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Node-Disjoint Multipath Routing Based on AOMDV Protocol for MANETS

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Abstract- **MANETs has mobile nodes which are connected through dynamic multi-hop channels. Routing in MANET is a difficult task which has received much attention from researchers. Consistent link failures occur in mobile ad-hoc networks because of node's mobility and use of fickle wireless channels for data transmission. Because of this, multipath routing protocols arrive with a critical research issue. In this, we propose to implement node-disjoint multipath routing based on AOMDV protocol. The main objective of proposed approach is to obtain all available node-disjoint routes from source-destination with minimum delay and high throughput. With this given approach, as first route for destination is dogged the source starts data transmission. All other backup routes, if available, via the first route are scheduled concurrently with data transmission. In the current work we are proposing the concept of Node Disjoint–Multipath based on the congestion threshold and results will be obtained through various simulations shown via the effectiveness of our suggested methods in terms of End to end delay, Throughput, hop count, Packet delivery Fraction.**

Keywords: **Mantes, Mobile Ad-hoc Routing, Node-Disjoint, Multipath, Route availability, AODV protocol AOMDV protocol**.

I INTRODUCTION

Mobile ad hoc networks (MANET) are collection of mobile hosts which are self-configurable, self-organizable and self-maintainable. These mobile hosts communicate with each other through wireless channels with no centralized control. The inherently infrastructure-less, inexpensive and quick-to-deploy nature of MANETs is providing a promise for its use in diverse domains. Over the years, multimedia streaming over the internet has established well with numerous applications including audio/video streaming, TV on demand, voice-over-IP and surveillance systems. Routing protocols that discover and save more than one route in their routing table for each destination node is referred to as multipath routing protocol. In wireless outline, paths are broken due to node movement. Also, the wireless links used for data transmission are inherently unreliable and error prone. Therefore, multipath routing protocols are used to overcome the disadvantages of shortest path routing protocols.

Multipath routing protocols are used to increase the reliability (by sending the same packet on each path) and fault tolerance (by ensuring the availability of backup routes at all times). It can also be used to provide load balancing, which reduces the congestion on a single path caused by busty traffic. A survey on multipath routing protocols for MANETs is presented in [1].

Node-disjoint multipath routing allows the establishment of multiple paths, each consisting of a unique set of nodes between a source and destination. We know that MANETs consist of mobile nodes that cause frequent link failures. This link failure causes two main problems. Firstly, when a route break occurs, all packets that have already been transmitted on that route are dropped and it decreasing the average packet delivery fraction. Secondly, the transmission of data traffic is halted for the time till a new route is discovered and it increasing the average end-to-end delay [15]. In this paper, we develop a node-disjoint multipath routing method (NDMP-AOMDV) based on (AOMDV) [2] ad-hoc on-demand multipath distance vector routing protocol. Our proposed approach will minimize the effect of link failure. Hence, the above mentioned two problems caused by frequent link failures are addressed. NDMP-AOMDV assures that after a path is broken, the node can consistently send data without delay, using any one of the backup routes which are stored in its routing table during route discovery process. It has been shown that NDMP-AOMDV discovers multiple paths with a very low end to end delay as compared to other existing multipath AODV[3] protocols and AOMDV protocol.

II RELATED WORK

Multipath routing creates multiple paths between a source-destination pair. In case of the failure of first route, the backup routes are used for continues data transmission. In multipath routing protocols, the paths between a source and destination can be link-disjoint, node-disjoint or zone-disjoint [15].

