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PERFORMANCE ENHANCEMENT OF ENERGY EFFICIENT PROTOCOLS FOR APPLICATION IN WSN

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ABSTRACT

This paper proposed a modified version of PEGASIS to reduce the energy consumption in Wireless sensor Networks. Here, the standard PEGASIS was modified and the performance of the routing was carried. It can be proved that the routing protocol discussed in this paper required minimum energy compared to normal PEGASIS . Two possible routing algorithm was implemented and results are discussed.
Keywords: *Wireless Sensor, Energy Efficient Algorithm, Double Cluster Head Algorithm, Battery life*

1. INTRODUCTION

A wireless sensor network essentially consists of thousands of standalone nodes which are battery operated and remotely active. They are programmed in such a way as to monitor parameters and report anomalies or simply act as transceivers over long distances depending on the application they are used for. So practically speaking all those nodes are active at any given point of time and relaying information across the network. Wireless sensor networks have many applications, such as military, homeland security, environment, agriculture, manufacturing, and so on. Routing is an essential operation in such a networks. Prolonged network lifetime, scalability and information security are important requirements for many wireless sensor network applications. Sensor nodes clustering is an effective technique, and the clustered hierarchy is an efficient approach [1,2,3] to make sure information security, efficient-energy management and adaptability of the complicated WSNs. In the cluster-based networks, nodes are organized into clusters, with cluster heads (CHs) relaying messages from ordinary nodes in the cluster to the base station (BS).

2. WIRELESS SENSOR NETWORKS

A wireless sensor network (WSN) is built of "nodes" – from a few to several hundreds or even thousands, where each node is connected to one (or sometimes several) sensors. Each such sensor network node has typically several parts: a radio transceiver with an internal antenna or connection to an external antenna, a microcontroller, an electronic circuit for interfacing with the sensors and an energy source, usually a battery or an embedded form of energy harvesting. Size and cost constraints on sensor nodes result in corresponding constraints on resources such as energy, memory, computational speed and communications bandwidth. The topology of the WSNs can vary from a simple star network to an advanced multi-hop wireless mesh network. The propagation technique between the hops of the network can be routing or flooding.

The sensor node is given in figure.4. Sensor node uses PIC Microcontroller, which was operated in deep sleep mode by which energy saving was carried out when sensor node not receiving any data. For wireless communication, Zigbee was used.

Wireless Sensor networks have varied applications these days. They are used in various fields like defense, healthcare and so on. Thus they provide good scope for improvement, because of their extensive usage. Power consumption is the Achilles heel of Wireless Sensor Networks.

3. PERFORMANCE ENHANCEMENT OF PEGASIS PROTOCOL

A new algorithm-Energy efficient PEGAIS was proposed (EEPB). It introduced a new method to avoid long chain between notes. That is to say the distance between notes is the first factor. For the short distance, we could permitted the branch chain existing. One note could have several connect notes, if the notes are near enough to someone note. Because of the existing of the branch chain, the subsequent step after chaining will make change. This article's algorithm improving is based on the branch chain. According to the branch

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chains, this article proposed a new improving algorithm based on double cluster head (PDCH). And we used hierarchical chain topology to relief time-delay. And adopt bottom level cluster head and super level cluster head to improve the load balance.

In the hierarchy structure, base station (BS) is the center of a circle, every note's distance to BS decided the level which it belongs to. The BS will preconfigure the number of levels. Every note receives the signal from the BS, then according to the signal strength to detect the distance to BS. The number of notes and the density of distribution, the location of BS and so on will affect the number of level. And every level has ID. The first level is 0, it belong to BS. The second level is 1, notes belong to this level is the most closest to BS and so forth. Look at the Figure 1, there are 5 levels.

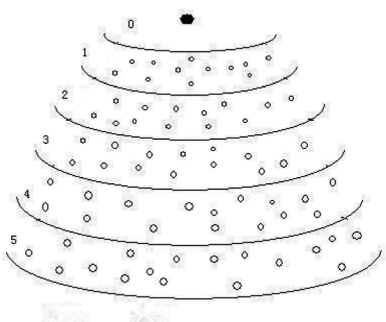

Figure1: Hierarchy

Notice that this hierarchy always run at the start, and once success, it will not be change in the whole process. So this can save energy compare to frequently stratify in every round.

Then according to the paper we adopt the Energy Efficient Algorithm (EEPB) to build chains in every level, the notes belong to different levels can't build in the same chain, only the notes with same ID can be built in the same chain. In PEGASIS Double Cluster Head (PDCH), we will make some change to build chains. We set up a parameter tag[i] on every note. If node Ni haven't join in the chains, tag[i]=0, when node Ni was selected by Ni-l to join the chain, we set tag[i]++ and tag[i-l]++, and so forth, every time when a new note join in a chain, the parameter tag[i] of select note and was selected note are both automatic accumulate. When the building chains were finished, we will statistics the parameter tag, if tag[i]>2, we consider that Ni has branch chain, in the new algorithm we make these notes to be cluster head preferentially.

