Journal of Applied Sciences Research 2(6): 336-340

Enhanced Routing Protocol for Video Transmission over Mobile Adhoc Network

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Abstract: The main objective of this paper is to design and implement an enhanced On-Demand Routing protocol for transmitting video over mobile adhoc network. Enabling video transmission over ad-hoc networks is more exigent, as the links are highly error-prone and go down frequently. The challenge in video transmission over ad-hoc networks is due to the nomadic nature of the host and identifying a dynamic routing protocol that efficiently finds stable route between mobile nodes. In this paper, an enhanced adhoc on demand distance vector routing protocol (EAODV) has been suggested, which determines more stable routes by including the signal power received from all other neighboring nodes as an association stability factor along with the conventional route identifying parameters. The proposed routing protocol is implemented using network simulator and its performance analysis has been carried out which shows better performance for various mobility models.

Keywords: Mobile Ad hoc Network, AODV, E-AODV, Mobility Model, NS-2

INTRODUCTION

Mobile Ad hoc Network (MANET) is an autonomous system of mobile hosts, which are free to move around randomly and organize themselves arbitrarily thus, making the network's wireless topology change rapidly and unpredictably. Ad-hoc networking[1] allows mobile devices to establish connection and communication independent of a central infrastructure. The random movement of the devices and the absence of central infrastructure give rise to various problems such as the design of communication and networking protocols for routing and security. Hence all the nodes of these networks behave as hosts as well as routers, forwarding packets to other mobile nodes in the network taking part in discovery and maintenance of routes to other nodes in the network. Consequently, in addition to incorporating the properties of wireless communications, novel approaches are needed to address the adhoc networking environment. Wireless mobile users are able to communicate through these adhoc networks where there is no communication infrastructure or it is not expedient to use. Adhoc networks have frequently changing network topology, no fixed routers and bandwidth constraints that necessitate for efficient adaptive routing protocols. Due to the limited transmission range of wireless network interfaces, multiple network hops may be needed for one node to exchange data with another node across the network through the router nodes that lies between the source and the destination.

Video transmission over adhoc networks is more challenging than the transmission over other conventional networks due to the changes in the topology, that results in a relatively short lifetime of the network paths, high transmission bit error rates during fading periods. Thus paths may become frequently invalid during connections, which may cause severe degradation in the video quality. In adhoc scenario, following a path failure switching over to an alternate route, may take an unacceptably long period of time, causing a temporary disruption of a video session. The network topology is not stable as new nodes may unexpectedly join the network or leave and hence the adhoc routing algorithms must minimize the time required in converging after these situations. To overcome the limitations in link-level reliability and the time-varying nature of the network topology, it is proposed to establish a stable path between the source and destination in a single virtual connection, enhancing the system robustness while increasing the usable bandwidth for an end-to-end connection. Several routing algorithms [2-6] have been proposed to facilitate communication in such dynamically changing network topology. Adhoc On Demand Distance Vector is a dynamic, self-starting on demand routing protocol that builds routes via a request query and route reply procedure that enables multi-hop routing between participating mobile nodes and hence establish and maintain an adhoc network. In order to transmit video over these adhoc networks the routes have to be more stable and reliable which can be achieved by enhancing the routing protocol, which is carried out in this proposed model.

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Choosing optimal routing protocol for video transmission-simulation model: The optimal routing protocol for transmitting video over adhoc networks is obtained by simulating the routing protocols with the Network Simulator-2[7,8]. The optimal protocol is identified and chosen by simulating three major routing protocols namely Destination Sequenced Distance Vector (DSDV) that maintains a complete list of routes to the destination, Dynamic Source Routing (DSR) that makes use of source routing and route cache where the sender knows the complete hop-by-hop route to the destination and Adhoc On Demand Distance Vector (AODV) routing protocol. AODV discovers routes on an on demand basis and builds a route table based on the number of required broadcasts with one entry per destination that guarantees loop free routes by sequence numbers indicating the freshness of the route. AODV relies on routing table entries to propagate a Route Reply (RREP) back to the source and subsequently route data packets to the destination. A set of predecessor nodes is maintained for each routing table entry, indicating the set of neighboring nodes which use that entry to route data packets. These nodes are notified with Route Error (RERR) packets when the next-hop link breaks which, in turn, forwards the RERR to its own set of predecessors, thus effectively erasing all routes using the broken link. AODV maintains a timer-based state in each node, regarding utilization of individual routing table entries, which expires if not used recently.

