Diksha Dinesh*, Deekshith KN and Saba Farheen NS, J Comput Eng Inf Technol 2022,11:8.

Journal of Computer Engineering and Information Technology

Research Article

A SCITECHNOL JOURNAL

An Energy Balanced Cluster Based Algorithm for MANETs

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Received date: 10 April, 2020, Manuscript No. JCEIT-20-9137;

Editor assigned date: 01 August, 2022, Pre QC No. JCEIT-20-9137 (PQ);

Reviewed date: 15 August, 2022, QC No. JCEIT-20-9137;

Revised date: 22 August, 2022, Manuscript No. JCEIT-20-9137 (R);

Published date: 29 August, 2022, DOI: 10.4172/2324-9307.1000241

Abstract

Mobile Ad-hoc Networks (MANETs) are self-configuring, autonomous and infrastructure-less type of networks, that associates mobile devices wirelessly. Every device often alters its link to other devices as MANET permits to move autonomously towards any path. The main challenge for MANET is to avoid congestion by routing the information appropriately by facilitating routing that involves equipping each and every device to constantly keep the required information. Different protocols with its abilities and also by assuming fluctuating degrees within a bounded space have been assessed by various academic papers, typically with all those nodes well inside few hops to each other. Important parameters like average bandwidth, average packet success ratio, and average throughput is obtained after simulation for various numbers of nodes and compared for performance evaluation. Therefore, an energy balanced cluster based algorithm is used for MANET to mitigate the common link breakage and for energy optimization of a node.

Keywords: Average bandwidth; Average packet success ratio; Average throughput; Leach Protocol; Proactive and Reactive Protocol; MANETs.

Introduction

The Mobile Ad-Hoc Network (MANET) is made up of infinite nodes that forms a cluster and can travel on any route. All these nodes are versatile in nature, and therefore the size changes dynamically for the established network. This facilitates packet routing, making every single node a router. The packets are routed to destination from the source in multi-hop manner. Due to node mobility, the routing path of the packets changes frequently. This in turn diminishes the packet delivery date.

MANETs are more reliable in the field of emergency communication and disaster management, and is most promising. In typical cases of natural disasters like floods or earthquakes, the entire telecom based infrastructure will fail and MANET comes to the rescue.

An example for MANET is shown in Figure 1. The Figure shows that it is made up of various types of electronic devices where each node acts like a movable node. The features of the Ad-Hoc network are as follows:

- Routing is multi-hopped.
- Network topologies are dynamic in nature.
- Node capabilities and link variation.
- Scalability of the network.
- Autonomous and Infrastructure-less.

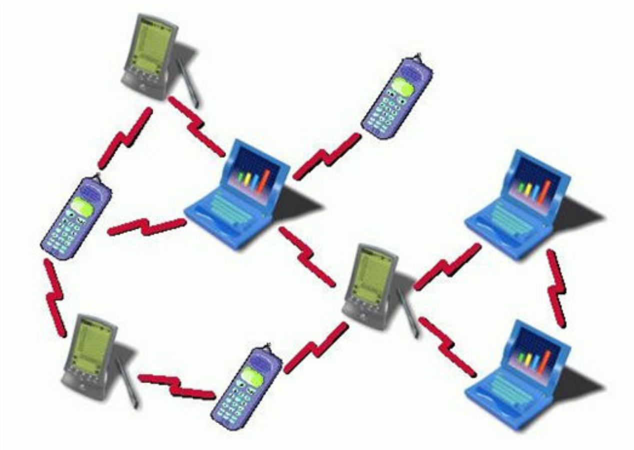

Figure 1: A Mobile Ad-Hoc Network (MANET).

MANETs are more reliable and promising making them very useful for the real time applications like traffic management, military communication, and also in places where the telecommunication is not reliable. One prominent application MANET has been Walkie-Talkies. Therefore it is helpful and really necessary to propose an algorithm to address the problems related to routing associated to MANET.

