Introduction to Combined Smart Decision Model for Vertical Handoff

Md. Mahbubul Alam Joarder and Khaled Mahmud
Correspondence E-mail: joarder@univdhaka.edu

***Abstract*-The performance of handoff is one of the key issues for providing the quality of services in wireless technology. Different model have been proposed to reduce the handoff .In this paper, we propose a Combined Model to decide the "best" network interface and "best" time moment to handoff. We enhanced original score function using the dynamic weight factor to make the smart decision based on various factors, such as the link cost, charge consumption, data rate, signal strength and user availability. The proposed combined model performs better in terms of usage-cost and consumption. We have simulated our proposed model and found that it saves 22.26%, of the usage cost and 21.67% of the charge consumption compared to the original model.**

***Keywords:* heterogeneous wireless network, vertical hand off, seamless handoff, dynamic weight factor and smart model**

1. INTRODUCTION

With the increase of population and advancement of technology mobile devices are very useful and one of the most popular devices. More mobile hosts nowadays are equipped with multiple network interfaces which are capable of connecting to the Internet. As a result, we have to take decision on how to choose the "best" network interface at any given time. It is found that the decision should be based on various considerations such as the capacity of each network link, ISP charge of each network connection, signal strength at that particular time, data rate and power consumption of each network interface.

A similar policy-based handoff scheme has been proposed in [1], where the authors designed a cost function to decide the "best" moment and interface for vertical handoff. However, the cost function presented in this paper is an enhanced version of the cost function described in [2]. In this paper, we concentrated on improving the performance of the cost function in terms of charge consumption and usage cost. We have introduced two more parameters, signal strength and channel capacity [6] with dynamic weight functions.

In the next generation wireless cellular network the Quality if Service (QoS) provisioning for emerging broadband multimedia services is one major challenge due to the limited bandwidth and the high rate of hand off events. Therefore one of the most important QoS issues in wireless cellular networks is how to reduce the hand off drops due to the lack of available resources in the new cell, since mobile user should be able to continue their ongoing connections.

Our Combined smart decision model smartly performs vertical handoff among available network interfaces. The proposed model can properly handoff to the "best" network interface at the "best" moment according to the properties of available network interfaces and user preferences. It helps this proposed system to be incorporated in an existing system easily.

In our study, instead of user defined arbitrary coefficients, we have introduced dynamic weight factors which will smartly choose the "best" network based on the properties of available networks. If the number or properties of available networks change, the weight factors will change automatically and then the new score function will determine the best interface among the available networks. A set of experiments are performed to evaluate the performance of dynamic weight factors on smart decision model which indicates that using dynamic weigh factors Smart Decision Model performs better.

Our Combined Smart Decision Model implementation is also employed on the top of the Universal Seamless Handoff Architecture [3] as the preliminary one. The goal of our thesis work is given bellow.

- To find out the function of two parameters such as signal strength and channel availability.
- Determine whether the model has minimum usage cost and charge consumption.
- The proposed model should produce a minimum handoff occurrence.
- Execute the code on a simple workspace and demonstrate its result
- Make a comparison among the various models and their savings in term of cost and charge consumption.

The project focuses on the development of a model of dynamic weight factor to minimize the handoff occurrences.

Simple implementations have been performed using each model with successful simulation. The saving s of charge consumption and usage cost is greatly improved

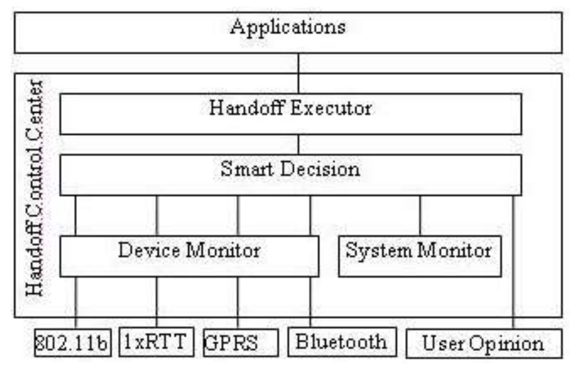

Fig.1. Smart Decision Model

in our proposed model using the channel availability as the multiplier. Moreover In enhanced model the number of handoff is not less than the previous model but in our proposed model the number of hand off is less than the previous one.

