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TO INVESTIGATE THE INFLUENCE OF PARAMETERS SELECTION IN LEACH PROTOCOL BASED WIRELESS SENSOR NETWORKS

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Abstract: The paper investigates leach protocol by varying Size of data packet & Position of Base Station (Sink) to prolong the network lifetime. The size of data packet taken are 1000, 2000, 3000, 4000 bytes. For the case 1000, simulation results show that nodes still alive for 17000th rounds. The Position of BS is set (50, 50), (50, 75), (50, 100), (50, 150). For this case (50, 50) simulation results show that nodes still alive for 4500th rounds. In general, nodes survived for longer time period provided smaller size of data packet & the position of BS in middle of network area. The work recommends that use of optimize size of data packet & adequate position of BS to increase network lifetime of Wireless Sensor Network Systems.

I. INTRODUCTION

Recent advancement in electronics technology enabled designer to develop low cost, low power and small size sensors [1], [2]. Hundreds and thousands of these sensors are deployed in wireless sensor network according to the requirement of network application. Wireless sensor network (WSN) is one of the evolving technologies. Sensor nodes are able to monitor physical environment, compute and transmit this information to core network. These sensors can communicate to each other and also to some external Base station [8]. Wireless sensor networks are used for both military and civil applications [5]. A wide-range of applications offered by WSN, some of these are environmental monitoring, industrial sensing, infrastructure protection, battlefield awareness and temperature sensing.

Routing is main challenge faced by wireless sensor network. Routing is complex in WSN due to dynamic nature of WSN, limited battery life, computational overhead, no conventional addressing scheme, self-organization and limited transmission range of sensor nodes [2], [3], and [4]. As sensor has limited battery and this battery cannot be replaced due to area of deployment, so the network lifetime depends upon sensors battery capacity. A Careful management of resources is needed to increase the lifetime of the wireless sensor network. Quality of routing protocols depends upon the amount of data (actual data signal) successfully received by Base station from sensors nodes deployed in the network region. Numbers of routing protocol has been proposed for wireless sensor network. The category of Hierarchical Clustering routing protocol is providing maximum energy efficient routing protocols [11]. Clustering schemes offer reduced communication overheads, and efficient resource allocations thus decreasing the overall energy consumption and reducing the interferences among sensor nodes. The basic idea of clustering routing [14], [15] is to use the information aggregation mechanism in the cluster head to reduce the amount of data transmission, thereby, reduce the energy dissipation in communication and in turn achieve the purpose of saving energy of the sensor nodes. Number of hierarchical routing protocol has been proposed. LEACH (Low Energy Adaptive Clustering Hierarchy) is considering as a basic energy efficient hierarchical clustering routing protocol. In LEACH protocol, all the nodes are grouped into the clusters, and in each cluster one of the nodes is assigned as a Cluster Head (CH). CH collects the data from the surrounding nodes and passes it to the base station. Usually, initial assignment of CH is random and the role of CH is rotated for every fixed duration. So that each node will act as a CH at least once in its life span. LEACH algorithm has two phases. They are set up phase and steady state phase. Setup phase is used to choose a CH and steady state phase is used to maintain the CH during the transmission of data. A node n is selected as a CH in next round based on applying the following formula. If $T(n)$ is 1 then the node n will be the CH in next round.

$$T(n) = \begin{cases} \frac{p}{1-p.\left(r \times mod \frac{1}{p}\right)}, & n \in G \\ 0, & otherwise \end{cases} \quad \ldots\ldots\ldots (1)$$