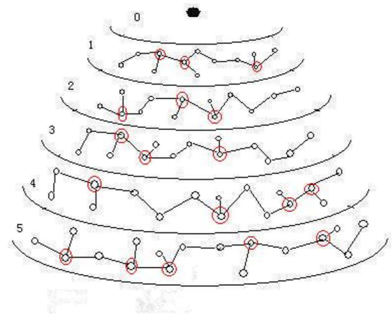

Figure 2: Process Of Building Chain

The red circles show that the notes which the number of tag is more than 2. These notes have one or more branch chain, so they have bigger chance to be selected to be cluster head than other notes in every level.

4. THE IMPROVING ALGORITHM OF CHOOSING DOUBLE CLUSTER HEAD

There is a sensor network in a play field. A typical application in a sensor web is gathering of sensed data at a distant base station (BS).
Each sensor node has power control and the ability to transmit data to any other sensor node or directly to the BS. We assume that all nodes have location information about all other nodes. Nodes would have to expend some extra energy to find their close neighbors. They could do this by sending with enough power to signal a node, and then gradually reduce its power to find which neighbor is closest to it. The sensor nodes are homogeneous and energy constrained with uniform energy and no mobility of sensor nodes.

4.1 Description of double cluster head algorithm

In the PEGASIS algorithm, there have "control packets" at data transmission process. The notes take turns to be cluster head is not suitable for the branch chain existing in the main chain. Because the notes at the branch chain is not fit to be a cluster head, for the control token method. Or change the control token method. when it turns to the branch chain notes; another, we could select not to choose the notes who belong to branch chain to be the cluster head, and this method will limit the scope of notes who being cluster head, not good to the load balance. In PDCH algorithm, we create a new method to settle this problem. And this new method not only solve the control token get to the branch chain note problem but also can select two notes to be the cluster head at the same time to make load of cluster head more balance. Now let's come to the process of selecting cluster head at the low level. At

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every level, we provides that only the notes belong to main chain can be the main cluster head; the notes belong to branch chain will be selected to be the secondary cluster head. If there is no branch chain in one main chain note at last, we will still use the method of unique cluster head.

According to the parameter tag on every note, we are inclined to choose the notes who have branch chains, that is to say the more the number of tag [i] the more priory we will choose the note. If tag [i] of the nodes is the same, we will choose the node which has more energy to be the main cluster head. Then the note we selected on the main chain as the main cluster head, and the note on the branch chain as the secondary cluster head. The main cluster head and secondary cluster head are both the cluster head in one chain, and they have different work to do. The main cluster head is in charge of data receiving and fusion, then transmit data to secondary cluster head; so, come to the secondary cluster head, it is in charge of transmitting the lower-level data and the local level data from main cluster head to upper-level cluster-head

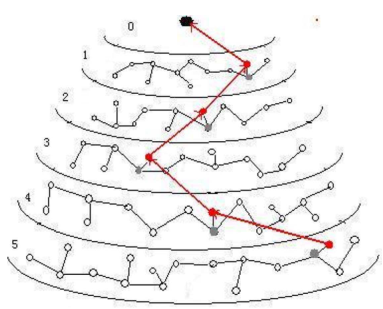

Figure 3: Double Clusterhead Method

From the picture we could see that the task of one cluster head in PEGASIS have allocated to two notes in the PDCH, this method make the cluster head work longer time, the efficiency of using energy rise, and based on this advantage ,we could reduce the frequency of change cluster head. In the process of data transmission, the main cluster head only in charge of receiving data from the local level, so it's burden isn't so hard as the secondary cluster head, so we will set up several candidate secondary cluster head based on the parameter tag. In the event of rest energy of the secondary cluster head is not enough, we will change it from the candidate secondary cluster head in time. Now let's discuss the choosing of secondary cluster head in the different situations:

a) If the tag [i] of the main cluster head equal to 3, there is only one branch chain with the main cluster head, and if the only one branch chain only have one note, we will select this note as the secondary cluster head, if the branch chain have one more notes, we will select the note who is the most closet to BS. b) If the tag [i] of the main cluster head more than 3, there is more than one branch chain with the main cluster head, and we will select the note who is more closer to BS. Then, let's come to the building chain of super-level. After the building chain in every level, we should chain up all the secondary cluster heads with the same method of building chain, and at last level secondary cluster head will receive and confusion all of the data and send them to BS. And many improving algorithm mentioned that the equation of choosing cluster head. Look at the equation , In PDCH, we don't need the equation; we design the cirque hierarchy, there must be the nodes belong to the level 1 is most closet to BS. So in the supper-level, cluster head in the level 1 is always being the supper cluster head in the super level. So in PDCH, we don't need rebuild chain in every round, only when there have note die; so as to the cluster head, when the average energy of all main cluster head lost 50%, we will select the cluster head again in time to make sure the main cluster head working. When the secondary cluster head die, its work will turn to the main cluster head till this round have done, then consider whether to change the cluster head. When the process going to the last, there have not branch chain notes to leave, the algorithm will turn to the PEGASIS method.

