TELKOMNIKA Telecommunication, Computing, Electronics and Control
Vol. 18, No. 6, December 2020, pp. 3339~3345
ISSN: 1693-6930, accredited First Grade by Kemenristekdikti, Decree No: 21/E/KPT/2018
DOI: 10.12928/TELKOMNIKA.v18i6.15998

A new clustering technique based on replication for MANET routing protocols

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Article Info

Article history:

Received Mar 5, 2020
Revised May 21, 2020
Accepted Jun 25, 2020

Keywords:

CBRP
Cluster based
MANET
Redundant
SCBRP

ABSTRACT

The cluster head nodes in most mobile ad hoc networks (MANET) clustering protocols take on an extraordinary role in managing routing information. The reliability, efficiency and scalability of the clustering in MANET will ultimately be dramatically impacted. In this work we establish a new approach to form the clusters in MANET called the square cluster-based routing protocol (SCBRP). That protocol is based on the theory of replication. The goal of the protocol is to achieve reliability, availability and scalability within the MANET.The proposed protocol is evaluated by caring the performance analysis using the NS-3 simulator. The performance shows 50% improvement in data delivering ratio in large network size, also shows an improvement in network stability and availability which is reflected in energy consumption measurements and increase in the system lifetime to 20%.

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1. INTRODUCTION

The extensive spread of wireless communication application and the quickly increasing loads over the last few years have guide the researches on mobile ad hoc networks (MANETs) in many concentration contexts [1]. These application contexts may vary from dangerous social networks to safety domains such as rescue action and field [2, 3]. The MANETs routing protocols are generally classified as proactive, reactive and hierarchical router [4]. The main drawback of the reactive routing protocol is not only extra traffic for communication along existing links but also, there is a significant delay in determining the route, while the main disadvantage of proactive protocol is high fixed head in maintaining updated periodic routing tables. The hierarchical routing protocols divide the mobile nodes in the network into subsets of nodes called clusters, in which a cluster head node (CH) is used to communicate data within the cluster. Election of a CH node occurs according to certain techniques and specific metrics. The other nodes can serve as ordinary nodes inside the cluster or gateways between clusters according to the cluster formation technique. Many algorithms have been proposed for dealing with the clustering problem [5]. An example of this type is the cluster-based routing protocol (CBRP) [6]. Many algorithms of cluster-based routing protocols were proposed. These algorithms were improved by many researchers using cluster head-based routing protocols.

R. Torres and L. Mengual, [7] proposed a hierarchical routing protocol called backup cluster head protocol (BCHP), which is based on the CBRP protocol, but each cluster consists of a CH and at least one backup cluster head (BCH) node. A node is selected as CH or BCH depends upon which of them has the best features. The authors showed that the BCHP improved the availability compared to the AODV and the CBRP protocols. Torres, Rommel, *et al.* [8] proposed the enhanced backup cluster head protocol (EBCHP). It has been realized, as an improvement to BCHP but, unlike BCHP, it uses a residual energy level strategy to change the BCH node status to CH, to improve the network lifetime in the process of cluster maintenance. Srungaram, K. and Krishna Prasad [9] proposed the enhanced CBRP (ECBRP). They used a weighted clustering algorithm in CH election. This enables anenhanced clustering approach.

Al-kahtani S. M. and Mouftah H. T. [10] suggested a new methodto restructurea cluster, namely the smooth and efficient re-clustering (SERC) protocol. In SERC, each CH elects a secondary CH (SCH). When the CH dies, the SCH will be a main CH. Since SCH is recognize to all cluster nodes, the cluster will be reformed right awayand the cluster looks balanced. Yassein M. B. and Hijazi N [11] proposed the Vice Cluster Head on cluster-based routing protocol (VCH-CBRP) by improve the CBRP. The CH sends a hello massage to every node about this VCH, If the firstCHexpirefor some purpose, then the VCH market it self as CH, which lowering the rate of calling cluster construction protocol due to mobility of the CH. After all, Shakarami *et al.*, [12] proposed a protocol which has separatedthe cluster into reliableand unreliablezones. If a CH shift to the unreliablezone then the chance of breaking route raises. So, the algorithm chooses a new node as a CH, before the existing CH moves out to unreliablezone. However, none of the researchers [13-24] has considered the network lifetime in high non-uniform node densities MANET or tried to decrease energy consumption.