Where p is the probability of the node being selected as a cluster-head node, r is the number of rounds passed, and G is the set of nodes that have not been cluster-heads in the last $1/p$ rounds, mod denotes modulo operator nodes that are cluster heads in round r shall not be selected in the next $1/p$ rounds. Once the cluster-head is selected, all nodes join the corresponding cluster according to the broadcast signal intensity of the cluster-head node. Then, the cluster set-up phase of this round is completed. When the cluster-head assigns time slots for members using TDMA mode, the network will enter the steady phase. The steady phase is divided into frame, where nodes communicate to cluster-head during allocated time slots otherwise nodes keep sleeping. Due to this attribute LEACH minimize energy dissipation and extend battery life of all individual nodes. When data from all nodes of cluster have been received to cluster-head.it will aggregate, compress and transmit to sink. The steady state phase is longer than setup phase. Distance between cluster- head & base station is more than distance between cluster member & cluster-heads [16]. Already there has been a lot of research work based upon LEACH to make this protocol more reasonable, efficient & increasing the

lifetime of Wireless Sensor Networks. But there is further scope to investigate LEACH protocol by varying simulation parameters like network size, number of nodes, probability of cluster head, size of data packet & Base station position. It is also seen that LEACH protocol is further improved by varying BS Position of Wireless Sensor Networks and Size of Data Packet [16], [17] and [18]. On these lines, the present work provides insight over variations for size of data packet & position of Base Station (Sink) for the protocol by using the conventional first order radio model & selection of cluster heads is done on the basis of above formula (1).

II. MODEL DESCRIPTION

In wireless transmission, attenuation of sending power decreased exponentially with the increasing transmission distance. Two types of channel transmission models are proposed in i.e., free space model and multi-path attenuation model. When distance d between sending node and receiving node is smaller than a certain value do, the free space model follow the rule that sending power decreasing exponentially by d^2. Otherwise, the multi-path attenuation model when employed follows the law that sending power decreasing exponentially by d^4. A wireless energy model same as mentioned in Ref. [12] is considered in this paper. The relation (2) computes energy lost when sending data of l bytes comprising sending circuit loss and power amplification loss. In the power amplification loss, the free space model and multi-path attenuation model are employed respectively depending on the distance between senders and receivers. Eelec is energy loss of sending circuit. ε_{fs} & ε_{amp} are energies for power amplification in the two channel models, respectively. The relation (3) represents energy loss for receiving data of l bytes which is caused only by circuit loss

$$E_{TX}(l,d) = \{E_{elect} \times l + \varepsilon_{fs} \times l \times d^2 \quad d < d_o$$
$$E_{elect} \times l + \varepsilon_{amp} \times l \times d^4 \quad d > d_o \ldots\ldots\ldots (2)$$

$$E_{RX}(l,d) = E_{elect} \times l \quad \ldots\ldots\ldots (3)$$

$$d_0 = \sqrt{\frac{\varepsilon_{fs}}{\varepsilon_{amp}}} \quad \ldots\ldots\ldots (4)$$

III. RESULTS & DISCUSSION

This paper uses Matlab tool to investigate LEACH protocol by varying simulation parameter to increase lifetime of Network. This will be analyzed by varying size of data packet & position of BS of LEACH protocol.

Case (A):-Varying Size of Data Packet

Table 1. Simulation Parameter of LEACH protocol by varying only size of data packet

Typical Parameter	
Parameter	**Value**
Number of Node	100
Network Grid	100*100
BS Position	50,50
$\mathcal{E}_{fs}$	10pJ /bit/m ^{2}
$\mathcal{E}_{amp}$	0.0013pJ /bit/m ^{4}
E_{elect}	50nJ/ bits
Maximum no. of rounds	18000
Probability of cluster Head	10%
Initial Energy	0.5 J
Varied Parameter	
Parameter	**Value**
Size of data packet	1000, 2000, 3000, 4000 bytes

The (fig.1.) depicts that on increasing the size of data packet the nodes starts dying at a faster rate. This is due to that the number of rounds decreasing as the size of data packet increasing because of more number of nodes is repeatedly used for the data transmission process. When the size of data packet is 1000, 2000, 3000 & 4000 bytes then nodes start dying after elapsing 6000th, 3000th, 2000th & 1000th rounds respectively.

