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Interoperability in Heterogeneous Wireless Networks Using FIS-ENN Vertical Handover Model

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Abstract
Wireless network system aims to provide dedicated links to the users for improving the quality of services. Particularly in heterogeneous network seamless connectivity is the important requirement for the users utilizing multimedia services. Vertical handover (VH) mechanism provides uninterrupted service to the users in a multiple wireless network region by selecting the best available network. Unlike horizontal handover (one base station to another or nearby access point) VH chooses the wireless access technologies (Wi-Fi to 4G). To improve the QoS of VH model the decision phase needs efficient metrics for providing excellent service. In general a fuzzy based operating model is most suitable for decision making and to implement a seamless handover, neural network is used in the proposed research work. An experimental result describes the best decision making module by comparing the proposed hybrid model with existing models.

Keywords Handoff · Wireless network · Handover management · Fuzzy · Elman neural network

1 Introduction

In the wireless access technologies utilization of one or more networks is common due to the user requirements and it is necessary for the service provider to provide uninterrupted service to the users. When an individual accessing heterogeneous wireless network such as wireless LAN and wireless WAN or Wi-Fi to GSM/LTE/UMTS/IEEE 802.x services vice versa based on the coverage area the quality of service varies in WLAN and WWAN for each user. Usually WLAN provides a hotspot access which covers only a small area and it doesn't have any mobility support. WWAN is a high mobility design which covers large area to provide better QoS to the user. Most of the devices in current era are supported by WLAN access specifies 802.11 standard and WWAN uses 4^{th} generation Long term

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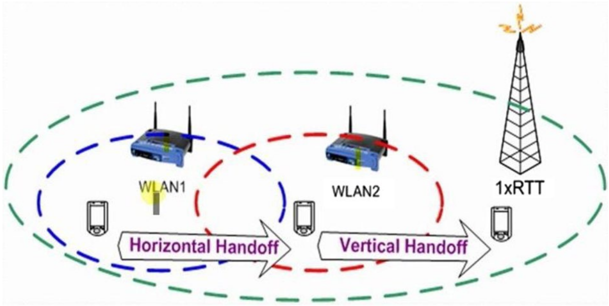

Fig. 1 Classification of hand over

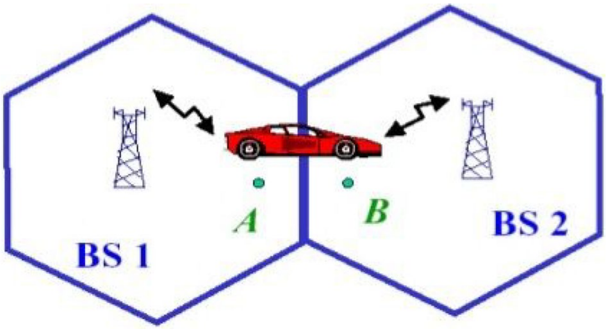

Fig. 2 Illustration of hand off process

evolution and 3rd Generation partnership project based on universal mobile telecommunication systems (UMTS).

Various approaches are considered in the handover execution process to provide uninterrupted services to the users. Based on the characteristics handover is classified into hard handover and soft handover. An internet protocol solution which is related to network phenomenon characterizes the handover into fast, smooth, seamless and lossless. Figure 1 depicts the illustration of hand over and its classifications.

Hard handover process operated based on the connection establishment between the target network and the current network. If the handover process is initiated and the user device is allowed to connect only one network at a time and to establish a new connection the previous link must be released. Such process defines hard handover and it has the limitation in connection establishment. Soft handover also defined as 'make-before-break' process (Fig. 2).

The limitation in the hard handover is overcome by this so that the connection loss problem is rectified due to its policies. In the soft handover the earlier connection is released only after the user gets connected into the new network. So that at some point while in the connection establishment time the user retain in the current network and also in the target network. Lossless handover defines about the packet loss when the handover process takes place. While compared to hard handover to soft handover it has an advantage of minimum packet loss. A seamless handover is the combination of fast and smooth handover and it has the advantage of transparent transition to the user about the packet information. Based on the handover types and its characteristics following handover strategies is followed in the decision making phase.