Related Work

Geographic position based routing with the help of Greedy Perimeter Stateless Routing (GPSR) has been described in the paper [1]. Multilayered feed forward architecture is used for neighborhood prediction method. This protocol sets up routing by implementing greedy algorithm and tags positional information based on destination node position while forwarding packets, and greedily selects the next hop. When the data packet is sent to the destination node by the source node, the next hop is chosen as the shortest route from the source node to the destination node, with the help of the neighboring nodes which are within the source node's communication range. This process is repeated until there is routing void, that is, the process is repeated until there is no node which is closer to the destination node than the current node. In paper [2] the authors speak about the importance of protocol selection for routing in order to achieve a highly efficient network. By comparing multiple routing protocols on Ad-Hoc network, especially between AODV and DSDV for complete results on performance analysis suitable protocol is used. Different performance parameters like throughput, jitter and end to end delay are used for comparisons. Using AODV reduces the effort of routing with the mobile nodes, as the result states. Therefore the network overhead is reduced by using AODV protocol. The authors in paper [3] display the attributes, usefulness, advantages and restrictions providing an outline of different routing protocols. Wide range of Mobile Ad-Hoc Network protocols have been developed by the scientists to expand the accessibility and also the popularity of the versatile wireless devices which are mobile in nature. Moving nodes with exceptional dynamic topology network are there for the Mobile Ad-Hoc Networks which is a subclass of wireless ad- hoc networks. There is no framework or built in control for Mobile Ad-Hoc Network, so they communicate with one another by accumulating the multi bounce portable wireless nodes. Since the wireless connections in this system can go down most of the times due the obstructions and portability of nodes, the wireless connections are highly sensitive in nature. Routing in MANET is basic step because of its dynamic environment. The MANETs have wide applications in rescue operations, sensor networks, military uses and so on, due to their moving nature.

The paper [4] speaks about a routing algorithm which is geographic, which is energy efficient with load balanced geographic routing (ELGR) for lossy mobile wireless networks. Highly active research is being done in MANETs due to its geographic routing and high efficiency. The lifetime of the network is affected by using simple greedy forwarding and the Packet Reception Rate (PRR) which dramatically decreases in wireless networks that are unreliable. Load balancing and energy efficiency are combined in ELGR to make the routing decisions. Extending MANET's lifetime simultaneously enhancing delivery performance is very important. Paper [5] tells about percentage of packet drop as it has a significant effect due to inter domain movement and also studies about node movements in the networks which resulted in high packet drop.

By studying all the results of the overall network tells that high inter domain movement's contribution to the % of packet drop which may not be always significant. Since the proposed work limits the movement of nodes, it reduces necessity of monitoring the same thus making it an energy efficient approach. However, the results are not consistent enough because of the focus is on the inter-domain movement of the nodes that are critical.

Earlier works that are discussed in the papers tells about mobility predictive techniques or network routing protocols separately. The papers give an idea about improving routing performances along with papers. Geographical routing algorithm which is energy balanced can be effectively used so as to improve performance of routing and thereby maximizing the throughput and packet delivery ratio [6].

Proposed Methodology

An enhanced GPSR (Greedy Perimeter Stateless Routing) algorithm has been discussed here by considering energy factor and node movement. The energy consumption rate drastically increases when the destination nodes are nearer to the nodes, considering the rules of GPSR algorithm. Based on the residual lifetime of the link, the algorithm splits the forward region first considering the node mobility. Again on the basis of node's residual time, the next hop node is selected which resides in the candidate region.

Using the LEACH (Low Energy Adaptive Cluster Hierarchy) algorithm the nodes are grouped into clusters and cluster head is selected for each cluster. LEACH is one of the earliest proposed clustering algorithms that save energy greatly when compared to the non clustering algorithms. In this algorithm, all the clusters formed are self organized [7].

