International Journal of Computer and Communication Technology

Volume 6 | Issue 1 Article 9

January 2015

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Recommended Citation
JERUSHA, S.; KULOTHUNGAN, K.; and Kannan, A (2015) "LOCATION AWARE CLUSTER BASED ROUTING IN WIRELESS SENSOR NETWORKS," *International Journal of Computer and Communication Technology*: Vol. 6 : Iss. 1 , Article 9.
DOI: 10.47893/IJCCT.2015.1271
Available at: https://www.interscience.in/ijcct/vol6/iss1/9

LOCATION AWARE CLUSTER BASED ROUTING IN WIRELESS SENSOR NETWORKS

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Abstract - Wireless sensor nodes are usually embedded in the physical environment and report sensed data to a central base station. Clustering is one of the most challenging issues in wireless sensor networks. This paper proposes a new cluster scheme for wireless sensor network by modified the K means clustering algorithm. Sensor nodes are deployed in a harsh environment and randomly scattered in the region of interest and are deployed in a flat architecture. The transmission of packet will reduce the network lifetime. Thus, clustering scheme is required to avoid network traffic and increase overall network lifetime. In order to cluster the sensor nodes that are deployed in the sensor network, the location information of each sensor node should be known. By knowing the location of the each sensor node in the wireless sensor network, clustering is formed based on the highest residual energy and minimum distance from the base station. Among the group of nodes, one node is elected as a cluster head using centroid method. The minimum distance between the cluster node's and the centroid point is elected as a cluster head. Clustering of nodes can minimize the residual energy and maximize the network performance. This improves the overall network lifetime and reduces network traffic.

***Keywords**: wireless sensor network; distance estimation; clustering; K means; Centroid point; routing.*

I. INTRODUCTION

A Wireless Sensor Network (WSN) is a collection of sensor nodes, capable of collecting information from their environment. These nodes have the ability of sensing, computing, and wireless communicating. Wireless sensor networks are widely 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 challenges in wireless sensor network.

By knowing the location of a sensor node, cluster the sensor nodes based on the highest energy and least distance. In that group of nodes, one node is select as a Cluster head (CH). This is to avoid communication over head between the sensor nodes. Clustering of nodes shows that the network is more stable and efficient. This 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 battery-constrained and inexpensive nodes. They have limited communication, processing and memory storage resources. Each sensor node can act as a cluster head or a cluster member. A cluster member directly communicates with its cluster head; there is no communication between sensors. In other words, there is 1-hop communication between a node and the CH. Further, 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 this paper a modified K means clustering algorithm is used to cluster the sensor nodes based on highest energy and shortest path distance. Centroid method is used to find the Cluster mean. The least distance between the Cluster mean and the Cluster member is select as a Cluster head.

The remainder of this paper is structured as follows: Section II provides the related work in the domain of Clustering of nodes in the WSN. It gives the different techniques used for Clustering in WSN. Section III provides detail about how the proposed system is implemented and describes the algorithm used. It includes system architecture and detailed design of various phases involved in the project. It describes the internal working of the system. Section IV deals with the performance evaluation. Finally, Section V describes the conclusion and future enhancement.

II. RELATED WORK

Shahram Babaie, Ahmad Khadem Zade and Ali Hosseinalipour have proposed a [5] new clustering method for increasing of network lifetime. Several sensors are distributed with a high-energy for managing the cluster head and to decrease their responsibilities in network. The performance of the proposed algorithm via computer simulation was evaluated and compared with other clustering algorithms like LEACH (Low energy Adaptive Clustering Hierarchy) and SEP (Stable Election Protocol). The simulation results show the high performance of the proposed clustering algorithm. In this paper sensor nodes and gateways are fixed and motionless.

Wei Peng and David J Edwards have proposed a novel cluster-head selection algorithm [8] is presented and analyzed which uses the minimum mean distance between sensor nodes as a selection parameter. The proposed algorithm has clear advantages and takes 1.2 times longer to reach the point where 50% sensor nodes remain alive than the Low Energy Adaptive Clustering Hierarchy algorithm (LEACH) while maintaining information throughput at a high level. This minimizes the energy consumption.

