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Development of hybrid artificial intelligent based handover decision algorithm

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ABSTRACT

The possibility of seamless handover remains a mirage despite the plethora of existing handover algorithms. The underlying factor responsible for this has been traced to the Handover decision module in the Handover process. Hence, in this paper, the development of novel hybrid artificial intelligent handover decision algorithm has been developed. The developed model is made up of hybrid of Artificial Neural Network (ANN) based prediction model and Fuzzy Logic. On accessing the network, the Received Signal Strength (RSS) was acquired over a period of time to form a time series data. The data was then fed to the newly proposed $k-step$ ahead ANN-based RSS prediction system for estimation of prediction model coefficients. The synaptic weights and adaptive coefficients of the trained ANN was then used to compute the $k-step$ ahead ANN based RSS prediction model coefficients. The predicted RSS value was later codified as Fuzzy sets and in conjunction with other measured network parameters were fed into the Fuzzy logic controller in order to finalize handover decision process. The performance of the newly developed $k-step$ ahead ANN based RSS prediction algorithm was evaluated using simulated and real data acquired from available mobile communication networks. Results obtained in both cases shows that the proposed algorithm is capable of predicting ahead the RSS value to about ±0.0002 dB. Also, the cascaded effect of the complete handover decision module was also evaluated. Results obtained show that the newly proposed hybrid approach was able to reduce ping-pong effect associated with other handover techniques.

1. Introduction

With recent increase in the demand for wireless communications services, there is need to address the problem of inefficient communication and sometimes poor Quality of Service (QoS) associated with wireless mobile communication. Seamless mobility with minimal packet loss and low latency across various mobile network operators have been a mirage [1–5].

In solving the problem of poor QoS coupled with the high demand for quality and efficient on-the-go communication capabilities, network operators have resulted into deployment of mobile cellular network stations in form of Base Transceiver Station (BTS). Signal coverage is usually segmented into cells and each cell is covered by overlapping BTS coverage areas. Movement of communication nodes or mobile stations sometimes refers to as cellular phones or mobile phones in wireless mobile communication system is handled by mobility management protocols which tracks the location of mobile stations in the network (known as location management) and ensures accurate delivery of packets as mobile nodes transverses from one BTS coverage area to another (Handover management) [6].

Handover (also known as Handoff) refers to the process of transferring the point of attachment of mobile station to the network from a BTS to another BTS as the mobile station moves from the region of coverage of the initial BTS to the coverage region of the target BTS. This process is expected to be seamless, thus ensuring that the ongoing process is not dropped and the user does not experience poor QoS.

Efforts in solving the aforementioned problem have resulted in the use of more than one mobile phone with multiple subscriber identification module cards. Despite the short term measures adopted by users, the identified problem especially handover problem across various networks of the same technology has not been solved. Hence, the development of hybrid artificial intelligent based handover decision algorithm has been developed in this

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paper. The hybrid approach consists of a cascade of $k-step$ ahead Artificial Neural Network (ANN) based prediction algorithm and Fuzzy inference system for handover decision making in wireless mobile communication system.

The remaining part of this paper is organized as follows: Detailed review of application of artificial intelligent approaches in handover process is discussed in Section 2. Mathematical derivation of the $k-step$ ahead ANN based prediction algorithm and Fuzzy logic system is presented in Section 3. Results obtained and conclusion are contained in Section 4 and Section 5 respectively.

2. Review: application of artificial intelligence techniques in handover scheme

Several efforts have been reported in the literature regarding application of various artificial intelligent techniques in Handover processes [1–5,7–9]. In this paper, review of reported efforts have been grouped into: ANN based approach; Fuzzy logic based approach; Genetic Algorithm based approach and prediction based approach. Review of ANN based approaches in handover decision process are presented in Section 2.1, while Fuzzy logic based approaches are contained in Section 2.2. Handover decision processes using Genetic Algorithm are presented in Section 2.3 and prediction based are contained in Section 2.4.

2.1. Application of ANN approach in handover Process

The use of a three-layer ANN in Cellular handover management was reported in [3]. The proposed approach involve the use of received signal strength and traffic intensities from the serving and target BTSs in implementing handover decision system. A threshold and hysteresis margin based scheme was adopted and handover decision was triggered only when the received signal is above certain value. Thus, handover decision was based on signal based measurement approach [3].

