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ENERGY EFFICIENT PACKET ROUTING MODEL FOR WIRELESS SENSOR NETWORK(WSN)

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Abstract:The formation of clusters and cluster heads in wireless sensor network(WSN)leads to overhead. Such overhead is reduced by using proper medium access control design . Reliability and sleep scheduling of nodes is achieved by such protocols. There are two types of Medium Access control protocol, they are contention and contention free based protocol. The contention based protocols are CSMA/ CA. There is heavy contention of nodes for channel access [1]. When node density and network traffic are moderate or high, they suffer high collision rates because of concurrent channel access, which in turn increases the packet drop rate. As a result, for large networks contentionbased protocols are not suitable. This drawback is overcome by using contention free protocol such as TDMA [2] [3]. In such schemes, a specific time slot to is assigned by the cluster head to each node in the cluster, and the node uses that time slot to transmit. The sleep time of nodes increases by using TDMA. The reliability and the energy efficiency of the network are also improved. In many of the clustering techniques that utilized TDMA hop selection and probability of packet failure was not considered. Packet loss introduces an overhead for both intra and intercluster communication. This makes network unreliable as energy consumption increases. This aspect is studied by determining packet failure probability. Here an energy optimization technique and a packet failure likelihood estimation technique are presented.The proposed energy efficient model performs better than the existing $\boldsymbol{LEACH}$ in term of lifetime of network. When the number of nodes are increased, results show that proposed model performs better than $\boldsymbol{LEACH}$(Low Energy Adaptive Clustering Hierarchy)

Index Terms**Intracluster, Intercluster, TDMA,WSN**

I. INTRODUCTION

The transmission of packet by the nodes is can be intra or intercluster. Every packet which is transmitted to a receiving node need not be properly decoded every time. So it is necessary to determine the likelihood of packet failure. Communication within the cluster is Intra cluster which takes place between the cluster headand the other nodes of that cluster. Intercluster communication is multi-hop transmission that takes place between cluster heads and the base station, and involves intermediate nodes that belong to different clusters.

Intra cluster communication is single hop communication within an individual cluster, and takes place over the intra cluster transmission links in the cluster.Inter cluster communication takes place between a *cluster head* and the base station, or the *cluster heads* for different clusters, and takes place over a multi-node path that includes hop nodes as well as cluster heads of other clusters. Here a hop node is a node that can communicate both not only with its *cluster head* and with *the* cluster head of an adjacent node. In order to do so, it must be situated within a distance p of the cluster head of the adjacent cluster. The function of the hop node is to facilitate communication between these two cluster heads.

II. LITERARTURE SURVEY

To reduce the energy consumption and enhance the efficiency of the network, an appropriate clustering mechanism was suggested by J. S. Leu et.al [4]. In this protocol, the selection of cluster head is based on the residual energy of each node and the regional average energy of all sensors in each cluster. Node isolation is overcome by using the regional average energy and the distances between sensors and the sink.

Energy efficient clustering protocol should not only focus on extending the lifetime of network but also in minimizing dead-spot occurrence. The improved energy efficient clustering protocol is proposed in [5] that addresses the limitations of existing routing protocol .In this model the energy load is uniformly distributed among all sensors nodes thus improving the cluster head selection approach. Thus energy is balanced is among the nodes of the network has increased the round number at which the first node dies, which minimizes the dead-spot occurrences.

The improved *LEACH* based protocols did not consider the nodes position for cluster-head selection. If a node present at the boundary of a cluster is selected as *cluster head,* it would drain the network energyas distance transmission distance increases. To address this problem M. Karimi et.al [6] implemented an algorithm that has 2 phases: network partitioning and selecting an optimal cluster heads. First partition of network occurs then one node is selected as cluster head in each partition. This maintains consistency of CH’s in the network and also balances the energy.CH selection based on both distance and remaining energy of individual nodes is presented using Genetic algorithm .

