International Journal of Engineering Research
Volume No.5, Issue No.1, pp :46-49
ISSN:2319-6890)(online),2347-5013(print)
01 Jan. 2016

Binomial Probability Density Function: Energy Efficient Approach to Wireless Sensor Network

Vishal Puri
Electronics and Communication Engineering Department, Baba Ghulam Shah Badshah University
Rajouri (J&K), India.
vishal_puri28@yahoo.com

Abstract: Energy consumption is the major issue in any Sensor Networks. The lifetime of a network is directly dependent upon the amount of energy consumed by the nodes. If the nodes consume energy intelligently and operate for longer period then lifetime of a network can be enhanced. WSN consists of hundreds to thousands of nodes which consume energy while transmitting the information and with a span of time whole energy get consumed and network life time gets reduced. From the data capturing, processing, transmission and reception large amount of energy has been consumed. The source of power used in WSN is irreplaceable which limits the lifetime of the system. A probability based approach to calculate initial probability is tried in this paper. MATLAB simulation tool is considered in this paper.

Keywords: Cluster Head (CH); Clustering; Energy Efficiency; Binomial probability density function (BDF) and WSNs.

I. INTRODUCTION

Wireless sensor network (WSN) is one of the most important technology, nowadays used and therefore has wide range of applications. While designing this network, variety of problems come into existence. One of the major problem is energy consumption and the sensor nodes used in this technology operate on battery which are deployed in a complex, rough or sometimes in extreme environment. So it becomes difficult to change the batteries. So to overcome this problem some protocols are framed to minimize the energy consumption especially of the nodes in order to increase the lifetime of the whole network [1-8]. This network collects the information from the environment, process it and transmit to the Base Station (BS). This information transfer process consumes energy, so a most important and crucial technique framed is clustering and Cluster Head (CH) selection.

Clustering is a hierarchical technique which reduces the energy consumption by distributing the load between the sensor nodes of the network. This technique increases the lifetime of the network. In clustering, the region of the network is divided into groups consisting of sensor nodes. The sensor nodes form the clusters on the basis of their position from the cluster head (CH) where CH are formed on the basis of distributed algorithm. After clustering and CH selection, the sensed data transmitted by the sensor nodes to the CH where processing of the data takes place and finally data packets transmitted to the sink/base station (BS). The transmission of data from CH to the BS is either by single-hop or multi-hop communication. In single-hop communication the CH sends data packets directly to the BS but in this case energy consumption is high if the distance between the two is large.

On the other hand in multi-hop communication the CH far from the BS uses the intermediate CHs for data transmission but energy consumption the CH close to the BS become very high. Different optimisation techniques have been used to improve the energy efficiency and enhance the network lifetime.

Low Energy Adaptive Clustering Hierarchy (LEACH) is the first optimized protocol used to distribute the energy uniformly by selecting CH on the basis of round robin [3]. In this protocol few nodes in a cluster are randomly selected with a certain/fixed probability to become CHs per round. It is also assumed that all the nodes have same amount of energy in every round and all the nodes are electing themselves to become CH with a constant predesigned probability.

LEACH-C is a centralized approach where BS has the energy level and distance information of all the nodes. The probability of CH selected is fixed by the BS [3].

In a Stale Election Protocol (SEP) weighted election probabilities based on residual energy of each node decides the node to become CH [4].

In Distributed Energy Efficient Clustering (DEEC), CHs are formed on the basis of the ratio between residual energy of each node and the average energy of the network [5]. There are so many protocols used to save the energy of the nodes to enhance the network lifetime

The existing protocols initially at the first most round assume that all the nodes in a cluster have same probability to become CH and as the rounds proceeds, probability varies. But practically the nodes could not have same probability because of some reasons. First it is not necessary that all the nodes in a cluster are in range with the BS which may cause more energy consumption due to longer distance between CH and the BS. Secondly some nodes might be at the boundary of the cluster which may cause high intra-cluster energy consumption. Thirdly the nodes might have different energy levels depending upon different power sources that may cause different probability for each node to become CH.

Above mentioned reasons imply that the probability of all the nodes initially to become CH is not same. In this paper we proposed *Binomial probability density function* which summarizes the number of trials, or observations, when each trial has the same probability of attaining one particular value.

II. BINOMIAL PROBABILITY DENSITY FUNCTION

A binomial probability density function has following properties:

1. The experiment consists of n repeated trials;

2. Each trial results in an outcome that may be classified as a success or a failure (hence the name, binomial);
3. The probability of a success, denoted by *p*, remains constant from trial to trial and repeated trials are independent.