Flow process of the model

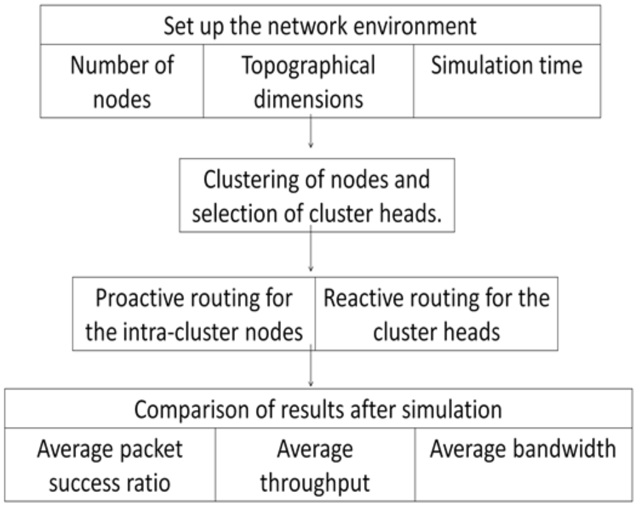

Figure 2: Flow process of the proposed model.

The overall process of the proposed model has been represented in Figure 2. The process commences with the establishments of a network, properties of which are defined by the user. Some of these properties include percentage of cluster heads, topographical parameters, routing protocols and total number of nodes. Once the network is established, the process of determining cluster heads begins. Based on the location of source and destination nodes, *i.e.,* inside the same cluster, or different clusters, either proactive or reactive routing takes place. This hybrid protocol is simulated and parameters like average packet success ratio, average throughput and average bandwidth are obtained. Comparative analysis is performed by varying number of nodes [8].

Setting up the network and selection of cluster head

The network environment is set up based on user-defined network parameters. The LEACH algorithm effectively clusters the nodes, and elects a candidate node. This candidate node is a potential cluster head. All factors considered, each node has an equal chance of becoming a cluster head. The candidate node broadcasts a random value, which is compared to the calculated threshold value. It r is lesser than the threshold value; it is made the candidate node. Each node is made the cluster head at least once. The cluster head broadcasts the identification number assigned to it, so that necessary nodes can accept the request, and consequently join the cluster. During the steady phase, r is repeatedly compared with the threshold value, and as long as it is lesser, the cluster head retains its position. Cluster head selection needs to be reiterated as nodes are mobile, and the network topology is continuously changing. Main communication takes place between cluster heads. When the source and destination nodes are defined, their cluster heads are determined. If located in the same cluster, proactive routing takes place, and if in different clusters, reactive routing takes place. Using AODV routing protocol, the cluster heads help establish a connection between the nodes.

Implementation and metric parameters

Once the cluster head is selected, the random value assigned to the cluster head is compared with the threshold value in the steady phase. The threshold value calculated by using the formula

$$T(n) = \begin{cases} \dfrac{CH}{1 - CH \times (r \bmod \frac{1}{CH})} & , if\ n \in G \\ 0\ , & otherwise \end{cases} \quad (1)$$

Where T(n) is the threshold value, CH is the percentage of cluster heads, n is node identification number, r is the random variable whose value varies from 0 to 1. G refers to all the nodes present in the network.

Throughput

Amount of data packets in seconds which are transmitted over a communication channel successfully to the destination node is known as average throughput of the network. It is calculated in terms of data packets/second or data packets/time slot.

The energy balanced cluster based algorithm is the combination of proactive and reactive routing protocol, forming a hybrid protocol. Ad-Hoc on Demand Routing (AODV) protocol is a type of proactive protocol. This protocol is table driven protocol where each node has to maintain one or more routing tables to store information, and any changes in network topology needs to be reflected in all of them by propagating updates. This protocol is used for intra-cluster routing. That is, all the nodes present inside the cluster communicate using proactive protocol. Similarly inter-cluster communication between the cluster heads is done using reactive protocol. In reactive protocol, the nodes do not maintain the routing tables initially. Routing table is written by the nodes only during the communication between them. Here the origin node initially does the route search process, whenever data needs to be sent to the destination node. This reduces the energy as the number of cluster heads are very less when compared to the total number of nodes. Reactive protocol being bandwidth efficient protocol reduces the energy usage also. Combination of these two protocols thus keeps a balanced energy usage with high efficiency.

Average packet success ratio

Ratio of the number of packets that the destination has received to the actual number of packets originated from the source. The level of delivered data to the destination is illustrated by this ratio. If this ratio is high then it simply means that the protocol is successful in delivering the data packets to the destination, which in turn indicates that the performance of the protocol is good.

