Routing Protocol
Route Alternating Multipath AODV (RAM-AODV)

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Abstract— This paper addresses the problem of multipath routing in MANET networks. The multipath routing enables the construction and the use of multiple paths to route traffic between a pair of source and destination nodes. It has advantages such as fault tolerance, uniform load distribution across the network, aggregate bandwidth and QoS improvement in indicators such as throughput, delay and loss. In this context, we propose the Route Alternating Multipath AODV protocol (RAM-AODV) to make the multipath routing with minimal overhead. The protocol allows us to limit the maximum number of paths to be determined and performs maintenance of those. The protocol is evaluated through simulations in Network Simulator 3 (NS-3), showing that it is a promising solution for MANET networks.

Keywords - Ad-hoc On-demand Distance Vector, Multipath routing, router counter.

I. INTRODUCTION

A MANET network is a collection of mobile nodes without any base station or infrastructure support. The mobile terminals communicate directly within the radius of wireless coverage and the out of range terminals communicate through multi-hop routes. Due to its fast installation, it has been used in several areas such as civilians, hospitals and military facilities etc. A MANET network has a dynamic topology, high mobility of nodes, low bandwidth and limited power of battery of the devices. In such scenarios, it is essential to make the routing with a maximum throughput and at the same time with a minimal overhead. As in any network, when applied in a real case, it is normal that some routes are used more frequently than the others. Techniques that enable satisfactory use of all possible paths become particularly relevant. The multipath routing is a promising technique for achieving this goal. When providing multiple routes between source and destination, it opens the possibility of using load distribution techniques, thereby increasing the bandwidth offered to the applications.

Many Studies have been done over the years and resulted in the development of several multipath routing protocols. In all studies that were done, the results showed that the protocols with multipath routing are more efficient and have better performance. The proliferation of portable devices able to communicate with wireless technology (e.g., 802.11a/b/g, etc...) is encouraging more research in the area of multipath protocol and application for MANET network. In this paper we propose a new multipath routing protocol that enables to find multipath partially disjointed with the minimal overhead possible.

We present the results obtained by simulating the protocol using NS-3.

The results show that RAM-AODV protocol can maximize the bandwidth and decrease the end-to-end delay. The remainder of the paper is organized as follows: section 2 presents the related work, section 3 describes the RAM-AODV protocol, section 4 presents the simulation model and section 5 presents the protocol evaluation. Finally section 6 presents the conclusions and directions for future work.

II. RELATED WORK

In order to reduce the number of route acquisition processes performed by the source nodes and the end-to-end delay of the communication, several protocols with multipath routing have been developed. In this section, we will summarize some of the multipath routing protocols most referenced when talking about MANET networks.

The protocol Optimized Ad-hoc On-Demand Multipath Distance Vector (OAOMDV) was developed to optimize the protocol AOMDV, which already is a protocol with multipath routing. The optimization consists in solving the problem of “route cut-off.” The problem was solved with the introduction of a new control packet, called RREP_ACK. This packet is sent by the source node, when detecting that paths towards direct communication (source node - destination node) have been omitted. The obtained results were better than the AOMDV protocol [7].

The Mobility Prediction Ad hoc On-Demand Distance Vector Multipath protocol (MP-AOMDV) computes several routes during the discovery process and performs the maintenance of all calculated paths. This protocol implements two versions:

- Node-Disjoint MP-AOMDV – in this version all calculated paths are completely disjoint. The connections are unique and do not have any nodes in common.
- Link-Disjoint MP-AOMDV – in this version the calculated paths may have node in common, but the links are unique.

The link disjoint version has fewer restrictions than the node disjoint version, therefore more alternative paths can be
determined. The maintenance of multiple paths is performed end-to-end by sending periodic heartbeat messages from the source node to the destination node through the active route. An interesting feature of this protocol is that it uses the quality of links as metric for calculating the various paths rather than counter hops (hop-count). The quality of the connections is a relative measure of the signal strength received by a node when it receives a packet from its neighbor. This metric is called mobility prediction (MP) and is given by the following equation:

\[ MP = \frac{p_{db} - p_{min}}{p_{min}} \]

The paths are arranged by MP value in descending order. The route that has the highest MP value is considered as the main route. In order to send packets choosing the best route, the protocol implements a mechanism for switching between the main route and alternative routes. To achieve this target, a threshold parameter was set, in such way that if the difference of the signal quality between the main path and the secondary path is lower than this parameter, then the second best route becomes the main path [2].

