ADVANCES in NATURAL and APPLIED SCIENCES

ISSN: 1995-0772
EISSN: 1998-1090
2016 April 10(4): pages 271-278

Published BY **AENSI Publication**
http://www.aensiweb.com/ANAS
Open Access Journal

Improving the Network Lifetime using Network Connectivity and Target Coverage in Mobile Sensor Networks

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Received 25 January 2016; Accepted 18 April 2016; Available 28 April 2016

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ABSTRACT

This work proposes an approach of improving the network lifetime by enhancing Network CONnectivity (NCON) and Target COVerage (TCOV) in randomly deployed Mobile Sensor Network (MSN). Generally, MSN is the collection of independent and scattered sensors with movable capability. Target coverage, network connectivity and network lifetime are the notified issues of mobile sensor networks. Target coverage is usually coverage area of a randomly distributed sensor, which selects and successfully activates mutual set of nodes such that each set completely monitors the entire area. Network connectivity is mainly used to collect and report data to the sink node through sensor nodes. Heuristic Random Network Coding (HRNC) is proposed to enhance the quality of target coverage and network connectivity and to improve the network lifetime. For both existing and proposed method, the performance metrics is calculated and the comparison analysis are simulated using NS2 for various parameters shows HRNC provides better performance than existing system.

KEYWORDS: Mobile sensor network, heuristic random network coding, target coverage, network connectivity and lifetime

INTRODUCTION

Now-a-days, Wireless Sensor Network (WSN) is an emerging technology for wide range of applications. The applications of wireless sensor network include security surveillance, environmental monitoring, smart homes and offices, object tracking [1], traffic management, navigation etc.

A wireless sensor network is a set of randomly distributed sensor nodes. Sensor node is a small wireless device with limited battery life, radio transmission range and storage size.

A WSN is also known as Wireless Sensor and Actor Network (WSAN), which are in a coverage area to monitor physical and environmental conditions such as temperature, sound, pressure, humidity etc. and to transmit their data to the main location through a network [2].

A sensor node also known as a mote in a sensor network that is capable of processing, gathering information and communicating with other connected nodes in the network. A sensor node should be small in size, consume low energy, operate in high densities, be autonomous and operate unattended, and be adaptive to the environment. In this paper, network coder sensor is used which is similar to other sensor in MSN but it has minimum energy consumption and it maximize the efficiency of the entire network.

Mobile sensor network (MSN) is the cluster of movable sensor nodes. After initial deployment, the sensor nodes are capable of changing their location. In general, mobility can be applied to all the nodes. It can be active

To Cite This Article: K.Jeya Sudha, P. Abinaya, M. Kalpana and T. Senthil Kumar., Improving the Network Lifetime using Network Connectivity and Target Coverage in Mobile Sensor Networks. **Advances in Natural and Applied Sciences**. 10(4); Pages: 271-278

or passive. Sensors are capable of finding their own shortest path and move in active mobility while in passive mobility; they are assisted by human or environmental conditions [3]. In MSN, the sensor deployment is considered as challenging one because it affects the quality of coverage and connectivity [4] [5] [6].

However, most of the existing studies aimed at improving the quality of network connectivity and target coverage. Little attention has been paid to increase the network lifetime of the MSN. To fill this gap, Heuristic Random Network Coding (HRNC) is proposed to achieve effective network connectivity and target coverage. By achieving these two solutions, the load of different sensors can be balanced and finally improves the network lifetime.

2.Related Work:

In Mobile Sensor Network, sensors work co-operatively to sense, process and route the data to base station. Some of the future potential related to connectivity and coverage problem are reviewed here. In [2], coverage and connectivity problems of randomly deployed mobile sensor are discussed. For target coverage problem, Basic algorithm based on clique partition [7] and Target based Voronoi Greedy algorithm are proposed to minimize the movement of the sensors. For network connectivity problem, Steiner minimum tree with constrained edge length is proposed. Initially, the Steiner points are needed to connect sensor node with target node. To move optimal sensors to these points, an Extended- Hungarian method is used. By using sensor mobility, WSN connectivity and coverage can be improved [8]. Sensor deployment is one of the major issues in MSN. Paper [9] provides connectivity and targeted coverage by introducing a better algorithm for sensor deployment in a given region. In [10], a competition scheme is proposed for k-coverage in order to minimize the consumption of energy in movement.

