A new distributed architecture for connectivity analysis in wireless networks

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Abstract

The objective of the paper is to analysis the connectivity performance of wireless network with new centralized and distributed network architecture. The problems in the wireless networks are finding a path to destination, connectivity maintenance and estimation of node positions. To solve these issues two algorithms are proposed, namely becon and bounding box algorithms in this work. The performance of the proposed approach is witnessed by analyzing the parameters like packet delivery ratio, throughput, delay and energy conservation ratio.

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1. Introduction:

Wireless networks (WNs) have been used in many fields, including environmental monitoring, habitat monitoring, precision agriculture, animal tracking and disaster rescue. In real time applications it is necessary that all the nodes position is to be known to the researchers. In geographical routing protocols such as Greedy Perimeter Stateless Routing (GPSR) \cite{1} it’s required to know the nodes position information in order to select the next-hop relaying nodes. In Localization, the nodes in the network are classified into two types: beacon nodes which know its position and sensor nodes which need to determine their position using localization algorithm. Localization in sensor networks uses Global Positioning systems (GPS) receiver on every nodes. Due to the economical constraints it is not possible to implement in the entire GPS receiver. In some recently emerging applications such as animal tracking and

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monitoring [2],[3] sensor nodes may move after deployment. The simple idea of executing these algorithms periodically in a mobile sensor network is infeasible, because this will incur high communication cost [4]. There are some localization algorithm specially designed for sensor networks. All of them are based on the sequential Monte Carlo (SMC) method [5].

In position based routing algorithms it is assumed that a node is aware of its position, the position of its neighbors, and the position of the destination. GPSR is a reactive position based routing algorithm. The drawback of this algorithm is that they may fail to find a route or they may find a non-optimum route in some situations [6]. Algorithms based on face routing guarantee to find a route to the destination if it is possible to extract locally a planar sub network of a given network [7][8][9]. Hence face routing algorithms do not guarantee data delivery and they often find a route that is much longer than the shortest path. ANTNET and ANTHOCNET have a high delivery rate and find routes whose lengths are very close to the length of the shortest path[10][11]. Since most applications depend on a successful localization, i.e. to compute their positions in some fixed coordinate system, it is of great importance to design efficient localization algorithms. In large scale ad hoc networks, node localization can assist in routing [12], and [13]. In the smart kinder garden node localization can be used to monitor the progress of the children by tracking their interaction with toys and also with each other. It can also be used in hospital environments to keep track of equipments, patients, doctors and nurses [14]. In this paper, the routing algorithm that is possible to have a stable data transmission with less energy consumption is suggested for connectivity. Our proposed approaches mainly focus on coverage and connectivity analysis in ad hoc domain. The performance of position based routing algorithms is studied from [15-18]

The rest of the paper is organized as follows: chapter 2 gives the Becon architecture with network model. The Bbox network structure and connectivity maintenance algorithm is given in chapter 3. The performance of the proposed architectures is given in chapter 4. Finally chapter 5 concludes the paper.

2. Becon algorithm:

In this proposed algorithm cluster based approach is used where the head is selected based on the weight calculation. It is based on centralized control method because cluster heads decide the route to destination. To estimate the location sequential Monte Carlo algorithm [5] is used. Firstly, Beacon nodes are identified and some samples are allowed to move around the network i.e. Filtering of samples and the position is identified by evaluating the average of the computed samples’ weight. Here again it is necessary that as the samples increases the localization accuracy increases. Secondly, estimating the nodes location: it is also considered for routing the packets but along with that all pair path routing comes into existence. In our approach the communication occurs between the cluster heads. In this algorithm each and every cluster heads search and computes its neighbors and its hop distance.