The simulation was carried out for a network of 20 mobile nodes placed randomly within a 500 X 500 meter area. Radio propagation range of 250 meters and channel capacity of 2 Mb/s were chosen for each node. Each node can buffer up to 50 packets waiting for transmission. The performance of a routing protocol is measured by varying the pause time. A random waypoint mobility model is chosen in which each packet starts its journey from a random source to a random destination (uniformly distributed between 0-20 mts). Once the destination is reached, another random destination is targeted after a pause. The chosen pause times are 0,10,30,60,90,150 and 200 and the simulations were carried out for 200 seconds. Video traces were used as input source and identical mobility and traffic scenarios were used for the protocols DSR, DSDV and AODV and the results were gathered. Multiple runs with different seed values were conducted for each scenario and the average is estimated. The simulation parameters that are used are tabulated as in Table 1.

The IEEE 802.11 MAC protocol with Distributed Coordination Function (DCF) is used as the MAC layer and Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) is chosen as the access scheme to transmit data packets to minimize the frequency and deleterious effects of collisions over the wireless medium.

Table 1: Simulation Parameter

Simulation Time	200s
Bandwidth	2 Mbps
Simulation Area	500 m X 500 m
Number of Nodes	20
Speed	Variable
Offered Traffic	4 - 10 packets/sec
Radio Range	250 meters
Application Traffic	Video Trace
Network Protocols	AODV, DSR, DSDV

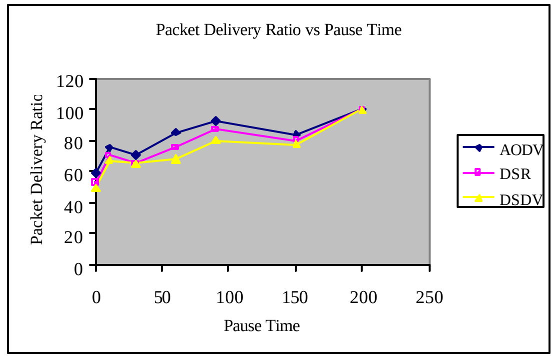

Fig. 1: Packet Delivery Ratio Vs Pause Time

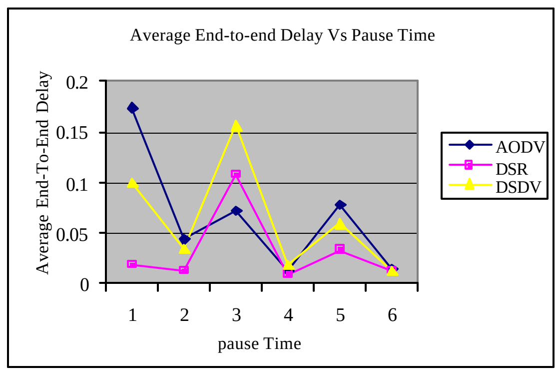

Fig. 2: Average End-to-End Delay Vs Pause Time

The performance metrics[8] that were used to choose the optimal routing protocol were Packet Delivery Ratio and Average end-to-end delay that are shown in Fig. 1 and 2 respectively.

The results show that AODV has better packet delivery ratio and low end-to end delay as compared to DSR and DSDV and it is the optimal routing protocol for transmitting video over MANET.

Estimation of stable route: As video is to be transmitted, the reliability and stability of the route is more important for a distortion less transmission. A more stable route to transmit video over MANET is achieved by enhancing the routing protocol AODV. Including Association Stability (AS) as an additional routing metric along with the existing metrics achieves enhancement in AODV so that a more stable route is identified and the performance is improved. Association Stability is defined as the connection stability of one node with respect to another node. A high degree of association stability indicates a low state of node mobility. Association stability is incorporated as a routing metric, which reduces data loss by avoiding routes that are not stable. Along with the hop count and freshness of the route, signal strength is used to predict the route lifetime and hence a stable route is chosen. The signal strength is calculated by measuring the distance between the two nodes using Frii's equation and is inversely proportional to the square of the distance between the nodes..

