Minimization of Handover Decisions with Quality of Service Using Fuzzy Logic Prediction Model

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***Abstract*—Artificial Intelligence (AI) based network technologies considered best method to enhance the Quality of Service (QoS) of handoff algorithms due to its ability to handle huge data in fast processing. It helps to take effective handoff decision based on Received Signal Strength (RSS), traffic intensity, speed and diversity. In this paper the fuzzy logic prediction model has been developed for handoff decisions. On retrieving the network, the RSS was developed to form a time series data over a period of time. The data is then proceeded with the newly proposed fuzzy logic prediction model for estimation and prediction coefficients, while the predicted values of RSS are organized as fuzzy sets and in conjunction with other measured parameters of network. Moreover, the Received Signal Strength Indicator (RSSI), traffic load in the network, channel capacity, network load (NL), Bit Error Rate (BER), received signal power level has been estimated throughput the Signal to Noise Ratio (SNR), In addition, to user preferences such as the security and cost of the network. The overall performance of proposed fuzzy logic prediction model is capable to predict the handover decision ahead then the available RSS method and other handover necessity estimation techniques. This model also reduces the ping-pong effect associated with other techniques of handover.**

***Keywords*—Fuzzy logic, handover model, RSS, quality of service, AI**

I. Introduction

An originated handover algorithm is needed to decrease the load on switches while upholding the QoS of the system. A handover is a process to transfer serving base station of mobile from one to another, when the mobile system relocates from one point to another [1]. The quality and the spectral efficiency perceived by users are determined by the handover process of system. The Quality of Service (QoS) and capacity of the communication system can be enhanced by the efficient handover algorithms [2].

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In the environments with heterogeneous networks the handover is a major challenge. The handover becomes more demand in vertical, as the users need to preferred network to serve from different technologies such as Wi-Fi, LTE/UMTS, Wi-Max and so on [3, 4]. The handover decisions depend deferent number of parameters as shown in Fig. 1. The decision making and selection of network is the main problem experienced in networks handover. The decision-making process needs to recognize where and when to initiate handoff, while as to select efficient algorithm for network with guaranteed QoS in less time is handled by selection process. However, in current technology it has become essential to offer efficient mechanism for handover to meet all requirements of QoS and utilize the network resource allocation efficiently.

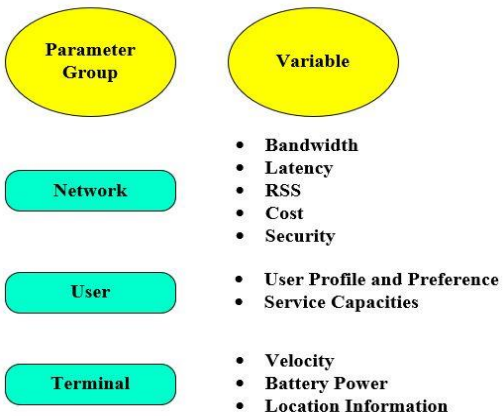

Figure 1. Decision parameters for handoff

Fuzzy logic is used to formulate the mapping from input to the output by the process known as fuzzy inference. Then the decision can be made by providing a basis of mapping. A fuzzy inference system is created by four operational blocks: fuzzy inference engine, fuzzy rule base, De-fuzzifier and Fuzzifier. A flawless handover is normally characterized by two performance constraints [5].

1) The latency of handover should be less than few hundreds of milliseconds

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2) QoS should be identical to sustain the same communication experience by the source and target access networks

To diminish the needless handover and call falling, an effective handover algorithm using the fuzzy logic prediction model including the information of mobile cell is presented in Rayleigh channel [6]. The handover algorithm is differentiated in two ways, handover criteria and processing of handover criteria. The handover algorithms are mentioned in Fig. 2.

TABLE I: DESIRABLE FEATURES OF HANDOVER ALGORITHM

Desirable features of handover (Maximize QoS and Capacity)		
Maximize	**Maintain**	**Minimize**
Reliability Communication Quality	Handover Global Interference	Cell Borders Traffic Balancing

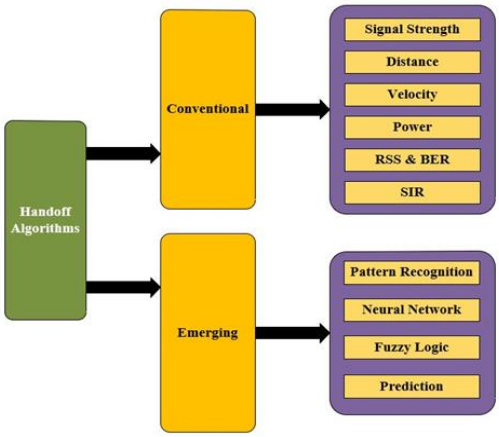


Figure 2. Classifications of handovers

II. SYSTEM MODEL

The handover is the physical transition from one network to other network in IP networks. The handover is of two types horizontal as well as vertical handover. In horizontal change of mobile node of network in the same technology where as in vertical handover the mobile node changes the network with different technology as shown in Fig. 3.

