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Implementation and Analysis of Energy Efficient Threshold Sensitive Minimal Spanning Tree-Clustering Protocol (TMST-CP)

Sindhu Hak Gupta* Asmita Rajawat* Srishti singh* and Priyanka jain*

Abstract : In Wireless Sensor Networks (WSN), one of the most important task is to continuously gather the information sensed by the sensor nodes and forward it to the sink. The sensed information is then transmitted to the base station for further processing to fulfill the desired requirements. Due to limited battery power in sensor nodes , it becomes difficult to have an energy efficient routing protocol .Hence ,designing and implementation of such energy efficient routing protocol for WSN will prove beneficial .In this paper a novel energy efficient routing protocol : Threshold Sensitive Minimal Spanning Tree-Clustering Protocol (TMST-CP)protocol is proposed .Simulation results reveal that proposed TMST-CP outperforms Low Energy Adaptive Clustering Hierarchy protocol (LEACH) in terms of delay time, total transmission distance and product of energy and delay time.
Keywords : WSN; Energy Efficient , TMST-CP; Cluster Head; Threshold Energy.

1. INTRODUCTION

With the advancement in technologies, new innovations have been seen in the field of Wireless Sensor Networks (WSN)[1][2]. WSN allows combining of all the sensed information, transmitting it to the base station and processing the transmitted information according to the requirement of the user. The information is retrieved by the user within desired time and is nearly accurate. WSN consist of sensor nodes spread over a wide geographical area. It consist of small , lightweight sensor nodes which have inbuilt sensors. Nodes perform the task of sensing the physical environment. Sensors used in the nodes help them in sensing and evaluating environmental conditions[3][4]. Mostly monitored parameters - temperature , pressure, vibration intensity etc. are further transmitted to the base station. This information is used in many potential applications like monitoring traffic, medical devices and the weather conditions[5][6].In order to make the network cost effective, low cost nodes are used in the network. These have limited battery life, once the battery life ends the node is declared as a dead node[7][8]. Major constraints faced in wireless networking are delay time , total transmission distance , energy utilization etc[9][10]. Various routing protocols had been introduced to overcome the mentioned drawbacks of WSN. LEACH by hienzalmann et. al. [11], is the first two layer routing protocol in which cluster heads are nominated randomly. CMST-DC (Cluster Based Minimal Spanning Tree- Degree Constraint) by Chiu-Kuo Liang , et.al.[12][13] , is self configurable cluster tree based protocol with degree constraint.

In this paper a novel two layer hierarchy energy efficient routing protocol , TMST-CP is introduced, which is based on CMST-DC.A routing tree is formed in every cluster to transmit the information. For an optimal number of rounds the Cluster Head(CH) remains the same. Remaining nodes form a cluster with the respective CH. Information from the remaining nodes is gathered by the CH and is transmitted to the

* Amity University, *E-mail: shak@amity.edu, arajawat@amity.edu, srish300@gmail.com, priyajain.jain259@gmail.com*

leader of the CH. Complete information from the network is sent to the base station(BS) from the leader. At the BS, the information is processed according to the need of the user. The same process repeats itself. Several parameters have been effectively reduced using TMST-CP.The main contribution of this research is

- Implementation of a newly proposed novel energy efficient protocol, Threshold Sensitive Minimal Spanning Tree –Clustering Protocol(TMST-CP).
- Analysis with the traditional LEACH protocol in terms of delay time, total transmission distance and product of energy and delay time.

Further the paper is organized as follows, Section two represents the network model. Implementation and analysis of TMST-CP using MATLAB is discussed in section three.

2. NETWORK MODEL

Network model in Fig.1. consist of sensor nodes, spread over a wide geographical area. These nodes have inbuilt sensors to sense the environmental conditions. The total area of the network is divided 100meter *100 meter dimensions, in which 500 sensor nodes are deployed. These nodes are used for collecting, transmitting and processing the information.

