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Modeling and Analysis of SAW based Mobile Centric Vertical Handoff Decision

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Abstract— The rapid growth in the field of wireless communications has led to the development of several wireless networks and standards. In addition, the mobile handsets with sophisticated features are enabling the mobile users to use numerous applications ranging from simple voice calls to real-time video streaming through wireless internet. Heterogeneous Wireless Networks (HWNs) are the integration of various wireless networks emerging to support seamless mobility with high bandwidth and QoS support for real-time multimedia applications. In this context, Vertical Handoff Decision (VHD) problem is one of the crucial design issues that need to be addressed in order to provide seamless mobility. VHD is the process of selecting the optimum network among the set of available networks, which greatly influences the performance of HWNs. This paper proposes an efficient mobile centric VHD model based on Simple Additive Weighting (SAW). Further, the sensitivity of network selection of this technique is analyzed to determine the impact of variation of individual parameters on the decision outcome.

Keywords— Heterogeneous wireless networks, Vertical handoff, Simple Additive Weighting , Optimum network, Sensitivity analysiss

I. INTRODUCTION

The area of wireless communications is witnessing a rapid growth worldwide. This growth is driven by the evolution of a plethora of wireless technologies and diversified user applications. The recent trend is towards the ubiquitous communications, through which communication is possible from anywhere, anytime using any technology. The vision of Heterogeneous Wireless Networks (HWNs) is to integrate the existing and evolving wireless networks, with Internet Protocol (IP) as the backbone [1] [2]. Mobility management is one important technical challenge that needs to be addressed in the development of heterogeneous wireless networks. This research work focuses on the Vertical Handoff Decision (VHD) problem, which is the major sub-component of mobility management.

Handoff refers to the process of transfer of an ongoing call, or a data session, from one Point of Attachment to another. Handoffs are classified according to the underlying technology used by the PoAs as horizontal handoff and vertical handoff [3] [4]. The handoff process that involves PoAs of same Radio Access Technology (RAT) is referred to as horizontal handoff. On the other hand, vertical handoffs involve PoAs of different Radio Access Technologies. Vertical Handoff Decision refers to the selection of an optimum network among a set of available networks in heterogeneous wireless environment. It enables the mobile user to connect to the best network depending on application's Quality of Service requirements, network parameters, user's preferences and mobility of the user. VHD plays a major role on the performance of heterogeneous wireless networks.

In this paper, Simple Additive Weighting based Vertical Handoff Decision algorithm is proposed that makes use of max-min method of linear transformation to normalize the parameters and finds the Network Selection Function (NSF) using SAW for making the handoff decision. This method is suitable for mobile terminals having low processing capabilities as it involves simple formulae and less complexity. Further, sensitivity analysis is performed on the proposed approach to verify its decision outcomes by varying the individual parameters, keeping the rest of the parameters constant.

II. LITERATURE SURVEY

Vertical handoff is one of the most important issues for the integration of heterogeneous wireless networks that has been studied extensively in the literature. VHD algorithms can be divided into different categories based on the decision parameters and methods used for the decision process. These categories include RSS based, Dwell Timer based, Averaging windows, Hysteresis margins, Cost function based and Policy based algorithms [5-9]. Most of the these VHD algorithms are RSS based solutions that are not sufficient to provide the Always Best Connected (ABC) feature of heterogeneous wireless networks. Though few works considered other parameters such as QoS requirements of the application, they decided about the optimum network between individual pairs of networks, specifically between cellular networks and WLANs. These solutions tend to connect to WLANs that offer higher bandwidths, as and when they are available. This behaviour increases unnecessary handoffs when the mobile is moving at higher speeds. Vertical Handoff Decision algorithms should be adaptive in terms of the decision parameters and number of networks. Though, it is difficult to consider all the parameters during the design of Vertical Handoff Decision model, considering more number of parameters improves the decision outcome [10].

This research work considers a comprehensive set of parameters including user mobility and preferences in addition to QoS requirements of the application and QoS parameters offered by the candidate networks.

