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30 Mai - 01 Juin 2016, Sétif, Algérie

Université Ferhat Abbas Sétif 1

Preface

It is an honor to have been asked by Mourad Baïou to contribute a preface to COSI'2016, and a pleasure to accept.

It has been my good fortune to have been invited to three COSI's, the first in 2005 at Bejaia, the second in 2012 at Tlemcen, the third in 2014 again at Bejaia. All three of those colloquia – so, I deduce, all of the twelve of the past – had a remarkable feeling and spirit about them that I have experienced at no other scientific congress. COSI exudes a very special friendliness and earnestness, of exchange and cooperation. That of 2005 in Bejaia – when memories of the country's difficult years were still vivid and discussions on all matters continued late into the nights – will forever remain engraved in my mind. The love of Algeria, the will to cooperate with their colleagues at Algerian universities, on the part of those many Algerians who live and work and pursue research in France, is at once striking and moving. Working in a country that has the means and traditions of sustaining fundamental research they are intent on helping their fellow countrymen who are forming the next generation of Algerian scientists.

COSI'2016 will no doubt continue the same tradition: a captivating spirit, high quality plenary speakers, a constantly improving quality of contributed papers.

Please be indulgent with me – an aged veteran of research who published his first two scientific papers exactly 55 years ago and continues to be passionate about the project which I now pursue – by allowing me a few words addressed to those who are at the beginning of their research careers.
The most important decision you make is the problem you choose to work on: know *why* you wish to, *why* it is important, *why* you care intensely about it. Do not pursue a problem merely because it is said to be "open" or is suggested to you. The best course – for people working in COSI's domains – is to seek real problems in real life. Most often they are too hard, surrounded by all kinds of complex conditions that hide their mathematical essence. But they are the founts of new ideas, and a new idea is what is most rare, most important, and most likely to lead to truly interesting results.
John von Neumann [1] makes the point beautifully: "I think that it is a relatively good approximation to truth – which is much too complicated to allow anything but approximations – that mathematical ideas originate in empirics, although the genealogy is sometimes long and obscure. But, once they are so conceived, the subject begins to live a peculiar life of its own and is better compared to a creative one, governed by almost entirely aesthetical motivations, than to anything else and, in particular, to an empirical science. ... As a mathematical discipline travels far from its empirical source . . . it is beset with very grave dangers. It becomes . . . more and more purely *l'art pour l'art* . . . [It may] develop along the line of least resistance, that the stream, so far from its source, . . . will become a disorganized mass of details and complexities. In other words, at a great distance from its empirical source, . . . a mathematical subject is in

danger of degeneration."

My greetings to you all: enjoy a productive, challenging, stimulating COSI'2016.

[1] "The mathematician." In J.R. Newman (ed.), *The World of Mathematics*, Simon & Schuster, 1956

Paris, May 24th, 2016 Michel Balinski [1]

[1] Michel Balinski, a Williams graduate, studied at MIT and Princeton. He has taught at Princeton, Penn, CUNY Graduate Center, Yale and SUNY, Stony Brook. Since 1982 he has been Directeur de Recherche de classe exceptionnelle, CNRS and Ecole Polytechnique, Paris, and Director of the Laboratoire d'Econométrie (1989-1999). He was awarded the Lanchester Prize in 1965, and an honorary degree in mathematics from the University of Augsburg in 2004. He is the founding editor of Mathematical Programming and a past President of the Mathematical Programming Society. Dr. Balinski is the author of Fair Representation: Meeting the Ideal of One Man, One Vote (1982, reissued 2001, with H. P. Young) and Le suffrage universel inachevé (2004), and author or co-author of some one hundred scientific articles (OR, mathematics and other journals). In 2013, the Institute for Operations Research and the Management Sciences (INFORMS) awarded him the John von Neumann Theory Prize, one of the highest honors an operations researcher can receive. His principal current interest is the theory and applications of ranking and the design of electoral systems. One of his electoral systems is used in Zürich, Switzerland.