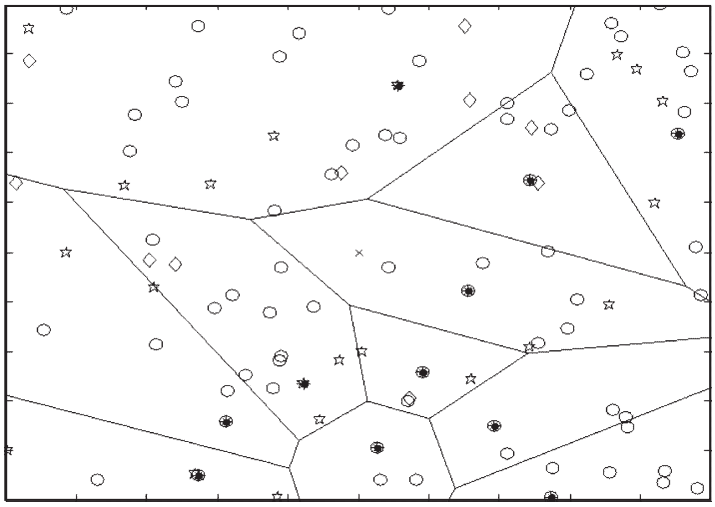

Figure 1: Cluster formation in TMST-CP

The major drawback with the sensor nodes is their limited battery power. Once the battery drains out, it is difficult to change or recharge the battery of the node, thereby the node is considered dead .Before a node is considered dead , major amount of data is to be transmitted to the base station for further processing.

Each sensor node has an energy value, Eb which is compared to the threshold energy value, Eb-th after an optimum number of rounds during the selection of cluster head. Value of Eb and Eb-th is compared, If the value of Eb exceeds the value of Eb-th , the respective node is elected as the cluster head. Once the cluster head is elected ,the tree formation is the cluster takes place. During the tree formation, nodes lying within the degree constrain combines with the cluster and form a minimal spanning tree with a degree constrain of equal to 3.According to the greedy algorithm one cluster head is elected as the leader of all the remaining cluster heads. Leader sends all the gathered information to the base station. Base station processes the information as per the need of the user.

As and when cluster is formed and CH is elected. Within the cluster the sensed information from the respective nodes move to the CH. The CH's send the data to the leader of the cluster head. Here the data is transmitted and received in the minimum time possible .A large amount of data is transmitted before a sensor node is referred to as a dead node. This complete process repeats itself after a random number of rounds, thereby not changing the cluster head after each and every round. An effective reduction is delay time, total transmission time and energy utilization is seen in TMST-CP.

Therefore, threshold sensitive minimal spanning tree- clustering protocol (TMST-CP) is proposed. The Proposed protocol work in two phases: formation of clusters based on the threshold value of energy followed by data transmission phase.