The entire network may break or create holes due to limited battery life and cause sensor failure during operation. In order to heal the holes and reduce energy consumption, Adaptively Hole Connected Healing (AHCH) is proposed and it guaranteed the connectivity of the entire system [11]. The AHCH algorithm has insufficient mobile sensors which lead to disconnection of coverage region. The effective coverage can be achieved by using Fuzzy Inference System (FIS) algorithm [12]. The FIS is used by Base Station (BS) to determine which nodes are in active or in sleep mode. For data sharing, multi-hopping is used between successive active nodes. The consumption of energy in movement can also be rectified by using parameterized algorithm. It is exploited to maximize the target coverage [13] and minimize the power multi-cast paths [14].

The connectivity and coverage problem can be solved by using the solution, Connected Cover Set based on Identity of node (CCSID). The graph theory concept is used here to build coverage sets [15]. CCSID divide the sensors into many subgroups. The connectivity and coverage is ensured by selecting minimum number of active nodes in each sub-group. In [16], Greedy Iterative Energy- Efficient Connected Coverage (GIECC) algorithm is proposed to find the active nodes.

After the completion of connectivity and coverage stage in MSN, the network lifetime must be enhanced. In paper [17], Logical Energy Tree (LET) is constructed by means of available energy in each sensor node. LET has two routing algorithms: LETCSN with centralized sink node and LETSSN with centralized sink node and secondary sink nodes. Sensor nodes are deployed in some fixed patterns. In order to deploy the sensor node in random manner, Random Linear Network Coding (RLNC) approach is used [18]. RLNC source coding perspective effectively compresses error creating correlated sources and achieves capacity of the network lifetime.

3.Methodology:

3.1 System Model:

In the system model, there are p targets $T =\{t_1,t_2,..,t_p\}$ with known locations to be enclosed and q mobile sensors $S=\{s_1,s_2,..,s_q\}$are randomly deployed in the configuration area. The working of system model is as follows:

1) Every sensor knows its own position via a mounted GPS unit or by means of localization service in the network.

2) The sensor is able to choose an appropriate shortest path to the destination based on the node energy.

3) In this work, the system efforts ondetermining WHERE they should move and WHICH sensorsshould move to in order to guarantee various performance of the network.

4) The network of the system model consists of two models: one is network model, which is adopted for both sensing and communication of sensors with the sensing radius $r_s$and the communication radius $r_c$respectively. Each sink can be covered by more than one sensor and each sensor can cover more than one target based on concentric circle and other is mobility model, in which sensors are able to move continuously in any direction and capable of stop anywhere in the configuration.

5) The distance that a sensor moves is used to present the sensor's energy consumption suffered in the movement. The movement distance of sensor s to cover target t is $dist(s,t)$, where $dist(s,t)$is the distance between

s and *t*. Similarly, the movement distance of sensor s_i to connect with sensor $s_j$is $dist(s_i,s_j)$, where $dist(s_i,s_j)$ is the distance between s_i and s_j.

3.2 Problem Definition:

With the system model, the definition of the MSD problem can be given as follows:

Definition 1:

Mobile Sensor Deployment (MSD) problem: given *p* targets with known locations and *q* mobile sensors deployed randomly in the configuration area, the MSD problem seeks the minimum movement of mobile sensors. The following objectives are achieved after the movement of sensor to new location:

1) Every target is covered by at least one mobile sensor.
2) The network formed by all the moved sensors is connected.

Definition 2:

Target COVerage (TCOV) problem: given *p* targets with known locations and *q* mobile sensors deployed randomly in the configuration area, move sensors to new positions, so that all the targets are covered and the total sensors movement is reduced.

