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A Queue Length Based Multipath Routing For MANET: A Stochastic Approach

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ABSTRACT

Ad hoc networks use AODV and AOMDV routing protocols to find path from source to destination. But when number of mobile nodes in the network or movement velocity increases, AODV and AOMDV routing protocols are not efficient and cannot overcome well handle the dynamic complexity of the mobile network. Thus, we need a routing algorithm that has a low level of fault and transmit data packets safely to the destination. To have a good performance in this case, we use multipath routing to control the traffic congestion in the network. In this article, we purposed a new routing algorithm based on AOMDV routing protocol named AOMDV-AQ that caused congestion control and load balancing in the network. Of order to route traffic congestion into less crowded neighbors who are less congested, this technique employs the average queue length in each intermediary node. This random routing procedure increase throughput and decrease end-to-end delay of packets from source to destination because of the effect on congestion level of network traffic on bottleneck nodes. Finally, it improves the performance of network.

1. INTRODUCTION

Mobile Ad-hoc network (MANET) is a collection of communicating mobile nodes which has no central controller and may have dynamic topology. In this network, each node has limited capacity in terms of transmission range, battery life, processing power etc. In MANETs, mobile nodes communicate with multi-hop mechanism. It means that the mobile node transmit the packet through multiple intermediate nodes. Otherwise, it might effect on performance of network. Therefore, an effective routing protocol is necessary for MANET [1].

In fact, routing procedure aims to seek the best route between a pair of source-destination based on specific criteria. In MANETs, there are many ways provide for routing by researchers.

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Generally, routing algorithms classified by the number of path providing to multipath routing and single path routing. Single path routing is an algorithm that tries to select the best path in many available paths and use it to transmit the data. If the path is broken, another try to find a path is established.

Multipath routing is a routing algorithm that uses two or more paths to transmit and it uses the other path as an alternative path if one of paths is broken. Thus there is no need to any try to find the new path.

In the multipath routing structure, if the dynamic routing apply in network, multipath routing will have a high level fault tolerant. Some of routing protocols, like OSPF, can balance the traffic load with the same factor in the network. When networks use distance-vector routing protocols, they might have a complex configuration structure and in convergence have a high probability of existing loop in the path.

Single path routing protocols detect paths and select one of them as a best path for each destination. These single path protocols are not able to balance traffic load. Using multiple path not only increase error tolerance, but also provide the transmission through disjoint routes which is a natural situation for selecting a set of efficient routes among the set of all available routes. This happens because the probability of correlation and concurrency of their faults is less than other overlapping routes [2].

Multipath routing protocols detect paths and can select more than one path to the destination. Multipath routing protocols are appropriate to load balancing in the network. Usually multipath routing protocols are used for large networks that consist of many nodes. They are not appropriate for small networks [3].

AOMDV is a multipath extension to its single path predecessor AODV [4]. In this article, we show that our provided algorithm has better performance in measurements of throughput and end-to-end delay.

2. AODV AND AOMDV ROUTING PROTOCOLS

Mobile nodes in Ad hoc network usually use AODV [5] routing protocol. AODV routing protocol adapts with dynamic conditions of links and detect single cast paths within Ad hoc network rapidly. One of specific property of AODV routing protocol is that it uses destination sequence number for each rout entry. Destination sequence number is a field in the RRER message that reveals freshness of path and ensures loop freedom in AODV routing protocol [6]. AODV routing algorithm has abilities like dynamicity and start routing between nodes take part in Ad hoc network. AODV routing protocol allow mobile nodes to react link breakage and any other change in network topology in specific scheduling.

AOMDV is a multipath extension to its single path predecessor AODV [7]. AOMDV algorithm is based on distance-vector and uses hop-by-hop routing approach. However, AOMDV uses rout discovery process based on on-demand method. The goal of AOMDV is development of AODV routing algorithm for calculating distributed and loop free paths in the rout discovery process.

The most important difference between AOMDV and AODV is number of paths that discovered in the rout discovery process. With dispersion of RREQ packet from source node to destination node in AOMDV, multiple reverse rout are created in intermediate nodes and destination node. After returning of multiple RRER packets through this reverse routs, multiple forward routs from source node to destination node will create. It is noted that, AOMDV uses the alternative paths in intermediate nodes to reduce the frequency of rout discovery process. Unlike AODV, when the link breakage occurs, it is not necessary for AOMDV routing protocol to start the rout discovery process again and uses alternate path exist in its routing table for transmitting data packets.

