Circuits and Systems, 2016, 7, 1962-1975
Published Online June 2016 in SciRes. http://www.scirp.org/journal/cs
http://dx.doi.org/10.4236/cs.2016.78171

Localized Coverage Connectivity Based on Shape and Area Using Mobile Sensor Robots in Wireless Sensor Networks

Rajaram Pichamuthu[1], Prakasam Periasamy[2]

[1]Department Computer Science and Engineering, Maha Barathi Engineering College, Chinnasalem, India
[2]Department Electronics and Communication Engineering, United Institute of Technology, Coimbatore, India
Email: rajaramnov82@gmail.com, prakasamp@gmail.com

Received 7 April 2016; accepted 1 May 2016; published 28 June 2016

Abstract

A wireless sensor network (WSN) is spatially distributing independent sensors to monitor physical and environmental characteristics such as temperature, sound, pressure and also provides different applications such as battlefield inspection and biological detection. The Constrained Motion and Sensor (CMS) Model represents the features and explain k-step reach ability testing to describe the states. The description and calculation based on CMS model does not solve the problem in mobile robots. The ADD framework based on monitoring radio measurements creates a threshold. But the methods are not effective in dynamic coverage of complex environment. In this paper, a Localized Coverage based on Shape and Area Detection (LCSAD) Framework is developed to increase the dynamic coverage using mobile robots. To facilitate the measurement in mobile robots, two algorithms are designed to identify the coverage area, (*i.e.*,) the area of a coverage hole or not. The two algorithms are Localized Geometric Voronoi Hexagon (LGVH) and Acquaintance Area Hexagon (AAH). LGVH senses all the shapes and it is simple to show all the boundary area nodes. AAH based algorithm simply takes directional information by locating the area of local and global convex points of coverage area. Both these algorithms are applied to WSN of random topologies. The simulation result shows that the proposed LCSAD framework attains minimal energy utilization, lesser waiting time, and also achieves higher scalability, throughput, delivery rate and 8% maximal coverage connectivity in sensor network compared to state-of-art works.

Keywords

Localized Coverage, Wireless Senor Network, Automatic Detection Framework, Geometric Voronoi Polygon, Acquaintance Area Polygons, Environment Monitoring, Mobile Sensor Robots

How to cite this paper: Pichamuthu, R. and Periasamy, P. (2016) Localized Coverage Connectivity Based on Shape and Area Using Mobile Sensor Robots in Wireless Sensor Networks. *Circuits and Systems*, **7**, 1962-1975.
http://dx.doi.org/10.4236/cs.2016.78171

1. Introduction

A large number of sensor nodes are deploying over a geographic area for the principle of monitoring assured events of interest (e.g., emergence of enemy's tanks, detonating a radiological dispersion device). Typically, each sensor node has a very inadequate sensing range within which it is capable to carry out its sensing operation and the sensed data will be transmitted to the base station (BS) over a multi-hop wireless path. The BS collects data from all associated nodes, analyzes this information to sketch conclusions about the activities in the ROI and serves as the bridge to connect the WSN with outside users. A wireless sensor network (WSNs) has received important knowledge in recent years because of its large variety of applications. A wireless sensor network creates a large scale of sensor devices set with sensor unit, a wireless communication unit. The sensor nodes are proficient for sensing, data processing, and communicating to others through radio transceivers. The nodes are grouped with each other to create a network for interacting with the physical world, such as to monitor a geographical area and to report sensed data to the monitoring center, which is linked to the base station.

As a consequence of special network architecture, a position in the ROI is actually under the surveillance of the WSN if and only if this position is surrounded by the sensing range. The sensing variety with at least one of the sensor nodes is connected to the BS. ROI identify the collection of all these positions as the associated coverage. The coverage in short and argue is that the continuous monitoring of the connected coverage is a must for all mission-critical WSN to present, regardless of their unambiguous application or focus. The connected coverage is the most important performance metrics used to measure the quality of service in WSN. Sensor network provides in a certain time and should be an inseparable complementarily of the report about the observed events in the ROI. For example, in the battlefield surveillance scenarios, the report obtained from base station as none of the enemies has been experiential in the ROI. ROI is misleading if it is not resistant with the explanation of the present connected coverage. Since as sensors running out of energy, or individual physically destroyed by natural or intended attacks, there is a predictable decentralization of the WSN. WSN characterized by the shrink of connected coverage or the expansion of coverage hole in the ROI and the WSN should incessantly self-monitor the transform of its coverage performance. Then the information of the associated coverage is also used to assist many fundamental operations of WSN. A significant role in research issue in wireless sensor network is the coverage difficulty which reveals that the sensor nodes are efficiently monitors the area coverage problem.

Constrained Motion Model (CMM) as described in [1] for mobile robots associated with target detecting but not effective in handling the complex environment. The description and calculation method based on CMM is not applied in mobile robotics. An Automatic Detection and Diagnosis (ADD) [2] Framework based on monitoring radio measurements build a threshold. The investigation in Automatic Detection and Diagnosis Framework also need a dynamic network environment with expert knowledge.

Position-based Opportunistic Routing (POR) protocol as demonstrated in [3] has possessions of geographic routing and the transmit character of wireless medium. When a data packet is sent out, some of the neighbor nodes eavesdrops the transmission. The overhead transmission will serve as forward candidates, and take turn to forward the packet if it is not relay by the precise best forwarder within a confident period of time. By utilizing such backup, communication is preserve without being interrupted. The added latency incurred by local direction recovery is seriously reduced and the spare relaying caused by packet reroute is also decreased. Geographical Density Control based on Cellular Learning Automata (GDC-CLA) [4] is developed for wireless sensor networks to maintain coverage and connectivity and reduced the total consumed energy of nodes.

Received Signal Strength Indication (RSSI) data as depicted in [5] offer a geo location and tracking technique based on sophisticated map-and mobility-based filtering. RSSI fails in location-dependent modulation, adaptive cell sizing, and network management platforms based on mobility prediction techniques. Also, RSSI information on user spatial distribution is not useful for network dynamic planning in hybrid urban and indoor scenarios. Adaptive Location-oriented content delivery as demonstrated in [6] performs pattern movement on mobile nodes.

