

Reducing Control Packets through Modified AODV with TCP Tahoe in MANET



Engineering

KEYWORDS : AODV, RouteRequest, Routing Overhead and Probabilistic Scheme based AODV with TCP Tahoe.

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ABSTRACT

The aim of this paper is to reduce the routing overhead by combining both network layer and transport layer operating in Mobile Ad hoc Network (MANET). A MANET is an autonomous system of mobile routers connected by wireless links. The routers are free to move and organize themselves arbitrarily and therefore wireless network topology may change rapidly and unpredictably. The traditional Ad hoc On-demand Distance Vector (AODV) routing protocol floods the RouteRequest packet in the network when a route is not available for the desired destination. The goal of the proposed Probabilistic Scheme is based on AODV (PSAODV). This modified protocol broadcasts the RouteRequest packet by setting the rebroadcast probability based on the number of neighbors around each node and the proper TCP variant is used to deliver the packets from end to end over MANET. TCP Tahoe variant is better at congestion avoidance and therefore use network resources efficiently. The simulation studies were carried out with different parameters, such as number of nodes, node mobility speed and various source types were compared with other existing routing protocol in terms of packet delivery ratio, end-to-end delay and routing overhead. The simulation results show that the modified protocol performs better than the existing AODV.

1. Introduction

A Mobile Ad hoc Network (MANET) is a wireless multi hop network, in which each node acts as a wireless router that has the capability to forward packets. In MANETs the nodes can be dynamically connected by radio waves. The data transmissions between the nodes are without the help of infrastructure, central controller, access point and base station. Many researches were carried out on evaluation performances of the MANETs as the performance analysis of the different routing protocols and the effect of the random mobility models on ad hoc networks. [1, 2]

Through review of literature it is found that there is a research gap in routing a packet through minimum routing overhead and use of the proper TCP variant can achieve the higher packet delivery ratio and end to end delay can be reduced. The on demand routing protocol namely AODV and different TCP variants are considered for performance enhancement. This paper aims to increase the packet delivery ratio by considering the cross layer design approach and the layers considered are Network and transport layer.

In MANET broadcasting is an essential operation for discovering neighbors. The routing protocol such as AODV is uses broadcast for route discovery. The routing protocols for MANETs are divided into three types, namely Proactive (Table Driven), Reactive (On-Demand) and Hybrid Protocols. This paper proposes finding path with minimum routing overhead and delivering packets with the appropriate TCP variant in Mobile ad-hoc networks. For the simulation of the proposed scheme, number of nodes, node's speed, traffic type, MAC Protocol, routing protocol, source type and mobility model are considered as simulation parameters. [3, 4]

The proposed scheme selects a routing path and delivers the packets based on the three main functionalities.

(i) Broadcasting the RouteRequest packet using probabilistic scheme for the route discovery. (ii) Whenever the path failure occurs, the path is re-established using probabilistic broadcasting. (iii) To avoid the congestion during data transmission, proper TCP variant can be identified. The rest of the paper is organized as follows. Section (2) presents previous research based on different routing techniques, proposed routing and delivery mechanisms in Section (3). Simulation analysis is provided in Section (4). Results are presented in Section (5) and the conclusion of the paper is provided in section (6). [12, 13]

2. Previous Research

The AODV routing protocol is a reactive routing protocol; therefore, routes are determined only when needed. Hello messages may be used to detect and monitor links to neighbors. If Hello

messages are used, each active node periodically broadcasts a Hello message that all its neighbors receive. Because nodes periodically send Hello messages, if a node fails to receive several Hello messages from a neighbor, a link break is detected. When a source has data to transmit to an unknown destination, it broadcasts a Route Request (RREQ) for that destination. If the receiving node is the destination or has a current route to the destination, it generates a Route Reply (RREP). The RREP is unicast in a hop-by-hop fashion to the source. Control messages are route request, route reply and Hello message [5].

