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Enhancing Routing for Wireless Ad-Hoc Networks to Improve Quality of Service in Mobile Learning

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ABSTRACT

The quality of mobile learning relies strongly on two relevant factors: quality of content and pedagogical techniques on one hand; and quality of the service related to connectivity and performance of the computing and communications platform on the other hand. The latter aspect, network performance, is in turn dependent on the quality of frame routing in wireless ad hoc networks, since this performance will affect both network link quality and battery life. An existing approach to this routing intends to maximize battery life, and among its exponents is a scheme which determines a route by computing first a minimum spanning tree between the source and destination nodes. The proposal presented in this paper finds this final route in one step, by means of a simple algorithm which uses binary decision diagrams to compute the minimum spanning tree for the sought-after route.

Key words :mobile learning, quality of service, wireless ad hoc networks, enhancing routing.

1. INTRODUCTION

The beginnings of the third millennium have been highlighted by the extraordinary changes brought to society in general and individuals in particular, by the accelerated progress of technology. Computers have especially undergone a tremendous evolution, going from huge, expensive, power-hungry, heavy, and cumbersome contraptions with tiny memory and computing capacity, to become these small and convenient devices with astounding computing capacities and until recently unthinkable amounts of storage capacity. The new digital computers are powerful devices able to process and move the user information in a friendly manner, with impressive applications supported by the advances in communications technologies. The former leads to an increasingly rich and broad spectrum of options, uses, and applications that frequently boggle the minds of members from previous generations. In this sense, education is undoubtedly immersed as well in this tsunami of changes, so much that such emerging concepts as mobile learning is al-ready a reality.

The role of quality of service in mobile learning is quite transcendental. This depends, in part, on one relevant factor: the quality of content and the pedagogical techniques underpinning such content [1].New mobile learning technologies have shifted the priorities towards what learner needs. If these challenges are properly tackled, educational contents and pedagogical techniques are bound to improve. Quite rightly, in [2] it is remarked that, as mobile communication technologies progress, the challenges faced by educators consist on testing new pedagogical models and instruments in order to guarantee the quality of contents and educative processes.

Beside the quality of content and pedagogical techniques, there is another relevant factor for the quality of service in mobile learning, which consists on the quality of service related to connectivity and performance of the computing and communications platform and collaborative learning [3,4].

This second relevant factor —quality of service related to connectivity and performance of the computing and communications platform— is in turn strongly dependent on the quality of frame routing in wireless ad hoc networks. This dependency is due to the manner in which frame routing performance will affect both network link quality and battery life, which are critical in mobile learning [5]. In a broader sense, it is important for students to have an appropriate infrastructure which fulfils certain minimal requirements, in order to obtain good results in mobile learning. Such requirements include: mobile devices with sufficient memory; an appropriate display with respect to the available content; and of course communications functionalities; optionally, intelligent mobile devices are desirable, where available.

Routing and connectivity are important issues in ad-hoc networks [6, 7]. The reduction of the transmission power in the physical layer of the OSI communications model increases the traffic carrying capacity of the network[8]. In order to solve this kind of problems in wireless ad hoc networks, the authors of [9] show that each node should be connected to log(n) NN in order to guarantee connectivity.

The current solutionsto maximize battery life tend to converge to a minimum spanning tree in an iterative procedure [10]. The proposal made in the current paper builds this final route in one step, by using a simple algorithm which uses binary decision diagrams to compute the minimum spanning tree for a given source to destination route.

The rest of this paper is organized as follows: section 2 is dedicated to explaining the relationship between mobile learning and wireless ad hoc networks. The third section describes the use of minimum spanning trees to improve routing in multi-hop networks, while the operation of spanning trees using binary decision diagrams is discussed in section 4. The proposal of this paper is then presented in section 5, leaving conclusions for section 6, and finally the references are included.

2. MOBILE LEARNING IN WIRELESS AD HOC NETWORKS

The raw concept of Mobile Learning has to do with the use of mobile technology in educational environments [11]. Through the use of mobile devices interconnected in wireless ad hoc networks, mobile learning enables teacher and students to create virtual worlds [12].