The New Node–Disjoint Multipath Protocol (NMN-AODV) based on AODV Protocol routing is interesting because it is able to realize multipath routing without adding any additional control packet to the AODV packet. It has a very simplified mode of operation, since it can make the routing multipath, with a simple manipulation of the flag F and D of RREP and RREQ packet respectively. When the destination node receives the RREQ packet, it responds with a RREP packet. To build the second route, after waiting for NET-TRAVERSAL-TIME span, the destination node sends to the source node a RREQ packet with the D flag initialized with the value "1", indicating that this packet can only be answered by its respective destination node. When the source node receives the RREQ packet with the D flag set to the value 1, it replies with RREP packet with the F flag initialized to zero, thus establishing the path created by the RREP packet as a secondary route. Thanks to this simple procedure, two routes are defined between the origin node and the destination node [3].

Many other multipath routing protocols have been developed to operate in MANET networks, such as MP-OLSR protocol, MP-DSR, AOMDV, EAODV2, AAODV MMDV, EAODV1 and AODV Multipath [4], [5].

III. ROUTE ALTERNATING MULTIPATH AODV (RAM-AODV)

In this section we will describe a new protocol that utilizes multipath alternately. This new protocol is designated as Route Alternating Multipath AODV (RAM-AODV). The RAM-AODV protocol was based on the AODV protocol [RFC 3561] protocol and MP-AOMDV [2]. It has a simple mode of operation, performing multipath routing utilizing only the AODV protocol messages.

The MP-AODV protocol and OAOMDV can compute several paths between the destination node and source node, but introduce a new packet control heartbeat and RREP_ACK respectively. The goal of this protocol is to determine multiple paths between the node of origin and destination with a minimal overhead. The NMN-AODV protocol performs multipath routing using only the signaling messages of the AODV protocol, but can only calculate two paths between the destination node and source node.

The RAM-AODV protocol is intended to perform multipath routing with a minimum overhead and can overcome the limitations of the NMN-AODV protocol.

A. Changes made to the AODV protocol

In order to determine several alternative routes using a single discovery process, some changes were introduced in the AODV. In this section we present some of those changes. The first change performed to the AODV protocol is the introduction of a new field in the RREQ packet, in order to carry the IP address of the neighboring node of the one that transmits the RREQ packet. Based on this information, the destination node computes several partially disjoint paths. Figure 1 shows the RREQ packet format used by the protocol RAM-AODV.

![Figure 1: RREQ packet format.](image)

The second important change introduced in the AODV protocol, is the change of the routing table entry so that it can store information of several next hops for each route found. Therefore, a list of next hops IP addresses was added to the next neighboring nodes.

Two new parameters were also introduced to the routing table entry. The first is a Max Num Routes, which indicate the maximum number of routes to be found during the discovery process. The second is a router counter, whose functionality is to count routes used and to ensure that it uses alternately all paths found.
B. Processing RREQ packet

When the intermediate node receives the RREQ packet based on information \(<ID \text{RREQ}, IP \text{Originator}>\), it identifies whether it is a new packet or a duplication. If it is handling a duplicate packet, this one will be discarded, otherwise it will create a new entry in the routing table and store information about the corresponding destination node of the packet. Following this, it will be registered in the table of pending requests RREQ and forwarded to network.

When the destination node receives the RREQ packet before responding with a RREP packet, it checks whether the number of RREQ packets that has already been answered is less than the maximum number allowed to the source node in question and whether the IP address of the neighbor’s two hops isn’t available in the neighbor table processed. If these two conditions are satisfied, the destination node replies with a RREP packet.

![Flowchart](image)

Figure 2: Flowchart of the algorithm implemented in the destination node.

The Figure 2 illustrates the flowchart of the algorithm implemented by the destination node when it receives the RREQ packet. Note that, if the two hops neighboring node is the source node, the destination node responds with a RREP packet, even that it appears in the neighbor table processed, since the number of RREP sent is less than a Max Num Routes.

C. Processing RREP packet

When the intermediate node receives the RREP packet, based on information \(<IP \text{Originator}, ID \text{RREQ}>\), it queries the pending RREQ request table and forwards it to the next node towards the source node. The Figure 3 illustrates the format of entry of RREQ requests pending table. For each source node there is an entry with two values, the IP address next-hop and RREQ packet identifier.

