Handover Decision in Wireless Heterogeneous Networks Based on Feedforward Artificial Neural Network

Archa G. Mahira and Mansi S. Subhedar

Abstract In heterogeneous networks, vertical handover decision is a significant issue due to increasing demand of customers to access various service features among them. In order to provide a seamless transfer between various technologies, the effect of various user preference metrics and network conditions needs to be considered. This paper proposes a multilayer feedforward artificial neural network algorithm for handover decision in wireless heterogeneous networks. Neural network aids in taking the handover and selection of best candidate based on data rate, service cost, received signal strength indicator (RSSI) and velocity of mobile device. Experimental results show an improvement in reducing number of handover effectively as compared to other existing systems. It is found that probability of handover decision is also improved.

Keywords Wireless heterogeneous networks · Seamless mobility · Self-adaptive handover · Artificial neural networks

1 Introduction

The customer's needs for accessing to high-speed data services anywhere at anytime led to the development of next-generation wireless technologies. The forthcoming wireless networks are capable of providing high-speed data services with seamless connectivity and integration among various mobile heterogeneous networks (HetNets). The goal of seamless connectivity is to provide continuity of access to any kind of desired data services at instant of time. Hence, mobility management is a very challenging task while maintaining service continuity.

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When a mobile station (MS) gets transferred from the coverage area of its serving base station (BS) to another, there occurs either a vertical handover or a horizontal handover. In 4G networks, vertical handover occurs due to the integration of different wireless technologies. In this paper, we proposed an artificial neural network (ANN)-based algorithm to decrease the effect of handover counts in forthcoming heterogeneous networks.

The rest of the paper is organised as follows: Sect. 2 reviews previous work related to this article. Section 3 presents artificial neural network-based handover decision algorithm. Experimental results are presented in Sect. 4. Section 5 concludes the paper.

2 Related Work

Recently, numerous research works have been proposed for the handover mechanism to provide an uninterrupted service to customers. Kustiawan et al. proposed a fuzzy logic-based handover decision algorithm with a channel equalisation technique called Kalman filter to reduce handover initiations effectively [1]. Simulation results show a 88.88% reduction in number of handover. Calhan et al. proposed a handoff decision system based on ANN in order to reduce the handoff latency. Simulation results show that a reduction in handoff delay and the number of handoff is satisfactory [2]. Alsamhi et al. discussed an intelligent handoff algorithm to enhance quality of service (QoS) in high-altitude platforms using neural networks [3]. Results show that handoff rate and blocking rate are enhanced. A machine learning scheme based on neural networks for vertical handover is presented to achieve seamless connectivity and always best connected call status [4]. The performance results showed an enhancement of QoS perceived by both voice and data services. A new network selection algorithm is proposed based on particle swarm optimisation [5]. Results show that performance of the system significantly reduces computational complexity and time. Xiaohuan Yan et al. presented a comprehensive survey of the vertical handover algorithms developed to satisfy user requirements [6]. A variety of vertical handover decision algorithms are also discussed that include RSSI-based, cost function-based and QoS-based schemes. A solution to the challenging task of handoff is proposed using artificial neural networks [7]. The proposed method is able to distinguish the best existing network by matching predefined user preferences. A new neural network prediction system that is able to capture some of the patterns exhibited by users moving in a wireless environment is presented [8]. A neural network-based method to model access network and an adaptive parameter adjustment algorithm is presented in [9]. The simulation study shows that the scheme allows user to access the destination network quickly and variation in throughput can be ignored efficiently. Another algorithm based on particle swarm optimisation for vertical handoff decision in HetNets is presented in [10]. This method reduces call blocking probability. Mubarak et al. introduced a self-adaptive handover (FuzSAHO) algorithm based on fuzzy logic [11]. The simulation results indicate a reduction in handover delay and ping-pong handover effectively.

3 Proposed System

A multilayer feedforward artificial neural network algorithm is employed to find the best target network accessible to user equipment to handover the ongoing call process. Figure 1 depicts architecture of proposed handover algorithm using artificial neural networks. The proposed algorithm consists of four layers. First layer is composed of four input neurons such as MS velocity, monetary cost, data rate, RSSI and output layer as handover decision. The two hidden layers are composed of several nodes which use hyperbolic tangent sigmoid transfer functions.

