Balanced K Means Based Clustering Algorithm for Energy Efficient in Wireless Sensor Networks

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***Abstract*-In wireless sensor networks, technology has provided the availability of small and low-cost sensor nodes with capability of sensing various types of physical and environmental conditions. Clustering is an important and widely used method, which can prolong the lifecycle of wireless sensor network. Existing clustering algorithm does not assure the maximum prolongation of the overall network lifetime. To address the above issues, this paper presents a balanced k-means protocol on the basis of space equivalent distribution and energy equivalent distribution. The simulation result shows that balanced k-means is more effective in prolonging the network life time compared to LEACH[1], LEACH-C[2] and LEACH K-Means[3].**
***Keywords*-LEACH, cluster head, Balanced K-Means**

I. INTRODUCTION

In wireless sensor networks, the tiny, low cost and low power sensors are able to communicate within a short range and work together to form a sensor network for gathering data from a field. These sensors have data processing and communication capabilities. They also have enabled us to monitor and collect data in any environment. They sense the condition in which they are surrounded and transform their data to electronic signals. The electronic signals are transmitted over radio waves to the base station (BS).

Wireless sensors networks routing protocols can be divided into flat and hierarchical routing protocols according to the topology of network. LEACH (Low Energy Adaptive Clustering Hierarchy) is the simplest hierarchical protocol which possess clustering approach. LEACH is a protocol that tends to reduce energy consumption in a wireless sensor network. Clustering is the main factor responsible for energy conservation in LEACH algorithm. Main objective of clustering are equal distribution of energy and equal distribution of nodes in space so that less energy is consumed and early death of nodes can be delayed[4]. In LEACH both of these objectives cannot be achieved.

According to the deficiency of the LEACH,Max-Energy LEACH and LEACH K-Means are almost improved based on the LEACH agreement. Among them LEACH K-Means algorithm improves the performance of network by the optimal number of cluster head and the mechanism of cluster head selection, making node energy consumption reduced and extending the network life cycle. This simulation result shows that LEACH K-Means have obvious advantage over LEACH and MAX-Energy LEACH agreement in overall performance but LEACH K-means has a problem as it can have unbalanced number of nodes in cluster. On the basis of clustering algorithm LEACH, this paper put forward a clustering routing algorithm Balanced K-Means based on re-electing cluster head method for balancing local clusters and uses the information which the cluster head have. This is called balanced energy based clustering.

II. LEACH PROTOCOL

Low Energy Adaptive Clustering Hierarchy (LEACH) first proposed by Wendi.B.Heinzelman of MIT is a clustering based protocol that utilizes randomized rotation of local cluster to evenly distribute the energy load among the sensors in the network[1]. The LEACH uses localized coordination to enable scalability and robustness for dynamic networks. LEACH incorporates data fusion into the routing protocol to reduce the amount of information that must be transmitted to base station. It rearrange the network clustering dynamically and periodically, making it difficult for us to rely on long lasting node to node trust relationship to make the protocol secure. LEACH assumes every node can directly reach a base station by transmitting with sufficiently high power. We have chosen four algorithms for clustering purpose in WSN routing in our experimentations. These are LEACH, LEACH-C, K-Means LEACH and balanced K-Means LEACH. These are explained as below:

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A. LEACH

LEACH comprises of 2 phases:- Set-Up Phase and Steady State Phase

(i)Set-Up Phase

At the beginning every single node computes a random number between 0 and 1, and then computes a threshold formula T(n). If the random number is less than the computed threshold the node becomes a cluster head. After its selection each cluster head will broadcast an advertisement message to the rest of the nodes by using CSMA MAC protocol. After that each node selects a cluster head based on the Received Signal Strength Indication (RSSI) of the advertisement. Each node uses CSMA MAC protocol to transmit its selection. Clusters are formed, each cluster head creates a TDMA schedule according to number of nodes in the cluster. Each node during its allocated transmission time.

(ii) Steady State Phase

Each sensor node senses and transmits data to its cluster head based on the TDMA schedule. The cluster heads receive all the data aggregate it and sends it to the base station. After transmission that network starts next round and again execute the setup and steady state phase

B. LEACH-C

(i) Set Up Phase

During the set-up phase, each node sends information about its current location using a GPS receiver and energy level to the base station. Along with determining good cluster, the base station needs to ensure that the energy node is evenly distributed among all the nodes. Base station computes the average node energy, and whichever node has energy below this energy cannot be the cluster head for the current round. Using the remaining node as possible cluster heads, the base station finds optimal cluster itself. Once the cluster heads and associated clusters are found, the base station broadcasts a message that contains the cluster head ID for each node. If a node cluster head ID matches its own ID, the node determines its TDMA slot for data transmission and goes to sleep until it is time to transmit data.