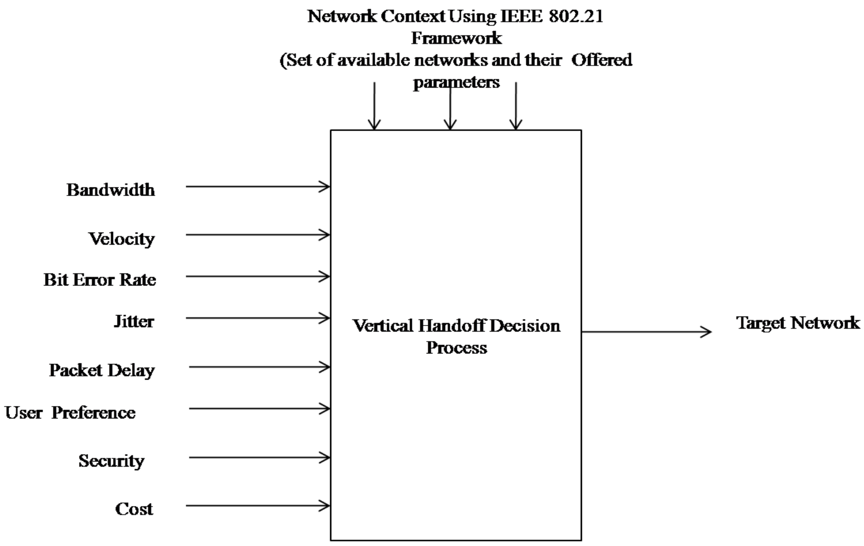
III. CONCEPTS RELATED TO VERTICAL HANDOFF DECISION

This section describes the concepts of VHD process, normalization of VHD parameters and the basics of Simple Additive Weighting.

A. VHD Process

Mobile node is assumed to be a multi-mode capable that can communicate with multiple interfaces and equipped with Media Independent Handover Function (MIHF) [11] [12]. The network to which the mobile node is presently associated is called the source network. On the other hand, the network to which the mobile handoffs is termed as the target network. VHD process is initiated when one of the events of the Media Independent Event Service (MIES) is triggered.

The network context is acquired by the Media Independent Information Service (MIIS) and the mobile context is obtained from the mobile terminal. The information about the set of available networks in the vicinity of the mobile node is also obtained from MIIS. This process is termed as Handoff Information Gathering. This information is given as the input to the handoff decision module. The input parameters are normalized using Max-Min method of linear transformation. Weights are computed using AHP [13] [14]. Next, based on the weights of these parameters, the Network Selection Function (NSF) for each available network is computed. The mobile stays in the same network if the difference of NSF values of the source network and the target network is less than the threshold value. On the other hand, if the difference is greater than the threshold value, the mobile is handed over to the target network. Vertical Handoff Decision Process is represented diagrammatically in Fig. 1.



`Fig. 1 Vertical Handoff Decision Process

B. Parameters and Normalization

The input parameters for the handoff decision process are classified as high and low parameters. Always, the network with greater values of high parameters and smaller values of low parameters is preferred. For example Bandwidth, supported velocity, QoS, Security and User Preference are high parameters. Conversely Bit Error Rate, Jitter, Packet Delay and Cost are low parameters. For high parameters, the normalized values are directly proportional to the actual parameter values. For low parameters, normalized values are inversely proportional to the actual parameter values.

Normalization function for high parameters is given by

$$N(x) = \frac{x - x_{min}}{x_{max} - x_{min}} \tag{1}$$

Normalization function for low parameters is given by

$$N(x) = \frac{x_{max} - x}{x_{max} - x_{min}} \tag{2}$$

C. Simple Additive Weighting

The Simple Additive Weighting (SAW) is the most popularly used MCDM technique for evaluating a given set of alternatives based on certain decision criteria [15] [16] [17]. For a given set of 'm' alternatives and 'n' criteria, the weighted sum (WS) of k^{th} alternative is given by

$$WS_k = \sum_{i=1}^{n} N_i W_i \tag{3}$$

Where N_i is the normalized value of the i^{th} criterion and W_i is the relative weight of the criterion. Relative weight of a criterion decides the importance of that criterion for deciding upon an alternative. The sum of relative weights of all the criteria is '1' as shown in Equation (4).

$$\sum_{i=1}^{n} W_{i=1} \quad (4)$$

After computing the weighted sum of all the alternatives, the alternative with highest weighted sum is chosen as the best among the available alternatives.