The basic architecture of fuzzy system is shown in Fig. 3, which consists of five sections:

- Fuzzifier- which converts crisp input data into fuzzified data.
- Data Base- Is the membership function of fuzzy sets.
- Rule Base- which contains if-then function.
- Fuzzy Inference System (FIS)- generates aggregated fuzzified data.
- Defuzzifier- which converts aggregated fuzzified data into scalar value.

The algorithm is responsible directly influences the handover performance for making the decision at any stage. Basically, it decides at this stage to which network is going to change, based on schemes like Received signal strength (RSS), decision function, quality of service and algorithms based on fuzzy logic techniques.

Algorithm: Handover based on fuzzy logic

Input(s):
- RSS
- Bandwidth
- Cost
- Velocity

Output:
- Handover to the network

Steps to be followed:
1. Scan all the available candidate network
2. Capture available network parameters
3. Calculate each candidate networks handover value
4. Handover to the highest score network

Actually, the decision is made on the basis of the data provided by the network, after the data is processing, then the algorithm decided which network to change. The whole idea is illustrated in Fig. 4. Some of the main criteria mostly used while making the decision which network to change are: Received Signal Strength Indicator (RSSI), traffic load in the network, channel capacity, Network Load (NL), Bit Error Rate (BER), received signal power level in wireless network, throughput, which measure the amount of data received successfully, Signal to Noise Ratio (SNR). In addition, user preferences such as the security and cost of the network.

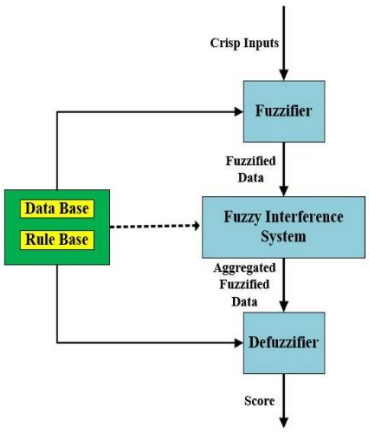


Figure 3. Architecture of fuzzy logic system

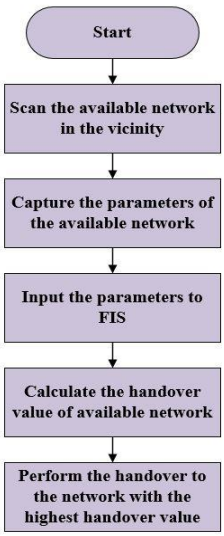


Figure 4. Handover flowchart

The fuzzy logic predication model has been used to demonstrate good prediction values and the output of prediction system was then fed up to fuzzy inference system to take efficient and necessary handover decision. The block diagram of Fuzzy Inference System (FIS) is shown in Fig. 5. The fuzzy inference system involves many factors where some factors can hinder quantification. Fuzzy logic uses all these policies to change the decision while try to balance the burden of network efficiency at the same time.

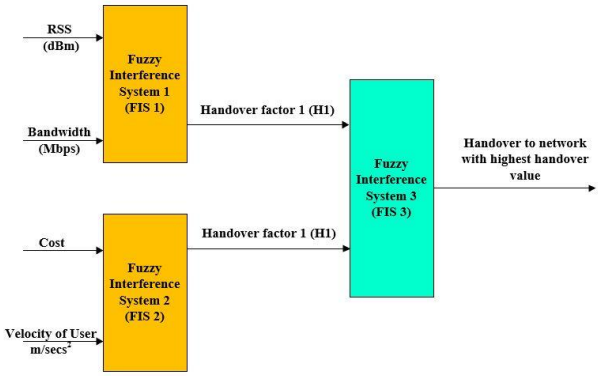


Figure 5. Block diagram of fuzzy inference system

The strength of signal is calculated [7] using

$$10log_{10}P_r = 10log_{10}P_0 - 10\alpha log_{10}D + X \quad (1)$$

where,

$10log_{10}P_o = 10log_{10}P_t + 10log_{10}G_t + 10log_{10}G_r + 20log_{10}\frac{\lambda}{4\pi}$ is received power, P_t is transmission power, λ is wavelength, $G_r = G_t = 1$ are the gains of receiver and transmitter antenna and $\alpha$is the gradient pathloss. However, the velocity is measured in [8] which depends on magnitude and direction of movement.

$$V_i = V_i * p + \sqrt{1-p^2} \times V_m \times X \quad (2)$$

where, the complex speed of NMs is V_i, the correlation of velocity between time interval is p, distribution magnitude of Rayleigh is X. the mobile nodes mean speed is V_m along with the distance D measured in between SMAG and MN. To predicted the best handover decision of the network these all parameters are used and are normalized by normalization function [9]

$$N = \frac{val - val_{min}}{val_{max} - val_{min}} \quad (3)$$

The value for normalization ids deducted by initially minimizing the minimum value from the variable to be normalized. The minimum value is deducted from the maximum value and the previous value is divided by the response earlier.

For the signal strength the normalization function NRS is written as,

$$NRS = \begin{cases} 0, & 0 \le RS \le RS_{th} \\ \frac{RS_x - RS_{th}}{RS_m - RS_{th}}, & RSS_x > RS_{th} \end{cases} \quad (4)$$

RS_x, RS_{th} and RS_m are the measured, threshold and expected values respectively. Also, for the velocity the normalization function NV is written as,

$$NV = \begin{cases} 0, & 0 \le V_x \le V_m \\ 1 - \frac{V_x}{V_m}, & V_x \ge V_m \end{cases} \quad (5)$$

where, the normalized function of distance is

$$S = \begin{cases} 0, & 0 \le d \le d_{max} \\ \frac{d}{d_{max} - d}, & d \ge d_{max} \end{cases} \quad (6)$$

Then all the normalized values while using the membership functions are converted into linguistic values. The output of the rule base is high, medium and slow.

III. Development of Fuzzy Logic – Based Handover Decision Algorithm

The fuzzy logic-based handover decision algorithm consists of three stages as shown in Fig. 6. Namely fuzzification stage, fuzzy inference stage and defuzzification stage [10]. Every stage is discussed below.

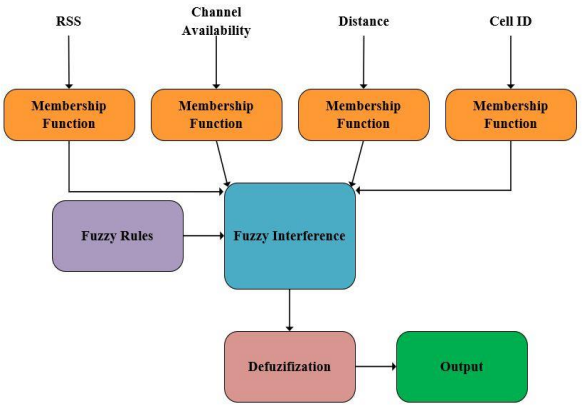


Figure 6. Fuzzy logic-based handover decision algorithm

A. Fuzzification Stage

This stage defines all memberships functions fuzzy logic inputs, the triangular membership is implemented in this stage. Other inputs used in this stage asides from RSS predicted value are, mobile station (MS) GPS to estimate the distance of the MS from nearby BTS, availability of channel and cell identity. For every input parameter the fuzzy sets are.

$$RSS = F(VL, L, H, VH, EH) \quad (7)$$

where, VL, L, H, VH and EH means (very low, low, high, very high and extremely high) RSS values.

$$CA = F(A, NA) \quad (8)$$

Here, A means availability of channel and NA is No availability of channel

$$D = F(VF, F, N, VN) \quad (9)$$

where VF, F, N, and VN means very far, far, near, very near from BTS

$$CI = F(VB, NT) \quad (10)$$

where NT means known terrain and VB means very new terrain.

Whereas the handover decision fuzzy set linguistic variable is defined as

$$HD = F(HG, HM, HHEHG) \quad (11)$$

where HG, HM, HE and HA mean handover to Glo, MNT, Etisalat and Airtel.

B. *Fuzzy Inference Stage*

The fuzzy inference stage is used in fuzzy logic-based handover decision, max-min inference was demoralized where implementing if-then rules. On the basis of set rules, the output was assumed by implementing the input parameters of minimum linguistic variables with the help of fuzzy inference.

