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Enhancing Routing Performance of AODV Protocol using 3rd Ordered Newton's Difference Equation

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Abstract

Objective: The main objective of our work is to use the interpolation based approach for the prediction of the time for which the active link will be available for the ongoing transmission of the packets containing information from the initial hub to the final destination hub. By using this interpolation method the performance of the routing protocol has been increased. **Method Analysis:** In our research we are using 3rd ordered newton's divided difference mathematical model for the estimation of the link failure time, so that prior to failure of link the message is divided through alternate path or local route repair is initiated. **Findings:** By applying the proposed algorithm with AODV routing protocol various quality of service parameter are calculated and compared with the previous proposed algorithm. From the results it has been concluded that the proposed algorithm gives better result in terms of performance gain of the routing protocol. It has been seen that throughput of the network increases with the use of this algorithm and also the various other parameters. The estimated time for link failure is more precisely measured, as a result of which the route recovery can be done in advance. **Improvement:** In our work we have proposed an algorithm that will be an improved version of previous existing algorithm. By the use of this algorithm performance has been enhanced incredibly.

Keywords: AODV (Ad-hoc on Demand Distance Vector), Link Availability, MANET (Mobile Ad-Hoc Network), Newton's Divided Difference Equation

1. Introduction

1.1 MANET

Mobile Ad-hoc Network[1] is a network that consists of dynamic nodes, which keeps on changing its topology frequently. In this network, communication occurs without the requirement of any stable infrastructure moreover there is no central authority for the control of the network. So as a result, the network is known as the infrastructure less network. Each node in the network coordinates with their neighboring nodes for the successful delivery of the packet from the source hub to final destination hub. In this network, each node individually acts as both the router and also the source node. In MANET, there is limited bandwidth so the data packets are not directly delivered from to the destination node from the source node, rather they choose to pass through the multiple intermediate nodes, also known as the hop to hop delivery of the information packet from initial node to the final node. As a consequence of this, the network is also known as the Multi-hop ad-hoc network[2,3]. In MANET, the nodes are randomly moving and can organize themselves within very short span of time. Due to which the network's topology keeps on changing rapidly which may be unpredictable at a certain period of time.

For the delivery of packets from one node to another node, the packets have to follow the certain dedicated

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path. Thus for finding the dedicated path there are some protocols for routing proposed by the researchers that must be followed by the mobile ad-hoc network. Protocols that are followed by the wired networks for routing are not directly compatible for wireless or mobile ad-hoc network[1], as they comprise of dynamic nodes and also due to an absence of any centralized authority. One of the protocols for routing is an on-demand distance vector ad-hoc protocol[4] for routing. Generally abbreviated as AODV, it comes under the class of reactive protocols for routing. This reactive protocol for routing is also known as the on demand protocol for routing, this is so because these protocols do not maintain any routing table. They search for the alternate route for forwarding the data packet from initial hop to the final node only when it is required. When the packet carrying information has to be sent to the movable node tries to catch on new link that joins the source and the destination node for delivering the packet with information towards the destination from the initial node.

1.2 AODV Protocol

AODV is an on-demand[5] protocol for routing. It does not maintain any routing table. It is called only when it is required or rather we can say that it comes into existence when it is demanded by the network. It is demanded when there is a need to find the link between the two nodes which are going into the dialogue with each other. The Sequence number is the key parameter in this protocol for routing. In this routing protocol, the destination number is used for the determination of the path between the two desired nodes, which are to be in communication with each other. In this, the initial node which has to send the packet containing information and the intervening node comprises the information of the node next to it corresponding for every stream of the information packet. In this network when there is no path available for the desired destination from the initial hub, then the initial hub makes sure that it should broadcast the route request message packet. As a consequence of this, there may be a possibility that the source node may get some appropriate link which will be held towards the destination node. As soon as the initial hub receives the valid link, it updates its route data; it happens only when the sequence number of the destination of the presently received data packet is capitalized than the already existing sequence number of the destination point.

The message packet of route request comprises of many elements in it, which are of great use. The elements in it are like sequence number of the destination point, the sequence number of the source point, initial identifier, final identifier, circulator identifier and also the living time. The sequence number of the destination points towards the newness of the link that has been accepted by the initial node. Whenever an intervening node gets the route reply message, it firstly checks whether it has any well-founded path which joins the initial and the destination node, if it has then, it sends the route reply message towards the initial node, if it does not find any path it simply forwards the route request message towards its neighboring nodes. For the authenticity of the path at the intervening node, is vindicated by the comparison of the sequence number for intervening hop and the sequence number of the final node of the message containing the request for the route. If the node receives the multiple packets at a time which contains the request for the new route, it simply sheds the replica copies and the multiple copies are identified by the circulator identifier. The sequence number of every intervening node has authenticated path towards the desired node which are allowed to forward the message containing reply for the route to the initial node. The timer is also used if it does not receive any message regarding the reroute, so before the expiration of this time it eradicates all the previous information. So due to the presence of timer, it allows the intervening node to store the information regarding current path.

Due to the presence of mobile node, links will break frequently and as a result of this topology of the network will also change dynamically which further leads to the frequent change of route. The consequence of this is that the routing presents in a MANET will have lot of challenges. Where there is breakage or failure in the link, the link has to be repaired, or else new route has to be discovered. During the discovery of alternate path after the link failure, the packet carrying information bits are eliminated. As the consequence, there will be wastage of the resources including power, energy utilization etc.

Author in[6] proposed different techniques for increasing the routing performance by using the prediction of mobility. Their main focus was to increase the routing performance of unicast and multicast routing by predicting the mobility of data packets. They made use of GPS for locating the position of packets between

the sender node and the receiver node. With the help of GPS, they tried to monitor the link between the sender and the receiver. If it is estimated that the link is at the edge of breaking, then packets deviate through another available route. Their main focus is to provide a path without any interruptions between the source and the destination, which will ultimately result into less number of link breakages. The main limitation of their work is the use of GPS in an indoor system which was not as efficient as it was in outdoor. As fading, multipath propagation, interrupts may become the source of interference, as a result of which GPS may not locate the path accurately.

In[7] main purpose was that initially the node itself tries to predict the time period for which it will remain in a continuous path, also they made the assumption that the nodes movement parameter will remain constant throughout the current movement. Then they try to make changes in the nodes manually, so that the path will remain continuous for the longer period. They used it by measuring the epoch length. They used predicted path that they have estimated through link availability and in addition to this they used metrics for the routing path, for the more reliability of the estimated path. By doing so, path reliability and network performance has improved. Their work is confined to exponentially distributed epoch length. The method is unable to calculate exact available link but rather provides the normal capacity of the available link. If epoch length is of non-exponential distribution, then this approach will not be able to estimate the link availability.

In[8] proposed an interpolation based mathematical model in which they used the strength of received signal. They have used the predictive preemptive approach on route maintenance and implemented it with the AODV protocol. They have used Lagrange interpolation method for finding the alternate path when the current path is going to demolish by using the information of signal strength of received packet and also tries to repair the existing path. The interpolation method used by them is quite complicated and the more power is consumed.

In[9] have used the preemptive routing approach on the ad-hoc network protocols. They have used the strategy of activation of selection of the route in advance and maintenance of that route towards routing algorithm of on-demand routing protocols. A sense of link failure is earlier predicted and in reference to this the warning packets are sent. They also increase the performance of routing protocol. The main limitation of their work is that although they have increased the performance but there is an increase in overhead which is the major issue.

In[10] used the mathematical model for the estimation of availability of link. They used the Pareto distribution to define the Probability Distribution Function (PDF) of epoch length. Their main focus was to detect the link breakage in advance before the active route gets demolished and as a result of which delivering the packets without failures through the new path. They implemented this approach on DSR protocol. The QoS has been increased significantly in it. They used their link prediction technique only for exponential distribution. In[11] proposed a mechanism in which path timeout is there, it is basically based on the prediction of node mobility and the intercalation of link cache that contained temporal information about the upcoming state of the network topology. They also had made the assumption that each node in the ad-hoc network has the strong ability to determine its location, bearing, and velocity. Their main idea was that by the use of temporal and spatial information routing decision can be taken in an efficient way.

In[12] proposed an algorithm that was implemented on Ad-hoc on Demand Distance Vector routing protocol (AODV)[13–15]. In this algorithm, they have detected the path in advance before the present path gets damaged. They have used the approach of preemptive. They have tried to increase the number of packets delivered to the destination node and also decreased the average delay in packet. In addition to this they have improved the throughput and balance the traffic. In[16] proposed an algorithm in which the link getting destroyed is predicted earlier than it actually gets demolished. They have performed this algorithm on the Dynamic Source Routing protocol (DSR)[17–19]. In this, the node makes use of received signal strength, which determines the time after which the link is going to destroy and in the stipulated time it sends warning messages to the neighboring node about the current path which is going to destroy. In their work, they have increased the performance by reducing the number of dropped packets in the network.

In[20], in their work have modified the behavior of AODV routing protocol. They have tried to make a hybrid of it by introducing the proactive routing protocol behavior into it and then tried to increase the performance of AODV. They have calculated the CBR and traffic parameters and

then compared the performance metrics of the protocol.

In[21], have discussed and analyzed about the various challenges and issues that arise in MANET during the internet connectivity.

In[22], have proposed a routing protocol for the wireless ad-hoc network, they used it for the source initiated routing protocol that is DSR[17–19] (dynamic source routing protocol). They made use of GPS receivers, by which they tried to locate the location of the data packets and the path followed by the same packet. This new protocol results into efficient use of energy and bandwidth and also there is reduction in delay. In their work, they have compared the routing protocol DSR without GPS and DSR with GPS.

In[23], have proposed a router handover mechanism that is basically based on preemptive approach. It is based on signal strength of the received packet in source initiated routing protocol. In this if a node, say M predicts the situation that the signal strength is going below the threshold value for the previous and the successor node for the node M itself, then the node M tries to find out the neighbor node let's say O, this node O should have the characteristics that it can reach both the previous node (X) and the successor node (Y), and node O must have the better strength. Then the path X-M-Y will be replaced by the X-O-Y, to reach the destination node.

In[24], in their work they have compared the different routing protocol and also given the introduction of the various routing protocol. They have compared both the proactive and reactive routing protocol. The main aim of their work was to analyze both the categories of routing protocol and to study their different performance parameters and also analyzed the quality of service parameter. They have done the comparison by varying the node numbers and simultaneously keeping the number of connections to be constant.

In their work in[13] they have proposed the routing algorithm, and named it as Ad-hoc on Demand routing protocol (AODV)[13–15]. It is a source initiated routing protocol. In this, they have verified that this protocol is valid for dynamic network and each node in the network is mobile and self-organizing. In[25], have mentioned about the work they have done, that is that they show the comparison of three routing protocols that belong to three different categories of the routing protocol. They compare the characteristics of proactive, reactive and hybrid routing protocol. From their simulation results, they have observed that the AODV routing protocol has better performance in all the parameters and also concluded that ZRP has unproductive performance.

In[26], in their work they have compared the two different routing algorithm. They have discussed the AODV and OSLR protocols and also about their advantages and disadvantages. They have taken the performance metrics into the consideration for the comparison and on the basis of their simulation results deduced the necessary conclusions.

In[27] used the mathematical model for the prediction of time. They have also proposed the interpolation based mathematical model known as the second ordered Newton's divided difference. They used this model for the prediction of the link. They have compared the routing parameter between the AODV with link prediction and without link prediction. They have tried to increase the quality of services of the system further in comparison to already existing one. Also, they tried to estimate the time for the link breakage so that they can route the data packets through the alternate path.

1.3 Intent of the Work

The main objective of our work is to use the interpolation based approach for the prediction of the time for which the active link will be available for the ongoing transmission of the packets containing information from the initial hub to the final destination hub. By using this approach, we are aiming to increase the serving qualities of the network and its efficiencies by predetermining the time at which the active link is going to break and in addition to this for the successful communication, routing the packets through the newly available path or repairing the currently active link. Several different approaches have been proposed for the route maintenance, discussed in the literature survey below. We are proposing a mathematical model which is based on interpolation technique namely third ordered Newton's divided difference for the prediction of the link breakage time. So we are going to apply this link prediction technique with AODV protocol for routing. The results of this proposed approach are then compared with, when there is no path prediction for the AODV[28] routing protocol and also with the AODV with path prediction using a mathematical model of lower order.

