TELKOMNIKA, Vol.14, No.4, December 2016, pp. 1368~1375
ISSN: 1693-6930, accredited A by DIKTI, Decree No: 58/DIKTI/Kep/2013
DOI: 10.12928/TELKOMNIKA.v14i4.4013

Energy Efficient Error Rate Optimization Transmission in Wireless Sensor Network

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Abstract

Wireless Sensor Network is a collection of independent nodes and create a network for monitoring purposes in various scenarios like military operation, environmental operation etc. WSN network size is increasing very rapidly these days, due to large network size energy consumption is also increased and it has small battery, lifetime of network decreases due to early death of nodes and it impact the overall system performance. Clustering is a technique for enhance the network lifetime in WSN. Here in this paper we propose a new multi-objective adaptive swarm optimization (MASO) technique for clustering and computes the maximum number of clusters, which is best suited for the network. Each cluster has cluster head and cluster members and performed the task of local information extraction. Cluster head gathers all the extracted information from member nodes and send it to the base station, where base station performed global information extraction from all the cluster head nodes and generate some useful result. In MASO technique, object is used to find the best global position for the node and compare with existing position value. If new value is better than the old value, than node moves to a new position and object update their table for this new position. We are considering error probability in transmission of data packet in one hop communication. Here obtained the results are compared with other research in terms of overall network lifetime and effect on network lifetime when the size of the network is changed. We have fine tuned the node's decay rate and throughput of the network.

Keywords: *MASO, Global, Extraction, Fitness*

1. Introduction

Wireless Sensor Network (WSN) is a collection of set of tiny sensor nodes and base station. Sensor nodes are deployed in an area from where we want to gather the sensitive information from various applications like military battle field, any environmental data, health operation etc. A wireless sensor node consists of memory which has capability to process the data and it consists of transmitter and receiver, battery etc. [1]. Sensor nodes are battery constrained, lifetime of nodes is depends on battery usage, it is not rechargeable again and again and sometimes it is not possible to remove. Sensor nodes dies after their usage of battery power and become useless, it affects the overall system performance and network lifetime. Sensor nodes senses the signal and gathers it and process the signal and turn it into information, and then send it to the base station. Base station which is residing inside the sensor field or outside the sensor network, it depends on locality or situation. Communication between sensor nodes and base station requires a lot of energy. Energy consumption for transmission of information by the sensor nodes depends on the distance between sensor nodes and base station. If distance is more it requires more energy for the communication and drains out the battery power. If we place the base station near the sensor network, it reduce the battery power consumption but it has some demerits nodes which are near to base station dies early as compare to nodes, which are far away from the base station. So it creates holes near the base station. it leads to coverage problem near the base station. In that scenario actual information is missed out from that particular area, so it impacts the system performance [2]. Now we can say. In WSN sensor nodes are energy constrained. So saving or reduced the consumption of energy in that area is challenge. Many techniques are proposed and research work is still going on but it is not satisfying the requirement of energy saving up to the mark. To reduce the energy consumption and to improve the overall system performance, a technique called clustering of network is used.

Received May 18, 2016; Revised August 8, 2016; Accepted August 22, 2016

Clustering is a mechanism to divide the large network into number of small sub networks called clusters [3]. LEACH is very popular clustering mechanism and gives the concept of cluster head and cluster members to reduce the energy consumption. A cluster is consist of Cluster Head (CH) and cluster members, cluster members communicate with CH ,they send data to CH and cluster head gathers or collects all the data and then send it to the base station, but LEACH protocol has problem that CH communicates with base station using single hop only causing more energy loss of CH [5]. To achieve better energy utilization and to create the energy efficient network, An artificial intelligence (AI) technique is used inside the cluster. AI technique works based on analysis of previous data and predicts the future data [4], Swarm optimization technique is inspired by AI. Swarm they are work in group if they do not know where is the food they just watch their nearest neighbor and go there. Here We are using the concept of swarm optimization in a different way and named as multi-objective adaptive swarm optimization. This algorithm is dynamic in nature based on the situation or energy level of object (node) and can change their position or cluster. Object compare their present position and global best position to check which is best and moves to that position. Probability of packet failure or transmission error is also considered for one hop communication. Here Authors optimize the overall energy utilized by the wireless sensor network in communication. Calculate the percentage of nodes live or die conditions based on time, Check the effect of energy consumption and node's energy decay rate when network size is increased. Rest of the paper is organized as follows: Second section gives the related work in WSN. In third section Network design with proposed method is discussed. Section four describes the results obtained after simulation and at last conclusion is given.

