Handoff using Machine Learning Techniques

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Abstract:- This paper demonstrates about Implementation of Handoff Techniques through Machine Learning Algorithms in Tele communications. A handoff is the process of transferring an active call or data session from one cell in a cellular network to another, or from one channel within a cell to another. Cellular networks are made up of cells, each of which can provide telecommunications services to customers roaming through the network. Each cell has a limited region and number of subscribers it can serve. A handoff occurs when any of these two thresholds is reached. When a certain mobile tower's capacity is exceeded, an existing or new call from a phone must be transferred to another cell tower that covers the same geographical area as the existing cell tower. A well-executed handoff is essential for providing continuous service to a caller or data session user. Using Machine learning algorithms. The present methodology examines the accuracies generated by three popular decision-making algorithms namely Logistic Regression, Decision trees, Random Forests.

Keywords:- *Handoff, roaming, cellular networks, Logistic Regression, Decision trees, Random Forests.*

I. INTRODUCTION

The design of an efficient Handoff Management is one of the most difficult challenges for improving quality of service (QoS) in wireless networks. It is necessary to assist a mobile terminal's decision to switch between different types of networks. In this paper we present a machine learning approach to improve the quality of service(QOS) by considering various contributing factors. A Neural Network-based model assists the Handoff device in making the most efficient Handoff decision. The simulation findings suggest that using a neural network-based machine learning method to carry out the Handover process can improve the QoS experienced by both voice and data services while also meeting the user's preferences to a large extent. In IP networks, the handover or handoff is the physical transfer from one network to another. There are two sorts of transitions in the handover. 1) horizontal handover and 2) vertical handover A horizontal handoff occurs when a Node Mobile (NM) switches networks in the same technology. As seen in the dotted box of Figure 1, if the network switches to a new technology, a vertical handoff is required. As depicted in Figure

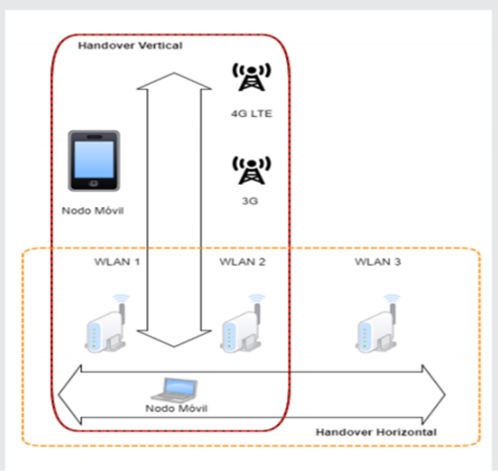

Fig. 1: Describes the NM and the switch networks

II. RELATED WORK

Handoff has been an important research problem because of its core problem of decreasing delay and associated transitions. Handoff, the overall procedure of the transition process, has been divided into three steps. 1) Measurement and preparation for the handover, 2) decision for the handover, and 3) execution of the handover. In the first stage, metrics from the next networks are measured; in the second stage, algorithms determine when to switch networks; and in the third stage, the necessary procedures to connect to the new network and reestablish services are carried out. In the presence of barriers, a machine learning-based handover management system for LTE has been employed to improve the user's Quality of Experience. The typical Wireless Local Area Network (WLAN) handoff management system causes visible delays during the handoff procedure, resulting in service interruption, which is especially noticeable in congested WLANs. The RNN-HM system is a revolutionary handoff management technique based on deep learning, specifically the recurrent neural network (RNN). RNN-HM may effectively improve the data rate during the handoff process, exceeding the standard scheme, according to numerical results obtained through simulation [1].

Handover methods are complicated by a number of aspects, some of which can make quantification difficult. Fuzzy logic is being used to handle change decision problems that include fuzzy parameters [2]. The fuzzy logic-based approach allows for systematic tweaking of the handoff settings, resulting in a fair tradeoff between various system features [3]. The information on the parameters linked to handover decisions in wireless communication networks, as well as their operating range, was collected in fuzzy logic for creating handover decision support systems. The table below shows the parameters along with their working ranges [4].

III. MODEL AND TOOLS USED

A. *Logistic regression:*

Logistic regression(Multivariate), has been employed for making handoff decisions based on the simulation data generated. Fig2 depicts the model which is used for model training, the machine learning model has parameters SNR, RSS, NwCOv, PowCon, SNR which are used for training the model for over 800 samples, the model has a sigmoid function which takes care of the decision handling process. And fig 3 shows how the model is analogous to the present problem of handoff.

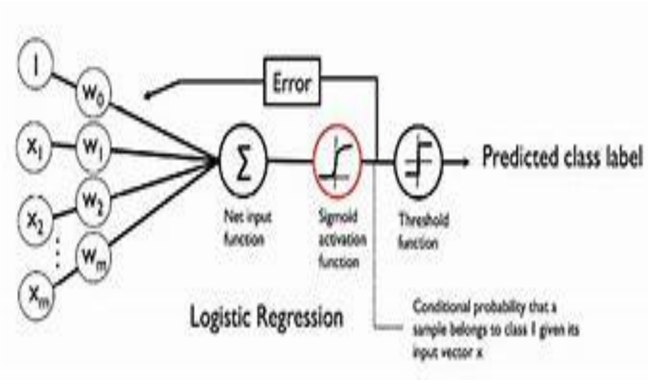

Fig. 2: Shows the model parameters and sigmoid function for decision making.

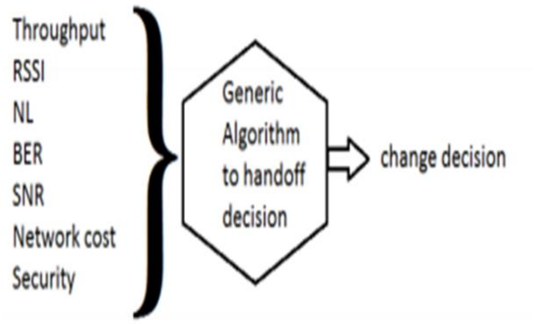

Fig. 3: depicts the analogy of how model is employed

B. *Decision Tree:*

A decision tree is a classification method that splits the instance space in a cyclical fashion. The nodes inside the decision tree form a rooted tree, which is a directed tree with no incoming edges and a "root" node. There is one incoming edge for each of the other nodes. A node having outgoing edges is known as an internal or test node. The term "leaf" refers to any additional nodes (also known as terminal or decision nodes). Based on a discrete function of the input attribute values, each internal node in a decision tree divides the instance space into two or more sub-spaces. In the simplest and most frequent scenario, each test evaluates a single attribute, with the instance space partitioned according to that same value of the attribute In the case of numeric properties, the condition refers to a range. A class is assigned to each leaf based on the best target value.

C. *Random Forest:*

Random Forest is a well-known machine learning algorithm that uses the supervised learning method. In machine learning, it can be utilized for both classification and regression issues. It is based on ensemble learning, which is a method of integrating several classifiers to solve a complex problem and increase the model's performance.fig 4 depicts the random forest analogy.

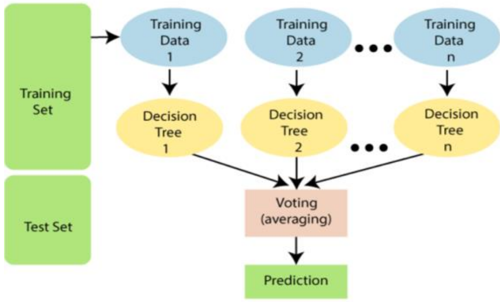

Fig. 4: Random forest analogy

D. *Handoff Decision*

The decision-making algorithm will have a direct impact on the performance of the handoff. The algorithm proposed in the project employs schemes based on Received Signal Strength (RSS), Quality of Service (QoS), multi criteria decision functions, and algorithms based on artificial intelligence techniques. In general, the decision-making algorithm is fed data from the network and, after processing the data, decides which network to change. Received Signal Strength Indicator (RSSI), power level of signals received in wireless networks and Network Load are some of the most common criteria used to make the decision to change.

IV. PARAMETERS CONSIDERED AND THEIR WORKING RANGE

Parameter Considered	Parameter Ranges	Functions	Favourable conditions for handoff
Received signal strength(RSS)	-100 to -20 dB	Weak, medium, strong	weak
Band-width (Bw)	1kbps to 20MHZ	low, average, high	low
Network coverage (NwCov)	0-72Km	Near, medium, far	far
Power consumption (PowCon)	0-2 Watts	Less,medium,high	high
Signal to Noise Ratio(Snr)	20-50 db	Weak, medium, High	high

Table 1: Approximated data ranges for parameters

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	RSS	BW	NWCOV	Powe cins	SNR	Handoff
0	-332	1166	8	0.65	28	0
1	-148	1559	57	1.20	45	1
2	-208	1616	26	0.24	40	1
3	-388	1830	49	1.10	44	1
4	-400	1426	57	0.68	48	1

Fig. 5: depicts a sample of data generated and associated label of handoff decision.

	RSS	BW	NWCOV	Powe cins	SNR	Handoff
count	1000.000000	1000.000000	1000.000000	1000.000000	1000.00000	1000.000000
mean	-60.577000	1006.933000	35.416000	0.999020	37.58200	0.521000
std	23.105799	565.578121	20.712314	0.583147	7.42849	0.499809
min	-100.000000	16.000000	0.000000	0.000000	25.00000	0.000000
25%	-81.000000	542.750000	17.750000	0.480000	31.00000	0.000000
50%	-61.000000	1005.500000	35.000000	1.010000	38.00000	1.000000
75%	-41.750000	1514.250000	54.000000	1.500000	44.00000	1.000000
max	-20.000000	2000.000000	70.000000	2.000000	50.00000	1.000000

Fig. 6: statistical analysis of the data generated

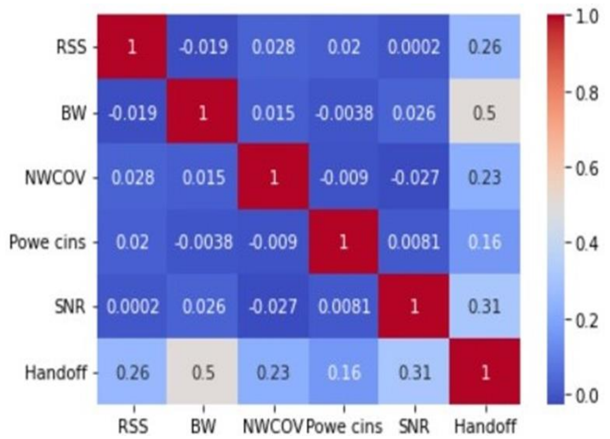

Fig. 7: correlation between parameters and handoff decision

Experiments have been carried out with parameters such as received signal strength, bandwidth, power consumption, and network coverage, Signal to Noise Ratio and corresponding ranges have been concluded as in table 1 The data is collected according to the approximations from the table and from the local service provider. Among all the parameters considered, Network Coverage is given utmost priority, while Power consumption is given the lowest.fig 5 shows the sample data generated with simulation environments. Fig6 shows the statistical analysis of the data that is generated.Fig7 shows the correlation between data that is helpful in analysing parameters and concluding what all the parameters are significant in making a decision of handoff. The entire data has been imported into the python environment for comprehensive evaluation with models undertaken.

V. RESULTS

The training is done for 600 samples and the confusion matrix is plotted over testing data. Fig below shows TPs (True positives), FPs (False positives), TNs (True negatives), FNs (False negatives), and corresponding accuracy scores, precision scores are depicted. The confusion matrix is plotted for 400 data points out of which 174 are true negatives and 170 are true positives. 25 are false positives and 31 are false positives in case of logistic regression. The model has done a decent job in predicting if a handoff has to be made to a particular station. The model had to be tested and tuned according to the real-world case scenarios for best fit. Fig 8 shows the same

The decision tree model has also been implemented working of which is explained in the above diagrams, the decision tree gave out an accuracy of 83%, which accounts to single decision tree usage which shall affect the model. In total the true positives generated are 181 and true negatives generated are 151, and false positives and false negatives account for 38 and 30 respectively. fig 9 depicts the confusion matrix for the same.

The Random Forest algorithm trained with the same data gave an accuracy of 87.5 which is considered as one of the best algorithms in the case of handoff decision out of selected algorithms of interest. Fig10 depicts the confusion matix for the same.