Transmit Channel State Information (CSIT) as demonstrated in [7], encode explanations at a common and constant rate, for the (successive) C&E strategy, determine the encoding order that minimizes the resulting distortion in the fusion centre but not estimated in random fields. A general random network model as shown in [8] is the asymptotic behaviours of secure throughput and delay with the ordinary broadcast range. The probability of neighbouring nodes having a main security connection is quantified when the network size is adequately huge.

The costs and benefits of secure-link-augmentation operations on the secure throughput and delay are not analysed.

Wi-Fi protected access (WPA) scheme in [9], which added more enhancements to both encryption and support for authentication. Despite its robustness and good verification and encryption characteristics, WPA suffers from a few flaws to tamper with the deployed network and its availability. Optimal selective forwarding as illustrated in [10] makes the most of the significance of messages that have been successfully retransmitted by at least one of its neighbours. More complicated schemes attain better importance performance, but also require information from other sensors.

RBNSiZeComm as illustrated in [11] provides a highly energy-efficient technique for information transmission. Considering an n-bit data representation and assuming that each of the 2n binary strings is evenly probable to occur. Theoretically available portion of energy savings by using our RBNSiZeComm transmission protocol on typical produces good result. A hybrid modulation scheme using FSK and ASK with non-coherent detection based receiver for the RBNSiZeComm protocol assume equal likelihood of all probable binary strings of a given length. The common interest model as illustrated in [12] is to mutually exclusive or incompletely overlapping interests, network performance degrade radically. Common interest model acknowledged two user strategies for the divergent interest model.

The neighbour coverage-based probabilistic rebroadcast protocol as illustrated in [13] decrease routing overhead in MANET. In order to efficiently develop the neighbour coverage knowledge, a novel rebroadcast delay to decide the rebroadcast order, and then get hold of the more accurate additional coverage ratio by sensing neighbour coverage knowledge. A connectivity factor fails to offer the node density adaptation combining the additional coverage ratio and connectivity factor. Deployment-polygon based methodology in [14], confirm their optimality amongst standard patterns but not under non-disc sensing and complex communication models. In [15], they specified a guarded number of sensors for endeavour to increase the positions of the sensors out of the region which will be needed to assure the detection requirements without fault sense. It articulates the process disaster as a dynamical method and devises the sensor operation difficulty as a best control problem. In [16], the data in large-scale intellection fields has been collected using several mobile robots and work out error models for the robot design, primarily the nonlinear models. In furthermore obtaining the outline boundary and area of localization positions into description for additional process of collecting the information has been the major issue in WSN.

The contribution of this paper is described as follows. The Localized Coverage based on Shape and Area Detection (LCSAD) Framework with two algorithms is developed to identify the coverage area on dynamic environment. Two algorithms are Localized Geometric Voronoi Hexagon (LGVH) and Acquaintance Area Hexagon (AAH). Localized Geometric Voronoi Hexagon monitors all the shapes and AAH based algorithm simply obtains directional information by locating the area of local and global convex points of the coverage area. To achieve task, expand a customizable WSN simulator tool to hold up all and study the behavior of these entire WSN dynamic coverage environment. The NS2 simulation tool is used for wireless sensor network LCSAD framework design and analysis.

The remainder of this paper is organized as follows. In Section 2, we describe the brief explanation of our study using related works. Section 3 presents the Localized Coverage based on Shape and Area Detection (LCSAD) Framework on dynamic coverage of complex environment with aid of block diagram. Section 4 explains about the network simulator with parametric factor description. The simulated results and discussions are presented in Section 5. Finally, we conclude this paper in Section 6.

2. Related Works

The coverage boundary is recognized previously by routing in a WSN especially for geographic routing. The reason is that overlooking coverage boundaries reason problems in communication, as routing along shortest paths have a tendency to put an increased load on boundary nodes, thus rapidly exhausting their energy supply and mounting the coverage hole. Semi definite programming (SDP) relaxation as expressed in [17] applies a cubic function for mobile sensor navigation. SDP estimate the location of the mobile sensor and aim equally to improve the tracking accuracy. SDP is not effective in a weighted tracking algorithm by using the measurement information more resourcefully and rapidly express the mobile sensor to follow the mobile target.

The investigation of the impact of a dynamic network environment on expert knowledge is also needed. An adaptive push system was described in [18] for dissemination of data in underwater acoustic wireless networks. Besides achieve adaptation of broadcast schedule according to the a priori indefinite requirements of the clients. Adaptive push system efficiently combats the difficulty of high latency of the underwater acoustic wireless environment. The problem of deploying the minimum sensors on grid points as described in [19] construct a connected wireless sensor network. Sensor network able to fully cover critical square grids, termed Critical-square-Grid Coverage. An approximation algorithm for Critical-Square-Grid Coverage performs NP-complete operation.

Several IDS (intrusion detection system) nodes as shown in [20] are organize in order to detect and prevent selective black hole attacks. The IDS nodes must be set in sniff mode in order to carry out the so-called ABM (Anti-Blackhole Mechanism) function, which is primarily used to estimate a suspicious value of a node according to the abnormal difference between the routing messages transmitted from the node. Network Interference Cancellation Engine (NICE), which opportunistically with draw out of-cell interference in [21] by exchange decoded leading interferer data among cooperating cells and reconstructing interfering signals. NICE cannot employ conventional Successive Interference Cancellation (SIC) procedures to locally cancel the interference caused by the mobile. OBDWF protocol as established in [22] attain a enhanced throughput and delay performance such as the conservative dynamic decode-and forward (DDF) and amplified-and forward (AF) protocol. In addition to simulation performance OBDWF consequent closed-form asymptotic throughput and delay expressions of the OBDWF protocol. Specifically, OBDWF protocol achieve an asymptotic throughput Θ (log2 K) with Θ (1) total broadcast power in the relay network.