Y. Xin et .al [7] proposed an algorithm that focuses on energy consumption by balancing the energies of nodes in order to increase the lifespan of the sensor network. To use this cluster based mechanism a greedy technique is presented in this paper. The election of cluster head depends upon the residual energies of the nodes. A node which has the strongest likability with the residual energy levels is elected as a $cluster\ head$. To create a transmission path a message is transmitted by sink node. $Cluster\ head$ defines a transmission path till sink node to contact with that sink node. Energy level and likability is a factor on which re-clustering is started after a fixed time.

Although $LEACH$ is one of the most used and popular cluster technology, its drawback is the arbitrary formation of clusters. M. Karimi et .al [8] presented two $LEACH$ mechanisms to increase efficiency, namely as $GP-LEACH$ and $HS-LEACH$. Network efficiency and energy consumption can be enhanced by appropriately subdividing the interconnected sensor nodes. On the basis of node location and remaining energy of nodes, the cluster head election is done by utilizing some evolutionary techniques. The authors demonstrate that the proposed mechanism can enhance the network lifespan as well as efficiency of the network.

In most of clustering techniques re-clustering is performed after every round. To avoid this,V. K. Subhashree et al [9] presented an advanced and revised version of clustering mechanism to enhance the lifespan of the network. The author proposed that the sensor network be divided into clusters by using simulated strengthening technique. The base station selects the successive cluster heads among the nodes based on their remaining energies. Re-clustering is not performed after completing every round as in $LEACH$. For every cluster head a threshold energy value is assigned, and whenever the energy of the $cluster\ head$ reaches below its threshold value, re-clustering take place. Through this approach, the efficiency of the network gets increased and failure of nodes is reduced.

III. ENERGY CONSUMPTION MODEL

Random deployment of nodes is considered, and average density as δ, expressed as $nodes$ per square meter. The nodes that are selected as cluster head(CH) serve as $cluster\ head$ and the remaining join the nearest cluster head; in this way, the clusters are formed. In order to make our analysis tractable, we assume that the clusters are identical in size, and that they are circular, with radius P.

The probability that a CH has x neighbors is given by the probability denoted by $\mathcal{F}_X(x)$, satisfies the Poisson distribution, and is as given in (1). Here $\delta\pi P^2$ denotes the average number of nodes that are found in a circle that has radius P when they are deployed with density δ

$$\mathcal{F}_X(x) = \frac{(\delta\pi P^2)^x e^{-\delta\pi P^2}}{x!}, where\ x = 0,1,2, \ldots\ldots \infty \qquad (1)$$

. Intra cluster communication is single hop communication within an individual cluster, and takes place over the intra cluster transmission links in the cluster. During intra cluster transmission, there is no guarantee that all nodes decode the packet correctly. So we need to derive the packet failure probability in a cluster as packet level is used for error detection .The nodes that decode the packet correctly in a cluster is determined. An expression for the energy consumption per bit is obtained. Here as distance is less square-law path loss is applicable.

Intra Cluster Communication

Considering sensor network characteristic it is not preferred to keep all sensor node active in satisfying packet failure rate. Also if we reduce nodes taking part for transmission it will aid in reducing energy consumption but it induces increase inenergy consumption in hop devices due to amplification of power for longer transmission. Therefore a bounding is set to determine number of active devices required to satisfy packet failure rate and minimization of energy consumption. The active/hop devices required to satisfy allowed packet failure rate and also minimizing the over- all energy consumption is presented.

Signal to Noise Ratio (SNR) is the parameter used to determine whether received node decoded the packet correctly. In Rayleigh fading channel, the SNR γ, of the signal received at distance p from the cluster head by a node is given by

$$\gamma = \mathcal{G}D1|c|^2/p^2\mathcal{N}_0, \quad (2)$$

Where $\mathcal{G} = \frac{(\mathcal{G}_{trns}\mathcal{G}_{rcvr}\lambda^2)}{(L_m F_n (4\pi)^2)}$, the quantity λ is the carrier wavelength, F_n is the noise parameter of the receiver, $\mathcal{G}_{trns}$ and $\mathcal{G}_{rcvr}$ are transmitter and the receiver antenna gains, respectively, and L_m additive background noise of the hardware devices. The quantity $\mathcal{N}_0$ Gaussian noise power, and $|c|$ is a parameter of the Rayleigh distribution. The energy consumed to transmit a bit in intra cluster transmission is given by $D1$. We have $c = 1$ for the gain of the wireless channel.