C. *Defuzzification Stage*

Centroid defuzzification is applied after obtaining the output to obtain the handover decision numerical value. The defuzzification stage decides on the base of De-fuzzifier on which network to handover.

IV. Result and Discussion

Fuzzy logic prediction model is used for making efficient handover decision to choose neighbouring base station. The input is applied to fuzzifier to transform the input into fuzzy sets, then these fuzzy sets are applied to fuzzy inference engine where IF-THEN rules are applied to obtain fuzzy decision sets then passed to the De-fuzzifier to convert into precise quality to make the efficient handover decision.

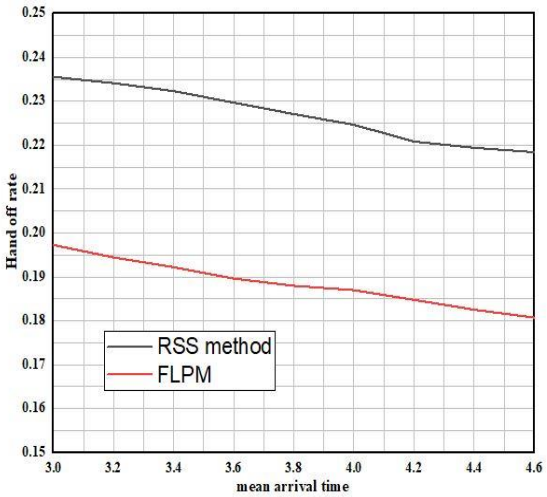


Figure 7. Handover rate versus mean arrival time.

In Fig. 7 the rate of handover decreases when the mean arrival time increases. While as in Fig. 8, the rate of handover increases when the intensity of traffic increases. Figs. 7-8 Shows the importance of using fuzzy logic to decide the efficient handoff decisions. By using the fuzzy logic prediction model the handover rate and blocking rate is lowest in any traffic intensity. To consider the position of user, direction, signal strength and unnecessary handover.

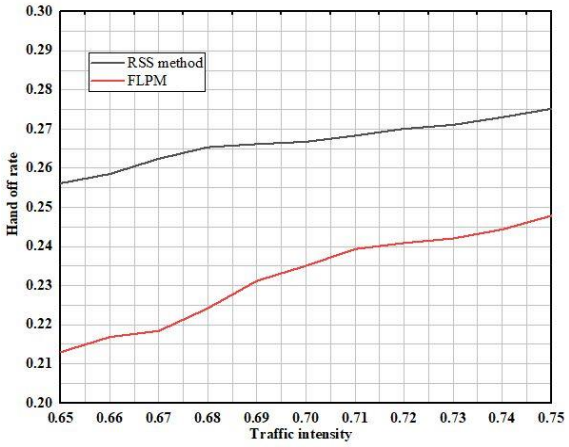


Figure 8. Handover rate versus intensity of traffic.

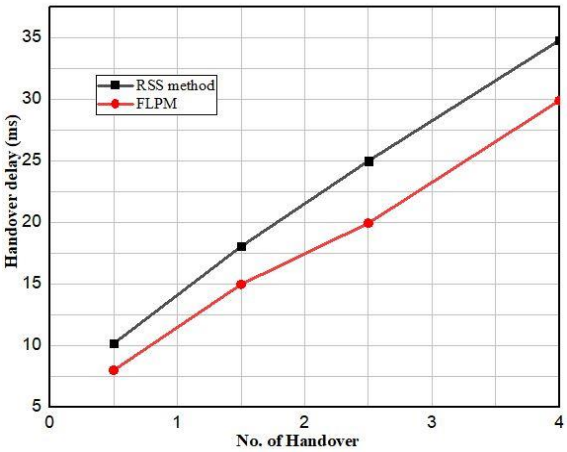


Figure 9. Handover delay reductions.

