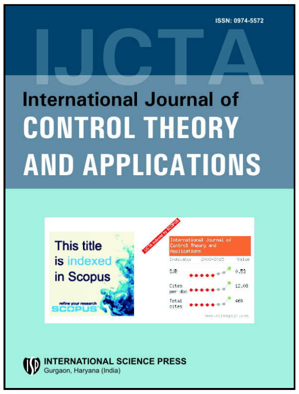

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Implementation and Analysis of Energy Efficient DEECin CBAN

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Abstract: Dogs have always proven to be helpful for mankind as they perform numerous tasks for humans, for example, hunting, herding and many more. Dogs have become a familyso, it is important to monitor the vitals of a dog to ensure their perfect health condition. With the advancements in technology it's now possible to keep a check on health condition of dogs Canine Body Area Network (CBAN) which is application of Wireless Sensor Networks (WSN) may be used for the same.In this paper a protocol namely DEEC has been implemented for CBAN. DEEC is supposed to possesshigh throughput and may sustain the lifetime of the sensor nodes for longer periods. This protocol makes use of the initial energy and residual energy in order to select a cluster head which will help the base station to receive data. The simulation results revealed that proposed model receives high number of packets at the base station and the nodes are alive for longer period of time. So, this protocol is an effective routing protocol to monitor dog even from far away distances for longer period.

Keywords: Dog Body Area Network, Health Monitoring, Sensor Nodes, Wireless Body Area Network, DEEC.

1. INTRODUCTION

Now a days WSN is widely used for the acquisition and processing of real-time information. Itsapplications are in the field of environmental monitoring, military, medical sciences, space exploration, home automation, etc. [4]. A WSN hasmany tiny sensor nodes which are interconnected through a communication network [5]. These tiny sensory nodes in WSN are used to keep check on different parameterssuch as,temperature, pressure, sound or motion and then they collectively send this information to central system called base station or sink. Wireless Sensor Network are mainly energy restrained due to the use of small capacity DC source for their working [6]. It does not need a fixed support and it may be employed rapidly, so it is having good application prospect.

One of the special type of WSN is WBAN (Wireless Body Area Network). Following the trends of increase in population and the increasing cost of health there is a wide scope for WBAN for health monitoring. They are used for monitoring the physiological signal and motion of body [7]. For health monitoring using WBAN the nodes are placed on different parts of body of the humans or altered into the body to keep a check on the parameters like blood pressure, heart rate, temperature of the body and many more.WBAN technologies considerably reduce the expenses for patients in healthcare. With WBAN the health of a patient may be monitored from the home itself. The patient may be continuously monitored and real-time information may be obtained about the patient from the sensor data by any family member or medical specialist whenever required. One of the benefits of WBAN is that the patient can experience great physical mobility and does not need to remain at the hospital for much longer time. Like in WSN the sensor nodes used in WBAN have a battery device which have low power and recharging these devices is a big problem. So, it is important to make sure that minimum energy is used to transmit the information obtained from sensor nodes to the sink. So, for this various energy-efficient protocols have been used [5][8] [9] and some are discussed in the section 3 of the paper.

The ability of mankind in training and taming dogs result into a unique relationship between the two species. In history, the dogs had been trained for the errands, for example, security, fellowship and hunting. In recent times a step further have been taken and they are being trained for detecting chemicals, guiding blind people, etc. Army has trained dogs for searching bombs, missing people which costs them tens of thousands of dollars [1] and some specialized personnel for a period of time which may not always lead to achieving the desired results. Canines can communicate with each other through vocal, visual, olfactory and tactile signals [2][3]. Over a period of time living closely with the human's dogs have begun to recognize the changes in the voices, facial expressions, and many more. Also, dog trainers have started recognizing signals sent by thedog based on their body stances and conduct. However, it is not possible for the non-professionals to understand the signals and predict the next move of the canines. Keeping above reasons in mind a Canine Body Area Network(CBAN) is being considered. CBAN incorporates algorithms and electronic sensing devices to build better canine training techniques and understanding the behavior of the canine.

