Chapter 6

Location Aware Cluster Based Routing Algorithm (Proposed) in Wireless Sensor Network

6.1 Introduction:

WSN is considered to be one of the most important technologies of the twenty-first century. WSN is a collection of sensor nodes, capable of collecting information from their environment. It consists of hundreds and thousands of unattended, resource-constraint and low–energy sensor nodes. Scheming of energy efficient routing protocols is significantly important in WSN. Design of an energy efficient and reliable routing protocols for mobility centric applications of WSN such as wildlife monitoring, battlefield surveillance and health monitoring is a great challenge because of the frequent changes in topology of the network. Clustering-based routing protocols has proven to be more useful in the context of energy efficiency where several sensor nodes in the communication range of one another form a cluster. Each cluster in WSN has a cluster head (CH), which coordinates all the nodes of a cluster. In WSN there may be a number of base stations (BS) also known as sink that communicate with other networks.

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http://ijcsn.org/IJCSN-2015/4-5/A-Study-and-Performance-Analysis-of-LEACH-and-LACBRP-Routing-Scheme-in-Wireless-Sensor-Network.pdf ##

The function of CH is to aggregate the data that are received from all member nodes of a cluster and sends to the BS. Apart from CH, there exist gateway nodes in a cluster that are used for inter-cluster communications. Hence, clustering protocols consume less amount energy by producing limited useful information from large amount of raw sensed data and transmitting this precise useful information to the BS of the network [90, 91]. WSNs are extensively being used in different environments to perform various monitoring tasks such as search, rescue, disaster relief, target tracking and a number of tasks in smart environments. In many such tasks, clustering is one of the fundamental challenge.

Clustering of the sensor nodes are formed by knowing the location of a sensor node, based on the highest energy and least distance. In the cluster of nodes, one node is selected as a cluster head (CH). Cluster head is formed to avoid communication over head between the sensor nodes. Clustering of nodes shows that the network is more stable and efficient. Clustering also increases the overall network lifetime and reduces traffic of the network. Each node in a cluster can directly communicate with their Cluster head. The Cluster head can forward the sensed information to the Base station (BS) through other Cluster heads.

Sensor nodes are mainly battery-constrained and inexpensive nodes. They have limited communication, processing and memory storage resources. An individual sensor node can act as a cluster head or a cluster member. The cluster member can directly communicate with its cluster head. However, there is no communication between sensors. In other words, there is single-hop communication between a node and the CH. Further, the Cluster heads can communicate with each other or directly to the base station, and there is multi-hop communication between the Base station and the Cluster head.

In the present work a modified *K* means clustering algorithm has been used to cluster the sensor nodes based on highest energy and shortest path distance. Centroid method is used to find the Cluster mean. The node with the least distance between the Cluster mean and the Cluster member is selected as a Cluster head. In our work we tried to decrease this percentage of energy consumption and more end-to-end data transmission.

6.2 Proposed Scheme:

In this section, we present the working principle of our proposed LACBRP algorithm in several phases. The proposed algorithm works with the following assumptions.

- Once a node is selected as a CH, it remains in the same cluster.
- Initially, all sensors have the same energy.
- A node in each cluster is work only for localisation. This node is known as an anchors node.
- Sensors are heterogeneous in terms of their roles since they work as anchor nodes, cluster heads and cluster members.

The location aware cluster based routing, mainly uses three phases in WSNs. In the first phase, the location information of each sensor node is computed by using the localization algorithm such as Trilateration, Triangulation etc. In the second phase, the sensor nodes are clustered to minimize the residual energy and to maximize the network performance, then the Cluster head is selected based on the minimum distance between the cluster node's and the centroid. In the third phase, routing takes place between the cluster head and the cluster members and also between the cluster head and the base station.

A. Location of Sensor node

Sensors localisation is very important since without location information sensors data are meaningless for many WSN applications e.g wild fire detection. However, localizing mobile sensors nodes and keeping the updated location information of mobile nodes is a great challenge. This localisation approach uses sensing range to communicate with nodes, where a pair of nodes communicates each other only when their sensing circles intersect each other.