System Model

In this section we explain our modelling approach to evaluate the behaviour of the sensor network. The network coverage is clear that the fraction of covered area by the network to the area of interest. This coverage area depends on the sensing model, number of nodes deployed in network, node position approach and routing protocol. We consider an area A where N number of nodes are randomly distributed using random way point model. In the Random Way Point (RWM) model, each node shift to a randomly chosen location with an arbitrarily selected speed between a predefined smallest amount and highest speed. It assumes the normal unit sensing disc bidirectional communication replica and adjust the message range, so that each node contains approximately 40 neighbours on average. Let us consider that the nodes are randomly arranged with homogeneous node density $\rho = N/A$.

If the event is occurred inside the sensing range of a node then the region will be assumed to be detected, or else not. Usually, the area enclosed by a sensor node is a circle with radius is always equals to sensing radius of the node. In our coverage based model, the q_s is sensing range of mobile sensor nodes. In homogeneous mobile sensor node, q_c is maximum communication range of sensor nodes and q_s is sensing range of mobile sensor nodes. We set $q_c = 2q_s$ it verified that, for random spatial distributions of mobile sensor nodes. The boundary area nodes are locally detected only if the condition $q_c \geq 2q_s$ is satisfied. Therefore, the LCSAD framework reduced the energy consumption and interferences. The number of sensor nodes are combined to form a cluster set for easily identified a shape and area of the network. The sensing disk of the mobile nodes are defined as,

$$D\left(sd_i, q_s\right) = D_0 + sd_i$$

The mobile sensor interior node is defined as,

$$\text{Interior Node}\left(sd_i\right) = u \in \text{cluster}\left(sd_i\right) : uAD\left(sd_i\right)$$

Then the coverage corresponding to a cluster is defined as,

$$\text{Coverage }\left(sd_i\right) = \left(\bigcup_{u \in \text{Cluster}\left(sd_i\right)} \left(u + D_0\right)\right) \cap AP_1$$

"u" and "v" are two points in the network with sensing range of sensor nodes q_s. The mobile sensor interior node is defined as,

$$\text{Interior Node}\left(sd_i\right) = u \in \text{cluster}\left(sd_i\right) : uAD\left(sd_i\right)$$

Based on the above system modeling, the proposed Localized Coverage Based on Shape and Area Detection (LCSAD) Framework is functioned and the detailed explanation is given below.

3. Localized Coverage Based on Shape and Area Detection (LCSAD) Framework

In this section, a localized coverage based on the shape (*i.e.*,) direction and area (*i.e.*,) position in wireless sensor network has been proposed. LCSAD framework is a distributed, range-based, absolute localization that work in either two or three spatial dimensions. The proposed LCSAD framework develops two different algorithms where one refers the shape localization and other algorithm with area localization. All non-secure mobile sensor nodes in wireless sensor network start out with the Localized Geometric Voronoi Hexagon in which they determine shape inference through a number of iterations. And then performs the Acquaintance Area Hexagon algorithm where those inferences are further improved by identifying the area during more iteration. The Flow process of Proposed LCSAD framework is demonstrated in **Figure 1**.

In LCSAD framework, mobile sensor nodes communicate with their one-hop neighbours during iteration by transmitting one message that preferably be heard by all the neighbours. Each message send through LCSAD framework contains information about the sender's inference of its own current position, its self-confidence in that inference and its stored data. Its stored data contains information about its one-hop neighbours and the anchors that it knows in sensor network. Each piece of packet concerning the transmitting node's one hop neighbours contain that neighbours' list reported shape inference, its reported self-confidence in that inference and the measured distance to it for processing. Similarly, LCSAD framework includes reported shape, the shortest known hop-count and the added measured area along that path. In LCSAD framework, a node listens to one message transmitted by each of its one-hop neighbours, broadcasts one message itself, and then updates its area inference (*i.e.* location information) based on its currently available information. The node's new area inference and the information received from other nodes are relevant to its neighbours. Therefore iterate the entire series again, thus making mobile sensor nodes collaborate in finding a global elucidation as illustrated in **Figure 1**.

LCSAD framework develops two deterministic, localized algorithms for coverage area and shape detection in WSN. LCSAD framework is based on two novel phase computations, namely, Localized Geometric Voronoi Hexagon and Acquaintance Area Hexagon. In Localized Geometric Voronoi Hexagon algorithm, the non-anchor nodes collect location information regarding the number of mobile sensor nodes simultaneously with the hop-count and the entire measured distance along a fewest-hops path to each of these anchors. The Anchor

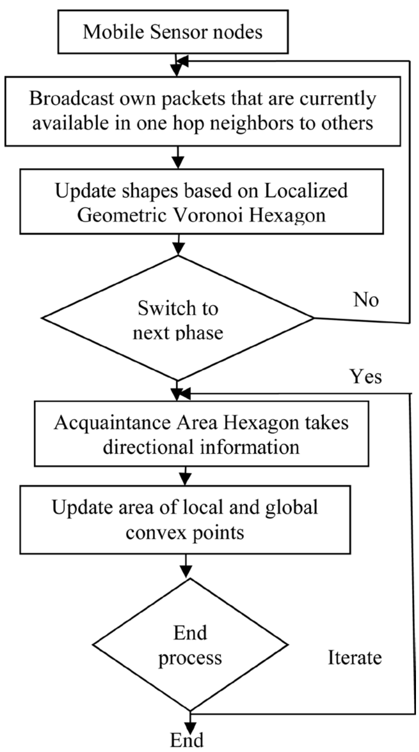

Figure 1. Flow process of Proposed LCSAD framework.

nodes are the nodes which are well-known with its current location. Neighbouring nodes or non-anchor nodes determine its location reference with the help of anchor nodes in mobile sensor networks. While getting the information about a current location, a node will store it and contain the new messages that it transmits, therefore making confident that this information distributed in the mobile sensor network. During each iteration, the LCSAD framework updates its area inference (*i.e.* location information) based on its currently available information. Therefore, each node in the mobile sensor networks is easily communicated with the other nodes which in turn improve the Coverage connectivity.

Similarly, In Acquaintance Area Hexagon (AAH) algorithm, the non-anchor nodes collects direction information about the number of mobile nodes in mobile sensor network. The AAH algorithm takes directional information by finding the area of local and global convex points of coverage area. The area of local and global convex points is updated based on its currently available information. Therefore, the AAH algorithm effectively delivered the data on the overall coverage area which in turn improves the delivery rate of mobile sensor network.

