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Energy Efficient Data Collection in Wireless Sensor Networks Using Quotient Partition Method (QPM)

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Abstract: In wireless sensor network (WSN) the data collection is more challenging one, because each node in the network having limited bandwidth and energy level. With the aim of reducing energy consumption and to achieve high data accessibility with low communication cost in the presence of multiple next hop nodes, the proposed approach is designed with 3 phases (i) initialization phase (ii) packet-splitting phase (iii) forwarding phase. Before the collection of data from sensor node, the sink node broadcast the message to all sensor nodes in the network to form the route path from the sensor to sink. To form the route path the proposed system incorporate the method of Self Centered Friendship (SCF) that means each node will consider itself as root node and appends the nodes that are connected to them by one hop. After the basic formation of SCF Tree the system moves forward with help of QPM for splitting the packets. The Quotient Partition Method (QPM) is characterized by a simple division between the integers. Finally the system simply forwards the sub packets towards the sink which broadcast the message for data. Once all sub packets (called QPM components) are received correctly the sink node will recombine them using mask. When, compared to the existing data collection techniques data collection using SCF Tree with QPM based packet forwarding is found to produce the best result in terms of energy consumption, data accessibility and low communication cost.

Keywords: Energy efficiency, data collection, mobile user, packet splitting, wireless sensor networks.

1. INTRODUCTION

Recent advances in computing and communication have caused a significant shift in sensor network research and brought it closer to achieve the original vision. Small and inexpensive sensors based upon Micro-Electro-Mechanical System (MEMS) technology, wireless networking, and inexpensive low-power processors allow the deployment of wireless ad hoc networks for various applications. Thus, the program developed with new networking techniques is suitable for highly dynamic ad hoc environments.

Unlike their ancestor ad-hoc networks, WSNs are resource limited, they are deployed densely, they are prone to failures, the number of nodes in WSNs is several orders higher than that of ad hoc networks, WSN network topology is constantly changing, WSNs use broadcast communication mediums and finally sensor nodes donot have a global identification tags. Routing is a process of determining a path between source and destination upon request of data transmission. In WSNs the network layer is mostly used to implement the routing of the incoming data. It is known that generally in multi-hop networks the source node cannot reach the sink directly. So, intermediate sensor nodes have to relay their packets. The implementation of routing tables gives the solution. These contain the lists of node option for any given packet destination. Routing table is the task of the routing algorithm along with the help of the routing protocol for their construction and maintenance.

The minimization of the energy spent in the transmission of sensor data back to the sink is the key challenge. The data collection techniques are classified into two namely, static node based data collection and Mobile element based data collection[7]. The sink is static node which acts as a gateway between the sensor network and users. The sensor nodes can send the sensing data to this sink node in a multi hop manner. The sensors near to the sink node become the bottleneck, because they should transmit the data of other nodes with more energy consumption[2]. In WSN, energy-efficiency is the major issue.

The sensor network requires large number of sensor nodes to operate over a long time period, and hence the energy resources should be managed efficiently. As the data gathering process requires more energy, the designing of energy-efficient communication strategies and its implementation is essential [11]. The sensor nodes gather data from the environment then aggregates them in the intermediate nodes and transmits to the base station. Many issues arise due to operations with limited power in a wireless media reliable communication, power efficiency and network survivability in the sensor nodes [6].

2. LITERATURE SURVEY

In this chapter brief description of different papers about tree construction, cluster formation, data collection, data forwarding and energy consumption is carried out. In