We have witnessed the recent accelerated development of mobile devices, wireless communication and network technologies, which we can see today as a part of campus environment for teachers and students [3]. Naturally, mobile learning is done on mobile devices interconnected through wireless ad hoc networks[13].

Several educative projects where mobile devices interconnected in wireless ad hoc networks are described in [13], which allow educators to freely experiment with mobile learning. Finally, there is a business training program offered in Singapore, which is called eBusiness on the Move.

Such successful projects offer a stimulus for researchers to look for more and better technological solutions to improve mobile learning environments [14]. The concept of Ambient Networking integrates ideas from all across communications, with a set of control functionalities (mainly) at the network level at its core. Such functions may well be implemented atop present and future connectivity technologies, so long as they expose certain information and capabilities. By employing these control functions as an umbrella over other network level technologies, convergence and migration of existing and new technologies are facilitated.

In every mobile learning environment, the quality of service related to connectivity and performance of the computing and communications platform is a critical issue. This is because mobile learning generates a strong demand of computational resources, as well as communications facilities, in order to offer adequate conditions for all processes of mobile learning to occur uninterrupted, which in turn facilitates a successful mobile learning [15].

However, wireless ad hoc networks present new challenges, since continuous end-to-end connectivity cannot be maintained under these conditions, information content needs to be differentiated and offered different services [16, 17].

3. ROUTING IN WIRELESS AD HOC NETWORKS

According to [18], mobile ad hoc networks (MANETS) are characterized by multiple entities. Wireless ad hoc means devices of MANETS are typically hand-held devices with lower power capacities [19].The authors of [20] propose that ad-hoc networks enable any kind of infrastructure.

On the other hand, [21] discusses the problem of service placement. In order to facilitate communication within the network, and guarantee service placement among other things, the main objective is to determine correct routes, enabling timely communication among them, and doing the latter in an efficient manner: path construction should consume as little overhead and bandwidth as possible.

On describing communication protocols, [22] states that routing in wireless ad hoc networks is of particular interest. In [23], a taxonomy of routing protocols for MANETS is included in that paper, which contains five categories.

1. Source-initiated (reactive or on-demand). One of themost widely referred routing algorithms is Dynamic SourceRouting (DSR).

2. Table-driven (proactive). An instance of this kind of routing protocol is Destination-Sequenced Distance-Vector (DSDV) which is based on the Bellman–Ford routing algorithm.

3. Hybrid combine the power of on-demand and table-driven routing protocols; a well-known example is Zone Routing Protocol (ZRP).

4. Location-aware (geographical). For example, the Location-Aided Routing (LAR).

5. Multipath: create multiple routes from source to destination. The Split Multipath Routing (SMR) protocol is an example.

Exploring the first category of the previous taxonomy, [24] analyzes two on-demand routing protocols: AODV and DSR. Indeed, their simulation results show significant increases in packet delivery ratio and decreases in packet latency.

Independently from the taxonomical level to which it belongs, a MANET routing protocol faces a critical issue, which in turn is immersed in the sustainable debate: energy costs control. Thus, the goal is to achieve a more efficient power management. In this regard, [25] reviews energy efficient algorithms and protocols joint with power control to improve energy efficiency.

Several alternatives for efficient routing protocols in MANETS have been devised [18], yet dynamic power control is a viable one, particularly when comparing against traditional routing protocols regarding power efficiency, as [10] correctly point. The existing schemes maximizes battery life through a minimum spanning tree, which is defined in [26-28].The authors of [29] and [30] created a dynamic power controlled routing scheme by using a minimum spanning tree.

Following this idea, [31] have been using MST for routing and energy reduction. It is important to note the efforts that researchers have made, worldwide, in applications of computational intelligence in various areas of human activity [32-78]. And the application of different models and computational intelligence algorithms in this type of MANETS-related tasks should be emphasized [87-89].

A notable case is that of [90], because “simulation results show that our proposed algorithm is very well for big area”.