3. RELATED WORKS

One of the major characteristics and feature of MANETs [7] is mobility along with variable transmission range, variable processing capability and their ability to join and leave the network arbitrarily. In such a scenario the job of a routing scheme is too successfully and efficiently delivery data packets from the source to the destination, which is further, complicated with absence of known topology and non-existence of a central controlling node. AODV and AOMDV routing protocols are so useful for these kinds of networks.

When the number of nodes n the network that have movement or velocity of them increases, AODV and AOMDV routing protocols will not efficient like before and cannot overcome this complexity of network. Thus, we need to a routing method that has a low level of fault and transmit data packets safely to the destination in the case of large number of nodes in the network and their high velocity movement. In this way, performance of network will increase.

There are many ways provided to improve routing in the network like AODV-AP [8]. In AODV-AP the authors try to increase the throughput by reducing the overhead caused by routing protocol and MAC layer, it's suggested that the overhead can be hugely reduced if the nodes become aware of each other relative position and movement.

They try to increase the performance of AODV by using location information.

Authors in NDMR [9], [10] try to extend AODV by using the path accumulation feature from DSR where the whole path is accumulated in the RREQ so as to reduce the overhead. Every time a node in the NDMR receives a packet, it checks the cumulative path in the RREQ, calculates the hop count from the source to itself, and saves the result as the smallest hop count in its reverse route table entry. Due to its many node-disjoint routing pathways, NDMR performs better than AODV and DSR.

[11] Maintains a table of one-hop nodes, or nodes in a specific area. Only a portion of the nodes in each neighborhood are permitted to transmit when a message is sent. Each node in the network will forward a route request message under the proposed scheme if and only if a criterion based on its neighborhood density at that particular instance is met. This suggested method performs better than the AODV routing protocol and reduces network congestion brought on by redundant transmission. The AODV-ABR [12, 13] Ad hoc the routing method known as On-demand Distance Vector with Adaptive Backup Routing is based on the AODV routing protocol. It creates a mesh structure and offers numerous alternative pathways using RREP messages from AODV. Purposed algorithm

Using multipath routing protocols allow network to apply load balancing. The purposed method in this article is based on AOMDV routing protocol. In the other words, it is the extension of AOMDV routing protocol.

AOMDV routing protocol used flooding in which a route request packet (RREQ) is broadcasted from a source node to other nodes in the network. If the intermediate node was not candid of destination itself or didn't have an appropriate route for desire destination in its routing table, forwards RREQ packet to its neighbors. Using this algorithm, allows all of the nodes in the network to be calculated in set of candidates.

In this article we defined conditions based on weighted average of queue length for RREQ packets, to avoidance from flooding broadcast of RREQ packets to all nodes exist in the network that causes congestion. Average of queue length defined as follows:

$$y_n = 0.9y_{n-1} + 0.1x_n \tag{1}$$

Where x_n denotes the queue length. Thus, using queue length in phase of route discovery process and information about traffic congested nodes, allows the network to have less congestion that results in low probability of link failure and node break. Finally, loos of performance will be compensated and the network will have better throughput and end-to-end delay.

The purposed algorithm in this article is named AOMDV routing protocol based on average queue length (AOMDV-AQ). In AOMDV-AQ, average queue length of intermediate node provided as decided factor using for RREQ packet transmission in intermediate nodes. It indicates that the likelihood of transmission in each node of the network drops if the average queue length of the intermediate node exceeds a certain threshold.

In this way, AOMDV-AQ checks average queue length term in each phase of route selection in each intermediate node and nodes satisfied conditions can be candidate to exist in selected route. Thus, it avoids from presence of nodes with large average queue length that have many packets in their forwarding queue and ensures existence of less congested nodes in selected route. Using this method in routing balances traffic load and apply congestion control in the network and finally improves performance of the network. Purposed algorithm in RREQ packet forwarding based on average queue length shown in Alg. 1.

In Alg. 1 y_n is average queue length in intermediate node that calculated in equation (1), C is a uniform probability distribution random number between 0 and 1 and β is a threshold for average queue length.