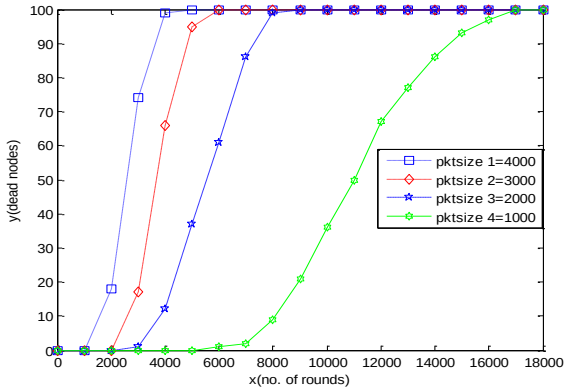

Fig. 1. Dead nodes versus number of rounds after varying the size of data packet

As shown in (fig.2.) on decreasing the size of data packet the nodes remain alive after experienced so many rounds. If the size of data packet is reduced then also energy consumptions is minimized and nodes remain alive for a longer time period because these nodes does not utilize all energy. Higher efficiency of using energies due to lesser number of nodes dies. Too large data may lead to earlier death of nodes. When the size of data packet is 1000, 2000, 3000 & 4000 bytes then nodes remain alive after 17000th, 800th, 6000th & 4000th rounds respectively.

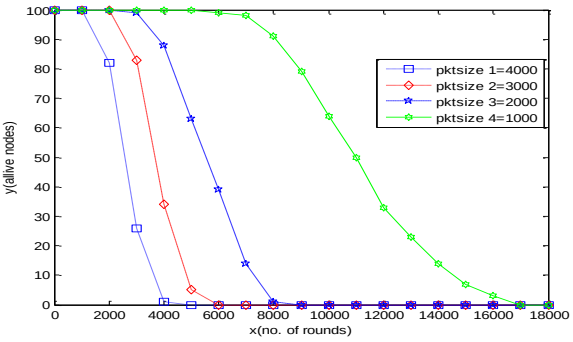

Fig. 2. Alive nodes versus number of rounds tell the network lifetime of system for varying the size of data packet

As (Fig. 3.) shows that with increasing the size of data packet, the data transmitted to base station decreases. This happens because of larger size of data packet may cause bit corruption which increases the retransmission of data packet i.e. send to BS. Size of data packet has directly effect on reliability & communication between nodes of Wireless Sensor Networks. Too much smaller size packet cause higher packet overhead and consume startup energy of each packet. So, optimize size of packet is preferred, neither too large size nor too much smaller size.

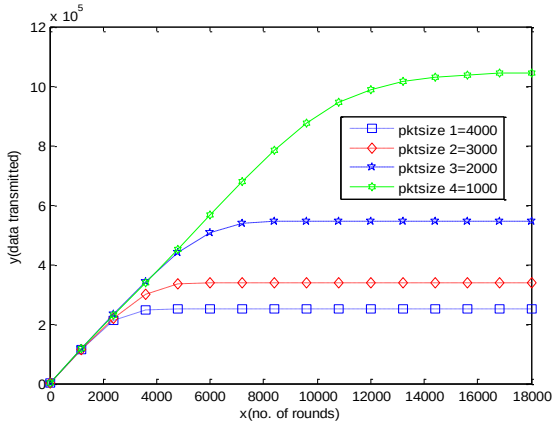

Fig. 3. Data transmitted to base station versus number of rounds for the different size of data packet

Table 2.Simulation results after varying size of data packet

Sr.No.	Size of data packet (bytes)	Rounds when nodes start dead	Nodes still alive at this round	Data transmitted to BS(Kbits)
1	4000	1000th	4000th	200
2	3000	2000th	6000th	300
3	2000	3000th	8000th	500
4	1000	6000th	17000th	1000

The (Fig. 4.) illustrate the counting of nodes that become cluster head after elapse so many rounds during each case of varying size of data packet.