The ratio of bits in error to total bits transmitted is Bit Error Rate (BER). Mean BER for a Rayleigh fading channel is $BER = \frac{1}{4SNR}$. Hence the mean BER $L_{\prime}^{b}$ for intra cluster communication is as follows:

$$L_{\prime}^{b} = {p^2\mathcal{N}_0}/{4\mathcal{G}D1} \quad (3)$$

Let the packet length be---- B. A packet is correctly decoded if every one of its B bits is successfully decoded. Hence, the packet failure likelihood $L_{\prime}^{z}$ is

$$L_{\prime}^{z} = 1 - (1 - L_{\prime}^{b})^B. \quad (4)$$

We assume that the cluster occupies a circle having radius P and $cluster\ head$ at its center, and the other nodes in the cluster are randomly distributed. As distance p is a random variable and follows probability density function:

$$F(p) = \frac{2p}{P^2}, 0 < p \leq P \quad (5)$$

Since the value of $L_{\prime}^{b}$ is small, we have $1 - (1 - L_{\prime}^{b})^B \cong BL_{\prime}^{b}$. Hence, the likelihood of packet failure is approximately given by

$$L_{\prime}^{z} = BL_{\prime}^{b}. \quad (6)$$

we obtain the mean probability of packet failure as follows

$$\overrightarrow{L_{\prime}^{z}} \cong \int_0^P B\left({p^2\mathcal{N}_0}/{4\mathcal{G}D1}\right){2p}/{P^2}\,dp = {B\mathcal{N}_0 P^2}/{8\mathcal{G}D1} \quad (7)$$

The average energy needed by $cluster\ head$ to transmit the packet $D1$ per bit within cluster. Equ (1) tells that there are $\delta\pi P^2$ nodes trying to receive the data in a cluster. $E1$is average energy consumed per packet in intracluster is

$$E1 = B\big((1+\beta)D1 + D_{trns} + \delta\pi P^2 D_{rcvr}\big) \qquad (8)$$

D_{trns} is energy that the transmitter consumes for processing a bit of data, and D_{rcvr} is the corresponding quantity for the receiver, where $\beta$is the transmission efficiency of power amplifier which is β= (ξ/ε)−1, with ξ being the peak to- average ratio (PAR) and ε being the drain efficiency of the RF power amplifier [44]. Here, it is assumed all nodes have identical values of D_{trns} andD_{rcvr}

Inter Cluster Communication

In intercluster transmission average bit failure probability being small (<10^{-4}), and probability of packet failure in inter cluster is obtained as which is as follows

$$L_2^z = 1 - \left(1 - L_2^b\right)^B \cong B L_2^b \quad (9)$$

In a cluster the mean number of devices that correctly decoded packet is given by $\vec{a}$.Here the hop devices is$\vec{a} + 1$ devices including CH. $E2$ energy consumption per packet for inter cluster is

$$E2 = B\big((1+\beta)(\vec{a}+1)D_2 + (\vec{a}+1)D_{trns} + D_{rcvr}\big) \qquad (10)$$

Over All Energy Consumption

Energy consumption required for transmission and consumption of energy associated with circuit are used for accurate analysis of overall consumption of energy. The intra and intercluster energy consumption gives overall consumption of energy. The $E1$ is the average intracluster energy consumption per packet. E2 is average intercluster energy consumed per packet. Then the overall energy consumption is obtained as follows

$$E = E1 + E2 \qquad (11)$$

$$E = B\left((1+\beta)\left(D1 + \delta\pi P^2\left(1 - \vec{L}_{\prime}^{z}\right)D2\right)\right) + B\left(\left(\delta\pi P^2\left(1 - \vec{L}_{\prime}^{z}\right) + 2\right)D_{trns} + (\delta\pi P^2 + 1)D_{rcvr}\right) \quad (12)$$

Analysis for Minimization of Overall Energy Consumption

The optimization of active nodes for energy minimization is presented below. Let k be the number of active devices required to satisfy packet failure rate.

