Time Critical Threshold Sensitive Protocol For HWSN

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Abstract: In WSN the nodes are equipped with restricted power, communication range, and computation power. The WSN sense the data at regular cycles and forwards the sensed data to the BS. The sensor node transmits data at regular intervals, when most of the times it is unnecessary. To limit the excessive data transmission proposed a time critical threshold based protocol, which use a specific parameter which is triggered only when the sensed threshold value meets the time critical based on high priority. Experimental results proved that our proposed protocol has outperformed the former one in terms of stable and unstable period.

Index Terms: Clustering, SEP, Stability period, Residual energy, HWSN, Threshold.

1 Introduction

The WSNs have comprised of a couple of hundreds to thousands of nodes distributed randomly or statically in a specified region. The data transfer and retrieval are performed over a wireless link by using a built-in dedicated antenna. The majority of the nodes ' energy is utilized to send or receive data. In certain scenarios, the nodes are deployed in extreme and harsh environments [1,2] and remain unattended and the nodes are likely to keep sensing the environment e.g. figure 2 for an extended period as it is hard to change the drained battery of the nodes. Moreover, the cost and difficulty of accessing the physical phenomena for placement and maintenance [2] become a challenging task. It is therefore important that the network should be able to operate for an extended time to overcome.

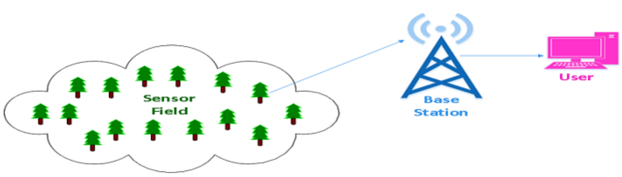

Figure 1:*Environmental monitoring using WSN*

Numerous new approaches related to HWSN were presented by the researchers in order to reduce power utilization of the node. The sensor node role can be split into three main phases the sensing, data processing and communication.During the sensing stage nodes sense the data and forward it power, memory, transmission range and processing power [3]. A sensor node utilizes energy during sensing, processing and transmission. Data transmission is responsible for a major chunk of energy consumption in a sensor node, consuming between 60% [4] and 80% [5]. At the same time, it consumes less energy, ranging between 20%-40%, in sensing and processing The main research trend of WSN is to extend the time period of the network to use the energy consumption of WSN efficiently by reducing operational costs, delay, congestion, communication [6] and to reduce the volume of communicated data using various retrieval methods so that the energy used for communication is diminished. Many of the most commonly used approaches are: routing, aggregation of data, scheduling, coordination and data compression etc. Despite the massive proportion of energy being depleted in transmitting and receiving, energy depletion in a node is triggered by multiple factors such as reach, scalability, QoS, network size, computing power, transmission, and security [7], thus minimizing the network's lifespan. various popular strategies have been proposed to utilize the network energy effectively [8, 9]. Hierarchical routing is prominent among them [10].

2 Clustering Process

In a clustering technique the nodes are combined into groups which are known as clusters [11]. Clustering based techniques plays an important role for network scalability and energy efficiency.It helps to improve network layer routing by minimizing the size of routing tables and reducing transmission overhead. Clustering consist of three main phases [11] i.e., Cluster formation, Cluster Head Selection and Data Transmission

to algorithm, but all Protocols have the aim of minimizing energy usage and extending network's lifetime. The CH normally coordinates for exchanging data with the other member of the same cluster and then transfers the aggregated data to the BS

3 Related Work

So far, based on clustering techniques many energy efficient routing protocols have been proposed. Clustering methods helps to improve the network life time by minimizing the power consumption. LEACH [12] is a homogeneous clustering-based protocol. In [12] the clusters are reinstated in every round, and in every round New CHs are identified which uniformly allocates the load. SEP[11] is a groundbreaking heterogeneous protocol that expands the stability, lifespan of the network. [11] employs weighted probabilities for CH selection. SEP is an evolved and two level algorithm comprising normal and advance nodes, the latter with more energy than the normal nodes. In order to enhance the [12] protocol in [13], its clustering algorithm was improved by setting the threshold for selecting CH and switching multiple node power levels. Compared to the original LEACH protocol, this protocol has increased efficiency in terms of stability region and network life.