3.1. Preliminaries

The notation present in the LCSAD framework are the proposals for the coverage area detection is discussed. The mobile sensor nodes are homogeneous, where q_c is maximum communication range of sensor nodes and q_s is sensing range of mobile sensor nodes. For convenience only, set $q_c = 2q_s$ throughout the LCSAD framework. First, it proved that, for random spatial distributions of mobile sensor nodes, boundary area nodes locally detected if and only if $q_c \geq 2q_s$. Therefore, the LCSAD framework reduced the energy consumption and interference. Second, the specification of $q_c = 2q_s$ holds for most commercially available sensors.

A combined set of mobile sensor nodes is called as maximally linked set or cluster. It is used to detect the shape and area of localized coverage. Based on the mobile sensors, the sensing disk of node sd_i is given by,

$$D\left(sd_i, q_s\right) = D_0 + sd_i \tag{1}$$

From "Equation (1)", D is defined as the disk and q_s is called as sensing range of mobile sensor nodes. The set of all points in AP_l that are within radius q_s from any mobile sensor node of Cluster (sd_i) as the set covered by Cluster (sd_i). Then the coverage corresponding to a cluster is defined as,

$$\text{Coverage }\left(sd_i\right) = \left(\bigcup_{u \in \text{Cluster}(sd_i)} \left(u + D_0\right)\right) \cap AP_1 \tag{2}$$

AP_l as being entirely enclosed with mobile sensor nodes if there is at least one cluster (sd_i) whose nodes shape every point in AP_l, namely, Coverage (sd_i) = AP_l. The area detection (AD) in mobile sensor nodes define the boundary area of cluster (sd_i) as those whose minimum distances to ∂ coverage (sd_i) are equal to r and denoted them by,

$$AD\left(sd_i\right) = u \in \text{cluster}\left(sd_i\right) : \min\left\|u - v\right\| = q_s \tag{3}$$

"u" and "v" are two points in the network with sensing range of sensor nodes q_s. Accordingly, mobile sensor interior node is defined as,

$$\text{Interior Node}\left(sd_i\right) = u \in \text{cluster}\left(sd_i\right) : uAD\left(sd_i\right) \tag{4}$$

"Equation (4)", denote the boundary area of the base station (BS) such that cluster (sd_i) is connected with the BS if and only if BS $\in$ Cluster (sd_i) $\oplus$ Cluster (0, q_c). Therefore, the connected localized coverage using LCSAD framework holds the total area under the surveillance of BS.

3.2. Localized Geometric Voronoi Hexagon Properties

To facilitate LCSAD framework, initially define hexagon planes. For two distinct points r_i, $r_j \in V$, the supremacy region of r_i over r_j is defined as the set of points which are at least as close to r_i as to r_j obviously, supremacy r_i, r_j is a half place bounded by the perpendicular bisector of r_i and r_j which separates all points in the plane than those closer to r_j. The LGVH associated with r_i is the subset of the place that lies in all the supremacy regions of r_i over other points. In LGVH subsection, present an algorithm for each node to detect whether it is on the coverage shape, which is illustrated with mobile sensor nodes in **Figure 2** q_s is sensing range of mobile sensor

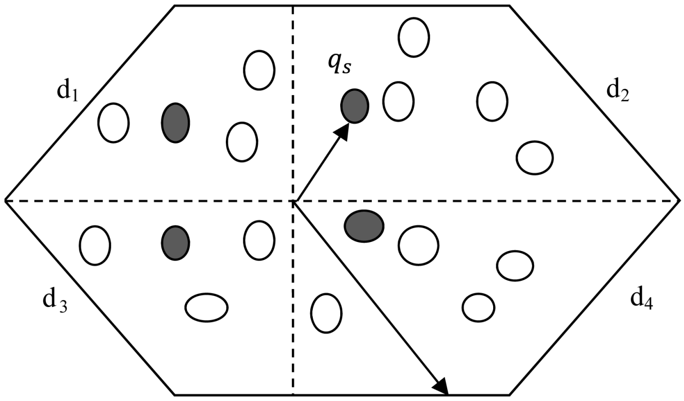

Figure 2. Detection based on localized geometric Voronoi hexagon.

nodes contains nodes of all bisectors. Then calculate $r_i \cap c_l$ by following the same procedure for calculating r_i. LCSAD framework contain both shape (*i.e.*,) directional and area (*i.e.*,) position information of the r_i neighbours as the input of algorithm. Primarily, consider two cases where the information about the border of c_l is available.

The output of LGVH algorithm is a unique property which updates the detection results and saves precious energy of each sensor nodes. The algorithmic step of the LGVH algorithm is as follows,

// Localized Geometric Voronoi Hexagon Algorithm
Input: Number of sensor nodes, number of neighboring nodes, q_c and q_s
Output: obtain the coverage shape
Step 1: Begin
Step 2: For randomly distributed sensor node
Step 3: if ($q_c \geq 2$ q_s)
Step 4: Boundary area nodes are locally detected
Step 5: else
Step 6: Node determines the distances to neighboring nodes and then performs the LGVH algorithm
Step 7: End if
Step 8: For each mobile sensor node
Step 9: Transmits own packets that are currently available in one hop neighbors to others
Step 10: Calculate coverage of mobile sensor nodes at different hexagonal position randomly using Equation (2).
Step 11: Find the boundary area of cluster using area detection (AD) from Equation (3).
Step 12: End for
Step 13: For each iteration
Step 14: Determine the interior node using Equation (4) for effective network connectivity.
Step 15: Repeat step 8 to 13 for updating the area inference based on its currently available information.
Step 16: End for
Step 17: End for
Step 18: End

In the first step, a given node checks whether it has satisfied LGVH and if so, decides that it is a boundary node. Otherwise, node determines the distances to neighboring nodes and then performs the LGVH algorithm. Each mobile sensor node obtains neighbors direction information using LGVH, so that it is easy to show all the boundary area nodes for all situations. Then, each sensor node distribute own packets that are currently available in one hop neighbors to others. After that, coverage area and boundary area are determined. For each iteration, find the interior node then updating the area information based on its currently available information.