In this contribution we develop aresourceful, reliable and scalable routing protocol for MANET, where we propose the square cluster based routing protocol based on replication protocol. In this protocol the CH node is nominated according to three metrics including, the remaining energy, the degree and the mobility. A backup minor cluster head (MCH) depending on the cluster size is used to ensure availability with large MANET. A threshold value α, is used to handle the scalability of the MANET network during the routing process. Instead of using common gateways between CHs we use a destination-sequenced distance-vector (DSDV) protocol to decreasethe energy consumption inside the cluster, and ensure the reliability between clusters.

2. THE PROPOSED PROTOCOL ALGORITHM

The square cluster-based routing protocol (SCBRP) algorithm divides the network into equally non-overlapping square zones; each containsa certain number of anodes. The nodes inside the cluster are categorized into three possible states as shown in Figure 1.

- A CH node as a coordinator inside each cluster. All other nodes within a cluster are one-hop neighbors of the CH.
- An MCH node as the second-best node at the cluster.
- A normal node (NN). No node can be excited between clusters each node must join to cluster according to receiving signal strength (RSS), so all nodes in a cluster are in transmission range of cluster head.

The suggested technique shapes a cluster by choosing all the nodes in one cluster that are closest to CH. In the same method as the CH collection, MCH chose but the present of MCH within the cluster relies only on the node density within the cluster. Both nodes assigned to the cluster retain the CH and MCH reference nodes. Via restricting the number of MCH per cluster, we 'd have load balancing across clusters, and we can avoid having large numbers of nodes per single cluster head, which makes it difficult to schedule and handle the cluster 's resources.

Clusters are formed around the lowest mobile and the highest energy node. Our proposed algorithm considers three metrics from nodes parameter for the election of CH. These metrics are mobility state, remaining energy and node degree. By selecting the most suitable node as CH stability of cluster increased. Each CHs have two tables wherein the information about the other neighbor CHs and information about the cluster nodes NN. Intercommunication between CHs has done using DSDV routing protocol, while the intra communication inside each cluster use using the CBRP routing protocol. The DSDV exhibits attractive performance when the network load and mobility are moderatewhich are appropriate for CHs network.

Figure 1. Model proposed structure for the MANET

2.1. Cluster head determination

In a MANET, every node sends HELLO messages to others to estimate the number of its neighbor nodes. By estimating three ratios according to following (1) each node decides its weight (NW) the nodes with the highest weight value election as CH and it produces a cluster. Other contact nodes in the coverage area are NN, and contact by CH.

$$NW_i = w_1 D_i + w_2 E_{ti} + w_3 S_i \quad (1)$$

where, N network size, Di represents node density, Ei is the residual energy at the node and Mi refers to mobility state of the node, while w1, w2 and w3 are the weight factors.

With increasing in the importance of metric they will be greater, $w_1+w_2+w_3 = 1$. Initially $w_1 = 0.25$, $w_2 = 0.5$ and $w_3 = 0.25$, and adjusted them adaptively according to network state. This NWi value indicates the stability of the node with reference to all neighbor nods, node with the maximum NWi value (i.e. less mobile and high energy) chosen as a CH and transmits a message containing its CH ID to the neighboring nodes. When the neighboring nodes obtain the CH notification, they respond to the CH to join the cluster, and all nodes inside the cluster take the alert. It is necessary to rotate the CH election algorithm among nodes once the CH runs out of energy or move away from cluster nodes, it is no longer operational, and all the nodes within the cluster lose communication ability.

