A New Improved Algorithm of AODV Protocol based on F-Lipschitz Optimization

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Abstract

With the rapid development and the daily appearance of the new tiny materials, the new technology attracts more and more the research community. Mobile Ad Hoc Networks offer various applications to users. However, This technology still suffer from routing problems. The main goal of this paper is to present a new enhanced algorithm of AODV protocol which is based on optimizing the number of RREQ messages using the F- Lipschitz optimization. The novel proposed approach focus on two parameters: distance and energy for enhancing routing performances. Simulation results show that the new protocol outperforms the basic AODV.

Keywords: F-Lipschitz Optimization, MANET, Routing, We AODV

1. Introduction

In general, A Mobile Ad Hoc Network (MANET)¹ is a huge number of units which communicate each other using their wireless interfaces without any predefined infrastructure. Even if this kind of networks is suitable for different applications²-⁶, It still has a various number of limitations like the computational capacities, the extra routing overhead, the dissipation of node energy , etc… Many mathematical traditional methods of optimizations are useful for resolving MANETs problems. However, their complex process lead to dissipate more time, which is more critical for treating data in MANETs. Thus, it is mandatory to use other faster and robust methods for achieving this objective. F-Lipschitz optimization⁷,⁸ becomes more utilized for resolving MANETs problems. This optimization method is characterized by its simplicity and fast process. In this paper, we tend to propose a new improved algorithm of AODV protocol based on the fast approach F-Lipschitz.

This paper is organized in: Section 2 summarizes some related works. Section 3 details the main characteristics of MANETs. Section 4 defines the routing in MANETs and their categories. Section 5 details the F-Lipschitz optimization and our proposed algorithm. Section 6 presents the simulation results. Section 7 resumes the proposed work.

2. Related works

AODV⁹,¹⁰ belongs to reactive family. It is based on the process of distance vectors algorithm and has the ability to establish both the unicast and multicast routing. It essentially represents an improvement of the DSDV proactive algorithm. AODV is an on demand protocol, which requests route only when needed. However, this protocol is based on broadcasting RREQ packets for researching a new destination. The use of an uncontrolled number of RREQ messages leads to degrade the performances of this protocol like the dissipation of the node energy and the delay. Several approaches are designed in order to overcome these problems like the link prediction. In¹¹, authors designed a novel version of AODV named as
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PPAODV (Predictive Preemptive AODV), which exploits Lagrange interpolation for predicting the link failure. This procedure is based on the past RSS (Received Signal Strength) information for defining a new route before the active path is broken, which will replace it for keeping the routing stability.

In [12], authors proposed a novel model for predicting the link availability in MANETs. It exploits pareto distribution for predicting the probability that an active link between two mobile units was broken using the mobility of nodes. In [13], authors designed a novel improved version of AODV based on a link prediction approach, which predict the time when an active link will break. For achieving this goal, they used Newton interpolation polynomial considering the RSS of the data packets. The new approach improves the protocol’s performances.

3. Mobile Ad Hoc Networks

A mobile Ad Hoc network (or MANET) represents a great number of units which had a random motion and characterized by the use of their wireless interfaces for communicating between them.

3.1 Characteristics of Mobile Ad Hoc Networks

3.1.1 Dynamic Topologies

MANETs are characterized by their dynamic topologies due to the random mobility of mobile units. Consequently, the Ad Hoc network topology changed in rapid way. Both bidirectional and unidirectional links are considered to form the network.

3.1.2 Bandwidth Constrained, Variable Capacity Links

One of the primary characteristics of wireless communication is the use of a shared communication medium. This sharing requires that the reserved bandwidth to a host is modest.

3.1.3 Energy Constrained Operation

The energy node in Ad Hoc network is mainly related to their battery lifetime. Thus, the design of systems should reduce the entire network energy.

3.4 Lack of Existing Infrastructure

Ad hoc networks category is characterized by the lack of existing infrastructure and any kind of centralized administration comparatively to other network categories. Also, Mobile hosts have to establish and maintain the network connectivity in continuous way.

4. Routing in MANETs

Routing in a MANET is related to several factors including topology, route demand initiation, efficient routers election, and specific underlying characteristic. This kind of networks suffers from the limited resources. Thus, it is mandatory to consider the efficient use of resources and offer strong works on optimal routing. Additionally, this network type is dynamic which push research community to work on achieving routing stability. Due to the difficulty of routing, several classifications are appeared as shown in Figure 1.

Routing protocols

3.2 Mobile Ad Hoc Networks Routing Protocols

3.2.1 Reactive Protocols

On-demand routing protocols were invented for reducing the overheads by maintaining information according to the activity of routes. That means that reactive routing family discovers a route when needed. The main advantage of kind of routing lies in the fact that the wireless channel does not need carrying a lot of routing over-head data for useless routes.

However, this advantage decreased according to the network traffic. Thus, the network performance is influenced significantly by the extra traffic between
nodes. The route-setup traffic strongly increases for maintaining routing data on each node. Additionally, it depends on the availability of capacities, the network performances are not affected by the reduced efficiency (increased overhead) when there are enough resources. DSR and AODV represent common reactive protocols.

4.1.2 Proactive or Table Driven

The proactive routing family consists of storing the node’s information in tables. Moreover, routing tables are updated when the network topology changed. Thus, routes are already available for easing the network communication. However, the cost of maintaining the topology information increased in high mobility case. The main advantageous feature of this type of routing is responding to the demanded routes. As examples of this category are DSDV and OLSR.

4.1.3 Hybrid Routing Protocols

This routing family represents a combination of proactive and reactive protocols. It considers their advantageous features. This type manages data routing depending on a zone. It uses the proactive routing inside this area and the reactive routing outside it. These algorithms are designed for a large range of nodal mobility and large network diameters. The most typical hybrid one is zone routing protocol (ZRP).