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In [14], the CREEP Algorithm, which selects multiple CHs to maximize network lifespan by adjusting thresholds in a two-level HWSN, was implemented to address high device complexities. Unbalanced use of energy neighboring to CHs limited the lifetime of the network; selection of CH-based particulate-swarm optimization was explored to increase the life of the network. The solution takes a consistent network into consideration as nodes are arbitrarily deactivated.This paper [15] implements a CH selection for an HWSN based on a threshold level. The threshold value maintains a balanced energy utilization between the CH and the member nodes. In [15], the threshold level determines whether the CH and the associated cluster will alter or proceed to transfer data in the next round. The residual energy of the CH is determined after every round. If the remaining energy is below the expected threshold level, the CH selection process will restart, and new clusters will be created. It limits the energy consumed in the excessive exchange of routing details for a new CH as well as decreases the excess energy expended in the creation of new clusters. In [16] the author suggested an improved threshold sensitive SEP protocol. It is centered on periodically modifying the likelihood of a cluster-head election. ETSSEP picks cluster heads based on the leftover energy level of the nodes and the required number of clusters per round. The selection phase therefore improves the life of the network, which is prolonged than that of the SEP.This article [17] proposes an improved energy-efficient routing mechanism called ITSEP for HWSN. Firstly, a sensor node state transition mechanism was used to monitor the numbers of CHs in high node regions. Secondly, the proposed technique strengthens the threshold factor by taking into account the separation from the senor node to the BS, the density of neighboring nodes, their remaining energy and the aggregate distance between nodes. Additionally, an optimal path with reduced energy usage for CHs has been established all across the data forwarding phase. SEP-E [18] has three-tier energy heterogeneity. SEP-E introduces additional nodes named intermediate nodes. The energy of the intermediate nodes is set between that of normal and advance nodes

4 TTSP: Time Critical Threshold Sensitive Protocol for HWSN

4.1 TTSP

TTSP is a reactive two level time critical heterogeneous threshold based protocol. At the advent cluster heads are selected on the basis of initial energy and preference is given to the advance nodes. In later stages the energy of the both nodes are compared on per round basis. The advanced nodes are demoted to normal nodes as and when their energy reduces to a level less than that of any normal node. To limit the excessive transmission of data we have introduced Threshold in our network, the transmission is done only when certain conditions are met. To prolong the network life time and limit excess transmission, in our proposed protocol we have modified the [23] in which two levels of threshold have been used, i.e. a soft threshold (ST) and a hard threshold (HT). HT was a specific value of an attribute over which a data transmission node can be triggered. ST was a little shift in an attribute value that could cause a node to re-transmit data. However, to cope with time critical applications and to limit the data transmission we have introduced another level of threshold which is" Time Critical T_C". If a sensed value equals the time critical value, it triggers data transmission based on high priority. Thus it gives utmost priority to time critical events by responding promptly and reducing the feedback time.

4.2 HWSN and Network Model

The proposed model comprises of "N" number of nodes distributed in "M x M" region. The advance nodes "m" have "α" times more energy as compared normal nodes "n" "which is "(1 − m) N" [13].

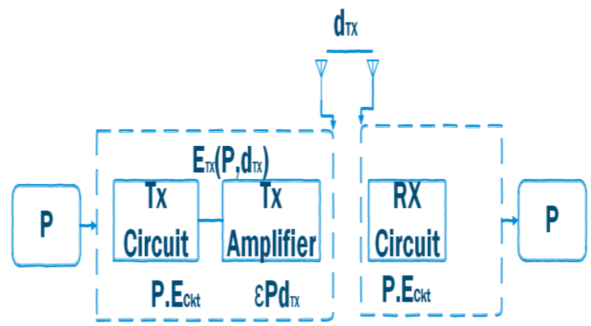

***Figure 2**: Network Radio Model*

We have used first order radio model that has been widely adopted in many earlier research works in this area [14]. To transmit a P-bit Packet across a distance d_{TX}, the energy consumed by the system is,

$$E_{Tx}(P, d_{TX}) = \begin{cases} P.E_{Ckt} + P.\varepsilon_{fs}.d_{TX}^2 & \text{if } d_{TX} < d_{NS} \\ P.E_{Ckt} + P.\varepsilon_{mp}.d_{TX}^4 & \text{if } d_{TX} \geq d_{NS} \end{cases} \quad (1)$$

