Fuzzy Logic Based Multi-input Criterion for Handover Decision in Wireless Heterogeneous Networks

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Abstract. Vertical handover is one of the most prominent challenges in heterogeneous networks (Hetnets) since most of the user devices come with mobility feature. In order to provide a seamless handover between various network topologies, several additional parameters other than signal strength must be taken in account to satisfy user preferences at an acceptable level. This paper proposes a fuzzy logic based multi-input criterion for handover decision in wireless heterogeneous networks that uses received signal strength indicator (RSSI), monetary cost, data rate and mobile station (MS) velocity as the input parameters. The simulation results show that proposed fuzzy logic based algorithm gives an improvement in reduction percentage of number of handover as compared to existing systems.

Keywords: Wireless heterogeneous networks · Self adaptive handover · Fuzzy logic

1 Introduction

For the past two decades, communication systems and portable devices have made a drastic change in our day to day life. This emerging demand of mobile devices need to have an incoherent connectivity in broadband networks and it is a major challenge for the network providers. This challenge is due to the increasing traffic of audio and video streams during any one of the ongoing application processes that includes handover of mobile devices between several base stations (BS) within a specified time duration. Since mobility feature of user devices comes in picture, a new critical operation handover exists in wireless heterogeneous networks during an on call process [8].

When MS travels from one BS to another, it may experience a horizontal or a vertical handover. Horizontal handover involves transfer of active connection between two different base stations within same wireless network where as vertical handover occurs between two different BSs of different wireless technologies [3]. The proposed handover decision algorithm is presented to reduce the number of

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handover in wireless heterogeneous networks. Simulation results show that when velocity of mobile station is increased, urgency of handover is more and when velocity is low and RSSI is high, number of handover occurred is very less compared to the different approaches described in [8].

The remainder of the paper is organised as follows: Sect. 2 reviews prior work. Section 3 discusses proposed fuzzy based algorithm. Simulation results are presented in Sect. 4. Section 5 concludes the paper.

2 Related Work

Nowadays, tremendous growth in the research area of mobile communication has been occurred. Hence, a number of research proposals have been found for the handover mechanism in the literature. Kustiawan et al. proposed a Kalman filtering and Fuzzy logic (FL) based approach to reduce the number of handover [8]. Simulation results show a reduction percentage of 88.88%. Another adaptive neuro-fuzzy based vertical handoff decision algorithm is developed for wireless heterogeneous networks [3]. Results show that it can provide an improvement in performance for both network and user. Calhan et al. discussed several adaptive fuzzy logic based vertical handoff decision making algorithms for wireless overlay networks which consist of UMTS, WiMAX, Wi-Fi, GPRS, GSM technologies [5]. According to the results obtained after comparison with classical MADM (Multiple Attribute Decision Making) method, the system is capable of deciding handover properly and selection of best access point. A FL-based handover method in LTE (Long Term Evolution) is proposed by utilizing input parameters like RSS, coverage area and data rate to improve the packet delivery ratio (PDR) [6]. The results showed a reduction of 33% in packet loss delivery after handover. A combination of genetic algorithm and fuzzy logic is employed to propose a new adaptive vertical handoff decision algorithm [4]. Results shows that the performance of the system significantly improved for user as well as network by reducing number of handover. Singhvora et al. implemented an adaptive neuro-fuzzy inference system to reduce the ping pong effect that inturn improves the performance of heterogeneous networks in [9]. A new adaptive fuzzy based handoff management algorithm is introduced for next generation wireless systems that uses mobile speed and handoff signalling delay information to improve the performance of HMIP (Hierarchical Mobile IP) handoff significantly in [7]. A combination of fuzzy logic and a PRE-MT (Pre-determined Motion Trend) based on motion trend and RSS is presented to mitigate the ping pong effect and thereby increasing system performance [10]. Another vertical handover algorithm, NG-VDA (Next Generation Vertical Handover Decision Algorithm), based on fuzzy logic to provide vertical handover between WLAN and LTE to the customer with reference to multiple parameters is proposed in [1]. Mubarak et al. proposed a handover mechanism based on fuzzy logic with multiple inputs and self adaptive handover parameters in [2]. Simulation results indicate that proposed FuzSAHO (Fuzzy logic based Self Adaptive Handover algorithm) managed to decrease ping pong effect and its delay.