IV. ALGORITHM

The proposed Vertical Handoff Decision Model using MCDM approach is shown in Algorithm 1.

Algorithm 1

Input

1. *Networks Wi-Fi, Wi-Max and CDMA as decision alternatives.*
2. *Network parameters values of Quality of Service, Cost of the network, offered Bandwidth and supported Velocity for the above alternatives.*
3. *Device parameter values of mobile Velocity, User preference, requested Bandwidth and QoS.*
4. *a) Threshold values that define upper limits for Bandwidth, QoS and User preference*
   b) Threshold limit for cost, above which the network is considered expensive.
5. *Threshold limit on the NSF value that minimizes frequent handoffs.*

Output

Selection of the best network among the available networks.

Steps

1. *Normalize the input parameters using Max-Min method of linear transformation.*
2. *Weights are computed using Analytic Hierarchy Process (AHP) for all the decision parameters.*
3. *Evaluate Network Selection Function (NSF) for each available network using SAW technique of MCDM*
4. *Find the maximum NSF value.*
5. *If the difference between the NSF value of network 'i' and maximum NSF value is greater than the threshold value, choose the network 'i' as the target network, Else the mobile stays connected to the same network.*

V. IMPLEMENTATION

The algorithm is implemented by considering high parameters Bandwidth (BW) and Quality of Service (QoS) along with low parameters User Preference (P), monetary Cost (C) and mobile Velocity (V). The normalization functions of BW, QoS, P,C and V are given by the equations (5) to (9).

$$N_{BW} = \begin{cases} \frac{BW_{OFF} - BW_{REQ}}{BW_{TH} - BW_{REQ}}, & BW_{TH} < BW_{OFF} > BW_{REQ} \\ 0, & \text{Otherwise} \end{cases} \quad (5)$$

$$N_{QOS} = \begin{cases} \frac{QoS_{OFF} - QoS_{REQ}}{QoS_{TH} - QoS_{REQ}}, & QoS_{TH} < QoS_{OFF} > QoS_{REQ} \\ 0, & \text{Otherwise} \end{cases} \quad (6)$$

$$N_{V} = \begin{cases} 0, & V_X > V_{MAX} \\ 1 - \frac{V_X}{V_{MAX}}, & 0 \le V_X \le V_{MAX} \end{cases} \quad (7)$$

$$N_{C} = \begin{cases} 0, & C_X > C_{TH} \\ 1 - \frac{C_X}{C_{TH}}, & 0 \le C_X \le C_{TH} \end{cases} \quad (8)$$

$$N_{P} = \begin{cases} 0, & P_X > P_{MAX} \\ 1 - \frac{P_X}{P_{MAX}}, & 0 \le P_X \le P_{MAX} \end{cases} \quad (9)$$

The parameters used in these equations and their description are shown in Table 1.

TABLE I NOMENCLATURE

Parameter	Description
BW_{OFF}	Bandwidth offered by the candidate network.
BW_{REQ}	Bandwidth requirement of the application.
BW_{TH}	Bandwidth threshold value.
QOS_{REQ}	Level of QoS required by the application.
QOS_{OFF}	QoS offered by the candidate network.
QOS_{TH}	Upper threshold limit of the QoS level is considered as 100 in this experiment.
C_X	Operating cost of the network to which the candidate base station belongs to.
C_{TH}	Threshold value on cost, above which a network is considered expensive.
V_X	Velocity of the mobile node.

V_{MAX}	Maximum velocity supported by the candidate network.
P_X	The preference value that the mobile user can assign to the available networks. It takes one of the integer values ranging from 0 to 10. As the preference increases from 0 to 10, the corresponding normalized values decrease from 1 to 0. i.e., the network that is given the first preference has the highest normalized value.
P_{MAX}	Maximum preference value that can be given to a candidate network and is equal to 10.