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recent years, a number of studies have discussed the issues of data collection techniques to discover the efficient path.
According to Cunqing Hua and Tak-Shing Peter Yum, the optimal routing and data aggregation scheme is used for the maximization of the network lifetime of sensor networks. The geometric routing is adopted as it determines the routing according to the nodal position. It allows the incorporation of different data correlation models without intervening with the underlying routing scheme[1]. According to Fang-Jing Wu and Yu-Chee Tseng, the data gathering issues in a spatially separated wireless sensor network are considered. Several isolated sub networks are formed by the sensor nodes which are far away from each other. Data collection is done by the mobile mules by traversing through sub networks[3]. According to Hemant Sethi, Devendra Prasad,R. B. Patel, the static clustering scheme is considered for the uniform distribution of sensor nodes (SNs) in each cluster. It is based on the interest generated by Base station (BS). The Sensor Nodes (SN) and the Cluster head (CH) match the interest of BS. The same interest id is generated by the SNs and the data is transmitted to the CH. The reliable SN's is selected from among the interested SN's by the CH. The aggregation function is applied to the data received from the SNs within the cluster. The aggregated data is delivered to the BS[4]. According to Miao Zhao, Dawei Gong and Yuanyuan Yang, a cost minimization problem constrained by the channel capacity, the minimum amount of data gathered from each sensor and the bound of total sojourn time at all anchor points is formulated to optimize the performance of mobile data gathering[5]. According to Rongbo Zhu, Yingying Qin, and JiangqingWang, the intelligent mobile data collector is used to collect data for the improvement of the networking facilities in the system. An efficient energy-aware distributed intelligent data-gathering algorithm (DIDGA) is proposed to improve the efficiency of data collection. It plans the data-gathering path for the mobile collector in WSNs[8]. According to Woo-Sung Jung, Keun-Woo Lim, Young-Bae Ko, Sang-Joon Park, adaptively choose a suitable clustering technique based on the status of the network, increasing the efficiency of data aggregation. It is also efficient in energy consumption and successful data transmission ratio. The adaptive clustering based data aggregation method performs well in target detecting and environment tracking[10]. According to Yi-hua Zhu, Wan-deng Wu, Jian Pan, Yi-ping Tang, the data gathering sequence (DGS) can eliminate mutual transmission and loop transmission among the nodes. Each node proportionally forwards traffic to its neighboring node. The objective function of the mathematical programming model incorporates minimal remaining energy and total energy consumption[12]. According to Z. Li, Y. Li, M. Li, J. Wang, and Z. Cao , efficient routing transition scheme such that the data collection tree can be carefully maintained and updated as the movement of the mobile user. This approach observe that there exist strong spatial correlations among routing structures at different positions, and take advantage of such an observation to additively update the routing structure with the user's movement[13].

2.1 Related Work

In Wireless Sensor Networks, an optimal data collection tree is usually built to collect the network-wide data. Tree is a commonly used structure for data gathering. In tree-based approach, each sink has a data gathering tree rooted at itself. This tree can be a localized minimum spanning tree including all the sensor nodes, or a simple reverse multi-cast tree with data sources as leaves. When the node is first powered on, it checks to determine whether or not it is a collection point (SINK). If it is a collection point, the node initiates the tree formation protocol by broadcasting INITIALIZATION messages. If it is not a collection point, it enters the IDLE state and remains there until it receives an INITIALIZATION message from some node in its neighborhood. For every INITIALIZATION message received, a node responds by forming the routing structure with their neighbors as child node to forward the message to the collection point. For that the node can search the neighbors based on strong signal strength and minimum distance. After the node finds out the neighbor it makes link between two nodes, then it means that there is a viable bi-directional wireless link between this node and its child node, which is originally the next hop to reach the collection point. Whenever a node finds a child node in the tree, it suitably updates its internal data structures to record its children. After the recording the child node it sends out the data through their child to the collection point which generates the INITIALIZATION MESSAGE.
In the presence of user mobility the data collection tree needs to be constructed or updated from time to time according to the mobile user's movement. Utilizing the spatial correlation to efficiently build and update the data collection tree. Whenever the mobile user moves and changes the virtual sink to access the network, a new data collection tree can be efficiently formed by locally modifying the previously constructed data collection tree in the network. In existing system collects the data based on the following three components.

- Data Collection Tree Initialization
- Data Collection Tree Updating
- Data Routing

Data Collection Tree Initialization
The sink node launches the routing tree construction by broadcasting a control message and the initial value of the communication cost to the sink node at each sensor side is set to be infinity. In general, by exchanging information, sensor node i configures child node to be the neighbor with the minimum cost to the sink compared with all other neighbors.