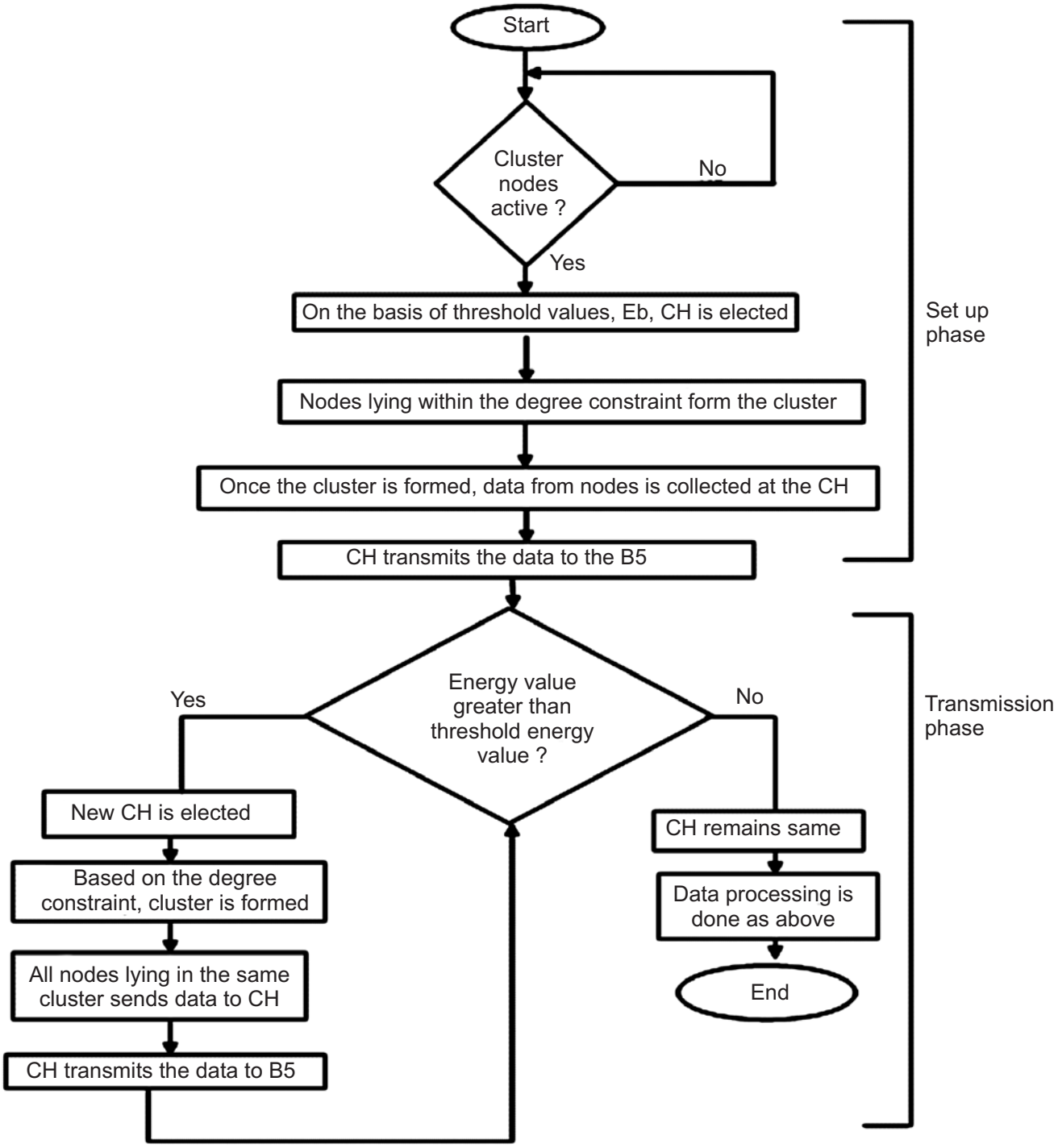

Figure 3: Flowchart depicting TMST-CP protocol mechanis

PHASE 1: SET UP PHASE

Target field comprises of randomly deployed sensor nodes which are used for the formation of cluster. In every cluster, one sensor node is elected as the head and forms a tree with the remaining nodes by using greedy algorithm. Out of all the cluster heads, one is nominated as the leader of cluster heads. The nominated leader sends the information to the required base station.

In the cluster formation phase, TMST-CP follows the same algorithm as that of LEACH[2][3] and the cluster head is nominated. Here the cluster head does not change after each and every round , but it changes according to the threshold energy value which when compared to the energy value should not exceed it for keeping the cluster head unchanged. The remaining nodes receive a broadcast message and depending on the value of degree constraint , joins the cluster head by sending an acknowledgment message .As soon as the cluster head receives the acknowledgment message , it starts forming a minimal spanning tree(MST) to shorten the total transmission distance. The same process repeats itself after an optimal number of rounds.

PHASE 2 : TRANSMISSION PHASE

Tree formation and nomination of cluster head has been done in phase 1 ,now the process of gathering information is initiated. Within the cluster, information from all the nodes is gathered and is combined at the cluster head. As the cluster size increases, delay time increases accordingly[1,3]. Therefore it is important to minimize delay and to achieve the same, threshold value mechanism is used.

Flow chart for the proposed protocol is as follows:

3. RESULTS & DISCUSSIONS

Comparative analysis has been done between the TMST-CP and LEACH protocol. Analysis here is done with MATLAB using GUI Interface and results have been discussed below in detail . These result clearly indicates that the newly proposed protocol TMST-CP outperforms LEACH in terms of delay time , total transmission distance and product of energy and delay.

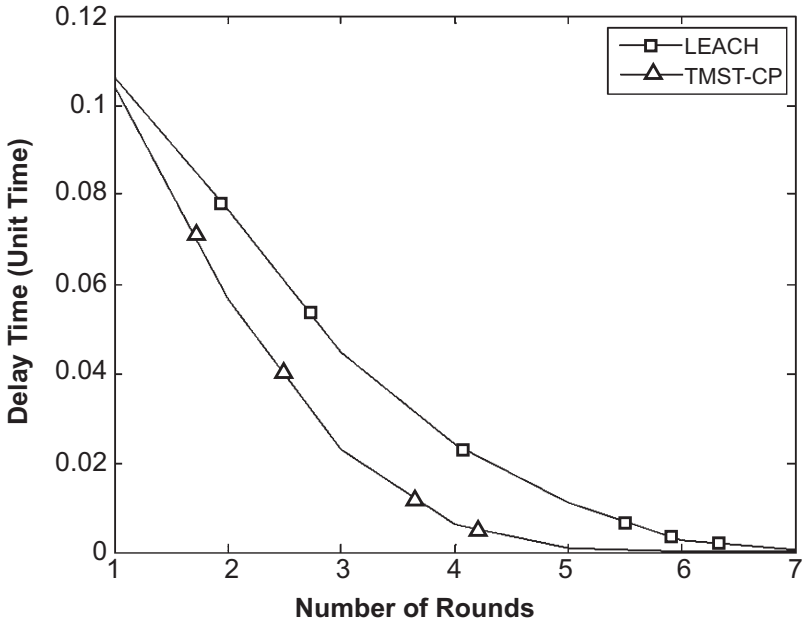

Figure 4: Delay Time (unit time)

Table 1

Delay Time (time(*ns*))

Number of Rounds	*DELAY Time –LEACH*	*DELAY Time- TMST-CP*
1.	0.12	0.104
2.	0.0742	0.0565
3.	0.0479	0.02301
4.	0.0213	0.006004
5.	0.0082	0.0007827

Fig. 4. depicts that TMST-CP performs much better than LEACH in delay time as the number of rounds increases. Table.1. gives a detailed insight of comparison between TMST-CP and LEACH. Delay can increase the total time of transmission of data from the source to the sink , therefore it is preferred to have less delay. Delay can be reduced by increasing the threshold energy value .It is observed that ,less the delay time more will be the efficiency of WSN.

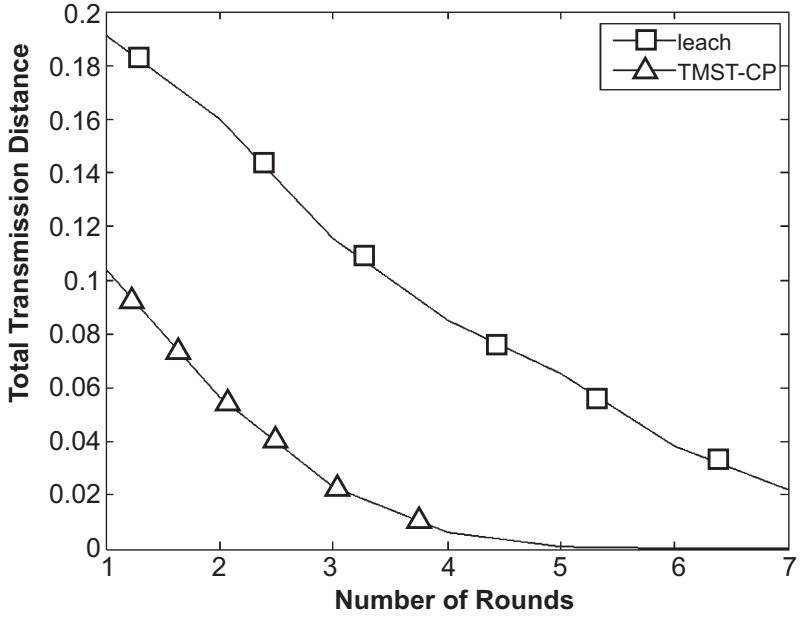

Figure 5: Total Transmission Distance

Table 2

Total transmission distance

Number of Rounds	*Total transmission distance- LEACH*	*Total transmission distance-TMST-CP*
1.	0.1877	0.104
2.	0.153	0.0565
3.	0.1221	0.02301
4.	0.0895	0.006004
5.	0.0623	0.007827

Fig. 5. depicts that TMST-CP outperforms LEACH in terms of total transmission distance with respect to the number of rounds. Table.2. gives a detailed insight of the comparison between LEACH and TMST-CP.Total transmission distance is the total distance covered by the data to finally reach the base station. Total transmission distance directly affects the transmission time and delay time . It is observed that less the transmission distance , less is the cluster size and more will be the network efficiency. And to reduce the cluster size concept of degree constraint is proposed here.