Definition 3:

Network CONnectivity (NCON) problem: given a sink, set of coverage sensors and rest mobile sensors after the TCOV problem is solved, NCON seeks the rest of mobile sensor deployment to connect coverage sensors and the sink with minimum movement.

By using an approximation algorithm named Extended Hungarian is to minimize the number of steiner points on all the edges by means of extended cost in which the steiner points are calculated based on information about the nodes and the number of repeated values can be reduced.

3.3Heuristic Random Network Coding (HRNC):
Algorithm:

In the mobile sensor networks, the number of mobile sensors is deployed in random manner to identify the sink node via intermediate nodes.

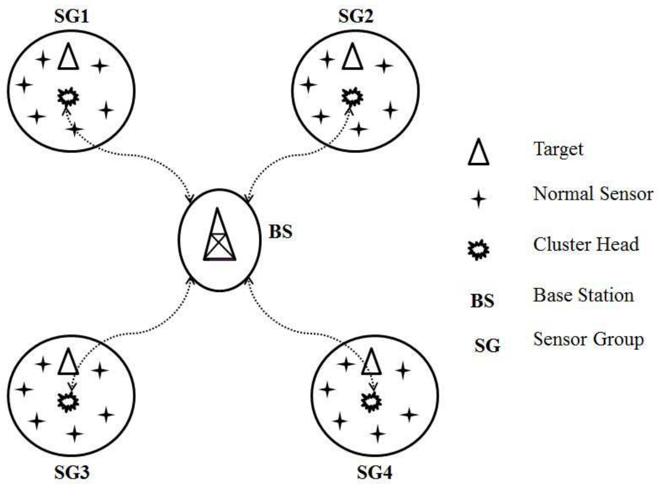

Fig. 1: System Architecture

Among several groups of normal sensors are subdivided into group of clusters shows in figure1. Each cluster has a target to be examined, normal sensors and a Cluster Head (CH). The information to be sensed are collected by the cluster head and transferred to the Base Station (BS) and then the processed information is send to the normal sensor of another cluster group through cluster head.

Heuristic random network coding algorithm is proposed to improve the target coverage and network connectivity, which improvises the lifetime of the network.

The basic idea of HRNC is used to select the nodes based on random approach for target coverage, which helps to improvise the network lifetime by means of target coverage and network connectivity, packet delivery ratio and the entire energy consumption of network.

HRNC Algorithm:

Input: $T=\{t_1,t_2,..,t_p\}$; //Position of targets $S=\{s_1,s_2,..,s_q\}$; //Number of sensor nodes r_s; //Coverage radius

Condition and IP address of the nodes

Output: $Node_{Identify\_Neighbor}$ //Identification of nearest nodes
1 Deployment of sensors
2 Determine d between each node
3 Find the n
4 Calculate the D from received packets
$$\mathbf{D = d_{proc} + d_{queue} + d_{trans} + d_{prop}}$$
5 Send the packet to receiver in its own time slot
6 check BER and noise to every packet
7 **if** conflict occurs; **then**
8 Records conflict message
9 **return** to 6
10 else
11 Send packet to all neighbor nodes 12 Process and send to base station
13 **return** $Node_{Identify\_Neighbor}$

Table1: Important mathematical notations used in the paper

Notation	Meaning
d	Distance between the nodes
n	Neighbor node
D	Delay
dproc	Processing delay
dqueue	Queuing delay
dtrans	Transmission delay
dprop	Propagation delay

