Energy Efficient Cluster Head Selection Using Optimized Round Policy in Distributed Wireless Sensor Networks

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Abstract- The clustering is the good technique to improve the lifetime and reduce the energy consumption of the sensor node in wireless sensor networks. Many clustering routing protocols choose the Cluster Head (CH) dynamically based on regular or fixed time interval. Due to this fixed time interval, unnecessary re-clustering is formed and CH rotates its responsibility to its cluster member (CM), which causes the routing overhead and more energy consumption. This type of round base policy used by many routing protocols like LEACH (Low Energy Adaptive Clustering Hierarchy) and HEED (Hybrid Energy Efficient Distributed). To solve the problem of re-clustering and route formation a novel protocol is proposed call as Optimized Round Policy (ORP) which select the CH on the basis of three parameters are residual energy, density and distance from the base station (BS). The simulation results demonstrate the improvement of the proposed protocol over the well-known clustering protocol like LEACH and HEED.

Keywords- *Clustering, Routing Protocol, Energy Efficiency, Wireless Sensor Network, Cluster Head*

I. INTRODUCTION

In many applications, the battery of sensor node is difficult to charge or replace, so this limitation moves for innovation in battery manufacturing and researchers are proposed new innovative protocol to elongate the battery life in the area of wireless sensor network (WSN). By optimum use of this limited energy of the sensor node to elongate the lifetime of the sensor network and avoid the early exhaustion of the sensor node.The optimum use of the battery can be achieved by the clustering protocol and this avoids energy dissipation due to overhearing, idle listening and collisions. The clusters are created in the network each sensor node is given a specific time to send data to the CH, so node need not awake all the time. This method avoids idle listening and overhearing. Therefore-clustering is a solution for every efficient wireless sensor network to extend the network life time [3, 5, 7].

In the clustering approach cluster Head (CH) consumes more energy than other nodes. To balance the energy consumed by CH round based policy (RBP) is used, the clustering task is schedules by dividing the time in fix length round. By rotating the responsibility of CH among the sensor node and periodic re-clustering is balance the network load but during the cluster formation overhead is created due to message exchange. Therefore to obtain the competent energy consumption model which increases network life time and improves in load balancing. We proposed a newly optimized round policy (ORP) protocol which addresses these issues. As far as very few researchers did the work on this scheduling policy.

II. RELATED WORK

In this section, we discussed the traditional well-known clustering approach and the recent clustering method.The first routing protocol by Wendi B. Heinzelmanuses the clustering for WSN called as LEACH. It is self-adaptive, well organized and hierarchical routing protocol. It forms the cluster among the network. On the basis of the residual energy of the node, it forms CH and that connect to the base station. The CH aggregates the data of all CM from its cluster and sends data to BS, but due to the homogenous network the energy of CH is drained out fast. LEACH uses TDMA technique to form a new cluster in periodic time. This also consumes more energy because re-clustering is done without its need. CH is responsible for data aggregation and fusion; and rotates its role and responsibility to the other node to balance energy consumption [1], [2]. However randomly selected the CH and cluster are not of the same size. It causes to decrease in network lifetime.

$$T(n) = \begin{cases} \frac{p}{1-P*(r \bmod (\frac{1}{p})} & if\ n \in G \\ 0 & otherwise \end{cases}$$

Where, P is the percentage to become CH among all sensor nodes in the network, ‘r’ is current round and ‘G’ is node that are not in selection procedure as CH in previous 1/p round.

The improved version of LEACH is HEED by using the primary and secondary parameter to mitigate the problem of energy consumption and random distribution.To select as CH, with the primary parameter as the residual energy of the node and more residual energy will have higher chances to become a CH. When a node is in the communication range of two CH, the secondary parameter coming to picture and that depends

on neighbor proximity or cluster density. The overhead can be reduced for multi or single hop network by clustering. CH can select by periodic re-clustering with a node having higher residual energy [4].

The CH selection depends on the primary and secondary parameter. Each node set its probability of becoming a CH as follow:

$$CH_{prob}(i) = C_{prob}\frac{E_{re}(i)}{E_{maxi}}$$

Where, E_{re} (i) is the node current estimated energy,E_{maxi} is the all node initial energy which is the same as a fully charged node.

In [12], Proposed Hexagonal Sectored Shortest Path Routing Algorithm(HSSPRA), It forms the clusters with different nodes from different sectors so that non cluster node can join the nearest CH of any cluster. That results less energy consumption in transmission and increase energy efficiency. With the help of weight equation CH selection is done by considering the remaining energy and degree of the node.

In [13], the authors proposed LCM to form a consistent path with a load balancing. On the basis of link quality and node residual energy, CHs are selected. The mechanism of clustering called predicted transmission count depends on priority and nodes with the highest priority are selected as CHs. Unbalance cluster size is the limitation of LCM.

In [14], author proposed the cluster based routing protocol by generating the typical path to select the cluster head. To form intra and inter cluster reliable data communication they proposed the multi hop routing protocol. To increase the network life time sensor node are uniformly distributed in clusters.

In [15], SrinivasKanakala et.al presented the novel energy-efficient coding-aware cluster based routing protocol (ECCRP) it reduce the no of packet transmission by using network coding , ultimately it reduce the energy consumption which is proportional to packet transmission.ECCRP scheme is applied at the cluster head selection to increase the network lifetime.

III. OUR CONTRIBUTION

The proposed protocol avoids unnecessary re-clustering like in round based policy. After each round algorithm checks the three parameters like residual energy, density and distance from BS to form the new CH. This protocol is more effective and improves the performance than two states of art WSN routing protocol LEACH and HEED. It focused on achieving low clustering, overhead, and improving the lifetime of the network by reducing power consumption.

IV. METHODOLOGY

The clustering is a better solution to increase the network lifetime and CH selection and it depends on the residual energy of the node. However unnecessary re-clustering is done to choose CH using round based policy causes the communication overhead and reduce the energy efficiency. In the proposed protocol, selection of CH depends on not only on the residual energy of node but also on density and distance from the base station. This additional parameter has improved the reliability, load balancing among the sensor network. In clustering CH can be selected on the basis of density, distance from base station, node mobility, residual energy, computing power of node etc. These parameters influence the energy efficiency, therefore, to take an appropriate parameter to select CH rather than only residual energy parameter.

Optimal hyper round (OHR) consist of many rounds with the idle condition. The length of the Optimum round is integer multiple of rounds and that depends on node condition. At beginning of OHR re-clustering is done and in next successive round, no need of re-clustering until the residual energy, distance from BS and density of any CH is less than Ethr. The length of OHR is long when all nodes have high energy, as node energy is decreased the length of OHR is also decreasing that affect the load balancing of network and re-clustering is done in the shorter period of time.

After CH selection stage each CM send the message to respective CH to join message as CMjoinalong with current residual energy. The average of CMs residual energy can compute by respective CH.

Threshold energy Ethr for each CH can be determined by,

$E_{thr} = RF * P_{CM}$

Where PCM average of CMs residual energy and RF is a re-clustering factor and it depends on the application requirement, $0 \leq RF \leq 1$.

After cluster formation, the CH check it's all three parameters as mentioned above if these are less than Ethr then CH broadcast the re-clustering task scheduling message to their nearby CHs and then they forward broadcasted message for the entire network. Once message received by CH, it updates its CMs to hold the setup phase incoming round. Re-clustering is performing under special event rather than fixed time interval. The setup phase is split into four stages: 1) CH selection; 2) CM join; 3) CH schedules, and 4) route discovery stage and in each stage energy is consumed. In CH selection stage, CH is selected at the starting of the setup phase. In CM Join stage every sensor node sends a CM_{join} message to its corresponding CH. After that, each CH sends a schedule message to its respective CMs in CH schedule stage. Last stage Rout discovery occurs in the worst condition. Average energy consumed in setup phase Esetup is,

$E_{setup} = E_{CH\_sel} + E_{CM\_join} + E_{CH\_sch} + E_{Route\_Dis}$

Where, E_{CH_sel},E_{CM_join} , $E_{CH_sch}$and E_{Route_Dis} average energy consumed inthe first, second, third and fourth stage of setup phase respectively.

The total energy consumed in steady phase $E_{stdy}$is,

$$E_{stdy} = E_{frame} + N_{frame}$$

Where, E_{frame} and N_{frame} are energy spend in network frame and a number of frames in one round of steady phase respectively.

V. PERFORMANCE EVALUATIONS

Our proposed protocol is improved the energy efficiency by comparing the parameter like network lifetime, throughput, packet delivery ratio and energy consumption.

All routing protocol is simulated using NS2 and evaluate the performance of LEACH, HEED and propose ORP protocol. The Simulation parameters are listed in table 1. To claim the network life time enhancement we evaluate LEACH, HEED and ORP with four performance matrix are average energy consumption, network lifetime, throughput and packet delivery ratio (PDR). The sensor nodes are placed randomly in area of 200 * 200 meter square, with varying node from 30 to 240 and simulation time is 30sec.

Table 1: Simulation Parameter

Parameter	Values
Monitor Region	(200, 200)
Node number	30 - 240
Routing protocol	LEACH, HEED and ORP
MAC	IEEE 820.11
Propagation model	Two- Ray Ground
Packet length	512 kbps
Data rate	1Mbps
Simulation time	30 Sec
Initial energy of each node	20.1 Jules
Transmission energy	0.660 J/bit
Reception energy	0.395 J/bit

VI. RESULTS

We executed each protocol at different node value. The readings from these eight trials were there averaged and plotted. A lower value of energy dissipation and higher no. of nodes alive indicates a more efficient protocol. This because of the task of re-clustering is performed in more effective than the LEACH and HEED. The proposed routing protocol performed the re-clustering on the basis of three parameters as we discussed earlier.

Figure 1 and 2 shows the energy consumption and network life with increasing the number of nodes, as no. of nodes increases the energy consumption decreases because of more no. of nodes are in sleep or idle mode and fewer nodes are involved in data transmission. Average energy consumption and network lifetime performance show the significantly increased the energy efficiency using ORP.