Dragos Niculescu and Badri Nath have proposed an Ad Hoc Positioning System (APS) Using AOA. In APS [1] a reduced number of beacon nodes (e.g., three or more) is deployed with the unknown nodes. Then each node estimates its distance to the beacon nodes in a multihop way. Once these distances are estimated, the nodes can compute their positions using trilateration. Three methods of hop-by-hop distance propagation are proposed: Dv-Hop, Dv-Distance, and Euclidean. In Dv-Hop APS the beacon nodes start the propagation of their position information. Working as an extension of the distance vector algorithm, all nodes receive the position information of all beacon nodes as well as the number of hops to these beacons. An advantage of the APS is that its localization algorithm requires a low number of beacon nodes in order to work. However, the way distances are propagated, especially in Dv-Hop and Dv-Distance, as well as the way these distances are converted from hops to meters in Dv-Hop, result in erroneous position computation, which increases the final localization error of the system.

Inderjit S. Dhillon, Yuqiang Guan and Brian Kulis have proposed Kernel k-means, [3] Spectral Clustering and Normalized Cuts. Kernel k-means and spectral clustering have both been used to identify clusters that are non-linearly separable in input space. Weighted kernel k mean’s spectral clustering algorithm with normalized cuts are used to group the sensor node. Nodes are clustered by using positive definite matrices. It is also applicable for non-linear environment. It is not suitable for indefinite matrices. It’s only suitable for positive definite matrices.

Zhexi Pan, Yuanyuan Yang and Dawei Gong have proposed a [10] distributed clustering algorithms for WSNs by taking into account of the lossy nature of wireless links. First formulate the one-hop clustering problem that maintains reliability as well as saves energy into an integer program and prove its NP hardness. Then propose a metric based distributed clustering algorithm to solve the problem and adopt a metric called selection weight for each sensor node that can indicate both link qualities around the node and its capability of being a cluster head. Further extend the algorithm to multi-hop clustering to achieve better scalability.

Veena, K.N. and Vijaya Kumar have proposed a method for clustering and their analysis to study the cluster formation, their behavior with respect to the system parameters and applications requirement. The most important challenge in Wireless Sensor Networks (WSNs) is to improve the operational efficiency in highly resource constrained environment based on dynamic and unpredictable behavior of network parameters and applications requirement. The technique involves the adoption of computational intelligence to form clustering. Nero-Fuzzy technique [7] is used to obtain dynamic clustering. The simulations are carried out to evaluate the performance of the proposed method with respect to different parameters of sensor node and applications requirement.

The large-scale deployment of wireless sensor networks (WSNs) and the need for data aggregation necessitate efficient organization of the network topology for the purpose of balancing the load and prolonging the network lifetime. Clustering has proven to be an effective approach for organizing the network into a connected hierarchy. Younis, O, Krunz, M. and Ramasubramanian [9] have discussed about the challenges in clustering a WSN, the design rationale of the different clustering approaches and classify the proposed approaches based on their objectives and design principles and several key issues that affect the practical deployment of clustering techniques in sensor network applications.

Geographic routing has been proven to be efficient to provide scalable unicast routing in resource-constrained sensor networks. However, its applications in multicast routing remain largely unexplored. Recently GMR (Geographic Multicast Routing) and DCGM (Destination Clustering Geographic Multicast) have been proposed by Gang Zhao, Xiangqian Liu and Kumar, [2] which preserve the distributed computation of geographic routing while delivering data packets to multiple destinations with efficient routes. To further reduce the number of transmissions, a clustering strategy is applied to GMR and DCGM. This strategy improves the performance of GMR and DCGM by dividing the destinations into many clusters and sending the packet first to the closest destination in each cluster, which then sends the packet to other nodes in the cluster. Simulation results show that the strategy can reduce the number of transmissions up to 35% percent.