Data Collection Tree Updating
At every data collection point, build a new data collection tree (T_v) for the new virtual sink v, from the original data collection tree (T_u). It needs not to update the routing paths

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for all the sensors over the network instead its simply reverse the path direction between u(old virtual sink) and v(new virtual sink) in T_u, all the sensor nodes can reach the new virtual sink through the routing paths on the original data collection tree and a large portion of those paths are of reasonable lengths compared with the optimal paths. In that case λ flooding algorithm which uses a threshold λ to quantify such an effect and only update certain sensor nodes whose original routing paths are excessively longer than the optimal ones can be implemented.

Data Routing
After Data Collection Tree Updating completes, a new routing structure is built. If sensor i has data to send or helps other sensors to relay data, it simply transmits data only through the neighbor indicated by H_i.

3. PROBLEM FORMULATION

Wireless Sensor Networks (WSNs) consist of small nodes with sensing, computation and wireless communications capabilities. Many routing, power management, and data dissemination protocols have been specifically designed for WSNs where energy awareness is an essential design issue. The focus has been given to the routing protocols which might differ depending on the application and network architecture. The innovative techniques that eliminate energy inefficiencies that would shorten the lifetime of the network are highly required. Such constraints combined with a typical deployment of large number of sensor nodes pose many challenges to the design and the management of WSNs and necessitate energy-awareness.

It is highly desirable to find methods for energy-efficient route discovery and relaying of data from the sensor nodes to the BS (Base Station) so that the lifetime of the network is maximized. Sensor nodes are tightly constrained in terms of energy, processing, and storage capacities. Thus, they require careful resource management. This paper considers the problem of efficient data collection by the mobile user in a Wireless Sensor Network. The mobile user's uses a handheld device to communicate with sensor nodes in the network. The mobile user roams within the network and instantly accesses network-wide data on a need basis.

4. PROPOSED SYSTEM

In communication network the sensors have the capabilities of doing sensing, data processing, and wirelessly transmitting collected data back to base stations by way of multiple-hop relay. Sensor itself supplies necessary operation with limited battery energy. Those operations that consume energy are transmitting and receiving data, running applications, measuring power, and even staying in standby mode. Among others, data transmission consumes the most energy. In a sensor network, network lifetime is important for applications. Energy consumption of each sensor directly affects the network operational lifetime. Those sensors which close to base stations consume more energy since they should relay data for more sensors, and thus are apt to reduce their lifespan while being bad. Neighboring sensors of those bad sensors must relay data with stronger power, the energy consumption of these sensors is even quicker.
CPU performance, memory, wireless communication bandwidth and Power control can be used to the radio wave attenuation. A transmitter can set the power of the radio wave, such that it will be received with an acceptable power level range. Since the transmission power of a wireless radio is proportional to distance squared or even higher order in the presence of obstacles, multi-hop routing will consume less energy than direct communication. However, multi-hop routing introduces significant overhead for topology management and medium access control. Direct routing would perform well enough if all the nodes were very close to the sink. Most of the time sensors are scattered randomly over an area of interest and multi hop routing becomes unavoidable.
In order to achieve fair distribution of energy consumption among all nodes the proposed systems use the SCF technique for tree formation in the initialization procedure. The connection of all possible neighbors as next hops, will increase the number of nodes that can use as forwarders. After forming the tree the data routing should be performed by QPM based forwarding procedure which splits the packets using Quotient Partition Method(QPM) and then forward through different next hops to reach the sink.

4.1Maximize the Network Life Time

In communication network sensor nodes can use up their limited supply of energy performing computations and transmitting information in a wireless environment. As such, energy- conserving forms of communication and computation are essential. Sensor node lifetime shows a strong dependence on the battery lifetime. In a multihop WSN, each node plays a dual role as data sender and data router. The malfunctioning of some sensor nodes due to power failure can cause significant topological changes and might require rerouting of packets and reorganization of the network. As the utilization of energy is done in random fashion, the node should alternatively work in low energy consumption and high energy consumption which leads to maximization of network life time.

4.2Fair Distribution of Energy Consumption

Since sensor nodes may generate significant packets from multiple nodes can be aggregated so that the number of transmissions is reduced. Data aggregation is the combination of data from different sources according to a certain aggregation function, e.g., duplicate suppression, minima, maxima and average. This technique has been used to achieve energy efficiency and data transfer optimization in a number of routing protocols. Signal processing methods can also be used for data aggregation.

