Designing an ML-Based Congestion Detection Algorithm for Routing Data in MANETs

Konduri Sucharitha and R. Latha

Abstract A wireless communication system using the ad hoc network plays an important role in the telecommunication system. Each node in the ad hoc network is autonomous and configured its own nodes. The node is used to send, receive, and transmit the information from source to destination using the telecommunication system. In wireless communication, nodes move randomly and adapt themselves to any environment without any fixed infrastructure or centralized administration. All the nodes in MANETs can reconfigure inter-connections dynamically due to their arbitrary nature. The frequent topology changes in the mobile ad hoc network cause significant changes and competition in wireless communication channels. One of the most essential concerns for providing safe and reliable transmission between endpoints is recognizing and detecting network congestion. Many congestion control algorithms have been proposed for MANETs. This paper mainly focuses on designing and developing a Machine Learning-based model using the K-means clustering method that classifies the congestion into fewer nodes for packet transmission by considering the QoS parameters such as bandwidth, delay, throughput, packet delivery ratio, and network overhead.

Keywords MANET · Wireless sensor network · Ad hoc network · Packet delivery ratio · Trust score · AODV · DSDV · CEESRA

K. Sucharitha (✉)
Department of Computer Applications, Women's Christian College, Chennai, Tamil Nadu, India

R. Latha
Department of Computer Science & Applications, St. Peter's Institute of Higher Education & Research, Chennai, Tamil Nadu, India

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1 Introduction

Ad hoc networking, through mobility, plays an important role in wireless sensors. The mobile ad hoc network is a network built on ad hoc with a volatile process. This mobile ad hoc network is made up of a variety of mobile nodes that function as independent units and are flexible in sending analogue data from one node to the next [1]. The infrastructure of the wireless sensor network is quick to deploy in the wireless environment and is implemented in the various domains of real-time applications.

Figure 1 represents the process of MANET.

The process of MANET involves a node, or router. Data is transmitted to the destination node from the source node. In a wireless sensor network, this is the node that sends and receives data. In a single-source shortest path problem, the router is primarily concerned with improving strategies for routing data from the source to the destination. These routers may break via the activities of the node transmission such as the data loaded on the network, bandwidth with insufficient data, and power insufficiency. MANET includes various categories of nodes through mobiles that are distributed with every node without existing hardware communication or commonly stored management. With the swift movement of these mobile nodes and frequent changes in the network topology, routing a packet is the greatest challenge for these kinds of networks [2]. Communication focused on wireless mobile includes MANETs, experiencing a layer focused on transport for transmitting data and providing proper attributes such as protocol to transfer data. The attributes used by the protocol on the transport layer are used to determine the traffic control process to determine the efficient allocation of the wireless network and optimize the network.

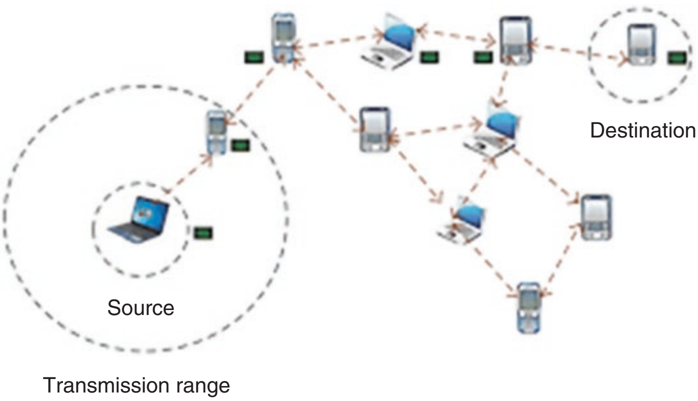

Fig. 1 Process of MANET

Fig. 2 Congestion in MANET

1.1 Congestion in MANET

Congestion control is a method that uses a wireless sensor network to control the entire telecommunications system. Congestion, such as traffic and data loss, can be avoided by collapsing the processing and capacities of intermediary nodes to reduce the number of steps involved in obtaining resources [3]. Various challenges in the transmission of data using congestion are referred to in Fig. 2.

