A Hybrid Routing Method for Mobile ad-hoc Networks

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Abstract

Mobile-Ad-Hoc-Networks (MANETs) are self-configuring networks of mobile nodes, which communicate through wireless links. The infrastructure of a Mobile Ad hoc Network (MANET) has no routers for routing, and all nodes must share the same routing protocol to assist each other when transmitting messages. The main issues in MANETs include the mobility of the network nodes, the scarcity of computational, bandwidth and energy resources. The routing is particularly a challenging task in MANETs that selecting paths in a network along which to send network traffic. Thus, Mobile Ad hoc Network (MANET) routing protocols should explicitly consider network changes and node changes in their operations. In this paper we present a novel routing algorithm for mobile ad hoc networks. It employs both reactive and proactive schemes in its design. Simulation results show that our protocol can outperform AODV, AOMDV and DSDV protocols in terms of, packet delivery ratio, packet loss and throughput.

Keywords: MANETs, Routing, Multi Agent, Multi Objective

1. Introduction

An ad-hoc network is a collection of mobile nodes that communicate with each other without any centralized control and infrastructure [1]. If the sender and receiver (transceivers) are not in communication range with each other, then the packet can be sent to the destination node using intermediate nodes .

The routing is particularly a challenging task in MANETs. Indeed, because of the frequent changes in the network topology triggered by nodes displacements, establishment of new nodes connections and nodes disconnections, the routes discovery process is unstable.

Practically speaking, efficient routes may quickly become inefficient or even unusable ones. To tackle this problem by ensuring a suitable routing through reliable algorithms, one important way is to update routing information more regularly than in wired networks. However, this requires - more routing control packets, which is specifically an issue in MANETs, since the bandwidth of the wireless medium is very limited and the medium is shared.[۲]

Our proposed protocol attempts to solve the problems of packet delivery ratio, throughput and packet loss. For this purpose, we propose a hybrid multi agent method

that entails both proactive and reactive steps. The routes are established and periodically maintained with a constant number of mobile agents. The main idea of our protocol is to build a multi agent based system where each node provides several kinds of agents.

The rest of the paper is organized as follows. In Section. 2, we introduce related work about routing in ad-hoc networks. In Section. 3, review of some routing protocols in MANETs is given. In Section. 4, we present our protocol. In Section. 5, describes the simulation setup and considered performance metrics. In Section 6 gives the simulation results and. finally section 7 brings concluding remarks.

2. Previous Works

Several types of routing protocols have been specifically designed for ad-hoc networks and have been classified into two main categories: reactive and proactive protocols. In reactive routing protocols such as AODV [2] (Ad-Hoc On demand Distance Vector) and DSR [3] (Dynamic Source Routing), the routes are only discovered when required in order to save node and network resources, while in proactive routing protocols such as OLSR [4] (Optimized Link State Routing Protocol) and DSDV [5] (Destination-Sequenced Distance-Vector) the routes are established in advance, avoiding consequently the delays that occur during the discovery of new routes.

The problem raised by proactive protocols consists in the routing overhead, especially when there are frequent topology changes. This is highly inefficient when updating routes that rarely carry traffic. A reactive protocol is, in contrast, much more appropriate for such situations, since it generates lower overhead in terms of used bandwidth.

There is another kind of protocol that combines both reactive and proactive approaches called hybrid routing protocols. In this paper, we focus on a particular class of hybrid routing protocols based on a multi agent and multi objective technique.

3. Routing Protocols in Mobile Ad-hoc Networks

Routing in the suggested algorithm is based on routing established upon demand. Each node has a routing table in which the node keeps its own routing information. The routing table contains fields such as destination node address, next node address, sequence number, distance, minimum requested bandwidth, maximum permitted delay, stream type, and route validity period. The destination node address field specifies the address of the destination node. The next node address identifies the next node on the route for sending packages to the destination. The sequence number field is used to avoid routing loops formations and repeated transmissions. As a routing message reaches a node, if the sequence number of the received message for a specific destination node is greater than the sequence number for that specific node in the routing table, the message will be processed. This simple act will prevent from repeatedly sending the routing packages, and avoids creation of routing loops in routing packages transmission. The distance field specifies the route length. The minimum requested bandwidth specifies the minimum amount of bandwidth required by the stream. This field is required only in cases of service quality streams (flows which require the service quality) and will be processed only when the stream type is of quality service. The maximum permitted delay field determines the maximum tolerable

delay for the service quality streams. This field is also used only when service quality streams are being sent. The stream type is determined by the stream type field. This field can have the service quality level or the best effort. This field specifies the type of requested service. The validity period field determines the period in which a route is valid. After passing this period, the route will not be valid anymore. If this field receives a package for a destination before end of the validity period, it will be re-initialized [6],[7],[8]. Routing protocols in mobile ad-hoc networks can be divided into two categories, table-based or proactive protocols and need-based protocols table-based or proactive protocols are used for periodic updating of the links. The routes information is kept in a table and is used whenever needed. However, need-based protocols do not require keeping route data, and whenever a route is needed, they start to explore a route based on source location.