The location information of each sensor node should be known to form a cluster in the WSN. The nodes which are deployed in the sensor network, knows their location information. The coordinates (x_i, y_i) of each sensor node are used to estimate the distance between two sensor nodes. Based on minimum distance and highest residual energy, the sensor nodes are clustered by using modified *K*-means clustering algorithm.

A node can compute its own position using any one of the localization method, if it possesses the information about distances or angles and positions,. Several methods can be used to compute the position of a node such as trilateration, multitrilateration, triangulation etc.

Trilateration is a geometric principle used to find a location, if their distances from other nodes are known. It computes a node's position via the intersection of three circles., Trilateration uses the known locations of two or more reference points and the measured distance between the unknown node and each reference point in order to calculate the unknown node's location. Moreover, in order to determine the relative location of a node accurately and uniquely using trilateration, at least three reference points are needed. The three reference nodes are assumed like a GPS enabled node.

The distance between reference nodes is computed by using this formula:

$$\text{Distance}=\sqrt{(x_2-x_1)^2+(y_2-y_1)^2} \quad (6.1)$$

Here, (x_1, y_1) and (x_2, y_2) are the coordinates of the reference node.

The new coordinate is computed by using this formula,

$$x = \frac{y(y_a - y_b) - v_b}{(x_b - x_c)} \tag{6.2}$$

$$y = \frac{v_b(x_b - x_c) - v_a(x_b - x_a)}{(y_a - y_b)(x_b - x_a) - (y_c - y_b)(x_b - x_c)} \tag{6.3}$$

Where,

x, y is the new coordinate.

V_a and V_b are the relative distance between two spheres.

x_a, x_b, x_c and y_a, y_b, y_c are the *x* and *y* coordinates of three reference points.

Table 6.1: Location Information of Sensor Node

LOCATION INFORMATION		
Node ID	X_i	Y_i
Node 1	200	300
Node 2	460	580
Node 3	300	600
Node 4	350	480

B. Cluster Formation

K-means is an exclusive clustering algorithm and it is one of the simplest unsupervised learning algorithms that solves the clustering problem. WSN has number of nodes, which are randomly scattered over the sensor network. The location information of each of the node is very important, because it is essential to know where the information is sensed in the sensor network. The sensor nodes which are deployed in the sensor network, knows their location information. The coordinates (x_i, y_i) of each sensor node are used to

estimate the distance between two sensor nodes. Based on the minimum distance and highest energy, the sensor nodes are clustered by using modified
K-means clustering algorithm.

In the first step, randomly select *c* cluster head with their x_i, y_i coordinates. Then calculate the distance between each sensor node and the randomly selected cluster head and also get the energy of each node. Assign the sensor nodes to the cluster head, whose distance from the cluster head is minimum of all the cluster heads and has the highest residual energy. In the next step, re-compute the cluster head by using centroid method. Calculate the sum of all *x* coordinate of sensor node in the cluster and divide it by the number of cluster nodes, similarly for *y* coordinate. This is the centroid method.

Cluster head selection:

After the formation of cluster, re-compute the centroid of the clusters resulting from the calculated distance. Calculate the centroid point of each cluster in the WSN. The centroid point is the new coordinate which is not equal to any position of sensor node in the WSN. So, this new coordinate cannot be selected as a cluster head, because it is a location based clustering scheme. The current position of the cluster head should be known. After finding the centroid position, find the minimum distance between the centroid position and the cluster members. The sensor nodes which have the minimum distance from the centroid point is a new cluster head. In some cases, if a cluster head gets down, when the threshold value becomes less than the fixed threshold value, recompute the cluster head based on minimum distance and highest energy.