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A nature-inspired routing protocol for MANET

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Abstract. This paper aims to show that techniques inspired from nature can solve routing issue in MANET. Thus, a new intelligent routing protocol for mobile ad hoc networks using a bio-inspired approached is described. The proposed routing protocol mimics processes that happen in the natural river systems, particularly, the actions that water drops perform in the rivers. It is observed that a river often finds good paths among lots of possible paths in its ways from a source to a destination. We mimic this behavior to design a new routing protocol for MANETs called Intelligent Routing for MANets (IRMAN). Further simulation results demonstrate that IRMAN is able to perform better results in terms of packet delivery and end-to-end delay in comparison with AODV. The achievement in this paper has certain reference value to the further study of using intelligent methods such as nature-inspired techniques to solve routing issue in MANETs.

Keywords: Mobile Ad Hoc Network, routing, nature inspired algorithm.

1 Introduction

Since the advent of mobile ad hoc networks, routing was one of the most critical issues that attracted more and more researchers. Routing is defined as the process of switching packets a pair of nodes along a certain path within the network. The routing in this network is highly complex because of the highly dynamic topology, thus a number of dedicated protocols have been proposed.

Many works have been conducted and proposed with the purpose of designing new techniques and protocols. This includes DSDV [1], AODV [2], DSR [3], OLSR [4], TORA [5], and ZRP [6]. These routing protocols can be classified into three types: proactive (table driven routing protocols) [1,4], reactive (on-demand routing protocols) [2,3], and hybrid routing protocols [6]. In proactive routing protocols, each node maintains a route to each of the other nodes in the network. The nodes would need to exchange routing updates periodically to maintain up-to-date information. In reactive protocols, nodes find a route to the destination only when needed. Hybrid routing protocols combine both proactive and reactive routing frameworks. Each node would maintain routing tables and would only offer routes to a destination that is within a certain maximum hop-count (zone radius) from the source node.

Bio-inspired techniques are being intensely studied for application in communication network routing. The potential advantages of using these kinds of algorithms against classical ones are extremely compelling. These models based on the collective behavior observed in natural, biological and physical systems such as ants, bees, rivers, termites, etc. Bio-inspired based routing can enhance the overall performances of the network including end-to-end delay, packet delivery ratio and routing overhead. Examples of bio-inspired techniques successfully used to enhance routing in MANETs are Ant Colony Optimization [7-9], Artificial Bee Colony Optimization [10], Genetic Algorithm [11], and Particle Swarm Optimization [12]. It is in this context that this paper focuses on applying a computational intelligent approach [13] to MANET routing. This technique has been successfully applied to many benchmark problems such as the traveling salesman problem (TSP) [14], and the multiple knapsacks problem [15]. A detailed description the technique is givenin section 3.

Our goal, when designing IRMAN, is to confirm the ability of such methods inspired from nature to perform well in MANET routing. Therefore, the main contributions of this paper are to:

- Propose a new intelligent hybrid routing protocol for MANET.
- Adapt an existing computational intelligent method to the routing problem.

The remainder of this work is organized as follows. Section 2 presents the most relevant work in the area. Section 3 briefly describes the used method and then a description of the proposed routing protocol is detailed in Section 4. Simulation results are discussed in Section 5. Finally, Section 6 concludes the paper pointing out some future works.

2 Previous works

Research in bio-inspired algorithms has revealed great matching properties with communication networks routing. Therefore some algorithms have been proposed for wired networks. Most popular of these is Antnet proposed by Gianni Di Caron ad Marco Dorigo. Getting inspirations from this popular Antnet a lot of research gave birth to more routing protocols.

Günes and al. have proposed another Ant Colony based Routing protocol called ARA [22]. The routing table entries in ARA contain pheromone values for the choice of a neighbor as the next hop for each destination. The pheromone values in the routing tables decay with time and the nodes enter in a sleep mode if the pheromone in the routing table has reached a lower threshold. Route discovery in ARA is performed by two kind of mobile agents: forward ants and backward ants. During route discovery, the forward and backward ant packets characterized by unique sequence numbers to prevent duplicate packets, are flooded through the network by the source and destination nodes, respectively. The forward and backward ants update the pheromone tables at the nodes along the path from the source and destination nodes respectively.