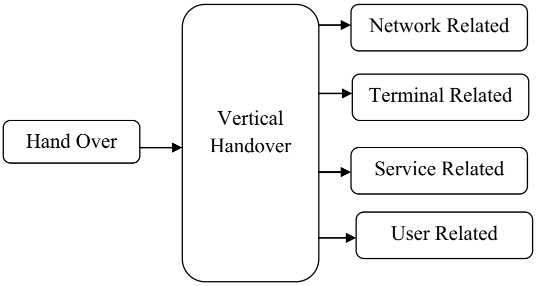

Fig. 3 Classification of VHO

- Network controlled handover (NCHO)
- Mobile controlled Handover (MCHO)
- Mobile Assisted Handover (MAHO)
- Network Assisted Handover (NAHO)

Vertical handover is the emerging research in the heterogeneous wireless networks as horizontal has limitations in its handover process. Since the availability of multi network creates a necessity to define a vertical handover model to process the context information which decide and identifies the handover requirements. The process is responsible for selection of best network which is readily available to establish connection rather than searching the same type of network. The general process is defined in to three steps such as system discovery, handover decision and execution.

System discovery is the initial step in the handover process which collects the information about the system and periodically checks for the necessary mobile terminal to be handed over. Based on the threshold value system discovery process initiates the current network only if the network doesn't able to provide service to the ongoing connection and this reduces the QoS of the network. This makes a VHO is necessary to make decision during the handover selection. Handover decision is the second factor in which decision making process is performed based on the available wireless access networks. In the system discovery process once the network is identified and the collected information is processed to select the network terminal. Based on the availability and present reliability handover decision is made in the handover process. A handover execution is the last phase in which procedure for signalling messages and establishing connection to the user from one network to another network. A vertical handover decision criterion is classified into four categories. Figure 3 depicts about the VHO classification and its sub classes.

Network related classification is defines based on the network conditions and its preferences. System performance is considered as important in the network related work. Network coverage, received signal strength, bandwidth, Load, Link quality (Bit error rate, signal to interference noise ratio), security is the important parameters considered under the network related classifications. Terminal related classification deals with the capabilities and mobility patters of the network and users. Parameters such as velocity, battery power, supported radio access technologies are considered before

VHO process. Service related classification deals with the parameters such as latency, reliability, and data transfer rate to support different classes of services. In the last user related classification defines the preference such as Quality of services and cost. Many research works is performed to address the decision parameters for developing a high potential user preference service provider. The research work is organized as follows. Section II gives the detailed description about the related works in the VHO, Section III provides a hybrid fuzzy and Neural based Decision model, Section IV concludes the research work with experimental results compared with conventional models of other research works.

2 Related Works

In heterogeneous wireless access technology various research works are evaluated by various researchers and this section discusses about the issues and challenges in their existing models. The literature work [1] describes the advances in the upcoming evolutionary 5G technology. This article highlights the issues in the existing technologies and compared the parameters for all the generation. Architecture of 5G mobile and the advantages in the user terminals are explained along with nanotechnology, cloud computing and IP platforms. Research work [2] focuses about the handover process using the cellular mobile communication modules such as mobile system and base station. Vertical and horizontal handover is discussed in [3–6] in which handover happening between the cell to cell in LTE [7] is considered as horizontal handover where as handover between LTE to WiMAX is described as vertical handover [8]. A survey [9] has been made on advanced LTE system requirements and discussed about the fractional soft handover and multi carrier handover along with the existing models.

The findings from research [10] describes about the reinforced handover algorithm for moving vehicles and users. In this research work bully s algorithm is used to select the coordinates. This selection module effectively reduces the requests in the handover process. Multi point coordinate is used in the literature [11] for the handover process in the Japan pioneer mobile internet connections. The aim of this research work is to improve the quality of the service to users in both channel and utilization domain. Ping pong avoidance is used in the research work [5] for improving the handover performance. Using the early handover ping pong avoidance system multiple commands are possible in the hand over process between the target NB and best NB.

Literature [12] describes about the multiple preparation and soft frequency reuse in the wireless networks to design a fast handover module with high performance and reduced interference. In the total bandwidth is subdivided into sub-bands for providing the full description about the radio protocol and companion specification of the 3GPP. It provides the details about the radio protocol and interface protocol for the complete series. Different versions of radio protocol is described and presented in the research work for signalling process between the NB and UTRAN.