The handover scenario assumes an overlaid network in which, smaller coverage networks are overlapped by larger coverage networks. Therefore, the coverage area of Wi-Fi is overlapped by Wi-Max network and the coverage of Wi-Max is overlapped by CDMA network as shown in Fig. 2. The mobile node is assumed to be multi-mode capable and MIH enabled, which initially is in the CDMA network. Later, it moves towards point 'B' which is under the coverage of Wi-Max and CDMA networks. Further, the mobile node moves towards point 'C' which is under the coverage of Wi-Fi, Wi-Max and CDMA networks. The mobile device acquires the network context by using Media Independent Information Service. It also acquires the device specific information required for Vertical Handoff Decision.

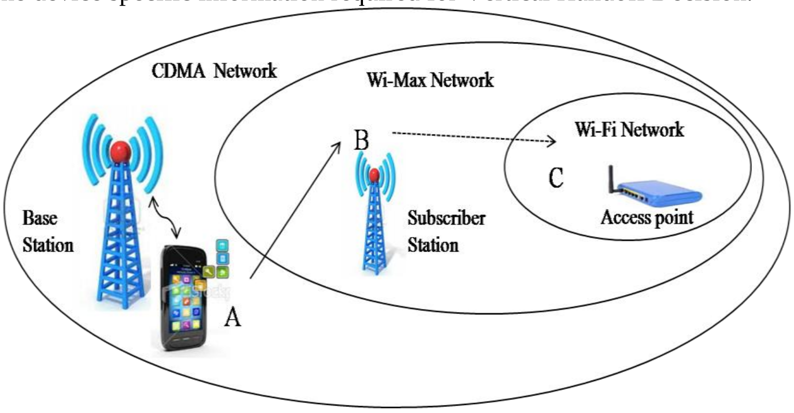


Fig. 2 Vertical Handoff Decision Process

TABLE III NETWORK PARAMETERS

Parameter	Wi-Fi	Wi-Max	CDMA
BW_{OFF} (Mbps)	60	40	30
QoS_{OFF}(%)	40	50	80
V_{MAX} (Kmph)	10	20	60
C_X (INR per 1MB)	0.2	0.4	0.6

TABLE IV DEVICE PARAMETERS

Parameter	Value
BW_{REQ} (Mbps)	20
QoS_{REQ} (%)	30
V_X (Kmph)	5

TABLE V THRESHOLD VALUES

Parameter	Value
BW_{TH} (Mbps)	80
QoS_{TH} (%)	100
P_{MAX}	10
C_{TH} (INR per 1MB)	0.8

The algorithm is tested for five different cases. In each case one parameter is given higher importance over the remaining i.e The parameter BW is given the highest importance in Case I, QoS is given the highest weight in Case II , the parameters V, C and P are given the highest preference in Case III, Case IV and Case V respectively. Now, the Network Selection Function (NSF) is computed using Simple Additive Weighting (SAW) method. Initially, the mobile node was associated with CDMA network at point 'A' and then moves towards point 'B', which is under the coverage of Wi-Max and CDMA networks. NSF values of all the candidate networks at point 'B' for all the five cases are shown in Fig. 3. Next, as the mobile node moves towards point 'C', it is under the coverage of Wi-Fi, Wi-Max and CDMA networks. NSF values are computed for these networks and are shown in Fig. 4.

From Fig. 3, the following observations are made: For Case I, which is a bandwidth-based decision and highest weight is assigned to bandwidth, Wi-Max network obtained the highest NSF value of 0.52 and therefore it is selected as the target network. Hence the mobile handoffs from CDMA network to Wi-Max network. For Case II, which is QoS-based decision, CDMA network obtained the highest NSF value of 0.61 and is selected as the target network. Since the mobile is currently associated with the CDMA network, no handoff takes place in this case. For Case III, highest weight is assigned to supported velocity. In this, CDMA network obtained the highest NSF value of 0.65. As the mobile node is already associated with the CDMA network, it does not perform any handoff. For Case IV, which is a cost-based decision, Wi-Max network obtained the highest NSF value of 0.49. Therefore, in Case IV, the mobile node switches its connection from CDMA network to Wi-Max network. For Case V, highest weight is assigned to user preference. In this, Wi-Max network obtained the highest NSF value of 0.67. Therefore, in case V, the mobile node switches its connection from CDMA network to Wi-Max network.