It is necessary to have an energy-efficient protocol in CBAN. The sensor nodes are equipped with energy constraint batteries to meet the cost and size constraints. The energy consumption by a sensor node plays a critical role in the impact of lifetime of the CBAN sensor. So, it is important to develop an energy-efficient protocol in order to preserve the battery life for a long time. The biggest power consumer in a CBAN is the communication needed by a typical sensor nodes. Two third of the total energy is consumed in the transmitting, i.e. sending and receiving of data between the sensor nodes. While the number of transmitting data packets of a node mainly depends on the routing protocol used in CBAN. To maintain the energy consumption level among the nodes in a CBAN an appropriate protocol should be used. Along with improving the lifetime of the nodes it can also enhance the quality of data transmission. Another problem while choosing a protocol is that most protocols assume their nodes to be static. But a dog is mostly in motion and it is necessary to use a protocol that uses the concept of mobility since it might lead to false life time estimation. So, a protocol that increases lifetime of CBAN and transmits data with better quality and is compatible with mobility is required.

In the given work, the sensor nodes have been fixed on various body parts of a dog. There are 6 nodes that are fixed in different position on the body of a dog. The base station is situated at the waist. Two nodes which are placed near the base station to monitor the ECG and PPG. The most important information about the dog is monitored by these sensor nodes. The network used is considered to be heterogeneous and the nodes used for monitoring EEG and PPG are more energy efficient. Since these nodes are energy efficient these nodes transmit the information directly to the base station and have a longer life time while compared with other.

2. NETWORK MODEL

In this paper, six sensor nodes having same energy is placed on the body of a dog. The base station is placed on the waist of the dog. The node 4 placed at the chest will determine the ECG whereas, the node 5 placed in the tail of the dog will measure the blood pressure. The nodes 4 and 5 placed near the waist will be directly transmitting the data packets to the base station. Rest all the nodes will transmit their data packets through the forwarder node to the base station.

Fig. 1shows the placement of the sensor nodes and the base station on the body of the dog.

The table below describes which perimeter is measured by which node.

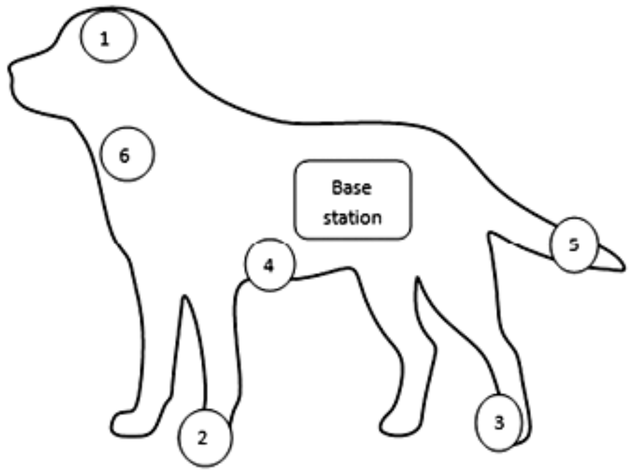

Figure 1: Node Placement on dog

Table 1
Node description

Sensor Node	*Description*
1	EEG(HEAD)
2	Temperature (Front Legs)
3	Temperature (Rear Legs)
4	ECG(Chest)
5	PPG(Tail)
6	Pulse(Neck)

Fig. 2 shows the radio model used in the proposed research work. This radio model has been used for CBAN due to its simplicity.

The protocol used should try to minimize the number of transmits or receive cycles while considering the minimization of transmission distances.