AODV allows mobile nodes to obtain routes quickly for new destinations, and does not require nodes to maintain routes to destinations that are not in active communication. AODV discovers routes as and when necessary, does not maintain routes from every node to every other nodes. Routes are maintained just as long as necessary. Whenever routes are not used then the routes get expired and discarded. AODV allows mobile nodes to respond to link breakages and changes in network topology in a timely manner. There are three types of messages namely Route Requests (RREQs), Route Replies (RREPs) and Route Errors (REERs). The RREQ ID field is incremented by one from the last RREQ ID used by the current node. Figure 1 shows a possible path for a route replies from node A to node J. Each node maintains only one RREQ ID. The Hop Count field is set to zero. The different types of On Demand driven protocols are Ad hoc On Demand Distance Vector (AODV), Dynamic Source routing protocol (DSR), Temporally ordered routing algorithm (TORA), Associativity based routing (ABR), Signal Stability-Based Adaptive Routing (SSA) and Location-Aided Routing Protocol (LAR) [6, 14].

The fundamental Characteristics of AODV are unicast, broadcast, and multicast communication, on-demand route establishment with small delay, multicast trees connecting group members maintained for lifetime of multicast group, link breakages in active routes efficiently repaired, all routes are loop-free through use of sequence numbers, use of Sequence numbers to track accuracy of information, only keeps track of next hop for a route instead of the entire route and use of periodic HELLO messages to track neighbors

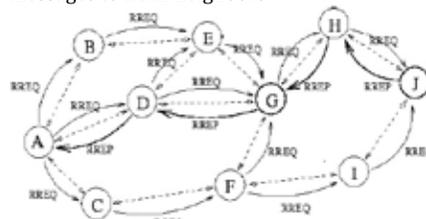


Figure 1. Broadcast of RREQ packets and unicast of RREP packets

A Route Request carries the *source identifier* (SrcID), the *destination identifier* (DestID), the *source sequence number* (SrcSeqNum), the *destination sequence number* (DestSeqNum), the *broadcast identifier* (BcastID), and the *Time To Live* (TTL) field. DestSeqNum indicates the freshness of the route that is accepted by the source. When an intermediate node receives a Route Request, it either forwards it or prepares a Route Reply if it has a valid route to the destination. The validity of a route at the intermediate node is determined by comparing the sequence number at the intermediate node with the destination sequence number in the Route Request packet. If a Route Request is received multiple times, which is indicated by the BcastID-SrcID pair, the duplicate copies are discarded. All intermediate nodes having valid routes to the destination, or the destination node itself, are allowed to send Route Reply packets to the source. Every intermediate node, while forwarding a Route Request, enters the previous node address and its BcastID. A timer is used to delete this entry in case a Route Reply is not received before the timer expires. [9]

Routes are discovered through a route discovery cycle, whereby the network nodes are queried in search of a route to the destination node. When a node with a route to the destination is discovered, that route is reported back to the source node that requested the route. Multi-path routing Routes discovered by AODV are maintained in a routing table. For each destination contained in the routing table, AODV stores the next hop needed to reach the destination, along with the number of hops to the destination. To increase robustness to link breaks, however, it is possible to store multiple next hops per destination. [5, 6] One disadvantage of this protocol is that intermediate nodes can lead to inconsistent routes if the source sequence number is very old and the intermediate nodes have a higher but not the latest destination sequence number, thereby having stale entries. Also, multiple RREP packets in response to a single RREQ packet can lead to heavy control overhead. Another disadvantage of AODV is unnecessary bandwidth consumption due to periodic beaconing. [7, 8]

To retransmit a lost segment, TCP employs a retransmission timer that handles the retransmission time-out (RTO), the waiting time for an acknowledgment of a segment. When TCP sends a segment, it creates a retransmission timer for a particular segment. Two situations may occur:

- If an acknowledgment is received for this particular segment before the timer goes off, the timer is destroyed
- If the timer goes off before the acknowledgment arrives, the segment is retransmitted and the timer is reset

A brief survey on the challenges TCP has encountered in MANETs and recent efforts to improve its performance. Due to some inherent characteristics of MANETs including time-varying wireless channel, medium collision, and mobility, traditional TCP which performs well in fixed wired networks. [10,11]

3. Probabilistic Scheme based AODV (PSAODV) with TCP TAHOE

The Probabilistic Scheme is based on AODV (PSAODV) to rebroadcast the RouteRequest packets to find a path to the desired destination with reduced routing overhead and to control congestion effectively during data transmission from end to end for finding proper TCP variant from different types of variants. Steps followed in the proposed PSAODV with TCP Tahoe are firstly, the neighbors for each rely node has to be identified and then calculate the average number of neighbors. Secondly, by comparing average number of nodes with each node, then assign a suitable re-broadcast probability to each node for reducing the routing overhead. Then, path establishment and path maintenance have to be followed. Thirdly, the Queuing discipline has to be set. Then, to control congestion effectively during data transmission from source to destination for finding the proper TCP variant from different types of variants to increase packet delivery ratio. Finally, transmit the data using modified AODV with appropriate TCP variant.