The literature [13] describes a door to door short distance radio communication and its interference issues. In MIMO system channel state information and high data rates are achieved and it is compared with the normal point to point communication. Handover

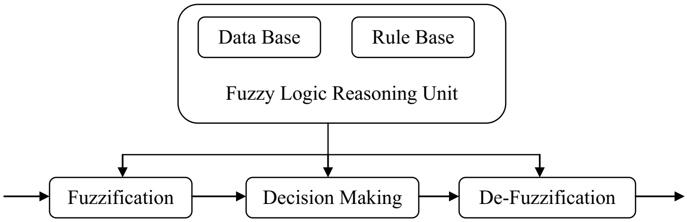

Fig. 4 The basic structure of a fuzzy inference system

failure reduction is discussed in literature [14] using the information received from the UE history. Ping pong handover is depends on the historical information of the domain region to trigger the network to initiate the handoff process even before the signalling takes places. In the literature [15] different types of hand over process in LTE network is discusses along with the radio link failure module. Early handover preparation is discussed in this research work for defining the authoritative transmission of the handover even in weak signal areas. Handover command (HOCMD) is used in the system model to define the commands in the connection establishment process.

An average detected signal power based research work is addressed in literature [16] to developing a simple handover module based on the detected signal power. Based on this signal power the link is selected by the network model to establish a continuous service to the users. LTE based synchronization model is defined in literature [17] for handling mobile network issues in the macro FDD and TDD. Research work provides the solution for existence LTE model and also has design for the proposed model which overcomes the issues in the FDD and TDD design. Research work [18] provides a detailed description about the LTE technology by highlighting the performance and characteristics development from 4G. In order to support radio access technology the architecture is compared and analysed along with the 3GPP and 4G. The findings from [17, 19] describe the LTE A system. This is a combination of LTE and coordinates multiple transmission and reception service. Joint processing in LTE use of CoMP handover is discussed in literature [17].

The last part of the survey work concludes with the research work [20] which discusses the time delay and prediction system of handover in LTE based on location tracking. In this research work user direction is predicted using the previous location as reference and selecting the target NB from UTRAN NB for handover process. From the findings it is observed that vertical handoff [21] is essential for the present heterogeneous type of networks and a suitable decision making model is to be designed for efficient utilization of network and to improve its QoS. This proposed model uses fuzzy and neural network based model in the handover process to improve the QoS [22].

3 Proposed Work

Fuzzy logic deals decision process uses and it has a capacity to analyze the imprecise data and the behaviour of receiver signal strength and the load or bit error rate. In order to obtain the best choice of link to the user fuzzy system is combined with other methods to provide desired results. The proposed model uses fuzzy as decision making tool along with the feed forward artificial neural network. A fuzzy multi criteria vertical handover algorithm is mainly based on the logic controls defined in the fuzzy system. Multiple criteria is considered for received energy and power density for the divided band. The mobile load terminal is used to describe the system behaviour. Using the multi layer artificial feed forward neural network obtains the relationship between the fuzzy parameters and traffic variations for the environment.

A heuristic multilayer feed forward artificial network is used for developing vertical handover decision model. Figure 4 depicts the neural network model used in the wireless networks. The process starts from collecting information from available wireless networks and send to the vertical handover manager through the available link. The network features are used to identify the handover decision based on the cost, transmission, range and capacity.

The VHD manager consists of network handling manager, ANN training module, and feature collector. FFANN is used to determine the best handover from the available network to the target network. The general topology of ANN consists of three layers such as input layer, hidden layer and output layer. Figure 5 shows the input has 5 nodes representing various parameters for the target network. The hidden layer has activated functions based on the number of nodes. The output layer consists of one node which generates network ID for the handover target. Some cost function is activated for ANN

