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A Novel Energy Efficient Distributed Clustering in Wireless Sensor Networks

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ABSTRACT
Under increased level of traffic, Hot spots emerge in a wireless sensor network. This leads to the depletion of network resources and disrupts the network operation completely. This scenario is high in the case of clustering process as cluster heads perform more data processing than other sensor nodes. This increase in load on Cluster Head (CH) varies with the distance to the sink. To eliminate this problem, data aggregation can be performed to reduce the processing and transmission of information. This approach works well in static environment but it is complex and expensive in the case of dynamic network. So the role of Cluster head is rotated among the different nodes in the network, thus balancing the load and conserves the important resources. The size of the cluster based on the distance or number of hops to the sink is also taken into consideration. This paper focuses on distributed clustering with multi hop routing to minimize the energy consumption, average end-to-end delay and improving network lifetime compared LEACH.

Keywords – Clustering, Cluster Head, Energy Efficiency, Wireless Sensor Networks.

I. INTRODUCTION
With resource-constrained Wireless Sensor Networks, effective use of these battery operated resources is a challenging task nowadays in the developing IT field. Though many clustering techniques like hierarchical exists, need is to find an optimal energy-efficient clustering mechanism that uses the limited resources in an efficient manner.

The cluster Head acts as the local controller in the scalable network for the process of data collection, data forwarding and performs aggregation functions. Each Cluster is formed based on the coherence between the set of nodes or having minimum distance between them. The one having the high processing power is chosen as the cluster head and it performs tasks like grouping, secrecy and allocation of tasks. It also controls various events like failure recovery and node movements. Various functions such as load sharing, membership abilities and inter-cluster establishment are assigned to nodes through inter-cluster links.

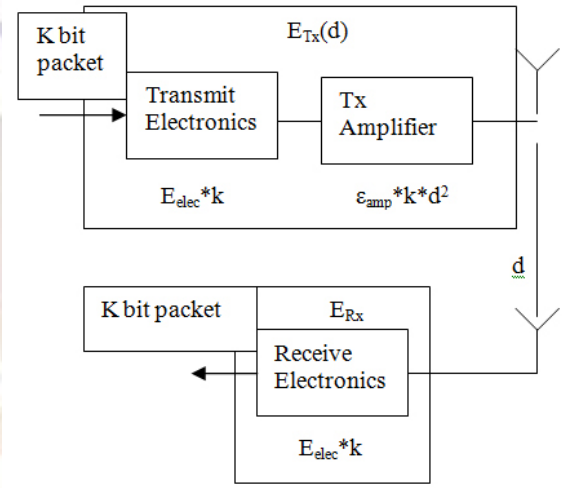

Fig.1 Energy Consumption Model

Dynamic allocation of heavy traffic and other functions of CH to different nodes help to prevent failure of nodes in case of resource depletion. In clustered environment, Hot-spots are an important site to take into account as the data is highly congested near to sink. So in distributed with multi hop routing critical location must be concentrated by transmitting the data through multiple high rate routes. Thus network lifetime is improved by reducing failures because of depletion of energy.

Hot –spot is an important site where all data are collected. As the distance to sink decreases, the amount of traffic on the nodes exaggerates. This correlation is to be studied mathematically to build a balanced network. For this, route establishment, route maintenance and other procedures have to be taken into consideration to know about energy depletion of each node. In our proposed work, load sharing, distributed, and energy-aware clustering with multi hop routing algorithm is used. Energy efficient clustering determines the cluster sizes based on the number of hops to the sink node. After choosing the cluster heads, this algorithm performs the efficient clustering balancing both traffic and complexity. Performance is achieved with multi hop network design reducing overhead and improving the network lifetime.

In the remainder of this paper, reviews of the related works are briefly discussed on clustered network and their drawbacks in Section II. Section III presents the distributed clustering with multi hop routing algorithm and the calculation of its energy consumption levels. Then, Section IV dealt with the performance evaluation compared with LEACH. Finally, Section V concludes the discussion.