From Fig. 4, the following observations are made: For Case I, which is a bandwidth-based decision, Wi-Fi network obtained the highest NSF value of 0.64 among the three available networks. Therefore the mobile node which was previously connected to the Wi-Max network at point 'B', now switches to the Wi-Fi network. For Case II, which is QoS-based decision, CDMA network obtained the highest NSF value of 0.61 and the mobile node which was previously associated with CDMA network at point 'B' remains connected to the same network. Therefore, no handoff takes place in this case. For Case III, in which highest weight is assigned to supported velocity, CDMA network obtained the highest NSF value of 0.65. As the mobile node is already associated with the CDMA network at point 'B', it does not perform any handoff in this case. For Case IV, which is a cost-based decision, Wi-Fi network obtained the highest composite weight of 0.59. Therefore in Case IV, the mobile node, which was previously connected to the Wi-Max network at point 'B', now switches its connection to Wi-Fi network. For Case V, highest weight is assigned to user preference. In this, Wi-Max network obtained the highest composite weight of 0.67. The mobile node which was previously associated with Wi-Max network stays connected to the same network. No handoff takes place in this case.

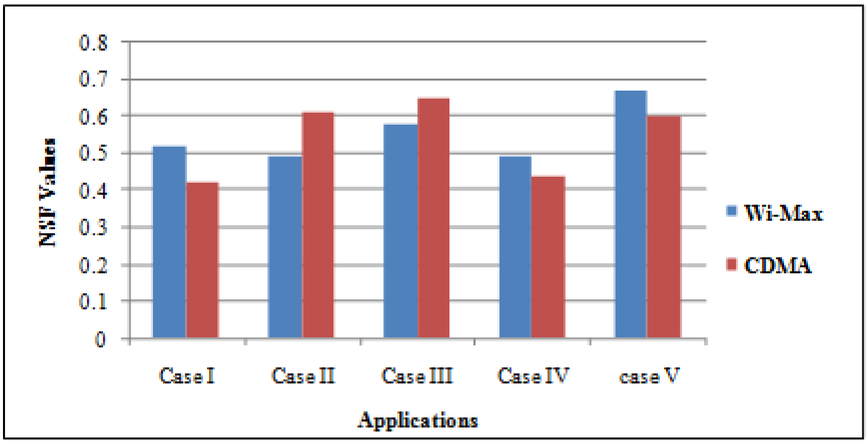


Fig. 3 NSF values when MN is at point 'B'

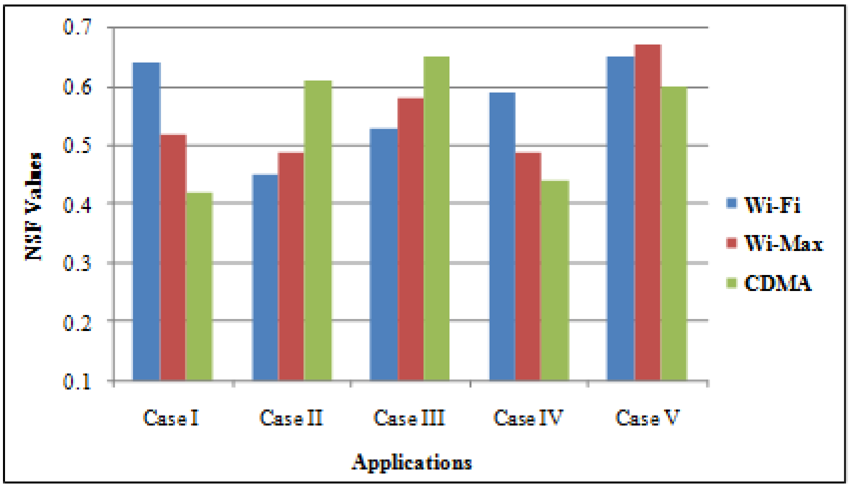


Fig. 4 NSF values when MN is at point 'C'