3.1 Table Driven Routing Protocols (Proactive Model)

In this category of protocols, each node keeps one or more tables containing routing information to the other nodes of the network, all nodes update their tables to maintain consistency and to have an up-to-date view about the network. As the network topology changes, the nodes broadcast updating messages throughout the network. This category of protocols is distinctive by the manner of distribution of information about topology changes throughout the network, and by the number of tables that are required for routing. WRP, DSDV, FSR, HSR, GSR, ZHLS & CGSR are some examples of table-based protocols.

3.2 On Demand Routing Protocols (Reactive)

In comparison with table-based routing protocols, in this category of protocols, not all updated routes are stored on each node; instead, the routes will be constructed whenever they are needed. When a source node wants to send one message to a destination, it will request the route discovery mechanisms to find a route to the destination (RREQ). The route remains valid until the destination is available or if is not for long-term needs. Once a route to the destination is found, the RREP mechanism sends, in reverse, the route to the source node. CBRP, AODV, DSR, TORA & ABR are some examples of need-based protocols [8].

4. Our Proposed Protocol

Our protocol is based on a mixed method, which has two phases:

In the first phase, every node (starting node) produces a corresponding agent that moves from one node to the other across the network, and creates routes from current node to the starting node and from current node to the ending node. When a connection is begun between a starting node (s) and a destination node (d), s checks to find whether there is a timely routing about d or not. If the answer is negative, the s node issues a local route request. In the protocol we offer, route request does not distribute to all of the nodes. However, it is just reserved (saved) in the s node, and the duty for distributing the request is assigned to the active agents, which have the responsibility of distributing the route request "intelligently" across the network.

4.1 Proactive Phase

Our protocol is a routing protocol for mobile ad-hoc networks, which are based on active, mobile agents. To establish routes between nodes, our protocol utilizes active agents being produced by each network node alternately. Every active agent belongs to a single, unique node, which is called starting node. Also, every active agent moves from one node to another across the whole network. When the active agent arrives to a node, it creates and records a route between the starting node and the current node in its own memory and in the node routing table. Then, the active node randomly begins to choose between its neighbors. To prevent rings from detection (Tracing), we designate the specific identifier < node_ID, Agent_ID> to the agent. This is added to every new active agent during its production. If a node receives a same agents several times, it accepts the information represented in the first time and ignores the subsequent ones. In order to control the Agent, we consider a lifetime or TTL for it; this means that an active agent has two phases in its life cycle**;**

Going Phase: when an agent creates a rout between its starting node and current node
Coming Phase: when an agent moves in reverse direction of the first phase **.**

In coming phase, in each tested node, active agents create and store a route from current node to the last tested node during their initial phases (when TTL=0). This is the first step in the process of routing discovery which is of proactive type.

4.2 Proactive Phase

During the proactive phase, numerous routes are created. Yet, when an *s* node intends to send or transfer packets to an unknown destination node *d,* it initiates a route request process, which is stored locally. When an active agent arrives to a node which has produced a route request (a node is able to have many route request), shifts to its coming phase, and informs other nodes (and active agents) about this route request. A node, during its going phase, takes the next step randomly. Choosing the next step randomly enables us to increase the number of launched agents towards desired node (*s*). This approach, on one hand, increases the chance of having active agents which are distributed from destination nod *d,* and on the other hand lets us to have a quick access to the nodes that are currently in the route leading to the destination *d.*

5. Simulation Methodology and Performance Metrics

5.1 The Simulation Model

We evaluate our protocol through a series of simulation tests. We compare its performance with AODV [2], DSDV [5] and AOMDV. In what follows, we describe the simulation environment and the test scenarios and then present and discuss the obtained results. We have evaluated our protocol under the NS2 environment. NS is a discrete event Simulator targeted at networking research NS provides substantial support for simulation of TCP, routing and multicast routing protocols over a wired and wireless network. NS-2 is written in C++ and OTCL. C++ for data per event packets and OTCL are used for periodic and triggered event [9]. NS-2 includes a network animator called Nam animator which provides visual view of simulation. NS-2 preprocessing provides traffic and topology generation and post processing provide simple trace analysis. AWK programming is used for trace file analysis [9].