The main visions of our work are as follows:

- To increase the efficiency of the existing network.

- To increase the network performance.
- Making a network having the qualities of self-organizer and the self-curable.
- Comparison of the results with the previously existing work.

2. Proposed Mathematical Model

2.1 Newton's Divided 3rd Ordered Difference Formula

P_r is the threshold signal strength.

P_1, P_2, P_3, and P_4 are the received data packets signal strength.

τ_1 τ_2 τ_3 and τ_4 are the time instances when packets arrived.

r_p is the predicted time

$P_r=P_1+ (r_p-\tau_1) \Delta+ (r_p-\tau_1) (r_p-\tau_2) \Delta^2+ (r_p-\tau_1) (r_p-\tau_2) (r_p-\tau_3) \Delta^3$

$P_r=P_{1+} [(r_p-\tau_1) (P_2-P_1)] / (t_2-\tau_1) + (r_p-\tau_1) (r_p-\tau_2) \{[\{(P_3-P_2)/ (\tau_3-\tau_2)\} - \{(P_2-P_1)/ (\tau_2-\tau_1)\}] / (\tau_3-\tau_1)\} + (r_p-\tau_1) (r_p-\tau_2) (r_p-\tau_3) \{[\{(P_4-P_3)/ (\tau_4-\tau_3)\}-\{(P_3-P_2)/ (\tau_3-\tau_2)\}- \{(P_2-P_1)/ (\tau_2-\tau_1)\}] / (\tau_4-\tau_1)\}$

Let, $A= (P_2-P_1)/ (\tau_2-\tau_1)$

$B= \{[\{(P_3-P_2)/ (\tau_3-\tau_2)\} - \{(P_2-P_1)/ (\tau_2-\tau_1)\}] / (\tau_3-\tau_1)\}$

$C= \{[\{(P_4-P_3)/ (\tau_4-\tau_3)\} - \{(P_3-P_2)/ (\tau_3-\tau_2)\} - \{(P_2-P_1)/ (\tau_2-\tau_1)\}] / (\tau_4-\tau_1)\}$

Now, the equation will be

$P_r= P_1+ (r_p-\tau_1) A+ (r_p-\tau_1) (r_p-\tau_2) B+ (r_p-\tau_1) (r_p-\tau_2) (r_p-\tau_3) C$

Expanding and solving the equation we will get

$Cr_p^3+ (B+C\tau_2+C\tau_3-C\tau_1) r_p^2+$
$(A-B\tau_1-B\tau_2+C\tau_2\tau_3+C\tau_2\tau_1+C\tau_3\tau_1) r_p+$
$(P_1-P_r-A\tau_1+B\tau_1\tau_2-C\tau_1\tau_2\tau_3) = 0$

