Cluster Based Distance Sequence Distance Vector Routing Protocols for Mobile Ad-hoc Network

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***Abstract*—Mobile Ad-hoc Network is a self-organizing and self-configuring network that has mobile nodes connected wirelessly to each other. Transmission of data packets takes place through single or multi-hop in MANET. Each node in the MANET acts as a router and a host device. MANET is a scalable network and can accommodate nodes to a great extent. However, due to the increase in traffic, it may occur congestion in mobile ad-hoc network. Congestion is a major issue for end to end delay and network overhead. The clustering technique is used to virtually divide the MANET in groups, which allows the data to divide in groups as well. Clustering technique is more efficient than the existing standard protocols used for routing. Such fundamental (DSDV) protocol leads to routing overhead in scalable MANET. In this work, we presented a cluster-based technique for DSDV (Distance Sequence Distance Vector) routing protocol to overcome routing overhead, reduce the packet size and utilize the bandwidth in a large network. Three steps are defined for the cluster based on DSDV, which are the cluster head selection, cluster formation and routing of packets. The cluster based on DSDV (CDSDV) is a Clustering technique to overcome the production of excessive information. Since, the algorithms are made in a manner that the nodes are required to share routing information inside the cluster instead of the entire network. Hence, the results of the CDSDV demonstrate about 10 to 15 percent improvement for throughput and Packet Delivery Ratio, while the average end to end delay seems to be degraded by a considerable degree because of the mutual communication of the cluster heads. The energy consumption of CDSDV is inadequate as it utilizes a slightly more energy than the standard DSDV.**

***Index Terms*—Ad-Hoc Network; Cluster Based DSDV; Nodes; Transmission.**

I. INTRODUCTION

A self-configuring and infrastructure-less network of mobile nodes communicate each other, facilitated by the connection via wireless channel known as Mobile Ad Hoc Network (MANET). Since the nature of MANET is dynamic, it does not rely on any central base station. In such network, each node acts as a mobile host as well as a router. The forwarded message is passed through a multi-hope because the range of transmission and reception of wireless network is limited. Therefore, routing protocol is the best way to facilitate the communication and to find best route between the nodes.

Routing protocols of MANET are categorized under three extensive fields [1]: Proactive (table-driven), Reactive (on-demand) and Hybrid routing protocols. Proactive (table-driven) routing protocols includes Destination Sequenced Distance Vector Routing Protocol (DSDV), Fisheye State routing (FSR), Global state routing (GSR), Hierarchical State Routing Protocol (HSRP), Wireless routing protocol (WRP), and Cluster head Gateway Switch Routing Protocol (CGSRP). While Reactive Protocols (on-demand) include Ad-Hoc On-demand Distance Vector Routing (AODV), Dynamic Source Routing (DSR), Temporally Ordered Routing Algorithm (TORA), Cluster based Routing Protocol (CRP) and Associative Routing. Meanwhile, the Hybrid protocol combines the advantages of both the reactive and proactive protocols. Hybrid routing protocol produces zones of nodes within network. It uses proactive routing protocol for inter zone routing and reactive routing for intra zone routing, which is called the Zone Routing Protocol (ZRP) [2].

Routing such as Distance Sequence Distance Vector (DSDV) [3] is one of the proactive or table-driven routing protocols for MANET. The main contribution of DSDV is to solve the routing loop and count to infinity problem. Such protocols broadcast routing updates frequently to maintain routing table at each node. With the help of routing table, the data is forwarded to and from one node to another node in the network. The routing table contains a sequence number, which is very useful for avoiding loop formation, next-hop-id, destination-node-id etc. In scaling network, the size of routing packet is bigger as compared to the small network. In other words, the frequent updates of routing table generate excessive routing traffic in the network, which may lead to network overhead [4].

Therefore, the clustering technique is used to divide network in groups to limit the routing traffic into defined groups. Each cluster has its cluster head (CH) and cluster member nodes [5]. The CH of each cluster is responsible for communicating the cluster member nodes as it knows the member table of the entire network. However, updating routing table is reduced to a small network with the help of clustering as compared to huge network. In this work, we used clustering technique for DSDV routing protocol to show that the routing overhead is reduced compared to the standard DSDV protocol.