2. Related Work

In literature review, Authors discussed about previous works done in the field of WSN. In [6] authors initialized the concept of virtual hexagons in making cluster which helps in avoiding overlapping of nodes of circular cluster. Based on the average distance between cluster head and cluster members, sub-circle can be made in the formed virtual hexagon. But Authors not discussed regarding channel collision conditions for making sub-circle and virtual hexagon. Better adjustment of transmission range for saving energy in [7, 8] based on geographical information and energy model is proposed, here it chooses the best transmission path for data. A quantitative analysis model [9] for the optimal transmission range problem, they use throughput as the optimization criteria and conclude that the optimal transmission power is determined by the network load, the number of nodes and the network size. It is difficult task for the researchers to maximize the network lifetime because sensor nodes have battery which contains limited power. During extensive data transmission, battery drains quickly. To overcome this issue, article [18] proposes a new scheme which uses optimal sink location based strategy. Another method is presented mitigate the congestion in network using relay nodes. In this work also, PSO based optimization is used fir optimal sink location with the corresponding relay nodes which results in energy efficiency. Optimal design of physical, network (routing) and medium access control layers is given. In [10] ad-hoc wireless sensor networks (WSNs) a particle swarm optimisation (PSO) algorithm is used to collectively estimate a monitored parameter by sensor nodes. In the proposed mechanism every sensor node is itself a wireless sensor network and is equipped with a Modified Particle Swarm Optimization (MPSO) algorithm for estimation of parameter of interest. Node self-localization is an important issue in wireless sensor networks (WSN). To solve this problem, a node self-localization algorithm is proposed. A modified particle swarm optimization (PSO) is introduced to find out the location of unknown nodes [17].

A very simple framwork serves as a benchmark to a Multi Objective Genetic Algorithm (MOCA) for the sensor placement technique, where two competing objectives are considered for the sensor coverage and the lifetime of the network [11]. They give the concept of vice-cluster head. When cluster head dies, vice cluster head take the charge. Communication is not discontinued and each time no need to elect the new cluster head. To improve the effeciency of the algorithm as an expoliting search phase a guided search method is embedded in a-vector Particle Swarm Optimization (PSO) algorithm, the main aim for this is to steer the search towards the desired direction. In this proposed strategy gradient computation of the Jacobina is excluded in determination of the corresponding desired direction in the parameter space. The components of the PSO algorithm are also redesigned accordingly [12]. Base station keeps track the record of residual energy of all nodes and based on energy level, base station choose the network. For increasing network lifetime multi-node clustering protocol is given in WSN for data gathering process [13]. In this work run-time is divided in to time slot rounds. Each round starts with a short re-clustering phase and longer data transmission phase. In time based protocol synchronization is needed in a network, so at the same time node can perform re-clustering mechanism as well as cooperative mechanism. In most of the case we have seen that most importance is given to the energy conservation but along with energy conservation, information retrieval task should also be kept in mind. If we save lot of energy without performing information retrieval task and not sent to the sink, In that case motive of WSN is not achieved. So total energy consumption and information retrieval task both should go hand in hand to serve the purpose of WSN. So here authors motive is to reduce the energy consumption without affected the information retrieval process. In [15] author used cloud algorithm which minimize the weight of particle, here all the path length is considered in the objective function. Ant colony and particle swarm optimization both concept used by the author in [16] for positive feedback ant colony algorithm is used, but maintaining two different algorithm utilize more energy.

3. Proposed Model

Wireless Sensor Network comes across the problem of information retrieval in multi-cluster system because of transmission packet failure or information retrieval failure.

3.1. Network Model

Following basic diagram shows WSN with clusters and communication with base station.