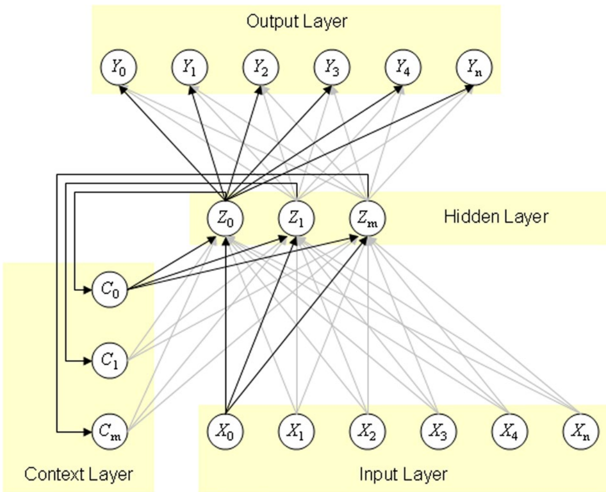

Fig. 5 Illustration of neural network model

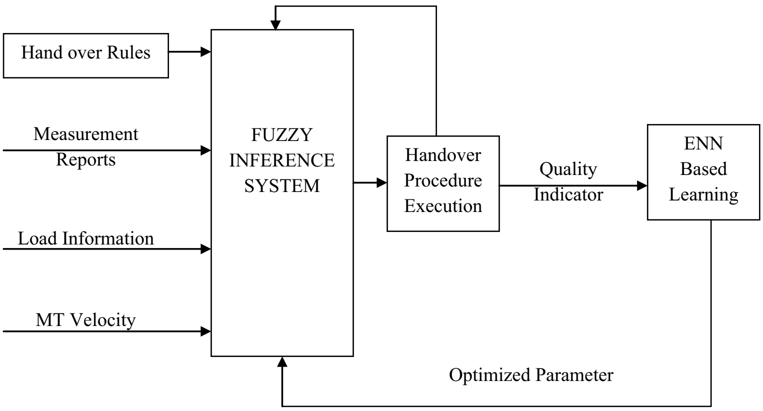

Fig. 6 Proposed FIS-ENN handover model

training module based on the user preference among all the candidates. By selecting the learning rate and error value the system was able to find the best network successfully. The limitation in the ANN based VHD manager is delay it takes long time for training process. In order to reduce the delay in the ANN module fuzzy control logic is included in the proposed model. This hybrid model provides better handover between the WLANs and UMTS. Figure 5 depicts the ANN based VHD model

In this proposed model the mobile terminal is connected to the WLAN and if the mobile terminal velocity ∂v_p is higher than the threshold velocity ∂v_t a handover to the UMTS is initiated to avoid disconnection of link. If the value is below the threshold value the pre decision unit predicts the receiver signal strength and its requirements. In this case of WLAN the predicted signal strength ∂P_{Rw} value is larger than the threshold ∂P_{Rwt} or the predicted signal strength from UMTS ∂P_{uw} is smaller than the threshold ∂P_{uwt} then no handover process is triggered. Once the pre decision model completes its process then a fuzzy based quantitative decision is applied along with the three procedures such as fuzzification, normalization, and decision. The current received signal strength and predicted signal strength is used to generate the performance metric values by comparing with other network candidates. If the UMTS and WLAN connectivity is available then the pre decision unit is used to avoid unnecessary handovers.

Figure 6 depicts the proposed hybrid FIS-ENN (Fuzzy interference system Elman Neural Network) decision model for heterogeneous wireless network. The algorithm is based on the fuzzy inference system and Elman neural network. Fuzzy considers the bandwidth and velocity for the predicted number of users and the input parameters makes handover based on the rules. ENN is used to predict the number of users after the handover takes places which is an essential variable of FIS. Based on the general model of ANN VHD manger this FIS-ENN is designed and performance measures are compared with the conventional model.

The following describes the algorithm for Elman neural network based handover model based on calculating the weights and the error representation values.

Elman Neural Network Algorithm

{

Set target value d,

Set data value n,

Set preceptor value y

Set NBs

Weight Calculation

{

Assign Targets to be 0 or 120 degrees

Inputs are the eNBs = 20

Error representation in the output,

If value above threshold

{

Perception obtained value $(n) = (n) - yi\ (n)$

}

Else

{

Applying the weights adjustments using $(n) = 0.5\ \Sigma\ ej^2(n)$

}

Weight adjustments in order to detect the change in each weight by

$$\Delta wj(n) = -\eta\big(\partial(n)\partial vj(n)\big)yi\ (n)$$

Assuming yi to be the previous neuron, η as the learning rate and vj the local field

Based on the algorithm the necessity of the handover requirements is identified and passes on the decision module. This information history is updated in for each new values based on the weights and neural networks values. The proposed model holds the present information and the previous information so that the time delay is reduced.

