization to rotate CHs for each round in order to evenly distribute the energy consumption.

Improving energy efficiency is an important metric in the wireless sensor networks. Energy consumption of a node is due to either “useful” or “wasteful” operations. The useful operations include transmitting or receiving data messages, and processing requests. Wasteful consumption is due to the operation of constructing routing tree, overhearing, retransmitting because of harsh environment, dealing with redundant broadcast overhead messages, and idle listening to the media.

2. PROPOSED SYSTEM

The WSN consist of root node which is called as the cluster head. The data’s have been transformed from the base station to the root node. Each and every sensor node has been connected based on the position of their neighbor

Firstly it identifies the shortest path ,because of this data’s have been transferred to the destination without data collusion. The selection of the root node and the shortest path selection of the sensor node ,which reduces the unwanted energy loss . only selected nodes will be active during data transformation Thus by using this self-organized tree-based routing protocol the lifetime of the root node and other neighbor node have been increased . The performance analysis of self-organized tree-based routing protocol has higher performance when comparing with the other protocol such as the LEACH and HEED.

2.1 Problem Objective

The main goal of this scheme is to reduce the data transmission distance of the sensor node by using the uniform cluster-based techniques. The distance between the sensor node is calculated energy consumption is reduced, and the lifetime is extended for the sensor nodes by balancing the network load among the clusters.

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The main intent is to develop an energy efficient routing protocol in order to balance the energy consumption. For this a routing tree is constructed and in every round the base station assigns a root node and this information is broadcasted to all the sensor nodes. Every node selects the parent by consider itself and neighboring information.

2.2 Architecture Diagram

The base station inform the beginning time ,length of time slot ,number of sensor node. Based on these information own energy level of the node is computed and stored. The nodes then select the parent node using EL from its neighbor. Finally collect the information from all sensor node and fuse the information transfer to the base station.

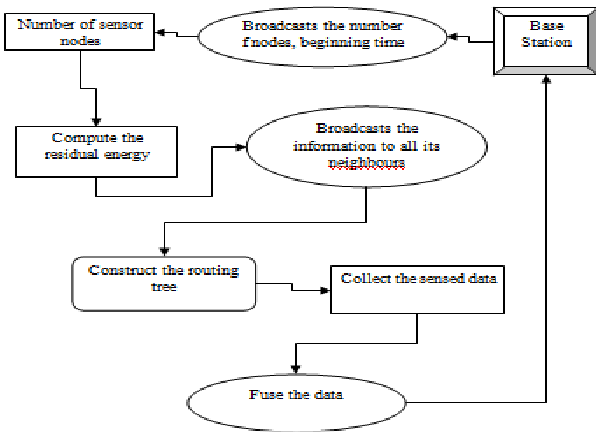

Figure 2.1

2.3 Advantages

- Balancing energy consumption
- High network lifetime
- Performance is high

3. RELATED WORK

A main task of WSN is to periodically collect information of the interested area and transmit the information to BS. A simple approach to fulfilling this task is that each sensor node transmit data directly to BS. However, when BS is located far away from the target area, the sensor nodes will die quickly due to much energy consumption. On the other hand, since the distances between each node and BS are different, direct transmission leads to unbalanced energy consumption. To solve these problems, many protocols have been proposed. Of the protocols proposed, hierarchical protocols such as LEACH, HEED, and STEB can achieve satisfactory solutions.

Low Energy Adaptive Clustering Hierarchy ("LEACH") is a TDMA based MAC protocol which is integrated with clustering and a simple routing protocol in wireless sensor network (WSNs). The goal of LEACH[2] is to lower the energy consumption required to create and maintain clusters in order to improve the life time of a wireless sensor network

W. R. Heinzelman, A. P. Chandrakasan and H. Balakrishnan [3] proposed Low Energy Adaptive Clustering Hierarchy (LEACH) protocol in 2000. It is one of the most popular hierarchical routing algorithms for sensor networks. The idea is to form clusters of the sensor nodes based on the received signal strength and use local cluster heads as routers to the sink. This will save energy since the transmissions will only be done by such cluster heads rather than all sensor nodes. Optimal number of cluster heads is estimated to be 5% of the total number of nodes. All the data processing such as data fusion and aggregation are local to the cluster.

Tree-Based Clustering (TBC) [10] is also an improved protocol of LEACH. It forms several clusters in the same way as LEACH, and each cluster has a cluster-head (CH). The nodes within a cluster construct a routing tree where the cluster-head is the root of it. For tree configuration, the cluster-head uses the distance information between the member nodes and itself.