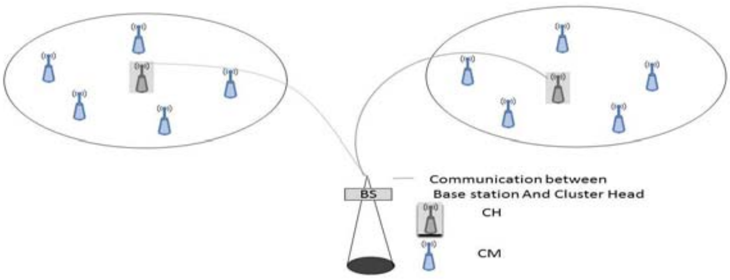

Figure 1. WSN Network Model

A wireless Sensor Network is basically combination of two things; one is Base station and second is sensor nodes. Area where sensor nodes are deployed known as sensor field and it can be given by $Am \times Am$. Base station may reside generally outside or inside the sensor network field with height R m above from center of area $R > A$. The distance from Cluster members to cluster head is denoted by α and it is $< A$.

1. Sensor Node: Sensor nodes deployed in an area to extract the information about the target and send it to the base station
2. Base Station: Base station receives the data from cluster head's and process it and generate useful result.
3. K is intermediate hop distance

Let S be number of sensor nodes are deployed in an area, where Q be the number of targets or information and $Q > S$,At a time one sensor can extract information from one target. Now network is divided in two cluster and now whole network is divided into H number of clusters. Each cluster has its own cluster head .So number of cluster head is equal toH_c. Rest of the nodes inside that cluster behaves as cluster members. Cluster members work is to sense the data and send it to the cluster head. Cluster head also senses data or extract target data and collect all data together and send it to the base station or sink. Here Network model channel is noisy and hence data travel through noisy channel. Data encoded by PCM (Pulse code modulation) method and send it to the sink bit by bit through fading channel. PCM decoding is done at the base station where sink extracts the global information received by the cluster heads.

3.2. Successful Packet Transmission or Target Extraction

Each round of transmission may not be successful, so here Authors computes the packet failure probability in communication. Cluster heads receives the data packets from cluster members locally and after receiving the data, they extract information successfully by removing duplicates call successful packet transmission or target extraction. Rate of successful packet transmission (data extraction) can be defined by the total number of successful packets transmissions to the total number of packets transmissions.

$$\alpha = \frac{total\ number\ of\ successfull\ packet\ transmission}{total\ number\ of\ transmitted\ packet} \quad (1)$$

Cluster head sends the packet to the base station. It has two possibilities either successful transmission or failure transmission, it means that base station may successfully receives the data packet called as information extraction or it may fail to extract the information from the cluster head's called as packet failure.

Reliability in the transmission of packet can be enhanced by the hop by hop error recovery scheme. In this scheme message is decoded by the intermediate CH, bit error is corrected by the CH and then broadcast it again. If after decoding word error comes then CH request to send data back by the previous CH.

When P_{total}/α changes with H and when its value reaches the lowest level, then this is given by H_{best} which is best value or good number of clusters, which minimizes the overall energy consumption.

3.3. Multi-Object Adaptive Swarm Optimization Techniques for Cluster Formaton

Traditional approach for cluster formation is not suitable for large or noisy network; it may get stuck in finding the optimal solution. Multi-object adaptive swarm optimization (MASO) is a object based algorithm. This technique is used in swarm optimization for finding the best feasible position solution. It uses the previous position details and has experience for finding the new global fit position solution. In this method each object is initialized for finding the global fit solution for a target problem. Some fixed threshold value is provided for a particular solution and object repeatedly iterate till that particular threshold is not found. Object is initialized with few parameters initially and tries to find the fitness value for the matched threshold. Object keeps track the record of each node's individual best fitness location given by (Z_{ibest}) and global fitness and location given by (Z_{gbest}) found at the time of iteration. Object uses these values for finding the best options to move towards a better position. When a object found an individual solution better than previous solution (fitness), then it replaces the old value by new one and update their data table. Let $Z(t)$ and $U(t)$ are the location and velocity vectors of each object at instance t. There are two self-learning factor γ_1 and γ_2.