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In this case, it is referred to as data fusion where a node is capable of producing a more accurate output signal by using some techniques such as beam forming to combine the incoming signals and reducing the noise in these signals.
Before collecting the data from sensors the sink node can flood the message to the sensor networks. After receiving this message the sensors in the network can form the tree based on SCF (Self Centered Friendship) Tree technique. The main objective of this technique is to reduce traffic overhead and achieving high data accessibility. The SCF Tree technique is inspired by human friendship management in the real world, where each person makes his/her own friends forming a web and manages friendship by himself/herself. He/she does not have to discuss these with others to maintain the friendship. Since the multiple routes confer high stability allocate more packets to the nodes that have multiple routes from the root node. The Node N_i builds its own SCF-tree. Each node has a parameter d, which is the depth of SCF Tree. When N_i builds its own SCF-tree, N_i first appends the nodes that are connected to N_i by one hop to N_i's child nodes. Then, N_i checks recursively the child nodes of the appended nodes, until the depth of the SCF-tree is equal to d. At every relocation period, each node updates its own SCF-tree based on the flooding message received from the sink at that moment. Once the tree was constructed, the source node can have multiple next hops because each node can choose all of their possible neighbors as child node. So, it can easily send the data to the sink through all the neighbors.

4.2.1 Functionality of Self Centered Friendship Tree (SCFT) Protocol

The user moving around the network based on their route plan. In the intermediate stage, if the user need data from the sensors means they contact the sink node through handheld device. The sink gathers the data from sensors through the route path formed from the sensor to sink. For this purpose, the sink can broadcast the message into each node whenever the user moving from one place to another place in the network.
The initial data collection is constructed by sensing the signal strength of the neighbor nodes. The node can choose the neighbors with strongest signal strength as forwarders which node can forward the packets in future. Then the node can split the data packet into several components and forward each component through separate forwarders. Thus the data can flow to the sink through different nodes which all are form the path between sink and the source node. The sink can reconstruct the components into original message using the values present in the mask which can include in each component for future reference. Once the sink can receive all the packets and reconstruct them using mask it will compare the total bits with value generated by the mechanism which is used for recalculate the total bits from the coefficient, bit representation for each sub packets, product of smallest set of consecutive primes. The SCFT protocol helps to achieve this scenario in this research. So, the data gathered in WSN was improved even though the sensors have very low energy.

4.3 Splitting the Packets into QPM Components

Basically, all nodes follow the same forwarding rule: If there is a number of neighbors at least equal to threshold, and the packet has not previously split, then split the packet; else use conventional shortest path approach. With the aim of fair distribution of energy consumption, the original message is splitted into several packets such that each node in the network will forward only small subpackets. The splitting procedure is achieved by applying the Quotient Partition Method (QPM) which is characterized by a simple division between integers. The splitting procedure is especially helpful for those forwarding nodes that are more solicited than others due to their position inside the network.

4.3.1 Quotient Partition Method

Basically, in its simpler form, the QPM can be formulated as: Given N neighbors, the number m i.e. bits needed to represent the word in the original message can be alternatively identified with the set of numbers m_i . Instead of m, m_i numbers are forwarded; the maximum energy consumed by each node for the transmission can be substantially reduced. By applying QPM based splitting procedure Original message m can be splitting into N (which can represent the number of neighbours) different lengths The bits needed to represent the message in the QPM components are calculated as follows . N is the value of total number of possible next hops that a node can use as forwarders .The N different lengths can be chosen by simple division between the integer's m and 2.

Then take the quotient value for subtracting the value from m and assign the same value to m for next iteration. Get the resultant value from the subtraction and use it as partition value for first sub packet. Repeat the step until reaching N-1 partition . Once complete the above process, get the difference between the value of m and the summation of N-1 partition value. Assign the difference as the value for N^{th} partition

4.3.1.1 On the Choice of the Partition value

Therefore the sub packet called as QPM component is composed by split the original message using 1 to N partition value for 1 to N sub packet respectively.