II. REVIEW OF RELATED WORKS

In WSNs, Clustering is an efficient technique to analyze and control the information in the network. Of which heavy traffic on the cluster head is a critical concern. To balance the load, Cluster Head is frequently rotated between different nodes in the network as indicated in LEACH. But it causes increase in transmission cost due to long distance as all nodes transmits the information directly to the sink. Due to this, the nodes that are far from the sink has high depletion rate than the nodes nearer. For this problem, EECS selects less number of nodes been far to sink. Even though energy depletion is not minimized due to single hop transmissions and scalability is not assured for large networks. In HEED , Cluster Head is selected based on the maximum energy it possesses and multi hop inter cluster communication is adopted, thus reducing the transmission cost of longer distance. With small cluster size, the traffic on individual cluster head is reduced distributing traffic among different clusters near to sink. This approach too has issues like overhead due to more number of clusters and control packets used for inter cluster communication. This again results in heavy traffic than the original message traffic. Therefore, considering the variability in traffic at different parts of the network, an analytical discussion is to be carried to remove the imbalance between inter and intra clustering energy utilization. In UCR and PEBECS , informing the formation of cluster throughout the network cause wastage in the energy available and also limited to small networks. So there requires a need to develop an energy-efficient clustering with multi hop routing protocol to reduce the control overheads and to eliminate broadcasting to all the nodes in the network. This protocol is designed in such a way to compromise between distance from the cluster nodes to the sink and the size of the clusters.

III. PROPOSED SCHEME

In WSN, Energy efficient clustering with multi hop routing is implemented in distributed environment by data collection processes like energy level equalization, hop distance towards sink and certain tradeoffs as discussed above.

3.1 Cluster Head Selection

At the starting of the data collection process, cluster is formed by electing the cluster head among the whole set of candidates that are grouped under each cluster and associating node with the cluster head.

Probability measure is used to determine the candidates for each cluster head for different clusters. Each node in the sensor network will decide to become as the candidate. Normally scaled down value S for probability P_K is chosen as the ratio of initial energy E_i to the average initial energy of the network E_{iavg}. $P_k=S\ (E_i / E_{iavg})$ for a node k in region R_m. After the network parameters initialization, this probability value is calculated only once. Each node k selects a random value on the interval 0 to 1 at the beginning of each data collection process. The node is selected as the CH candidate when the node value is lesser than the calculated probability P_k. Thus each sensor node is compared with the measure to elect as the candidates for the CH. To obtain accurate measure, residual energy can be used instead of initial energy at the expense of increased message overhead or complexity of the network. By this approach, the chance of being selected as the candidate is directly proportional to the initial energy levels. Therefore energy consumption is reduced by avoiding the message overheads for broadcasting and additional circuits for monitoring the status of each node.

Each selected candidate sends the broadcast packet indicating their residual energy to the candidates residing within the radius of r_m which is calculated from the clustering algorithm. On receiving the broadcast packets, each candidate leaves the selection process if the higher residual energy is received compared to them. Thus the CH is chosen among the candidates.

3.2 Cluster Formation

To have knowledge of the presence of CH by all other non-CH nodes, announcement packet is transmitted by the node having high residual energy within the radius αr_m. Region-wide broadcast is done to confirm the reception of availability packets by all other non-CH nodes. This causes additional transmission cost. In order to avoid this, α is chosen to have high probability of association between CH and its candidates. The number of CH nodes in each region can be modeled using poisson distribution is given by $\exp(p_m \pi \alpha^2 r^2_m)$ in region R_m . To have high association between the CH and non-CH nodes, probability value is chosen as 99%.When multiplied with the distribution probability, minimum value of α is selected to reduce transmission cost.

After the gathering all the announcement packets from the all CH nodes by the candidate nodes, CH is chosen by candidates in each cluster based on the highest residual energy that CH possess. Each cluster selects the CH which is nearest to it within the transmission range. This association happens by sending request and reply messages by candidates and CH nodes respectively.