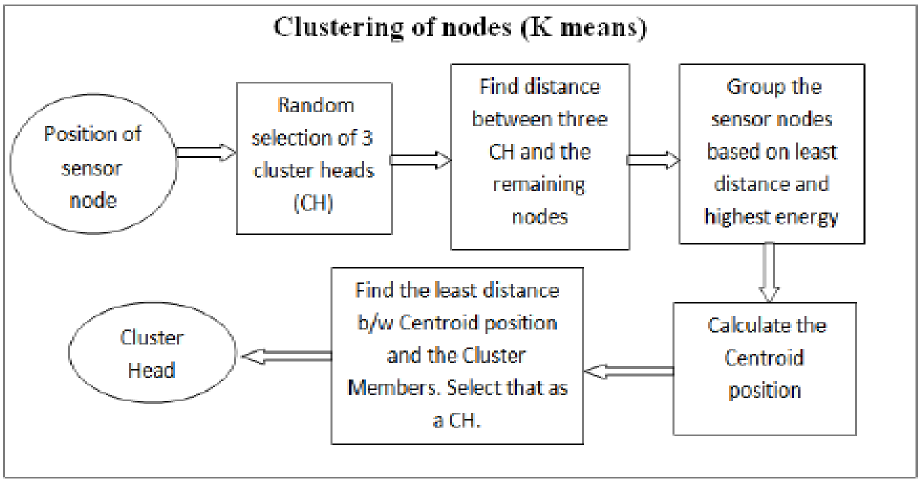

Figure 6.1: System architecture

C. Routing Protocol

Routing is the process of selecting paths in a WSN along which to send network traffic. Ad-hoc On Demand Distance Vector (AODV) is a distance vector routing protocol. It is a reactive routing protocol; therefore, routes are determined only when needed. Here, the modified *K*-means Clustering algorithm is added to the existing AODV protocol, to form a new *K*-AODV where, *K* represents the *K*-means clustering algorithm.

Routing takes place between the cluster head and the cluster members and also between the cluster head and the base station. There is no direct communication between the cluster members and the base station. The Cluster members forward the packets to the respective cluster heads and the cluster head will forward the packets to the base station. If the base station is far away from the cluster head, multi-hop communication will takes place. The cluster head will forward the packets to the nearest cluster head and this nearest cluster head will send the packets to the base station.

Algorithmic steps for Modified k-means clustering:

Input : Position of each node and their distance and energy Output : Grouping of nodes

Let $X = \{x_1, x_2, x_3, \ldots\ldots, x_n\}$ be the set of nodes and

$C = \{c_1, c_2, \ldots\ldots, c_n\}$ be the set of centers.

Step 1: Randomly select *'c'* cluster centers.

Step 2: Calculate the distance between each node and cluster centers and also get the energy of each node.

$$D_{i=1\, j=1} = \sum^{c} \sum^{ci} (\|x_n - c_n\|)^2 \tag{6.4}$$

where, 'D' is the distance between each node and the cluster centers.

'$\|x_n - c_n\|$' is the Euclidean distance between x_n and c_n.

'c_i' is the number of nodes in i^{th} cluster.

'c' is the number of cluster centers.

Step 3: Assign the node to the cluster center whose distance from the cluster center is minimum of all the cluster centers and has highest energy.

Step 4: Recalculate the new cluster center using:

$$C(x) = \left(\frac{1}{c_i}\right) \sum_{j=1}^{c_i} x_i \tag{6.5}$$

Similarly for y coordinate,

$$c(y) = \left(\frac{1}{c_i}\right)\sum_{j=1}^{c_i} y_i \quad (6.6)$$

where,

C(x) and *C(y)* is the *x* and *y* coordinates of the cluster centre.

c_i represents the number of sensor node in i^{th} cluster.

x_i represents the *x* coordinate of the sensor node.

y_i represents the *y* coordinate of the sensor node.

Step 5: Calculate the minimum distance between the Centroid position and the cluster nodes. Then elect it as a new Cluster head.

Step 6: If no node was reassigned then terminate the process, otherwise repeat from step 3.

6.3 Performance Evaluation:

The simulation of Clustering is done in ns2. In the simulation model, there are 40 sensor nodes are used here. All the nodes are set as static nodes. The type of the wireless propagation model is TwoRayGround. Routing protocol which is used in this simulation is AODV.