Find the density around each node of each node by counting its neighbors,

$$D_i = |d_i - \frac{N}{4} \quad (2)$$

where, di = sum [distance (x, y) < range]. The size of the cluster is an important metric. There is a trade-off between the cluster dimensionand the number of CHs. If the cluster size is decreased, the energy consumption within each cluster is smaller, but with complex MANET due to increase in the number of CH. Larger cluster size gives higher energy in each cluster, with simpler MANET network.

Supposing current remaining energy of a node is (E_r) and defined threshold energy E_{th}, which is $\frac{Et}{\alpha}$ where parameter α set depends on the size of MANET. Only the node with adequate energy has a high metric to avoid node failure resulting from exhausted energy. The energy weight for calculation of delay, E_{ti}calculated according to the ratio between receiving energy to total energy $E_{ti} = \frac{Er}{Et}$. A node engage inlow mobility should be elected as CH. The mobility of the node S_i is consideredwith the difference in node location and time according to formula,

$$S_i = \frac{\sqrt{(x_t - x_{t-1})^2 - (y_t - y_{t-1})^2}}{T} \quad (3)$$

2.2. Minor cluster head election

Changeablenodes densities in clusters effects on the operationof the MANET, to address this issue SCBRP use MCH, which is the second-best node in the cluster, chosen during the same procedureof an election the CH. In non-uniform density cluster or large size cluster, with a number of nodes excesses a certain threshold CH can nominate a second CH to help in internal data exchange between nodes in the same cluster. Characterizing the impactof a non-homogeneousnode density on SCBRP operationand determining the leastperformance level is significant in our study SCBRP set the MCH creation threshold to $\frac{N}{\alpha}$. This parameter helps manage the trade-off between cluster size and number of MCHs to keep MANET congestion within the same cluster simple, high availability and control. The creation of the SCBRP cluster and the choice of CH and the MCH algorithm are shown in Table 1.

3. SQUARE CLUSTER BASED ROUTING PROTOCOL CLUSTERING COMMUNICATION

There are two levels of routing:

- Within the cluster: there are two ways to exchange data between nodes. In the same cluster nodes can communicate directly (within small size cluster), which the nodes can be retrievedirectly since they have scope between them and are directly visible. Otherwise (in case of large size network), the source node and destination node must exchange data through CHs or MCH.
- Outside the cluster: node decides that there is now path to the desired location when the packet is received to the CH. The CH includes an additional DSDV forwarding table for inter-cluster communication. The CH passes the data to the departure point CH.

A message has information about a node's ID and tasks, to keep the neighbor table and CH information updated. If no Hello message is establishedfrom a neighbor the neighbor is thought goneand removed from its table. If no CH is found, a new one is chosen. For illustrations consider the clusters mentioned below:

– In Figure 2, node S act as source and wants to send data to node D, they hear each other so they can send data directly without aid of CH.
– In Figure 3, S must send a request to its attached cluster CH or to MCH at first, and then S sends the message to D through CH in case of Figure 3 (a) or MCH Figure 3 (b).
– In Figure 4, the source node S requests to its attached CH and then the CH will broadcast this request to its neighbours CH through DSDV routing protocol, and the process will continue until the request arrives at the cluster which belongs to the destination node. Finally, D sends a replay along the discovered path to S through CHs.

Table 1. SCBRP Algorithm

Algorithm1 SCBRP cluster developmentand selectionof CH and the MCH

Require: Routing table of the neighbor nodes K ={NN….NN$_n$}
Ensure: Node Status (ξ_n) updated from S ={UNMEMBER, NN, CH, MCH}

```
if (ξn = UNDECIDED) then
ξn← CH
while (K ≠ φ) do
get the neighbors from K and α
get neighbor status ξn and neighbor weight NWi
end while
Sort K by NWi
NN1← K[1]
NN2← K[2]
if  (NN1st ∩ { UNMEMBER; MEMBER; MCH}  then
if (Ki ≥ NN1st) then
ξn←  CH
else if (NNi ≥ NN2nd&& MCH thr  =  n/α) then
ξn←  MCH
       Else
ξn← MEMBER
     end if
end if
returnξn
```