AntHocNet [30] is a hybrid routing protocol proposed by Caro et al. It is a hybrid protocol consisting of both reactive and proactive components. Nodes do not maintain routes to all possible destinations at all the times and generate mobile agents only at the beginning of a data session. The mobile agents search for multiple paths to the destination and these paths are set up in the form of pheromone tables indicating their respective quality. During the course of the data session, the paths are continuously monitored and improved in a proactive manner.

Genetic Algorithms (GA) have, also, been used to solve routing issue in MANETs. Therefore, authors in [31] proposed to use GA with immigrants and memory schemes for dynamic shortest path routing in MANETs. Routes are encoded as potential solutions containing integers (nodes' IDs).

It consists, first, of initializing the population of solutions. It starts looking a random path from s to r by randomly selecting a node v1 from N(s), the neighborhood of s. Then, it randomly selects a node v2 from N(v1). Solutions are evaluated using a fitness function. Genetic operators are, then, applied to these potential solutions to improve paths qualities.

Another promising metaheuristic approach that has been successfully applied to many optimization problems is Artificial Bee Colony Optimization (ABC). Authors in [32] have introduced BeeAdHoc, an energy efficient routing algorithm for MANETs inspired by the foraging principles of honey bees. BeeAdHoc is a reactive source routing algorithm. It uses four kinds of agents, scouts, foragers, packers and swarms. The goal of packers is to find a forager for their data packet. However, scouts are launched from a source node s to a destination node d in order to discover new routes. Foragers are responsible of transporting data packets to their destinations. Simulation results obtained in [32] show that nodes in BeeAdHoc consume significantly less energy as compared to DSR, AODV, and DSDV.

Many other protocols have been designed; an interested reader is referred to relevant survey papers [16-21].

3 Background

Intelligent Water Drop (IWD) is swarm-based optimization algorithm which has been inspired by natural rivers and how they find almost optimal paths to their destination. These near optimal or optimal paths follow the natural river system and the actions and reaction that take place between water drops in the river. Each water drop possesses the following two proprieties:

1. S(IWD) : the amount of soil.
2. V(IWD) : the moving velocity.

Let consider $\Delta S(i,j)$ the amount of soil carried by a water drop IWD when moving from position *i* to next position *j*. It is calculated as follows:

$$\Delta S(i,j) = \frac{a_s}{b_s + c_s * time(i,j;v(IWD))} \quad (1)$$

Where: a_s, b_s and c_s are parameters of the algorithm.

And $time(i,j;v(IWD))$ is the time needed to traverse from i to j when moving with a velocity of *v(IWD)*.

This amount is removed from the path (equation 2).

$$S(i,j) = (1-\rho) * S(i,j) - \rho * \Delta S(i,j) \qquad (2)$$

Where ρ is a parameter of the algorithm.

In the same time, IWD velocity is updated according to the equation (3).

$$V(IWD, t+1) = V(IWD, t) + \frac{a_v}{b_v + c_v * S(i,j)} \qquad (3)$$

Where a_v, b_v and c_v are positive values.

The next position is selected from all the neighbors according to :

$$P(i,j) = \frac{f(S(i,j))}{\sum_{k \in neighbors(i)} f(S(i,k))} \qquad (4)$$

Where i is the current node, $neighbors(i)$ represents neighbors list of node i, and

$$f\big(S(i,j)\big) = \frac{1}{\varepsilon + g(S(i,j))} \qquad (5)$$

This approach has been demonstrated to be effective in solving several optimization problems like TSP in [14], Robot Path Planning [26, 27], Vehicle Routing Problem [28], optimal data aggregation tree in wireless sensor networks [29], and multi-objective job shop scheduling [30].