A. **Review of Link-Disjoint Multi-path Routing Protocols**

Multi-path routing protocols for MANETs are mostly either multi-path extensions of DSR or AODV. In Split multipath routing (SMR) [4], intermediate nodes forward RREQs which are received via a different link and with the hop count not to be larger than the first received RREQ. The destination select the route on which it received the first RREQ packet (which will be a shortest delay path), and then it waits to receive more RREQs. The destination node then selects the path which is maximally disjoint from the shortest delay path. If it has more than one maximally disjoint path exists then the tie is broken by choosing the path with the shortest hop count. The Ad hoc on-demand Multipath Distance Vector (AOMDV) routing protocol [2] is an extension of AODV to compute multiple loop-free link-disjoint routes. The RREQs that arrive via different neighbors of the source node define the maximum number of link-disjoint paths that are possible. For every destination node *d*, an intermediate node *i* maintains the list of next hop nodes, the hop count for the different paths to the destination node *d* and the "advertised hop count"(the maximum hop count for all paths from *i* to *d*), with respect to the latest known sequence number for *d*. An intermediate node accepts and forwards a route advertisement as an alternate path to the destination only if the route advertisement came from a neighbor node that has not yet sent the route advertisement for the destination sequence number and the hop count in the route advertisement is less than the advertised hop count to the destination. When a node receives a route advertisement for the destination with a higher sequence number, the next hop list and the advertised hop count values are reinitialized. The destination node replies for the RREQs arriving from unique neighbors. A multi-path routing scheme that extends AOMDV by using a traffic-path allocation scheme has been proposed in [5] and it is based on cross-layer measurements of path statistics that reflects the queue size and congestion level of each path. The scheme utilizes the Fast Forward (FF) MAC forwarding mechanism [6] to reduce the effects of self-contention among frames at the MAC layer.

B. Review of Node-Disjoint Multi-path Routing Protocols

The AODV-Multi-path (AODVM) routing protocol [7] is an extension of the AODV protocol to determine node-disjoint routes. An intermediary node does not abandon duplicate RREQ packets and records them in a RREQ table. The destination acknowledge with an RREP for each RREQ packet received. An intermediary node on receiving the RREP checks its RREQ table and ahead the packet to the neighbor that lies on the shortest path to the source. The neighbor entry is then removed from the RREQ table. Also, whenever a node hears a neighbor node forwarding the RREP packet, the node removes the entry for the neighbor node in its RREQ table. More recently, a geographic multi-path routing protocol (GMP) [8] has been proposed to reduce interference due to route coupling. The RREQ will have information regarding the locations of the first hop and the last hop intermediate nodes on the path. The destination chooses the path through which it first received the RREQ. For a subsequently received RREQ, the destination measures the distance between the first hops of the path traversed by this RREQ and the already selected paths and also the distance between the last hops of the path traversed by this RREQ and the already selected paths. If both these distances are greater than twice the transmission range of the nodes, the path traversed by the received RREQ is selected. EMRP is an energy-aware multi-path routing protocol [9] that considers the available energy and the forwarding load at the intermediate nodes of the multiple paths before distributing the load across them. The destination node replies with a RREP packet for each RREQ packet. An intermediate node receiving the RREP packet updates information regarding the distance between the node and the next hop node, the number of retransmission attempts corresponding to the last successful transmission, the current queue length, the current remaining energy of the node. The source node then computes a weight for each route through which the RREP traversed. Routes with minimum weight are preferred as such routes have more remaining energy, less energy consumption due to transmission and reception, less crowded channel in the neighborhood of the nodes in the path and more bandwidth available.

C. Review of Zone-Disjoint Multi-path Routing Protocols

The Zone-Disjoint Multi-path extension of Dynamic Source Routing (ZD-MPDSR) protocol [10] suggested for the Omni-directional system work as follows: Whenever the source node has no other path to send data to a destination node, the source node starts broadcasting of the Route-Request (RREQ) messages. Number of active neighbors for a node indicate that the number of neighbor nodes which have received and forwarded the Route Request (RREQ) message during the route discovery process. The RREQ message has a *ActiveNeighbourCount* field & it is updated by each intermediary node before broadcasting the message in the neighborhood. When an intermediary node receives a RREQ message and it broadcast a 1-hop RREQ-query message in its neighbor to determine the number of neighbors who have seen the RREQ message. Number of RREQ query and replies received from the nodes in the neighborhood is the value of the *ActiveNeighbourCount* field updated by the node in the RREQ message. The destination node receive several RREQ messages and selects the node-disjoint paths with lower *ActiveNeighbourCount* values and sends the Route-Reply (RREP) messages to the source along these paths. Even though the selection of the zone-disjoint paths with lower number of active neighbors will lead to reduction in the end-to-end delay per data packet, the route acquisition phase will incur a significantly longer delay as RREQ-query messages are broadcast at every hop (in addition to the regular RREQ message) and the intermediate nodes have to wait to receive the RREQ-query-reply messages from their neighbors. This will significantly increase the control overhead in the network.