3.3. Equations Acquaintance Area Hexagon properties

AAH algorithm identifies all the boundary area nodes after the directional information identification. AAH in computational geometry show a complementary tool of the LGVH for coverage boundary area detection. For AAH algorithm, coverage area boundaries without any distortion had done its best. However, that only desires to know the coverage area boundaries without any distortion and the whole information about all the boundary nodes are detected. In practice, conversely, degree distortion on the coverage connectivity is typically bearable for the users to make the effective decision in sensor network.

// Acquaintance Area Hexagon Algorithm
Start
Step 1: Localize positioning of mobile nodes in sensor network
Step 2: Perform the steps of Localized Geometric Voronoi Hexagon Algorithm to update the shapes (*i.e.*,) directions
Step 3: Switch the phase to Acquaintance Area Hexagon
Step 4: Start from the root node (BS)
Step 5: Entire moving sensor nodes, target packets to compute area
Step 6: Replicate step 4 and 5 until all mobile sensor node is null in network
Step 7: Update area of local and global convex points
Step 8: Confirm major shape and area of the sensor network connected coverage
Step 9: End

The two algorithms combined in the following way such that shape information is relatively simply to obtain than area (*i.e.*,) position information. Both algorithms need to be executed for some nodes, the overall energy consumption and response time is reduced in contrast to the case when only the LGVH algorithm is used, as accurate distance information with energy efficient. In addition, the property of the coverage area boundaries make use of the users to improve some lost data in boundaries. Therefore, main objective of LCSAD framework is to detect coverage area boundaries. The simulation result provides the assurance and fairly positive to represent the major topological shape of the connected coverage area.

4. Simulator Descriptions with Parametric Factors

Localized Coverage based on Shape and Area Detection (LCSAD) Framework using mobile sensor robots in a wireless sensor network use Ns-2 network simulator. In simulation, set up 'n' nodes consistently at randomly surrounded by 9000 × 9000 squares, with n unpredictable among 100 and 1000 formative the mobile sensor node group patterns. In particular, to accurately estimate the production of the structure in which each node progress to a randomly selected position with a randomly selected velocity between a predefined minimum and maximum speed.

The affecting mobile sensor networks continue there for a predefined pause time. After the pause time, it randomly selects and moves to another location. This random progression is constant during the simulation period. All simulations were performed for 700 simulation seconds, fixed a pause time of 30 simulation seconds and a minimum moving speed of 1.5 m/s of each node.

In the Random Way Point (RWM) model, each node shift to a randomly chosen location with a randomly selected speed between a predefined smallest amount and highest speed. It assumes the normal unit disc bidirectional communication replica and adjust the message range, so that each node will have roughly 40 neighbors on average. RWM uses standard number of mobile sensor nodes of the communication requirements and measure scalability, energy utilization, delivery rate, normalized waiting time, coverage connectivity ratio and throughput. Scalability defined as the ability of a wireless network to handle a coverage area based on the shape and area in a efficient manner. Scalability is measured in terms of percentage (%). In LCSAD Framework, Energy utilization is defined as the amount of energy consumed to run the both LGVH and AAH algorithms in mobile robotics. Energy utilization is measured in terms of mill joule (mJ). Delivery rate factor is the rate at which the data delivered effectively on the overall coverage area and it measured in terms of bits/sec.

Normalized waiting time is defined as the amount of time waiting in queue to find the area of local and global convex points. Normalized waiting time is measured in terms of milliseconds (ms).Coverage connectivity ratio is defined as the amount of area, in which a wireless network contributor offers cellular service. Coverage is usually expressed as a percentage of the resident nodes scattered throughout the network. Coverage connectivity ratio is measured in terms of percentage (%). Wireless network throughput is refers to the average rate of successful information delivery over a coverage communication channel. Throughput is measured in terms of megabytes (MB).

5. Results

Localized Coverage based on Shape and Area Detection (LCSAD) Framework is compared against with the existing Constrained Motion and Sensor (CMS) Model and Automatic Detection and Diagnosis (ADD) Framework. Figure 3 describes the LCSAD Framework improvements with beneficial simulation results when compared with existing system.

The scalability in wireless sensor network is based on LCSAD framework, CMS model [1] and ADD framework [2] has been tabulated in Table 1. The Localized Coverage based on Shape and Area Detection (LCSAD) Framework attains the higher scalability when compared with CMS model [1] and ADD framework [2].

The scalability is improved in LCSAD framework without any distortion and the whole information about all the boundary nodes is detected. Acquaintance Area Hexagon algorithm identifies all the boundary area nodes after the directional information identification to improve the percentage of scalability. It has been found that LCSAD framework has enhanced 9% and 5% when compared with CMS model [1] and ADD framework [2] respectively.

Table 2 and Figure 4 describe the utilization of energy based on the neighbor node count varies from 5 to 35. From the figure, our proposed LCSAD Framework improves the performance with minimum energy utilization.

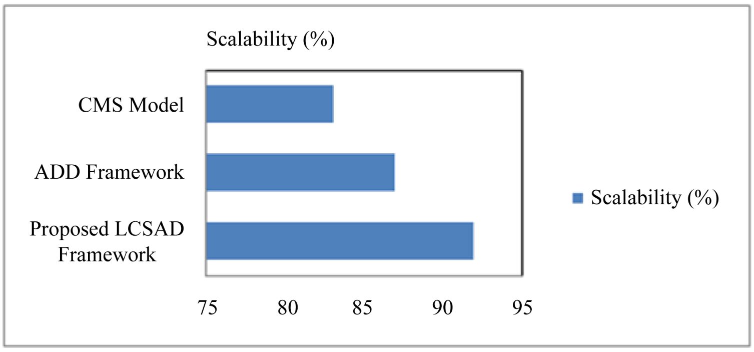

Figure 3. Measure of scalability on various techniques.

Table 1. Tabulation of scalability.

TECHNIQUE	SCALABILITY (%)
Proposed LCSAD Framework	92
ADD Framework	87
CMS Model	83

Table 2. No. of neighboring nodes vs energy utilization.