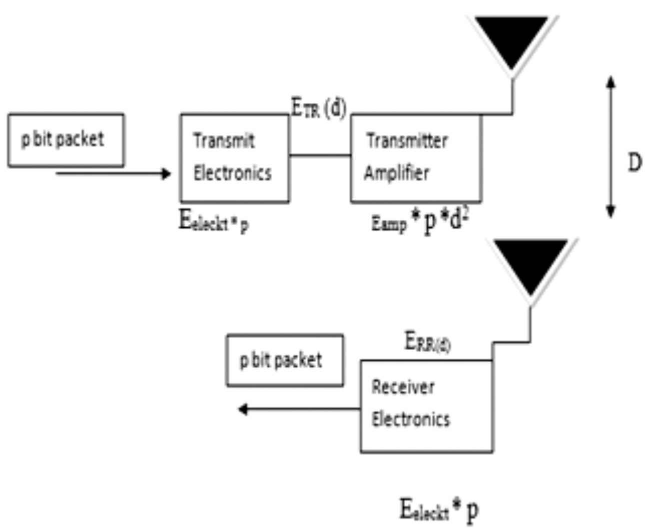

Figure 2: Radio Model

The energy consumed in transmitting packet of p bits at a distance d, by the radio transmitter is calculated as follows:

$$E_{TR}(p, d) = E_{TR-eleckt}(p) + E_{TR-amp}(p, d) \quad (1)$$

Where, E_{TR} is the energy drained during transmission, $E_{TR\text{-}eleckt}$ is the energy required by the transmitter to work, E_{amp} is the energy which is consumed by the amplifier circuit, d denotes the distance and p denotes the packet size. We can further refine equation (1) by elaborating on the formula for (p, d):

$$E_{TR}(p, d) = E_{TR-eleckt} * p + E_{amp} * p * d^2 \quad (2)$$

Similarly, the energy required by the receiver to receive and process p bits of data can be expressed as:

$$E_{RR}(p) = E_{RR-eleckt}(p) * E_{RR}(p) = E_{RR-eleckt} * (p) \quad (3)$$

$$E_{RR}(p) = E_{RR-eleckt} * p \quad (4)$$

Where E_{RR} is, the energy drained in receiving, $E_{RR-eleckt}$ is the energy required by the receiver to run.

This model assumes that communication through the radio channel is symmetric and energy required to send package from node 1 to node 2 is same as that of sending the same package from node 2 to node 1, for constant SNR. Above equations tells that every type of communication is not a low-cost operation that's why the protocol stacks the run on the nodes should try to reduce the number of transmitting and receiving operations to keep the energy of the model under a certain threshold. The transceiver used in the CBAN is VOYCE Ultra-Wide Band(UWB) which uses a frequency between 3.1 to 8 GHz. It sends short duration pulses on the body parts on which the specific parameters need to be determined and the pulses reflected is then used to analyse and study the physiological information.

Table 2
Network parameters

Parameter	*Value*
Initial Energy, Eo	0.5 J
Transmitting Energy Etx(elec)	4e-8 J/bit
Receiving Energy Erx(elec)	4e-8 J/bit
Data Aggregation Energy(EDA)	5e-9 J/ bit
No. of Nodes(n)	06
Implementation tool	MATLAB 7.6

3. SOME ROUTING PROTOCOLS

The selection of appropriate routing protocol is very important in WBAN as they can have pretty much effect on the life period of the network.

3.1. Simple

Stable Increased-throughput Multi-Hop Protocol for Link Efficiency(SIMPLE) protocol have been used in many wireless body area networks. The multi hop communication may be used for reducing the energy consumed by the nodes and increasing the life of nodes. This is achieved with the help of selection of the parent node or the relay node which is decided by using the cost function. The cost function is a relationship between the distance and residual energy of the node [11] [12].

3.2. Leach

Low Energy Adaptive Clustering Hierarchy(LEACH) protocol is an energy-efficient protocol based on Time Division Multiple Access(TDMA). It is a routing protocol that uses hierarchal routing for WSN. Its aim is to expandthe life of the system. In this one the nodes group themselves into local clusters from which a node is selected as the cluster head. All the information from the local nodes are forwarded to the cluster head which is further transmitted to the base station. Thus, when the cluster head dies all the nodes connected to it stops functioning.

3.3. SEP

Stable Election Protocol(SEP) is also a cluster forming protocol. The nodes selected as cluster head dies much earlier due to more power consumption because of the additional functions performed by these nodes. The stability region period before the first node dies, is low in these protocols [12]. The parameter used for the selection of cluster head is residual energy.