$$U(t+1) = U(t) + \gamma_1 \times \left(Z_{ibest} - Z(t)\right) + \gamma_2 \times (Z_{gbest} - Z(t)) \quad (2)$$

$$Z(t+1) = Z(t) + U(t+1) \quad (3)$$

From the above discussed network model ,where number of sensor nodes is given by S then total nodes in a network can be given as $\{K_1, K_2, \dots, K_S\}$ and portioned into H clusters $h_1, h_2, \dots . h_H\}$. Location or position of each object shows the coordinates of H cluster heads in WSN.

$$Z_r(t) = (Y_1, Y_{2,\dots} Y_H) \quad (4)$$

$Z_r(t)$ is the position of rth object at time t and Y represent the cluster head's coordinate points. Energy consumption is directly proportional to the distance of the communication, so distance between cluster head and its members should be reduced. Sensor node K_i belongs to, h_j , when $|K_i - Y_j|$ is minimum. If fitness value is more it means distance between cluster head and cluster members is less.

3.4. Energy Consumption in the Network

In a sensor network, consumption of energy by the nodes in transmission or encoding the data packet or at the time of receiving or deocoding the packet in hop by hop communication. Now here considering i information bits encoded as symbol bits of m of linear block code as (m, i, t). Encoded sysmbol is denoted as a packet from this now size of packet is m bits.

Energy Consumption in the packet transmission in one hop communication where number of intermediate node is L and distance between nodes is considered as r in local cluster. BW is the bandwidth utilized, P_{tc}, P_{cr} is the energy consumption in the transmitter and recciever

$$E_0(r_o, L) = ndr_0^2 + {nP_{tc}}/_{BW} + {nLP_{cr}}/_{BW} \tag{5}$$

Now finding the consumption of energy in transmission the packet in between cluster numberof symbol in block code is defined as N now for block size one L intermediate hop with:

$$E_1(P_b, r_{id}, L) = \frac{nN}{N-L_N}\left(\frac{LN_0}{P_b^{\frac{1}{L}}} S(r_{id}, x) + \frac{LP_{tc}+P_{cr}}{BW}\right) \tag{6}$$

In the above equation r_{id} is the inter cluster distance of $l\ th$ hop. $SG(r_{id}, x)$ is the power of antenna gain, P_b is the error probability in per hop transmission. Total Energy utilized in per packet transmission in the lth hop communication .

$$E_{ch}(l) = E_{bs} + E_0(r_o, L) + E_1(P_b, r_{id}, L) \tag{7}$$

E_{bs} is the energy utilized by the base band signal in encoding and decoding the signal.

Energy utilized in overall communication or transmission of packet, average transmission in per packet transmission time in a singal hop. For this purpose probability of error in block code (m, i, t) computed as:

$$PE_{wd}(P_b) = \sum_{j=t+1}^{m} \binom{m}{j} P_b^j (1 - P_b)^{m-j} \tag{8}$$

Time for transmission tha packet in one hop communication can be given as:

$$T_{avg} = \frac{1}{1 - PE_{wd}(P_b)} \tag{9}$$

Now we can give the overall energy consumption in per packet transmission.

$$E_{overall} = \times \{H[E_{bs} + E_0(r_o, L)] + \sum_{l=1}^{K} E_1(P_b, r_{id}, L)\} \tag{10}$$

Where K is the number of hop, P_b impat on both transmission time and energy consumption.

Once cluster is formed, the cluster head is near to the center of cluster area and$R^4 < P\{a_{k,h}^4\} < (R^2 + A^2/2)^2$. Here we have taken, that each cluster has average number of sensor nodes and defined as $\sum_{h=1}^{H} S_h^2 \approx {S^2}/_{H}$. Now H_{best} is maximum number of clusters for minimizing the total energy consumption. Overall energy consumption is function of the number of clusters$H$. $P_{total}(H)$ by setting the derivatives of P_{total} (with respect to *H*) ,we obtained the minimum or maximum number of H as H_{best}^*. If $H_{best}^*$is the minimum, it has optimal number of clusters.With respect to minimizing the total energy consumption. Successful packet transmission rate α will get saturated as the number of H increases without showing the local extremism. $\alpha(H)$ denotes the successful packet transmissions with respect to H clusters.

