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AN EFFICIENT MATHEMATICAL ANALYSIS FOR SAVING ENERGY IN WSN ROUTING PROTOCOL

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ABSTRACT

The issue of energy efficiency in wireless sensor networks (WSNs) is a prime consideration. Therefore, we propose an energy-saving scheme for use in wireless sensor networks and this the goal of this Research. The proposed protocol is a mixture of the low energy adaptive clustering hierarchy (LEACH) and mediation device (MD) protocols. It combines the advantages of both. The suggested protocol includes a mechanism for avoiding the collisions that exist in the MD protocols. Also, it allows the cluster head to be in sleep mode if there is no data to be sent. (In addition, MD Device in the proposed protocol will send ID to the node which will send the data to the cluster head that avoid collision signals that unfortunately happen in MD protocols and know which node sent data). This is in contrast to the LEACH protocol and MD protocol, where the cluster head is always switched on. Placing the cluster head in sleep mode contributes to reducing energy consumption.In the proposed scheme, clustering is used as in LEACH, but the cluster head is asleep by default. However, when a sensor node has data to send, it informs the MD, which then awakens the cluster head, making it ready for receiving sensor data. To evaluate the proposed scheme, we suggest a mathematical model that estimates the energy that the scheme saves as compared with LEACH. The results show that substantial energy saving is possible when the cluster head can be placed in sleep mode for a large percentage of time. Intuitively, this time percentage is higher when sensors have less data to send.

Keywords: WSN ,Energy Saving, LEACH , Sleep , Wake up ,Routing

1. INTRODUCTION

Wireless sensor networks have many applications, depending on the type of sensors they use. These applications include disaster relief applications, precision agriculture, and

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medical and health care applications [6].

The wireless sensor network is the key to gathering information needed by smart devices that are a part of pervasive computing (pervasive sensor networks), whether used in buildings, homes, transportation or industrial systems. A wireless sensor network is composed of individual nodes (sensors) that are able to interact with the environment by sensing some physical parameters.

In many WSN applications, nodes can not easily be connected to a wired power supply, but rather have to rely on on board batteries [9]. In such cases, the energy efficiency of the communication protocols is a very important figure of merit because long operation time is usually desirable. In other applications, the power supply might not be an issue and hence other metrics, such as the accuracy of the delivered results, may be more important[6].

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2. PROPOSED PROTOCOL

(Schema)	Method, Technique, Approach	Brief Description	Strength & Weaknesses
(TDTCGE)	Two Techniques	Calculate Center of Gravity and Energy Center	*Improvement life time by Solving the Distance *(idle Listening, less management)
Mediation Device (MD)	Management device	Work as mediator to schedule the active time and sleep time between nodes by sleep and wake up beacons	*solve Idle listening by periodic sleep beacons *saving energy low energy consumption *collisions
(LEACH,)	TDMA Schedule	Elect CH by using (TH) and using TDMA Schedule for Collect Data	*low Consumption but not enough , Distributed protocol *(idle Lestining, Bad TH, not applicable for large Regions, Extra overhead)

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In the proposed protocol, it is suggested that the target area be divided into subareas (clusters), where each cluster has a cluster head, and member nodes that consist of all the other nodes in the cluster. In addition, there is an MD [10] node (see figure 1).

Node:

If Node does not have data when its time slot begins

Node produces sleep Beacon to itself

else {

Node sends RTS to MD

Node waits for CTS from cluster head

Node sends data to cluster head

Node receives (ACK) from cluster head.

Node produces Sleep Beacon for remaining time slot

}

MD;

If an RTS is received from a node A

MD produces a wakeup signal that contains the address of the node and sends it to the node's cluster head.

Cluster head:

When a cluster head receives a wakeup signal on behalf a source node:

The cluster head sends CTS to the source node.

Cluster head receives the data from the node

Cluster head sends back an (ACK) to the node

Cluster head produces a sleep beacon for the remaining part of the time slot.

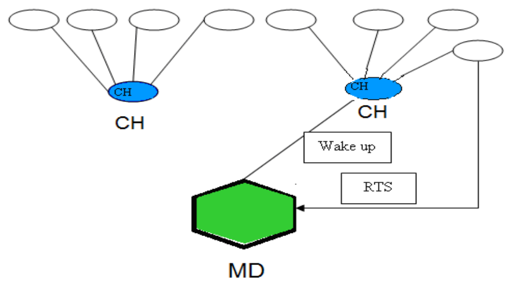

Figure1. Proposed Protocol

Proposed protocol consist of all the other nodes in the cluster. In addition, there is an MD [10] node (see figure 1). The cluster head is responsible for aggregating the data and The MD node is Responsible for schedule management the routing protocol and do synchronization between nodes and cluster head by letting them on the most time on sleep mode and let the cluster head wake up only for a short time to receive packet.