The following chapter will give a thorough background on all of the concepts used in this report which derive from the work of others and explain how they relate to the project. The rest of the paper is organized as follows. The background and related works on vertical handoff decisions are covered in section II. In section III, the simulation, result and analysis have been provided. In section I the findings and comparison of various models from different perspective have been included. Conclusion goes in the last section.

II. BACKGROUND AND RELATED WORK

In this chapter we present some useful topic for vertical handoff. Before we go through the details of our thesis it is important to know the topics we covered. Our objective is to perform a vertical handoff seamlessly and smartly.

Text must be fully justified. A format sheet with the margins and placement guides is available in both Word and PDF files as <format.doc> and <format.pdf>. It contains lines and boxes showing the margins and print areas. If you hold it and your printed page up to the light, you can easily check your margins to see if your print area fits within the space allowed.

A. Basic Smart Decision Model

In this section, we present the original Smart Decision Model. Figure 1 shows the original Smart Decision Model. In this figure, a Handoff Control Center (HCC) provides the connection between the network interfaces and the upper layer applications. HCC is composed of four components: Device Monitor (DM), System Monitor (SM), Smart Decision (SD), and Handoff Executor (HE). DM is responsible for monitoring and reporting the status of each network interface (i.e. the signal strength, link capacity and power consumption of each interface). SM monitors and reports system information (e.g. current remaining battery). SD integrates user preferences (obtained from user set default values) and all other available information provided by DM, SM to achieve a "Smart Decision", to identify the "best" network interface to use at that particular moment. HE then performs the device handoff if the current network interface is different from the "best" network interface.

There are two phases in Smart Decision model: the priority phase and the normal phase. The Smart Decision algorithm is described below:

Smart Decision Process
Priority Phase:
1. Add all available interfaces into candidate list.
2. Remove user specified interfaces from the candidate list.
3. If candidate list is empty, add back removed devices from step 1.
4. Continue with Normal Phase.

Normal Phase:
1. Collect information about every wireless interface in the candidate list from the DM component.
2. Collect current system status from SM component.
3. Use the score function to obtain the score of every wireless interface in the candidate list.
4. Handoff all current transmissions to the interface with the highest score if different from current interface.

Priority and normal phases are necessary to accommodate user-specific preferences regarding the usage of network interfaces. For instance a user may choose any network or leave any network service. With priority and normal phases in place, the module provides flexibility in controlling the desired network interface to the user. Additionally, SD deploys a score function to calculate a score for every wireless interface; the handoff target device is the network interface with the highest score. More specifically, suppose there are n factors to consider in calculating the score, the final score of interface *i* will be the sum of n weighted functions. The score function for interface *i* is as follows:

$$S_i = \sum_{j=1}^{n} w_j f_{j,i} \qquad 0 < S_i < 1, \quad \sum_{j=1}^{n} w_j = 1 \qquad (1)$$

In the equation, w_j stands for the weight of factor n, and $f_{j,i}$ represents the normalized score of interface *i* of factor *j*. Our desired target connection interface at any given moment is then derived as the one which achieves the highest score among all candidate interfaces. In the original model the score function was broken down to three components and they are usage expense (E), link capacity (C), and power consumption (P), respectively. Therefore Eq.1 becomes:

$$S_i = w_e f_{e,i} + w_c f_{c,i} + w_p f_{p,i} \quad (2)$$

Additionally, there is a corresponding function for each term $f_{e,i}$, $f_{c,i}$ and $f_{p,i}$, and the ranges of the functions are bounded from 0 to 1. The functions are illustrated below:

$$f_{e,i} = \frac{1}{e^{\alpha_i}}, \quad f_{c,i} = \frac{e^{\beta_i}}{e^{M}}, \quad f_{e,i} = \frac{1}{e^{\gamma_i}} \quad (3)$$