Let, $a = C$

$b = (B+C\tau_2+C\tau_3-C\tau_1)$

$c = (A-B\tau_1-B\tau_2+C\tau_2\tau_3+C\tau_2\tau_1+C\tau_3\tau_1)$

$d = (P_1-P_r-A\tau_1+B\tau_1\tau_2-C\tau_1\tau_2\tau_3)$

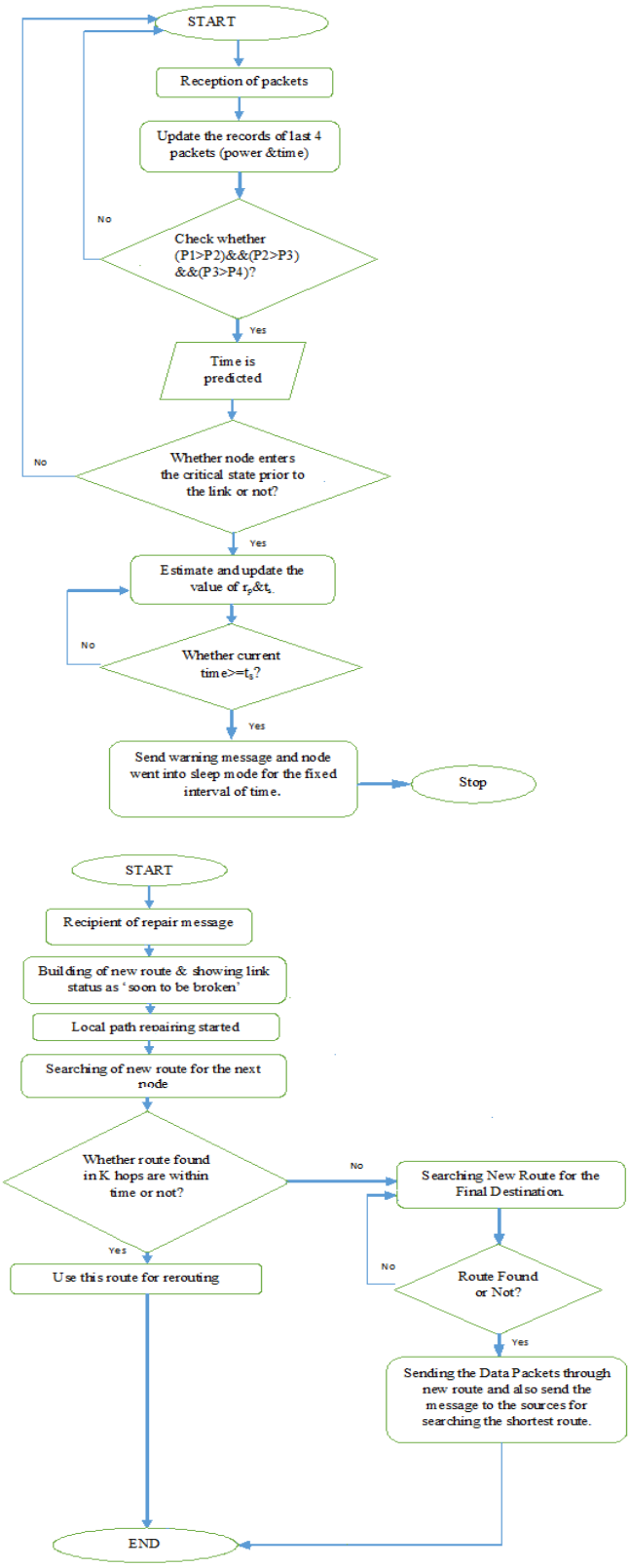
Therefore the equation is reduced to

$ar_p^3+br_p^2+cr_p+ d=0$

2.2 Flow Chart for Algorithm

Algorithm of sending repair massage and finding path contain various steps which are thoroughly presented in the form of follow chart.Information can be easily depicted from these flow chats.

2.2.1 *Flow Charts for Sending Repair Message and Finding Path*



2.3 Simulations and Results Analysis

Different parameter are considered and simulated using the NS2 tool. The comparison between different scenarios on the basis of different parameter are considered during the simulation. The comparison is made for normal AODV, AODV with link failure, AODV with link prediction using the Newton's second ordered divided difference equation and Newton's third ordered divided difference equation. We have simulated AODV routing algorithm for different routing algorithm situation, like for AODV with link failure, AODV without link prediction, AODV with link prediction using Newton's 2nd ordered divided difference equation and AODV with link prediction using Newton's 3rd ordered divided difference equation.

Table 1. Simulation parameter

Traffic Pattern	Constant Bit Rate (CBR) and TCP
Simulation Time	500s
Simulation Area	1000 m by 800 m
Data Packet Size	1000 bytes
Total number of nodes	50
Node velocity	6m/s
Traffic load	5 packets/s

In the simulation we have generated 5 packets per seconds, defined as packet generation rate. CBR and TCP traffic pattern is used. Using all the above parameters we have tried to evaluate the throughput, end to end delay and packet loss which results in increase in quality of service parameters and higher performance gain. The number of packets successfully delivered to the destination per second is defined as the throughput. The Figure 1 shows the variation of throughput with the time. The results shows that using the link prediction technique the throughput of the network increases significantly in contrast to the situation when no link prediction technique is applied and also when the route failure is there. Using the even higher ordered of link prediction technique as in our work we have used third ordered newton's divided difference equation gives more throughput.