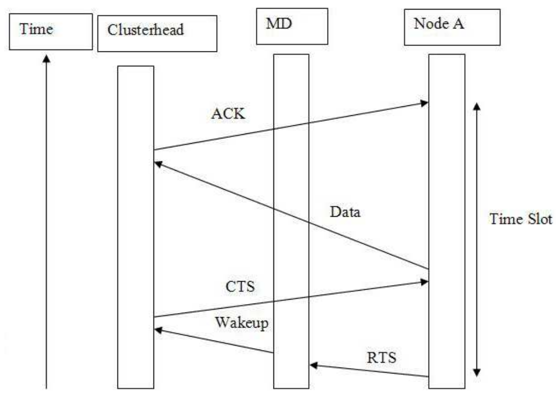

Figure 2,Mechanism Of Operation When There Is Data.

In Figure 2, if a node has a new data, it will save this data until its time slot begins. Once the time slot begins, it will transmit a control signal called Request To Send (RTS) to the MD, then the MD

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creates a wake up beacon that contains the address of the node that is going to transmit a packet and transmits it to the cluster head, which in turn responds by transmitting a Clear To Send (CTS) signal to the source node (node A). Node A then transmits the data directly to the cluster head. Once the cluster head has finished receiving the data, it sends an acknowledgment back to node A to indicate that the transmission was successful.

3 MATHEMATICAL ANALYSIS

The cluster head and the nodes within each cluster periodically go to the sleep mode as much as possible. This contributes to power saving. Figure 3 illustrates this idea.

The following equations, defined in [2], are used to

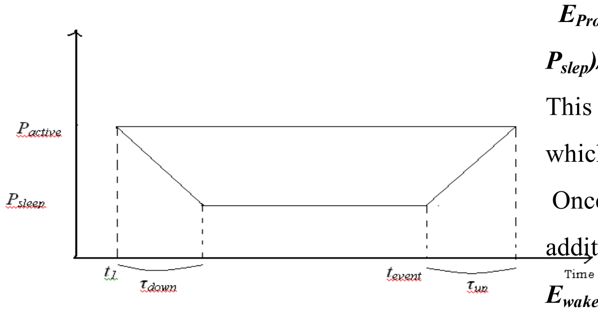

Figure 3. Energy Saving And Overhead For Sleep Modes.

3.1-Algorithm Of The Proposed Protocol.

In the Figure 6, the decision as to whether or not a transceiver has to go into sleep mode to reduce the power consumption from P_{active} to P_{sleep} is made at time t_1. If the transceiver remains active and the next event occurs at time t_{event}, then a total energy of $E_{LEACH} = P_{active}\,(t_{event} - t_1)$ **(1)**

is consumed. This formula can be applied to the cluster head in LEACH for the round during which it is active. This is because the transceiver of the cluster is always on and active during its round.

On the other hand, putting the transceiver into sleep mode requires a time τ_{down} until the sleep mode has been reached. We assume –as a simplification– that the average power consumption during this phase is:

$$(P_{active} + P_{slep})/2 \qquad (2)$$

In the proposed protocol, the cluster head is put to sleep for a part of its round. We assume that the transition time from P_{active} to P_{sleep} is τ_{down} . Based on this, we have the following energy saving:

$$E_{Proposed} = (t_{event} - t_1)P_{active} - (\tau_{down}\,((P_{active} + P_{slep})/2\;) + (t_{event} - t_1 - \tau_{down})\,P_{sleep}) \qquad (3)$$

This formula represents the proposed protocol, which is ***Eactive - Esleep.***

Once a new data event has occurred, an additional wakeup overhead of:

$$E_{wakeupoverhead} = \tau_{up}\;((P_{active} + P_{slep})/2) \qquad (4)$$

is consumed during the transition from the sleep

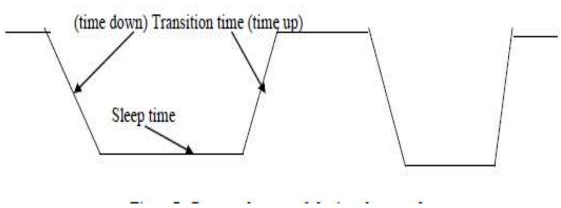

Figure4. Proposed Protocol During The Round.