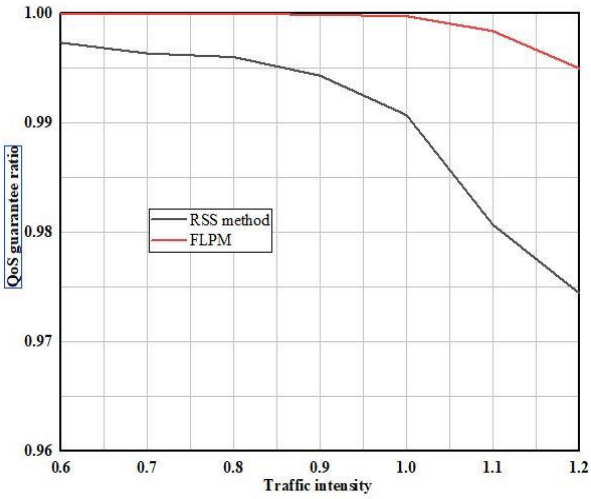
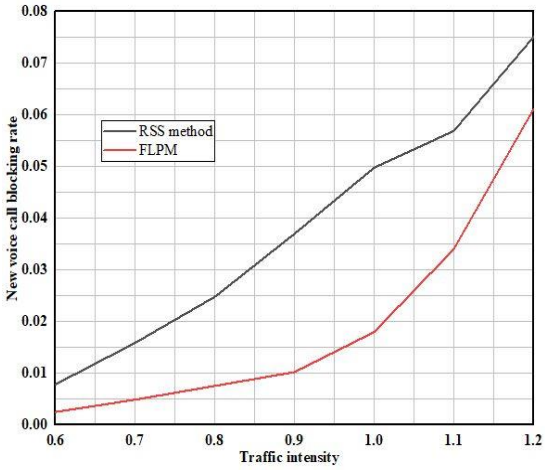


Figure 10. Mean QoS guarantee ratio versus intensity of traffic.

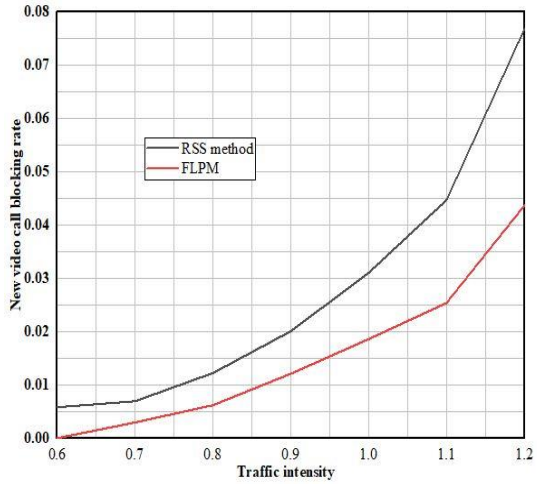
The Fig. 10 shows the mean QoS guarantee ratios of all services with intensity of traffic it can found that it maintains the QoS requirements with the traffic intensity is as high as 1.2. the reason is that the FLPM choose the appropriately efficient decision and significant system measures to reject or accept the handover request.

Fig. 11 (a-b), show the new voice and video call blocking rates versus the average time intensity. In above

figures it is found that the FLPM has lower average call blocking rates the other techniques. The main reason is that the FLPM considers well realistic, user mobility and essential system measures in the WCDMA systems as well as WLAN systems.



(a)



(b)

Figure 11. (a) New voice call blocking rate and (b) New video call blocking rate

V. Conclusion

In this paper the fuzzy logic prediction model has been developed for handoff decisions in wireless communication system. Basically, the FLP model has been used to demonstrate good prediction values and the output of prediction system was then fed up to fuzzy inference system to take efficient and necessary handover decision. The results after simulation shows that the FLP model approach was able to take necessary and efficient handover decision and avoid ping-pong effect. The fuzzy logic prediction model decides to which network is going to change, based on schemes like received signal strength indicator (RSSI), traffic load in the network, channel capacity, network load (NL), bit error rate (BER), received signal power level in wireless network. Throughput, which measure the amount of data received successfully, signal to noise ratio (SNR). In addition, user preferences such as the security and cost of the network. Whereas the QoS requirements and the candidate's admission request has been considered.

Conflict of Interest

The authors declare no conflict of interests.

Author Contributions

The authors confirm contribution to the paper as follows:

Study conception and design: Altaf. A. Balkhi, Javaid A. Sheikh; data collection: Altaf A. Balkhi; analysis and interpretation of results Altaf A. Balkhi, Javaid A. Sheikh, Ishfaq B. Sofi, Zahid A. Bhat, and G. M. Mir; draft manuscript preparation: Altaf A. Balkhi, Ishfaq B. Sofi, Zahid A. Bhat.

All authors reviewed the results and approved the final version of the manuscript.

The author confirms sole responsibility for the following: study conception and design, data collection, analysis and interpretation of results, and manuscript preparation.

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