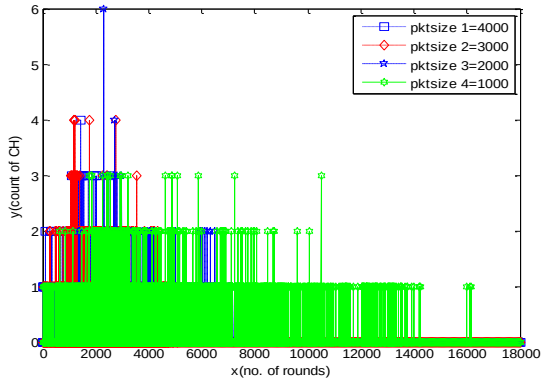

Fig. 4. Counting number of CH's versus number of rounds during various size of data packet

From the Ref. [17] S Taruma and Sakshi Shringi, considers the residual energy of sensor nodes while selecting CH's among the nodes. An equation (5) shows computation of the threshold value for a cluster head selection.

$$T(n) = 1\begin{cases} \frac{p_t \cdot E_{res}}{p_t(r \bmod 1)\_E_{max}}, & n \in G \\ 0, & otherwise \end{cases} \quad \ldots\ldots\ldots (5)$$

The energy consumption for transmitting /receiving H-bit data message for a given distance d is formulated by equation (6).

$$E_{TX}(d,H) = K\left(E_{elec} + \epsilon_{amp} d^{\beta}\right)$$
$$E_{RX}(d,H) = HE_{elec} \quad \ldots\ldots (6)$$

Where E_{TX} denotes the energy consumption for transmitting data, E_{RX} denotes the energy dissipation by receiving data, E_{elec} denotes the energy dissipation per bit by the transmitter or receiver circuits, ϵ_{amp} denotes the energy dissipations per bit by the transmitter amplifier, and β is pass loss exponent. The pass loss exponent α is set to 2 for the transmission from each node, and β is set to 2.5 for the transmission from a cluster head to BS. During Simulation, taken the size of data packet are 12000, 10000, 8000, 6000, 4000 & 2000 bytes then maximum numbers of rounds come 350, 372, 515, 567, 650, & 810 respectively. Investigations use the above equation (1) for CH's selection among the nodes and conventional radio model for LEACH of first order is considered. While doing simulation the size of packet data is taken 4000, 3000, 2000, & 1000 bytes then maximum number of rounds come 4000, 6000, 8000, & 18000 respectively. Simulation result shows that when packet size is 1000 bytes then nodes consume less energy & nodes have enough energy to survive for longer time period due to this the lifetime of Wireless Sensor Networks increases.

Case (B):-Varying position of Base Station (Sink)

Table 3.Simulation Parameter of LEACH protocol by varying position of BS

Typical Parameters	
Parameter	**Value**
Number of Node	100
Network Grid	100*100
$\mathcal{E}_{fs}$	10pJ /bit/m ^{2}
$\mathcal{E}_{amp}$	0.0013pJ /bit/m ^{4}
E_{elect}	50nJ/ bits
Maximum no. of rounds	5000
Size of data packet	4000 bytes
Probability of cluster Head	10%
Initial Energy	0.5 J
Varied Parameter	
Parameter	**Value**
BS Position	(50,50) , (50,75) , (50,100) , (50,150)

The (fig. 5.) represent the distribution of nodes in the network field. * denotes the position of BS. The position of BS is varying and it is taken at position (50, 50), (50, 75), (50, 100) & (50, 150).