3.4. M-ATTEMPT

Anenergy-efficient multi-hop protocol is based on hotspot detection and the possibility of single or multi hop communication. If a hotspot is selected the node is able to select an alternate route for reducing the data transmission loss in the network [10] [12].

3.5. DEEC

Distributed Energy Efficient Cluster(DEEC) Protocol is a routing protocol that uses initial energy and residual energy of the nodes to appoint the cluster-heads. Advantages of DEEC protocol is that it reduces the energy consumedby the network and increases the lifetime of network. It is discussed in detail in the following section.

4. THE DEEC PROTOCOL

In this protocol to select a cluster-heads, the initial energy and residual energy level of the nodes is used.

4.1. Selection of Cluster-Head using Residual Energy

Let n_i be the no. of rounds required to be a cluster head for the node s_i referred to as rotating epoch. The rotating epoch cannot be same for all the nodes as the energy distribution would not be equal for all the nodes and nodes having low level of energywill die fast as compared to the one'shaving high energy. In this protocol, different n_i are chosen according to the residual energy $E_i(r)$ of node s_i at round r.

The average probability for a node to be selected as a cluster-head during n_i rounds is calculated as

$$P_i = 1/n_i$$

At each epoch when all the nodes have the same energy then choosing average probability p_i to be p_{opt} follows that $p_{opt}N$ cluster-heads are available in each round and all nodes will die at the same time approximately. The p_i of the nodes having more energy should be greater than p_{opt} if nodes have different amount of energies. Let $\bar{E}(r)$ denote the average energy of the network at round r, which is calculated as

$$\bar{E}(r) = \frac{1}{N}\sum_{i=1}^{N} E_i(r)$$

For $\bar{E}(r)$ to be reference energy,

$$p_i = p_{opt}\left[1 - \frac{\bar{E}(r) - E_i(r)}{\bar{E}(r)}\right] = p_{opt}\frac{E_i(r)}{\bar{E}(r)}$$

This assures that the average total number of cluster-heads per round per epoch is

$$\sum_{i=1}^{N} p_i = \sum_{i=1}^{N} p_{opt} \frac{E_i(r)}{\bar{E}(r)} = p_{opt} \sum_{i=1}^{N} \frac{E_i(r)}{\bar{E}(r)} = Np_{opt}$$

It is the optimal cluster-head number which is needed to be achieved.

The probability threshold which every node s_i uses to determine whether to become a cluster-head or not in each round is calculated as

$$T(s_i) = \begin{cases} \dfrac{p_i}{1 - p_i \left(r mod \dfrac{1}{p_i} \right)} & if \ s_i \in G \\ 0 & otherwise \end{cases}$$

Where, G are the nodes that are eligible to become cluster heads at round r. If node s_i was not a cluster head in the last n_i rounds,then $s_i \in G$. In every round r when node s_i finds that it can be a cluster-head, it chooses either 0 or 1 randomly and if it is less than $T(s_i)$ the probability threshold, the node s_i becomes a cluster head during the current round.

4.2. Calculating the Average energy of the network

Average energy $\bar{E}(r)$ is only used as the reference energy for each node. It is the energy that each node should have in the current round to keep the network working to its greatest extent. In such situations, the network energy and node energy are distributeduniformly, and all nodes die at the same time. The average energy $\bar{E}(r)$ of r^{th} round is calculated as

$$\bar{E}(r) = \frac{1}{N} E_{total} \left(1 - \frac{r}{R} \right)$$

Where R is the total number of rounds of the network lifetime which means that every node consumes same energy in every round, which is necessary for an energy efficient algorithm.

5. PERFORMANCE EVALUATION & ANALYSIS

The software used for the simulation is MATLAB R2015a. Various performance metricssuch as nodes alive, nodes dead, packets transmittedto base station and packets transmitted to cluster head station have been evaluated and are as follows:

5.1. Nodes alive

Fig. 3 shows the plot between no. of rounds and no. of nodes alive. Itshows that the nodes have high initial energy as we can see that first node dies after 1900 rounds of data transfer and concludes that CBAN using DEEC has longer stability period.