4. SPANNING TREES AND BINARY DECISION DIAGRAMS

This section describes one of the central topics for the development of the current paper proposal. First, Binary Decision Diagrams (BDDs) are presented, in order to later establish their relationship with MST, given that the proposal made in the current paper builds this final route in one step, by using a simple algorithm which uses BDDs to compute the MST for a given source to destination route.

According to [91] Binary Decision Diagrams are very useful to represent Boolean functions, which allows to perform certain tasks related to circuit design and verification applications. Bryant is recognized as the creator of this branch of science and technology [92]. Currently a large number of international research teams are working on projects related to the subject.. In Figure 1 an example of ROBDD for a certain boolean function is shown.

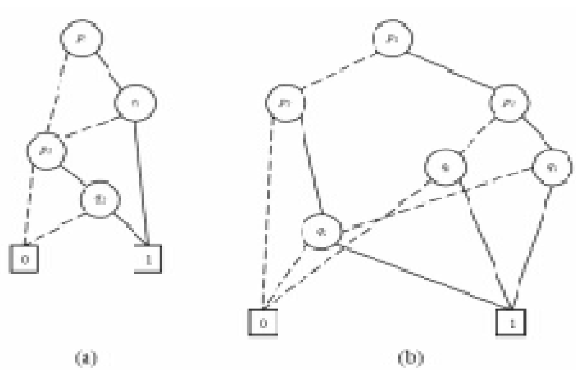

Figure 1. BDDs for boolean function *[(p1)AND(q1)]OR[(p2ANDq2)]*: (a) with ordering *p1<q1<p2<q2*, and (b) with ordering *p1<p2<q1<q2*; *low(v)* children are represented with dotted lines, while *high(v)* children are represented with solid lines

After BDDs were stirred, ideas soon appeared in the specialized literature, where the possibility of representing MSTs through representations using and BDDs was expressed. In this context, Sangireddy and Somani ventured into the use of BDDs in reconfigurable hardware [93], especially in the design of specialized lookup schemes. The advancement in speed was brutal: the authors got results of throughput of up to 229.3 millions of lookup results per second on dedicated hardware.

5. ENHANCING MANET ROUTING WITH MSTS AND BDDS

As was explained previously, one important alternative to improve the quality of service in mobile learning is to enhance the underlying networking technology; if this is done in a more energy-efficient manner, even better. Now, taking advantage of the use of mobile devices inherent to mobile learning, we can assume that connectivity will be realized by means of MANETs in many cases; thus, improving network operation and energy consumption in such a setting would be congruent with the goal mentioned above.

In particular, the use of MSTs and BDDs has been previously explored in order to use dynamic power control in wireless ad hoc networks routing. The proposal of this paper is to take one very successful application of MSTs to MANET routing [30], and modify it by calculating the MST using the algorithm introduced in [94].

An illustration of the proposed method operation is presented in Fig. 2, Fig. 3, and Fig. 4. Our proposal offers the advantage of computing the MST for that route with low complexity —which is O(log3|V| where V is the set of nodes— thanks to the algorithm in [94].

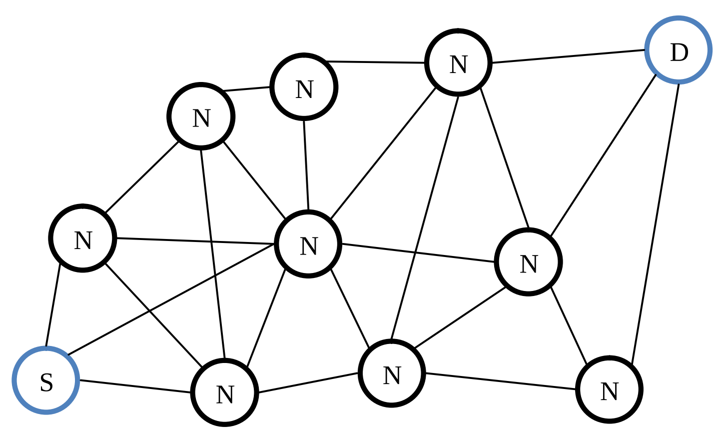

Figure 2. Step 1: initial setting for the proposed method, with nodes S and D indicated

The worst-case scenario is that the final route is already one iteration away from the initial state, and that the corresponding power savings are meagre. In this situation, the improvement in battery life may be evened out by the increased computational strain incurred, thus implying a low cost and low risk situation.