Algorithm 1: Becon algorithm: 

1: N is the no. of nodes in the network, m0 is the beacon Samples, w0 is the weight of the samples, adj [i][j] is the adjacent nodes, dist[i][j] is the distance, k is no.of hops 
2: Step 1: Initialization
3: for i ←----- 1, N in Clusters
4: Samples m0~p (n0)
5: end
6: move the samples
7: Step 2: Evaluation of samples’ weight
8: Weight: \( w_i = \frac{p}{\sum_{j=1}^{N} w_j} \)
9: Normalized weight \( M_i = \frac{w_i}{\sum_{j=1}^{N} w_j} \)
10: Positions of the nodes are estimated
11: Step 3: path selection (all pair)
11: Initialize \((i,j)\) where \(i\) and \(j\) are nodes coordinates
12: if
\[
\text{adj}[i][j] = 0 \quad \text{then the path is set to} \quad 0 \quad \text{and}
\]
\[
\text{dist}[i][j] = \infty
\]
else
\[
\text{dist}[i][j] = \text{adj}[i][j] \quad \text{and path is equal to} \quad i
\]
13: Increment \(i\) and \(j\)
14: Increment \(k\) i.e. no. of hops
Select Path < \(k\) with minimum distance
15: Repeat the above computation for all pairs i.e. total no. of nodes in the network

To find the position of the adjacent nodes, the cluster head use this method. If the neighbor in the area distance in the routing table is set to 0 and distance is set to infinity. In our proposed algorithm it computes for all pairs or all possibilities of path and selects the shortest path based on the hop distance. For example if it computes at \(k=3\) hop then it takes the maximum hop count with minimum distance as a shortest path and routes the packet. If the path length is same it considers both the hops and the position of the nodes. Computation depends on the number of nodes in the network.

3. Bounding box network architecture:

In this proposed structure (figure 1) bounding box based approach is used where the nodes are allowed to move in the random fashion. To estimate the location of nodes bounding box is used. Firstly, bounding box is created by varying the size of the node. With random \(V_{\text{max}}\) the nodes are allowed to move in the network. Here again it is not necessary that the samples should be more to increase the localization accuracy. Secondly, after estimating the nodes location the location is also been considered for routing the packets. The area of the box is shrinked and allowed to repeat the above.

![Figure 1. Bounding box architecture](image)

3.1 Bbox Algorithm

In this approach the positions are estimated with less energy consumption. It then checks the difference between the \(X_{\text{max}}\) and \(X_{\text{min}}\) position with the original positions. If the difference is minimum compared to the other one it is consider as the original position of the node. Thus the path in which the node moves can be easily tracked. The minimum or smallest bounding or enclosing box for a point set in \(N\) dimensions is the box with the smallest measure (area, volume, or hyper volume in higher dimensions) within which all the points lie. When other kinds of measure are used, the minimum box is usually called accordingly, e.g., "minimum-perimeter bounding box". If the path length is same it considers both the hops and the position of the nodes is given figure 2. Computation depends on the number of nodes in the network.
Algorithm 2: BBOX algorithm
\{ N is the no. of nodes in the network, cc is the size of node, Vmax is the random velocity\}
1: **Step 1: Bounding box creation**
2: for i ← 1, N randomly deployed
3: set
   \[
   cc \leftarrow n \times \text{size}(Ni)
   \]
   end
5: cc acts as a bbox i.e. coverage area
6: **Step 2: Set Vmax**
7: Initial positions are set
8: Allow the N nodes to move randomly i.e. Vmax
9: Position depends on the Vmax and the speed of the run
10: **Step 3: Position Estimation**
11: Shrink the bbox & with the random movement the dist is estimated between beacon and other nodes
12: Set
   \[
   X_{\text{max}} \text{ and } Y_{\text{max}}
   \]
   \[
   X_{\text{min}} \text{ and } Y_{\text{min}}
   \]
13: Calculate the difference from real \( \text{pos}(t) \) i.e. after Vmax with \( \text{max} \) and \( \text{min} \) \( \text{pos}(t) \)
14: set minimum distance as estimated position
15: Real positions are estimated

![Node movement in Bbox](image)

3.2 Connectivity Maintenance
In this algorithm the connectivity maintenance is proposed by considering various factors of the wireless networks. Bounded box approach is the novel based approach in which the maximum transmission range is fixed for the nodes in the bounded area. Firstly, the nodes are deployed randomly in the field. The Marking nodes are selected based on the criteria that is been considered earlier. This selection helps in maintaining the topology of the network. After selecting the nodes the boundary is fixed. The nodes in the network are allowed to move randomly in the area (dynamic) and simulated. If the marking node moves out of the bounded area it handovers to the next prior node that can maintain the connectivity of the network. Through this algorithm the scenario outperforms and conserves energy comparatively.