The table below shows in detail that after how many rounds each node dies.

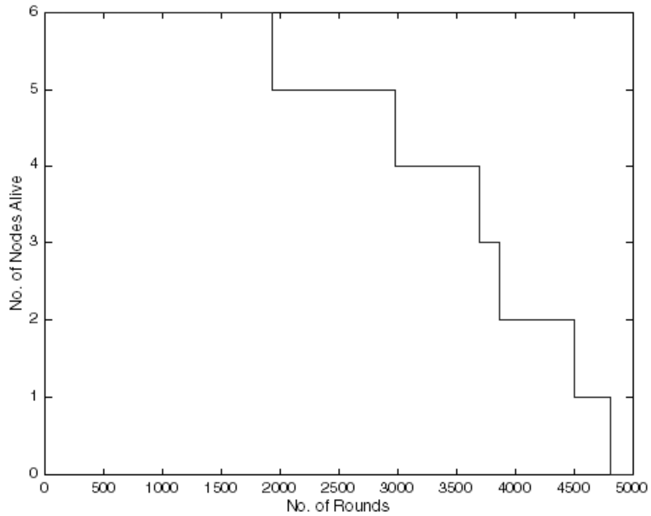

Figure 3: Number of Nodes Alive after each round.

Table 3
Between Rounds and Nodes Alive

Serial no.	*Rounds(r)*	*No. of Nodes Alive*
1	0-1900	6
2	1900-3000	5
3	3000-3700	4
4	3700-3900	3
5	3900-4500	2
6	4500-5000	1

5.2. Data packets sent to the base station

Fig. 4 shows that due to longer stability period of DEEC, more packets are sent to the base station w.r.t the number of rounds because the number of packets transmitted are proportional to the number of nodes alive. It

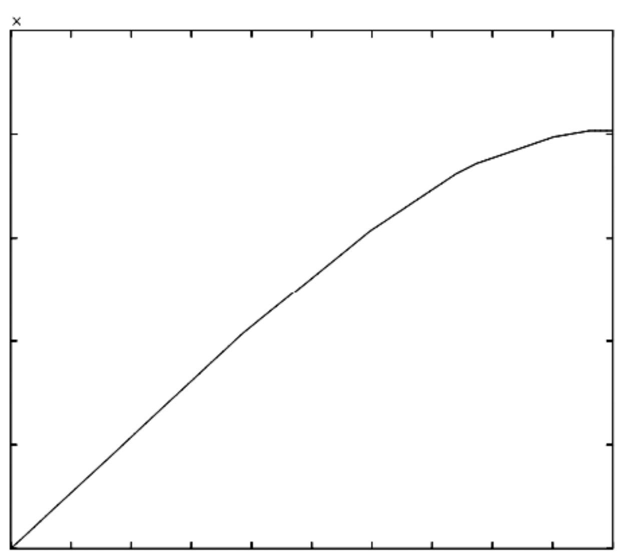

Figure 4: Number of Packets sent to BS after each round.

can be seen in the below table that in first 1000 rounds 5363 packets were sent and gradually it is decreasing with the increase in number of rounds.

The table below give details regarding the number of packets sent to base station after every 1000 rounds.

Table 4
Between Rounds and Packets Sent to BS

Serial no.	*Rounds(r)*	*No. of Packets Sent*
1	1000	5363
2	2000	10704
3	3000	15398
4	4000	18853
5	5000	20174

5.3. Data packets sent to cluster head station

Fig. 5 is the plot betweenthe number of packets sent to the CHS in each round which is gradually decreasing as the number of nodes alive are decreasing.

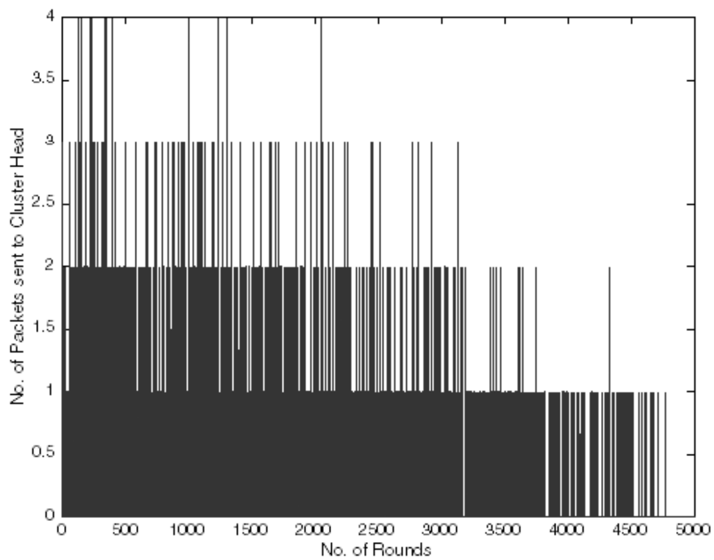

Figure 5: Number of Packets transmitted to CHS after every round.

The table given below shows how many packets are sent to the cluster head selection after every 1000 rounds.

Table 5
Between Rounds and Packets Sent to CHS

Serial no.	*Rounds(r)*	*No. of Packets Sent*
1	1000	637
2	2000	1227
3	3000	1515
4	4000	1620
5	5000	1620

5.4. Nodes dead

The table given below shows that after how many rounds a node dies.

Table 6
Between Rounds and Nodes Dead

Serial no.	*Rounds(r)*	*No. of Nodes Dead*
1	0-1900	1
2	1900-3000	2
3	3000-3700	3
4	3700-3900	4
5	3900-4500	5
6	4500-5000	6

Fig. 6 shows that how many nodes die after each round which further helps us to know that which node has high initial energy. The graph shows that all the node die after 5000 rounds of transmitting data.

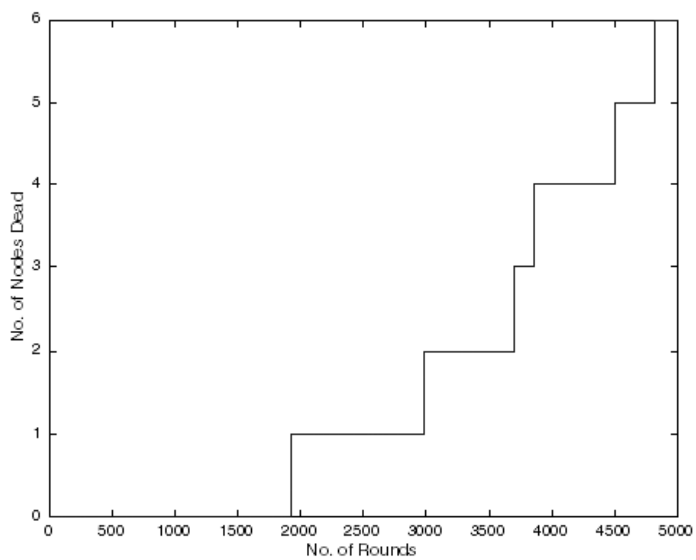

Figure 6: No. of Nodes dead after each round.

6. CONCLUSION AND FUTURE WORK

Dogs are said to have the most widespread form of interspecies bonding with human. Keeping this in mind the CBAN system have been designed. CBAN simplifies monitoring and measuring different parameters of the dog. It works as the first-aid for the dogs initially and later on may replace theveterinary hospitals. In this work, CBAN has been implemented using the DEEC protocol which forms the cluster-head nodes in every round using the initial and the residual energy of the nodes. In the model implemented the nodes having high residual energy and at lesser distance from the base station sends data directly to the base station. The simulation results reveal that CBAN using DEEC transfers large number of packets containing information to the base station and a life of a node is more. The results indicate that 6 nodes are alive for the first 1900 rounds of data transfer, 20,174 packets are transmitted to the base station and 1,620 packets transmitted to the cluster head station in the network lifetime. Thus, this model can prove to be very successful for CBAN using DEEC protocol.

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