No. of Neighboring Nodes	Energy Utilization (mj)		
	CMS Model	Add Framework	Proposed LCSAD Framework
5	0.971	0.858	0.805
10	0.841	0.743	0.701
15	0.998	0.872	0.812
20	0.711	0.626	0.573
25	0.533	0.473	0.435
30	0.618	0.545	0.506
35	0.920	0.815	0.765

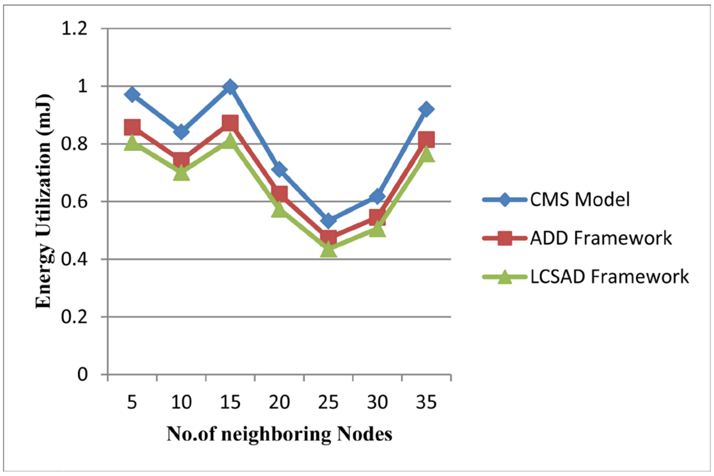

Figure 4. Energy utilization measure.

This is because; the LGVH algorithm is used for finding accurate distance inference. LGVH algorithm is a unique property which updates the detection results and saves precious energy of each sensor nodes. The dominance region of r_i over $\mathbf{r_j}$ is defined as the set of points which are at least as close to r_i as to $\mathbf{r_j}$. As the neighbor node increases, the energy utilization is reduced to 16% - 20% when compared with the CMS Model [1] and 7% - 10% reduced when compared with the ADD Framework [2] respectively.

Table 3 and **Figure 5** illustrate the delivery rate based on the different iterations results. The iteration result varies each time through fraction of points. The LGVH algorithm associated with r_i is the subset of the place that lies in all the supremacy regions of $\mathbf{r_j}$ over other points. For each iteration, find the interior node then updating the area information based on its currently available information. This helps to increase the delivery rate. The process of delivery rate is improved in LCSAD Framework by 6% - 8% when compared with ADD Framework [1] and 10% - 15% when compared with CMS Model [2] respectively.

Table 4 and **Figure 6** describe the normalized waiting time based on the speed. Speed measured in terms of the meter/seconds (m/sec). Supremacy $\mathbf{r_i}$, r_j is a half place bounded by the perpendicular bisector of $\mathbf{r_i}$ and r_j which separates all points in the plane than those closer to r_j. A separate point reduces the waiting time to 2% - 8% reduced when compared with ADD Framework [1]. The waiting time of LCSAD Framework is also reduced by 10 - 12 when compared with CMS Model [2].

Table 5 and **Figure 7** describe the coverage connectivity ratio and it is measured based on the node count ranges from 10 to 70. From the figure it is clear that the LCSAD framework provides higher connectivity ratio compared to CMS model [1] and ADD framework [2]. By using Geometric Voronoi Hexagon, the shape inference through wide range of coverage area is measured. Hexagon form of coverage improves the coverage connectivity ratio by 5% - 10% in LCSAD Framework when compared with CMS Model [1]. Proposed LCSAD Framework improved the coverage connectivity ratio by 2% - 5% when compared with the ADD Framework [2]. Acquaintance Area Hexagon where those inferences are further improved by identifying the area through more node count.

Table 6 illustrates the throughput measure based on the simulation seconds. The Each simulation time varies 30 seconds. Simulation starts from 100, and depending on count, throughput is measured based on LCSAD framework, CMS model and ADD framework. **Figure 8** depicts the throughput based on the simulation time. The area detection in mobile sensor nodes defines the boundary area cluster as those minimum distances to coverage are equal to q_s to improve throughput level. The LCSAD framework maintains the throughput ratio in higher level. Therefore the throughput value is improved by 14% - 18% when compared with CMS Model [1] and 10% - 15% improved when compared with ADD Framework [2]. As final point, LGVH properties increases synchronously for hexagon based approaches. Therefore, LCSAD framework with hexagon based approaches in sensor network achieves remarkable energy savings. By contrast, the theoretical results always show the approximation results, whereas simulation results produces the experimental outputs obtained through repetitive iterations. To facilitate the analysis, LCSAD frameworks precede communications in rounds taking simulation time unit and supporting reliable coverage connectivity.

Table 3. Tabulation of delivery rate.

Iterations	Delivery Rate (bits/sec)		
	CMS Model	ADD Framework	Proposed LCSAD Framework
1	120	125	135
2	123	131	138
3	167	175	189
4	148	153	166
5	140	151	164
6	198	218	231
7	134	139	151

Table 4. Tabulation of normalized waiting time.

Speed (m/sec)	Normalized Waiting Time (ms)		
	CMS Model	ADD Framework	Proposed LCSAD Framework
20	1123	1045	992
40	954	904	852
60	1541	1410	1385
80	1610	1698	1426
100	171	156	151
120	2089	1980	1828
140	2545	2340	2245

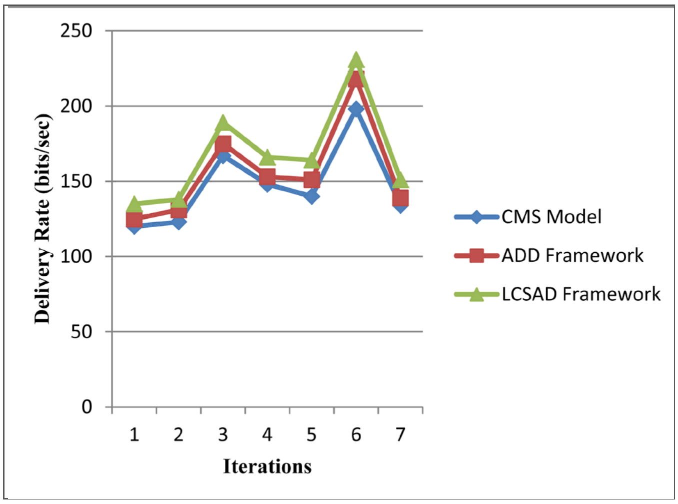

Figure 5. Performance of delivery rate.