4.4 Forward the QPM Components to Possible Next Hops

Once the QPM components are formed the components should be forward towards the sink through the possible next hops by simply send the QPM components to them. The original message is splitted into number of QPM components, thus the sink node, once all sub packets (called QPM components) are received correctly, will recombine them, thus reconstructing the original message using mask which contain the index of the received

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component. The mask could be the binary representation of the index followed by the number of components [i.e., a pair (i , N_x)] . Finally, when the sink receives components of the original message, it can reconstruct the message by using mask values

SIMULATION ENVIRONMENT

The simulation environment for this research was set up with following parameters:

Environment size	:	(500,500)
Antenna model	:	Omni Antenna
Routing Protocol	:	SCFT
Number of Mobile Nodes	:	5
Type of MAC Layer	:	802_11
Radio Propagation Model	:	Two way ground

After run this simulation the following factors are analyzed in WSN.

1. Performance between data collection tree and Self Centered Friendship Tree in WSN is increased.
2. Difference between packet delivery ratio between shortest path and multiple next hop is increased.
3. The throughput of the network is increased.

The above factors are increasing the performance of the networks using SCFT protocol. The optimal route for fair energy consumption is calculated with Quotient Partition Method.

5. EXPERIMENTAL EVALUATION

The main aim of this paper is to increase the data collection in WSN and also ensure that the data is correctly reached the sink without data trouncing. The below graph shows that the average consumption of Self Centered Friendship Tree (SCFT) Protocol and Data Collection Tree (DCT) Protocol in WSN.

The performance of Self Centered Friendship Tree (SCFT) Protocol and Data Collection Tree (DCT) Protocol in WSN. The packet delivery of Self Centered Friendship Tree (SCFT) Protocol and Data Collection Tree (DCT) Protocol in WSN.
The throughput of Self Centered Friendship Tree (SCFT) Protocol and Data Collection Tree (DCT) Protocol in WSN.

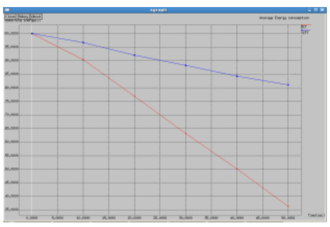

Fig. 1 Shows the Average energy consumption of SCFT

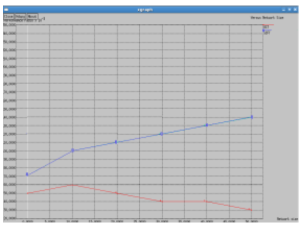

Fig. 2 Shows the Performance analysis of SCFT

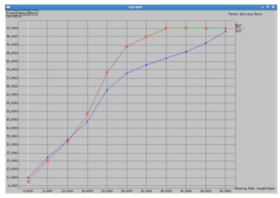

Fig. 3 Analysis of packet delivery of SCFT

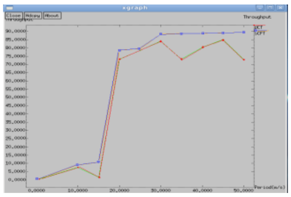

Fig. 4 Throughput analysis of SCFT

From the above graphs it is concluded that the remaining energy was increased in WSN when implemented with SCFT Protocol. When compared with DCT protocol this simulation helps to gather large amount of data in WSN.

6. CONCLUSION AND FUTURE WORK

This paper analyzed the fundamental characteristics and energy limitations of the WSN. To solve the energy limitation of WSN the proposed system uses an efficient strategy to forward data toward the sink was developed. This approach, enable the nodes to choose multiple next hops. Dissemination of the data among multiple next hops was done by QPM based forwarding technique. With the proposed system, the remaining energy of the nodes will be increased and the life time of the whole network will be increased, too. The SCF Tree approach designs the path for data routing that maximizes the data gained from the sensors under multiple possible neighbors as next hop. The solution is based on QPM which reduces the energy consumed for each node, and consequently increases the network lifetime. This approach has further refined by defining the method to randomly choose the number of packets that will have same bit representation. The packet delivery rate is also further increased by using the retransmission of missing packets by receiving retransmission request from the sink to the source. The retransmission is made through the possible alternate route. To overcome the maintenance of routing table overhead while the creation of multiple next hop the method can be defined for reducing the information which the node can hold about next hops.

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