$$where\ \alpha_i \geq 0,\ M \geq \beta_i \geq 0,\ and\ \gamma_i \geq 0$$

$$\alpha_i = x_i / 20 \qquad ;\ x_i = \phi / \min$$

$$\beta_i = Min(y_i, M) / M \qquad ;\ M = 2Mbps$$

$$\gamma_i = 2 / z_i \qquad ;\ z_i : hours$$

The coefficients can be obtained via a lookup table or a well-tuned function. In Eq. 3, the inversed exponential equation was used to bound the result between zero and one (i.e. these functions are normalized). M is the maximum bandwidth demanded by the user. Our target is to provide the network with the highest score value. Because the highest score ensures the maximum quality of service.

B. Dynamic Weight Factor for Smart Decision Model

In the basic smart decision model weight factors were user defined and preferably assumed. But in the dynamic weight factor model [4] weight factors is weighted dynamically by calculating the three basic parameters usage expenses (E), link capacity (C) and power consumption (P) of every available network interfaces. Here, w'_{ei} indicates the intermediate weight of network *i* for link cost. Similarly, w'_{ci} and w'_{pi} indicate intermediate weights of network *i* for link capacity and power consumption respectively.

$$w'_{ei} = \frac{Min(E_1, E_2, E_3, \ldots, E_k)}{E_i} \quad (4)$$

$$w'_{ci} = \frac{C_i}{Max(C_1, C_2, C_3, \ldots, C_k)} \quad (5)$$

$$w'_{pi} = \frac{Min(P_1, P_2, P_3, \ldots, P_k)}{P_i} \quad (6)$$

where k denotes the number of available network at any time.

To keep the value of the intermediate weights between 0 and 1, it has normalized the weights in the equation (4), (5) & (6). The summation of all the weights has to be one. So, to get the final weight factors the model has divided each intermediate weight by the summation of all the intermediate weights.

Thus weight factors become

$$w_{ei} = \frac{w'_{ei}}{X}, \quad w_{ci} = \frac{w'_{ci}}{X}, \quad w_{pi} = \frac{w'_{pi}}{X}$$

$$where,\ X = w'_{ei} + w'_{ci} + w'_{pi}$$

So now the equation can be rewritten as

$$S_i = w_{ei} f_{e,i} + w_{ci} f_{c,i} + w_{pi} f_{p,i}$$

C. Enhanced Smart Decision Model

The enhanced model [5] new functions have been used instead of logarithmic ones. They have named them as data rate (dF), link cost (lC), and charge consumption (cG). Our proposed functions are stated below:

$$f_{dF,i} = \frac{d_i}{D}, \quad D = \max(d_i),$$

$$where\ \ i = available\ netwwork$$

$$f_{lC,i} = \frac{1}{lc_i}, \quad f_{cG,i} = \frac{1}{cg_i},$$

Here, d_i indicates the data rate of network *i.* D is the maximum data rate of the available network. By, available network, they mean the networks availability for mobile users at the time of the calculation the score function. lc_i and cg_i are the link cost and the charge consumption of network *i* respectively.

The model introduce two more parameters in the final score function. The new parameters are signal strength (sG) and channel availability (aC) for a user to be switched into that channel. The final score function is:

$$S_i = w_{dF} f_{dF,i} + w_{lC} f_{lC,i} + w_{cG} f_{cG,i} + w_{sG} f_{sG,i} + w_{aC} f_{aC,i}$$

Definitely $\sum_{j=1}^{5} w_j = 1$ is preserved. The new two functions are:

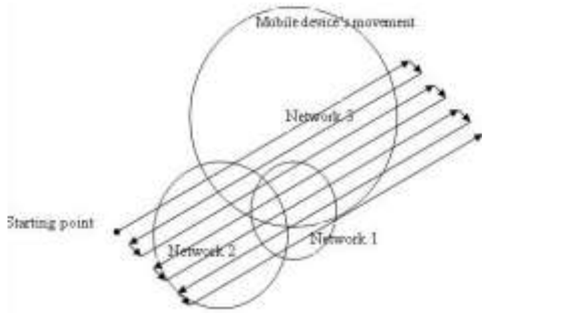

Fig.2. Scenario 2 (Networks are overlapping)

$$f_{aC,i} = \frac{mU_i - cU_i}{mU_i}$$

where mU_i = no of maximum users of network *i*
cU_i = no of current users in network *i*

$$f_{sG,i} = \frac{Pw_i}{A_i}$$

where Pw_i = Total power of netwoek *i*

$A_i = 4\pi(ds_i)^2$ *, area using ds_i as radius*

ds_i=distance of the user from the center of the network i

First, they have simulated Eq.2 according to the functions of Eq.3, and then we have simulated Eq.2 again with the above functions considering three factors only. They showed that the simulated result according to function of Eq.3 and the above function provide same result.

III. PROPOSED MODEL

From the previous chapter we know details about vertical handoff, smart decision model, USHA. Our proposed Combined Smart Decision model is implemented on the basis of USHA vertical handoff. The basic smart decision model, dynamic weight factor model, enhanced model are described in the literary review portion .We have proceeded our experiments on the basis of these previous works.

A. Network Scenario

We have worked with three different types of networks. In the first scenario they were side by side, in the second they were side by side overlapping, and in the last scenario they were eccentric. Each network has 5 five properties of their own. We have assumed different values for the network properties.

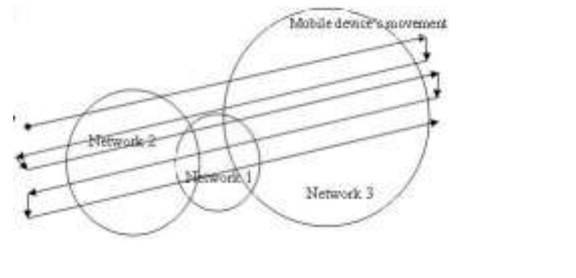

Fig.3. Scenario 1 (Networks are side by side)

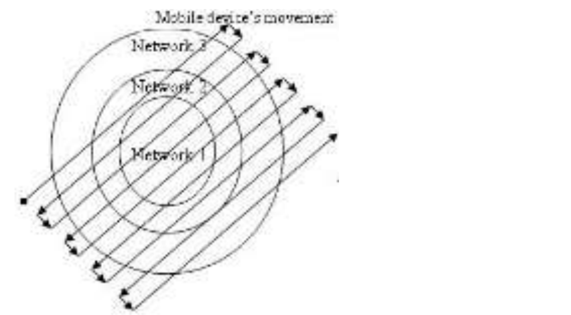

Fig.4. Network scenario no 3(Eccentric)

In all these scenarios, we have considered movements in every direction and especially we focused on the overlapping places because our intension was to observe vertical handoffs.

B. Network Properties

There are different properties those can make important role for making smart handoff decision. In Basic Smart decision model three parameters are used to take handoff decision. Those are Link cost, charge consumption, data rate. Network properties for basic Smart Model are given below:

Table 1 Value of the network parameters value of the network parameters

Name of the parameter	Network 1	Network 2	Network 3
Link cost, lc (per unit time)	2	3	5
Charge Consumption, cg (per unit time)	25	30	40
Data Rate, d (in Kbps)	256	128	512

In our experiment we have these three parameters and two more additional parameters. The values of those additional parameters are given below these parameters also used in enhanced smart decision model:

Table 2 Value of the additional network parameters

Name of the parameter	Network 1	Network 2	Network 3
Link cost, lc (per unit time)	2	3	5
Charge Consumption, cg (per unit time)	25	30	40
Data Rate, d (in Kbps)	256	128	512
Maximum User, mU	20	50	100
Power (db), Pw	30	60	90

C. Weight Factors

There are different parameters those can take place for handoff. But all parameters are not equal prioritized. Most prioritize parameter should be get highest weight factor for making handoff decision.