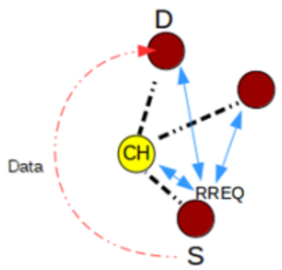
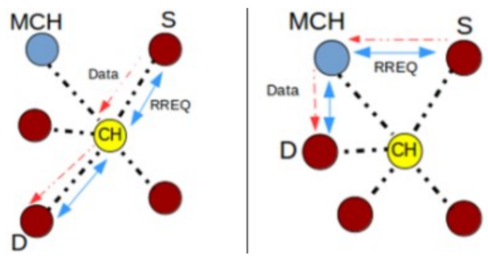


Figure 2. Communication inside small cluster



(a) (b)

Figure 3. Communication inside large cluster, through; (a) CH, (b) MCH

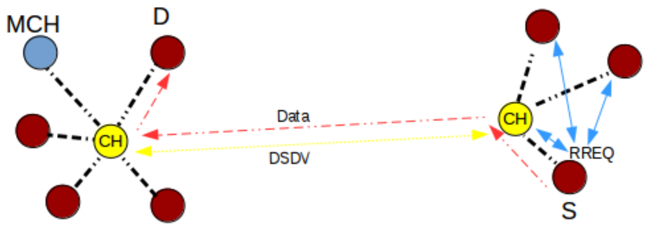


Figure 4. Communication between clusters

4. RESULTS AND DISCUSSION

Simulation is carried out on NS-3 simulator [25] to assess the clustering method. A series of simulation experiments designed to assess our proposed SCBRP, EBCHP, ECBRP and VCH-CBRP testing performance. 200 nodes were randomly placed inside a 1000x1000 m when simulation began. Simulate agility with a pause time of 0 second and simulation of 300-second. Other parameters for simulation are seeing in Table 2. SCBRP, EBCHP, ECBRP, and VCH-CBRP efficiency is measured in terms of packet delivery ratio (PDR), E2E latency, and average energy usage.In addition, we find the number of clusters created which have a major effect on cluster stability and reduces the overhead clustering.In this study α equal to 5 in case of a small network or 10 in large MANET.

Figure 5 illustrates the average E2E delay of our suggested technique and the existing clustering protocols. It can be seen that SCBRP protocol's average E2E delay is smaller than others. The packet distribution ratio (PDR) is the ratio of the amount of packets the endpoint collects to the number of packets the source node produces.The proposed approach does the highest in PDR followed by ECBRP as seen in Figure 6, this is attributed to working practically with limited sub networks (i.e. cluster) such that SCBRP will attain roughly constant PDR orbiting the real network scale. Even with large clusters, by decreasing congestion inside the cluster, BCH can improve PDR. With all packets provided by the recipient, the energy usage is the electricity used by the network. This is calculated as the overall energy absorbed divided by the total amount of the received packets.