3 Proposed System

Figure 1 exhibits framework of proposed handover algorithm. It consists of four input variables as RSSI, monetary cost, data rate, MS Velocity, fuzzifier, fuzzy inference engine with knowledge base, defuzzifier and output variable as handover decision.

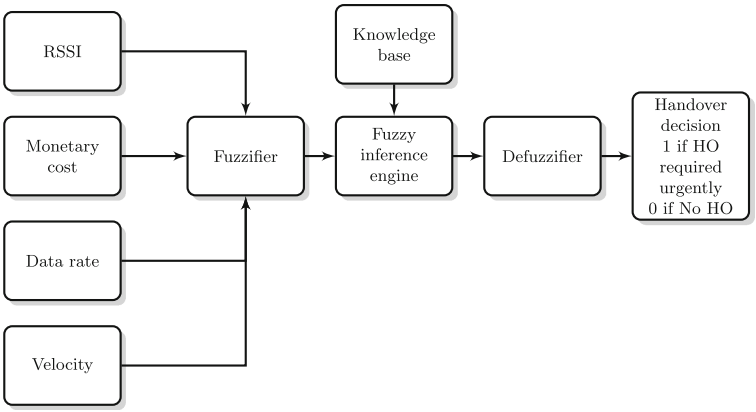


Fig. 1. Block diagram of proposed system

RSSI (Received Signal Strength Indicator) gives the information about availability of a network to access. Network bandwidth conditions are indicated with the help of data rate (DR). Velocity indicates movement of mobile terminal in network coverage area [1]. Monetary cost indicates cost of different services offered to the user. These input parameters are then converted to grades of membership functions from crisp values with the help of a fuzzifier. Mamdani based Fuzzy Inference engine is used to interpret these fuzzified input values based on several predefined rules. The membership functions used in fuzzy logic for these four input variables are shown in Fig. 2. Their linguistic variables are defined as Low (L), Medium (M), and High (H). Information rules are defined in terms of fuzzy IF-THEN rules. For example, *If RSSI is low and Monetary Cost is low and Data rate is low and MS Velocity is low then Handover factor is medium.* To fuzzify all the input and output parameters, both triangular and trapezoidal membership functions are used. Output values are again converted to a set of crisp values by defuzzifier and output parameter i.e. handover decision will determine the urgency of handover.

4 Experimental Results

Experiments are carried out in MATLAB R2012a environment. In proposed system, RSSI, monetary cost, data rate and MS velocity are the fuzzy input variables and handover decision is considered as output variable. It varies between