SIMULATION PARAMETERS:

```
#====================================
#     Simulation parameters setup
#====================================
set NS          /home/Project/Desktop/leach/ns-allinone-2.34/ns-2.34/
set val(chan)   Channel/WirelessChannel    ;# channel type
set val(prop)   Propagation/TwoRayGround   ;# radio-propagation model
set val(netif)  Phy/WirelessPhy            ;# network interface type
set val(mac)    Mac/802_11                 ;# MAC type
set val(ifq)    Queue/DropTail/PriQueue    ;# interface queue type
set val(ll)     LL                         ;# link layer type
set val(ant)    Antenna/OmniAntenna        ;# antenna model
set val(ifqlen) 50                         ;# max packet in ifq
set val(nn)     40                         ;# number of mobilenodes
set val(rp)     LACBRP                       ;# routing protocol
set val(x)      1407                       ;# X dimension of topography
set val(y)      732                        ;# Y dimension of topography
set val(stop)   30.0                       ;# time of simulation end
set val(em)     EnergyModel                ;# energy model
set val(Energy) 1000                       ;#Joules
set speed       0.5                        ;#
set packet_size 811                        ;#
set interval .05                           ;#
source $NS.ns1
#====================================
```

Table: 6.2: Simulation Results:

Time(Sec)	Energy Values	Latency Values	PDR Values	Residual Energy Values
10.000	8.777	12.7867	0.9976	38991.2
15.000	25.342	12.5031	0.9982	38973.3
20.000	44.595	11.8059	0.9989	38955.4
25.000	62.524	11.6385	0.9991	38937.5
30.000	80.417	11.5275	0.9993	38919.6

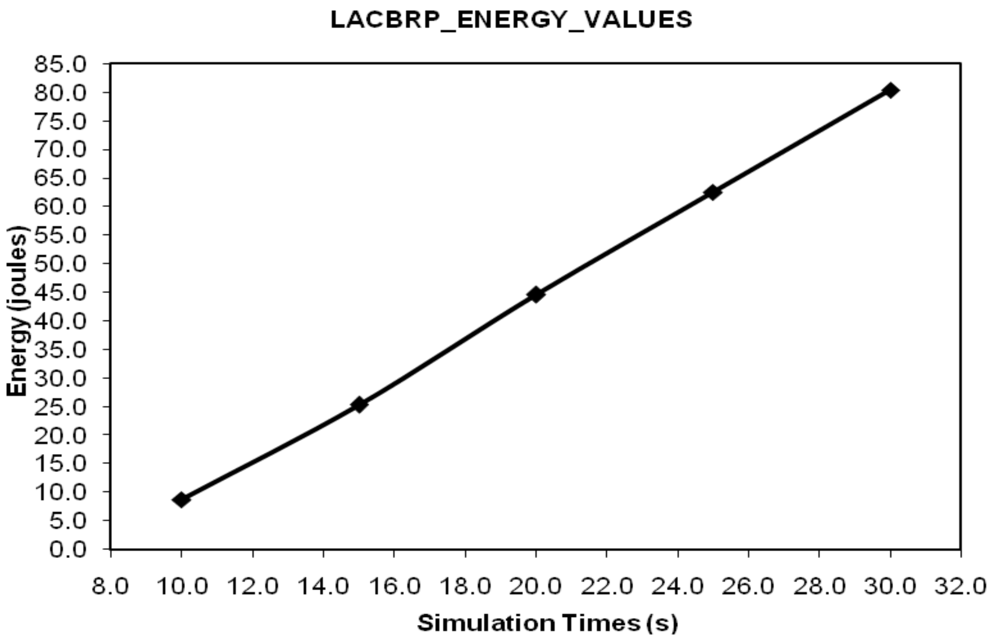

Figure 6.2: Simulation Time Vs Energy Values

The Energy Consumption Value at 10 sec Simulation Time is observed to be 8.777 for Proposed Location Aware Cluster Based Routing Algorithm, at 15 sec, 20 sec, 25 sec, 30 sec are 25.342, 44.595, 62.524, 80.417 respectively. So it can be clearly seen in Figure 6.2 that the variation of Energy Values with simulation time is increasing.