The number of successes *X* in *n* trials of a binomial experiment is called a binomial random variable. The probability distribution of the random variable *X* is called a binomial distribution.[5]

III. ENERGY EFFICIENT TECHNIQUE

LEACH is one of the most important, earliest, basic and dynamic hierarchical routing protocols used in WSNs to minimize the energy consumption of the nodes. The clusters are formed and one of the node acting as CH. If a CH remains fixed throughout the network lifetime then the CH would die quickly and ends the useful life of all nodes belonging to that particular cluster. Each node in a cluster elects itself as local

CH at any round with a certain probability and broadcast its information to the other nodes [1][8]. In every cluster one of sensor nodes acts as CH and remaining sensor nodes act as member nodes of that cluster. CHs collect the data from all nodes, aggregate received data, process/compress them and finally transmit information to BS.[9]

LEACH uses a Time Division Multiple Access (TDMA)/code-division multiple access (CDMA) MAC to avoid or reduce inter-cluster and intra-cluster collisions. After a given interval of time, random rotation for the selection of CH is conducted so that uniform energy get consumed by every node in each cluster. The operation of LEACH consists of two phases, the setup phase and the steady state phase.

Setup phase: The clusters are organized and CHs are selected. In the steady state phase, the actual data transfer to the BS takes place. The duration of the steady state phase is longer than the duration of the setup phase in order to minimize overhead. During the setup phase, a predetermined fraction of nodes '*p*' elects themselves as CHs. A sensor node or set of nodes that have not been selected as a CH in the last (1/p) rounds chooses a random number between 0 and 1 and if this random number is less than a threshold value T(n) the node becomes a CH for the current round. The threshold value is calculated by

$$T(n) = (p/ (1-p (\mathrm{mod}\ (1/p)))) \qquad n \in G$$

where *G* is the set of nodes that are involved in the CH election. All the nodes elected as CHs broadcast an advertisement message to the rest of the nodes in the network that they are the new CHs. All the non-CH nodes, after receiving this advertisement, decide on the cluster to which they want to belong on the basis of signal strength of the advertisement. The non-CH nodes inform the appropriate CHs that they will be a member of that particular cluster. After receiving all the messages from the nodes, the CH node creates a TDMA schedule and assigns each node a time slot when it can transmit. This schedule is broadcast to all the nodes in the cluster.

Steady state phase: The sensor nodes start sensing and transmitting data to the CHs. The CH node receives all the data, aggregates it, process it and transmit it to the BS. After this process again the network goes back into the setup phase and again selects new CHs for next round.

IV. ENERGY MODEL

The energy model used is a simple first order model where the energy consumption is calculated for the transmission of data in the form of bits from transmitter to the receiver. This model used to calculate the amount of energy consumed for transferring the data from simple node to CH, from CH to intermediate CH, from CH to BS and also from node to BS. The radio dissipation energy model consists of transmitter having transmit electronics (E_{elec}) which depends upon factors like coding, modulation, filtering and transmit the signal and amplifier depends on the distance to the receiver and the tolerable bit-error rate.[1-8][10].

If the distance between transmitter and receiver is less than threshold distance (say d_o) then free space (d^2 power loss) channel model used and if distance between transmitter and receiver is greater than threshold distance (say d_o) then multi path fading (d^4 power loss) channel model used. If the distance between transmitter and receiver is less than threshold distance (say d_o) then free space (d^2 power loss) channel model used and if distance between transmitter and receiver is greater than threshold distance (say d_o) then multi path fading (d^4 power loss) channel model used [5-8].Table I contains first order radio model parameter used to calculate the energy consumed by each node in a cluster at various distances.

Table I. Radio Parameters

Parameters	Operation	Values
Tx / Rx Electronics	E_{elec}	50 nJ/bit
Transmit amplifier (if d to BS<do)	E_{fs}	10 pJ/bit/4m^2
Transmit amplifier (if d to BS>do)	E_{mp}	0.0013 pJ/bit/m^4
Data aggregation energy	E_{DA}	5 nJ/bit/signal

V. PROPOSED METHODOLOGY

A. Binomial Probability Density Function

In proposed method, the CHs are selected on the basis of varying probability which is calculated by using *Binomial probability density function* for a given value x and given pair of parameters n and p is

$$m=f(x|n,p)=(n/x)\ p^x q^{(n-x)}$$

The parameter n represents the number of nodes, the p is the probability must lie on the interval [0, 1].