The proposed vertical handover criterion uses several input parameters to provide seamless connectivity among various wireless heterogeneous technologies such as received signal strength, monetary cost, data rate and mobile station velocity. RSSI

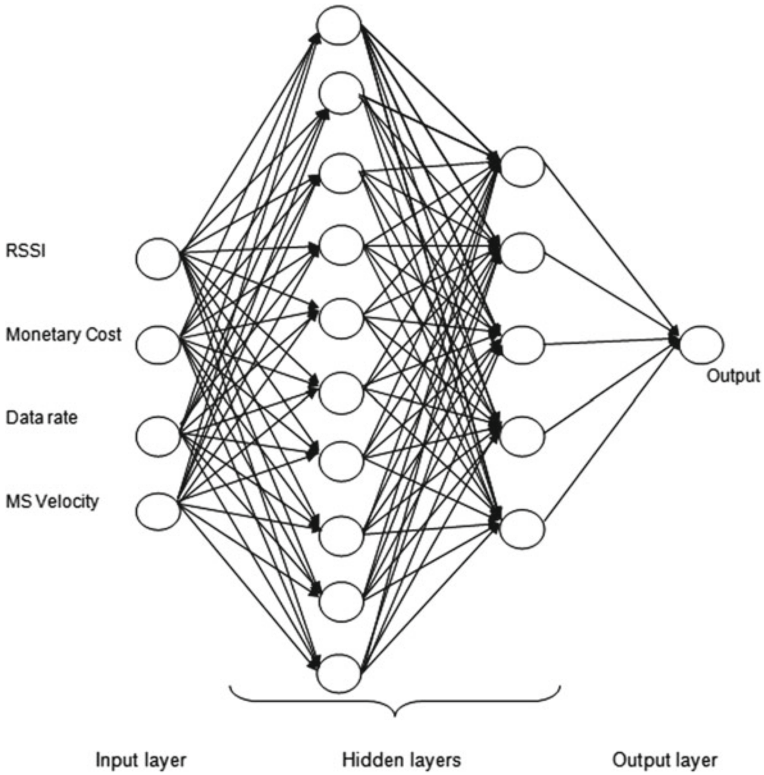

Fig. 1 Structure of proposed artificial neural network

Table 1 Range of input parameters

Inputs	Range
RSSI (dBm)	−90 to −65
Monetary cost	0.5–2.7
Data rate (mbps)	1–4
MS velocity (m/s)	0–40

(received signal strength indicator) indicates the availability of a network, and velocity indicates the movement of mobile terminal in network coverage area. These are the most important criterion for both the horizontal and vertical handover mechanisms. Network bandwidth conditions are provided with the help of data rate. Monetary cost indicates different charging policies provided by different networks to the user. The range of input variables is depicted in Table 1.

The proposed algorithm for handover decision can be summarised as follows.

Step 1: Define simulation parameters and measure the received signal strength using cost231hata propagation model

Step 2: Load trained ANN structure and get the parameters for all neighbouring base stations for handover

Step 3: Decide whether the mobile station is in the coverage area of current wireless heterogeneous network. If location of MS $\leqq$ 200 and location of MS $\geqq$ 1, then MS is in the coverage area of current BS

Step 4: Save parameters of various BS in the Handover Decision Matrix (HDM)

Step 5: Evaluate each BS's parameters with simulated neural network and get BSCV (Base Station Candidacy Value)

Step 6: Save the BSCV in HDM

Step 7: Compare each BS's BSCV value and choose the best BS with largest BSCV

Step 8: Compare the largest BSCV with handover resolution

Step 9: If the best BS's BSCV value is higher than handover resolution and current BS's BSCV, handover will be initiated.

4 Experimental Results

Experiments are obtained using MATLAB 2012a platform. In the proposed system, to train the input and output pairs, Levenberg Marquardt backpropagation algorithm is chosen which is the fastest and repetitive neural network algorithm. The feedforward ANN architecture with 4 input variables and two hidden layers is developed based on LM algorithm. The simulation parameters used are depicted in Table 2.

The input layer consists of four neurons corresponding to each input variable such as RSSI, monetary cost, data rate and MS velocity. First hidden layer consists of 10 neurons, and second hidden layer consists of 5 neurons in the proposed ANN architecture. The hyperbolic tangent sigmoid transfer functions are selected for first two hidden layers. Hyperbolic tangent is used as activation function since it is

Table 2 Parameters used for simulation

Simulation parameters	Value
Propagation model	cost231hata
Effective BS antenna height	50 m
Effective receiver antenna height	2 m
Distance between BS to BS	1 km
Handover resolution	0.2

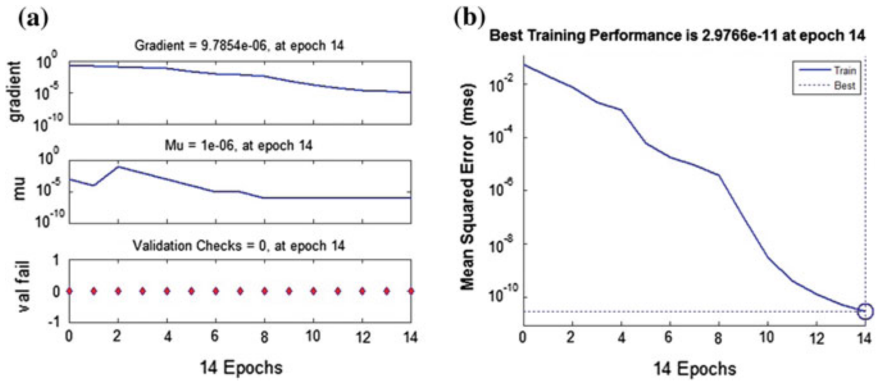

Fig. 2 **a** Training process of ANN and **b** performance plot of proposed ANN

completely symmetric, and its derivative can easily be obtained [2]. Output layer gives handover decision value. It is a binary signal that varies between 0–1 where 1 represents urgently required handover and 0 represents no handover is required. The linear function is selected as transfer function for output layer. The value of RSSI varies from −90 to −65 dBm, and the range of velocity varies between 0 and 40 m/s. The learning rate and maximum number of epochs to train ANN have been set to 0.01 and 1000, respectively.