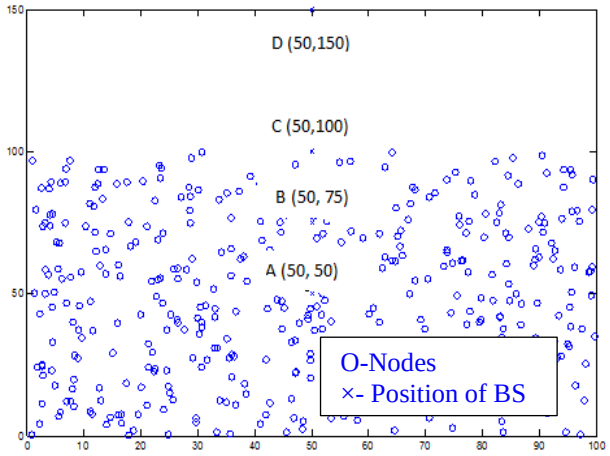

Fig. 5. Location of BS in Network Field with number of nodes 100

The (fig. 6.) states that as position of BS is varying from the middle position of network area then nodes starts dying at a rapid rate. As BS goes far away from the middle position of network area then number of round decreases due to the involvement of the path for data transmission is more. So a node starts dead at a faster rate because of decreasing the number of rounds in a Wireless Sensor Network. If the position of BS is set (50, 50), (50, 75), (50,100) & (50,150) then nodes start dead after going through 1500^{th}, 1000^{th} ,500^{th} & 0^{th} respectively. As shown (fig.7.**)** when the position of BS is located at center (50, 50) of network area then nodes remains alive for more number of rounds than the position of BS goes far away from center. Location of BS has influence on the lifetime and stability period of Wireless Sensor Networks. Stability period is high when BS is placed at the middle of network area and decreases as going far away from middle position. Lifetime of Wireless Sensor Networks increases due to nodes alive for longer time period. Position of BS is set (50, 50), (50, 75), (50, 100) & (50, 150) then nodes still alive at 4500^{th}, 4000^{th}, 3900^{th} & 3000th respectively.

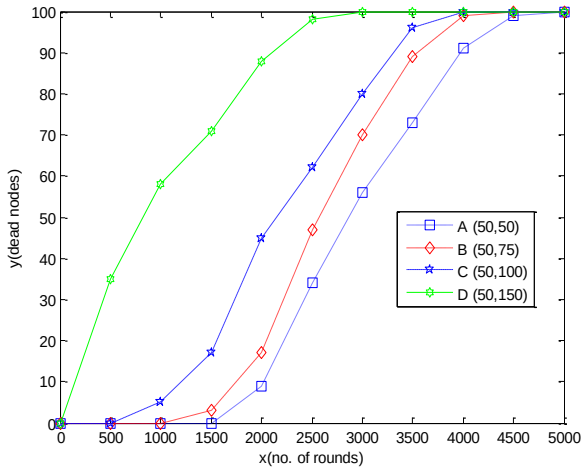

Fig. 6. Dead nodes versus number of rounds after varying the location of BS

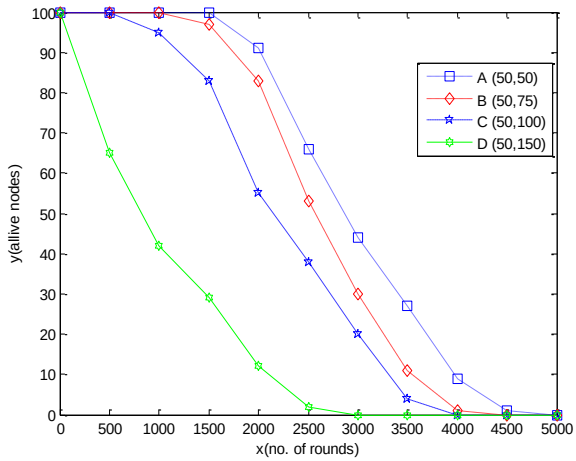

Fig. 7. Alive nodes versus number of rounds tell the network lifetime of system for varying the location of BS

It is observed from (fig.8.) that the data transmitted to BS decreases as the location of BS is varied from the middle position of network area. When the base station is set as center of network area, then the probability of becoming cluster heads is more as the BS is taken away from center position. More cluster heads will reduce the efficiency of data fusion and more data transmitted to BS.