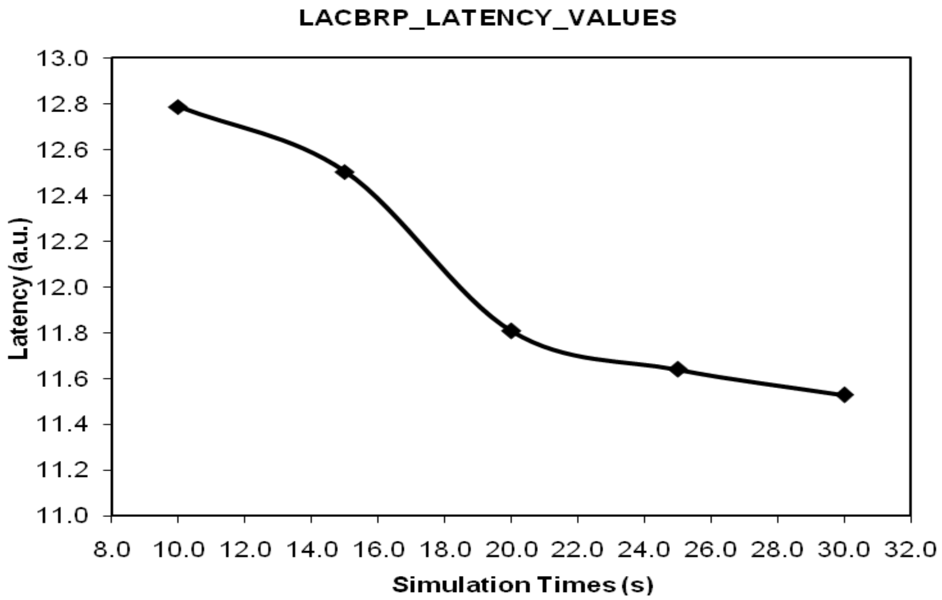

Figure 6.3: Simulation Time Vs Latency Values

Form the Figure 6.3 it is shown that the Latency Value at 10 sec Simulation Time is 12.7867. Then at 15 sec, 20 sec, 25 sec and 30 sec are observed to be 12.5031, 11.8059, 11.6385, and 11.5275 respectively. So from the above results we can say that the variation of Latency Values with Simulation Time is increasing