At first, our proposed protocol is similar to

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LEACH because they both have a setup phase that determines the cluster head and the nodes within the cluster. The proposed protocol is different from LEACH in the steady state phase. We assume that the transition from active mode to sleep mode and from sleep mode to active mode takes some percentage of time, τ_{trans} (e.g., 10% of the time of a round). We also assume that a cluster head is in sleep mode for a fraction of time, τ_{sleep} (e.g., 50% of round time). The cluster head will spend more time in sleep mode if few cluster nodes have data to send when their TDMA turn comes around. The final formula of energy saved by our protocol is:

Eproposed = Pactive - τ_{trans} (Pactive +Pslep)/2 –

Esleep= τ_{sleep} * Psleep.

3.2-Letreture Research Parameters:

Parameter Values that will used in the research

Network size = 100*100 m

Ee= 50nJ/bit %Eelec=Etx=Erx %Eelec is the energy to transmit one bit of a message

Fs= 10pj/bit/m2 / // amplification coefficient of free-space signal

mp= 0.0013pj/bit/m4 % multi-path fading signal amplification coefficient

Nodes number= 100 //number of nodes in the network

D=87m //Distance

L= 1000 //Length

4.1 Mathematical Analysis Algorithm Code

```
if (Time >= Mathematical model Time) break;
double mode = rand.NextDouble();
float distance = (float)Math.Sqrt((HeadNode.x - node.x) * (HeadNode.x - node.x) + (HeadNode.y - node.y) * (HeadNode.y - node.y))*30;
float active = Pac * distance;
float sleep = .25f * distance * Pac / Psl + .75f * distance * Psl;
float saved = active - (.25f * distance * (Pac + Psl) / 2 + .75f * distance * Psl);
float overhead = .25f * distance * (Pac + Psl) / 2;
if (mode < .05)
{
Eac += active;
} else if (mode < .6)
{
Esa += saved;
}
else if (mode < .97)
{
Eac += active;
Eo += overhead;
}
else
{
Esl += sleep;
}
```

4.2 Mathematical Model Results

In this section, we describe the mathematical model experiments carried out in this research. The C# programming language is used to compute E_{LEACH} and $E_{proposed}$. In our mathematical model s, a hundred sensor nodes are generated randomly. In the next experiment, we assume that cluster heads are asleep 10% of the total time. Also, we assume that the transition time is 10% of the total time.

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Table2.Input Parameter Model For Model1

Parameters	Variables
Number of nodes	100 sensor
Percentage of time in sleep state	0.10 of the time
Percentage of time in transition state	0.10 of the time

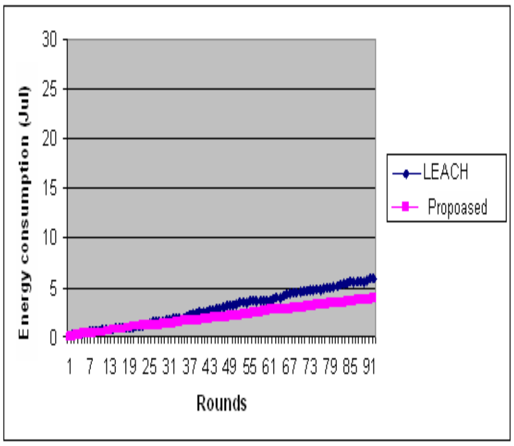

Figure8. Energy Consumption Over Rounds For Percentage Of Time Sleep 0.10 Percentage Of Transition Time 0.10.

In Figure 8, we observe that our proposed protocol does not save much energy. In addition the graph shows a slow start in energy consumption. This is because of the input parameter values used (0.10 for the percentage of time in sleep state and 0.10 for the percentage of time in transition state). As we see in the figure, the proposed protocol begins to save energy, as compared with LEACH, after round 50. The amount of energy saved is 29% of E_{LEACH}. The saving is calculated using the equation: $(E_{LEACH} - E_{proposed})/E_{LEACH} *100\%$ (6).

In the next experiment, we assume that cluster heads are asleep 30% of the total time. Also, we assume that the transition time is 10% of the total time.

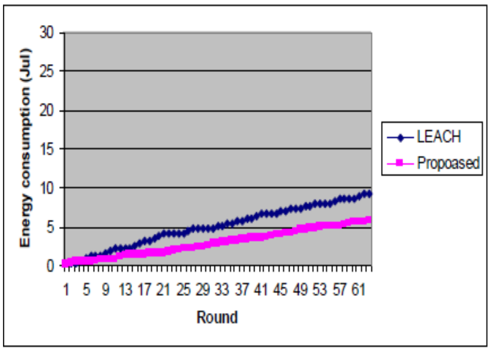

Figure 9, Energy consumption over rounds for percentage of time sleep 0.30 Percentage of transition time 0.10.