Total energy P_{total} consumption and best number or optimum number of clusters is H^{*}_{best}.it varies with number of nodes in network. If S increases than energy consumption and number of nodes in some cluster also increases. H_{best} Increases with S.

4. Simulation and Result Analysis

The system requirement is windows 8.1 enterprises 64-bit operating system with 4GB RAM. We have used Sensoria simulator which is based on C# programming and used dot net framework 4.0 visual studios 2010. We have conducted simulation study based on following parameters by considering network lifetime, increasing number of nodes (increasing network size) and communication overhead. We have Compared with existing “Energy Aware Swarm Optimization with Inter cluster Search for Wireless Sensor Network” systems and found that our proposed system is more efficient. We have varied network nodes size like 600, 1200 and 1800 in our simulation and Simulation parameters considered are shown in Table 1.

Table 1. Network nodes simulation

Network Parameter	Value
No. of Nodes	600,1200,1800
Network Size	30×30
Base station location	1m*1m
Size of Data Packet	2000 bits
Energy of sensor node initially	0.1 J
Energy dissipation	50 nj/bits
Data packet processing delay	0.1 ms
Amplification energy	100 pJ/bit/m2
Ideal energy consumption	50 nj/bit
Bandwidth	5000 bit/s
Rate of Transmission	100 bit/s
q_1	Random number between 0 and 1
q_2	Random number between 0 and 1
γ_1	2000
γ_2	250
γ_3	1000
M	4
SNR	15dB

Distribution of sensor nodes in the area of $30m \times 30m$ and base station location considered at 1m*1m. After nodes distribution cluster formation is taken place, than overall energy consumption is computed, we compared network lifetime with different network size and throughput.

From Figure 2 we have compared our proposed system (PS) simulated values with existing system (ES) values. We found that in PS as network size increases, network lifetime also increases but in ES as network size increases its lifetime decreases.

In the following graphs shown in Figure 3, 4 and 5; we are analyzed network life time for 600, 1200 and 1800 nodes respectively. Here authors computed the network life time, when it reaches 30% for both existing and proposed works. In Figure 3 network lifetime reached 30% after 53 rounds of iteration for existing while for proposed work number of rounds is 96. For 1200 nodes network lifetime for existing system for 30% nodes death after 58 rounds of iteration while for proposed system number of rounds is 70 which is shown in Figure 4 and when network is considered with 1800 nodes lifetime of existing model reached 30% after 68 rounds while in case of proposed system it goes up to 111 rounds. So our proposed work is more stable and efficient in terms of network lifetime as compare to existing system.

In the Figure 6 authors analyzed the node’s decay rate for 600, 1200 and 1800 nodes.In Proposed work node’s decay rate is always lower than existing ones for all network sizes. In existing system node’s decay rate is fast when the number of nodes increases in the sensor network.

In Figure 7 network throughput is compare between existing and proposed systems and we have analyzed and proved that proposed system’s throughput is much better than existing one.