Figure 2a depicts the training process of multilayer feedforward system for vertical handover decision (MFVHO). It shows that error between desired output and actual output reduces by the correction of network weights. The error value obtains minimum value 9.7854e-06 at epoch 14. The best training performance is 2.9766e-11 at epoch 14 as shown in Fig. 2b. As shown in Fig. 3, handover decision probability increases as velocity increases. Hence, the system is capable of transferring the access to the neighbouring BS quickly and efficiently, whenever the user reaches the boundary of coverage region of current base station (BS).

We compared handoff initiation scenarios with several existing schemes in the literature. We have 4, 14, 27 and 36 number of handoffs using combination of Kalman filter and fuzzy logic scheme [1], Mamdani fuzzy logic, Kalman filtered RSSI and traditional fixed RSSI approaches. As shown in Fig. 4, the proposed MFVHO system reduces the number of handover considerably as compared to other existingalgorithms with a relative reduction percentage of 93.75. The calculation of relative

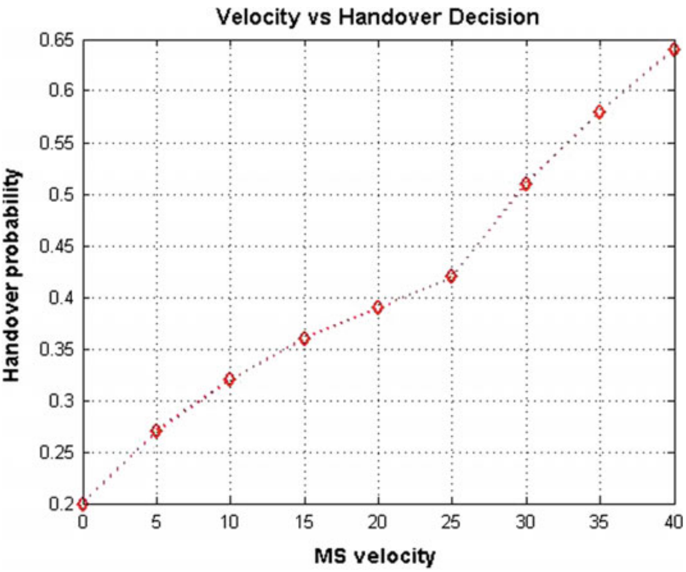

Fig. 3 MS velocity versus handover probability

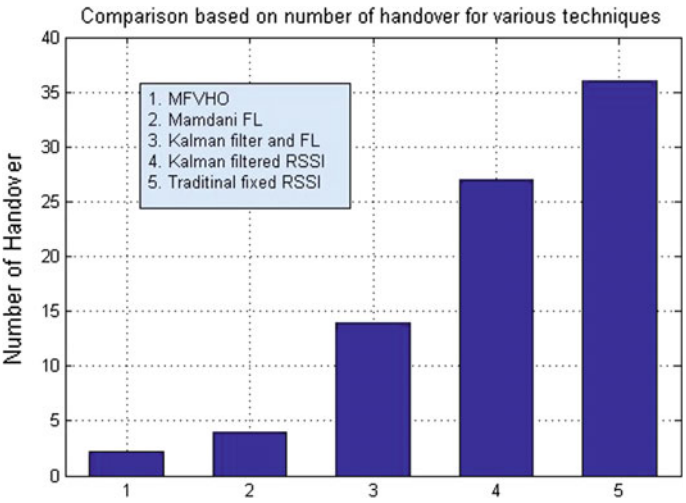

Fig. 4 Comparison based on number of handover for various existing techniques with MFVHO

reduction is given as follows: $(36 - 2.25)/36 * 100 = 93.75\%$. During an ongoing call process, if the number of handovers is more, then it results in a greater probability of call dropping, a delay in processing of handover requests. Thus, RSSI will get reduced to a level of unacceptable quality over a longer period of time due to higher number of handover.

5 Conclusion

A feedforward neural network-based handover decision algorithm has been presented in this paper for the selection of best available network while transfer of ongoing call or data services takes place. The input set of MFVHO algorithm considered several factors such as data rate, monetary cost, velocity of user equipment and received signal strength. The simulation study shows that the proposed multicriterion improves reduction percentage by 93.75% and reduces the number of handover effectively. The reduction in number of handover reduces call dropping probability as well as delay in processing of handover initiation requests effectively. Thus, it is endorsed that our MFVHO criterion outperforms various existing handover decision techniques for intersystem roaming scenarios between heterogeneous networks.

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