3.1 Finding the Neighbors for Each rely Node

A broadcast packet may not be blindly forwarded, but broad-

casting is useful to enable dissemination of AODV messages throughout the ad hoc network. This information will be exits in the routing protocol itself. AODV is a routing protocol, and it deals with route table management. Route table information must be kept even for short-lived routes, such as are created to temporarily store reverse paths towards nodes originating RREQs.

AODV uses the following fields with each route table entry: Destination IP Address, Destination Sequence Number. Valid Destination Sequence Number flag, other state and routing flags (e.g., valid, invalid, repairable, being repaired), Network Interface, Hop Count (number of hops needed to reach destination), Next Hop, List of Precursors and Lifetime (expiration or deletion time of the route). Managing the sequence number is crucial to avoiding routing loops, even when links break and a node is no longer reachable to supply its own information about its sequence number. A destination becomes unreachable when a link breaks or is deactivated. When these conditions occur, the route is invalidated by operations involving the sequence number and marking the route table entry state as invalid.

3.2 Calculate the Average Number of Neighbors

Average number of neighbours for all the nodes in the network can be calculated as in equation (1) :

$$n_{avg} = \frac{\sum_{i=1}^n N_i}{n} \quad (1)$$

where,

n_{avg} is mean average number of neighbours
 N_i is the number of neighbours around each node
 n is the total number of nodes

3.3 Fixing the Various Regions and assigning Suitable probability

The various regions are identified by comparing average number of nodes with each node and assign a suitable probability to each region to reduce the rebroadcasting of RouteRequest packets and hence the routing overhead can be reduced.

The following are the steps in the Probabilistic Scheme algorithm.

1. Upon receiving an RREQ packet at node x
2. Get the number of neighbors n_i at node x
3. Get the average value N_{avg}
4. Calculate the values below average, which is N_{min}
5. Calculate values greater than the average and it is N_{max}
6. If $n_i \leq N_{min}$
Node x is situated in a sparse region
(i.e. Group -1)
Set rebroadcast probability to very high $p=p1$
7. If $N_{min} < n_i \leq N_{avg}$
Node x is situated in a medium sparse region
(i.e. Group -2)
Set rebroadcast probability to high $p=p2$
8. If $n_i = N_{avg}$
Node x is situated in a medium region
(i.e. Group -3)
Set rebroadcast probability to medium $p=p3$
9. If $N_{avg} < n_i \leq N_{max}$
Node x is situated in a medium dense region
(i.e. Group -4)
Set rebroadcast probability to low $p=p4$
10. If $n_i > N_{max}$
Node x is situated in a dense region
(i.e. Group -5)
Set rebroadcast probability to very low $p=p5$
11. Generate a random number (Rnd) over the range [0,1]
12. If $Rnd \leq p$ Broadcast the packet
13. Else Drop the packet.

If the node 'x' is situated in a sparse region, then set rebroadcast probability to very high $p=p1$ and if the node 'x' is situated in a

dense region then set rebroadcast probability to very low $p=p_5$. Since the node is fixed in dense region, the rebroadcast probability is low and therefore it is only minimum number of times RouteRequest packets will be rebroadcasted and hence routing overhead can be reduced. The TCP Tahoe has been preferred to TCP Vegas to deliver the packets effectively with congestion control using slow start and other congestion control mechanisms.

3.4 Path Establishment and Maintenance

Whenever the path failure occurs, the RouteError message will be received. Then, path must be reestablished to deliver the rest of the packets in the reestablished path. Every route table entry at every node must include the latest information available about the sequence number for the IP address of the destination node for which the route table entry is maintained. This sequence number is called the "destination sequence number". The Route Error format is shown in Figure 2.