II. RELATED WORK

The DSDV Routing Algorithm is the idea of Bellman-Ford Routing Algorithm [1]. DSDV is an improved version of the basic DV routing protocol. The metrics used in this protocol is derived from the distance between the two nodes and the sequence number. This protocol generates routing table at each router, containing routing information of the entire network. Routing information contains Source node ID, receiving node ID, next hop ID, hop count to receiving node, installation time of node and sequence number originated by destination. The important component of DSDV is the sequence number, which is used to avoid loops by distinguishing the new routes from the old ones. Each node frequently exchanges routing table with its neighboring nodes in the network. The exchange of routing table is done to ensure that the network is up to date after joining or leaving the nodes. There are two types of routing updates, which are the “full dump” and the “incremental update”. The full dump sends all information of routing table, while the incremental update sends only important entries after some changes occur at the final update. The full dump updates are frequent, and the exchange of the entire information of routing table can flood every node. Incremental updates are preferred, when the network is relatively stable.

S. Nithya et al. [6] proposed Cluster Techniques using mobile ad hoc networks (CTMAN). These techniques contain three components. The proactive source routing protocol is used for controlling traffic overhead, while the Destination Sequence Distance Vector (DSDV) is used to maintain the packet delivery ratio (PDR) and the Dijkstra’s algorithm is used to find the shortest path between two nodes. The Cluster technique in mobile ad hoc network (CTMAN) maintains the data loss and increases performance in large area network.

V. Lalitha and Dr. R. S. Rajesh [7] showed that transmission power plays an important role in MANET. The authors also discussed the performance of protocols such as DSDV, DSR and AODV under different transmission ranges. Metrics and transmission ranges considered for simulation are the PDR, Routing Load, End to End delay, Throughput, Energy consumption, Routing overhead and transmission ranges that varied from 100m to 550m. The DSDV routing protocol shows the best performance result for routing overhead and long-range communication.

S. Muthuramalingam et al. [8] worked on weighted cluster algorithm (WCA) [9] and proposed modified weighted clustering algorithm (MWCA) for Manet. MWCA uses WCA for cluster formation and uses nodes mobility prediction to maintain that cluster. The cluster formation and maintenance involve a few steps. Initially, a beacon message is forwarded to 1-hop to calculate the weights for assumed the co-efficient [5], number of neighbors, sum of distances, average speed of each node within a given time and battery power for cluster. Finally, the cluster maintenance is conducted. There are two phases involved in the cluster maintenance, which are the observation of the battery power and the movement of nodes outside of cluster.

III. CLUSTER BASED DSDV

In this work, Cluster Based DSDV Routing Protocol, DSDV is a primary protocol for routing as it has low latency, because all paths are predefined in routing table, and higher routing overhead. The proposed CDSDV scheme for DSDV protocol, virtually divides the whole MANET into clusters. Splitting the network into sub parts by means of clustering limits the number of nodes into their defined boundaries as well as routing overhead. Each cluster maintains two types of nodes, cluster member (CM) nodes and cluster head (CH) nodes. Further, each cluster of the network maintains two types of tables, which are the cluster member table and the DSDV routing table.

A. Cluster Member Table

As MANET is virtually divided into clusters and each cluster has its own number of nodes, such nodes that establish a cluster are said to be cluster member nodes. These nodes are maintaining a cluster member table. The cluster member table is achieved by collecting the nodes information of each cluster. The CM nodes generates cluster member table to assure that they are the member of associated cluster.

B. DSDV Routing Table

Routing protocol is a fundamental component for any type of network. Thus, DSDV is the central routing protocol in the proposed work. Choosing DSDV routing protocol for clustering technique is the best choice as it provides high packet delivery efficiency, end-to-end delay and reliability of transmission. The whole network virtually divided into clusters and uses DSDV protocol for routing, including CM node as well as CH nodes. Each node associated with the network maintains a routing table based on the DSDV protocol.

IV. SIMULATION PARAMETERS

The application layer parameters used for performance evaluation are described below.

A. Throughput

Throughput is the ratio of data bytes received over time to a host. Throughput is basically calculating in kilo bit per second (Kbps) or Mega bit per second (Mbps).

B. Packet Delivery Ratio (PDR)

PDR is the ratio of the number of received packets by all host nodes to the number of packets transmitted by all source nodes.

C. End-to-End Delay

End-to-End Delay is the interval of time, in which a packet is generated by source node and successfully received by the host node. End-to-End delay is the collection of processing delay, queuing delay, transmitting delay and propagation delay. End-to-End Delay is measured in milliseconds (ms).