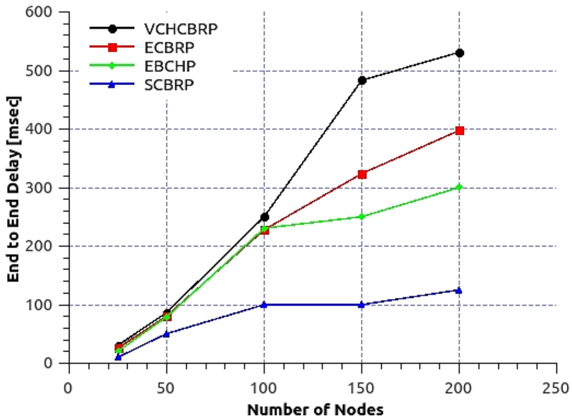


Figure 5. E2E Delay vs. network size

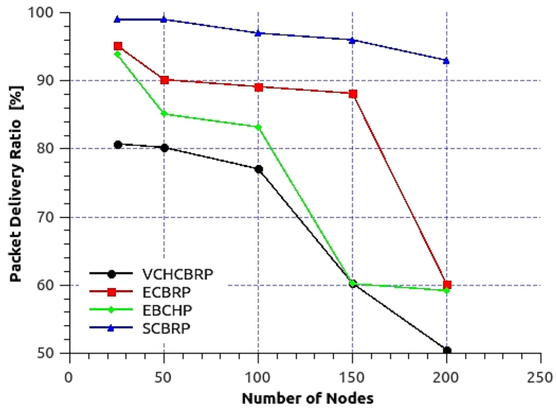


Figure 6. PDR vs. network size

Figure 7 displays average energy consumption with regards to particular number of nodes. Our proposed protocol explicitly uses less energy than other protocols. The SCBRP protocol offers a standardized environment for energy usage in MANET and thus extends MANETs' lifetime to 20 percent higher than other protocols, even though the number of connected nodes ranges from 100 to 200. Figure 8 shows the bondbetween amountof nodes in MANET and number of cluster formation, also its shows that SCBRP form small number of clusters comparing to other protocols, due to using of more specific metrics.The number of backup CH in other protocols equal to CH at all network sizes, because there are no rules to create backup cluster head on these protocols, in other hand SCBRP form MCH under certain condition so, it's not necessary to find MCH in all clusters.

Table 2. Simulation parameters

Parameter	Values
Transmission range	250 m
Traffic type	512 byte-CBR
Deployment Model	Random
Mobility Model	Random Way Point Mobility
Moving Speed	5, 10, 15, 20 m/s
Initial Energy	100 J

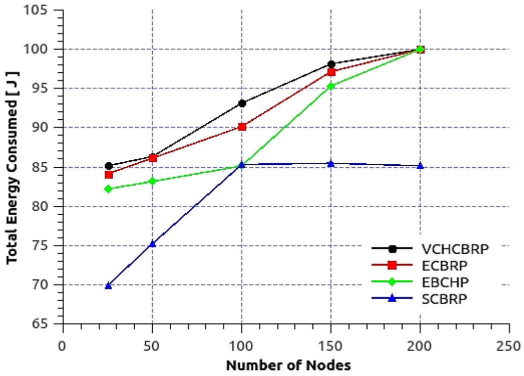


Figure 7. Total energy consumption

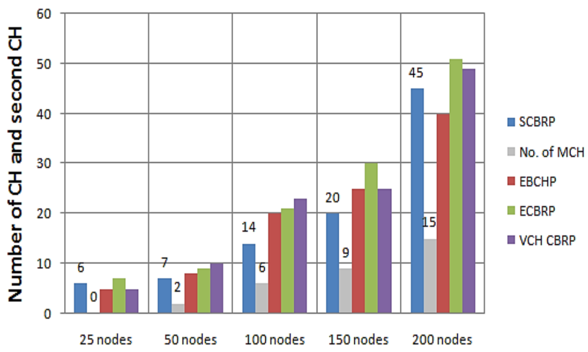


Figure 8. Number of CH at each algorithms and number ofMCH at SCBRP

5. CONCLUSION

A new MANET routing protocol based on replicationprotocol called square cluster-based routing protocol (SCBRP) is proposed. SCBRP algorithm presents a simple, light and quiet solution to MANET routing constraints. The SCBRP divides the traditional MANET into non-overlapping clusters and connects them using a proactive routing protocol. The SCBRP estimates the network metrics of each node in network and an efficient CH is selected based on these metrics. Congestion inside a cluster is controlled by a threshold based on network size and the selection of the MCH. This has improved the availability of MANET. The outcomes of the expermontsimulation shows that the introduced clustering method enhances the MANET 's network efficiency, reliability, availability and scalability taking into account the effect of network size.

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