AN ANT-BASED ADAPTIVE DISTRIBUTED ROUTING PROTOCOL FOR MOBILE AD HOC NETWORKS

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Abstract

Mobile ad hoc network (MANET) is a network in which all nodes are mobile and communicate exclusively via wireless connections. There is no fixed infrastructure in the network, and there is no hierarchy. Routing is the task of directing data flows from source nodes to destination nodes while maximizing network performance. Due to the ad hoc and dynamic nature of the network, the topology can change constantly, and paths between sources and destinations that were initially efficient can quickly become inefficient or even infeasible. In this work, we present an adaptive distributed routing protocol for mobile ad hoc networks based on Ant Colony Optimization (ACO). The simulation results show how this new protocol is better than AODV protocol.

Keywords - Mobile Ad Hoc Network, MANET, Routing, Protocol, ACO, Swarm Intelligence.

1 INTRODUCTION

One of the most important developments in recent years in the field of telecommunication networks is the increased use of wireless communication. A wide range of different wireless technologies and standards have been developed, including Wireless-Fidelity [1] (WiFi, IEEE 802.11), Bluetooth [2] (IEEE 802.15.1), Zigbee [3] (IEEE 802.15.4), Ultra Wide Band [4] (UWB, IEEE 802.15.3), Worldwide Interoperability for Microwave Access [5] (WiMax, IEEE 802.16), etc. These technologies are being made available on an ever increasing number of devices such as laptops, mobile phones, palmtops, etc., allowing them to connect to a variety of different networks. This explosive growth has made wireless communication networks one of the most important areas of research in computer science.

Hence, in recent years [6], a growing number of devices are getting equipped with networking capabilities. Many of these devices are mobile and communicate using a variety of wireless technologies, which allow them to connect to existing telecommunication networks and to each other. One can then combine a number of such devices with minimal planning to form a network.

Mobile ad hoc networks (MANETs) [6] are networks in which all nodes are mobile and communicate exclusively via wireless connections. Usually, the nodes are equipped with a single, omnidirectional wireless antenna. There is no fixed infrastructure in the network, and there is no hierarchy: all nodes are in principle equal, and can function both as end points of data communication, and as routers, forwarding data for each other in multi-hop fashion.

Routing is the task of directing data flows from source nodes to destination nodes while maximizing network performance. Due to the ad hoc and dynamic nature of the network, the topology can change constantly, and paths between sources and destinations that were initially efficient can quickly become inefficient or even infeasible. This means that routing information should be updated more regularly than in traditional wired telecommunication networks. However, this can be a problem in MANETs, with their limited bandwidth and node resources, and their possibly unreliable communication channels. New routing algorithms are therefore needed, which can give adaptivity in an efficient and robust way[7].

There are several routing approaches, so-called traditional algorithm (OLSR [8], AODV [9]), even though they are valid for routing, something these ones does not offer expected results according to analyzed performance metrics. For this reason, the researchers are focused on natural behavior of some animals (the most of them are insects) to solve complex problems. These kinds of techniques are called bioinspired algorithms and they can solve computational problems in an efficient manner.

There is a particular type of these algorithms that treats about the behavior of the ants at the time of obtaining the food. Ant Colony Optimization (ACO) [10][11] is proposed by Dorigo in his Thesis [12] and it has much influence to solve problems, such as the routing. Moreover, ACO is also based on Swarm Intelligence [13], in the collective behavior of the animals.

In this work we present a proposal of a ACO routing protocol. This paper is divided into 4 sections with the first section this introduction. In section 2 we discuss the most relevant hybrid related work in the routing based on ACO. In section 3 we present our proposal, explaining its major characteristics and analyzing the simulation results. Finally we offer conclusions in section 4.

2 RELATED WORKS

The ACO-based routing protocol can be classified, as well as the traditional protocol, in proactive, reactive and hybrid.Proactive protocols frequently need to exchange packets between mobile nodes and continuously to update their routing tables. It leads a lot of overhead. To avoid this, the reactive protocols appear, but they have more latency. This protocols act on-demand, they sent reactive agents only when needed, i.e., when one node has active data session and the node is prepared to send the data.To get the advantage of both approaches, there are hybrid protocols. They are a combination between proactive and reactive.

There are some representative hybrid protocols proposed in the literature: Ant-AODV [14], HOPNET [15], ZHLS [16], etc. But undoubtedly the most representative is AntHocNet [17] [7]. It constitutes a hybrid, adaptive and multipath protocol that takes into account the dynamic topology and other characteristics of the MANETs, presenting a hybrid mode of operation: it is reactive because it has agents operating in the route setup to destinations and proactive due to other agents collecting information to discover new routes in the prevention against link failure. It is multipath because it establishes different paths to send the information to the destination. Finally, it is adaptive because it suits the traffic and network conditions.

Finally, AntOR [18] is a protocol based on AntHocNet but it differs from this in the following characteristics: i) it is a protocol that works in two separate modes: Disjoint-link and Disjoint-node; ii) it takes into account the pheromone separation in the diffusion process; iii) Use of the distance metric in path exploration. In such protocol there are two kinds of routes: Disjoint-node and Disjoint-link. The first corresponds to routes in which nodes are not shared and the latter refers to routes in which links are not shared.

3 OUR PROPOSAL

In this work, we present a new hybrid bioinspired protocol. Main characteristic is that it belongs to hybrid algorithms because it is a combination between proactive and reactive parts:

- Reactive: It acts on-demand sending reactive agents or ants for routing setup process, when there is available data packet to be sent toward destination.
- Proactive: In the path exploration process, the source node of the data session sends proactively, in time intervals, agents for creation of alternatives routes. This process only occurs when the communication between source and destination has succeeded during the reactive process.