Algorithm 3: Connectivity Maintenance algorithm:
\{ N is the no. of nodes in the network, \( m_0 \) is the marking nodes in the network \}
1: **Step 1: Initialization**
2: for i ←----- 1, N in Random fashion
3: marking nodes m₀~p (m₀)
4: end
5: move the samples
6: Step 2: Selection of marking nodes
7: Marking nodes: m₀(i) \cap cc
8: Color code the node that has more number of links
9: Position the nodes that intersects cc
10: Step 3: Bounding box construction
11: set
   \[
   cc \leftarrow n*\text{size}(N_i)
   \]
   End
12: cc acts as a bbox i.e. coverage area
13: N ←-----mobility (Rᵥmax) random motion
14: m₀ within cc range
   \{
   \text{Put "continue"}
   \text{else}
   \text{out of range – elect new marking node to tx in one traffic}
15: Maintains connectivity

At a point of time the marking nodes from the bounded box may move from it. This leads to the connectivity problems in the wireless network. The topology may lose its maintenance because of the marking nodes that moves away from the coverage area in the network. In this level, our Bbox method shows the boundary of coverage area to resolve the above problem. This helps the transmission process very simple through the marking nodes where it takes control of the neighboring nodes. Thus connectivity is maintained in the wireless network.

4. Performance Analysis:
4.1 performance metrics:
- System throughput: Measured as the total number data packets received at the destination during the simulation.
- End to end delay: Includes all possible delays caused by backbone construction process, topology based reconstruction and time taken for selfish node behavior during self organization is taken into account.
- Packet delivery ratio: It is calculated as the ratio between the number of data packets that are sent by the source and the number of data packets that are received by the intermediate or destination node.
- Energy efficiency: It is measured as the number of routing packets transmitted per message packet for construction of the network scenario.

4.2 Simulation results:
All the simulations are conducted using ns-2 with 50 nodes, a 1500x2000 m² deployment area, 0.90s hello interval and random way point model. We would like to observe the performance of the proposed system with energy consumption, packet delivery ratio, delay and throughput. Total simulation time is 120 seconds and the packet sized 64 Bytes. The simulation parameters are given in Table 1.
In Becon algorithm, about 50 nodes are considered and deployed in a clustered fashion. Initial energy level is 100 joules. In this graph, the amount of energy consumed is about 15% from the total energy. Initially the consumption is 0(constant) and decreases deeply due to the routing overheads in the routing strategy.

In this graph (figure 3), throughput of this method is better when compared to the normal approach because the delivery ratio is extremely high and there is no packets drop. As soon as the marking node leaves the bounded area it chooses the other node which has more links so that the topology, connectivity is maintained. It proves the efficiency of the strategy used to select and route the packets successfully.

From the figure 4, as the time increases the delivery ratio shoots up initially and vary slowly. Due to the simple and successive discovery of the intermediate node (shortest path) the delivery ratio reaches the peak efficiency and remains constant. It achieves around 50% and 77% for Becon and Bbox algorithm.
From figure 5, as the time increases the delay remains the same with slight variation. Normally the delay in our strategy is very less because of the time required to compute the path is low and the successive transmission makes the delay considerably low for the network. In this scenario (figure 6), only the localization of unknown nodes is estimated. The energy efficiency for estimating the position is compared. In Becon method the sample extraction consumes considerable amount of energy. Samples are allowed to move around the network, this consumes 10% of energy in the network. But that is not the case in Bbox method. In this method the nodes are allowed to move randomly and the easy task is the node that comes under the bounded box is estimated with its position; it consumes less amount of its initial energy. With Bbox only 30% of energy is consumed. By comparing both the techniques Bbox method shows it best with energy efficiency.

6. Conclusion:
In this work, an accurate energy efficient localization and routing strategy for ad hoc sensor networks is proposed. The results from our simulation validates that our proposed work outperforms from the normal algorithms with less energy consumption and delay. The data delivery rate is very high, but in localization it suffers from low sampling efficiency or requires high beacon density to achieve high accuracy. To overcome these problems construction of bounding box is done. In this bounding box technique the accuracy does not depends on the number of samples to be filtered out. It overcomes the drawback of position based algorithms and requires the random Vmax only. The accuracy depends on the runtime of
the scenario. By incorporating the bounding box concept in the dynamic network the connectivity of the network is maintained. Thus resolves the connectivity problem in the wireless networks.

References:


