Handoff Decisions in Hetnets using Fuzzy Logic and Machine Learning Techniques

Payal Mahajan, Zaheeruddin

***Abstract:** Handover is a vital part of any wireless Mobile Communication Network. Efficient handover algorithms provide a gain in monetary cost effective method for enhancement in the capacity and QOS(quality of services) of cellular system. The work reported here presents a handover decision support system for wireless heterogenous communication. Fuzzy inference system along with neural network techniques in Matlab has been used for the development of the system.Results for performance of five different neural network techniques have been drawn on basis of their training time,classification accuracy and number of neurons taken. The neural tools used here are Back propagation, Radial Basis Function, Nave Bayes, Bayes net and C4.5 decision tree. On the basis of their performance, a best neural tool has been selected for the use in making handover decisions in wireless communication systems and it is seen that among all the neural network tools C 4.5 decision tree gives the better results in terms of classification accuracy and training time for handover decisions.*

***Keywords:** fuzzy inference systems, Handover, heterogeneous wireless networks, Neural tools,quality of service.*

I. INTRODUCTION

The evolution of the internet and the advances of wireless te chnologies have had a tremendous impact on people's lifesty les around the world over the past 25 years.Together, these t wo factors changed the way people communicate, work, and get their entertainment. People around the world were enthu siastically adopting new wirelesscommunications methods in 1897.The mobile radio communication industries have grown-up by huge numbers ,fueled by improvements in the manufacture of RF and digital circuits,new large scale integration of circuits and other miniaturization technology that make convenient radio equipment not only cheaper, smaller but reliable also[1]. These trends may continue at a greater pace in the next decade. Wireless communication has become an integral part of everybody's life today.decade. Mobility is its strength in heterogeneous wireless cellular communication systems to improve the quality of service and to maintain continuous service. Mobile terminals(MT) provide more quality of service as compared to the telephone system on the landline. The mobile terminal very easily transmits the data services or voice speeches[1]. The large geographic coverage areas or regions is divided into smaller services area in cellular mobile networks and they are called cells. The whole frequency band is divided into smaller bands prior to communication between two users in a network and these particular bands can be reused in cells which are non-interfering and should be assigned to the group of bands or channels. If a mobile terminal(MT) crosses the boundary of the cell or moves out of the range, the signal becomes unacceptable[2] then an ongoing call must be transferred to the new adjacent base station to allow the user to enjoy interrupted services.. Now days, there is another need to change the user's connection point, which is the application type that the user wants to run. Similarly, there are other reasons why the user's point of connection is changed. The method of moving a current call or data session from one channel to another channel while maintain connection to the core network is referred to as the handover. The MSC (mobile switching centres) adjust the transmitted power of the mobile device once a call is in progress and changes the channel of the base station and mobile unit. The increase in demand for new and better services, technologies is varying the way user gain Internet access. According to Cisco by the end 2021, 74.5% of mobile phones will generate approximately 98% of traffic data out of which 78% will come from video traffic[3]. It is essential to provide high communication rates and better quality services by popularizing the use of multimedia applications and increasing the number of mobile users[4]. The wireless network must be multiple access networks that offers access to a broad range of technologies, such as WiMAX, LTE, Bluetooth and Wi-Fi, all in the present conditions and in near future. [5].There will be the need of the co-existence of various wireless technologies to work together to achieve a heterogeneous network for allowing the mobile users to stay forever best connected[6].

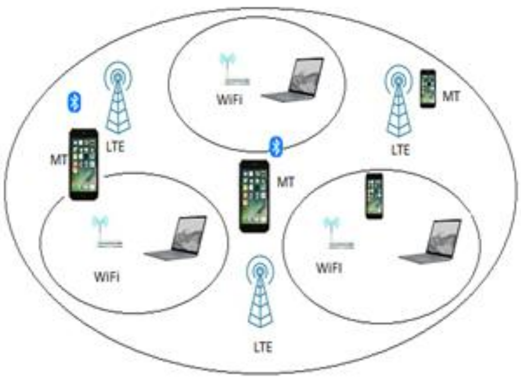

Figure 1: Interworking technologies in Heterogeneous Networks

Revised Manuscript Received October 05, 2019

Payal Mahajan, Research Scholar, Department of Electrical engineering, Jamia Millia Islamia University
Prof. Zaheeruddin , Professor, Department of Electrical engineering, Jamia Millia Islamia University

Handover has been introduced since the time of the introduction of wireless communication. There have been different handover strategies from the handover strategies used now days in the earlier times[7]. Factors on the basis of which categorization of handoffs is done can be number of connections, administrative domains involved, user based, necessity of handover,network types and frequencies engaged. The phenomenon is called horizontal handover when decoupling and connection involves the same network access technologies, while vertical handover involves the use of dissimilar network access technologies[8].Handover is an important task in maintaining cellular system call continuity and its failure can result in termination of the current call. Some parameters such as relative signal strength bandwidth, velocity, etc. should be carefully considered during the handoff process[9]. The quality of service [QOS] may degrade under an adequate level if transfer does not occur quickly.

II. VERTICAL HANDOVER

A vertical handover is a type of handover which involves two access points based on various wireless technologies[10]. An example of a vertical handoff might be when a user moves from a network to another network, but in the process switches from 1xRTT to 802.11. The connection is disrupted in a vertical handoff scenario while moving to an area covered by another wireless access technology[11]. In addition, when the seamless handoff server makes chooses the network access technology based on quality of service and throughput , it is known as vertical handoff. Such a system provides seamless coverage ; the typical network handover latency is (a few) hundred milliseconds with minimal bandwidth overhead and power consumption[12]. The following must be considered for a vertical handover to occur:

• A vertical handover-supporting device must have dual card for making the connection between two different wireless networks.

• On the basis of handover metrics, two wireless communication technologies are being compared in vertical handover. Wireless technology with better metric handover is preferred.

•Relative signal strength, User needs and preferences, costs and overall network conditions are significant.

When dealing with vertical handoffs, there are many challenges. First, because at one time there are more than one devices active, power consumption become a problem[13]. While multiple active network interfaces are running, power drain must be minimized. Measurements of wireless network interfaces that are commercially available shows that keeping a WaveLan RF Infrared and interface consumes about 2 watts[14]. This power drainage is about 20 percent of a typical laptop computer's total power drain. In addition to power loss, addition of more devices increases the network traffic and bandwidth consumption in the handoff system architecture[15]. The handoff/handover server needs to be conscious of extra devices that will cause more packets and messages to be sent. Horizontal as well as vertical handovers work mutually to deliver seamless handoff goals[16]. The handoff/handover server is accountable for managing both of the scenarios irrespective of current use of the exact scenario[17].

III. METHODOLOGY

The results and implementations are carried as follows:

i. Fuzzy inference system of handover decision support system: In this research work. First of all, FIS of handover decision support system is developed by using Mamdani model.

ii. Dataset creation:Secondly, a dataset of 2500 values is created depending upon above mentioned parameters which are necessary for taking handover decisions.

iii. Training and testing of dataset by using Machine Learning Algorithms: In this research work, Back Propagation Neural Network(BPNN)/multilayer perceptron, Radial Basis Function Neural Network(RBF), Bayes Net Algorithm ,Naïve Bayes and C4.5 decision Tree algorithm, are used for classification handover decision support system. For this purpose, MATLAB and Weka tool are used.

iv. Comparative Analysis of Results: In this research work, results are taken using Matlab and Weka tool and then the comparative analysis of performance various neural techniques is done on basis of training time, accuracy in classification and number of neurons taken to train the network.

I. A fuzzy system for handovers in heterogeneous wireless network architecture

In this research work, datasets for making handover decision support system have been developed by collecting the information about the parameters related to handover decisions in wireless communication networks and their working range. The parameters with their working range (which we have considered in this work) are shown in the table below:

Table 1: PARAMETERS AND THEIR WORKING RANGE

Parameter	Range	Membership functions	Favorable conditions for handover
Received signal strength	-100 to -20 dB	Weak, medium, strong	Weak
Bandwidth	1kbps to 20MHz	Low, average, high	Low

Network coverage	0-72 kms	Near, medium, far	Far
Velocity	1-100 kms/hr	Low,medium, high	Low
User preference	0 – 1 unit	Less, medium, high	Low
Power consumption	0-2 watts	Less, medium, high	High

(a) Fuzzy inference system for handover decision support system

In this section, fuzzy inference system for the handover decisions is discussed.The parameters RSS, bandwidth, user preferences, velocity, power consumption and network coverage are given as input to fuzzy logic system to get the output as handover decision. Each input parameter is having three membership functions and each membership function is assigned with a particular range and then depending upon these membership functions output is taken:

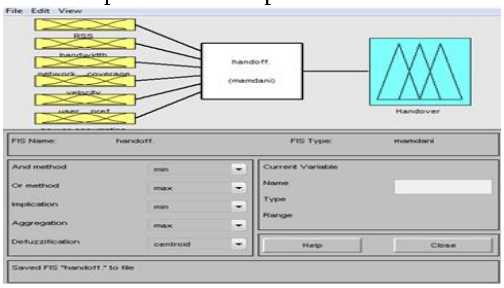

Figure 2:Fuzzy Inference system

(b) Fuzzy Rules:

The below shown figure is the rule editor of the fuzzy inference system where the rules are defined to make a handover support system for wireless hybrid networks. A fuzzy rule is a simple IF-THEN rule presented by a condition and a conclusion .The rules generated are based on the above given input parameters.

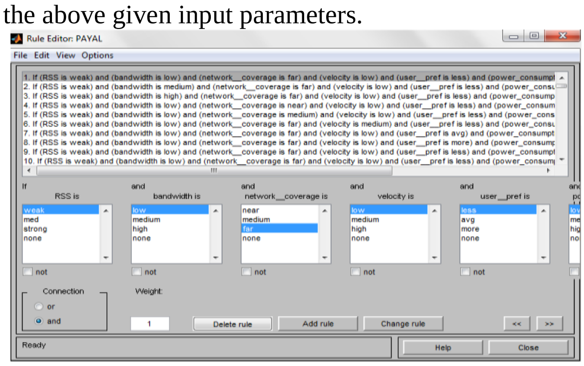

Figure 3: Rule editor

The following graphs show the desired output of handover decision taken and are shown in the surface viewer of the FIS.

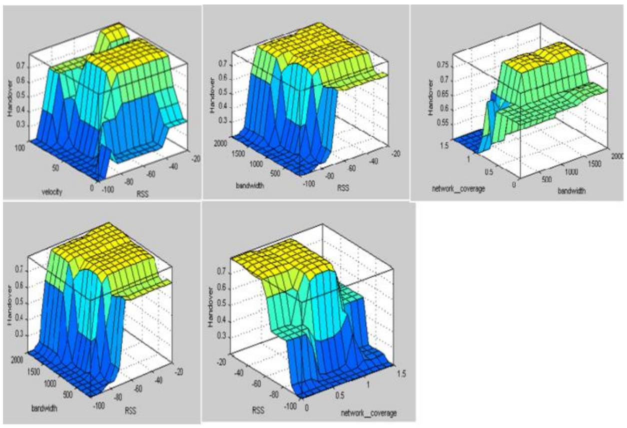

Figure 4: surface viewer of the FIS

The rules defined in the rule editor are checked manually and are validated by taking the range of input and output parameters. The following table shows that the output defined falls well under the range decided. For example: let us take the case given in first row. Here the RSS is given as -96(low), bandwidth as 200(low), network coverage as 0.8(far) and user preference as 0.02(low) and power consumption as 1.9(high). All these values are then evaluated in MATLAB using evalfis and we get the output as 0.2 which shows that the handover decision should be taken. Similarly, some more rules defined in rule editor are manually checked and validated and all the results drawn are accurate.

Table 2: dataset created and validated using matlab commands

serial no.	RSS	B. W	N/ W cov	velo city	user pref	pow er con s	han doff	manual validation
1	-96	200	0.8	20	0.02	1.9	0.2	yes
2	- 95.5	230	1.1	20.5	0.05	1.2	0.2	yes
3	-22	180 0	0.02	99	0.58	0.1	0.8	no
4	-21	190 0	0.05	99.5	0.9	0.11	0.8	no
5	-65	900	0.75	50	0.5	0.2	0.8	no
6	-97	950	0.03	98	0.03	1.99	0.5	can't say
7	-20	960	0.76	51	0.59	0.8	0.5	can't say
8	-96	160	1.4	21	0.59 1	1.97	0.2	Yes
9	-95	990	0.06	22	0.9	1.95	0.2	Yes
10	-66	300	1.45	20	0.07	0.07	0.3	Yes

Retrieval Number: F95831088619/2019©BEIESP
DOI: 10.35940/ijeat.F9583.109119

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

11	-95	150	0.8	51.5	0.09	1.98	0.2	Yes
12	-20.5	800	0.12	98	0.9	0.82	0.8	No
13	-96	850	0.15	23	0.4	1.46	0.2	Yes
14	-67	870	1.46	90	0.9	0.08	0.8	No
15	-22	1950	0.05	52	0.98	1.8	0.5	can't say

Similar to the values shown in the table, a manual data set of 2500 values is created using fuzzy inference system and each value of dataset is evaluated to get the accurate output using MATLAB commands and this data set is used in training and testing of the Neural network classifiers which we have used in our work.

IV. EXPERIMENTAL ANALYSIS USING WEKA TOOL

In this work, well-known supervised Machine learning algorithms named as Multilayer Perceptron (MLP)or Backpropagation neural networks(BPNN), Naïve Bayes algorithm ,Radial Basis Function Neural Network (RBF), Bayes Net, and C4.5 Decision Tree algorithm are employed for making handover decisions in heterogenous wireless communication networks. Performance of Machine Learning algorithms is evaluated on the basis of training time classification accuracy of classifiers and number of neurons involved for training the dataset.

In this part of research work handover decision datasets have been developed by carefully observing the importance of each of the six parameters taken for designing the handover decisions.

In addition, Weka tool, a well-liked data mining tool, is used with popular supervised machine learning algorithms like Multilayer Perceptron (MLP)/backpropagation(BPNN), Radial Basis Function Neural Network (RBF), Naïve Bayes,Bayes Net Algorithm and C4.5 Decision Tree Algorithm, to implement handover decision support system..Among which 2000 are taken for training purposes and 500 are taken for the testing purposes.

V. RESULTS AND CONCLUSION

In this research work, training time ,classification accuracy of classifiers and number of neurons taken are used for the assessment of performance of these supervised ML classifiers. The parameters can be defined as follows:

• Classification accuracy: this is the percentage of samples correctly classified over all samples classified.

• Training Time: Total training time for an ML classifier is required. It is measured in seconds in this part of research.Result Analysis

Results of handover decision efficiency using five supervised ML algorithms with 2500 samples of dataset are given in table 3. This table training time and classification accuracy of ML algorithms for this dataset.Table 3 shows the accuracy of classification and training of dataset classifiers MLP, RBF, Bayes Net,C4.5, Naïve Bayes ML It is obvious from the table that C4.5 classifier provides utmost classification accuracy for 2500 dataset samples, which is 94 %.

Table 3: showing classification accuracy and training time of five neural network tools

	MLP(BPNN)	RBFNN	C4.5	Bayes Net	Naïve Bayes
Classification Accuracy (%age)	80	88	97	91	70
Training time (seconds)	8.32	7	0.13	0.04	0.02

Graph 1:

Bar-graph given in figure 5 visualizes classification accuracy of ML algorithms for 2500 samples of datasets for handover decision in wireless communication. It is again clear from this figure that for this given dataset, C4.5 gives maximum classification accuracy for handover decision.

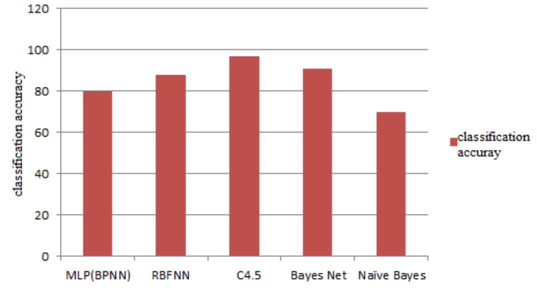

Figure 5: Classification accuracy of different ML algorithms

From these results, it is evident that C4.5 decision tree algorithm gives better performance in terms of classification accuracy as compared to other four ML classifiers for 2500 samples of dataset of handover decision support system. The classification accuracy of C4.5 algorithm is much greater than all other ML algorithm that is 97%.

Graph2:

The given graph visualizes training time of ML algorithms for 2500 samples of datasets forhandover decision support system. It is again clear from this figure that for this given dataset, Naïve Bayes gives less training time approximately 0.02 seconds for handover decision support system but it does not give more classification accuracy than C4.5 algorithm which is very important parameter to enhance performancehandover decision support system.

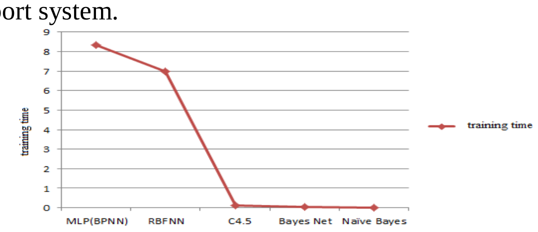

Figure 6: Training time for five neural network tools

VI. CONCLUSION

In this research work of comparative analysis of machine learning technique for handover decisions is done, various machine learning techniques are employed forhandover decisionsusing 2500 samples of dataset. During this process, various conclusions are made which are discussed in following points:Radial Base Function Neural Network provides good performance in decision-making regarding classification accuracy and MSE values and has more training time and high computational complexity due to the need for a large number of hidden layer neurons compared to BPNN.Thus, Radial Basis Function is a good neural network classifier for making handover decisions in hetnets communication networks.

As the duration of data transmission decreases, the performance of ML classifiers provides better performance in terms of classification accuracy and training time-forming decision-making in wireless communication networks. This analysis makes compatibility more real-time.In this analysis, C4.5 and Bayes Net gives very good performance formaking handover decisions in wireless communication networks.

Finally, it is concluded that the C4.5 Decision Tree Algorithm is the most effective machine learning technique for decision-making in wireless communication networks and makes this classification more compatible in real time.

REFERENCES:

1. Li, Bin, Lizhong Li, Bo Li, Krishna M. Sivalingam, and Xi-Ren Cao. "Call admission control for voice/data integrated cellular networks: performance analysis and comparative study." *IEEE Journal on Selected Areas in Communications* 22, no. 4 (2004): 706-718.
2. S. Choi and K. Sohraby,*"Analysis of a Mobile Cellular Systems with Hand-off Priority and Hysteresis Control"*, IEEE INFOCOM, vol. 1, pp. 217-224, March 2000
3. CISCO, "Cisco Visual Networking Index: Global Mobile Data Trafc Forecast Update, 2016-2021,"whitepaper,online:https://www.cisco.com/c/en/us/solutions/collateral/serviceprovider/visual-networking-index-vni/complete-white-paper-c11- 481360.pdf (accessed 28.03.2018).
4. E. Gustafsson and A. Jonsson, "Always best connected," *IEEE Wireless Communications Magazine*, vol. 10, no. 1, pp. 49–55, 2003
5. Coqueiro, Thiago, José Jailton, Tássio Carvalho, and Renato Francês. "A Fuzzy Logic System for Vertical Handover and Maximizing Battery Lifetime in Heterogeneous Wireless Multimedia Networks." *Wireless Communications and Mobile Computing* 2019 (2019).
6. Tillapart, Piyakul, Thanachai Thumthawatworn, Piboonlit Viriyaphol, and Pratit Santiprabhob. "Intelligent handover decision based on fuzzy logic for heterogeneous wireless networks." In *2015 12th International Conference on Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology (ECTI-CON)*,. IEEE, 2015. pp. 1-6
7. Coqueiro, Thiago, José Jailton, Tássio Carvalho, and Renato Francês. "A Fuzzy Logic System for Vertical Handover and Maximizing Battery Lifetime in Heterogeneous Wireless Multimedia Networks." *Wireless Communications and Mobile Computing* 2019 (2019).
8. Halabian, Hassan. "Distributed Resource Allocation Optimization in 5G Virtualized Networks." *IEEE Journal on Selected Areas in Communications* 37, no. 3 (2019): 627-642.
9. Smys, S., Robert Bestak, Joy Iong-Zong Chen, and Ivan Kotuliak, eds. *International Conference on Computer Networks and Communication Technologies: ICCNCT 2018*. Vol. 15. Springer, 2018.
10. Jain, Aabha, and Sanjiv Tokekar. "Application based vertical handoff decision in heterogeneous network." *Procedia Computer Science* 57 (2015): 782-788.
11. Ahmed, Atiq, Leila Merghem Boulahia, and Dominique Gaiti. "Enabling vertical handover decisions in heterogeneous wireless networks: A state-of-the-art and a classification." *IEEE Communications Surveys & Tutorials* 16, no. 2 (2014): 776-811.
12. V Saboji, Shivakumar, Savitri Bevinakoppa, and Channappa B Akki. "Agent based vertical handoff decision algorithm for heterogeneous wireless networks." *Recent Advances in Communications and Networking Technology (Formerly Recent Patents on Telecommunication)* 3, no. 2 (2014): 117-126.
13. Han, Zijun, Tao Lei, Zhaoming Lu, Xiangming Wen, Wei Zheng, and Lingchao Guo. "Artificial Intelligence Based Handoff Management for Dense WLANs: A Deep Reinforcement Learning Approach." *IEEE Access* (2019).
14. Bhattacharya, P. P. "Application of artificial neural network in cellular handoff management." In *International Conference on Computational Intelligence and Multimedia Applications (ICCIMA 2007)*, vol. 1,. IEEE, 2007. pp. 237-241
15. Coqueiro, Thiago, José Jailton, Tássio Carvalho, and Renato Francês. "A Fuzzy Logic System for Vertical Handover and Maximizing Battery Lifetime in Heterogeneous Wireless Multimedia Networks." *Wireless Communications and Mobile Computing* 2019 (2019)
16. Aibinu, A. M., A. J. Onumanyi, A. P. Adedigba, M. Ipinyomi, T. A. Folorunso, and M. J. E. Salami. "Development of hybrid artificial intelligent based handover decision algorithm." *Engineering Science and Technology, an International Journal*20, no. 2 (2017): 381-390.
17. Memon, Salman, and Muthucumaru Maheswaran. "Using machine learning for handover optimization in vehicular fog computing." In *Proceedings of the 34th ACM/SIGAPP Symposium on Applied Computing*,.AC M, 2019 pp. 182-190.

AUTHORS PROFILE

Author 1	Payal Mahajan
	Research Scholar Department of Electrical engineering Jamia Millia Islamia University payal27mahajan@gmail.com Research Interests- fuzzy logic,wireless communication, mobile networks, neural networks, optimization techniques

Author 2	Prof. Zaheeruddin
	Professor Department of Electrical engineering Jamia Millia Islamia University zaheeruddin@jmi.ac.in Research Interests- fuzzy logic,soft computin, mobile networks,artificial Intelligence neural networks, optimization techniques