5.2 The Simulation Model

In this simulation, we used a wireless network with MAC 802.11 standards, which is a 1000 * 1000 simulation environment. According to, we employed MAC 802.11 protocols for the network layer, with node transmission range of 250m, link bandwidth of 11 Mbps, and packet size of 1024 bytes and simulation time of 200s. We consider 15 random simulation runs to generate 15 random scenario patterns and the performance of the considered factor is the average of these 15 outputs. In all our experiments we considered five sample points of a particular factor and verified for three different protocols i.e. AODV, AOMDV, DSDV and our protocol. Therefore 200s simulation runs were conducted to analyze each performance factor for these three protocols. Since our experiments is based on network layer characteristics so changes in routing strategy is only observed where as other characteristics like antenna gain, transmit power, ground propagation model and receiver sensitivity as physical layer characteristics, MAC 802.11 as wireless Ethernet for data link layer characteristics, UDP as transport layer characteristics and CBR as application layer characteristics remain fixed. The parameters in our simulation are reported in Table (1).

Table 1. Values of Parameters for Routing Protocols

Simulator	**NS2 2.32**
Protocols	AODV, AOMDV, DSDV, Our Protocols
Simulation duration	200 Second
Simulation area	1000m X 1000m
Number of nodes	30, 40, 50, 60, 70, 80
Transmission range	250 m
Movement model	Chain topology
MAC Layer Protocol	IEEE 802.11
speed	5, 10, 15,20, 25, 30 m/s
Packet rate	4 packets/sec
Traffic type	CBR (UDP)
Data payload	512 bytes/packet

5.3 Performance Metrics

PDR is the ratio of the number of data packets received by the destination node to the number of data packets sent by the source mobile node. It can be evaluated in terms of percentage (%). This parameter is also called as "success rate of the protocols":

$$PDR = (Sent\ Packet\ No\ /\ Receive\ Packet\ No) * 100 \qquad (1)$$

Where PDR is the package delivery rate, Sent Packet No is the number of sent packages, and Receive Packet No denotes the number of received packages. Throughput

it is the amount of data transferred over the period of time expressed in bits per second or bytes per second. The following formula shows how to calculate the throughput:

$$X = C / T \tag{2}$$

Where X is the throughput, C is the number of requests that are accomplished by the system, and T denotes the total time of system observation.

End to End Delay is the time taken for an entire message to completely arrive at the destination from the source. Evaluation of end-to-end delay mostly depends on the following components i.e. propagation time (PT), transmission time (TT), queuing time (QT)

$$EED = PT + TT + QT + PD \tag{3}$$

Packets Loss: this metric measures the number of packets which are not delivered to their destinations; it gives us, on the one hand, quantitative information about the robustness of our protocol and, on the other hand, information about the network congestion.

6. Simulation Methodology and Performance Metrics

In graphs, we presented the results for simulation of performance of the AODV, AOMDV, DSDV and our protocol. Routing protocols by increasing the number of nodes from 30 to 80 and in speeds from 5 until 30 m/s in a dynamic topology and with the terms of packet delivery ratio, end to end delay, throughput and packet loss.

6.1 Throughput

Figure 1 shows the variation of throughput considering respectively the variation of the number of nodes. It shows that AODV has the worst performance in the Throughput criterion but proposed method protocol has the higher throughput.
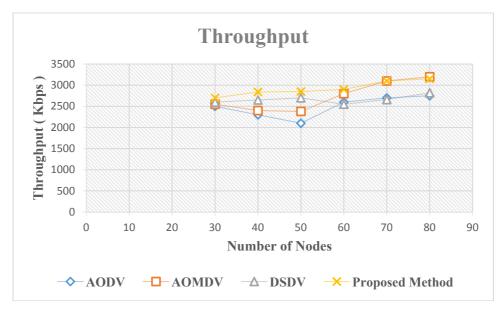
Figure 1. Throughput according to the number of nodes

Figure 2 shows the variation of throughput considering respectively the variation of the speed of nodes. It shows that DSDV protocol has a better throughput in the speed range of 5 to 15 m/s. But in the speed range of 15 to 20 seconds the throughput of this protocol has reduced, and its performance decreases. On the contrary, in the speed range of 20 to 30 m/s, AOMDV shows the better throughput. Also, proposed method has a better throughput in the speed range of 5 to 20 m/s.

Figure 2. Throughput according to the variation of nodes speed

6.2 Packet Delivery Ratio

Figure 3 shows the variation of PDR considering respectively the variation of the number of nodes. It shows that the DSDV protocol has the lower PDR compared to other protocols, while proposed method and AOMDV shows a better PDR in the nodes ranging from 30 to 80.
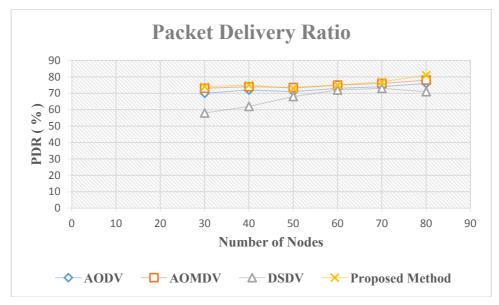
Figure 3. PDR according to the number of nodes