Average bandwidth

Estimation of bandwidth in MANETs is a basic function that is required to provide QoS. Average bandwidth is defined as the ratio of product of difference in number of packets delivered and number of packets lost and total simulation time to number of packets delivered. Average bandwidth is a way to find the data rate available on a network route.

Simulation Results

This section consists of the results obtained after simulation using Network Simulator Version 2 (NS2) software. This tool is distinct event simulator tool that is best suitable for simulations of a network. TCL (Tool Command Language) should be used for programming. The snippets of the simulation include step by step implementation of the model.

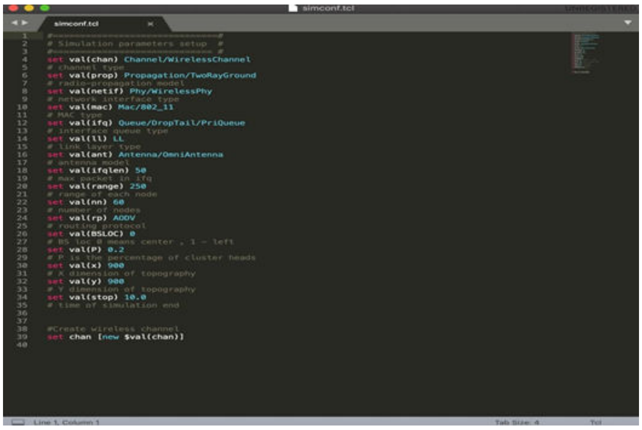

Figure 3: Simulation configuration.

Configuration file for simulation is shown in Figure 3, which configures 7 layers of OSI reference model altogether. Number of nodes can be varied and results can be compared and 802.11 wireless protocol is used. The graphical region for the nodes is set as 900x900 pixels.

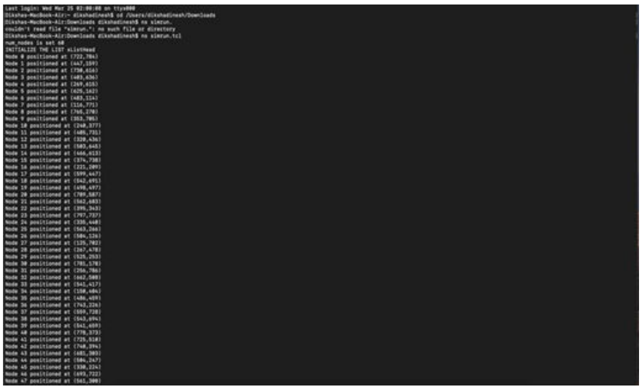

Figure 4: Simulation instance for 60 nodes, and geographical location of each node.

Simulation instance for 60 nodes is shown in Figure 4. Each node is placed at random locations, and their respective location is represented in the form of (X,Y) coordinates.

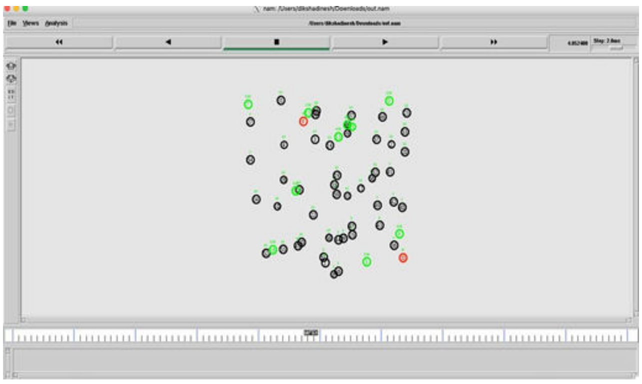

Figure 5: Clustering of the nodes on the network simulator.

All the nodes placed in their respective location will form a cluster slowly as shown in Figure 5, which shows the simulation done network simulator.