D. Energy Consumption

Energy consumption is the average consumed energy of all nodes in the network. Energy consumption is measured in joule (*j*). Other parameters used in the simulation for analysis are described in Table I.

Table 1
Parameter Consideration for Simulation

S. No.	Parameters	Values
1	Number of Nodes	10,20,30,40,50
2	Simulation Time	50 seconds
3	Node Speed	5 m/s
4	Ranges of cluster	200 to 250 m
5	Transport Protocol	TCP, FTP
6	Packet Size	1000 bytes
7	Network Area	2500m × 2500m
8	Initial Node Energy	100 J
9	Application Layer Parameters	Throughput, End-to-End Delay, PDR, Energy Consumed

V. STRUCTURING CLUSTER BASED DSDV

There are two types of cluster formation: static or fixed cluster and dynamic cluster formation. Static cluster is easy to form and it remains for life time, once it is created. The dynamic Cluster formation is challenging because of the dynamic nature of MANET. The mobility of nodes randomly changes the network topology, hence it is necessary to select the CH randomly.

A. Formation of Cluster

Initially, all nodes in the network broadcast a beacon message (contain all information about the node) to their neighbor nodes. A node can assure its existence in the network via beacon message. Using the idea of modified clustering algorithm with mobility prediction [10], each node collects information from beacon message related to location, speed and energy of other nodes. These are the parameters used to form a cluster. Each cluster is expanded up to 250 meters because the CHs communicate directly with the other CHs. A direct communication of CHs will discard the gateway node. Discarding the gateway node permits the CH to rout the packet itself as the CH has already maintained routing table and cluster member table. The main reason for dividing the MANET into clusters is that, it restricts the nodes from maintaining the information of the overall network; thus, avoiding network overhead.

B. Cluster Head Selection

Cluster Head selection is the main part in the cluster formation because CH manages the cluster such as base station. Cluster management involves maintaining the CM nodes, routing information and packet routing to and from other clusters. The CH selection is based on two criteria, which are the node mobility and the node energy. A node that has the combination of low mobility and high energy is selected as the CH node.

C. Packet Routing

The packet in the cluster is simple to rout from the source to the destination, although the packet transmission outside the cluster routs through the CH node. Data Packet generated by the source node conveys to the cluster head on behalf of DSDV routing protocol. The CH of the transmitting node then looks for receiving node's CH from the cluster member table. The CH of transmitting node routs the data packet towards receiving the node's CH. Finally, the cluster head forwards the data packet to the receiving node easily because the receiving node is the member of existing cluster.

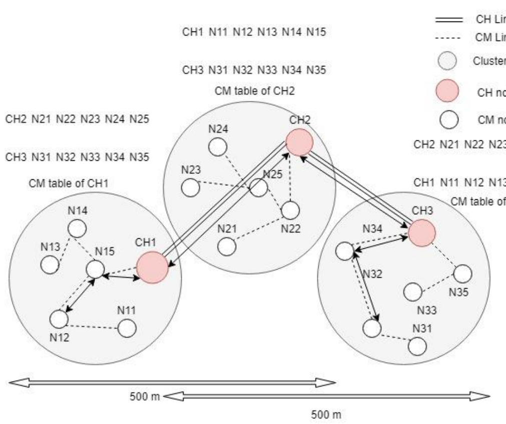

Figure 1: Example of cluster based DSDV routing from node N12 to N32 (scenario)

Figure 1 shows the example of a cluster based on DSDV routing from node N12 to N32. This figure has three clusters that have their own CH and CM nodes. The cluster heads maintain the cluster member table of each cluster as shown in Figure 1. The membership of the nodes are transmitted based on their sequence number to ensure the cluster is updated.

The range of the cluster is defined as 250 because of the direct communication of the two cluster heads. The transmission range of nodes under DSDV is about 500 meters or above [4]. They can communicate directly even when the cluster heads are at the edges of clusters.

The simulation analysis was carried out with NS2.35 using Ubuntu version 18.04. The aim of the simulation was to compare the basic DSDV routing protocol with the cluster based on the DSDV routing protocol. The parameters under which the analysis is performed are the Throughput, End-to-End Delay and Packet Delivery Ratio and Energy consumed by the nodes.

VI. Results And Discussion

The graph in Figure 2 shows the performance of protocols concerning the throughput, where the performance of Cluster based Distance Sequence Distance Vector (CDSDV) is better than DSDV. When the number of nodes increases, the throughput decreases in both scenarios. However, the performance of CDSDV is quite satisfactory.