4 Proposition

The proposed routing protocol IRMEN mimics the behavior described in the previous section. The routing table used by IRMAN at each node contains the following information:

- *destination_id,*
- *Next_hop,*
- *Soil_amount,*
- *delay.*

IRMAN consists of two phases:

- route discovery
- route maintenance

4.1 Route discovery

When a node s needs to send a data packet to a destination d and no route is available, it selects the link with less soil. Algorithm of selecting next hop is given bellow.

```
Algorithm 1: Select next hop

If (No route is available to d)
Begin
    Launch a route discovery to d;
    return;
End

Min = MaxValue
Next_hop = -1
For each neighbor n of s with a route to d do
Begin
    If(S(n) < Min)
    Begin
        Min = S(n)
        Next_hop = n
    endIf
end
return Next_hop
```

If no route is available to destination d, a route discovery process is launched. During this phase, a FIWD packet is broadcasted from the source node until the destination node. Nodes' IDs, reached times are memorized by the FWID along its path. When arrived at the destination node, the FIWD packet is destroyed and a BIWD packet is generated. The BIWD traverses the same nodes but in the reverse way. Its goal is to establish a route or multiple routes for every visited node i, and to initialize soil amount for all traversed links (i, j). The value of soil amount $s(i,j)$, is given by equation 8:

$$s(i,j) = delay_d(i,j) \quad (8)$$

Where $delay_d(i,j)$ is the end-to-end delay between current node i and destination node d when choosing j as the next hop.

A. *Route maintenance*

During this phase, routes between each couple of nodes s and d are updated. Periodically, a FIWD packet is sent from node s to d. FIWD play the role of water drops and contains the same proprieties as in real world. A node i receiving a PFIWD chooses j as the next hop for this packet according to a probability $P_d(i,j)$:

$$P_d(i,j) = \frac{f\big(s(i,j)\big)}{\sum_{k \in neighbors} f\big(s(i,k)\big)} \quad (9)$$

Where $f\big(soil(i,j)\big) = \frac{1}{\varepsilon + s(i,j)}$ (10)

While traveling, FIWD performs the following tasks:

- It maintains the values of soil amount of every traversed link. The dropped value is given by equation (11).

$$\Delta soil(i,j) = \frac{a_s}{b_s + c_s * g(i,j)} \quad (11)$$

Where : $g(i,j) = (\frac{S(i,j)}{v(IWD)})^2$ (12)

- It updates its velocity

$$v(IWD) = v(IWD) + \Delta v(i,j) \quad (13)$$

Where $\Delta v(i,j) = \frac{a_v}{b_v + c_v * s(i,j)}$ (14)

The role of BIWD is to update delay between current node and destination node, to be used next time by FIWD.

5 Simulations and Discussion

To evaluate the performance of the proposed protocol, we have used the network simulator NS2. The obtained results were, then, compared to those obtained using, AODV, an existing routing protocol for MANETs.

5.1 Simulation parameters

Table 1 summarizes a list of all essential parameters and their values used during all simulations (unless specified otherwise, all parameters use values specified in Table 1).

Parameter	Values
Simulation time	200 Seconds
Simulation area	1000 m * 1000 m
Number of nodes	40
Pause time	20 Seconds
Max Speed	15 m/s
Transmission Radius	250 m
Number of CBR sources	10
Packet transmission rate	1 packet / s
Packet size	512
Physical layer	IEEE 802.11
Mobility model	RWP

Table 1 Simulation Parameters

5.2 Results

The goal of these simulations is to explore how the two protocols will perform under various mobility scenarios. Node mobility is reflected with varying: (1) Pause Time (from 600 seconds until 0 second), or (2) node speed (between 5 m/s and 25 m/s). A smaller pause time indicates a more dynamic network topology. The results are shown in Figures from 1 to 4.