The flow diagram of HRNC is shown in figure 2

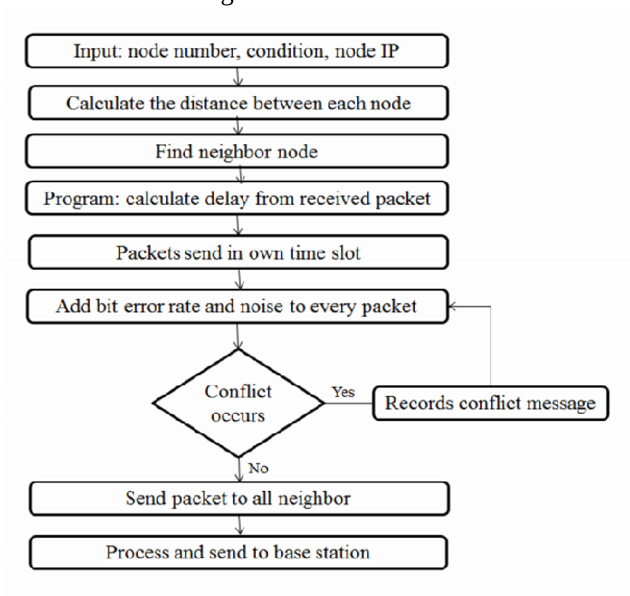

Fig. 2: Flow diagram of HRNC

By using Steiner minimum tree with constraint energy length solution, the rest mobile sensors are relocated to some other location where they are needed to connect sensor node and target as in figure 3.

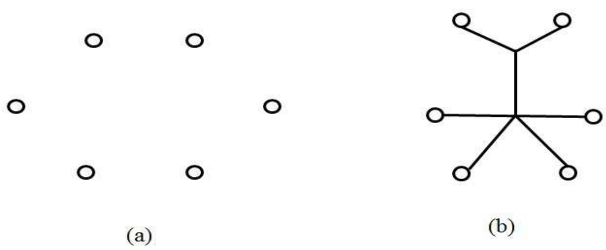

Fig. 3: Illustration of Steiner Minimum Tree: a) Initial position of sensors; b) Relocation of sensors

It is also used reduce the number of sensors need to be moved. The problem can be solved in following steps:

- Construct steiner edge length tree covering all the sensors and the sink node.
- Relocate the rest mobile sensor to connect sensor node and sink node.
- Dispatch the dedicated sensor to cover the each target.

Simulation Parameters And Results:

4.1 Simulation Parameters:

In this section, the heuristic random network coding algorithm is entirely based on a stationary network with sensor nodes and targets randomly located in the configuration area.

Table 2 shows the simulation parameters that were used.

Table 2: Simulation Parameters

Parameters	Value/Type
Simulation area	1500m × 1500m
Number of nodes	100
Channel	Wireless channel
Propagation	Free-space
Network interface type	Wireless physical interface
Mac-type	Mac 802.11
Interface queue type	Drop-tail
Antenna	Omni-antenna
Routing protocol	BTS/HRNC

We assume sensors are consistent and initially have the same energy. In the simulation, we consider the following tunable parameters: 1) the number of sensor nodes N, 2) network coder sensor.

The figure 4.1(a) shows the random initial deployment of 100 nodes and figure 4.1(b) shows the output window consisting the simulation result of proposed system with concentric circles at 2.42ms.

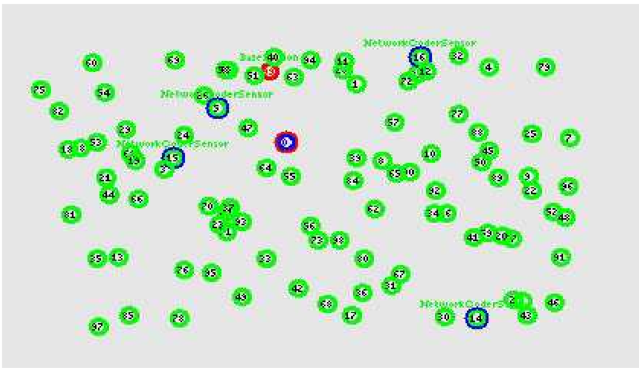

Fig. 4.1(a): Initial Deployment of nodes

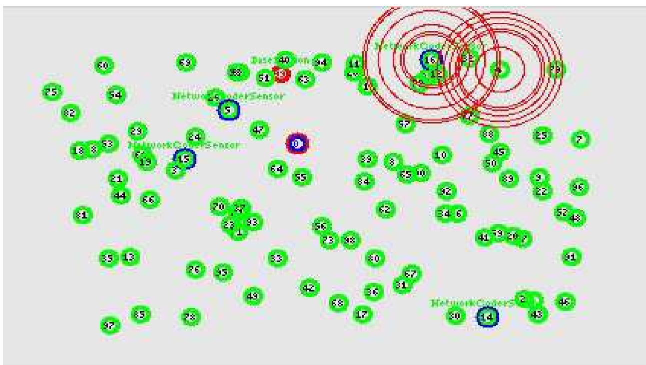

Fig. 4.1(b): Deployment of nodes with Concentric Circle

4.2Simulation Results:

The performances parameters such as latency, packet delivery ratio, energy consumption, network connectivity and target coverage are simulated in NS2. The simulation results are compared with the Basic TV Greedy Steiner (BTS) algorithm.

Figure 4.2 (a) shows that the overall latency for simulated MSN, which shows minimum performance for proposed algorithm HRNC than the BTS. Figure 4.2 (b) shows that the overall packet data rate of simulated MSN shows better performance for HRNC, when compared to BTS. Figure 4.2 (c)-(e) shows that the comparison of simulated MSN, which shows better performance for HRNC than the existing method

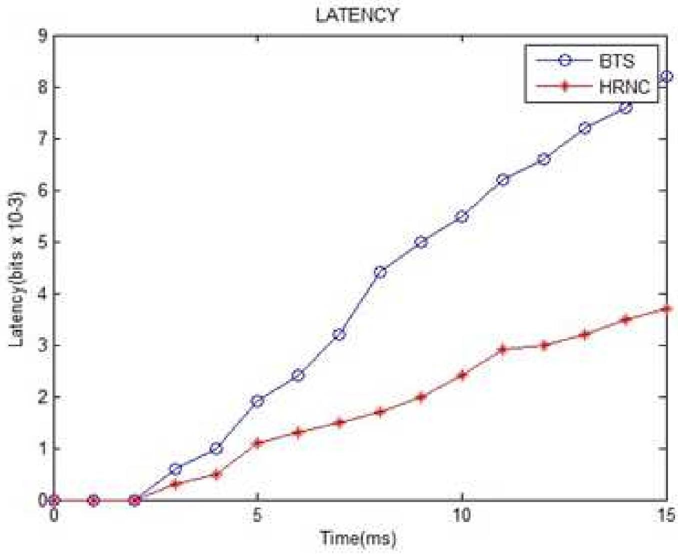

Fig. 4.2(a): Latency vs Time

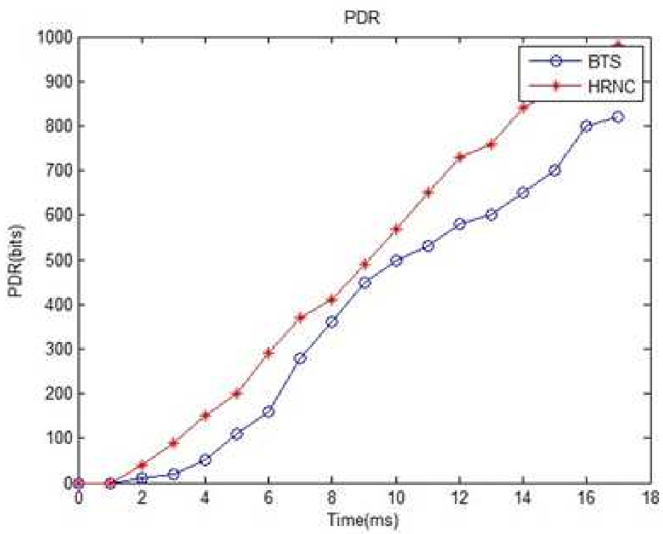

Fig. 4.2(b): Packet Delivery Ratio (PDR) vs Time

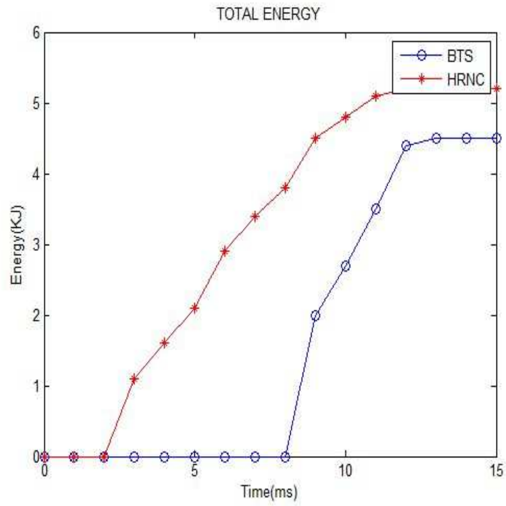

Fig. 4.2(c): Energy vs Time

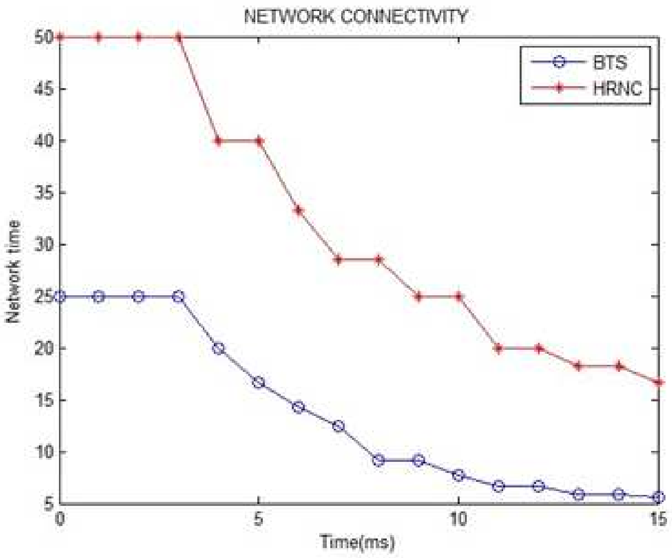

Fig. 4.2(d): Network Connectivity vs Time

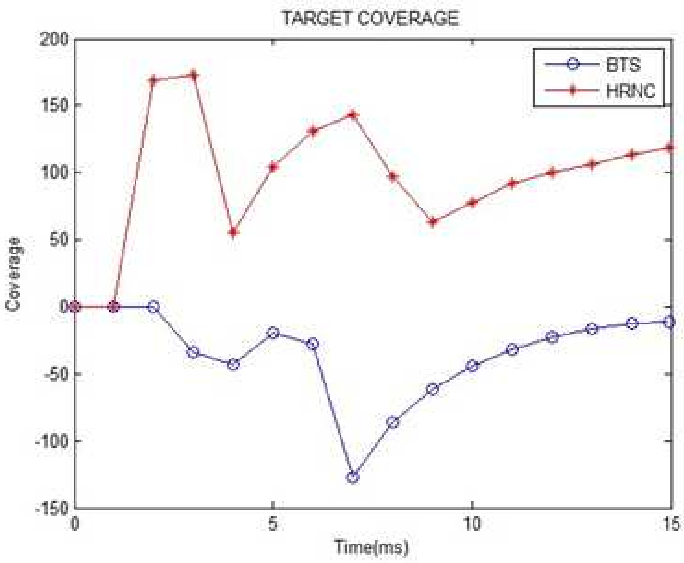

Fig. 4.2(e): Coverage vs Time

Conclusion:

The issues of TCOV, NCON and network lifetime are the main consideration in mobile sensor network. Heuristic Random Network Coding provides an optimal solution and helps in minimizing the sensors movement.

By applying the algorithm, while sending data from the sensor node to sink node increases the computation speed of transmission and efficiently solve the TCOV and NCON problem. Hence, the proposed scheme successfully overcomes the issues of TCOV and NCON in mobile sensor networks and increases the network lifetime. The simulation results of HRNC shows better performance than the existing algorithm.

In future research, we proposed to increase the security of the system by deploying symmetric encryption key algorithm like AES (Advanced Encryption Standard). For dynamically increasing the TCOV and network lifetime, newer mechanism like Sink Trail can be used in mobile sensor network.

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