Table 1 Simulation parameters

S. no	Parameter	Values
1	Simulation range	2500 m × 2500 m
2	Simulation duration	250 s
3	Frequency bandwidth	2.4 Ghz
4	Data range	12 Mbps
5	Antenna	Omni antenna
6	Routing protocol	DSDV
7	Modulation and coding	16 QAM
8	LTE uplink bandwidth	384 kbps
9	LTE downlink bandwidth	384 kbps
10	Link data rate	100 mbps

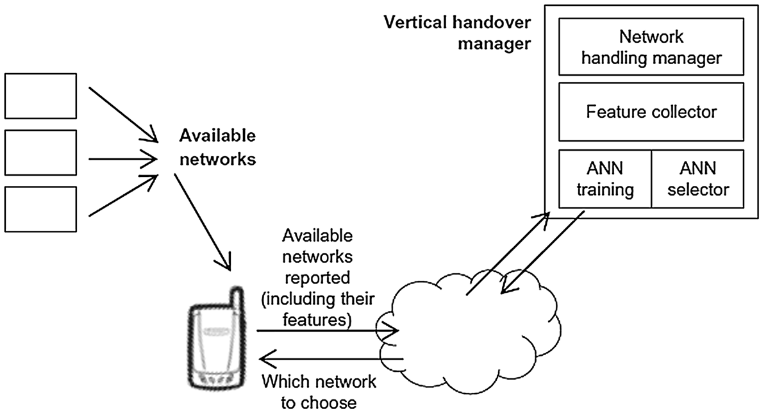

Fig. 7 Illustration of ANN based VHD model

4 Experimental Results and Discussion

The simulation setup is used to experiment the proposed model uses radio technologies such as Wi-Fi and LTE. LTE is used as ad-hoc network and the simulation is implemented in NS2.28 with integrated mobi simulator. Various moving models is used to obtain the desired scenario such as freesim, mobisim etc, The model has features includes pattern selection and the data traffic is transformed and the feed into NS2 to evaluate the Qos performance. The mobility protocol version is used in simulation model and MIH mechanism is used to interface the Fuzzy and Neural models in the network simulator. A separate C++ algorithm is developed and included in the MIH library of NS2.28. Simulation time assumed to be 250 s for the entire heterogeneous network includes LTE and Wi-Fi interfaces. Table 1 shows the simulation parameters in NS2.28

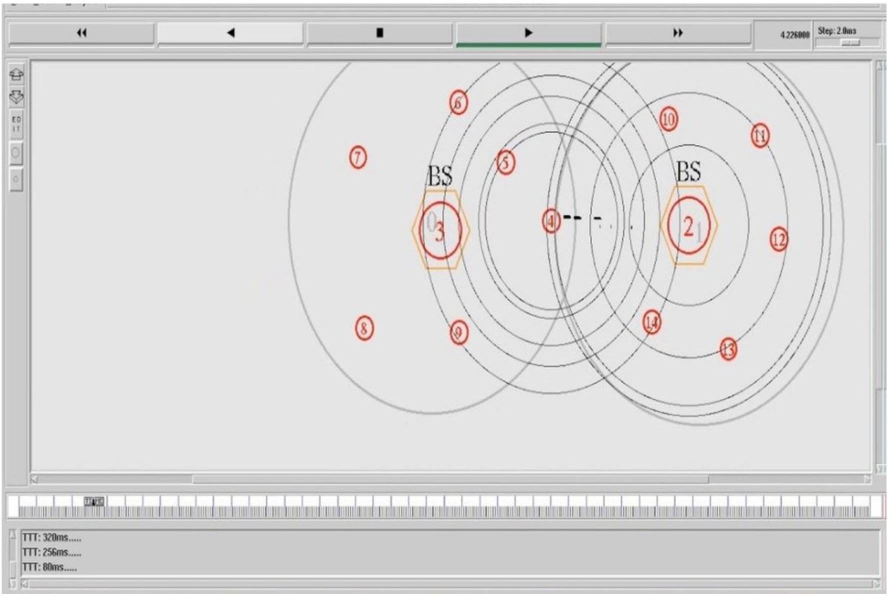

Fig. 8 Proposed FIS-ENN handover model

Table 2 Performance comparison of proposed model

S. no	Parameter	ANN VHD (%)	Proposed FIS ENN (%)
1	Number of handover	75.86	90.23
2	Failed handoffs	88.43	56.34
3	Perfect handoffs	67.34	82.28
4	Anticipated handoffs	48.23	79.22
5	Total	79.965	87.01

The QoS performance of the proposed vertical handover module compares the performance of received signal strength based on the threshold values along with the parameters such as handover latency, end-to-end delay, and packet loss using the different speeds of the moving users such as 40, 50 and 60 km/h.