Seema Bandyopadhyay and Edward J. Coyle have proposed a distributed, randomized clustering algorithm [6] to organize the sensors in a wireless sensor network into clusters. A wireless network consisting of a large number of small sensors with low-power transceivers can be an effective tool for gathering data in a variety of environments. The data collected by each sensor is communicated through the network to a single processing center that uses all reported data to determine characteristics of the environment or detect an event. The communication or message passing process must be designed to conserve the limited energy resources of the sensors. Clustering sensors into groups, so that sensors communicate information only to cluster heads and then the cluster heads communicate the aggregated information to the processing center, may save energy. This algorithm is extended to generate a hierarchy of cluster heads and observe that the energy savings increase with the number of levels in the hierarchy. Results in stochastic geometry are used to derive solutions for the values of parameters of our algorithm that minimize the total energy spent in the network when all sensors report data through the cluster heads to the processing center.

Kihyum Kim, Honggil Lee, Byeongjik Lee, Youngmi Baek and Kijun Han have proposed [4] an Energy Efficient Intersection Routing Protocol in Mobile Sensor Networks. Typically, sensor networks consist of fixed sensor nodes. Sometimes, creating such a fixed sensor networks could be a daunting task. Sensor nodes assume deploying a stationary sensor network over a dangerous area such as a battlefield. Even if an advanced method to make the deployment safer is used, diverse element will cause a coverage holes. Even though perfect coverage can be achieved initially, various factors such as malicious attacks will certainly degrade network coverage as time goes on. However, mobile sensor networks can solve some of the problems. Each node of mobile sensor network is mounted on various unmanned vehicles as a result the sensor nodes have mobility. Mobility reinforces fault-tolerance and the scalability of the network. But conventional sensor routing protocols find it hard to deal with the mobile sensor networks. Therefore, this study suggests an energy efficient routing scheme by using the location information of a global positioning system (GPS) and the energy levels of sensor nodes.

III. PROPOSE SCHEME

The location aware cluster based routing uses three phases in wireless sensor networks. 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 maximize the network performance then the Cluster head is elected 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*

The location information of each sensor node should be known to form a cluster in the wireless sensor network. 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.

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

Trilateration is a geometric principle which is 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. To calculate the unknown node's location, trilateration uses the known locations of two or more reference points, and the measured distance between the unknown node and each reference point. To accurately and uniquely determine the relative location of a node using trilateration, generally 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,

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

(1) Where, (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,

$$x = \frac{y(y_a - y_b) - V_b}{(x_b - x_c)} \quad (2)$$

$$y = \frac{V_b\,(x_b - x_c) - V_a(x_b - x_a)}{(y_a - y_b)(x_b - x_c) - (y_c - y_b)(x_b - x_c)} \quad (3)$$

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 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 the one of the simplest unsupervised learning algorithms that solve the clustering problem. Wireless Sensor Network has number of nodes, which are randomly scattered over the sensor network. The location information of each node is required, 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 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 wireless sensor network. The centroid point is the new coordinate which is not equal to any position of sensor node in the wireless sensor network. So, this new coordinate cannot be select 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.

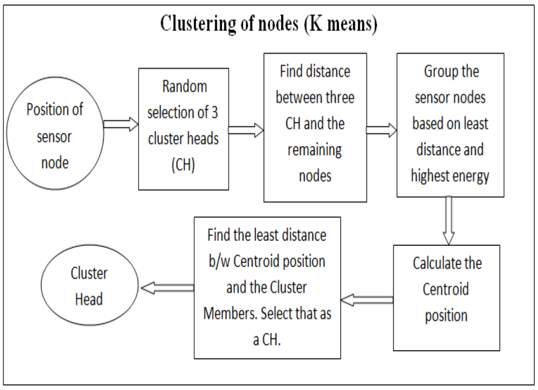

Figure 1 System architecture

C. Routing Protocol

Routing is the process of selecting paths in a wireless sensor network 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. In this paper, 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, multihop 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,……..,x_n} be the set of nodes and C = {c_1,c_2,…….,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.

$$D = \sum_{i=1}^{c} \sum_{j=1}^{ci} (||x_n - c_n||)2$$

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:

$$C(x) = \left(\frac{1}{ci}\right)\sum_{j=1}^{ci} xi \quad (5)$$

Similarly for y coordinate.

$$C(y) = \left(\frac{1}{ci}\right)\sum_{j=1}^{ci} yi$$

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.

xi represents the x coordinate of the sensor node.

yi 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.