The total energy consumption is minimized by optimizing $D2$ and k

$$E_T = B\left((1+\beta)D_{,} + \left(K\delta\pi P^2\left(1 - \vec{L}_{\prime}^{z}\right) + 1\right)D2\right) + B\left(\left(K\delta\pi P^2\left(1 - \vec{L}_{\prime}^{Z}\right) + 2\right)D_{trns} + (K\delta\pi P^2 + 1)D_{rcvr}\right), \qquad (13)$$

Where $D_{\uparrow}$ is the maximum energy consumption and $\vec{L}$ represents objective packet failure rate and $L_T^z$is total packet failure probability. therefore the total packet failure likelihood $L_T^z$is obtained

To determine optimized k for given $D2$ with respect to minD_T, we continuously find k under condition D_2. to compute optimization $L_2^b$is upper bounded as follows

$$L_2^b \leq \binom{2a-1}{a}\left(\mathcal{N}_0 j^2 / 4\mathcal{G}D_2\right)^a \leq \left(\mathcal{N}_0 j^2 / \mathcal{G}D_2\right)^a \quad (14)$$

The packet failure rate L_T^Z is upper bounded by utilizing sequence set of exponential function we get total packet failure probability as

$$L_T^Z = \frac{B\mathcal{N}_0 j^2}{4\mathcal{G}D_2} \exp\{k\delta\pi P^2(\vec{L}_{\prime}^Z - 1) + (k\delta\pi P^2 - k\delta\pi P^2 \vec{L}_{\prime}^Z\ )^{\mathcal{N}_0 j^2} / \mathcal{G}D_2\} \quad (15)$$

The k is determined for a particular D_2 as follows

$$\kappa = \frac{ln\left(4L_T^Z \mathcal{G}D_2 / B\mathcal{N}_0 j^2\right)}{\left(\mathcal{N}_0 j^2 / \mathcal{G}D_2 - 1\right)\delta\pi P^2\left(\vec{L}_{\prime}^Z - 1\right)} \quad (16)$$

IV SIMULATION RESULTS

Windows 10 enterprises 64-bit operating system with 12GB of RAM.is the system environment used. We have conducted simulation study using C# programming language used by sensoria simulator (IEEE WSN) which is a dot net based simulator. Simulation studies are conducted to obtain performance in terms of the following parameters: lifetime of network. The reults are compared with $LEACH$ protocols for networks that contain 1000, 1500 and 2000 nodes.

The lifetime of network is obtained for 40% of death of nodes. In below tables , we can see that the proposed model performs better than the existing $LEACH$ for lifetime of network. The result shows that $LEACH$ protocol is not suitable for large network and the proposed model is adaptive in nature with increase in node density.

Name of protocol	First node death(FND)	30% of node dead
LEACH	23rounds	111 rounds
Proposed work	1869 rounds	1928 rounds

Table 1Network life time for 1000 nodes

Name of protocol	First node death(FND)	30% of node dead
LEACH	22 rounds	65 rounds
Proposed work	1799 rounds	1884 rounds

Table **2** Network life time for 1500 nodes

Name of protocol	First node death(FND)	30% of node dead
LEACH	17rounds	93 rounds
Proposed work	2226 rounds	2274 rounds