O. Younis and S. Fahmy proposed [4] Hybrid Energy Efficient Distributed clustering Protocol (HEED) protocol in 2004. It extends the basic scheme of LEACH by using residual energy as primary parameter and network topology features (e.g. node degree, distances to neighbors) are only used as secondary parameters to break tie between candidate cluster heads, as a metric for cluster selection to achieve power balancing. The clustering process is divided into a number of iterations, and in each iterations, nodes which are not covered by any cluster head double their probability of becoming a cluster head. Since these energy-efficient clustering protocols enable every node to independently and probabilistically decide on its role in the clustered network, they cannot guarantee optimal elected set of cluster heads.

H. O. Tan and I. Korpeoglu[5] Power efficient data gathering and aggregation in wireless sensor networks[PEDAP]. PEDAP is a tree-based routing protocol that makes all the nodes form a minimum spanning tree, which costs minimum energy for data transmitting. It also has another version called PEDAP-PA which slightly increases energy for data transmitting but balances energy consumption per node. PEDAP has the same network assumptions as PEGASIS[6] and uses data fusion. we use the same radio model as in PEGASIS analysis[4], [5], [7], [8], which makes it easier to verify our simulation results and compare the performance of TEB with thatof PEGASIS. However, both PEDAP and PEDAP-PA are protocols that need BS to build the topography which will cause a large amount of energy waste. This is because if the network needs BS to build the topography, BS should send a lot of information to the sensor nodes, including what time is the Time Division Multiple Access (TDMA) slot, who are their child nodes and who are their parent nodes. This kind of information exchanging will cause a lot of energy to be wasted or will cause a long delay..

Tree-Based Energy-Balance Routing Protocol

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The main aim of TEB is to achieve a longer network lifetime for different applications. In each round, BS assigns a root node and broadcasts its ID and its coordinates to all sensor nodes. Then the network computes the path either by transmitting the path information from BS to sensor nodes or by having the same tree structure being dynamically and individually built by each node. For both cases, STEB can change the root and reconstruct the routing tree with short delay and low energy consumption.

Initial Phase begins, BS broadcasts a packet to all the nodes to inform them of beginning time, the length of time slot and the number of nodes N.When all the nodes receive the packet, they will compute their own energy-level (EL) using function:

$$EL(i) = [residual_{energy(i)}/\alpha]$$

EL is a parameter for load balance, and it is an estimated energy value rather than a true one and only used in Case2, i is the ID of each node, and α is a constant which reflects the minimum energy unit and can be changed depending on the demands.

Tree based Energy Balance routing protocol (TBEB) consider a situation in which the network collects information periodically from a terrain where each node continually senses the environment and sends the data back to BS [14].

a) The time from the start of the network operation to the death of the first node in the network [15].
b) The time from the start of the network operation to the death of the last node in the network.

Parent node selection based on QoS factors

If the parent node has high communication capacity, it can handle more data. Real time Communication Capacity is computed by,

$$RTCC = B\sum_{x} Ut_x\,(t)$$

Where,

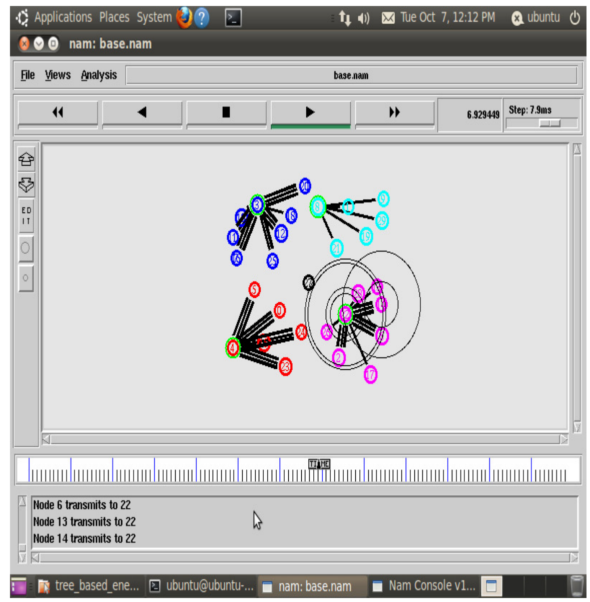
$$\sum U\;tx(t) = \sum_{P_i \in Kx(t)} \frac{T_1}{D_i}$$

Where, tx(t) = utilization factor, D_i is Distance of each node with respect to sink node, T_i is Transmission Time with each packet, B is Bandwidth utilization, i ratio of packet size and effective bandwidth.

4. EXPERIMENTAL ANALYSIS

Transmission of process

After the routing tree is constructed, each sensor node collects information to generate a DATA_PKT which needs to be transmitted to BS. For Case1, TDMA and Frequency Hopping Spread Spectrum (FHSS) are both applied. This phase is divided into several TDMA time slots. In a time slot, only the leaf nodes try to send their DATA_PKTs. After a node receives all the data from its child nodes, this node itself serves as a leaf node and tries to send the fused data in the next time slot. Each node knows the ID of its parent node. In each time slot, in order to reduce communication interference, apply FHSS in which each child node communicates with its parent node using the frequency hopping sequence determined by its parent node ID.