Figure 7 gives the illustration of NS2 simulator FIS-ENN model. A simulation result for the proposed model is depicted in Fig. 8 which shows two networks with base stations. The base station is and the coverage area is mentioned in the network model which is designed based on the proposed algorithm.

Table 2 provides the comparison of proposed FIS ENN model along with conventional ANN VHD model in terms of computation time and performance metrics based on packet loss and connection continuity.

Handover latency is calculated based on the data packet transmitted from one node to other node. It is used to represent the entire network latency. In Fig. 9 it is clearly visible that the handover latency of the proposed FIS ENN model is less than the ANN VHD model. The average latency is observed as 3.25 and 3.12 respectively. If the speed is

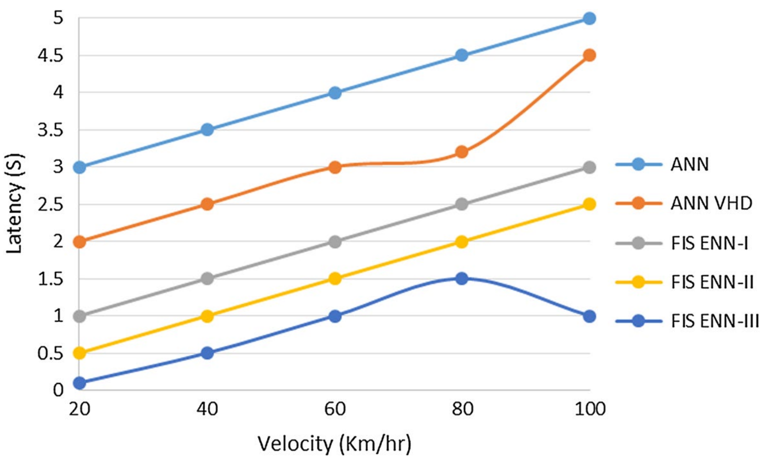

Fig. 9 Illustration of handover latency for proposed model FIS ENN

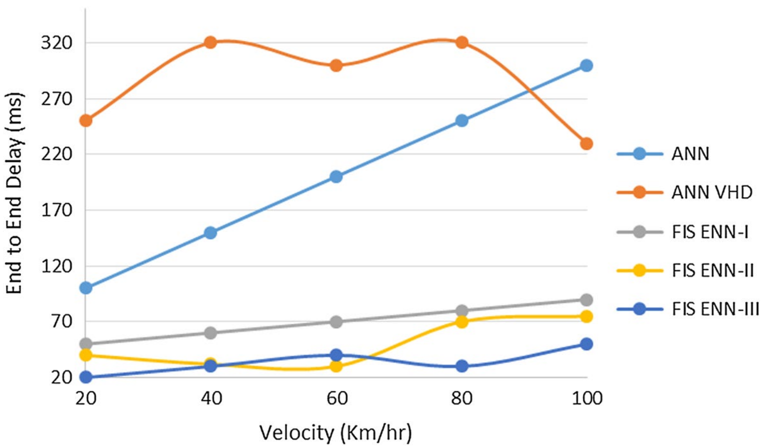

Fig. 10 Comparison of end to end delay

increased up to 100 km/h 25% of reduction in handover latency in proposed model and 28% in the ANN model. The proposed model is analysed based on the different weights based on the certain threshold value. The first condition acquires output value is equal to the threshold value, the second condition depends on the value greater than the threshold value and the last condition based on the output value lesser than the threshold value. In the third condition only, there is the possibility of weight adjustments in each node and that leads to better outcome compared to other conditions.