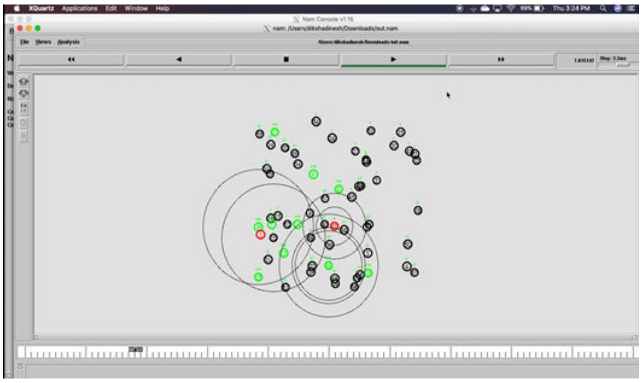

Figure 6: Identification of the next hop nodes (in circles) on network simulator.

Figure 6 shows the next identification of the next hop (in circles) nodes in the network simulator, where all the nodes are placed in random locations. After identifying the next hop routing is performed.

Figure 7: Simulation instance of cluster heads for each node.

Each node is assigned with a cluster head as shown in the Figure 7. All the nodes inside a cluster have the same cluster head and each cluster head has an unique identification number.

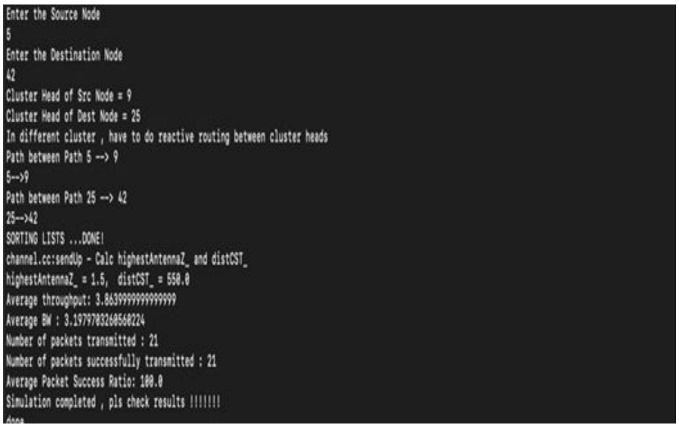

Figure 8: Simulation instance for 75 nodes. Average throughput, bandwidth and packet success ratio are obtained Figure 8.

Figure 9: Simulation instance for 90 nodes. Average throughput, bandwith and packet success ratio are obtained.

Figure 9 show the results for 90 nodes and 150 nodes respectively. Average packet success ratio, average bandwidth and average throughput can be compared for different number of nodes.

Number of Nodes	Average Packet Success ratio	Average bandwidth	Average throughput
60	100%	3.26	3.68
75	100%	3.19	3.863
90	95%	3.0458	3.68
100	91.60%	2.443	3.128

Table 1: Quantified results of variation in packet success ratio, average bandwidth and average throughput.

Average packet success ratio, average throughput and average bandwidth are obtained for different cases by varying the number of nodes is shown in Table 1 respectively. By comparing all the simulated results we can conclude that as the number of nodes increases, packets are dropped. Therefore the average packet success ratio and throughput decreases. Since the number of nodes is increasing in each case, the distance between them will be less. Therefore the average bandwidth also decreases.

Conclusion

Energy based geographical positioning algorithm has been proposed in this work which overcomes the problems of node breakage and also the frequent issues with link breakages caused due to the residual energy constraints and also due to random movement of the nodes. This multi-hop routing algorithm thinks about the parameters that contribute to the important factors like residual time of the node for selection of next hop, energy requirements and node mobility. By using the clustering methods of partitioning the nodes computational complexity is reduced. By considering all the results of simulation done on MANETs, conclusion can be drawn that the delay is reduced, packet delivery rate is increased and also network's overall lifetime is improved. Wireless links have been used for data transmission in Ad- Hoc networks, and hence are prone to network attacks. Even though works have been done related to on the security issues of MANETs, lot of issues and challenges are yet to be addressed. The main challenge of security here is due to the absence of authority or centralized architecture of the Ad- Hoc networks. Therefore, a lot of efforts must be put in order to make MANETs reliable for communication and also to secure data transmission.

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