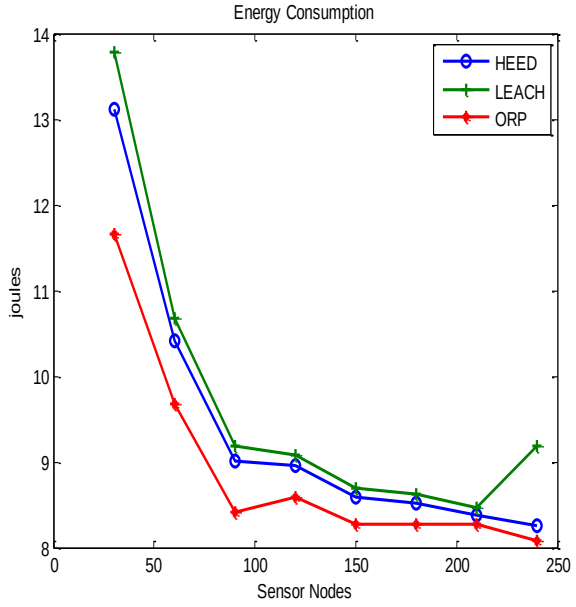

Fig.1: Average energy consumption

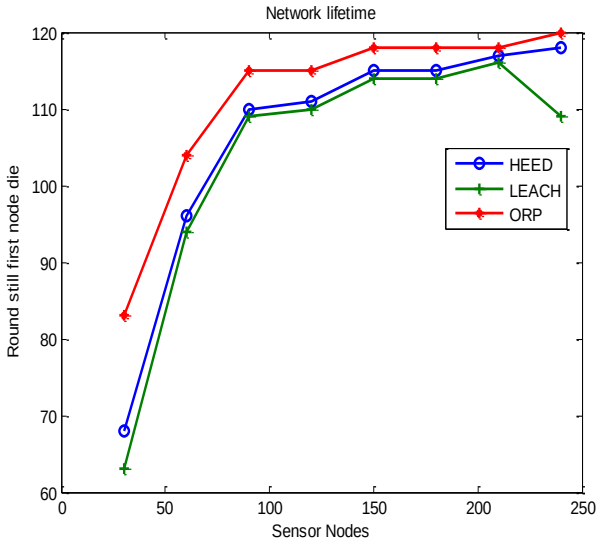

Fig.2: Network Lifetime

The objective of this paper is to propose the optimum design routing protocol which consumed less energy and good quality of Service (QoS). Figure 3 and 4 shows the simulated result for through put and PDR shows the improved QoS as compared with well-known protocol HEED and LEACH because routing is performed on the basis of a distance from BS and no of neighbor to transmit the data towards the sink node.

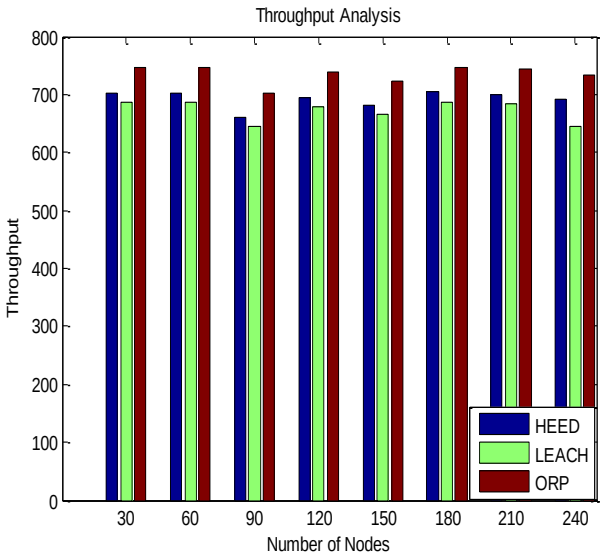

Fig.3: Average through put performance

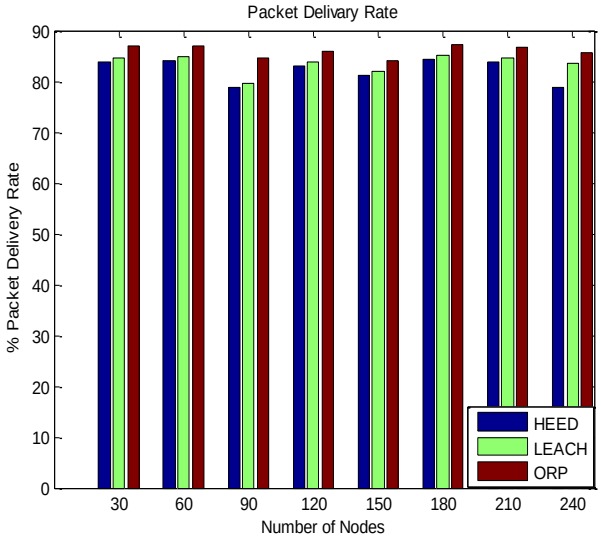

Fig.4: PDR performance

VII. CONCLUSION AND FUTURE WORK

In this paper, the main objective is to improve energy efficiency and network lifetime. The performance of the proposed process is measured in terms of average energy consumption, network life, through put and PDR. The experimental result of proposed techniques performs the improve results than the state of art routing protocol when compared. By adding some more parameter to select the CH and some optimization techniques for path selection of data transmission is a future work.

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