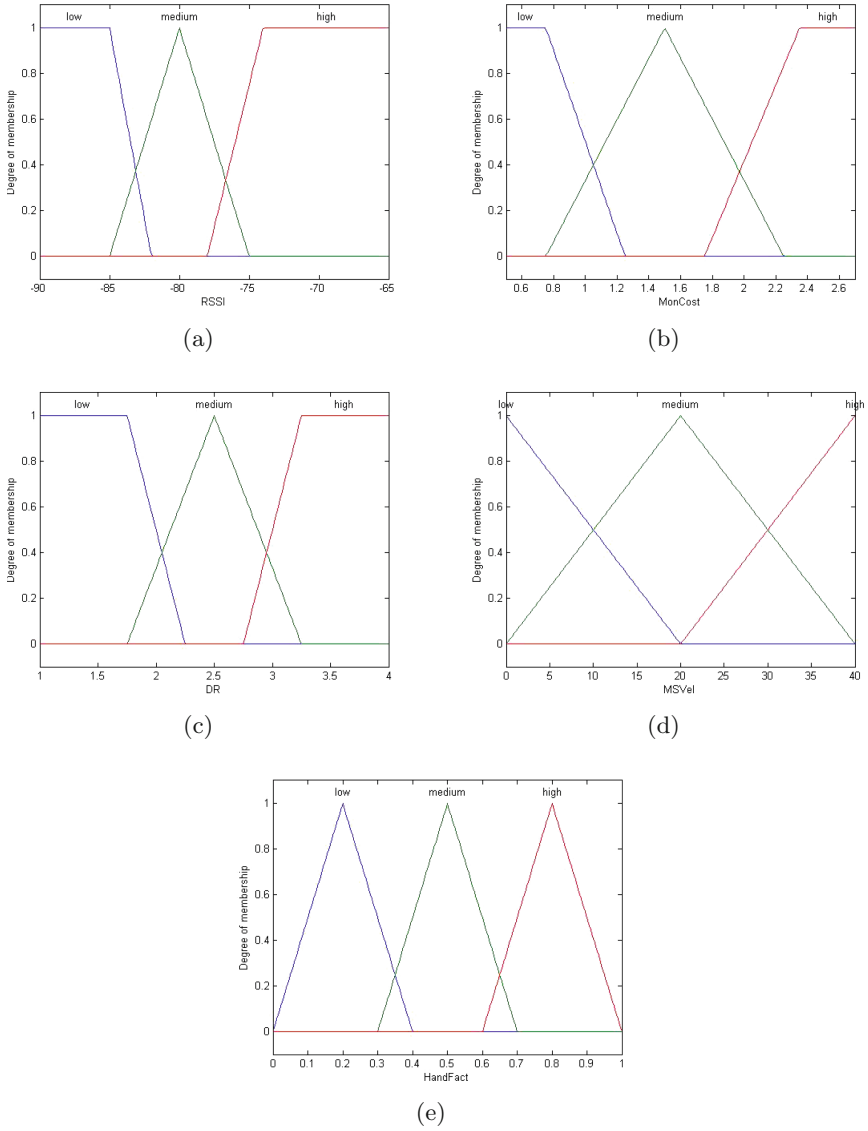


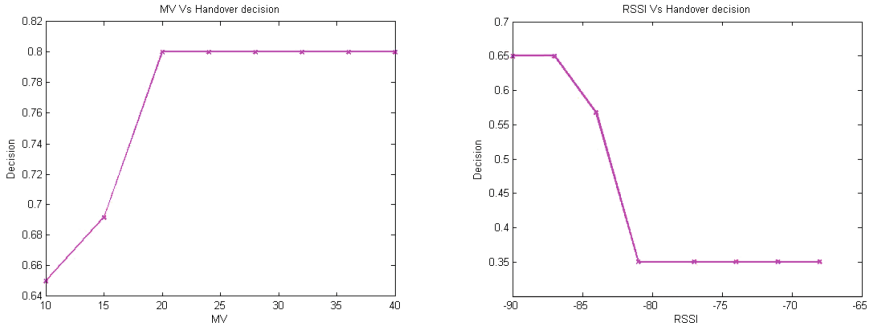
Fig. 2. Membership functions of (a) RSSI (b) Monetary cost (c) Datarate (d) MS velocity and (e) Handover decision factor

0 and 1 where 0 represents no handover and 1 represents urgently required handover. The handover decision factor is set to 0.65. The range of RSSI is between −90 dBm to −68 dBm and velocity ranges from 0–40 m/s. To fuzzify input and output parameters, both triangular and trapezoidal membership functions are

selected in the proposed system. It is found that they gives better performance for most of the real applications [3].