Several other implementations like AOMDV [11], AODVM [12] and AODVM-PES [13] also present multipath versions of AODV protocols. But unlike above discussed methods, the multiple routes identified in these approaches are link-disjoint rather than node-disjoint. In all these methods, data transfer starts only after all multiple paths are discovered. This incurs initial delay in data transmission.

NDMP-AODV has been implemented. But it has problems with the route selection process of NDMP-AODV. As from the previous research on comparison of performance evaluation of AODV and AOMDV, shows that AOMDV performs better than AODV .Therefore, we proposed NDMP-AOMDV routing protocol. It addresses many problems associated with the previous node-disjoint multipath routing protocols. NDMP-AOMDV has back-up routes for active flows at all times which greatly reduces the delay. Approximately, above 80% control messages in

AOMDV are RREQ messages. Our method minimizes the RREQ messages in the network by finding all the available node disjoint paths between a source-destination by flooding a single RREQ. NDMP-AOMDV is also combined with three different route maintenance processes. Also we have compared the NDMP-AOMDV with existing AOMDV.

III. Proposed Node-Disjoint Multipath AOMDV Routing Protocol [NDMP-AOMDV]

In this section, the proposed NDMP-AODV protocol is described. The main goal of NDMP-AOMDV is to find all available node-disjoint paths between a source and destination pair with minimum routing overhead. To achieve this goal, NDMP-AOMDV protocol works in three phases: (a) Route Discovery Phase, (b) Route Selection Phase and (c) Route Maintenance Phase.

A. Route Discovery Phase

When a source node has a data packet to send, it checks for the routing table for the next-hop towards the destination of the packet. If there is an active entry for the destination in the routing table, the data packet is headed to the next hop. Else the route discovery phase starts. In the route discovery phase, routes are determined by using the two types of control messages: (a) Route request messages (RREQs) and (b) Route reply messages (RREPs).The source node flood RREQ message into network. Each intermediary node that receive a RREQ, checks whether it has a duplicate node or a fresh one by searching an entry in the Seen Table. Seen Table store the two entries (i.e. source *IP* address and RREQ flooding ID that uniquely identifies a RREQ message in the network. If an entry is present in the Seen Table for the received RREQ message, it is considered a duplicate RREQ message and discarded without further broadcasting. Else the node creates an entry in the Seen Table and updates its routing table for forward path before broadcasting the RREQ message.

Source IP Address	Flooding ID	Seen Table
……	……	……

Fig.1. NDMP-AOMDV Seen Table Structure

By using this concept if some route gets failed due to heavy congestion or traffic then an alternate path will be followed. Since it has been defined in NDMP-AOMDV Table. In such case we will compute the level of congestion using threshold-value of congestion.

In NDMP-AODMV, only the destination node can send RREPs upon reception of a RREQ message. The intermediate nodes are forbidden to send RREPs even if they have an active route to destination. This is done so as to get the node- disjoint routes. In NDMP-AODV, the destination node has to send a RREP message for each RREQ received, even if the RREQ is a duplicate one. We change the data structure of Seen Table and RREP message as shown in Figures 1 and 2. In Seen Table, we add an extra field that works as a flag known as seen-flag. This flag is set to FALSE at start i.e. when an entry is first inserted in the Seen Table after a node gets its first RREQ message. The RREP messages initiated by destination node in NDMP-AODMV contain one extra field known as broadcast ID (*b id*).

When a destination node receives a RREQ message, it creates the corresponding RREP message. The destination node copies the *f id* from the received RREQ message into the *b id* field of sent RREP message. This RREP is unicast towards the originator of the RREQ using the reverse path to construct the forward path. For every RREQ received (i.e. either first or duplicate), the destination does the above mentioned process. When the intermediate nodes in the reverse path receive the RREP message, they check the seenflag value in their Seen Table. If the seenflag is set to FLASE, this indicates that this is the first RREP message on the reverse path towards the source node. So, the intermediate nodes relay the RREP towards the source and reset the value of seenflag. When the intermediate node gets a RREP message for the same RREQ message it got earlier, the node simply discards the RREP message on the basis of seenflag value. Due to this, the intermediate node's can only take part on any one route from the existing multiple routes.