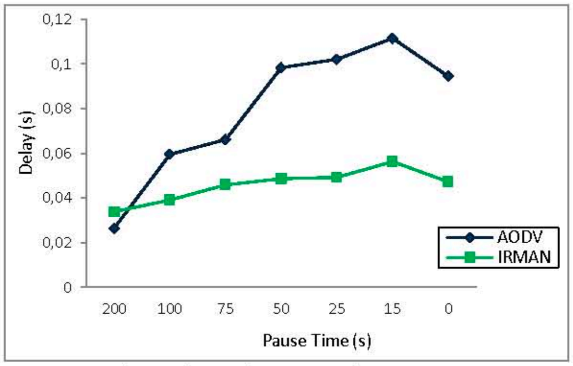

Figure 1 Delay under various pause times

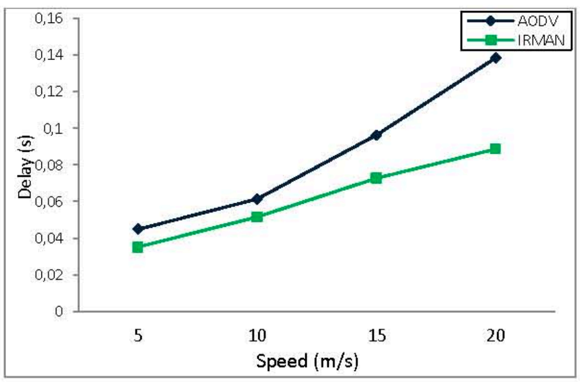

Figure 2 Delay under various speed values

Figure 1 demonstrates that end-to-end delay is proportional to the mobility degree. However, when Pause time is less than 10 seconds, delay decreases.
It is observed in figure 2 that IRMAN performs better with high speeds.

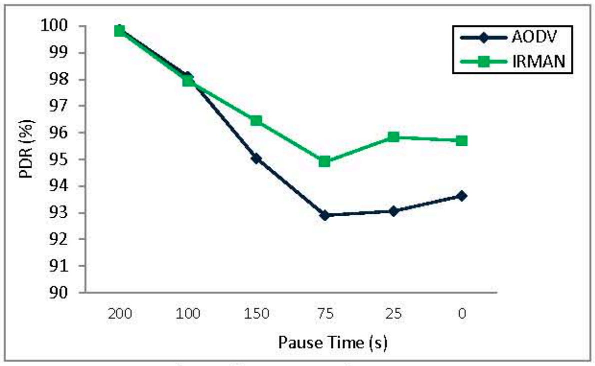

Figure 3 PDR under various pause times

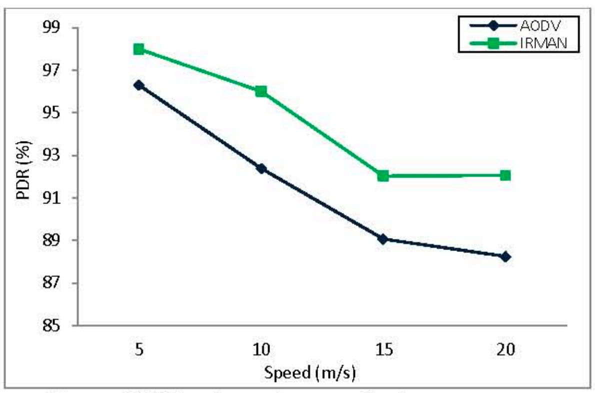

Figure 4 PDR under various speed values

Figures 3 and 4 show the results of packet delivery ratio when varying pause time and speed respectively. These results confirm those obtained in Figures 1 and 2

6 Conclusion

In this paper, a new concept for routing in MANETs based on a nature-inspired method, called IWD, has been proposed. It is inspired from the interactions observed between the water drops and the river bed. We have adapted this method to routing issue. The use of this kind of technique was motivated by observations of the problem characteristics in MANETs. The proposed scheme has been implemented under NS2 environment and has been compared to AODV. Simulation results showed the protocol's effectiveness in terms of high delivery ratio, lower end-to-end delay compared with AODV.

As future work, we expect to add QoS constraints to support QoS mechanism. Another identified potential perspective is to reduce overhead by using an efficient route error management.

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