Where E_{Ck} is the energy consumed per bit to make the device operational, and the path propagation model between sender and receiver is based on distance between transmitter Tx and receiver Rx i.e, free space (εfs) and multipath (εmp) while the distance between the network nodes and the BS is at all times less than or equal to d_{NS}. By simplifying the two equations at $d_{TX} = d_{NS}$, we have "$d_{NS}=\sqrt{\varepsilon fs/\varepsilon mp}$." To receive P−bit message the systems utilizes energy equal to "$E_{RX}=P.E_{Ck}$" A CH selection is carried out based on the weighted selected probabilities and nodes' residual energy. The weighted probabilities for selections [14-15] is calculated as follows:

$$P_{NS} = \frac{P_{opt}}{(1 + \alpha * m)} \quad (2)$$

$$P_{AS} = \frac{P_{opt}}{(1 + \alpha * m)} * (1 + \alpha) \quad (3)$$

In addition, the selection of CHs is based on the cutoff value. Each node yields a randomized number among 0 and 1 and, if this value is less than its sets threshold, the node becomes a potential competitor for the CH role. Computation of threshold values as discussed in [11]. The sensor nodes are randomly distributed in the region of M*M and the energy consumed by CH in the specified round is determined by the following formula [8].

$$E_{CH=}P.E_{Ck}\left(\frac{n}{C} - 1\right) + P.E_{AD}\frac{n}{C} + P.E_{Ckt} + P.\epsilon_{fs}d_{TX}^2 \quad (4)$$

Where C is the shows the number of clusters in a given round, EAD aggregation factor and d_{TX} is the distance between the associated CH and the BS. The energy consumed in a non CH is as follow

$$E_{NCH} = \{P.E_{Ck} + P.\varepsilon_{fs}.d_{CH}^2 \text{ if } d_{CH} < d_{SK} \quad (5)$$

Where $d_{CH}$is the transmission distance between member node to their respective CHs and its average value can be found by "d_{CH}=M/ (√2π)",dskis the distance between closet node and the BS. The average distance between a CH and BS be found by d_{TX}=0.765(M/2), The overall energy expended in the network is equal to

$$E_{TOT} = P.\left(2nE_{Ck} + nE_{AD} + \epsilon_{fs}\left(C.d_{TX}^2 + n\frac{M^2}{2\pi C}\right)\right) \quad (6)$$

7 Simulations and Discussions

7We conducted simulations to test our claims by considering two instances. i.e. Case-I and Case-II. Each simulation was run separately on MATLAB. Following parameters given in Table-I were used in simulations.

Table 1: *Parameters*

Parameter	Value
Area	100*100
n	100
E_{Ckt}	50nJ/bit
E_{AD}	5nJ/bit/message
E_0	0.5J
Packet Size	4000
P_{opt}	0.1
ε_{fs}	10pJ/bit/m^2
ε_{mp}	0.0013pJ/bit/m^4
d_{NS}	87.70

CASE-I: m=0.1, a=0.1 r=8000

In our first case, the number of advance nodes were kept total 10% of the network nodes and total number of rounds was 8000. It can be seen from the statistics (3) that TTSP greatly improved the reliability of the network relative to SEP and LEACH. The failure of the first node happened in LEACH and SEP at the 881th and 997th rounds respectively while in TTSP it was 2360 rounds for the scenario when the network was configured with m=0.1. Moreover, TTS greatly enhanced the unstable region of the network as compared to LEACH and SEP.

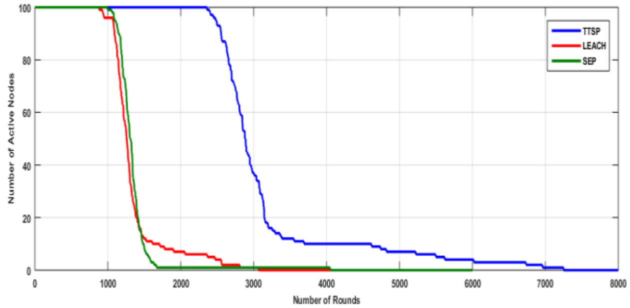

Figure 3 *Comparison of Active Nodes*

In LEACH protocol the energy of the last network node was exhausted at 3056th round while in SEP was 4049th round and for TTSP it was 7249th round. So it can be clearly seen that in figure (4) TTSP is more energy efficient as compared to LEACH and SEP.