The next parameter we considered in our simulation is end to end delay. The difference between the time at which the initial node send the data packets and the time when the destination node receives the data packets is defined as the end to end delay. It compromises of all types of delays including propagation delay, transmission delay, retransmission delay, queuing delay. From the Figure 2, it was concluded that using the link prediction with AODV routing algorithm the end to end delay has been decreased to greater extent. Using the third ordered newton's divided difference equation the delay has been decreased significantly and as the result of this packets are delivered with the minimum of delay and maintaining the integrity of the data.

In Figure 3, shows the variation of packet loss with respect to time. The difference between the total number of packet send by the source node and the number of packets received at the destination node, gives the number of packet loss during the entire transmission period. From the results it has been analyzed that the when the

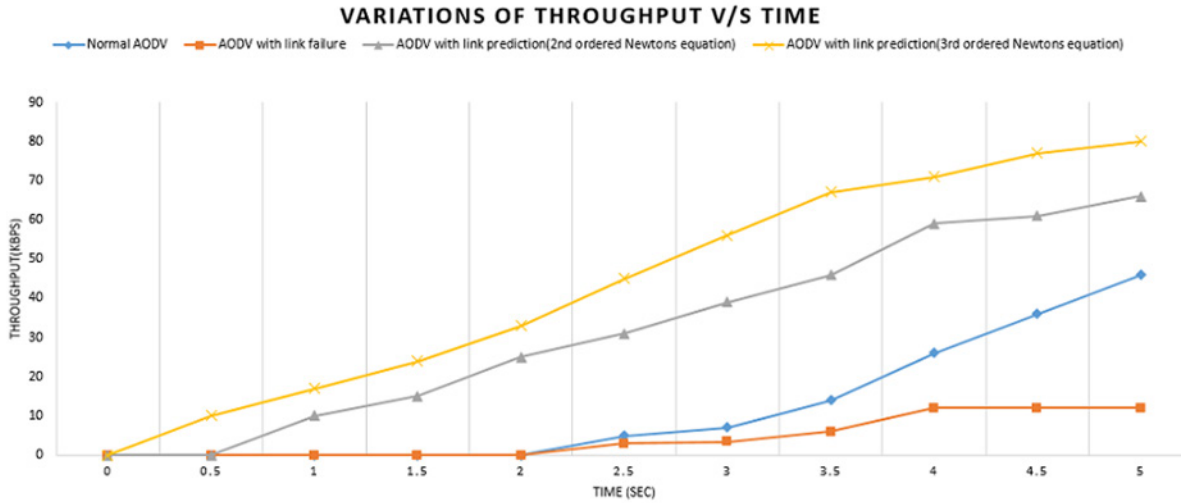


Figure 1. Throughput versus time.

