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Adaptive Membership Functions for Handover Decision System in Wireless Mobile Network

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Abstract

Wireless mobile networks in the future are envisioned to demand more intelligent handover decision mechanisms to achieve seamless mobility and services. Fuzzy logic algorithms were proposed to enhance the handover decision process in recent years. However, most proposed algorithms deploy fixed fuzzy membership functions (FMFs). This approach gives an unsatisfactory network selection performance when different traffic types (service options) are required. In this work, we are proposing a new approach to handover decision system (HDS) design. The proposed design incorporates self-tuning of FMFs, which dynamically modifies the FMFs to match the requirements requested. The simulation results show improvements in network selection performance.

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Keywords: Adaptive; Fuzzy Logic; Tuning; Wireless Mobile Networks

1. Introduction

Future architectures of wireless network are pictured to consist of several wireless technologies (e.g., WiFi, WiMAX and 3G/4G Cellular) enabling mobile devices to achieve seamless and universal services, which support numerous traffic types. To achieve such goal, a mobile device may conduct several handovers (either vertical handover (VH) or horizontal handover (HH)). A HH is initiated mainly based on the received signal strength (RSS). For a VH, the initiation relies on numerous parameters [1] resulting in a more complex decision process. Accordingly, a satisfactorily intelligent handover decision system (HDS) deems necessary to accomplish a vertical handover

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procedure optimally. In recent years, fuzzy-based algorithms for VH procedures have been presented [1-2]. Their works are mainly based on a monolithic design having just one fuzzy engine, and deploys fixed set of FMFs. Two major shortcomings discovered are related to unacceptable algorithm execution time (τ) and degraded network selection performance for different traffic types.

Previously, we proposed an adaptive modular design philosophy [3] to reduce τ, and additionally an adaptive mechanism was incorporated (referred to as adaptive modular fuzzy-based HDS (AMHDS design II)) to improve the performance of network selection. In the above work, fixed and dedicated FMFs were used in each individual fuzzy engine. In this paper, we are proposing a new approach to the design of AMHDS, which incorporates a FMF self-tuning process (referred to as dynamic AMHDS) with the aim to further enhance the network selection performance. The dynamic AMHDS design facilitates self-tuning of FMFs to match the requirements of the service option requested. As a result, a single FMF set is maintained. The dynamic AMHDS design is simulated and compared with the AMHDS design II. The results show that the dynamic AMHDS design shows an improvement ranging from 19.61% to 100%.

2. Related Handover Decision Techniques

Several VH decision algorithms with different degree of intelligence and complexity were proposed in the recent years. Due to the rapid growth in multimedia services, the design and development of QoS-aware, fuzzy-based, handover decision algorithm [4] has been attempted. A monolithic fuzzy engine design has been deployed in most of the proposed work. As mentioned earlier the monolithic design has two main drawbacks. It has been shown that a multi-engine design can cope with the former issue [3]. As a result, the value of τ can be significantly reduced.

For the latter issue a fixed FMFs set used in fuzzy engine is unable to perform well in different environment. Hence, the idea of an adaptive mechanism has been introduced within the decision process in order to address this issue. In [5], dedicated FMF sets are used for different parameters to match with different wireless technologies. The approach helps improve a network load balancing and a reduction in handover failure. Different FMF sets are used for data rate and RSS, which helps reduce a number of handovers [1]. In [3], an adaptive modular fuzzy-based HDS has been presented. Unique FMF sets and fuzzy rules were deployed to match with different traffic types. The proposed work improves the network selection performance.

The mentioned adaptive mechanisms do bring about improvements but at a price, i.e. they use a dedicated set of FMFs or fuzzy rules for each individual network parameter or each individual traffic type. This leads to the need for multiple sets of FMFs or fuzzy rules in a given fuzzy-based handover decision system. Clearly, realizing an adaptive behavior without the need for multiple FMFs or fuzzy rules would be of great interest.

3. Proposed Work

Our previous AMHDS design II [3] are based on a static FMF philosophy, i.e. the FMFs are dedicated and fixed for each dedicated fuzzy engine. However, the use of a static FMF-based AMHDS design may become unattractive if the number of dedicated fuzzy engine increases. Instead, the notion of a dynamic FMF philosophy seems much more appealing. In a dynamic FMFs philosophy the adaptive behavior of a fuzzy engine is realized by dynamically modifying its FMF sets. This may be accomplished by the FMF self-tuning process.

3.1. Architecture of Dynamic AMHDS

The dynamic AMHDS architecture is shown in Fig. 1.(a). It is essentially an extended AMHDS design II [3]. A new module, Tuning Engine (TE), has been include to decide whether to initiate the process of FMF self-tuning, to carry out FMF self-tuning process and to communicate with AMHDS design II at different stages of the operation. The TE architecture is shown in Fig. 1.(b). The Tuning Decision Processor (TDP) has the following functions: (i) receives information (service option and usage price preference) from the user, (ii) determines the required wireless network attributes (the minimum data rate and QoS) that satisfy the service option. The required attributes for each service option are pre-defined and stored in the threshold database and (iii) gathers information about the current status of the heterogeneous networking environment, and determines as to which of the available wireless networks offer the required attributes.