VI. SENSITIVITY ANALYSIS

Sensitivity Analysis is used to determine the impact of variation of individual input parameters on the output of the decision making system. Sensitivity Analysis is performed on the proposed algorithm and the results of the analysis are presented in this section. From Fig. 5, it is observed that, for increasing weights of Bandwidth, the decision converges to Wi-Fi network which offers highest bandwidth among the three available networks. From Fig. 6, it is observed that, for increasing weights of QoS, the network CDMA that offers highest quality of service among the three networks, obtained higher NSF values. Therefore, for higher weights of QoS, the decision converges to CDMA network. From Fig. 7, it is observed that for higher weights of Velocity, CDMA network covering larger distances outperformed the other two networks despite its higher cost and lower data rates. From Fig. 8, it is observed that for increasing weights of user

Preference, Wi-Max network that is given the first preference obtained higher NSF value. Therefore, Wi-Max is selected as the target network for higher weights of user Preference. From Fig. 9, it is observed that, for increasing weights of monetary Cost, the network Wi-Fi that offers lowest cost obtained higher NSF values. Therefore, for higher weights of monetary Cost, Wi-Fi is selected as the target network.

VII. CONCLUSIONS

In this paper, the Vertical Handoff Decision algorithm based on SAW based MCDM is presented. The SAW based VHD model involves simple formulae and suitable for mobile nodes that have low computational capabilities. Since, the algorithm considers the speed of the mobile node; it reduces unnecessary handoffs to low coverage networks, when the mobile is moving at higher speeds. Further, the algorithm considers user preference in the handoff decision enabling the mobile user to connect to the preferred network. The performance of the algorithm is improved by considering a threshold on the difference of NSF values of the source and target networks in order to prevent frequent handoffs. Further, the sensitivity of the proposed approach is analyzed by varying the weights of the individual input parameters. This analysis clearly shows that, for any given set of input parameters, the proposed approach is able to select the optimum network.