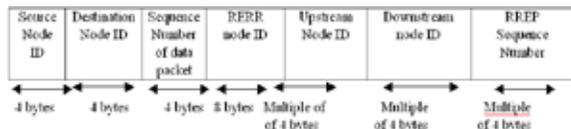


Figure 2. Route Error format

3.5 Setting the Queuing Disciplines

There are various queue management mechanisms exist in router, such as Drop Tail, RED and CBQ and many more. In this simulation, queue management mechanism is used as Drop Tail.

3.6 Find the Proper TCP Variants to increase Packet Delivery Ratio

The simulation runs initially with TCP Tahoe for various node densities with different routing Protocols (PSAODV and AODV) then with TCP Vegas. The result shows that the former is better than the latter in terms of packet delivery ratio.

3.7 Data Transmission using PSAODV with appropriate TCP Variant

Each simulation is tested through different routing protocols with TCP Tahoe and TCP Vegas. As a result of each run, the performance measurements are carried out, such as packet delivery ratio, end - to-end delay and routing overhead.

4. SIMULATIONS

Simulations are performed using NS-2.34 for a 1000m x 1000m grid consisting of 25 nodes, distributed randomly over the two-dimensional grid. The source destination pairs are randomly chosen from the set of 25 nodes in the network. We consider three different speeds of 2 m/s, 4 m/s and 8 m/s in our simulations. In Random Waypoint Mobility Model, the Mobile Nodes travels at a constant speed throughout the entire simulation. The simulation parameter values are given in Table 1.

Table 1. Simulation Parameters

PARAMETER	VALUE
Transmission range	250 m
Bandwidth	2 Mbps
Simulation Time	300 s
Packet size	512 Bytes
Packet Rate	5 Packet / s
Topology size	1000 m X 1000 m
Number of nodes	5,10,15,25 nodes
Node's speed	2m/s,4m/s,8m/s
Traffic type	CBR
MAC Protocol	IEEE 802.11
Routing protocol	AODV
Source Type	TCP Tahoe, TCP Vegas
Mobility model	Random Waypoint

In this simulation, the layered structure of MANET uses multimedia packets in Application layer, TCP Tahoe and TCP Vegas as the Transport Layer Protocol, PSAODV as the network layer protocol and IEEE 802.11 is used in MAC layer. The simulation snapshot for the Packet transmission between nodes is shown in the Figure 3.

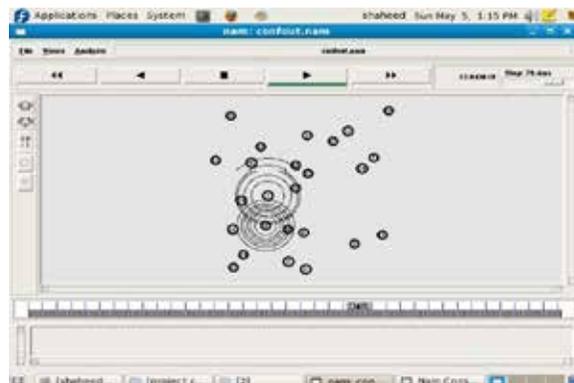


Figure 3. Simulation Snapshot

4.1 Performance Metrics

The metrics which are used in this paper are given below:

Packet Delivery Ratio (PDR):

The ratio between the number of packets originated by source and the number of packets received by the destination.

$$Packet\ Delivery\ Ratio = \frac{NumberOfReceivedDataPackets}{NumberOfSentDataPackets}$$

End-to-End delay:

The average time between sending the packets at the source and receiving the packet at destination.

$$End-to-end\ delay = \frac{(TimePacketArrive@Dest - TimePacketSent@Source)}{TotalNumberOfConnectionPairs}$$

Routing Overhead:

In wireless ad hoc networks, nodes often change their location within network. So, some stale routes are generated in the routing table which leads to unnecessary routing overhead. The routing overhead is the total number of Control packets transmitted during the simulation time.

$$Routing\ Overhead = \frac{TotalBytesOfControlMessagesTransmittedByAODV}{TotalBytesTransmitted}$$

5. RESULTS

5.1. Analysis of Packet Delivery Ratio (PDR)

Figure 4 shows the packet delivery ratio against the number of nodes. In this simulation, the node speed is from 2 m/s,4 m/s and the maximum mobility speed of 8 m/s. Because of the AODV does not consider the number of times rebroadcasting the RouteRequest packet and hence it generate more control packets, thus packet drop rate is high It is observe that the packet delivery ratio of all routing protocols decreases as the number of node increases. As a result, PSAODV has highest packet delivery ratio than AODV.