6. Conclusions

In this paper, an efficient Localized Geometric Voronoi Hexagon and Acquaintance Area Hexagon algorithms are developed for coverage boundary detection in WSN. This Algorithm is based on two novel computational geometric techniques, namely, localized Voronoi and acquaintance area hexagon. Proposed LCSAD framework is

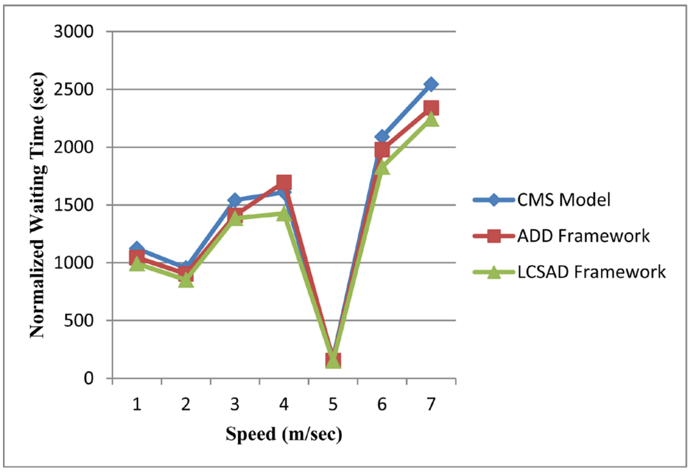

Figure 6. Measure of normalized waiting time.

Table 5. Tabulation for coverage connectivity ratio.

Node Count	Coverage Connectivity Ratio (%)		
	CMS Model	ADD Framework	Proposed LCSAD Framework
10	75	81	85
20	68	69	74
30	74	76	80
40	60	65	69
50	75	79	83
60	77	81	85
70	82	88	92

Table 6. Tabulation of Throughput Measure.

Simulation (Sec)	Throughput (MB)		
	CMS Model	ADD Framework	LCSAD Framework
100	605	617	710
130	550	558	653
160	721	770	865
190	491	512	592
220	515	572	623
250	370	375	447
280	535	565	645
310	642	685	768

truly distributed and localized with minimal location information of one-hop neighbors and a limited number of effortless local computations. The LCSAD framework differs from current implementation work is that for densely deployed WSN, the number of neighbors information needed is a constant. While hexagon forms gain all the neighbors information with higher the node density and the greater the benefit using LCSAD framework.

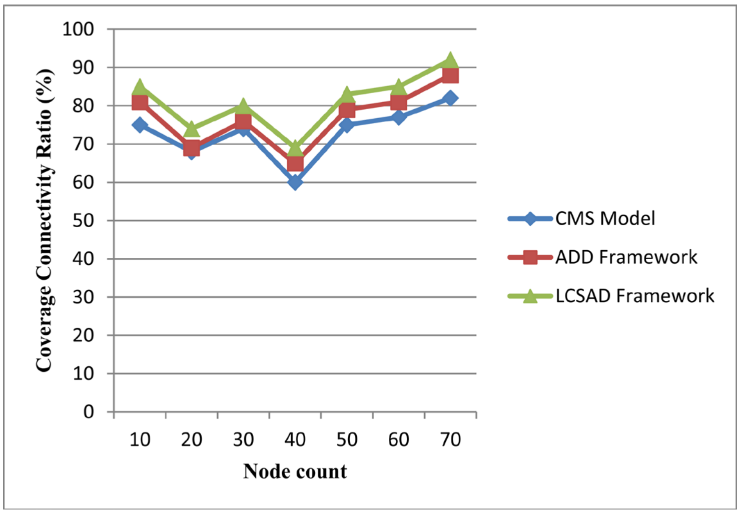

Figure 7. Coverage connectivity ratio measure.

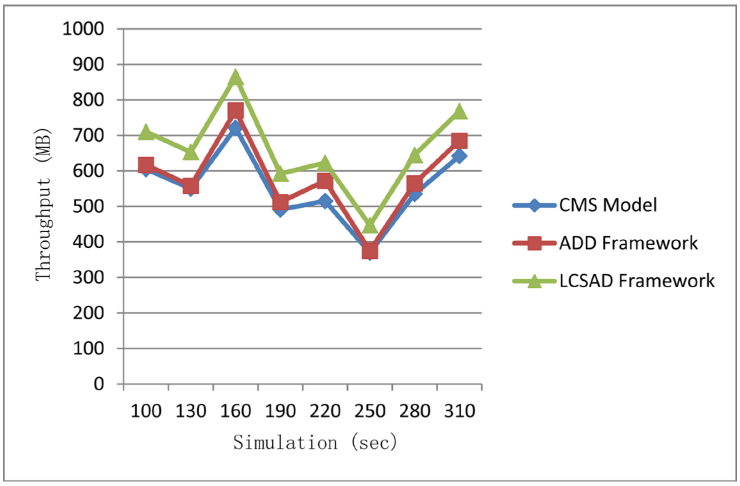

Figure 8. Measure of throughput.

Simulation results show that, algorithms applied to WSN of random topologies with varying node densities and have the minimal computation and communication costs, as compared to state of the art works. From the simulation result, it has been found that the proposed LCSAD framework attains minimal energy utilization and achieves maximal coverage connectivity in sensor network when compared with state of the art works.

References

[1] Zhang, F., Xi, Y.G., Lin, Z.L. and Chen, W.D. (2009) Constrained Motion Model of Mobile Robots and Its Applications. *IEEE Transactions on Systems, Man, and Cybernetics, Part B: Cybernetics*, **39**, 773-787.

[2] Szilagyi, P. and Novaczki, S. (2012) An Automatic Detection and Diagnosis Framework for Mobile Communication Systems. *IEEE Transactions on Network and Service Management*, **9**, 184-197. http://dx.doi.org/10.1109/TNSM.2012.031912.110155

[3] Yang, S.B., Yeo, C.K. and Lee, B.S. (2012) Toward Reliable Data Delivery for Highly Dynamic Mobile Ad Hoc Networks. *IEEE Transactions on Mobile Computing*, **11**, 111-124.