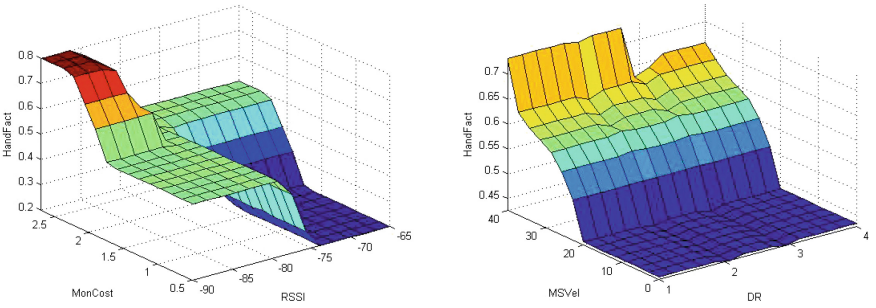
The knowledge base of the fuzzy system consists of several predefined rules and they are exploited by a series of IF-THEN rules which can be defined as a model of expected sequences of possible events. Since proposed algorithm utilizes four input parameters and one output parameter, knowledge base consists of 81 rules (3^4) which are generated by all the possible combinations of input and output parameters of the system. Based on these IF-THEN rules, it unfolds the meaning of input vector values and allots these values to its output vector i.e. whether the handover is urgently required or not. According to different input values i.e. RSSI, Monetary Cost, Data Rate and MS velocity, proposed fuzzy based algorithm provides a handover decision which is self-adaptive.

For this self adaptive fuzzy based multi input handover decision algorithm (FLMCHO), Figs. 3 and 4 show simulation results as per the predefined knowledge base. In Fig. 3a, it shows that when velocity is high, handover decision factor



(a) (b)

Fig. 3. Simulation results (a) MS velocity Vs handover decision (b) RSSI Vs handover decision



(a) (b)

Fig. 4. Surface view for (a) RSSI, monetary cost Vs handover decision (b) MS velocity Vs handover decision

possess high value, i.e. handover is urgently required when velocity is more than 20 m/s. Similarly, when RSSI is low(less than −80 dBm), handover decision is high as shown in Fig. 3b. As per simulation results, our system is able to decide the urgency of handover whenever the signal strength is low and the velocity of the mobile station is high. Figure 4a and b shows surface plot of handover decision factor with respect to input variables. We compared handoff initiation scenarios with several existing schemes in literature. We have 4, 14, 27 and 36 number of hanoffs using combination of Kalman filter and fuzzy logic scheme [8], Mamdani fuzzy logic, Kalman filtered RSSI and traditional fixed RSS approaches. In Fig. 5, it shows that proposed algorithm i.e., FLMCHO reduces the number of handover to 3 as compared to the other approaches hence improves the reduction percentage is improved to 91.66%. The calculation of relative reduction is given as follows: $[(36-3)/36] * 100 = 91.66\%$.

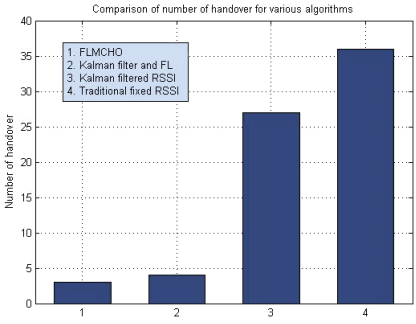


Fig. 5. Comparison of number of handover for various algorithms

5 Conclusion

Due to the impact of several input parameters, handover decision making phase is a crucial task to be performed during vertical handover process. In this paper, we proposed multi-input criterion fuzzy system to verify the urgency of handover. This is done effectively by employing multiple input parameters like RSSI, monetary cost, data rate, and MS velocity. The handover factor should not be either too low or too high to manage quality of services at an acceptable level. Hence, we determined good handover initiations by setting handover decision factor to 0.65. Simulation results show that proposed method effectively reduces number of handover. It improves reduction percentage by 91.66% and outperforms existing handover decision schemes.

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