5.2. Analysis of Average End-to-End Delay

Figure 5 shows that the End-to-End delay versus number of nodes. If the number of nodes increases, the end-to-end delay also increases. This is due to different reasons like mobility speed, number of packets travels in the route and path break. In Figure 5, the simulation results states that PSAODV has minimum end-to-end delay than AODV.

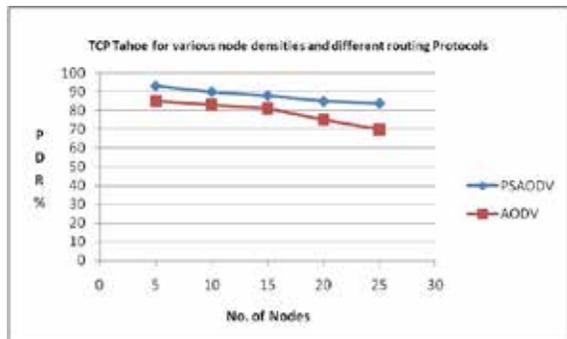


Figure 4. TCP Tahoe for various node densities and different routing Protocols

The result proves that TCP Tahoe performs better than TCP Vegas for this scenario.

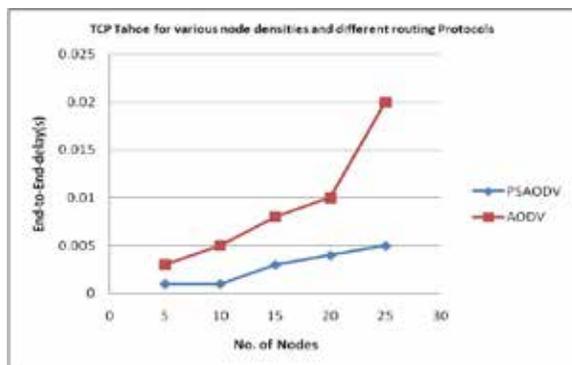


Figure 5. TCP Tahoe for various node densities and different routing Protocols to measure end-to-end delay

5.3. Analysis of Routing Overhead

Figure 6 shows the routing overhead of the PSAODV with AODV. The routing overhead of PSAODV shows the curve decreased significantly compared with AODV. This is due to AODV broadcasts the RouteRequest packets in simple flooding, whereas PSAODV rebroadcast the RouteRequest packets based on probability.

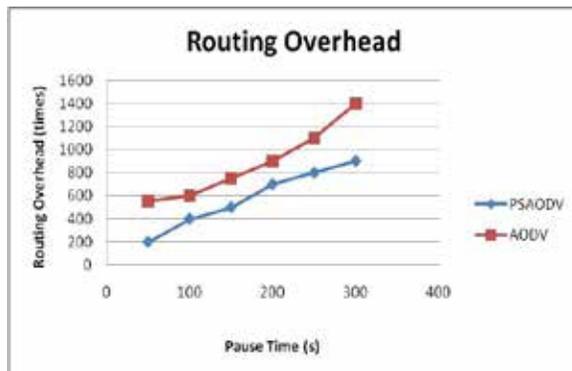


Figure 6. Routing Overhead

6. CONCLUSION

Thus, the results explicate that the interaction between transport layer with the network layer protocol has a significant impact on the achievable packet delivery ratio, end-to-end delay and routing overhead in ad hoc networks. Results further show that in all instances, the quality of service parameters gives 10- 15% improvement in packet delivery ratio with appropriate TCP variant and 40-45% improvement in end-to-end delay and reduced drastically to 40-50% of routing overhead. It is observed that the PSAODV routing algorithm with TCP Tahoe achieves high performance in packet delivery ratio, end-to-end delay and routing overhead.

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