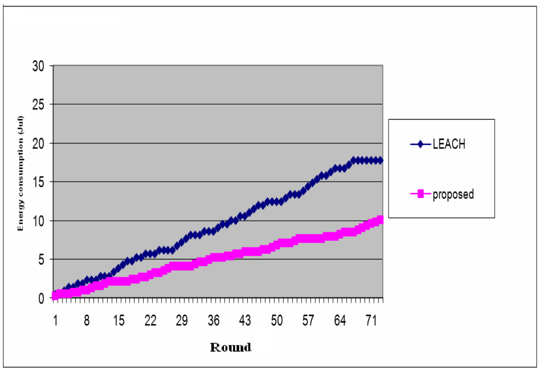

Figure10. Energy Consumption Over Rounds For Percentage Of Time Sleep 0.50 Percentage Of Transition Time 0.10.

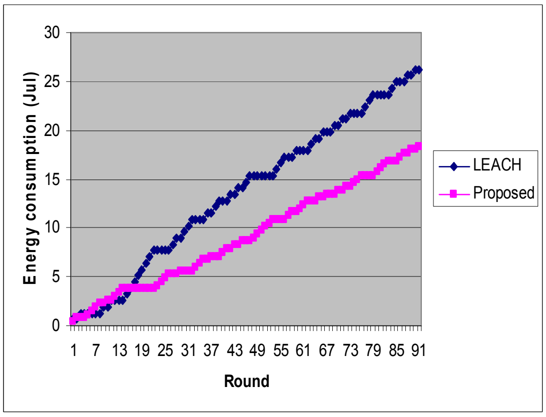

Figure 11. Energy Consumption Over Rounds For Percentage Of Time Sleep 0.70 Percentage Of Transition Time 0.10.

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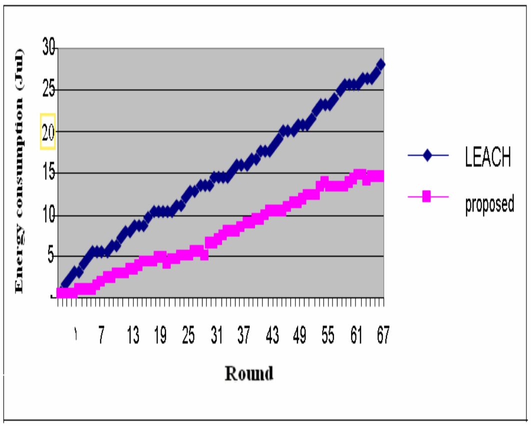

Figure12. Energy consumption over rounds for percentage of time sleep 0.90 Percentage of transition time 0.10.

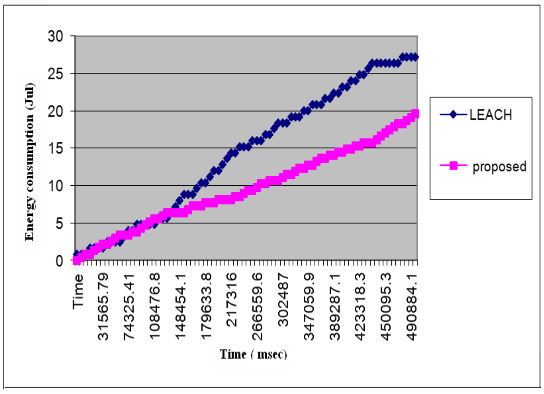

Figure15. Energy Consumption Over Rounds For Percentage Of Time Sleep 0.70 Percentage Of Transition Time 0.30

4.3 Limitations & Research Questions

In WSN, the routing protocols have many issues and problems that faced the Researchers to solve it: How to save more Energy ? how to improve the Life Time for the network? in addition how to Select of CH and how to form Cluster ? how to minimize the energy dissipation's? How to Improve an Efficient Mechanism for saving Energy ?

4.4 Research Objectives

The main objectives of this work are:

The objective is to propose a new protocol or a mechanism for reducing the idle listening and energy consumption of the cluster head radio transceiver which its always

5. CONCLUSION

In this thesis, the suggested protocol is a combination between the LEACH and MD protocols. Each node is given a predetermined time slot during which it can transmit data to its cluster head. The mediation device synchronizes data transmission between the cluster head and member nodes, and the cluster head is responsible for aggregating the data and transmitting it to the base station.

Saving energy as compared with LEACH is clearly the principal goal of this protocol. The idea is that the sleep mode for a cluster head and a member node is left only when an event (data) has occurred and the member node is about to transmit data to the cluster head.

In the mathematical model, it can be seen that the proposed protocol saves more energy if we increase the percentage of the time that the cluster head is in sleep mode. The cluster head sleep time is long in networks where sensors have relatively little data to send. For example, in a sensor network used for monitoring water supply in Jordan, sensors would typically be idle for five to six days per week, which is a large time percentage.

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