![Table Format](image)

Figure 3: Table format of the RREQ requests pending.

When the source node receives the RREP packet, it will update the entry in its forwarding table. This update is applied based on the following criteria:

- If the sequence number of the received packet is greater than the sequence number stored in the table for the destination node, all information in table entry is updated with the information received from RREP packet.
- If the sequence number is equal and the route is not a new one, then the list of next hops is updated if value of hop-count of the received packet is less than the hop-count in the list of next hops or if the state of the route in the list of next hops is invalid.
- If the sequence number is equal, but the IP address of the node from which was received the RREP packet is new, this route is added to the list of next hops.

Thus ends the processing of the RREP packet.

D. Counter of Calculated Paths - CCP

We have implemented a mechanism to count the calculated paths, in order to reduce the number of RREP packets sent to the network by the destination node. The mechanism consists of counting the number of RREQ answered by the destination node. For each RREP packet sent by the destination node in response to RREQ packet, the CCP is incremented. When the number of calculated paths reaches the maximum value for a determined source node and if it receives again RREQ packets from the same source node, the packet is discarded. If the destination node receives RREQ packet from a source node and this packet has a different identifier than the previous received packet, the CCP is reset to zero. The maximum value of CCP is defined manually by the network administrator and is called Max Num Routes.
E. Operation of the protocol

To better understand the operation of the protocol implemented, I will illustrate an example using the network of Figure 4. The node S is the source node and the node D is the destination. In this example, we assume that the value of CCP is equal to 2. The RREQ (X, Y) packet must be understood as a packet sent by node Y and was received from node X.

The node S initiates the route discovery by sending the RREQ packet to the network. The node A, G and B node receives the RREQ packet, update the routing table entry in order to build the inverse path A-S, G-S and B-S. Assuming that the node C receives the first copy of RREQ packet coming from node A, then forwards it to the network and when it receives the copy of RREQ packet of the node B and that will be discard. When the node E and F receives the RREQ packet, updates its routing table entry forming the inverse route E-C-A-S and F-C-A-S. The node E and node F forwards the RREQ packet to the destination D. The copy of the RREQ packet sent through the route G is transmitted to node H, forming the following inverse route H-G-S. When the destination node receives the RREQ packet of the neighbor E, it checks whether or not CCP has not reached the maximum value. If not, the node D consults the table of neighbors processed, and concludes that it had never processed the neighbor C, and therefore it responds with the RREP packet. Then increments the CCP value and insert the neighbor C in the table of neighbor processed. The destination node sends the RREP packet by inverse route formed by the RREQ packet until the source node. From the node E, it forward to the node C, and the node C on the basis of information stored in the entry of the pending RREQ request table concludes that the RREP packet must be sent to node A and then is routed to the node S, is established the following route S-A-C-E-D. Shortly thereafter the destination node receives the RREQ packet sent by node F. As CCP value is less than 2, then, the node D will consult the table of neighbor processed and it concludes that the neighbor C was already processed, so the RREQ packet is discarded. Finally, when the destination node receives the packet RREQ sent by node H, and since the value of the CCP was not reached the maximum value, the destination node D consult processed neighbor table and finds that the neighbor G had not been processed. Therefore, responds with RREP packet to the node H, and it forwards the RREP packet to the source node. When the source node receives the RREP packet, the second path is established S-G-H-D.

IV. SIMULATION MODEL

The purpose of testing the performance of the protocol RAM-AODV, two scenarios were considered and three tests. The first scenario consists of a static network (nodes are not mobile). In this scenario two different tests were performed. The first test is to evaluate the protocol performance varying the number of network nodes per unit of area. The goal of this test is to evaluate the performance of the protocol in dense networks.

The second test is to evaluate the protocol performance by varying the time interval of sent packets. The goal is to measure the maximum throughput of the protocol. The second scenario was simulated with the purpose of evaluating the performance of the protocol in the presence of mobility (the nodes are mobile).