IV. PERFORMANCE EVALUATION

The simulation of Clustering is done in ns2. In the simulation model, there are 30 sensor nodes deployed in a 800x600 m^2 field. 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. Table 1 shows the various parameters used for simulation.

TABLE 2: SIMULATION PARAMETERS

Parameter	*Value*
Number of nodes	30 nodes
Mac Layer Type	802.11
Topology size	800 x 600 (mxm)
Routing protocol	AODV
Propagation model	TwoRayGround
Energy model	Energy Model

The graph shows the overall network energy before the formation of cluster and after the formation of cluster using modified k means algorithm.

TABLE 3: OVERALL NETWORK ENERGY

ENERGY EFFICIENCY		
Time	*Energy - AODV*	*Energy –K means*
5	30	30
10	28	29
15	27	28
20	26	27
25	25	26
30	22	25
35	20	24
40	18	24

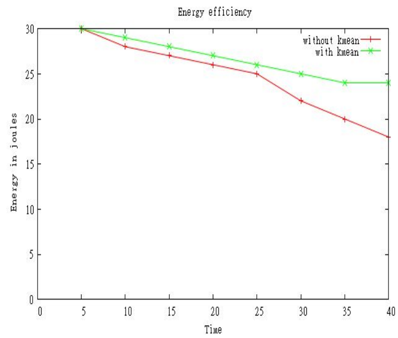

Figure 3 Overall network energy

This graph shows the packet delivery ratio, before and after using k means algorithm. This shows the better performance of packet delivery after using the modified k means clustering algorithm.

TABLE 4: PACKET DELIVERY RATIO

PACKET DELIVERY RATIO		
No. of nodes	*% of packets successfully delivery -AODV*	*% of packets successfully delivery – K means*
5	50000	50000
10	48000	50000
15	45000	48000

20	40000	47000
25	30000	45000
30	25000	40000

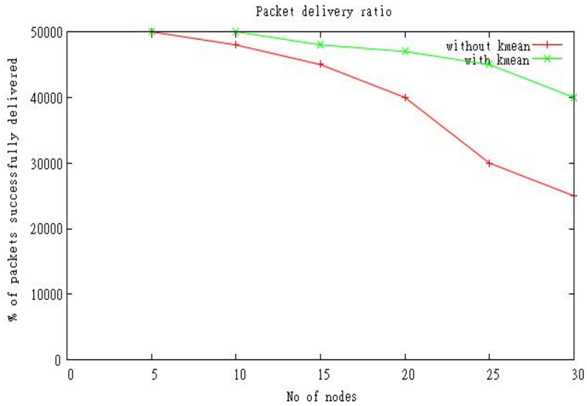

Figure 4 Packet delivery ratios

V. CONCLUSION

Clustering is an important issue in Wireless Sensor Network. Information gathering and routing are carried out based on the position of the sensor node. It can be easily achieved by enabling GPS in every node. The sensor nodes are deployed in the wireless sensor network which aware of their own position information. By knowing the position of the entire sensor node in the WSN, cluster the sensor nodes based on the energy, shortest path distance. The cluster head will be selected based on Centroid position Clustering of nodes by using modified k means clustering algorithm can minimize the residual energy and maximize the performance. It improves the network lifetime and reduces network traffic.

Future Work:

Wireless sensor networks are widely being used in location monitoring, military surveillance etc. In these cases, the information transmitted from the nodes to the base station should be secure (i.e.) communication between two nodes must be encrypted. This requires the generation of secure keys between the sensor nodes in the wireless sensor networks to avoid attackers.

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