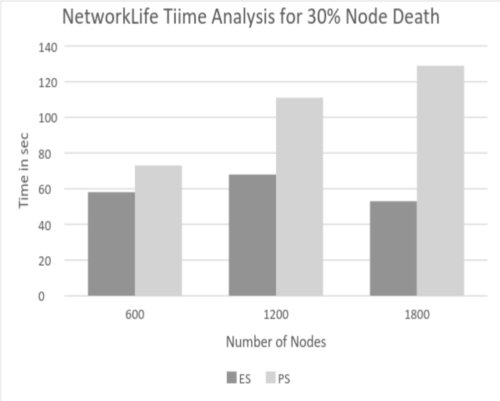

Figure 2. Network Lifetime

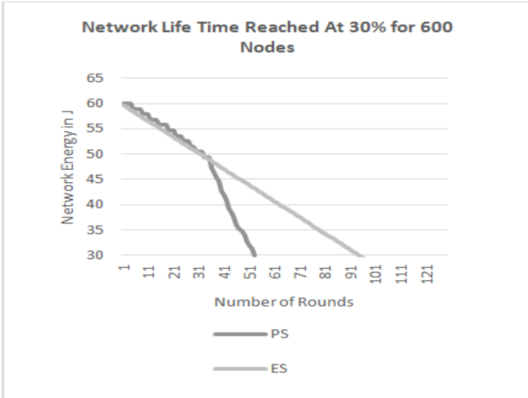

Figure 3. Network Lifetime analysis for 600 nodes

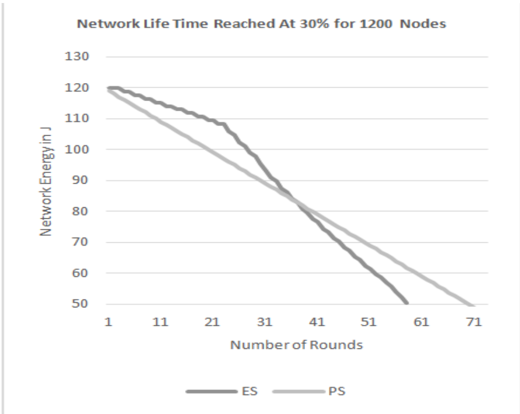

Figure 4. Network Lifetime analysis for 1200 nodes

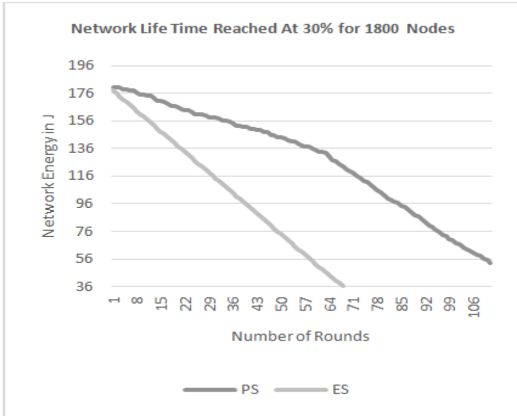

Figure 5. Network Lifetime analysis for 1800 nodes

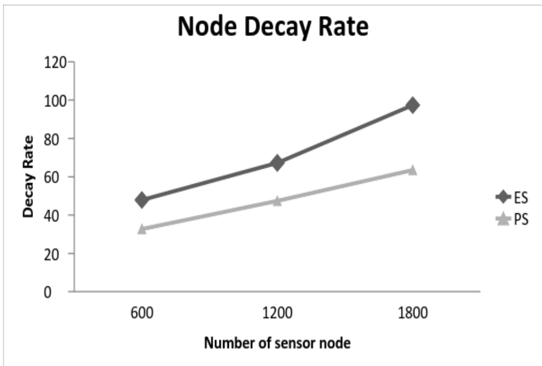

Figure 6. Node decay rate for different network Size

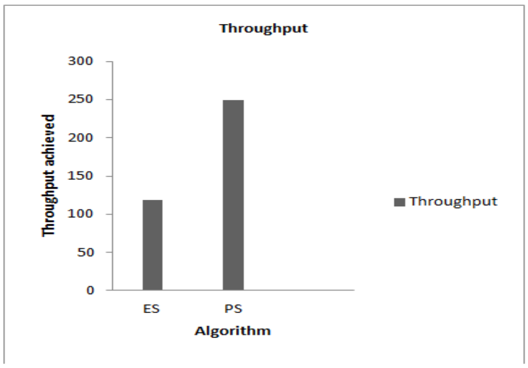

Figure 7. Throughput Comparison for Existing and proposed work

5. Conclusion

In our proposed network ,We have achieved better energy model for WSN by using MASO technique by reducing the overall energy consumption in a network. Enhanced the network lifetime for different increased network sizes. Node's decay rate is also less in the proposed work as compared to existing works. Our proposed work is enhanced the network quality by selecting the maximum or optimum number of clusters based on network efficiency and in future we want to verify with the real mute system.

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