C. LEACH K-MEANS

(i) Set-Up Phase

In set up phase, it first chooses k nodes as K clusters. Then assign other nodes to these clusters. It then calculates the every node's cost. Node having the smallest cost is selected as cluster head. This cycle doesn't stop until K-cluster heads fix down.

(ii) Steady State Phase

When node is selected as cluster head, the cluster broadcast the signal (Advertisement message,ADV) to the other nodes. Each node receive ADV from different cluster heads, according to the strength of the signal, it chooses to join proper cluster, and rely to the corresponding cluster head. The cluster head receives the joining information, producing a TDMA schedule .The cluster head receives data from members of cluster, and transmits to base station after merging into a packet. After data transmission, the network chooses the cluster head again.

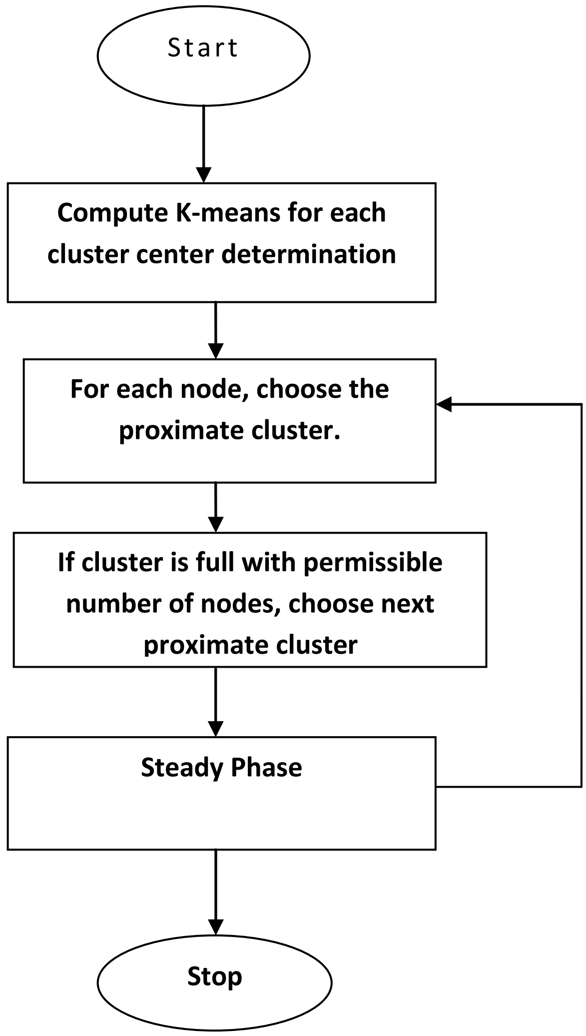

Figure 1. Flow graph for Balanced K-Means Algorithm

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D. PROPOSED PROTOCOL(BALANCED K-MEANS)

(i) Set Up Phase

During set up phase, the sensor nodes are divided equally into clusters which are selected by K-Means. Depending on the size of the network and number of sensor nodes, the sensor nodes can be equally divided into n numbers of clusters while selected cluster by each node if in a cluster number of nodes exceed than the maximum permissible node than they choose another cluster.

(ii) Steady State Phase

Proposed protocol's steady state phase is identical to that of LEACH-KMEANS.

Table 1 Comparisons of LEACH, LEACH-C, LEACH-KMEANS and Proposed Protocol

Name of the Protocol	Organization of clusters	Distribution
LEACH	First Cluster Heads are chosen, then cluster are formed.	Random and Distribution
LEACH-C	Clusters and Cluster Heads are chosen by the Base Station	Centralised and fixed Distribution
LEACH-KMEANS	First, Clusters are made, then Cluster Heads are chosen.	Random Distribution
Modified LEACH	First, Cluster Heads are chosen, then cluster are formed.	Even Distribution

III. EXPERIMENTATION SETUP AND SIMULATION

(i) Experimental Setup

To simulate LEACH, we have used random 200 nodes network for our simulation with parameters used in[3]. We placed the base station at a far distance from all the nodes. For a 50×50 plot, our base station is located at(50,200) so that the base station is at least 100m from the closest sensor node. All the nodes in the network have limited energy and homogenous. The initial energy of all the nodes are same.