Table 3

Energy*Delay(Joule*time(*ns*))

Number of Rounds	*Energy*Delay – LEACH*	*Energy*Delay- Modified CMST-DC*
1.	0.1326	0.05621
2.	0.1044	0.03739
3.	0.07795	0.02275
4.	0.5705	0.01239
5.	0.0368	0.00587

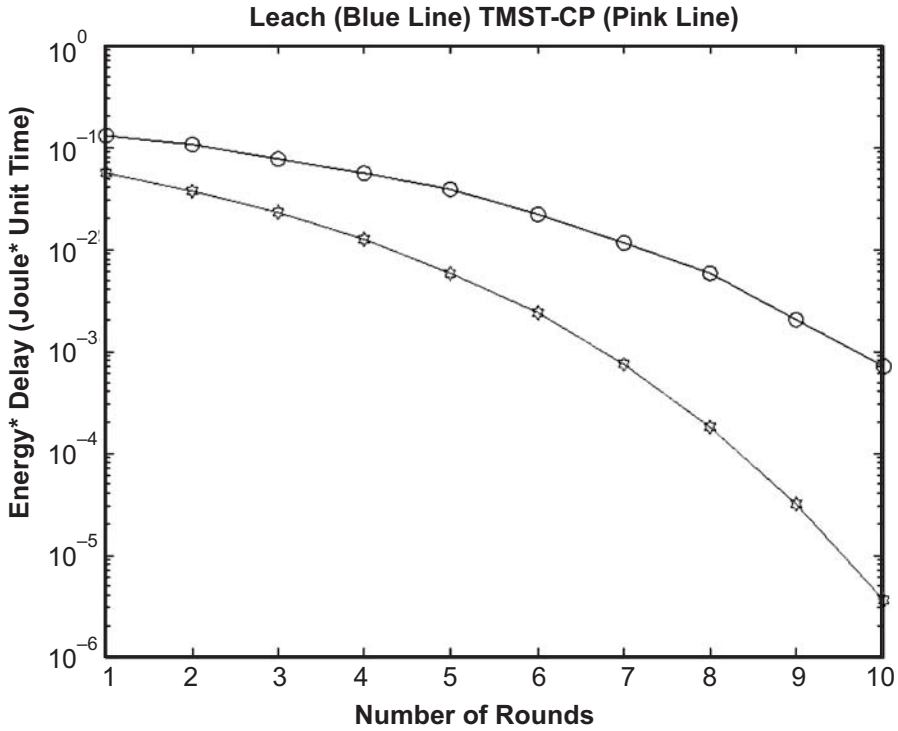

Figure 6: Energy*Delay (joule *time(*ns*))

In Fig. 6. it is seen that TMST-CP is more energy efficient than LEACH . The sensor nodes used in the network are battery powered so , main focus here is to reduce the energy consumption by sensor nodes while transmitting the data. As the energy consumption by the nodes decreases , the lifetime of the wireless sensor netwok increases. A detailed comparison of product of energy efficiency and delay is shown in Table.3.with respect to the number of rounds.

4. CONCLUSION

In this paper, a novel energy efficient protocol termed as Threshold Sensitive Minimal Spanning Tree – Clustering Protocol (TMST-CP) is proposed and analyzed .It is a hierarchical threshold sensitive tree based routing protocol for efficiently gathering and transferring the information in a sensor network. By using MATLAB the comparative analyses between TMST-CP and LEACH has been achieved successfully .As per the detailed analyses, it has been observed that energy utilization is reduced approximately by 56.3% , the delay is reduced approximately by 13.3% and total transmission distance is reduced approximately by 44.5% in case of TMST-CP over the traditional LEACH protocol. TMST-CP has better performance than the traditional LEACH in terms of network delay, total transmission distance and the product of energy utilized and delay time. This clearly indicates that proposed protocol TMST-CP outperforms the traditional LEACH protocol.

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