$$SignalStrength = 1/d^2 \quad (1)$$

The stability of a route depends on the strength of links in that route which is determined by the strength of the link. The association stability a_s between two nodes n and m, is a prediction of the lifetime of the link $l_{n,m.}$ between the nodes. Association stability a_5 is the time taken by node *n* to move out of range of node *m*. Node *n* samples the strength of signals received from node *m* periodically and the affinity of neighboring nodes is determined by making use of the information available in Association Stability (AS) packets that each node broadcasts at a regular interval. Each node uses the received AS packets to measure the signal strength of all the other nodes that are within its range. A node calculates the association stability of a neighboring node based on its movement either the neighbor is moving away or coming close. The association stability is calculated using the equation

$$a_s = \frac{d_d}{d_v} \quad (2)$$

Where

d_d is the relative distance(ie) the distance remaining before the neighbor is out of transmission range d_v and is the relative velocity (ie) the relative velocity of the neighbor with respect to this node.

$$\alpha_{n,m} = \frac{D_{n2} - D_{th}}{D_v} \quad (3)$$

$$D_v = ?d/?t \quad (4)$$

- If a neighboring node is moving away and the last two AS packets were received with signal strengths SS_1 and SS_2, then association stability of that neighbor at this node is calculated as

$$a_s = \frac{(\sqrt{(s_{s2}/s_{th})}-1)?\,t}{1-\sqrt{(s_{s2}/s_{s1})}} \quad (5)$$

- If a neighboring node is moving towards the node and the last two AS packets were received with signal strengths SS_1 and SS_2, then AS of that neighbor at this node is calculated as:

$$a_s = \frac{(\sqrt{(s_{s2}/s_{th})}+1)?\,t}{1-\sqrt{(s_{s2}/s_{s1})}} \quad (6)$$

Association stability table: A new table called as association stability table has been created, to store the values of power corresponding to a particular node. The table consists of three fields namely IP address of the node, Signal Power of the last received AS packet and the sending time of the last received AS packet. This table is maintained by periodically sending for every one second an Association Stability packet that is a modified route reply packet. In order to implement this, a timer has been introduced which periodically sends Association Stability packets. These packets contain the receiving power, which is used to calculate the stability of the route and the association stability is then inserted into the association stability table.

Route discovery: Whenever a node needs to find a route to another node it broadcasts a Route Request (RREQ) message to all its neighbors. The RREQ message is flooded through the network until it reaches the destination or to a node with a fresh route to the destination. On its way through the network, the RREQ message initiates creation of temporary route table entries for the reverse route in the nodes it passes. If the destination, or a route to the destination is found, the route is made available by unicasting a Route Reply (RREP) message back to the source along the temporary reverse path of the received RREQ message. On its way back to the source, the RREP message initiates creation of routing table entries for the destination in the intermediate nodes that expire after a certain time-out period.

Route maintenance: To identify the maintenance of the route to the node Hello messages are advertised checking for the continued presence of the node. The route is marked as a valid route as long as the neighbors are using the routes through the broadcasting node. If a node along the route moves, it notifies that move to its upstream neighbors and propagates a link failure notification to each of its active upstream neighbors by Route Error (RERR) message to inform them of the erasure of that part of the route until the source node is reached. The source node may then continue to reinitiate the route discovery for that destination if a route is still desired. If a source node moves, it is able to reinitiate the route discovery protocol to find a new route to the destination.

Association stability algorithm: Whenever a source initiates the route discovery process, the Association Stability is set to maximum in the RREQ.

If (node is intermediate)
{
if (a_5 < a_{RReq})
insert the cached value into RREQ
insert the AS into AS table
}
else (node is source)
{
if (a_5 < a_{RReq})
use route in new RREQ
else
use route in RREQ cache
}

Performance analysis: The performance analysis of EAODV is carried out for the simulation parameters chosen in table1. The performance metrics Packet Delivery Ratio, end-to-end delay and routing overhead suggested by the MANET working group for routing protocol evaluation[9,10] were used. The performance results of both AODV and EAODV with respect to pause time, speed and number of nodes were obtained using NS-2 simulator are shown in Fig. 3-5. The EAODV algorithm has high packet delivery ratio when the speed and the pause time are lower. EAODV has slightly higher control overhead compared to AODV because of the periodic transfer and updation of Association Stability packets. This is due to the fact that the algorithm for routing the packets uses only stable routes.

The average end-to-end delay of both the protocols is shown in Figure3. In EAODV the end-to-end delay is little less than AODV. By sending a search reply packet, the end-to-end delay can be decreased as the reply packet determines the route through which the data packets should be transferred. When the number of nodes in the network increases EAODV algorithm performs better, when compared to AODV.