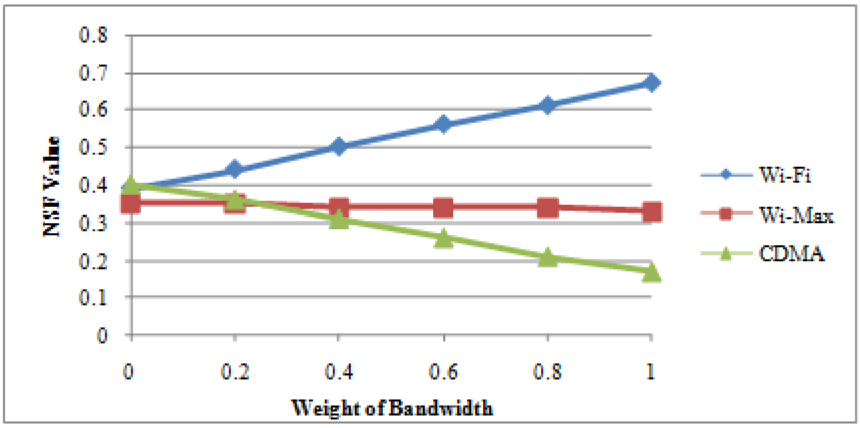


Fig.5 NSF values for varying weights of Bandwidth

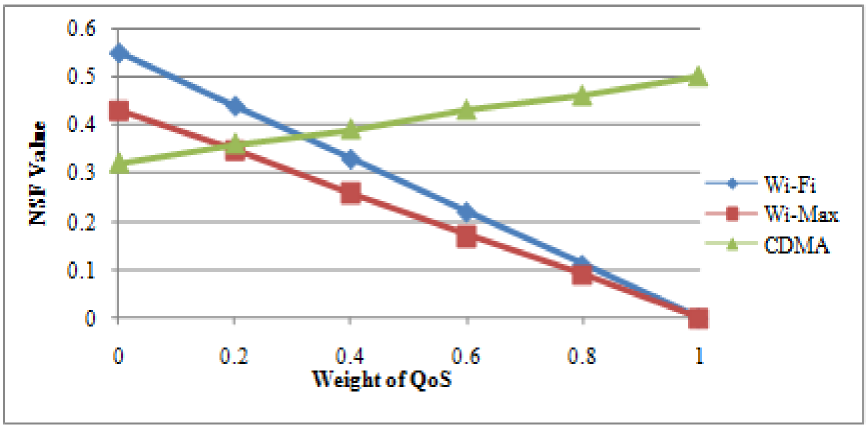


Fig. 6 NSF values for varying weights of QoS

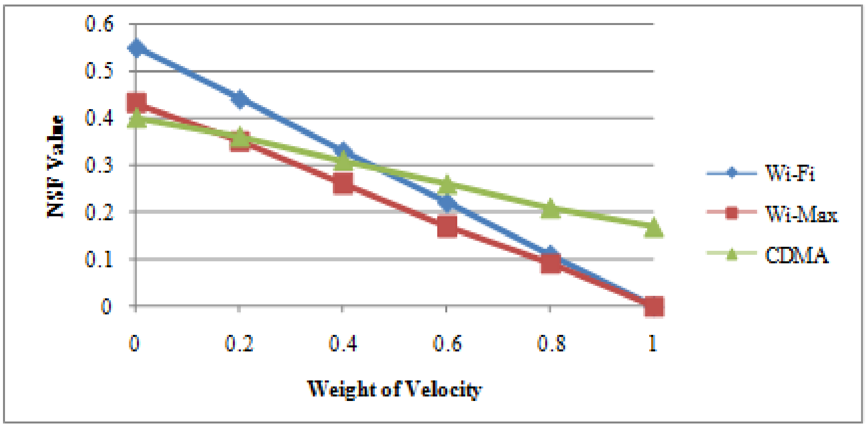


Fig. 7 NSF values for varying weights of Velocity

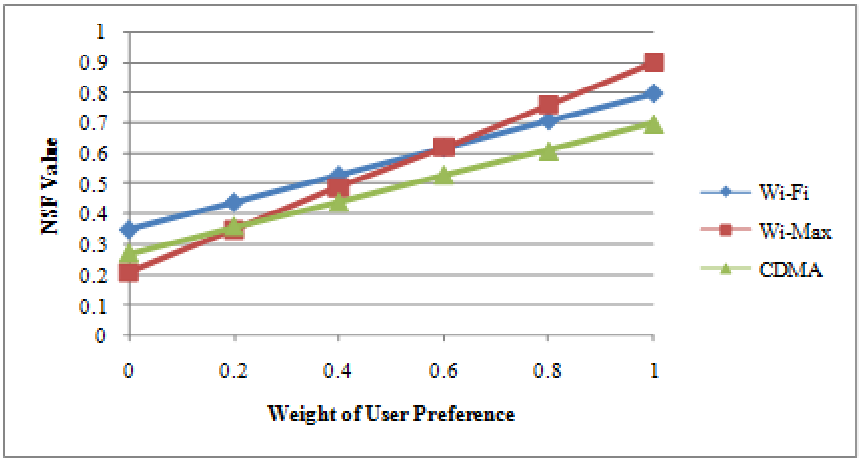


Fig. 8 NSF values for varying weights of User Preference

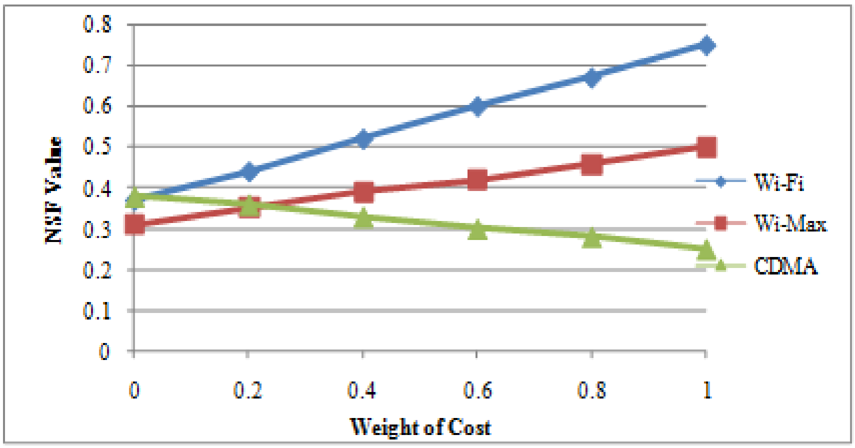


Fig. 9 NSF values for varying weights of monetary Cost

REFERENCES

[1] Christian Makaya and Samuel Pierrie, " An Architecture for seamless mobility support in IP-Based Next Generation Wireless Networks", IEEE Transactions on Vehicular Technology, Vol. 57, No. 2, March 2008.

[2] N. Shenoy and S. Misra, "Vertical Handoff and Mobility Management for Seamless Integration of Heterogeneous Wireless Access Technologies", Heterogeneous Wireless Access Networks: Architectures and Protocols, Springer, June 2008.

[3] Ikram Smaoui · Faouzi Zarai · MohammadM. Banat Lotfi Kamoun, "HeterogeneousWireless Networks: Configuration and Vertical Handoff Management", Wireless Personal communications, Springer science, pp.417-445, 2010.

[4] Ru Li, Jioo Shen, Qiuhuan Liu, " A Vertical Handoff Decision Algorithm Based on ARMA Prediction Model", In Proceedings of Fourth International Conference on Machine Vision : Machine Vision, Image Processing and Pattern Analysis, ICMV 2011.

[5] G.P.Pollini "Trends in Handover Design" IEEE Communications Magazine, 1996.

[6] Brahmjit Singh, "An improved handover algorithm based on signal strength plus distance for interoperability in mobile cellular networks", Wireless Personal Communications Volume 43, pp. 879–887, DOI 10.1007/s11277-007-9261-8, 2007.