5. The Proposed Approach

This section aims to detail the new approach. In the basic reactive routing protocol AODV, there are two phases: route discovery and route maintenance. The first phase consists on discovering a path to destination when the source has data packets to send. This primary phase uses a flooding technique for achieving this step. The second phase aids to remove the entries from routing table when the path entry is outdated or related to a broken route. The new approach aims to optimize the number of RREQ messages using the F-Lipschitz optimization. Reducing the number of RREQ messages will certainly improve the performances of AODV protocol.

5.1 F-Lipschitz Optimization

In this sub section, we present the definition of the F-Lipschitz optimization. This optimization problem can be defined as follows:

\[
\begin{align*}
\max & \ fct_0(x) \\
& x_i \leq fct_i(x) \ i = 1, \ldots, l \\
& x_i = h_i(x) \ i = l + 1, \ldots, n \\
& x \in D
\end{align*}
\]

Where:
\[
D \subseteq R^n \text{ and } D \not\subset \Phi \\
l \leq n
\]

\[
\begin{align*}
& f_0(x) : D \rightarrow R^m, m \geq 1 \\
& f_i(x) : D \rightarrow R, i = 1, \ldots, l \\
& h_i(x) : D \rightarrow R, i = l + 1, \ldots, n
\end{align*}
\]

The F-Lipschitz optimization is characterized by the existence of a unique optimal solution, which represent the great motivation for using this method.

5.2 Our Algorithm

Our algorithm aims to reduce the number of RREQ messages, which is very important for improving the AODV performances.

The node decision for rebroadcasting a RREQ message is controlled by the algorithm described in Figure 2. In our case, the RREQ messages are controlled using an F-Lipschitz function described as follows:

\[
\begin{align*}
\max & \ Fct(x) \\
& x_i \leq Fct_i(x) \ i = 1, \ldots, l \\
& x_i = h_i(x) \ i = l + 1, \ldots, n \\
& x \in D
\end{align*}
\]

\[
Fct_i(x) = w_1 \frac{E_i(x)}{E_{init}} + w_2 \frac{D_i(x)}{D_{tot}}
\]

Where:
\[
E_i \text{ is the residual energy value.} \\
E_{init} \text{ is the initial energy.} \\
D \text{ is the distance separating the current node and the next hop.} \\
D_{tot} \text{: total distance of current node’ neighbors.}
\]

wt1 and wt2: represent the weight value of energy and distance respectively and wt1 + wt2 = 1

This function combines two important parameters: energy and distance, which avoids the RREQ rebroadcast to nodes with less energy and those close to the current node. Thus, the number of RREQ messages is controlled
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considering two essential parameters, which permits improving the routing efficiency of the protocol.

Figure 1. Our proposed algorithm.

6. Simulation and Results

This section aims to evaluate the performances of the new proposed approach. We compare the novel approach and the basic protocol AODV in terms of different metrics like the end-to-end delay and PDR and the energy consumed. The protocols are compared considering the parameters listed in Table 1.

It is clearly shown from Figure 2 and Figure 3 and Figure 4 and Figure 5 and Figure 6 that our approach outperforms the basic AODV. Our new protocol minimizes delay values and the energy consumption and the number of dropped messages. This is due to the control of RREQ rebroadcasting by optimizing the number of these messages considering multiple criteria (energy and distance). This control avoids RREQ rebroadcasting for closest nodes and those having less energy. This smart rebroadcasting method reduces the number of RREQ message in the communicational process and avoids the use of nearest distances (nodes) which improve the energy consumed and the end-to-end delay. Moreover, considering the energy of nodes in the RREQ rebroadcasting procedure in the new approach reduce the number of messages dropped.

In addition, it permits increasing the throughput and the PDR. We observe that the highest PDR values are depicted for denser network. This is due to the increasing of rebroadcasted RREQ messages because the function considered finds more adequate distances for achieving such rebroadcasting. That means the forwarding process finds the suitable values according to suitable distances which allows rebroadcasting RREQ messages for denser network. However, the small network doesn't verify more suitable distances (closest distances). Consequently, the RREQ rebroadcasting can't be occurred which reasons the lowest PDR values in this case. This reasons greatly the improvement the performance of AODV.

Table 1. Simulation parameters

| Parameter              | Value                      |
|------------------------|----------------------------|
| Number of nodes        | 10, 20, 30, 40, 50         |
| Area                   | 600*600                    |
| Simulation time        | 120 sec                    |
| Interface queue type   | Droptail/priqueue (FIFO)  |
| Network interface type | Phy/WirelessPhy            |
| CBR packet size        | 512 byte                   |
| MAC Layer              | 802.11                     |
| Channel type           | Channel/Wireless channel   |
| Propagation model      | Two Ray Ground             |
| Simulator              | NS2 (2.35)                 |
| Traffic type           | CBR                        |
| Platform               | Linux(Ubuntu)              |

Figure 2. Average delay (sec).

Figure 3. Average throughput.
7. Conclusion

In this paper, we proposed a novel version of AODV protocol for enhancing the performances of the basic protocol. The new approach is based on F-Lipschitz optimization using a smart function. This function is defined considering two important parameters: energy and distance in order to control the rebroadcast of the RREQ messages. Consequently, the number of RREQ messages reduced thanks to the new approach. Simulation results show that our approach reduces well the energy consumed and the end-to-end delay and the number of packets dropped. In addition, it permits increasing the throughput and the PDR values. In the future, other optimization parameters will be included for enhancing routing performances. It is also possible to combine other efficient methods with the F-Lipschitz optimization for improving the QOS.

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