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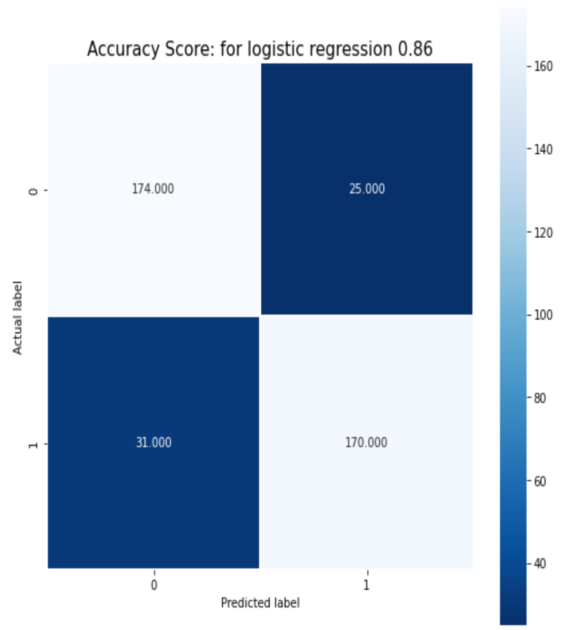

Fig. 8: confusion matrix for the predicted label using Logistic regression

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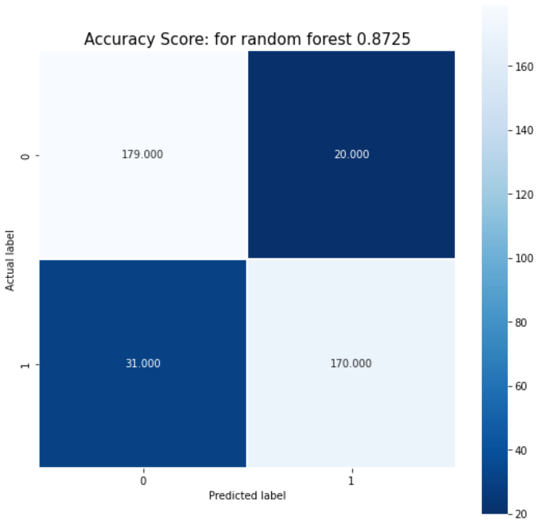

Fig. 9: predicted labels using Decision trees

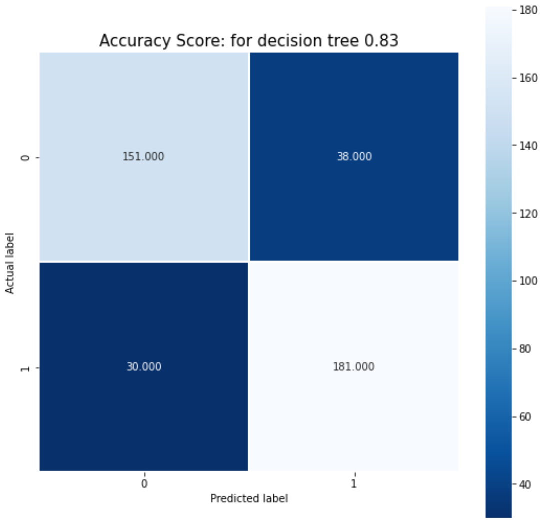

Fig. 10: predicted labels using Random forest

VI. CONCLUSIONS AND FUTURE WORK

In this comprehensive analysis of machine learning techniques for handover decisions, the logistic regression, Decision trees, and Random Forests technique have used 1000 samples of the dataset which is created through simulation to make handover decisions. The training data was divided into three categories: training (600 samples), test (200 samples), and validation (200 samples) (200 samples). This approach yields an accuracy of 86% of accuracy for logistic regression, 83% of accuracy for Decision trees and 87% for Random forests. It can be concluded from the simulations data that the Random Forest algorithm has given the most accuracy for handoff decisions, The present solution aims to consider various devices doing the handover process at the same time in future development.

Algorithm Used	Accuracy achieved
Logistic regression	86%
Decision tree	83%
Random forest	87%

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