The end to end delay is define to used to calculate the time taken for a packet to transmit across the network from one place to another place. It is measured in milli seconds and Fig. 10 depicts the end to end delay for the proposed simulation work. The proposed FIS ENN

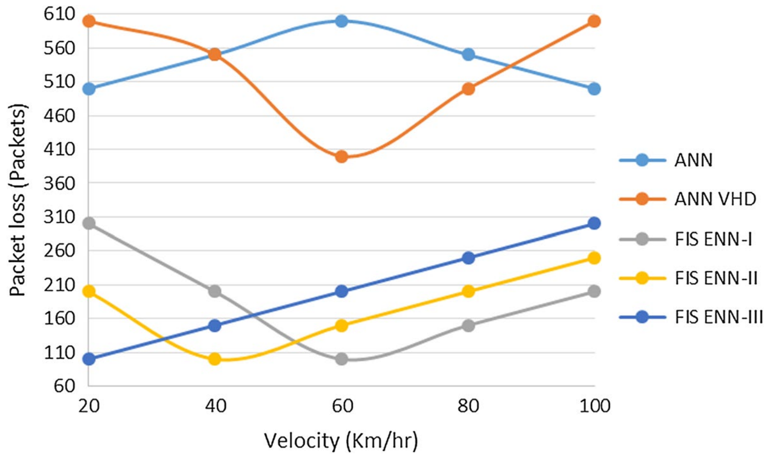

Fig. 11 Packet losses versus velocity illustration

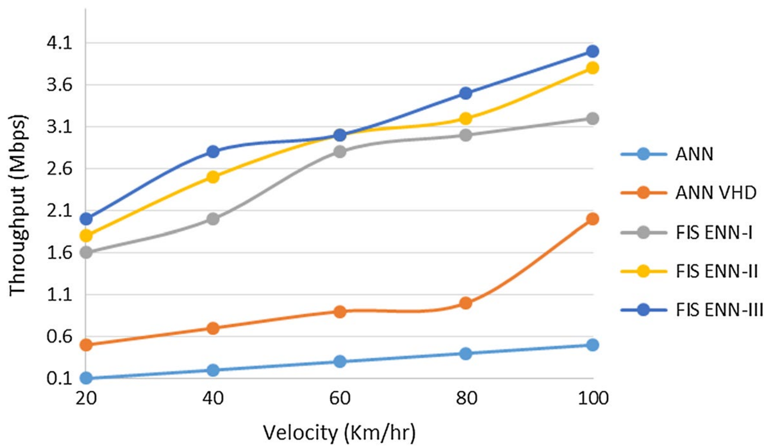

Fig. 12 Throughput analysis ANN versus FIS ENN

is much better than the ANN model which has low average end to end delay. If the speed varies the end to end delay decreased up to 30 ms. Packet loss is the next parameter that describes the details about the number of packets that failed to reach the destination during the handover process. This parameter can be measured when the triggering operation starts in several access networks. The existing ANN and ANN VHD model has high end to end delay, but the proposed FIS ENN in three different conditions produces the lesser end to end delay. These three different conditions obtained based on the weight calculation depends on the threshold value.

Figure 11 depicts the packet loss vs. velocity illustration and it is observed that average packet loss is decreased when the handover latency decreases. Based on the observation the proposed model has reduced average packet loss which is lower than the artificial neural network model and artificial neural network vertical handover decision model. The proposed Fuzzy interference system Elman Neural Network decision model defined in three different stages based on their weights depending on the output value and threshold value.

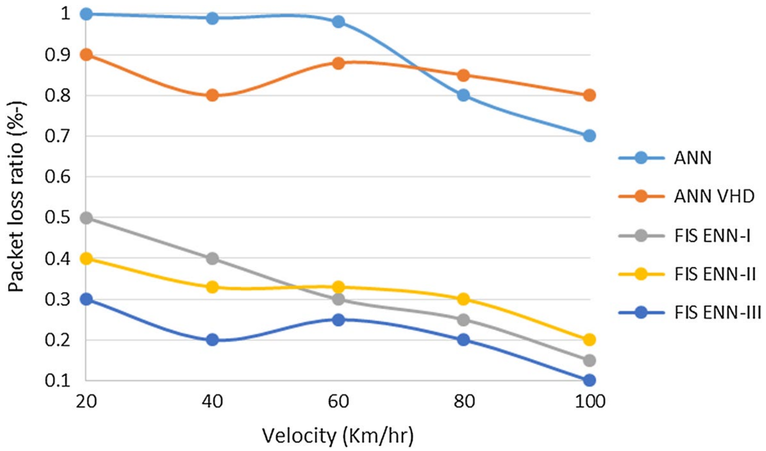

Fig. 13 Packet loss ratio—ANN versus FIS ENN

These three different stages helps to predict the error and weight estimation in the proposed Fuzzy interference system Elman Neural Network decision model. Compared to the Artificial neural network and Artificial neural network in vertical handover decision model provides the lesser packet loss.