[4] Ghaderi, R., Esnaashari, M. and Meybodi, M.R. (2012) A Cellular Learning Automata-Based Algorithm for Solving the Coverage and Connectivity Problem in Wireless Sensor Networks. *Ad Hoc & Sensor Wireless Networks*, 1-33.

[5] Anisetti, M., Ardagna, C.A., Bellandi, V., Damiani, E. and Reale, S. (2011) Map-Based Location and Tracking in Multipath Outdoor Mobile Networks. *IEEE Transactions on Wireless Communications*, **10**, 814-824. http://dx.doi.org/10.1109/TWC.2011.011811.100025

[6] Zhang, Y., Wu, Z.B. and Trappe, W. (2011) Adaptive Location-Oriented Content Delivery in Delay-Sensitive Pervasive Applications. *IEEE Transactions on Mobile Computing*, **10**, 362-376. http://dx.doi.org/10.1109/TMC.2010.167

[7] Matamoros, J. and Antón-Haro, C. (2011) Optimal Network Size and Encoding Rate for Wireless Sensor Network-Based Decentralized Estimation under Power and Bandwidth Constraints. *IEEE Transactions on Wireless Communications*, **10**, 1121-1131. http://dx.doi.org/10.1109/TWC.2011.012411.091737

[8] Zhang, C., Song, Y., Fang, Y.G. and Zhang, Y.C. (2011) On the Price of Security in Large Scale Wireless Ad Hoc Networks. *IEEE/ACM Transactions on Networking*, **19**, 319-332. http://dx.doi.org/10.1109/TNET.2011.2106162

[9] Obaidat, M.S. and Guelzim, T. (2010) A Counter Disassociation Mechanism (CDM) for Wireless LANs and its Performance Simulation Analysis. *IEEE Systems Journal*, **4**, 57-64.

[10] Arroyo-Valles, R., Marques, A.G. and Cid-Sueiro, J. (2011) Optimal Selective Forwarding for Energy Saving in Wireless Sensor Networks. *IEEE Transactions on Wireless Communications*, **10**, 164-175. http://dx.doi.org/10.1109/TWC.2010.102810.100014

[11] Sinha, K., Sinha, BP. and Datta, D. (2011) An Energy-Efficient Communication Scheme for Wireless Networks: A Redundant Radix-Based Approach. *IEEE Transactions on Wireless Communications*, **10**, 550-549. http://dx.doi.org/10.1109/TWC.2010.120610.100244

[12] Yuen, W.H., Mau, S.-C. and Yates, R.D. (2009) Existence of Data and Multiuser Diversities in Noncooperative Mobile Infostation Networks. *IEEE Transactions on Mobile Computing*, **8**, 1117-1131. http://dx.doi.org/10.1109/TMC.2009.41

[13] Zhang, X.M., Wang, E.B., Xia, J.J. and Sung, D.K. (2013) A Neighbor Coverage-Based Probabilistic Rebroadcast for Reducing Routing Overhead in Mobile Ad Hoc Networks. *Transactions on Mobile Computing*, **12**, 424-433. http://dx.doi.org/10.1109/TMC.2011.277

[14] Bai, X.L., Xuan, D., Yun, Z.Q., Lai, T.H. and Jia, W.J. (2008) Complete Optimal Deployment Patterns for Full-Coverage and k-Connectivity ($k \leq 6$) Wireless Sensor Networks. *Proceedings of the* 9*th ACM international symposium on Mobile Ad Hoc Networking and Computing*, 401-410. http://dx.doi.org/10.1145/1374618.1374672

[15] Rajaram, P. and Prakasam, P. (2014) Data Collection Using Mobile Robot in WSN: A Review. *Journal of Theoretical and Applied Information Technology*, **65**, 437-446.

[16] Rajaram, P. and Prakasam, P. (2013) Analysis on Data Collection Using Mobile Robot in Wireless Sensor Networks, *International Conference on Current Trends in Engineering and Technology* (*ICCTET*), Coimbatore, 3 July 2013, 264-269. http://dx.doi.org/10.1109/ICCTET.2013.6675963

[17] Xu, E.Y., Ding, Z. and Dasgupta, S. (2013) Target Tracking and Mobile Sensor Navigation in Wireless Sensor Networks. *IEEE Transactions on Mobile Computing*, **12**, 177-186. http://dx.doi.org/10.1109/TMC.2011.262

[18] Nicopolitidis, P., Papadimitriou, G.I. and Pomportsis, A.S. (2010) Adaptive Data Broadcasting in Underwater Wireless Networks. *IEEE Journal of Oceanic Engineering*, **35**, 623-634. http://dx.doi.org/10.1109/JOE.2010.2049674

[19] Matamoros, J. and Antón-Haro, C. (2011) Optimal Network Size and Encoding Rate for Wireless Sensor Network-Based Decentralized Estimation under Power and Bandwidth Constraints. *IEEE Transactions on Wireless Communications*, **10**, 1121-1131. http://dx.doi.org/10.1109/TWC.2011.012411.091737

[20] Su, M.-Y. (2011) Prevention of Selective Black Hole Attacks on Mobile Ad Hoc Networks through Intrusion Detection Systems. *Elsevier Journal of Computer Communications*, **34**, 107-117.

[21] Balachandran, K., Kang, J.H., Karakayali, K. and Rege, K.M. (2011) NICE: A Network Interference Cancellation Engine for Opportunistic Uplink Cooperation in Wireless Networks. *IEEE Transactions on Wireless Communications*, **10**, 540-549. http://dx.doi.org/10.1109/TWC.2010.120610.100169

[22] Wang, R., Lau, V.K.N. and Huang, H. (2011) Opportunistic Buffered Decode-Wait-and-Forward (OBDWF) Protocol for Mobile Wireless Relay Networks. *IEEE Transactions on Wireless Communications*, **10**, 1224-1231. http://dx.doi.org/10.1109/TWC.2011.020111.100466