(ii) Energy Model for LEACH

This paper adopts the same energy consumption model of[5].In the process of transmission k through long distance d, the energy consumption of the sending end is:

$$E_{TX}(k,d)=\begin{cases} k*\left(E_{elec}+\varepsilon_{fs}d^2\right) d<d_o \\ k*\left(E_{elec}+\varepsilon_{amp}d^4\right)_, d\geq d_o \end{cases} \quad (1)$$

The receiving energy consumption of receiving k data is:

$$E_{Rx}(k)=k*E_{elec} \quad (2)$$

In(1), E_{elec} is the power consumption of sending and receiving, decided by the circuit itself.If the transmission distance is less than threshold d_o, the power amplifier ε_{fs} of free space model is adopted. Conversely, when the transmission distance is equal or greater than the value, the power amplifier ε_{amp} of multi path attenuation model is adopted.

$$d_o=\sqrt{\frac{\varepsilon_{fs}}{\varepsilon_{amp}}} \quad (3)$$

In[5], node energy consumption of computing is far less than energy consumption of data transmission, so in this paper we ignore node calculation energy consumption.

(iii) Parameter Selection For Simulation

Following table presents the list of parameter required for the simulation of LEACH with encryption strategies.

Table 2: Simulation Parameter

Network Architecture	
Parameter	**Value**
Network size	50x50 m
No. of nodes	200
Base Station (BS)	25, 200
Initial energy of node	0.5 J
d_0	87.7 m
Energy for transferring of each bit (ETX)	50e-9 J
Energy for receiving of each bit (ETX)	50e-9 J
Data Aggregation Energy (EDA)	5e-9 J
Packet length (number of bits in packet sent from CH to BS)	6400 Bit
ctrPacketLength (number of bits in packet sent from node to CH)	200 Bit
Power amplifier of Free space(Efs)	1.0e-11 J
Power amplifier of Multi Path (Emp)	1.3e-15 J

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IV SIMULATION RESULTS AND ANALYSIS

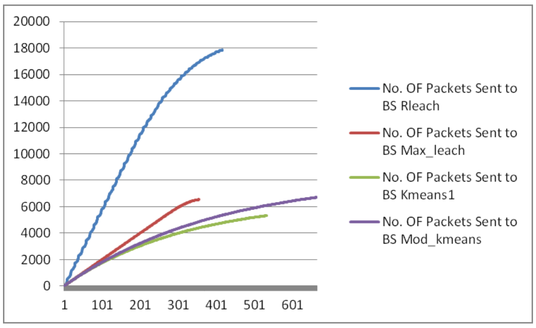
Following table shows the result obtained from the experimentation done as per the setup. The performance of the proposed protocol is evaluated and compared with existing LEACH,MAX-LEACH and LEACH-K Means in terms of number of rounds, packet sent to the base station, energy and number of nodes.

Table 3: Simulation Results

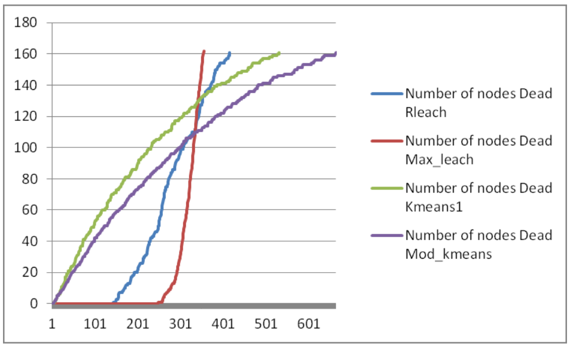
Name of the Protocol	Round	Packet to BS	Energy	Dead nodes	
				Node	Round
Modified LEACH-KMEANS	664	6701	Start: 20	1^{st}	6
			End: 2.27	50^{th}	297
				80^{th}	664
LEACH-KMEANS	534	5322	Start: 20	1^{st}	6
			End: 6.02	50^{th}	232
				80^{th}	534
MAX_ LEACH	355	6538	Start: 20	1^{st}	248
			End: 2.59	50^{th}	355
LEACH	418	17757	Start: 20	1^{st}	144
			End: 3.38	50^{th}	337
				80^{th}	418

In above table 3 and graphs, it is clearly shown that modified K-means perform far better as compared to random LEACH and MAX_LEACH and marginally better than K-means as compared to for each and every criterion except number of packets sent to BS. The balanced K-means algorithm performs nearly two times better than random LEACH and MAX_LEACH and as compared to K-means LEACH performance is nearly 20%.

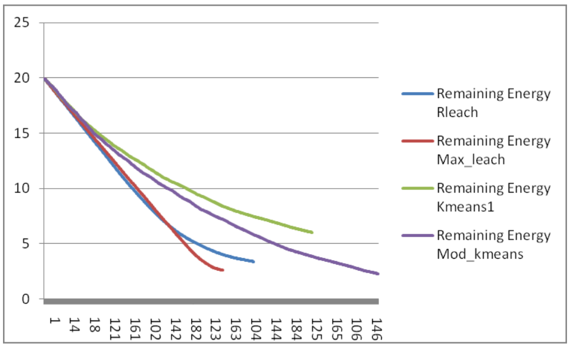
If we consider a network, dead if 50% nodes are dead then LEACH and MAX_LEACH are performing better than k-means based LEACH but they survive longer time as a whole. Random LEACH has performed worst in energy and dead nodes criterion. If we consider 80% node criterion for network life then again k-means based LEACH perform better than other two algorithms. If we compare the number of dead nodes as per our simulation results MAX_LEACH and performs better, but there nodes once start dying accelerates network decay very fast We have shown this statistics in the following graph 1 to 3.LEACH and MAX_LEACH and marginally better than k-means as compared to for each and every criterion except the number of packet sent to base station.