5. EVALUATION OF ROUTING PERFORMANCE

5.1 Routing perfomance under different node densities

In this section, the performance evaluation of LEACH and PEGASIS - is compared with a popular sensor network routing protocol. The delivery ratio, delay and residual energy for different nodes densities are compared for the fixed 800m × 800m routing area and the number of nodes varies from 25 to 50 nodes.

In the simulation, the underlying medium access control protocol is IEEE 802.11 Distributed Coordination Function (DCF). The default simulation test bed has 1 base station and 50 nodes. The transmitting, receiving and idling power consumption rates are 0.032W, 0.032W and 00.00000032W, respectively. The initial energy rate is 0.6J. Figure 4.1 shows the cluster-based aggregation of wireless sensor networks.

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5.2 Performance comparison and analysis

In this paper, we use OTCL to develop the simulation environment for wireless sensor networks. Some assumption and parameters are described as follows.

5.3 Parameters set up

The simulation variables are set up as follows.

- Sensor field: 50m x 50m
- Number of sensor nodes: 5 to 15 nodes uniformly deployed
- Initial energy of sensor nodes: 0.25 (J)
- The coordinate of base station: (50, 200)

Also, to evaluate energy consumption, the same parameters as in LEACH are used. E_{elec}=50nJ/bit,ε_{amp}=100pJ/bit/m2 , k=200 bits, and every node consumes 5nJ/bit to complete data fusion. (1J = 10^9nJ = 10^{12}pJ)

In this section, Direct, LEACH, and PEGASIS are implemented and compared. Direct represents each node directly transmits its sensed data to base station. Three evaluation metrics, which are widely-used in data gathering for WSNs, are utilized to evaluate the performance. They are defined as follows.

- Round: a round for data gathering stands for all active sensors successfully transmit its sensed data to base station.
- Coverage ratio: In some situations, numbers of round is not enough to represent the efficiency of a scheme. Uneven energy consumption, for example, may lead some nodes still having energy to operate, resulting in
- Higher number of rounds, but actually it cannot provide user with sufficient and full information about the sensor field. Therefore, in addition to number of rounds, by observing the coverage ratio, how long the complete information can be provided to end users is known.
- Total energy consumption per round: the sum of every sensor's energy consumption in one round data gathering. An efficient data gathering
- scheme should have lowered total energy consumption per round. Here, the equation used for compute this value is

$$\text{Avg. total energy per round} = \frac{\textit{Total energy consumption of a system before the 1st node dies}}{\textit{Number of rounds a system has run before the 1st node dies}}$$

- Energy x Delay metric: the energy is described above. We refer to the definition of a transmission, which is defined, one transmission for a sensor node takes one unit time, and delay is defined as the unit time that a system need to complete data gathering in one round. For example, in PEGASIS, a WSNs system spends 100 unit time completing one round for WSNs that consists of 100 sensor nodes. More details and explanation will be discussed in following sections.

6. IMPROVEMENT FOR PEGASIS

On the other hand, in PEGASIS, Initially, it takes the advantage of sending data to its closet neighbor, which will save the battery for sensors. However, as mentioned, it causes serious delay and if there is one node become inactive, it will have to reconstruct the chain, plus, if failed nodes increase, the distance between nodes becomes larger; the performance will drop very soon.

An improvement idea proposed is also simulated here, in which after constructing the chain as PEGASIS did, all sensor nodes are paired up, a node send data to its pair node simultaneously, and only the node that receives data can be higher up to next level and send data to its neighbor in the same level, eventually the node in the highest level, which is leader, send data to BS. Simultaneously transmission for every pair reduces delay significantly. The behavior of Algorithm can be described in Figure 4.

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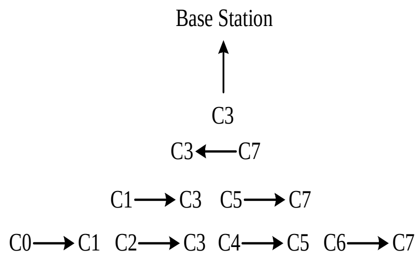

Figure 4: Binary Chain-based PEGASIS

The comparison results are shown in Table1. The more the nodes are, the worse the performance of PEGASIS becomes due to delay issue. In revised version of PEAGSIS, by simultaneous transmission on each pair, it saves relatively large time, although it spends more energy in higher level pairs, the cost is still considered improved from Energy × Delay cost of view.