Packet Loss Estimation: This is the packet that is sent by the sender, and the packet that may not be received by the receiver due to transmission.

The packets which focus on transport protocol traditionally lead to the packet loss which causes congestion. This process may lead to congestion in the degradation process of management.

Estimating Bandwidth Availability: According to the market, network condition estimation and congestion management [4] square measures are required within the transport layer for adverse combating of the information measure and delayed conditions in MANETS. To send prime quality media files, finding the network information (jitter, packet delivery quantitative relation, and delay) is extremely vital. As a result, in the market, information measurement is taken into account as part of the side concert for reliable information transmission.

Mobility Management: In MANETs, links between nodes are measured at [5] start and break because every node is mobile indiscriminately. The resulting routes are often extraordinarily volatile, creating winning circumstantial routes captivated with efficiency as they react to those topology changes. There are two forms of quality models: Entity quality models that represent the nodes' movements are from the square measure, free of every other.

- Nodes in cluster quality models represent movements whose square measure is captivated by one another. The model examines numerous parameters of a network, including node quantity, the dimension of the network, and the range of transmission radio.

1.2 Clustering Using K-Means

The cluster approach is a strategy for organizing knowledge into distinct categories with similar features. It is the most well-known bunch technique due to its ease of application and quick convergence. The growth knowledge clustering indicates if we will utilize the K-means cluster algorithmic program for the bunch. In the K-means algorithmic program, it is straightforward and quick, and it selects a K centre arbitrarily.

Hence, seeding of the centre is quick, but the information is slow. The drawback of K-means is that the user must outline the centre of mass purpose. This becomes even more important when managing document collections because each central purpose is represented by a word, and calculating the distance between words is not a simple task.

The procedures for implementing K-means clustering are as follows:

- Elect K nodes into the area incontestable by the objects that become clusters. These opted nodes are going to be designated as initial cluster centroids.
- Assign every object to the set that has the adjacent centre of mass.
- Despite everything, objects are allotted; estimate the placement of the K centroids.
- Repeat Steps 2 and 3 up to the centroids, which are now moving. This method segregates the objects into clusters based on the standards to be reduced.

1.3 Mobile Ad Hoc Networks Criteria

The mobile ad hoc networks have the following criteria as displayed in Fig. 3.

Throughput: It is best to use a wireless routing protocol that has the highest probability of knowledge delivery and the lowest probability of packet loss. As a result, the problem in wireless networks has always been focused on an end-to-end high capability path.

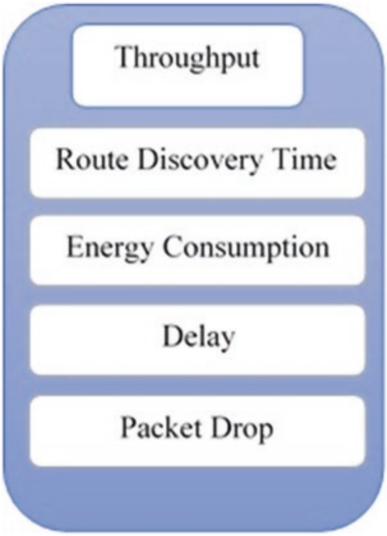

Fig. 3 Mobile ad hoc networks

Route Discovery Time: All route discovery mechanisms aim to construct, maintain, and repair methods between nodes in a very large network. In a MANET, overhead packets will be propagated to regions wherever they make no sense. However, they still consume inadequate network resources. Therefore, reducing the route discovery time means guarding against the ineffective use of network resources in MANETs.