We calculate throughput in various maximum speed of mobile nodes, after modifying AOMDV routing and applying our purposed algorithm using various value of β, as shown in Fig. 1. In the Fig. 1 we can see that appropriate β that has the highest throughput is 0.1. In this way, we used $\beta = 0.1$ for analyzing simulation and comprising our new algorithm with AODV and AOMDV routing protocols.

Alg. 1. Average queue length algorithm in RREQ packet forwarding

1. If $y_n \leq \beta$ then forward RREQ packet.
2. If not then calculate:
   $(1+\beta)-y_n$
3. Then generate C, is a uniform probability distribution random number
4. If $(1+\beta)-y_n \succ C$ then forward RREQ packet.
5. If not then drop RREQ packet.

4. SIMULATION ENVIRONMENT

The Network Simulator Version 2 (NS-2) is a useful tool for simulating the standards and operations of a real-world network. Linux is used to run the open-source simulation program NS-2. It supports numerous languages and created tools. This simulator mostly uses C++ and TCL as its backend object-oriented and scripting languages by default. In contrast to the latter, which is used to create the actual scripting scripts for the simulations' output scenarios, the former is used to develop and implement low level processes and algorithms. In order to code and extend a scenario in a desired network, such as a wired or wireless network, TCL is a scripting language. There are some tools that are related to NS, such as Network Animator (NAM), which association is primarily used for visualizing data.

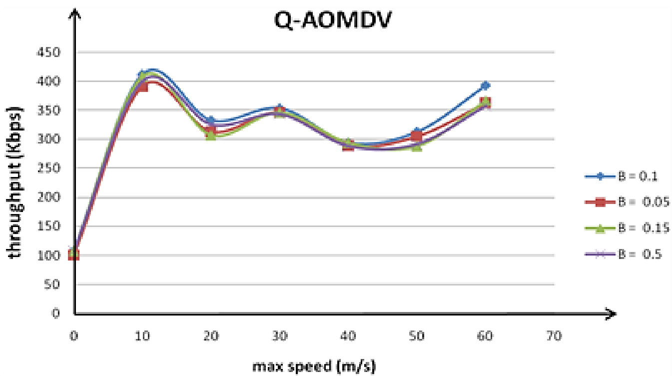

Fig. 1. Comparison of throughput in various maximum speeds of mobile nodes using various.

In this article we use the last version of network simulator (NS-2.35) for comparison routing protocols in Linux environment and analysis results of simulation using Perl (Practical Extraction and Reporting Language) scripting code. Perl is a scripting language uses good features of other programming languages like C, AWK, … . Perl programming language used for analyzing TCL output file of NS-2 and achieving desired factors like throughput and end-to-end dely. In this proposed scheme, parameters that are used are defined in Table. 1.

Table 1. Parameters that are used in simulation

Simulator	**NS-2.35**
MAC layer standard	802.11
Number of nodes	50
Topology Size	800m x 800m
Routing Protocols	AODV, AOMDV, AOMDV-AQ

Simulation Time	150s
Traffic Type	CBR & TCP
Packet Size	512 bytes
Number of Connection	5
Maximum Speed	10, 20, 30, 40, 50, 60 m/s

5. SIMULATION RESULTS

In this article we analysis two factors, throughput and end-to-end delay, in our purposed algorithm with other routing protocol like AODV and AOMDV routing protocols in NS-2.35. Above two factors are defined as follows:

Throughput (bps, Kbps): number of transmitted data packets from source to destination per time.

End-to-end delay (s): consuming time to receive data packet since leave soured node.

5.1. Throughput

In Fig. 2, we simulated a scenario consist of 50 mobile nodes with maximum speed of 10 m/s in Ad hoc network. Other parameters were same as defined in Table. 1. We executed the simulation for 10 times in random position of mobile nodes for AODV, AOMDV and our new algorithm then calculated averages throughput among the simulation trials. We can see that in most of the times throughput, our purposed algorithm outperforms the two competitive well-known AODV and AOMDV routing protocols, as shown in Fig. 2.

In Fig. 3, throughput of AODV, AOMDV and AOMDV-AQ routing protocols are compared in various amounts of nodes speed in the network area are shown. We can see that throughput in various speeds in our purposed algorithm is better than AODV and AOMDV routing protocols.