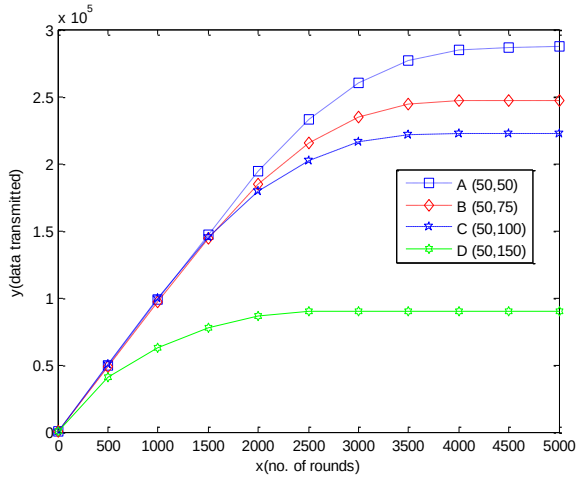

Fig. 8. Data transmitted to base station versus number of rounds for the different location of BS

Table 4.Simulation result by varying position of BS

Sr.No.	Coordinates of BS position	Rounds when nodes start dead	Nodes still alive at this round	Data transmitted to BS(Kbits)
A	(50,50)	1500^{th}	4500^{th}	250
B	(50,75)	1000^{th}	4000^{th}	200
C	(50,100)	500^{th}	3900^{th}	190
D	(50,150)	0^{th}	3000^{th}	70

The (fig.9.) depicts the counting of nodes that become cluster head after elapse so many rounds during each case of varying location of BS.

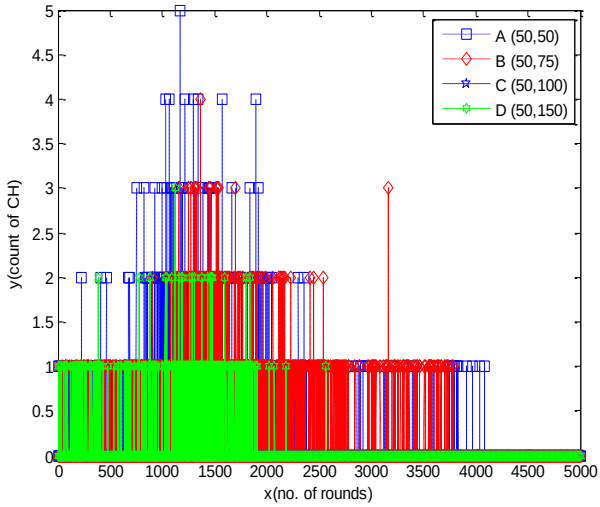

Fig. 9. Counting number of CH's versus number of rounds during various location of BS

From the Ref. [17] S Taruma and Sakshi Shringi, uses the above equation (5) for CH's selection among the nodes and calculating the energy consumption for transmitting /receiving H-bit data message for a given distance d is equation (6). The position of BS is set (50, 50), (50, 75), (50, 100), (50, 125) & (50, 150) then maximum number of rounds comes 1082,1049,1021,1001, & 902 respectively. Investigation uses the above equation (1) for CH's selection among the nodes and conventional radio model for LEACH of first order is considered & position of BS is set (50, 50), (50, 75), (50, 100) & (50, 150) then maximum numbers of rounds come 4400, 4000, 3900, & 3000 respectively. The work suggest that when the position of BS is set in the middle of network area then lifetime of network increases then the BS goes far away from the middle position.

IV. CONCLUSIONS

The paper investigates simulation parameter of LEACH protocol in first order radio model & explored the life time under the variation of size of data packet and location of BS. It is observed from simulation results that with increasing the size of data packet and with the location of BS taken away from middle position of network area maximum number of rounds reduce. Because of reducing number of rounds, the probability of becoming cluster heads is also reduced. Lesser the number of cluster heads then also less data is transmitted to BS. The investigations suggested that on decreasing the size of data packet i.e. 1000 bytes within same network grid & set the base station position is (50, 50) then network lifetime of system increases because of nodes consuming less energy and nodes starts dying after 6000th rounds & surviving at 17000th rounds. In future, scope of research will extend on improving the method of computing energy consumption by nodes and calculating the distance between cluster heads & BS, and also between cluster members & cluster heads to achieve longer lifetime of wireless sensor networks.

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