Energy Consumption: Whereas battery life limits network node autonomy, energy consumption may be a major issue for all wireless networks. Choosing a non-optimized approach with an unreliable link would almost certainly result in increased delays, higher retransmission rates, and higher energy consumption. Most of the research focuses on the communication protocol style. For instance, the routing protocol uses a manipulated impromptu Ad Hoc On-demand Distance Vector (AODV) route to be applied by low-power devices.

Delay: It is intriguing to figure out which network path has the least amount of latency. The delay of a network path defines how long it takes a packet to go from one node or terminal to the destination node via the connection of host supply. It is generally done in fractions of a second. Depending on the precise position of the associated node's attempt, the delay might vary significantly.

Packet Drop: In MANETs, packet loss occurs when one or more packets of data traveling across an electronic network fail to reach their destination. Wireless link transmission errors, quality, and congestion are major reasons for packet drop.

2 Literature Survey

Researchers in [6] reported that client-to-client congestion management had been extensively studied for more than 30 years, mutually confirming the most important process for ensuring the economical, truthful distribution of network resources among users. Future networks were becoming increasingly complex. Errors and inefficiencies resulted from typical rule management congestion. Researchers began pushing their expertise towards the approach based on rules-based Machine Learning (ML) after seeing a significant advance in Machine Learning (ML), which proved to be a large-scale solvable problem. Either way, these facilitate the intermediate to create congestion focused on intelligent management calls, bringing home the bacon of increased performance.

Researchers in [7] described how intelligent data technology plays an important role in the document of trade four. Encapsulating IIoT with Machine Learning is critical to achieving industrial-based intelligence with the internet of things (IIoT). The heterogenous network based on IIoT has become dynamic and changeable as the number of terminals on a large scale has increased. This paper first proposes a CC-based IIoT design for intelligent IIoT services and expounds two ML strategies for analysis focused on IIoT with deep learning (DL) and reinforcement learning (RL). Second, applications on the advancement level and improvement trends in the CC are summarized in the industrial field. Challenges and improvements to the architecture of CC with analysis of IIoT are mentioned. Finally, this proposed paper aims to indicate the behavior of AI (Artificial Intelligence) on IIoT during the large read with data.

Researchers in [8] outline a method for distributing various metrics in a logical manner, based on far path performance. The prevailing protocol focused on the proactive protocol and the reactive protocol, that is, Ad-Hoc On-Demand Distance Vector (AODV) and optimized link-state routing protocol (OLSR). The AODV tends to provide a method for the route request which has yet to be modified, and a reply mechanism based on the route to get a path which is stable to mistreatment MCDM. The OLSR concept plays a vital role in the Totendency to modification strategy, which proposes an MPR choice formula to take care of topology focused on stable mistreatment MCDM. The proposed results show that the planned theme with routing reduces the overhead by V-day and 13, packet loss rate by the 12-tone system and Bastille Day, and peer-to-peer delay by 21st and 19 seconds. Researchers in [9] studied different schemes in routing, such as MCDM, OLSR, and AODV, based mostly on routing protocols on geographical information.

3 Proposed Optimization Scheme

The proposed research work consists of three phases: (a) selecting, (b) formulating, and (c) optimization of the path as shown in Fig. 4.

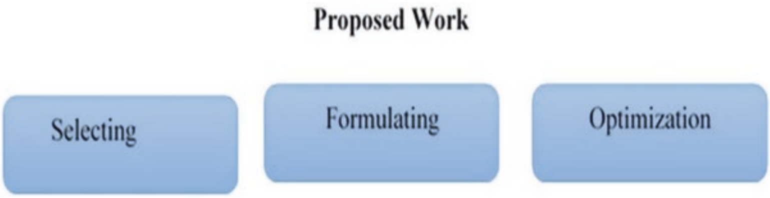

Fig. 4 Proposed optimization scheme

Phase 1: Selecting: The process of selecting the centre head initially starts by selecting random nodes in the network thereby applying the K-means clustering algorithm to find the cluster heads. Allocation of nearest nodes with minimum Euclidian distance in the network *N* to the clustering heads *C* is as follows.

