A Survey on Fuzzy Reasoning Applications for Routing Protocols in Wireless Ad Hoc Networks

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ABSTRACT

The challenge in creating a routing protocol for ad hoc networks is to design a single protocol that can adapt to the wide variety of conditions that can be present in any ad hoc network environment. The routing protocol must perform efficiently in environments in which it suffers from high nodes mobility and many wireless transmission constraints. Because it is often impossible to know in advance what environment the protocol will find itself in, and because the environment can change unpredictably, the routing protocol must be able to adapt automatically. In this paper, we survey fuzzy reasoning algorithm (FRA) as a highly adaptive algorithm used to achieve that goal. We present the various application of that algorithm to ad hoc routing protocols. In particular, the exposition includes a discussion of strength and weakness of these applications and how they can be improved.

Keywords: ad hoc networks; fuzzy systems; intelligent networks; mobile technologies; wireless technologies

INTRODUCTION

Mobile wireless ad hoc networks are networks without infrastructure, where every node works as a router. In these networks, every node must discover its local neighbors and through those neighbors it will communicate to nodes that are out of its transmission range (multi-hop routing). These networks suffer from all kinds of uncertainty, randomness, and
fuzziness. This uncertainty is due to high bit error rate (BER) in the wireless channel, increased collisions due to the presence of hidden terminals, signals interference and attenuation, location dependent connection, uni-directional links, and frequent link breaks due to nodes mobility. This emerges the need for high adaptive routing protocols with adapting capabilities to high variability and uncertainty for these types of networks.

Recently, many researchers adaptively optimize the ad hoc routing protocols functions and parameters using the fuzzy reasoning algorithm (FRA). The FRAs are proposed to overcome the above shortcoming in ad hoc networks. The routing protocol parameters can be determined more accurately and dynamically by fuzzy reasoning, instead of static values. The application of fuzzy reasoning to ad hoc network problems allows us to specify these parameters using “if...then...” type of linguistic rules.

In this article we present a survey of fuzzy reasoning-based routing for mobile ad hoc networks. We outline the main problems that have been solved by this class of routing protocols and discuss some drawbacks of the proposed methods and possible solutions. Our survey is only on fuzzy reasoning applications for ad hoc routing protocols and we will not report its applications to other layers of wireless ad hoc networks. Surveys on fuzzy reasoning applications for wired telecommunication networks exist in Ghosh et al. (1998) and for ATM networks in Sekercioglu et al. (2001).

The remainder of this article is structured as follows: we present a review of current research efforts classified according to the routing optimization targets. A later section discusses the validity of the performance metrics that may be used in fuzzy reasoning, implementation complexity of the fuzzy reasoning algorithms, compatibility between conventional and fuzzy-based routing protocols, the article’s conclusion, and then further research possibilities.

**REVIEW OF CURRENT RESEARCH EFFORTS**

The major challenges that the FRAs tried to optimize in ad hoc routing field are: routes costs estimation, QoS-based routing, energy-aware routing, position-based routing, zone-based routing, clustering, parameters configuration, and routes local repair. A detailed discussion on each of these optimization targets is given below. This classification of FRAs according to the routing optimization targets is not mutually exclusive and some methods fall in more than one class.

**Routes Costs Estimation Techniques**

In this technique the route cost is calculated for every available route. Some performance measures are used to estimate the stability of the routes. The fuzzy reasoning is used to map the relation of route stability and its

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