[7] S.F. Yang, J.S. Wu and Hsu Hung, " A vertical media independent handover decision algorithm across Wi-Fi and WiMAX networks", in Proceedings of the 5th IFIP International Conference on Wireless and Optical communications Networks (WOCN), pp.1-5, May 2008.

[8] Qing He," A Fuzzy Logic Based Vertical Handoff Decision Algorithm between WWAN and WLAN", Proceedings of IEEE Conference on Networking and Digital Society", pp.561-564, 2010.

[9] Vahid S. Azhari, Mohammed Smadi and terence D. Todd, "Fast -Client Based Connection Recovery for Soft WLAN-to-Cellular Vertical Handoff", IEEE Transactions On Vehicular Technology, vol.57, No.2, March 2008.

[10] Mandeep Kaur Gondara and Dr. Sanjay Kadam, "Requirements of Vertical Handoff Mechanism in 4G Networks", International Journal of Wireless & Mobile Networks (IJWMN) Vol. 3, No. 2, pp. 18-27, April 2011.

[11] De La Oliva, A. Banchs, I. Soto, T. Melia and A. Vidal, "An Overview of IEEE 802.21: Media Independent Handover services", IEEE Wireless Communications, vol. 15, pp.96-103, 2008.

[12] Kenichi Taniuchi et.al. "IEEE 802.21: Media Independent Handover: Features, Applicability and Realization", IEEE Communications Magazine, January 2009.
[13] Saaty, T.L, 1980. The Analytic Hierarchy Process, McGraw-Hill, New York.
[14] Saaty, T.L. and Vargas L.G. "Models, Methods, Concepts and Applications of the Analytic Hierarchy Process", Kluwer Academic Publishers", Boston, 2000.
[15] Hwang C.L., Yoon K., "Multiple Attribute Decision Making" Berlin: Springer (1981).
[16] Friedman, M., and Savage, L. J. (1947), "Planning Experiments Seeking Maxima," in Techniques of Statistical Analysis, eds. C. Eisenhart, M. W. Hastay, and W. A. Wallis, New York: McGraw-Hill, pp. 365-372.
[17] Daniel , C. (1973) ,"One-at-a-Time Plans," Journal of the American Statistical Association 68, 353-360