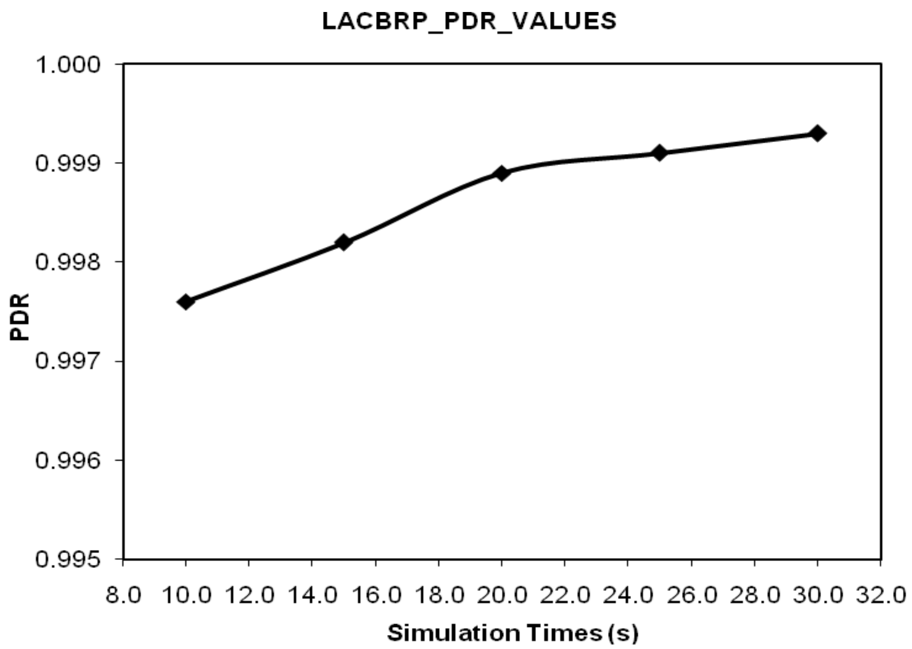

Figure 6.4: Simulation Time Vs PDR Values

Figure 6.4 shows the variation of Packet Delivery Ratio (PDR) values with simulation time from 10 sec to 30 sec at an interval of 5 sec. The PDR values are observed to be 0.9976, 0.9982, 0.9989, 0.9991 and 0.9993 respectively.

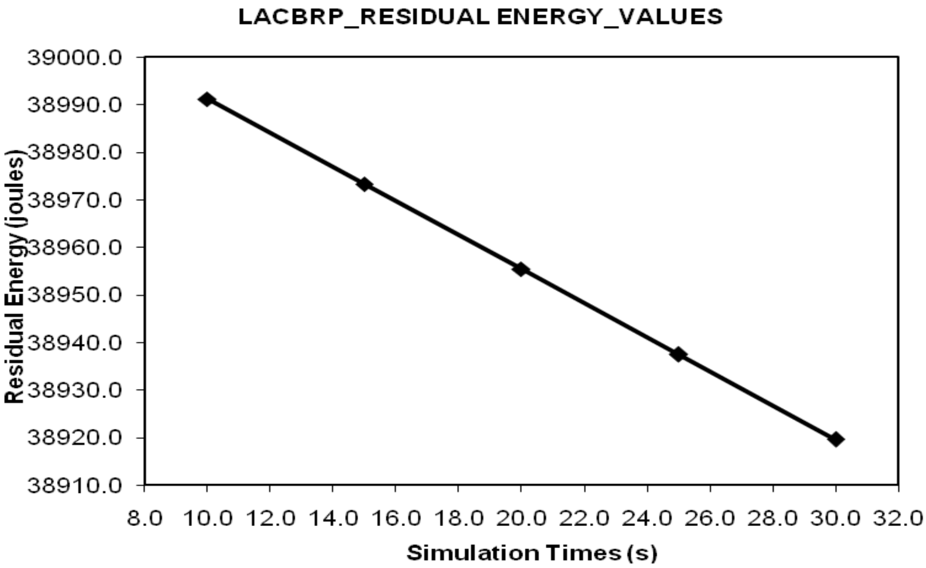

Figure 6.5: Simulation Time Vs Residual Energy Values

The Residual Energy Values at 10 sec Simulation Time is observed to be 38991.2 for Proposed Location Aware Cluster Based Routing Algorithm, at 15 sec, 20 sec, 25 sec, 30 sec are 38973.3, 38955.4, 38937.5, 38919.6 respectively.

6.4 Conclusion:

In this work we have measured the performance of the Proposed Location Aware Cluster Based Protocol in terms of network energy consumptions and lifetime. Network energy consumption is defined as the total energy consumed by all the sensors nodes for routing data over a certain period of time. Network energy consumptions also reflect the lifetime of the network, that is, the remaining network energy since network energy consumptions is inversely proportional to the network lifetime. We have measured the end-to-end delay as the time that is required to transmit data from any source sensor node to the BS based on the traversed Euclidean distances. Another important parameter to measure the performance of a mobile routing protocol is the packet delivery ratio which is defined as the total number of packets received at the BS to the total number of packets transmitted by the senders. We have also measured the Residual Energy Values.

The present simulation represents the variation of different performance parameters for the Location Aware Clustering Scheme. Efficiently use of energy in the network has been the main issue in WSNs for prolonging lifetime of the network. This graph shows the Energy values, Latency values, Packet Delivery Ratio and Residual Energy Values using this algorithm. This shows the better performances of Energy values, Latency values, Packet Delivery Ratio and Residual Energy Values after using this clustering algorithm.