$$D = \text{Sqrt}\left[x_2 - x_1\right]^2 + \left[y_2 - y_1\right]^2 \tag{1}$$

$$\text{Calculate Avg Min D}\left(x_i, c_j\right) \tag{2}$$

where

$$C = \sum i_{1\,\text{to}\,n}\, x_i \,/\, n$$

In the above formula, (1) and (2) calculate the new centroid for each cluster and assign the nearest node x_i to the cluster c_j by calculating the average minimum distance *D* for each cluster $j = 1, \ldots, K$.

Phase 2: Formulating: Formulating the objective function by considering the parameter to detect the congestion: Congestion aware parameter can be determined by K-means algorithm from each node by using the following parameters: explicit link failure notification, buffer availability, packet loss, notification, packet delay, round trip time, packet delivery ratio, and available bandwidth.

The average means of all clusters by considering the congestion awareness parameter *cwpiin*, the network *N* can be determined by the objective function *f*(*cwpi*) for each cluster head as follows.

$$f\left(cwpi\right) = Avg\left(\min \sum j = 1 \sum j cwpi \left|xi - cj\right| 2\right) \tag{3}$$

Where, $cwpi = [cpw1, cpw2, \ldots, cpwk]$ is the congestion aware parameter for all the centroid (cluster heads) in the network *N*.

Phase 3: Optimization: To find the optimal path between the end nodes, two parameters are considered 1. The received signal strength (RSS) is denoted by ‘*r*’ 2. Link availability time (LAT) ‘*l*’ chooses the next node for transmitting the data. The optimal node to carry the data can be determined by the K-means objective function $f(yi)$ for each cluster can be formulated as

$$f\left(yi\right) = \max \sum i = lrilj \tag{4}$$

4 Experimental Result

The proposed research work consists of selecting, formulating, and optimization techniques to determine the congestion detection system based on the Machine Learning system. A simulation experiment was conducted by the NS2 tools based on the ML-Based Congestion on Routing Algorithm. For the experimental results, a collection of 50 sample nodes was considered using the network simulator. This experiment determines the traffic of the network, the node used, and a model based on propagation and routing protocols using OTcl Scripts. Two files were considered for the simulation, such as a file for processing the data and a file for visualization using the NAM file. ML-CA routing protocol performance will be compared with conventional routing algorithms (AODTV, DSDV, and CEESRA).

Experiment Result 1: Packet Delivery Ratio (PDR)

Table 1 is generated with ML-Based Congestion Detection Algorithm (ML-CA) along with AODTV, DSDV, and CEESRA.

Table 1 represents the comparison of packet delivery ratio using the proposed algorithm (ML-CA) along with AODV, DSDV, and CEESRA algorithm.

Experimental Result 2: Average Trust Score in Percentage for Cluster

Table 2 is generated to determine the average trust score in determining the percentage of the cluster along with the proposed techniques.

Table 2 is estimated with the number of nodes and along with the clusters in determining the trust score of the proposed work.

Table 1 Comparison of PDR

Algorithm	PDR
ML-CA	97.65
AODV	94.52
DSDV	96.89
CEESRA	95.55

Table 2 Trust score of the proposed work

Number of nodes	Number of clusters	Trust score			
		MLCA	AODV	DSDA	CEESRA
100	5	87.25	85.62	84.22	86.34
200	10	89.66	88.43	88.95	87.26
300	15	84.26	81.89	79.65	82.43
400	20	91.35	89.6	85.4	88.76