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of simulation</td>
<td>100s</td>
</tr>
<tr>
<td>Transport Protocol</td>
<td>UDP</td>
</tr>
<tr>
<td>UDP packet size</td>
<td>256 bytes</td>
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<tr>
<td>Technology</td>
<td>IEEE 80211b</td>
</tr>
<tr>
<td>Propagation model</td>
<td>Values Defaults of the NS3</td>
</tr>
<tr>
<td>Node numbers on horizontal</td>
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</tr>
<tr>
<td>Distance between nodes</td>
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</tr>
<tr>
<td>Source nodes</td>
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</tr>
<tr>
<td>Number packets sent</td>
<td>500</td>
</tr>
<tr>
<td>Inter-packet interval</td>
<td>0.001s</td>
</tr>
</tbody>
</table>

The default values of the propagation model used by NS-3 are the following:

- \textit{ConstantSpeedPropagationDelayModel}: defines a constant propagation velocity, with initial default value equal to the speed of light \((3 \times 10^8 \text{ m/s})\).
- \textit{LogDistancePropagationLossModel}: defines a constant propagation delay. The propagation losses are based on the model of the logarithm of the distance defined by:
  \[
  L = L_0 + 10n \log_{10} \left( \frac{d}{d_0} \right)
  \]

Where the meanings of the parameters and their default values are the following:

- \(n\): Attenuation coefficient which characterizes the propagation medium \((n = 3)\);
- \(d_0\): Reference distance (m), the default value is 1 m;
- \(L_0\): Reference attenuation (dB), and the initial value 46.6777 dB (obtained by Friis equation using...
the distance of 1 m for the frequency 5.15 GHz);
- \( d \): Distance (m);
- \( L \): Propagation loss (dB);

For the first test, the simulations were performed using networks composed by 40, 50, 60, 70, and 80 nodes. In the second test, the number of nodes was 80 and we utilized three different values of inter-packet interval (0.001; 1e-04; 1e-05 s).

In addition to the parameters defined in Table 1, we defined in the second scenario some parameters that are specific to the test mobility, such as:

- Number of nodes: 80;
- Model Mobility: Random Waypoint Mobility Model;
- Intervals of minimum speed of movement of the nodes: 2, 4, 14, 16 m / s;
- Intervals of maximum speed of movement of the nodes: 6, 10, 30, and 34 m / s;
- Dimensions of the simulation area: \( 0 = \{X_{\min}, X_{\max} = 1000\}, \{Y_{\min} = 0, Y_{\max} = 1000\} \)
- Pause time of nodes in a position: 10s;

V. SIMULATION RESULTS

The indicators of QoS parameters that were utilized to evaluate the performance of the protocol are: delay, jitter, throughput and number of packets received. The following presents a summary of setting each of the metrics mentioned:

- **Delay** - This delay includes all possible delays caused by buffering during route acquisition, queuing delays at the network interface, the MAC transmission delays and propagation times.
- **Jitter** - an Ad-hoc network can understand the delay variation (jitter), as the variation in time and in-sequence delivery of information (e.g. packets) due to variation in network delay.
- **Throughput** - the throughput is the number of bits received by the destination node during the simulation, counting the data that is actually transmitted per unit time.
- **Rate of packets received** - corresponds to a fraction of packets received by the destination node of the set of packets that were sent by the source node.

The protocol reference adopted to evaluate the performance of RAM-AODV protocol was AODV protocol. Until now none protocol has been implemented with the multipath routing in NS-3.

A. Performance of RAM-AODV and AODV protocols in static networks, by varying the number of nodes in the network.

This section aims to analyze the performance of RAM-AODV protocol and define the optimal number (Max Num Router) of paths that will be applied in multipath routing. To define the optimal Max Num Router, the RAM-AODV protocol was simulated with different value of Max Num Router (1, 2, 3 and 4). In order to have a reference to evaluate the performance of RAM-AODV protocol, AODV protocol was simulated. Therefore, all approach made on the performance of RAM-AODV protocol, has as reference the results of the AODV protocol.