B. Cluster Head Formation

After the evaluation of the probabilities, the nodes select themselves to the CH on the basis of threshold value , $T_{s(i).}$. The sensor node chooses a random number r between 0 and 1. The node becomes CH for that current round, if the value of r is less than the threshold value, $T_{s(i).}$ The threshold value is evaluated by:

$$T_{s(i)} = \{\frac{m(i)}{1 - m(i)(r \bmod \frac{1}{m(i)})}\} if s(i) \in G$$

$$\{0 otherwise$$

where is the set of nodes that have not been CH in the last $1/p_i$ rounds.

C. Cluster Formation

After the selection of CHs, the CH nodes broadcast an advertisement (ADV) message to the whole network using non-persistent carrier sense multiple access (CSMA) MAC protocol. This small message contains the CH's ID and a header which specifies the type of the message. After receiving the message, the non-CH nodes choose the CH on the basis of minimum communication distance by calculating the signal strength of the ADV message from different CHs.

After selecting the CH by the non-CH nodes they send a join-request (JOIN-REQ) to their corresponding CH for which they form the cluster. Again the join message is a short message consisting of the CH node's ID, non-CH node's ID and the header. The clustering done in this algorithm is a soft clustering where the nodes are not restricted to a cluster but in every round the clusters changes dynamically.

D. Data Transmission

The data then sensed by the environment and transmits to the CH where the data aggregated and processed so that only useful data get transmitted to the BS and small data transmission must preserves the energy. The CHs close to the BS uses single hop or direct transmission where as the CHs far away from the BS uses multi-hop transmission/communication i.e. they transmit there data to the next CH close to the BS and soon.

VI. SIMULATION RESULTS

The simulation is performed on MATLAB version 7.9.0.529 with intel (R) Core (™) 2 Duo CPU with 2GB RAM. In this method, our effort was to enhance the energy efficiency of the network. We focused on the lifetime of the network by enhancing the overall lifetime of the nodes. We also took into account number of packets transmitted from node to CH and from CH to the BS. In our opinion the proposed method enhances the lifetime and energy efficiency of the network. The performance is compared with the existing protocol.

We consider a wireless network with 100 nodes distributed randomly within a region of 100m x100m and assume that the BS is at the centre of the region. The number of rounds considered to be 2500. Comparative results are as follows:

A. Stability

It is not necessary that initially the probability of the nodes to become CH is same. In our approach the evaluation of probabilities of the nodes on the basis of certain criteria whereas in existing approach all the nodes assumed to have equal probability.

Fig.1 shows that by varying the probability in the initial stage of the network cause an overall enhancement of the network. In case of binomial probability, the last node dead at 2400th round while in case of constant probability the last node dead at 2150th round.

Considering the varying probability into account the overall stability of the network has been enhanced.

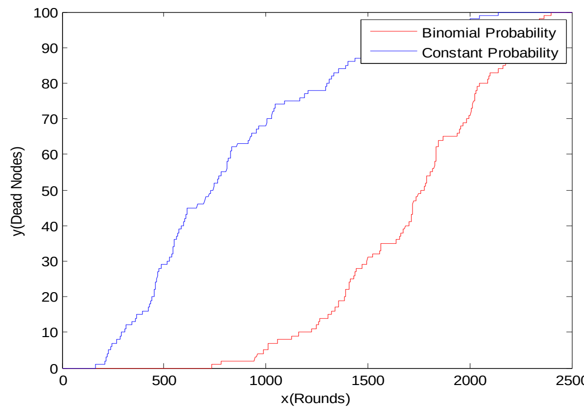

Fig. 1 Comparison of the Stability

B. Packets to BS

Fig.2 shows that the number of data packets transmitted from the CHs to BS is more in case of binomial probability, than in case of constant probability. The number of packets transmitted by binomial probability is approx. $3.4x10^4$ while in case of constant probability it is approx. 1100. This shows that binomial probability transmits data packets more from CHs to BS then the constant probability.