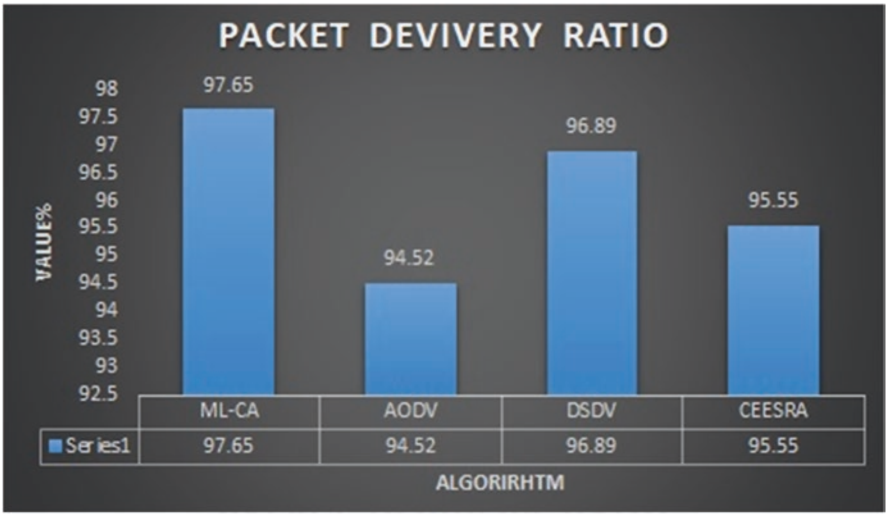

Fig. 5 Packet delivery ratio

5 Result and Analysis

Result Analysis-1: From the experimental result 1, the following graph is generated as shown below in Fig. 5.

According to Fig. 5, the proposed work proved (with the sample data) to have the highest packet ratio when compared with the existing algorithm. This proposed work has proven to be more efficient in the packet delivery ratio.

Result Analysis-2: From the experimental result 2, the following graph is generated as shown in Fig. 6.

The following graph represents that the trust score of the proposed work is more effective and efficient when compared with the existing algorithm, which is verified with the sample data taken for consideration.

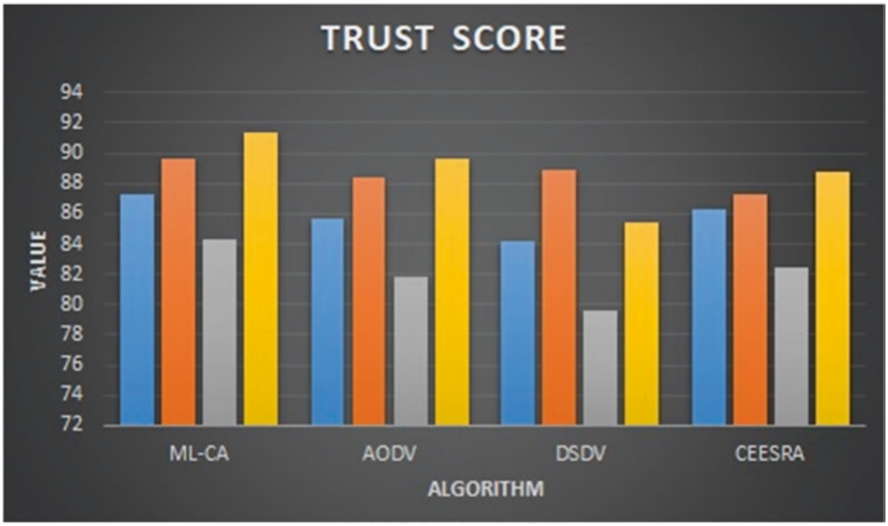

Fig. 6 Trust score

6 Conclusion

Designing an ML-Based Congestion Detection Algorithm (ML-CA) for Routing Data in MANETs is proposed. Due to the random mobility nature of the network, electing the cluster heads and determining the optimal node to transmit the data is a challenging task. In this paper, this challenge is addressed with the K-means clustering algorithm, which will result in a drastic change in increasing network flow by identifying the congestion-ware nodes and identifying the next probable node for transmitting the data. The performance of the proposed work (determined by the packet delivery ratio and average trust score of the packet data in the MANET) proved to be effective and efficient.

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