<table>
<tr><td>Type</td><td>R</td><td>A</td><td>Reserved</td><td>Prefix-Size</td><td>Hop-Count</td></tr>
<tr><td colspan="6">Destination IP</td></tr>
<tr><td colspan="6">Destination Sequence Number</td></tr>
<tr><td colspan="6">Source IP Address</td></tr>
<tr><td colspan="6">Source Sequence Number</td></tr>
<tr><td colspan="6">Broadcasting ID</td></tr>
</table>

Fig. 2.NDMP-AOMDV RREP structure

B. Route Selection Process and Data Packet Transmission

When source node has data packets to send and there is no route available in routing table, the node initiates the route discovery process. The source node starts data transmission as soon as it gets the first route for destination node known as *primary route*. All the other node-disjoint routes that are discovered will be stored in the routing table as *secondary routes*. After storing the primary route and a specified number of secondary routes in the routing table, all the other routes (if any) are not stored. All the other routes that are discovered after storing the primary and secondary paths can replace the existing secondary paths if they have lower hop count for destination as compared to existing ones. The route selection function works in such a way that whenever a route is required for data transmission, it always selects the primary route if it is available. If the primary route is not active, then the route selection function selects the route with lowest hop count from the available secondary routes.

C. Route Maintenance Process

Route maintenance process is invoked when an active route is broken during completion of a data flow. We implement and analyze the performance of three route maintenance methods in case of route breaks. In the first method, when the primary route is broken, transmission of data is continued using the secondary routes. To keep the secondary routes active while using the primary route, we increase the lifetime of each active secondary route after a fixed amount of time. When all the secondary routes are also broken, the source starts a new route discovery process. In this way, we can minimize the routing overhead caused in finding and maintaining multiple routes.

IV SIMULATION AND RESULTS

In this section, we perform various simulations and analyze the results obtained. We incorporate changes in traditional AOMDV to make it node-disjoint multipath routing protocol. We evaluate and compare the performance of our proposed route discovery method when used with three different route maintenance schemes and with traditional AOMDV. We use a commercial scalable network simulator called NS2-allinone-2.34 to simulate our proposed methods.

Table 1 Simulation Parameters

Parameters	**Values**
Simulator	NS-2.34
Simulation Time	50 sec
Scenario Dimension	1000x1000
Number of Nodes	50
Transport Protocol	UDP
Routing Protocols	AOMDV,NDMP-AOMDV
Mobility Model	Random way-point
Path-loss model	Two ray
Radio type	802.11b
Velocity	8.32 m/s

For the evaluation following metrics will be used:

1. **Packet Delivery Ratio (PDF):** It is the ratio of the packets received by destination to those generated by the sources. CBR traffic type is used by source. It specifies the packet loss rate, which restricts as well as limit the maximum throughput of the network. The routing protocol which have better PDR, the more complete and correct. This reflects the usefulness of the protocol. And provide good performance.

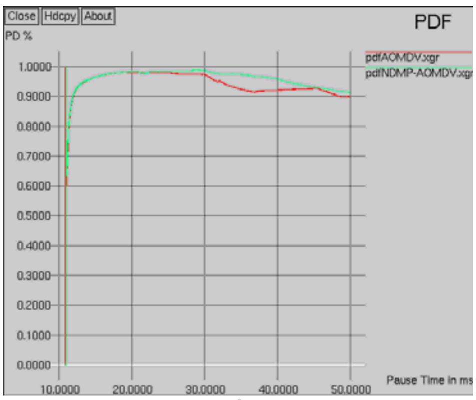

Figure 1. PDF Graph

2. **End to End Delay:** Average ee-delay is the average time taken by the packet to reach to destination in seconds.

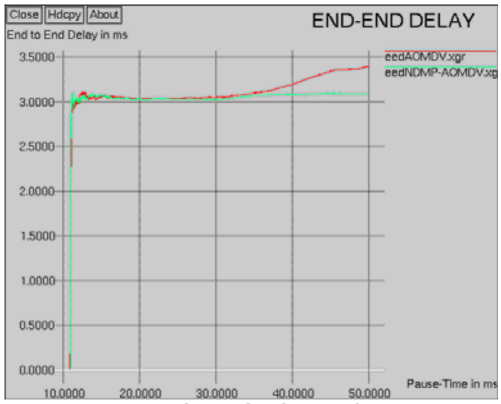

Figure 2. End to End Delay Graph

3. **Throughput:** No. of packet passing through the network in a unit of time. It is measure in kbps.