Moreover it operates in a multipath way because it establishes different paths to send the information to the destination. Also, it is adaptive because it suits the traffic and network conditions. It has the following enhancements: Control Packet Buffering, Outdated Route management, Data Packet Management, Link Failure Management, and Route Exploration Management. These enhancements are very important and constitute the main core in this protocol.

We have performed several tests with the Network Simulator NS-3. We have compared our proposal with purely reactive protocol AODV. We vary the pause time from 0 s to 240 s using a time interval of 60 s. We use randomly distributed 100 nodes with transmission range of 300 m. The nodes are moved according to the Random Way Point (RWP) pattern. The scenario was rectangular with dimensions 3000 m x 1000 m. The speed is constant with value of 5 m/s. It use 10 random data sessions using the application protocol Constant Bit Rate (CBR) beginning to send data at random from 0 s to a maximum of 180 s. The sending rate is 512 bit/s, i.e., sending a packet of 64 bytes per second. The maximum simulation time is established to 900 s. It employs a total of 10 runs in the experiment.

Fig. 1 shows how our proposal has a better delay than AODV at all pause time. We can note that in our protocol the ratio never reaches the value of 100 ms.Increasing the pause time has two different effects on the general properties of the scenario that are relevant for routing.Firstly, there is a decrease in node mobility: since nodes stay still for longer periods, they are less mobile, and the network becomes less dynamic. As a consequence, the scenario becomes less difficult. Secondly it is related to the distribution of nodes over the network area when the RWP mobility model is used.

Regard to overhead in bytes, in Fig. 2 we appreciate how the overhead in our proposal is lower than in AODV at all pause time. Also we show that the curve of our protocol does not have extreme behaviour and it is practically a straight line.

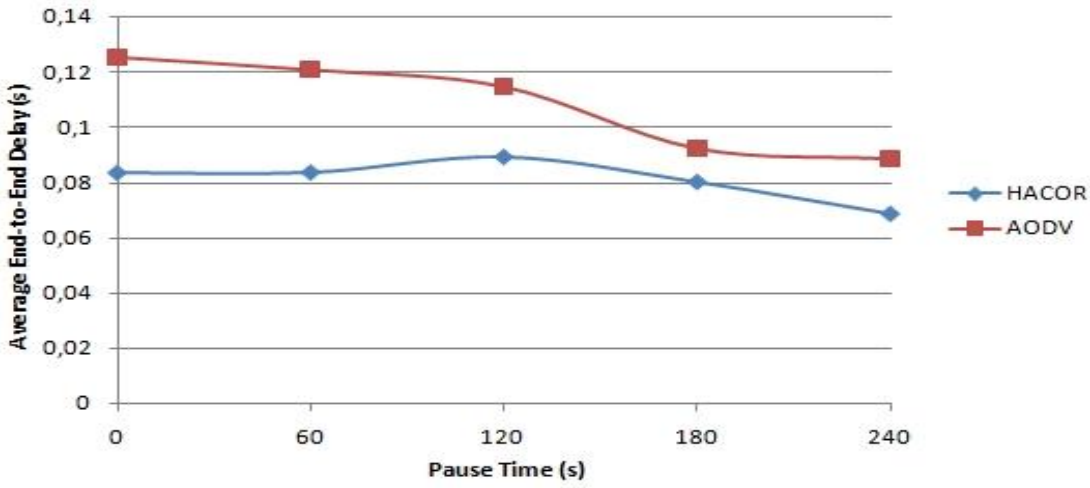

Fig.1 Average End-to-End Delay

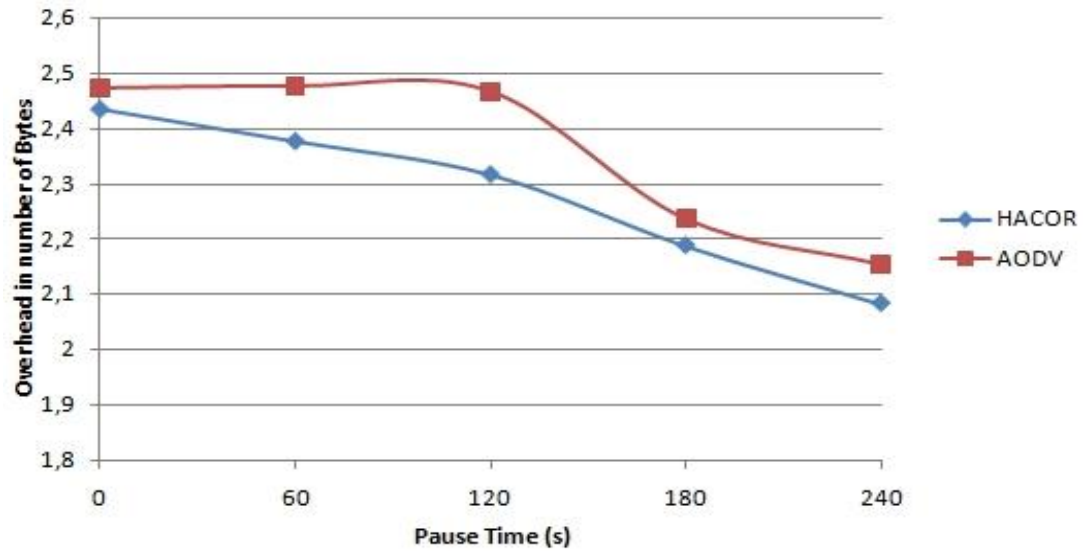

Fig.2 Overhead in Number of Bytes

4 CONCLUSIONS

In this paper we present a hybrid ACO-Based routing protocol which has novel characteristics such as control packet buffering, outdated route management, data packet management, failure link management, and route exploration management.The experimentation results show that this new protocol has a better behavior than AODV according to analyzed metrics.

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