However, according to [29] and [30] power savings of up to 60% may be achieved by using variable-range power control, although this is originally done in several iterations. By building a MST representing the network topology (using information which has already been gathered), the final route is determined in one step, reaching the target power savings in one iteration. Since the algorithm followed has low complexity, it is to be expected that the power consumption incurred will be relatively small, both due to the computing power needed and to the time employed.

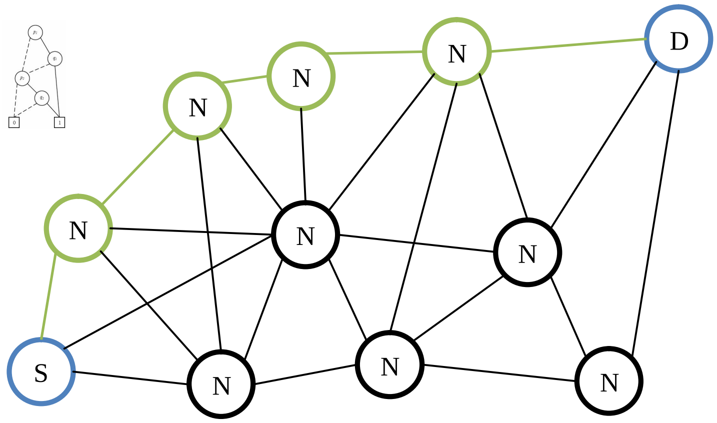

Figure 3. Steps 2 and3: topology represented on a BDD, and MST from S to D built from the BDD; the nodes and links present in the MST are indicated in green

Thus, greater power savings are to be expected. The natural implication of these lesser power consumption is a longer battery life, which is a major concern for mobile devices. With such increased uninterrupted operation time, a more flexible experience is offered to the student, thus enabling a richer, more satisfying, and better learning process. This latter goal is, of course, the final objective of mobile learning.

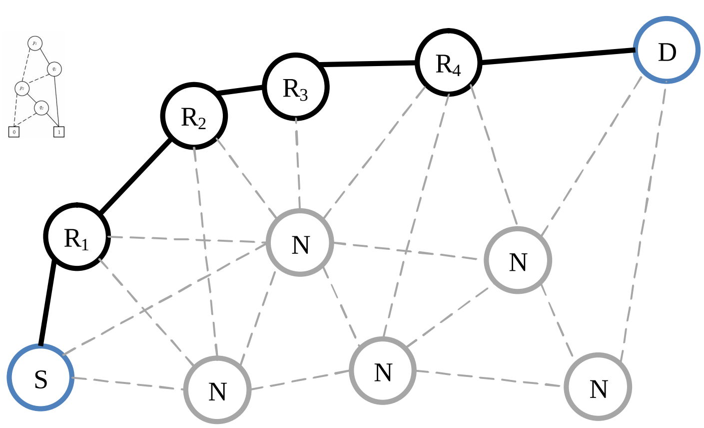

Figure 4. Step 4: all nodes in the MST are made redirectors for the route from S to D

6. CONCLUSION

Among the different alternatives to improve the quality of service of mobile learning, a viable path is that of ensuring a better quality of service at the communications and computing infrastructure. In this sense, and taking into consideration that thanks to its mobility component, mobile learning will most likely be realized on mobile devices, one particular area of interest to reach the aforementioned goal is to enhance the operation of wireless ad hoc networks. More specifically, in this paper a proposal regarding MANETs routing protocols has been presented. The objective in this proposal is to develop a more efficient method of path building for routing in variable power transmission, both in the sense of lower power consumption, little computing processing, and extended battery life.

By computing the final route in only one step instead of several, greater power savings (of up to 60%) are achieved in less time, which impacts positively on the battery life of the mobile device. This longer operational period for the mobile device implies in turn a better learning experience for the student involved in mobile learning, in diverse and varied topics of science and engineering [95-99].

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