Graph 1 Comparison of four algorithms for no of packets sent to BS Vs No. of Rounds.



Graph 2 Comparison of four algorithms for Residual Energy Vs No. of Rounds



Graph.3 Comparison of four algorithms for no of dead nodes Vs No. of Rounds

The balanced k-means algorithm performs nearly two times better than random LEACH and MAX_LEACH and as compared to K-MEANS performance is nearly 20%. In these graphs,it is clearly shown that modified k-means perform for

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better as compared to random. If we consider no of packets sent to BS then the LEACH is clear winner. Later has sent highest number of packets to BS. This may be due to uneven and large number of cluster formation. Large numbers of clusters are not desired but a fair amount of data is desired in which balanced k-means seems to perform better.

V CONCLUSION

In this paper, we put forward an improved routing algorithm Balanced K-Means. This algorithm improve the performance by making equi-distribution of space in the nodes for better clustering in k-means and balancing of cluster loads have increased the energy efficiency by increasing the numbers of rounds .The simulation results show that Balanced k-means have obvious advantages over LEACH,MAX-LEACH and LEACH-K Means in overall performance.

VI REFERENCES

[1] Stefanos, A. N., Dionisis, K., Dimitrios, D. V. and Christos D. (2013), “Energy Efficient Routing in Wireless Sensor Networks Through Balanced Clustering”, Algorithm, 6, 29-42.

[2] Heinzelman, W. B., Chandrakasan, A. P. and Balakrishnan, H. (2002), “An application-specific protocol architecture for wireless micros sensor networks”. IEEE Transactions on Wireless Communications, Vol. 1, Issue 4, pp. 660-670.

[3] Park, G. Y., Kim, H., Jeong, H. W. and Youn, H.Y. (2013), “A Novel Cluster Head Selection Method based on K-Means Algorithm for Energy Efficient Wireless Sensor Network”, 27th International Conference on Advanced Information Networking and Applications Workshops, pp. 910-915.

[4] Yunjie, J., Ming, L., Song, Z. and Pengtao, D. (2012), “A clustering routing algorithm based on energy and distance in WSN”, International Conference on Computer Distributed Control and Intelligent Environmental Monitoring, pp. 9-12

[5] Natarajan, M., Arthi, R. and Murugan, K. (2013), “Energy Aware Optimal Cluster Head Selection in Wireless Sensor Networks”, 4th ICCCNT, pp.

[6] Ahmed, A., Qazi, S. (2013), “Cluster Head Selection Algorithm for Mobile Wireless Sensor Networks”, International Conference on Open Source Systems and Technologies, pp. 120-125.

[7] Anitha, R. U., Kamalakkannan, P. (2013), “Energy Efficient Cluster Head Selection Algorithm in Mobile Wireless Sensor Networks”, International Conference on Computer Communication and Informatics, pp

[8] Ran, G.,Zhang, H. and Gong, S. (2010), “Improving on LEACH Protocol of Wireless Sensor Networks Using Fuzzy Logic”, Journal of Information & Computational Science, Vol. 7, Issue 3, pp. 767–775.

[9] Ahlawat, A., Malik, V. (2013), “An extended vice-cluster selection approach to improve v leach protocol in wsn”, Third International Conference on Advanced Computing & Communication Technologies, pp. 236-240.

[10] Firuzbakht, A. R., Bouyer, A. (2013), “An optimal Algorithm based on gridding and clustering for decrease energy consumption in WSN”, MIPRO, pp. 474-478

[11] Rahmanian, A., Omranpour, H., Akbari, M. and Raahemifar, K. (2011), “Novel genetic algorithm in Max_LEACHrouting protocol for sensor networks”, IEEE CCECE, pp. 1096-1100

[12] Shi, S., Liu, X. and Gu X. (2012), “An Energy-Efficiency Optimized MAX_LEACH for Wireless Sensor Networks”, 7th International ICST Conference on Communications and Networking, pp. 487-492.

[13] Raj, E. D. (2012), “An Efficient Cluster Head Selection Algorithm for Wireless Sensor Networks –Edrleach”, IOSR Journal of Computer Engineering, Vol. 2, Issue 2, pp. 39-44.

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