The packet delivery ratio of the two algorithms for 20 nodes is shown in Figure 4. As the Pause Time increases both EAODV and AODV algorithm performs well whereas, the AODV algorithm shows a slight degradation in the packet delivery ratio at lower pause time because of heavy traffic. As the number of packets delivered by EAODV is higher at lower pause time EAODV is better than AODV.

The routing overhead of EAODV algorithm for 20 nodes with mobile speed of 10m/s is shown in Fig.5. The graph indicates that EAODV produces more overheads as compared with AODV. As the number of Source-

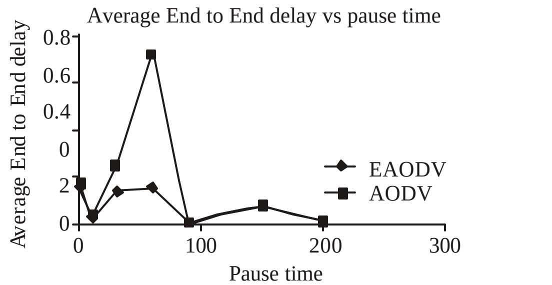

Fig. 3: End-to End delay vs pause time

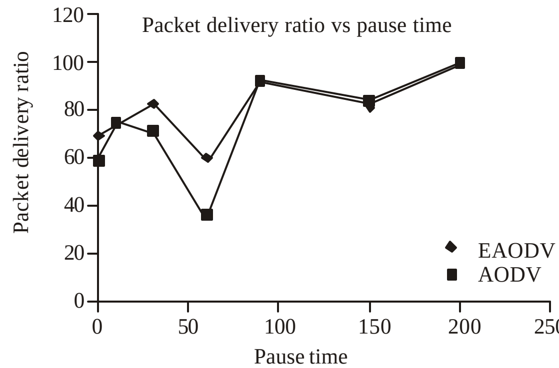

Fig. 4: Packet Delivery Ratio Vs Pause Time

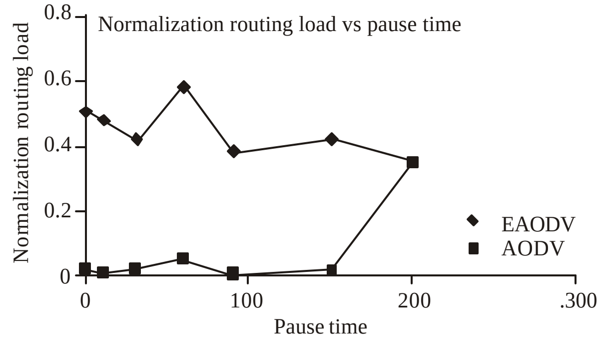

Fig. 5: Routing Load vs Pause time

Destination pair increases there is slight increase in control overhead at lower values of pause time because of the RREQ and RREP packet for every S-D pair. This increase is due to the identification of a more stable path using the stability metric. The control overhead for AODV and EAODV are comparable as the pause time increases. The route validity for the routing protocols (EAODV, AODV) for different values of pause time with maximum speed of node as 10 m/s is calculated. ***Route valid time*** is the time for which a determined route is valid before a link break occurs due to the mobility of the node.

The route valid time for EAODV is better than that of other routing protocols. This is due to the fact that the other routing protocol determines the shortest path to the destination to compute the route whereas EAODV determines the most stable path to the destination based on the association stability values along with the other routing metrics. Hence the occurrence of a link failure is less in the EAODV routing protocol, which implies that the route validity time or stability of the protocol is longer.

Conclusion: The optimum protocol for the transfer of video over Mobile Adhoc Network is identified to be AODV. The performance of DSDV is found to be lesser and the performance of DSR is efficient for smaller networks and its performance degrades for larger networks. Hence an enhancement has been suggested to AODV routing protocol, by adding Association Stability as metric in identifying a stable route. The Enhanced Routing algorithmbased on stability of the route is found to perform well with increase in the number of video packets delivered which improves the quality of video. The packet delivery ratio is found to increase by 20% when compared to AODV at lower pause time and almost equals performance by 98% at low mobility with a lesser end-to-end delay. As every node processes all the packets it hears whether it is destined to it or not and extracts the last address field to update the route table, the routes are maintained efficiently and the video data is delivered more effectively.

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