The graph in Figure 5, enables us to analyze the performance of RAM-AODV and AODV protocols, when we compare the respective values of the delay. Through analysis of the graph, we can conclude that the AODV protocol has smaller values of delay for less dense networks, in this particular case networks composed by 40, 50, and 60 nodes. However, for most dense networks (composed by more than 70 nodes) the less delay is obtained by RAM-AODV protocol. Note also that in this graph the biggest delay was obtained by the RAM-AODV protocol, when performing routing with a single route. It was expected that the RAM-AODV protocol with a single route had a performance similar to the AODV protocol. In AODV protocol, the intermediate nodes are able to participate in the process of route acquisition, enabling them to respond to the RREQ packets when they have valid routes to the destination node. In the RAM-AODV protocol, only the destination nodes can reply to RREQ packet, since the intermediate nodes are limited to only forward the RREQ packet. This additional functionality of intermediate nodes at AODV protocol accelerates the acquisition process of routes and decreases the number of dropped packets, thereby contributing to improve performance of the AODV protocol. For a network composed by 40, 50 and 60 nodes, the protocol AODV had better performance than the RAM-AODV protocol with a single route. For a network with more than 60 nodes, the performance of the AODV protocol begins to decrease significantly, whereas for the RAM-AODV protocol there is an improvement in performance. One cause of the decline in the performance of AODV protocol is directly related to network congestion, caused by the signaling messages. When the number of nodes increases, also increases the number of RREP packets sent by the intermediate nodes, because of the broadcast response of RREQ message. Also increases the number of hello messages sent by nodes that are part of active routes. All this, contributes to increase overhead and congestion of the network, resulting an increased collisions between packets and the number of packets discarded by the network.
In order to conclude which of the two protocols have better performance and optimal value for the parameter *Max Num Router*, it is necessary in addition to the graph in Figure 5 examines the other graphics. The graph in Figure 6 shows that performance of the RAM-AODV and AODV protocols, by calculating the jitter. Through analysis of the graph, we conclude that, for both the protocols the jitter value is small and can be neglecting when compared with the delay. However, the AODV protocol had the highest jitter.

The graph in Figure 7 shows the performance of the RAM-AODV and AODV protocols by calculating the average rate of packets received by the destination node. The results presented in this graph show clearly that the RAM-AODV protocol with more a route had better performance than the AODV protocol. The AODV protocol presented an average rate of received packets always less than 50%, while the RAM-AODV protocol with more than one route, had an average rate of received packets always exceed 60%.

The graph in Figure 8 shows the performance of the RAM-AODV with AODV protocol, by calculating the throughput. Although the great evolution of wireless communication technologies, they still need mechanisms and solutions that enable the transfer of multimedia data that require high data transfer rates. According to the graph of Figure 8, in all of the simulation results, the throughput was always less than 100 Kbps. However, comparing the performance of the RAM-AODV with AODV protocol, the RAM-AODV protocol had the best performance than AODV protocol. Although, the maximum throughput is approximately 90 kbps, with RAM-AODV protocol was obtained an improvement of 50%. Note that if we used the technology 802.11a or 802.11g, the throughputs could be higher than those obtained with the 802.11b technology. However, 802.11b is more robust with respect to propagation phenomena, such as multipath fading.
According to all the analysis on the results obtained in this section, we obtain the following conclusions:

- The multipath routing performed by RAM-AODV protocol is more efficient and yields better performance than single path routing performed by AODV protocol.
- It also follows that for dense networks (in this scenario network composed of the 70 and 80) the performance of multipath routing decreases when we increase the number of routes between the source node and destination node. As can be seen in the graph of Figure 7, from 60 nodes the average received packets and throughput start to decrease for the RAM-AODV protocol with 3 and 4 routes. One of the reasons why the protocol performance decreases when we increase the number of routes between the source node and destination is directly related to congestion caused by increased signaling messages. Moreover, when we increase the number of routes between the source node and destination node, begins to have interference between the routes. The interference between the routes, designated by routes coupling, has a negative impact on communications and decreases the performance.

B. Performance of RAM-AODV and AODV protocols in static networks, by varying the time interval of sending packets.

In this section, we present the performance of both protocols by varying the time interval of transmission of packets. We considered only three different intervals of transmission of packets, since for time intervals less than 1e-05 s, the average rate of packets received and throughput are practically null, for both protocols. According to the graph in Figure 9, for the interval 0.001 s, both protocols have the same delay value. However, when examining the graph in Figure 11, it appears that this delay value, the average rate of packets received by AODV protocol is less than 20%, while for the RAM-AODV protocol is more than 80%. We conclude that the RAM-AODV protocol had better performance than the AODV protocol for this transmission interval.