Figure 4 shows the variation of PDR considering respectively the variation of the speed of nodes. It shows that AODV and DSDV protocols PDRs have decreased drastically and they show worse performance compared to other protocols, while proposed method and AOMDV shows better performance in the speed range of 5 to 30 m/s.
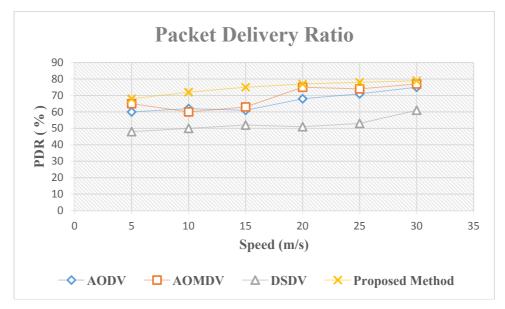

Figure 4. PDR according to the variation of nodes speed

6.3 End to End Delay

Figure 5 shows the variation of E2E delay considering respectively the variation of the number of nodes. It shows that the DSDV and AOMDV protocols have better performance than other protocols in terms of delay. But in the distance of 40 to 80 nodes, the delay of proposed method and AODV protocol has increased. The reason for

the lower delay of DSDV and AOMDV protocols is the limiting of the number of steps, which cause the packets to be sent by the optimized route.
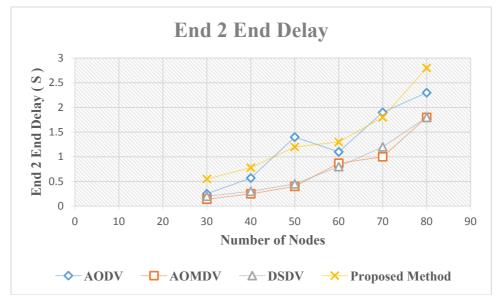

Figure 5. E2E delay according to the number of nodes

Figure 6 shows the variation of E2E delay considering respectively the variation of the speed of nodes. It shows that, between the speeds 5 to 20, the proposed method and DSDV protocol had a lower delay, while the delay of protocols have in speeds (20 to 30) has increased. Also AODV and AOMDV protocols have the higher delay, and its performance decreases.
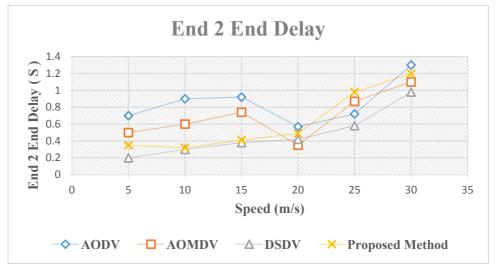

Figure 6. E2E delay according to the number of nodes

6.4 Packet Loss

Figure 5 and figure 6 shows the variation of packet loss considering respectively the variation of the number of nodes and the variation of the speed of nodes. The packet loss metric allows us to evaluate and to compare the robustness and the effectiveness of the four protocols. It is clearly shown in these figures that proposed method and DSDV protocol have less packet loss than AODV and AOMDV protocols. The number of lost

packets increases very quickly in networks of more than 70 nodes and in networks with high traffic.
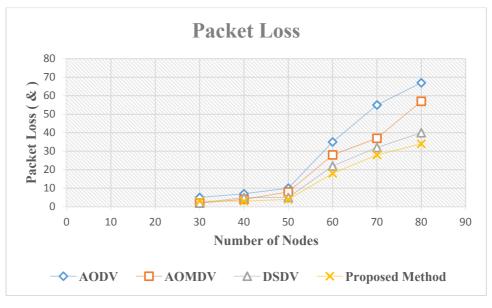

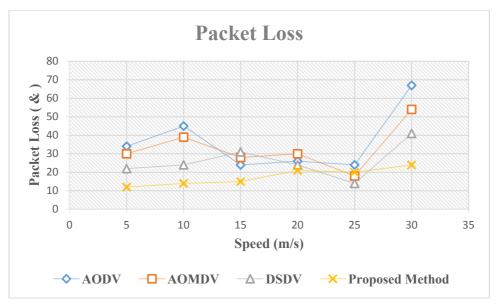*Figure 7. Packet loss according to the number of nodes*

Figure 8. Packet loss according to the number of nodes

7. Conclusion

In this paper, we provided a hybrid routing method based on agent for mobile ad-hoc networks. This method jointly includes two phases namely reactive and proactive**.**
Regarding the results obtained from simulation, our protocol has increased the level of PDR and throughput considerably and has reduced the level of Packet loss. Also our algorithm, in terms of PDR and Throughput, has developed greatly compared to AODV, AOMDV and DSDV protocols. Though the level of End 2 End Delay is higher in our

suggested protocol compared to AODV, AOMDV and DSDV routing protocols, but it has developed in terms of packet loss.

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