There may be nodes which do not joined in any of the clusters due to missing of announcement packets at the end of the cluster formation stage. To have association with the closest CH, the algorithm extends the transmission range of those nodes to recover from the node isolation problem. Among n number of nodes in wireless sensor networks, for selection of candidates' nS messages are needed, where S is the scaled down value of probability of initial energy of the nodes in the network. For the CH selection, totally K messages are needed, where K is the number of CH sending the announcement messages.

3.3 Inter-cluster routing in Distributed clustered environment

The aim of the routing algorithm is to minimize the message and circuit overheads required for the selection of candidates, cluster heads ,cluster formation and their association before the actual message transmission begins and compromise the energy wastage among the nodes in the network or between the clusters.

To solve these issues, CH in region R_m take its next hop to the sink through the nodes in region R_{m-1} The received nodes make reply based on the timer it set. The timeout for replying is inversely proportional to the residual energy of individual nodes. Thus the node having highest residual energy will timeout sooner sends the reply back to the CH first. When hearing this reply packet, remaining nodes resets its timer. By this, both overhead and energy wastage is reduced.

IV. PERFORMANCE EVALUATION

In this section, the performance of our E2DC is compared with LEACH. The parameters of simulations are listed in Tabel.1, and the parameters of the radio model are the same as LEACH.

Tabel.1 Simulation Parameters

Parameters	Value
Network Size	100m x 100m
Number of Nodes	100
Initial energy	2 J
Eelec	50 nJ/bit
	5 nJ
EDA	25 bytes
Packet size	

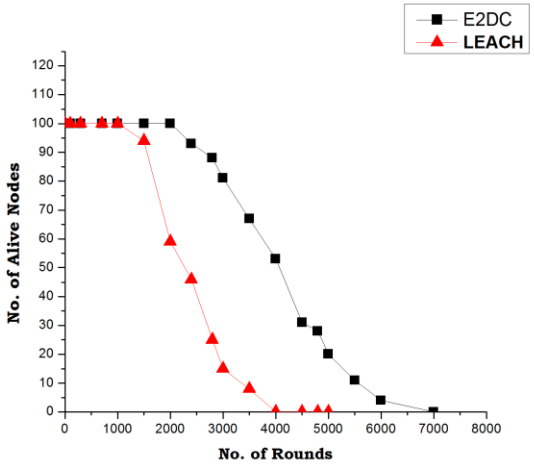

Fig.2 Comparison of Network Lifetime

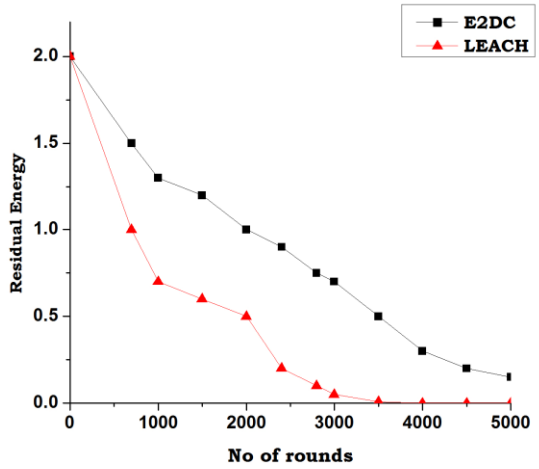

Fig.3 Average Residual Energy vs No. of Rounds

V. CONCLUSION

In this paper, we present a novel distributed, energy efficient clustering scheme applied for periodical data gathering. E2DC produces a uniform distribution of cluster heads across the network through localized communication with little overhead. The results are better compared to LEACH. Simulation results show that E2DC prolongs the network lifetime and the total energy is efficiently consumed. All of our contributions here are focused on the cluster set-up stage. There are still much space to improve the performance of data transmission. In the large scale sensor networks, multi-hop communication is a mainstream technique for energy saving.

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