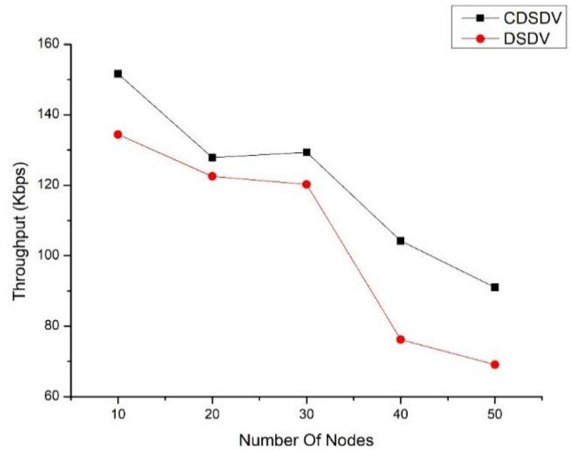

Figure 2: Number of nodes vs throughput

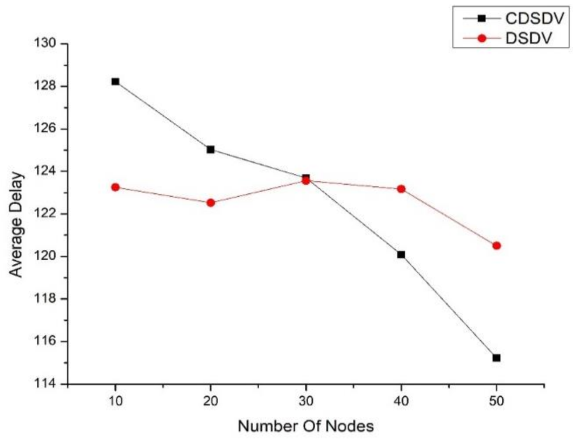

Figure 3: Number of nodes vs end-to-end delay

The graph in Figure 3 shows the performance of protocols concerning end-to-end delay. The nodes operated at low transmission power for a short transmission range, hence the packet routs via multiple hops and increases the end-to-end delay. Both protocols used for the simulation performed an average for 30 number of nodes, but there was a contradictory performance before and after the 30 nodes. End-to-End delay of CDSDV gradually degraded incrementally in the nodes. This is because the clustering techniques of CDSDV utilize only the cluster heads for communication and the average delay degrades gradually, while the average end-to-end delay for DSDV seemed to be constant.

The graph in Figure 4 shows the performance of protocols concerning packet delivery ratio. According to the PDR, the performance of the network shows the best result with increment of nodes. However, the CDSDV produced good performance with the maximum number of nodes to DSDV.

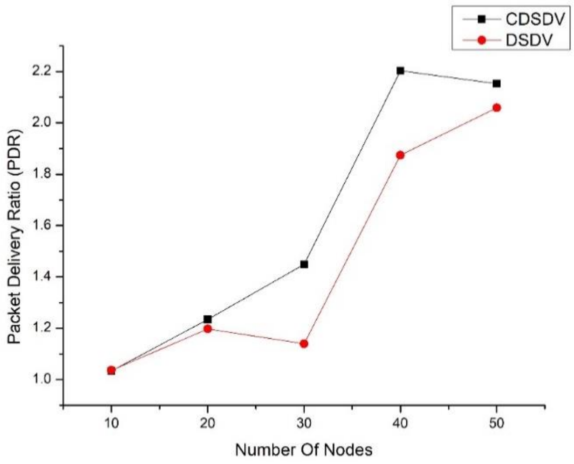

Figure 4: Number of nodes vs packet delivery ratio

The graph in Figure 5 shows the performance of protocols concerning Energy Consumption. Comparatively, the average energy is consumed by both protocols, but the CDSDV consumed less energy than the DSDV because of the CH selection and cluster formation process in the CDSDV.