4.1Transmission of process

Packet delivery ratio

It is defined as the ratio of the number of delivered data packet to the destination. This illustrates the level of delivered data to the destination.

∑ Number of packet received / ∑ Number of packet sent

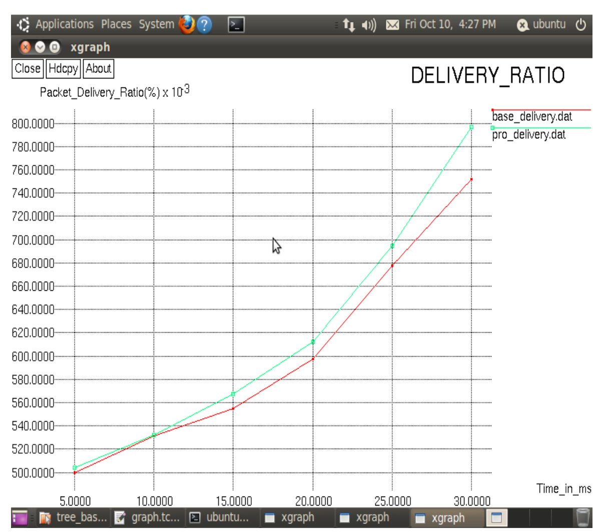


Figure 4.2. Packet delivery ratio

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Figure 4.2. shows the packet delivery ratio. In the X-axis time in ms is taken. In the Y-axis packet delivery ratio is taken. In the existing method, a hybrid, energy-efficient, distributed clustering algorithm (HEED) is used. HEED is an improvement of LEACH on the manner of CH choosing. In the proposed system, a Tree-Based Energy-Balance routing protocol (TBEB) is used in which each node dynamically decides to communicate with BS directly or through others. All the nodes try to find neighbours with higher EL as parent nodes. When compared to the existing system, there is high packet delivery ratio in the Tree-Based Energy-Balance routing protocol.

Balanced Energy

Figure 4.3 shows the energy consumption. In the X-axis time in ms is taken. In the Y-axis energy consumption is taken. In the existing method, a hybrid, energy-efficient, distributed clustering algorithm (HEED) is used. HEED is an improvement of LEACH on the manner of CH choosing. In the proposed system, a Tree Based Energy Balance routing protocol (TBEB) is used in which each node dynamically decides to communicate with BS directly or through others.

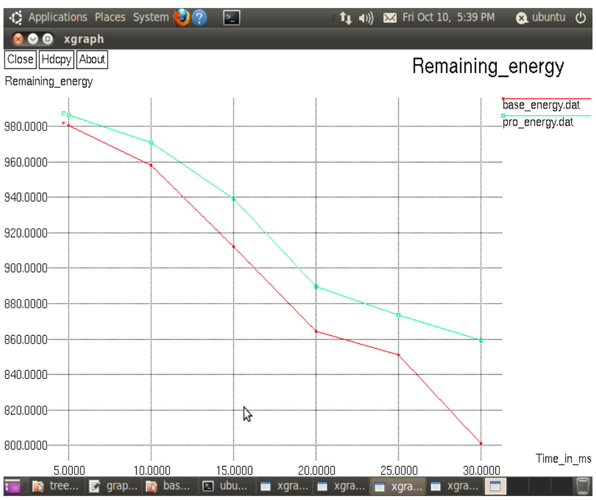

Figure 4.3. Balanced Energy

All the nodes try to find neighbours with higher EL as parent nodes. When compared to the existing system, there is high remaining energy in the Tree-Based Energy-Balance routing protocol.

5. CONCLUSION AND FUTURE ENHANCEMENT

The simulations show that when the data collected by sensors is strongly correlative, TBEB outperforms LEACH, PEGASIS,TREEPSI [11]. In the presented work, a Self-Organized Tree-Based Energy-Balance routing protocol (TBEB) is used for improving energy efficiency in the wireless sensor networks. When the data collected by sensors cannot be fused, TBEB offers another simple approach to balancing the network load. In fact, it is difficult to distribute the load evenly on all nodes in such a case. Even though TBEB needs BS to compute the topography, which leads to an increase in energy waste and a longer delay, this kind of energy waste and longer delay are acceptable when compared with the energy consumption.

5.1 Future Enhancement

The existing method selects the parent node based on only the residual energy level. So the drawback in this method is if the parent node has less communication capacity, high interference and congestion there will be less network performance in terms of packet delivery ratio, delay, throughput etc. So, this can be considered in future work.

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