Table. 2 shows average amount of throughput in various speeds in three different routing protocols.

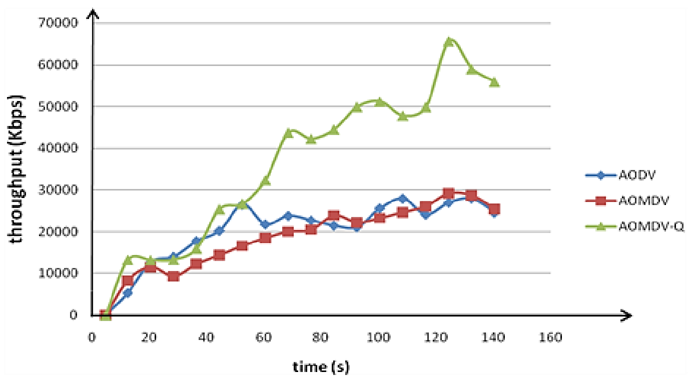

Fig. 2. Throughput versus time for AODV, AOMDV and AOMDV-AQ routing protocols.

5.2. End-to-end delay

Fig. 4 shows end-to-end delay in various maximum speeds of nodes in AODV, AOMDV and AOMDV-AQ routing protocols. According to this figure, end-to-end delay in our purposed algorithm in various speeds became less than AODV and AOMDV routing protocols which is because the congested nodes are less probable to take part in route discovery process in purposed algorithm. Thus, routes with low congestion level are selected and data packets can receive to destination as soon as possible.

Average number of end-to-end delay in various maximum speeds in three desired routing protocols are shown in Table. 3.

Table 2. Average of throughput in different maximum speeds

Routing protocol	AODV	AOMDV	AOMDV-AQ
Average-throughput (Kbps)	225.59921	258.525749	315.362380

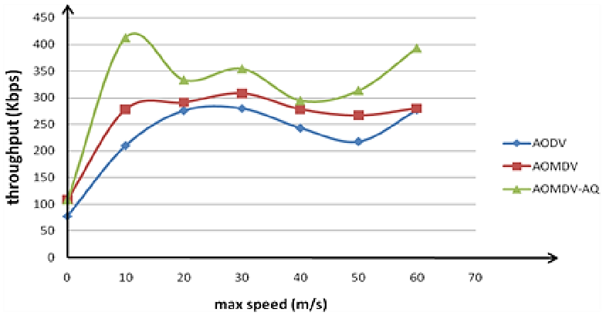

Fig. 3. Comparison of throughput in AODV, AOMDV and AOMDV-AQ routing protocols.

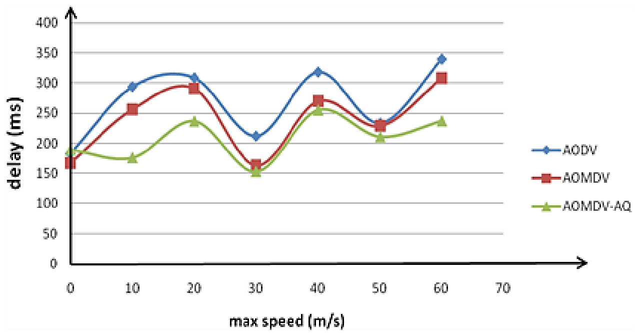

Fig. 4. Comparison of end-to-end delay in AODV, AOMDV and AOMDV-AQ routing protocols.

Table 3. Average of end-to-end delay in various maximum speeds

Routing protocol	**AODV**	**AOMDV**	**AOMDV-AQ**
Average-delay (ms)	269.79989	240.510701	208.7397133

6. CONCLUSION

In this article, we purposed a new algorithm to control congestion and to balance traffic load in the network. Our new purposed stochastic algorithm is based on AOMDV routing protocol and apply load balancing and congestion control with analyzing average queue length of the intermediate nodes in route discovery phase. Simulation results show that throughput in our purposed algorithm outperformed two competitive well-known AODV and AOMDV routing protocols. Our results showed that end-to-end delay in our purposed algorithm is also less than the two earlier routing protocols. Thus, our purposed algorithm improves the two-performance metrics of the network at the same time.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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