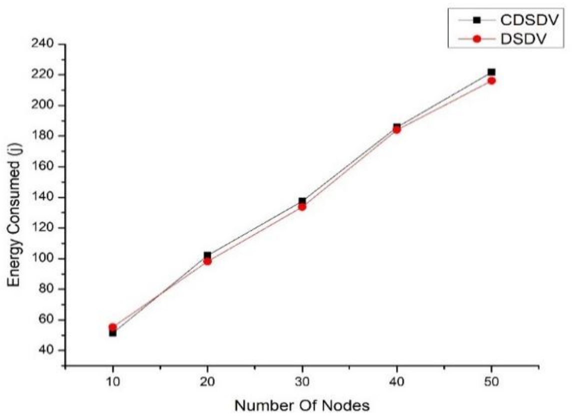

Figure 5: Number of nodes vs packet delivery ratio

VII. Conclusion

In this work, a new mechanism is adopted for the DSDV routing protocol to reduce network overhead and bandwidth utilization. CDSDV and DSDV were simulated with NS2.35 platform and the results showed that the performance of CDSDV is adequate. It is concluded that CDSDV is better than DSDV for performance metrics, which are selected for simulation except for the energy consumption. This result si drawn from the observation that the CDSDV consumes a slightly high energy compared to DSDV. This outcome is due to the cluster formation, cluster maintenance and election of cluster head in each cluster. The performance metrices, such as the Throughput, Energy consumption, End-to-End delay and Packet Delivery Ratio (PDR) were analyzed for standard DSDV and CDSDV routing protocol. The major steps involved in the CDSDV are the cluster formation, cluster head selection and routing of packet. The simulation results show the efficiency of the idea, and it produced better quality CDSDV than the standard DSDV. The findings indicated that CDSDV has better expression on routing protocol than the standard DSDV in terms of throughput, end-to-end delay and packet delivery ratio. According to the throughput, the performance of CDSDV is better than the standard DSDV. Based on the analysis of the end-to-end delay, the performance of both protocols is the same for 30 nodes, and the impact of CDSDV is improved due to the clustering technique. The performance of both protocols is analyzed and it shows that the PDR increases comparatively with the increment of nodes. Although, the performance of CDSDV is efficient with the increased number of nodes in comparison to the standard DSDV. The analysis of energy consumption shows that comparatively the average energy is consumed by both protocols, but the CDSDV consumed rather more energy than the standard DSDV.

The impact of CDSDV on energy consumption is unsatisfactory. The underlaying cause of energy consumption is that the CDSDV has to form and maintain clusters and cluster head node selection. The issue of extensive energy consumption as compared to the standard DSDV can be solved in future research work.

References

[1] S. Shruthi, “Proactive routing protocols for a MANET — A review,” 2017 International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC), pp. 821–827, 2017.

[2] O.I. Al-Sanjary, A. Abdullah Ahmed, H. M. Zangana et al, “An Investigation of the Characteristics and Performance of Hybrid Routing Protocol in (MANET)” International Journal of Engineering & Technology, 7 (4.22), pp.49-54, Dec 2018.

[3] C. E. Perkins and P. Bhagwat, "Highly dynamic destination sequenced distance-vector routing (DSDV) for mobile computers, " pp. 234-244, 1994.

[4] S. Rajasekar and D. Subramani, "Reduced Routing Overhead in Mobile Adhoc Networks Using HCH Algorithm", Vol 10, No. 4, 2018.

[5] D. Mehta, I. Kashyap, S. Zafar, “Random Cluster Head Selection Based Routing Approach for Energy Enrichment in MANET”, pp. 119-123, 29, October 2017.

[6] S. Nithya, G. Arul Kumar and P. Adhavan “Destination-Sequenced Distance Vector Routing (DSDV)using Clustering Approach in Mobile Adhoc Network” pp.319-323. 22 December, 2012.

[7] V.Lalitha and Dr.R.S.Rajesh “The Impact of Transmission Power on the Performance of MANET Routing Protocols” pp. 34-41. 2 February 2013.

[8] S. Muthuramalingam, R. Raja Ram, et al “A Dynamic Clustering Algorithm for MANETs by modifying Weighted Clustering Algorithm with Mobility Prediction,” International Journal of Computer and Electrical Engineering, Vol. 2, No. 4, pp. 709-714, August, 2010.

[9] V.B.Vieu, N. Nasser and N.Mikou “A Weighted Clustering Algorithm Using Local Cluster-heads Election for QoS in MANETs” *IEEE Globecom 2006*, San Francisco, CA, pp. 1-5, 1, Dec 2006

[10] A. Tiwari, M.Fatima and M.Manoria, “Survey of Impact of Transmission Range on MANET Routing Protocols,” Communications on Applied Electronics (CAE) – ISSN : 2394-4714, Foundation of Computer Science FCS, New York, USA, Volume 7 – No.4,pp.28-32, July 2017.