Figure 12 depicts the average throughput illustration for both ANN and FIS ENN model and it is observed that when the number of nodes increased the throughput decreases. Based on the observation the proposed model has less throughput value when compared to ANN model and artificial neural network vertical handover decision model. The maximum of throughput obtained in the Fuzzy interference system Elman Neural Network decision model in three different stages. Achieving of high throughput helps to utilize the maximum of users without interference. This proposed Fuzzy interference system Elman Neural Network decision model reduces the interference in the artificial neural network and provides the better results.

Packet loss ratio for proposed model is compared with ANN based on the network load is depicted in Fig. 13. The ratio is smaller for proposed Fuzzy interference system Elman Neural Network model compared to the ANN model and artificial neural network vertical handover decision model. The proposed Fuzzy interference system Elman Neural Network decision model have lesser packet loss rate even in the three different condition. The third condition helps to modify the weights of each node available in the network. Lesser packet loss rate lead to high optimum performance in the Fuzzy interference system Elman Neural Network.

Table 3 shows that the comparison of parameters include throughput and packet loss rate with respect to velocity. Here velocity varies, possible presence of variation in output variable and weight adjustments and that lead to provide the expected results in loss rate and throughput. The proposed Fuzzy interference system Elman Neural Network decision model have high throughput and lesser packet loss rate in three different conditions compared to existing artificial neural network and vertical handover decision model. Table 4 shows that the comparison of latency and delay in various models based on the different velocity conditions varies from 20 to 100 km/h. The latency and delay has been successfully reduced in the proposed Fuzzy interference system Elman Neural Network decision model compared to the previous exiting conditions.

Table 3 Comparison of parameters with respect to velocity

Velocity (km/h)	Packet loss ratio (%)					Throughput				
	ANN	ANN VHD	FIS ENN-I	FIS ENN-II	FIS ENN-III	ANN	ANN VHD	FIS ENN-I	FIS ENN-II	FIS ENN-III
20	1	0.9	0.5	0.4	0.3	0.1	0.5	1.6	1.8	2
40	0.99	0.8	0.4	0.33	0.2	0.2	0.7	2	2.5	2.8
60	0.98	0.88	0.3	0.33	0.25	0.3	0.9	2.8	3	3
80	0.8	0.85	0.25	0.3	0.2	0.4	1	3	3.2	3.5
100	0.7	0.8	0.15	0.2	0.1	0.5	2	3.2	3.8	4

Table 4 Comparison of latency and delay in various models

Velocity (km/hr)	Latency (s)					End to end delay (ms)				
	ANN	ANN VHD	FIS ENN-I	FIS ENN-II	FIS ENN-III	ANN	ANN VHD	FIS ENN-I	FIS ENN-II	FIS ENN-III
20	3	2	1	0.5	0.1	100	250	50	40	20
40	3.5	2.5	1.5	1	0.5	150	320	60	32	30
60	4	3	2	1.5	1	200	300	70	30	40
80	4.5	3.2	2.5	2	1.5	250	320	80	70	30
100	5	4.5	3	2.5	1	300	230	90	75	50

5 Conclusion

The issues in the present VHD using ANN has lack of defects in the network parameters. Research involves in vertical handover algorithm is still a challenging task. The proposed Fuzzy interference system Elman Neural Network decision model vertical Handover model overcomes the existing model issues and it is useful in wide ranging of applications. The results obtained from simulation depict that enhancement in the quality of services over the Wi-Fi and LTE network. The proposed Fuzzy interference system Elman Neural Network decision model of VHD management has less handover latency, end to end delay and packet loss when compared to the ANN module. This proposed Fuzzy interference system Elman Neural Network decision model achieves high throughput and that leads to maximize the users in the network without any loss and interference. In future, Fuzzy interference system Elman Neural Network decision model concentrate on the routing overhead to lead the successful network for the effective communication in the artificial neural network.

Compliance with Ethical Standards

Conflict of interest Authors declare that they have no conflict of interest.

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