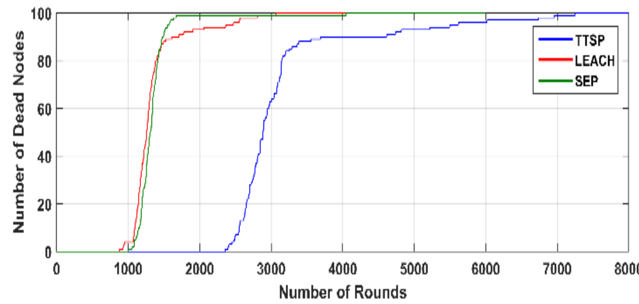

Figure 4 *Comparison of Dead Nodes*

CASE-2: m=0.2, a=0.2 r=14000

Similarly, in case II, we have increased the number of advance nodes to 20% of the network nodes and their energy was increased from a=0.1 to 0.2. The results given in the figures (5) and table-II reveals that's TTS significantly increase the stable region as compared to LEACH and SEP. The Table-II and figure (6) reflects the results of the unstable region.

Table 2 *Comparison of Protocols*

Rounds	Nodes	LEACH	SEP	TTSP
Case-I	1st Dead	881	997	2360
	Last Dead	3056	4049	7249
Case-II	1st Dead	1046	1234	2662
	Last Dead	5106	6039	16929

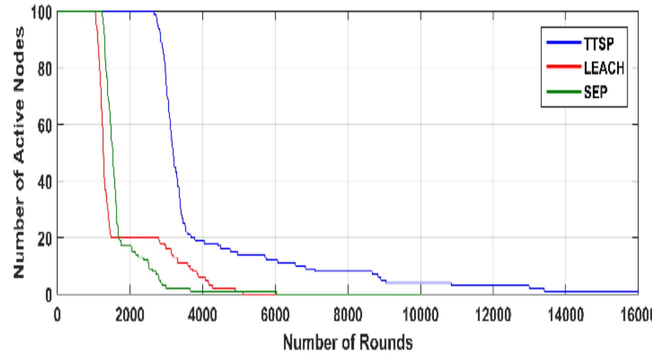

Figure 5 *Comparison of Active Nodes*

In LEACH protocol the energy of the last network node was exhausted at 1046th round while in SEP was 6039th round and for TTSP it was 16929th round. So it can be clearly seen that TTSP is more energy efficient as compared to LEACH and SEP. By altering the initial energy and number of advance nodes in the network, the network stability period and unstable region has further improved resulting in enhanced lifetime of the network.

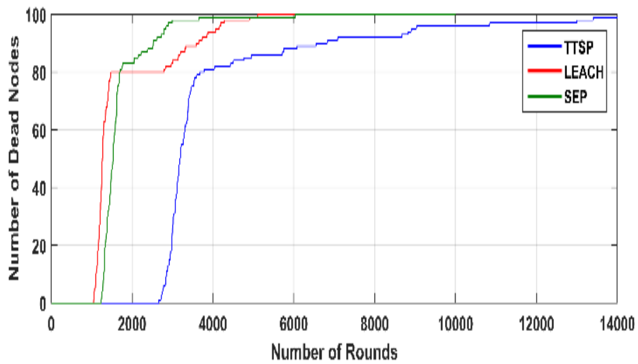

Figure 6 *Comparison of Dead Nodes*

This significant improvement in the network is based on the residual energy and as well as the new threshold level implemented. In this manner every member node gets equal opportunity to become cluster head as it is based on residual energy of each node compared with other nodes in the network rather than the initial energy of the node. Secondly we have introduced threshold in the system which limits the transmission of the data until it is required to be sent. As node consumes more energy during transmission so the excessive transmission is limited by the set threshold value which ultimately improves the stable and unstable region.

5 Conclusion

This study presented time based threshold sensitive protocol which was compared with LEACH and SEP. The extensive simulation proved that our proposed protocol has outperformed the aforementioned protocols in terms of stable and unstable region and has prolonged the network life time.

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