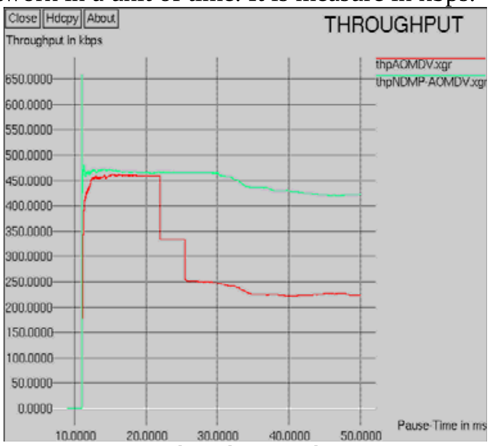

Figure 3. Throughput Graph

B. Experimental Process-

The simulation scenario and parameters used for performing the detailed analysis and study of NDMP-AOMDV on MANET protocols is described below. This facet represents that how the effective performance parameters have been analyzed to simulate the protocols.

Following steps have been used for simulation.

1. *Inputs to Simulator:-*
    - Scenario File – Movement of nodes.
    - Traffic pattern file.
    - Simulation TCL file
2. *Outputs File from Simulator:*
    - Trace file
    - Network Animator file
3. *Output from Trace Analyzer:*
    - xgr file

C. NAM (Network Animator)–

NAM stands for Network Animator. It has data for network topology and shows graphical representation. It begins with the proceeding command 'nam <nam-file>' where '<nam-file>' is the name of nam trace file i.e. .tr file. At linux terminal, the command to run NAM is ./nam.

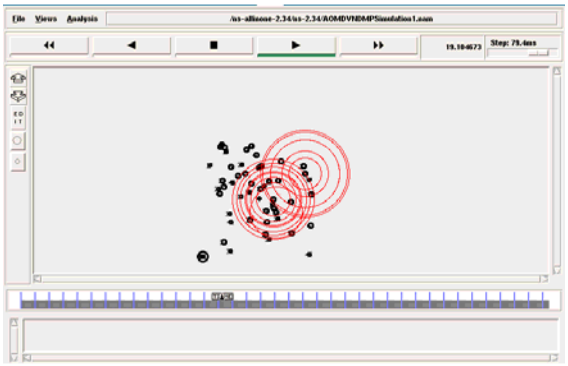

Figure 4. NAM

After performing simulation as per network scenario, trace files are produced. Trace file have following information:

1. Send/Receive Packet
2. Time
3. Traffic Pattern
4. Size of Packet
5. Source Node
6. Destination Node etc.

D. Analysis done using Trace Analyzer-

Awk scripts i.e. awk files trace analyzer is used to evaluate trace outputs from simulation. When files are evaluated using this trace analyzer then an output .xgr file is produced which results in the creation of graphs i.e. xgraphs.

E. Simulations Result Table-

Table 2- Shows Result Table

Routing Protocol	Average End-End Delay (in ms)	Average Packet Delivery Fraction (%)	Average Throughput (in kbps)	Averag Count
AOMDV	3.401 655	0.898 9	223.0 4	0.828 473
NDMP-AOMDV	3.094 637	0.913 7	422.3 9	0.5845