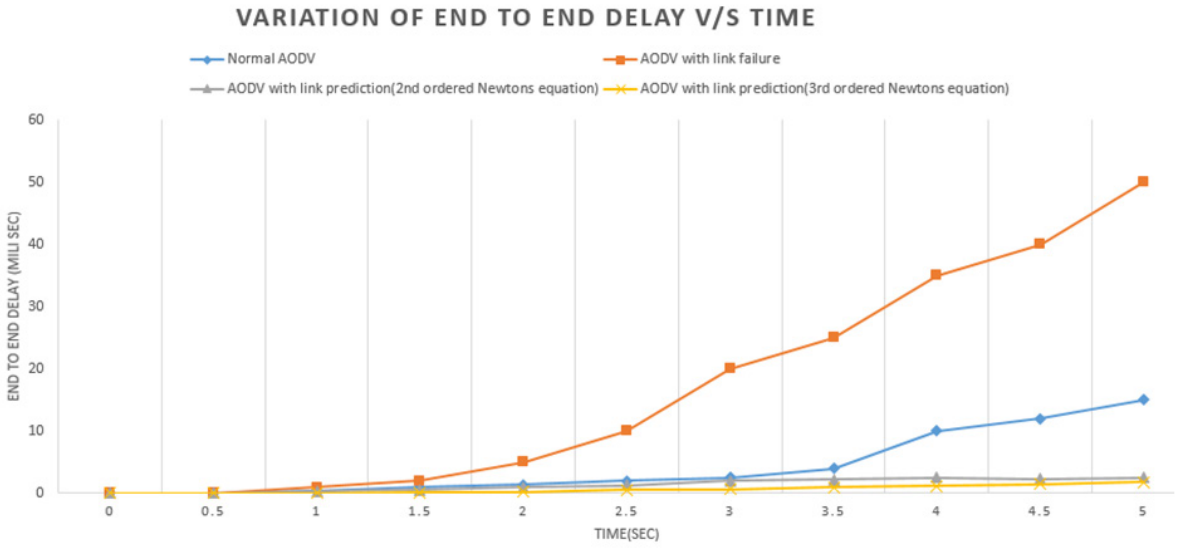


Figure 2. End to end delay versus time.

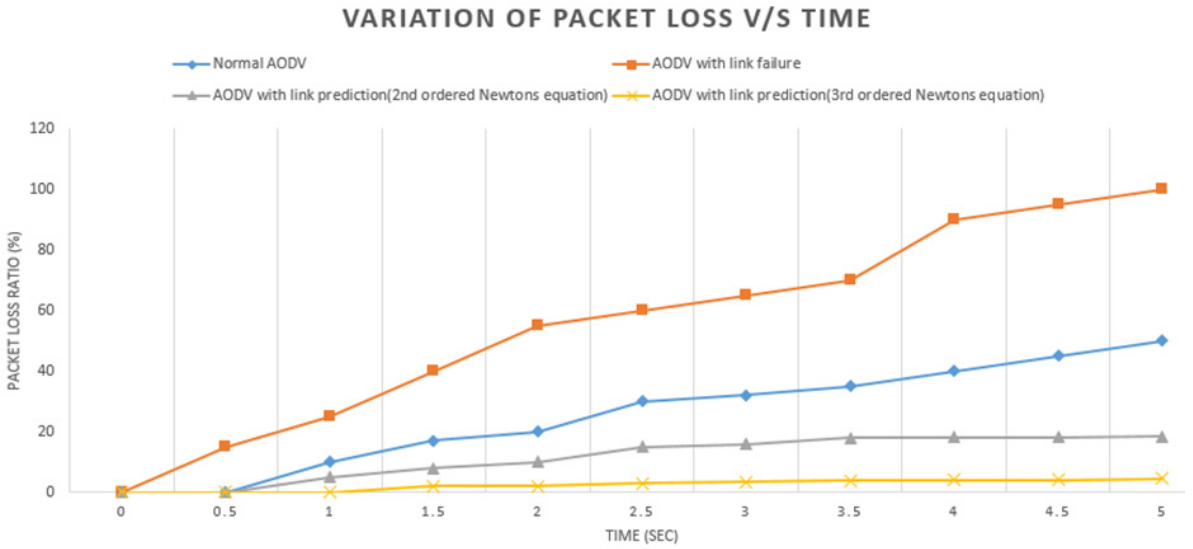


Figure 3. Packet loss versus time.

link prediction method is used the probability of packet loss is very low and hence the increase in the performance of the network.

3. Conclusion and Future Scope

It is expected that the routing performance is evaluated on its impact on performance using detailed simulations. The simulation result is expected to show that the proposed approach can be expected to improve performance significantly. It is expected that it should reduce communication overhead, decrease in the number of breaks in active links, reduce end-to-end packet delays, and improve throughput. In addition to this it also expected that the predicted time will be calculated as soon as possible which will be more précised hence, there will be known link breakage in advance and the network can take the necessary steps to avoid the link failure. Various parameters of quality services are expected to vary which will ultimately lead to high routing performance. TCP simulation is expected to be there and also the throughput which is the main quality of service

parameter are expected to be increased such that system will be more reliable and efficient. It is expected that using the interpolation based technique, the predicted time is known in advance and knowing about the predicted time after which the link is going to fail and broadcasting the message for the discovery of new path or repair of same path so that there will no packet or information lost and safe transmission of data will be there.

Further there will be scope of improvement by using the same interpolation technique. And we can also implement it on other available routing protocol and improve their routing performance and work on other parameters.

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