Development of an ANN based pattern recognition handover Algorithm for micro-cellular systems was proposed in [4]. The scheme adopted the use of Received Signal Strength (RSS) as the measured network parameter for handover decision system. The algorithm works on the assumption that two BTS between which a mobile device moves has the capacity to provide same services. Though, this is often not true due to differences in cell capacity and other conditions. The proposed algorithm involves sampling of the RSS and spatial averaging to formatting pattern at each sampling point as the mobile device moves from one BTS to another. It then assign patterns to different BTS to represent the classes after which ANN was then used for pattern classification. The scheme keeps the average number of handovers and call-drops low, though there was a negligible handover decision delay with the introduction of threshold technique. The method also requires only one training vector of each path and environment which makes the method simpler than other pattern recognition based schemes.

The development of handover performance enhancement in heterogeneous wireless network using ANN was reported in [10]. It involve access modeling along with an adaptive parameter adjustment algorithm using ANN technique. The reported scheme has an adaptive parameter adjustment which makes the handover adaptive to the destination network environment quickly and the variation of the throughput can be avoided efficiently.

Handover decision in wireless mobile communication system using ANN approach was carried out in [11]. A model of 7 cells with different traffic intensities was adopted. The adopted model uses the principle that mobile station in the hysteresis area can connect to more than one BTS and may decide to handover to the BTS with the lowest traffic intensity. ANN was used in taking decision to handover to target BTS. Reduction in the number of handovers was achieved using the proposed approach despite the fact that it considered traffic intensity instead of the number of free channels. Although, incoming calls from mobile stations not in the hysteresis area were blocked.

Using predictive RSS and dwell time, handover decision using ANN was reported in [12]. Adaptive dwell time and merit function were defined, with the dwell time being adjusted according to the movement of the mobile station. In evaluating the proposed approach, heterogeneous wireless network integrating the UMTS, Mobile WiMAX and WLAN was modeled and the proposed network selection algorithm was tested using mobile Internet protocol.

Nasser et al. in [5] presented a handoff network arrangement that depends on neural networks to choose the best cellular network. The developed approach is expected to add into the arrangement of predefined users inclinations, and network parameter. The criteria of weighted elements like cost function, security and bandwidth utilization were normalized between 0 and 1 before being fed into ANN algorithm for handover decision. Performance analysis shows that higher success rate was achieved when compared to other handover techniques.

The use of Cell-based neural networks and K-Means clustering in estimating road traffic congestion from Cellular handover information was reported in [1]. By performing multiple rounds of data collection covering various times of the day, traffic data of various degrees of congestion were obtained. Cell down time information were measured by a cellular phone with specialized features and classified accordingly by K-means clustering algorithm and ANN. The results were then compared against human classification. The results obtained from ANN approach shows better performance with high true positive rate for all degrees of congestion as compared to other techniques. However, the proposed method only estimated for non-signaled road which expert consider to be simple and the pooled cell down time values from all cell sites, without their associated cell identification information, were not adequate to train the network.

2.2. Application of Fuzzy logic approach in handover process

In [7], three separate fuzzifier namely: RSS, speed, and load-balancing were obtained from three distinctive wireless networks in initiating handover process. The approach aimed at applying Fuzzy logic to accomplished the standardization of network parameters so that the same parameters measured from various wireless network would be examined by the fuzzy induction technique. The yield of the fuzzy deduction framework is a numerical measure that is utilized to rank every candidates network. The ranked networks in conjunction with the user inclinations was then utilized in deciding the optimal network.

A multi-adaptive handover technique implemented with Fuzzy logic and optimized with Elman neural system was proposed in [8]. RSS was fundamentally used to trigger handover procedure while the neural system was used to forecast the number of network users in terminal network. The number of users and the mobile station speed, and the bandwidth of the terminal network served as input data to the fuzzy network. The normalization and the converging velocity pace of a conventional Elman neural technique is very slow which needs to be modified by the adjoining network nodes and adjusting the weights to obtain better performance. The technique was benchmarked against the traditional-based vertical handover approach and results obtained shows that the proposed technique gives better precision during handover execution and decision making process.

In [9], Fuzzy logic handover system capable of avoiding ping-pong effect in wireless mobile communication system was

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