F. Comparison-

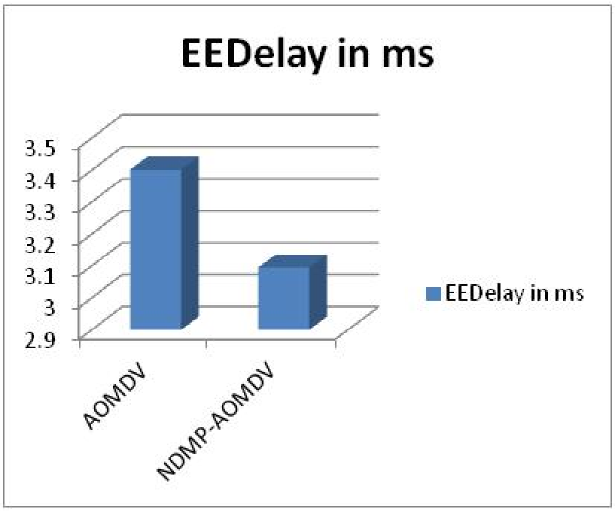

Figure 5. End to End Delay Comparison

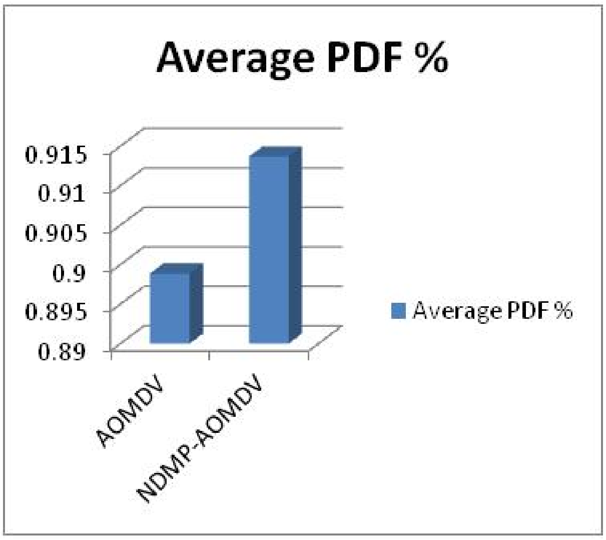

Figure 6. Packet Delivery Fraction Comparison

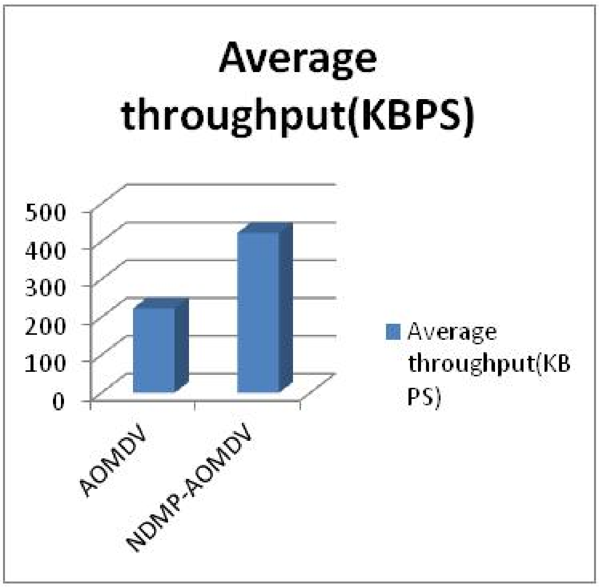

Figure 7.Throughput Comparison

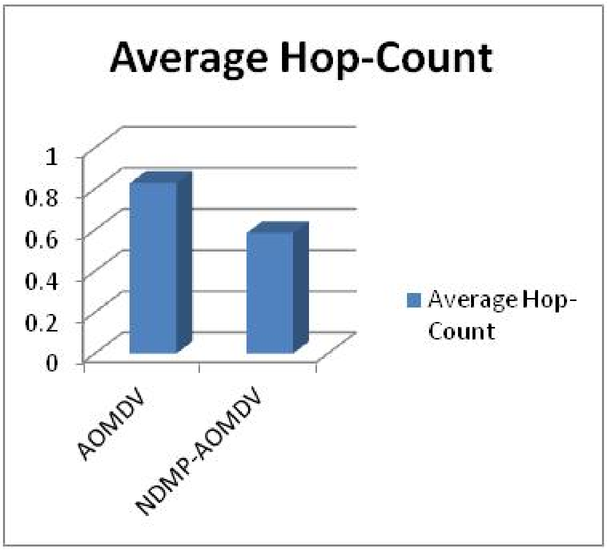

Figure 8.Hop-Count Comparison

V CONCLUSION AND FUTURE WORK

In this paper, we propose a NDMP routing method based on AOMDV protocol. The proposed route discovery method identifies all the available node-disjoint routes using a single flooding of a RREQ message. This greatly reduces the routing overhead caused by route discovery and maintenance processes thus increasing the network capacity.

Our method is suitable for low and moderate mobility networks as shown by the results in simulation section. Also, three different route maintenance methods are proposed and implemented to show the performance of our route discovery method. To reduce the initial delay, source node can send data as soon as it gets the primary route. Due to multiple routes stored in routing table backup routes are always available for continuous data transmission when the primary route is broken. We presented the work using threshold based congestion control cocept. Simulation results shows that NDMP-AOMDV is able to provide low end-to-end delay and high packet delivery ratio, low hop-count while keeping high throughput.

In future we will implement the same concept for multicast routing protocols. Also, comparison with existing node-disjoint multipath routing protocols is left as a future work in this paper.

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