Table 3Network life time for 2000 nodes

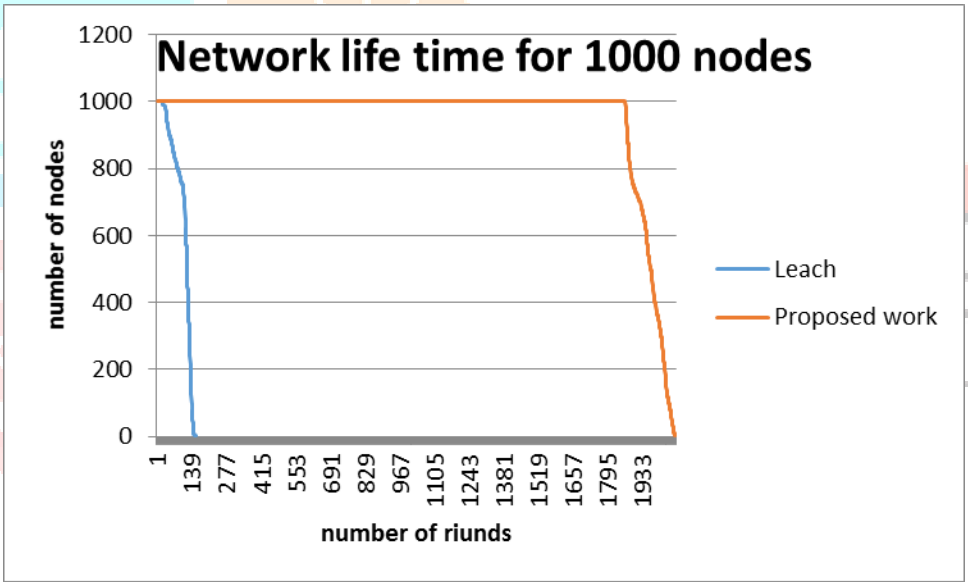

Fig1lifetime of network for 1000 nodes

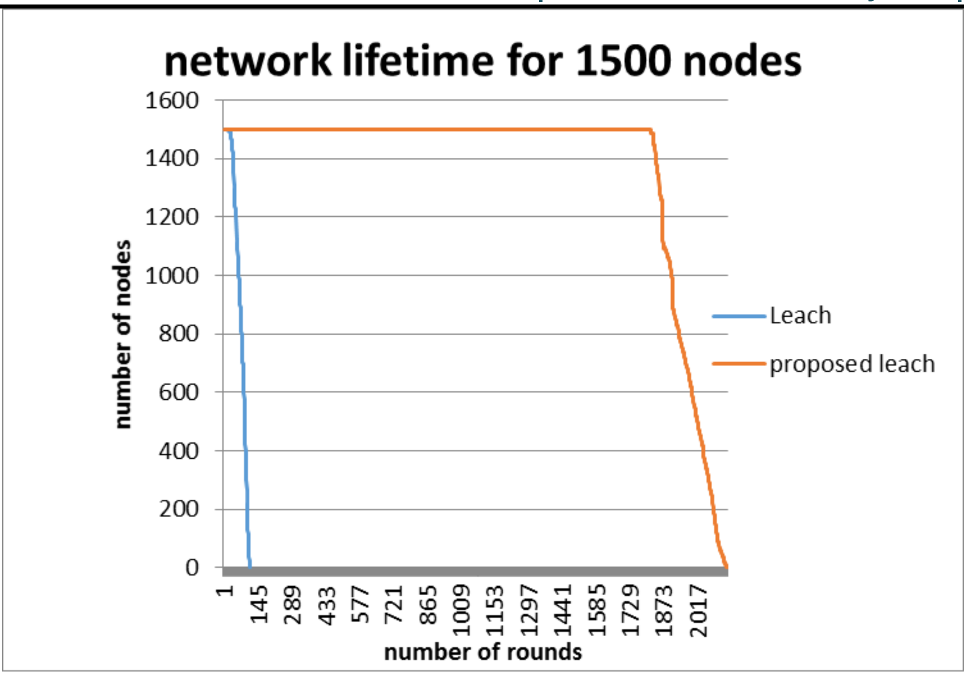

Fig2 Lifetime of network for 1500 nodes

V CONCLUSION

The overhead involved in clustering algorithm is overcome by using TDMA scheme. All the nodes need not decode the data correctly. Hence likelihood of packet failure within a cluster is determined. The energy consumption for intra and intercluster transmission is computed. Further an attempt is made to minimize the over all consumption of energy by minimizing intercluster energy consumption there by evaluating the active nodes required for transmission. The simulation results are compared with $LEACH$ and the proposed model shows improvement compared to $LEACH$ in terms of lifetime of network

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