The graph of Figure 10 shows the average jitter of the both protocols by varying the time interval of transmission of packets. When lower the interval of transmission of the packet, the higher the network traffic and therefore higher congestion. The jitter value decrease with a decreasing in the time interval of transmission of packets, as also decreased the number of packets received. By comparing the delay graph of Figure 9 with the jitter graph of Figure 10, we conclude that the jitter is not significant relatively to the delay. For the time interval of transmission of packets equal to 0.001 s, we have approximately 0.714% of jitter for the AODV protocol and 0.428% for the RAM-AODV protocol (2 routes), so the jitter is very small relatively to the delay.

![Figure 9: Average delay in static networks, with packet sending interval variable.](image9.png)

![Figure 10: Average jitter in static networks, with packet sending interval variable.](image10.png)

![Figure 11: Average rate of received packets in static networks, with packet sending interval variable.](image11.png)
The graphic of Figure 12, allows us to conclude also that the multipath routing performed by RAM-AODV protocol is more efficient than single routing paths done by AODV protocol. These results indicate that there was obtained an improvement of more than 50 % with the RAM-AODV protocol.

Figure 12: Average throughput in static networks, with packet sending interval variable.

C. Performance of the RM-AODV and AODV protocols in dynamic networks.

The mobility of nodes is one of the fundamental characteristics of MANET networks. It is essential the study of performance of the RAM-AODV protocol in these types of networks. Several simulations were performed and the results obtained are represented in four graphs. The graph of Figure 13 presents the average delay by varying the speed of movement of the nodes.

Figure 13: Average value of the delay in dynamic networks.

Note that excluding the statistical effects imposed by the randomness of the simulation and the model used for the mobility scenario, the two protocols have the same performance, for the level of the delay. To conclude that the RAM-AODV protocol (2 routes) had better performance is required together with the graph of delay, examine the other graphs. For example, if we consider the graph of Figure 13 and Figure 14, we conclude that for the same delay value, the RAM-AODV protocol (2 routes) has better throughput and a largest average rate received packets.

Figure 14: Average value of the jitter in dynamic networks.

The graph in Figure 14 presents the average values of jitter protocol AODV and RAM-AODV (2 routes), taking into account the mobility of the nodes. When making a comparison between the graph of jitter (Figure 14) and the graph of the delay (Figure 13), we conclude that the results of jitter are negligible compared to the results of the delay. The highest value of the jitter of the RAM-AODV protocol (2 routes) is obtained for a speed selected in the interval [12, 16] m / s and was 0.012 s. For this same speed the delay was 0.9 s [see Figure 13]. By comparing the two values we see that the jitter is negligible relatively to the delay.

Figure 15: Average rate of packets received on dynamic networks.

The graph of Figure 15 shows how the change in movement speed of the nodes influence the average rate of packets received by the destination node. When the movement speed of the nodes increases, there are more links failures and more packets are dropped. With the RAM-AODV protocol (2 routes), due to alternative routes few packets are dropped with frequent links failures. The possibility of using alternative routes, contribute for RAM-AODV protocol (2 routes) had an average rate of packets always higher than that of AODV.
In order to study the throughput achieved by both protocols in networks with mobility support, we built a graph showing the average values of throughput when vary the movement speed of the nodes. The behavior of the graphic is similar to the graph of the average rate of packets received, since the throughput varies directly proportional with the number of packets received. The graph of Figure 16 allows us to conclude also that the performance of the two protocols decreases with increasing movement speed of the nodes. The increasing of the movement speed of the nodes, contributes significantly to the network instability and changes in topology. There is an increase in the breaking of connections, which causes a degradation of performance in both protocols. However, due to the use of the various alternative routes partially disjoint the RAM-AODV protocol better overcome the increase of the network instability. We conclude that the RAM-AODV protocol is a considerable alternative for mobile networks in relation to the AODV protocol. Independently of the value of movement speeds of the nodes, the RAM-AODV protocol had better throughput.

VI. CONCLUSION

In this article we present the RAM-AODV, a new protocol to support multipath routing in MANET networks. The protocol determines partly disjoint paths with a minimum of overhead. All calculated routes are periodically updated so that the nodes follow the network topology changes. The protocol uses multiple routes alternately to send packets to the destination node. The experimental results show that the RAM-AODV protocol has better than either AODV protocol in mobile and static networks.

The RAM-AODV allows us limit the number of routes to be determined between the source node and destination node. The definition this parameter is manually configured by the network administrator in the current implementation. It would also be interesting to explore our solution to optimize the way it is done updating the various routes.

VII. REFERENCES