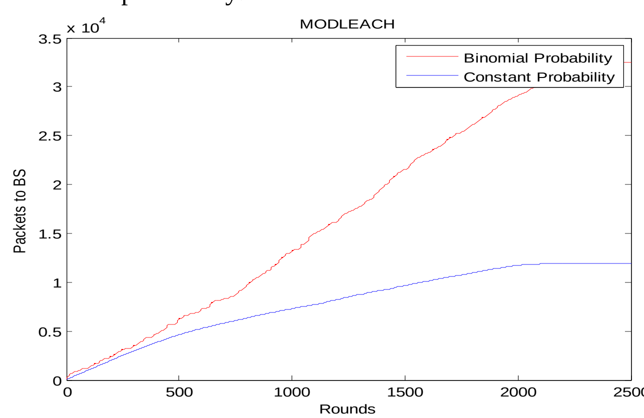

Fig. 2 Comparison of the packets sent to the BS

C. Packets to CHs

Fig.3 shows that the number of data packets transmitted from the non-CH nodes to the CHs is more in case of binomial probability as compared to the constant probability protocol. The number of packets transmitted by the binomial probability is approx. $14x10^4$ while in case of constant probability it is approx. $7x10^4$. This shows that binomial probability transmits data packets more from non-CH nodes to the CHs then the constant probability.

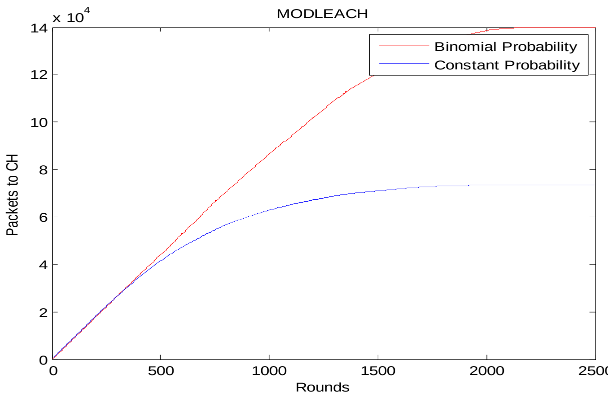

Fig. 3 Comparison of the packets sent to the CHs

REFERENCES

i. W. Heinzelman, A. Chandrakasan, H. Balakrishnan, Energy-efficient communication protocol for wireless microsensornetworks, in: System Sciences, 2000. Proceedings of the 33rd Annual Hawaii International Conferenceon, IEEE, 2000.

ii. M. Aslam, M. B. Rasheed, T. Shah, A. Rahim, Z. A. Khan U.Qasim , M. W. Qasim,,A. Hassan, A. Khan, N. Javaid "Energy optimization and Performance Analysis of Cluster Based Routing Protocols Extended from LEACH for WSNs"International Journal of Modern Engineering Research (IJMER www.ijmer.com Vol.3, Issue.2, March-April. 2013 pp-1100-110.

iii. Georgios Smaragdakis and Ibrahim Matta, 2004. SEP: A

iv. Stable Election Protocol for Clustered Heterogeneous

v. Wireless Sensor Networks.

vi. L. Qing, Q. Zhu, M. Wang, 2006. Design of a distributed energy- efficient clustering algorithm for heterogeneous wireless sensor networks, In ELSEVIER, Computer Communications.

vii. Ilker Demirkol, Fatih Alagoz and Cem Ersoy "Wireless Sensor Networks for Intrusion Detection: Packet Traffic Modeling" IEEE Communication letters, VOL. 10, No. 1, January 2006.

viii. Lindsey S., Raghavendra C.,"PEGASIS: Power-Efficient Gathering in Sensor Information Systems", IEEE Aerospace Conference Proceedings, 2002, Vol. 3, 9-16 pp. 1125-1130.

ix. Manjeshwar A. and Agarwal D. P., "TEEN: a routing protocol for enhanced efficiency in wireless sensor networks," In 1st International Workshop on Parallel and Distributed Computing Issues in Wireless Networks and Mobile Computing, April 2001

x. Gupta S, Bhatia V, "GMMC: Gaussian Mixture Model Based Clustering Hierarchy Protocol in Wireless Sensor Network", International Journal of Scientific Engineering and Research (IJSER) ISSN (online): 2347- 3878

xi. Rodoplu V. and Meng T. H.,"Minimum Energy Mobile Wireless Networks", IEEE Journal Selected Areas in Communications, vol. 17, no. 8, Aug. 1999, pp. 133344.

xii. Li L., and Halpern J. Y.," Minimum-Energy Mobile Wireless Networks Revisited," IEEE International Conference on Communications (ICC) 2001. Vol. 1, pp. 278-283.