Chapter 3.18
Fuzzy Reasoning Approach for Local Connectivity Management in Mobile Ad Hoc Networks

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ABSTRACT

Routing is an important functional aspect in wireless ad hoc networks that handles discovering and maintaining the paths between nodes within a network. Due to nodes' mobility, the efficiency of a dynamic ad hoc routing protocol depends highly on updating speed of network topology changes. To achieve continuous updated routing tables, the nodes periodically broadcast short Hello messages to their neighbors. Although benefits of these messages have been proven, many studies show some drawbacks for these messages. In this paper, we adaptively optimize the frequent needs of those messages using a fuzzy logic system. The proposed fuzzy algorithm is used to model the uncertainty measurements for updating local connectivity successfully in time. Extensive performance analysis via simulation proves the effectiveness of the proposed method to improve the accuracy of neighborhood information and, hence, overall network performance.

INTRODUCTION

A mobile ad hoc network is one without infrastructure, where every node works as a router. In this network, 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). These networks suffer

from nodes' mobility that may cause continual links break. This causes the routing protocol to use different techniques to update its knowledge about local neighbors, which is known as Local Connectivity Management (LCM). One of those techniques is periodically broadcasting short beacon messages (called Hello messages).

Although continually broadcasting the Hello messages helped to get a clearer view of the local network topology, it also produced some drawbacks for the whole network in general. Increased number of these messages consumes network resources and bandwidth, increases collisions and interferences with data and control messages, and consumes the limited nodes' battery life during sending and receiving operations. On the other hand, the decreased number of Hello messages results in a time gap between a link failure event and its detection. In essence, it means that the protocol designer has to trade-off sending these messages carefully to represent the real needs for connectivity updating.

In this study, we attempt to adaptively optimize the maximum time period that can transpire before the node broadcasts the next Hello message. Optimization of this time directly affects the number of sent Hello messages during a fixed period of time. Optimization is based on the correlation between the topology reconstruction and the periodical interval for the Hello message transmission. The highly changeable topology, due to nodes' movements, should increase the number of sent Hello messages to get fast and accurate update of link breaks. In contrast, slow changeable topology should decrease the needed Hello messages to update connectivity information.

The decision of increasing or decreasing the frequency of Hello messages is made during a fixed period of time through a fuzzy logic system. Fuzzy set theory allows high flexibility to imply information and model complex or ill-defined systems. Uncertainty associated with node mobility estimation and drawbacks of a mathematical model for local connectivity management makes the fuzzy system the best choice.

To implement the proposed method, the Ad hoc On-demand Distance Vector (AODV) routing protocol (Perkins& Royer, 1999; Perkins, 2001; Perkins, 2003) is utilized as the underlying routing platform. AODV is a reactive routing protocol where the routes are determined only as needed. It manages local connectivity using two parameters: `hello _ interval` and `allowed _ hello _ loss`. The `hello _ interval` (HI) specifies the time between two Hello messages; generally set to 1 second. If a neighbor does not receive any packets (Hello messages or otherwise) for more than `allowed _ hello _ loss` × `hello _ interval` seconds, the node should assume the link to this neighbor is broken. The recommended value for `allowed _ hello _ loss` is 2 (Perkins, 2003).

There are several ad hoc routing protocols in the literature that use Hello messages for neighborhood discovery, such as Wireless Routing Protocol (WRP) and Optimized Link State Routing protocol (OLSR), besides AODV (Abolhasan, 2004; Boukerche, 2004; Royer, 1999). Although our proposed method is evaluated with AODV, we believe it can be employed by other ad hoc routing protocols, as well.

The rest of this paper is organized as follows. Next we summarize related work on optimum LCM. This section is succeeded by the implementation of the proposed fuzzy Hello interval method and performance analyses of the proposed method, and then the paper is concluded.

RELATED WORK

Many studies have evaluated ad hoc routing protocols efficiency via utilization of Hello messages in LCM as a metric for those comparisons (Abolhasan, 2004; Boukerche, 2004; Royer, 1999). Research has also focused on the usage of mathematical methods to estimate the stability of the links in ad hoc networks (Jiang, 2001; Turgut, 2001; Gerharz, 2002; Samar, 2004). These studies focus on the choice of links depending