6.1 Simulation assumption

In our simulation environment, we assume that all nodes always have data to send and sensor devices are not with mobility, same initial energy, and capable of transmission range adjustment. No multiple access interference problems when Sensors broadcast and data can be correctly transmitted and received. Furthermore, for correctness of simulation, initially base station provides address localization for each sensor. We use the same assumption described and the number of cluster-heads is 5% of number of sensor nodes.

6.2 Advantages and drawbacks

From the simulation results, it makes sense that direct scheme has worst performance because all sensor consume more energy to transmit data directly to base station, resulting in shorter network lifetime whereas LEACH utilizes the advantage of clustering, only a few cluster-heads take the responsibility to send data and every sensor takes turn to be the cluster-head, causing the energy consumption distribute to other sensors so that higher network lifetime can be achieved. However, PEGASIS outperforms LEACH in three ways. First, the distance between neighbors in a chain is much shorter than the distance between a node in a cluster and its head, so each sensor won't take that much energy. Furthermore, only one node transmits a data packet to BS per transmission round instead of several cluster heads in LEACH. Finally, the amount of data that the leader will receive in PEGASIS is two rather than from all cluster nodes in LEACH, it is approximately almost 3 times better than LEACH.

Similarly, their corresponding performance on coverage ratio show reasonable results. If nodes drain battery very quickly, of course, the coverage cannot be efficiently provided. However, it is important to mention here that a network with longer lifetime (higher rounds) does not guarantee a better coverage and although coverage ratio is related to node death percentage, a good energy-balanced scheme, which well distributes energy consumption among sensors and may lead all sensor die at about the same time, the value it brings is that a good coverage has been provided long enough before they are almost all dead simultaneously. That's why we include the "coverage ratio" metric in the simulation in addition to number of rounds.

Table1: Energy comparison of different Protocols

Protocol	Energy(J)	Delay	Energy*Delay
Direct	1.02134	200	204.268
LEACH	0.289854	32	9.275328
PEGASIS	0.050609	200	10.1218

It is the known that energy consumption and delay is a trade-off. Higher energy consumption may bring the decrease of delay. Therefore, as discussed in, it is valuable to evaluate the performance from the Energy*Delay cost of view. From table 1, PEGASIS minimize the energy consumption per round by transmitting to closest neighbors within the chain. However, although it achieves less energy consumption per round, it produces longer delay to collect data, especially when it takes the end point node of the chain to be the leader in the current round. Besides, if failure nodes increase, longer distance between nodes needs more energy to communicate with; this will result in the performance drop rapidly. On the contrary, although LEACH has the mechanism that all sensors take turn to be cluster-head, as far as sensor concerns, it still takes a bit more energy to send data to its head when comparing with PEGAISIS. But because of the advantage of the clustering architecture, lower delay is achieved. In term of Energy*Delay cost, it outperforms PEGASIS.

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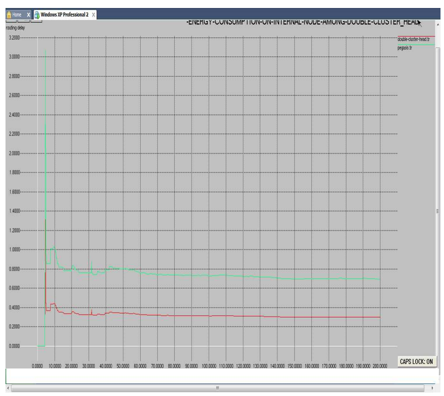
Performance evaluation and discussion



6.1 CONCLUSION

A double cluster head choosing protocol that is near optimal for a data-transmission algorithm in sensor networks. PDCH outperforms PEGASIS and EEPB by eliminating the overhead of dynamic cluster formation, minimizing e distance non-cluster heads must transmit, limiting the number of transmissions and receives among all nodes, and using only one transmission to the BS per round. Distributing the energy load among the nodes increases the lifetime and quality of the network. Our simulations shows that PDCH performs better than PEGASIS and EEPB. PDCH shows an even further improvement as the size of the network increases.

Table2: Performance Comparison of Different Protocols

Protocol	**Implementation simplicity**	**Number of Rounds**	**Coverage**	**Energy-Balanced**	**Energy *Delay**
LEACH	**X**				
Revised LEACH	**X**				
PEGASIS		**X**	**X**	**X**	
Double ClusterHead	**X**	**X**	**X**	**X**	**X**

We briefly state the comparison among these main schemes in WSNs. "**X**" represents the corresponding protocol outperforms in that metric issue. However, it does not really elaborate what the best scheme is for WSNs. As it can be seen that WSNs have many applications, it is not clear as to what the optimal scheme is for optimization in a sensor network. The protocol is designed depending on the requirement of applications.

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