i. Static Weight Factor. Static weight factor means weight factors are fixed or user defined. The weight factors or the contribution of those parameters are different in our experiment than those of original Smart Decision Model. In original Smart Decision Model weight factors are static.
Weight factors of original Smart Decision Model:

Table 3 Value of the network parameters' weight factors

Name of the parameter	Value of weight factors
Usage Expanse, *We*	0.30
Link Capacity, *Wc*	0.30
Power consumption, *Wp*	0.40

ii. Dynamic Weight Factor. Dynamic weight factor is not like static weight factor. Here weight factor are not pre definer. Instead of this weight factor are calculated dynamically when new network interface is available. In the basic Smart decision Model the weight factors are static but in our experiment weight factors are dynamically calculated in the basis of five parameters (Link Cost, Charge Consumption, Data Rate, Channel availability and Signal Strength). In previous work three intermediate weight factor equations are developed. Those are in Eq. 4,5,6.

In our experiments we developed additional two parameters intermediate weight factor.

$$w'_{si} = \frac{Pw_i / d_i}{Max\,(Pw_1/d_1,\ Pw_2/d_2,\ Pw_3/d_3 \ldots\ldots Pw_k/d_k)} \qquad (7)$$

$$w'_{aci} = \frac{Min\,(cU_1/mU_1,\ cU_2/mU_2,\ cU_3/mU_3 \ldots\ldots cU_k/mU_k)}{cU_i/mU_i} \qquad (8)$$

where, k denotes the number of available network at any time

Here, w'_{si}, w'_{aci} indicates the intermediate weight of network *i* for signal strength and channel availability.

To keep the value of the intermediate weights between 0 and 1, we have normalized the weights in the equation (4), (5) , (6), (7) & (8). The summation of all the weights has to be one. So, to get the final weight factors we have divided each intermediate weight by the summation of all the intermediate weights.

Thus weight factors become

$$w_{ei} = \frac{w'_{ei}}{X},\quad w_{ci} = \frac{w'_{ci}}{X},\quad w_{pi} = \frac{w'_{pi}}{X},\quad w_{si} = \frac{w'_{si}}{X},\quad w_{aci} = \frac{w'_{aci}}{X}$$

Where $X = w'_{ei} + w'_{ci} + w'_{pi} + w'_{si} + w'_{aci}$.

So the Score function is

$$S_i = W_{dF,i}f_{dF,i} + W_{lC,i}f_{lC,i} + W_{cG,i}f_{cG,i} + W_{sG,i}f_{sG,I} + W_{aCi}f_{aC,i}. \qquad (9)$$

We made different experiments with the above equations. Our ultimate goal is work with above five parameters. But first we examine with four parameters.

D. Proposed Model 1

In our proposed combined model we consider more one parameter that is signal strength than basic three parameters (Link Cost, Charge Consumption, and Data Rate) and dynamic weight factor is used. Here weight factors are

$$w_{ei} = \frac{w'_{ei}}{X},\quad w_{ci} = \frac{w'_{ci}}{X},\quad w_{pi} = \frac{w'_{pi}}{X},\quad w_{si} = \frac{w'_{si}}{X}$$

Where $X = w'_{ei} + w'_{ci} + w'_{pi} + w'_{si}$

And the score function is

$$S_i = W_{dF,i}f_{dF,i} + W_{lC,i}f_{lC,i} + W_{cG,i}f_{cG,i} + W_{sG,i}f_{sG,I}$$

We compare our combined model with Basic model on the basis of -

1) Usage cost
2) Charge consumption and
3) Number of handoff occurred.

The average saved Usage cost of our combined model is 17.60%, saved charge consumption is 10.11% and number of handoff is 83.5833. If we compare the save of link cost and charge consumption with the basic model then we can see it provides better result than basic model. We choose channel availability because it is very important for establishing connection. If a network has everything perfect but no channel is available, no connection can be established. So we consider another more parameter channel availability in our next combined model.

E. Proposed Model 2

In this combined model we take into account two extra parameter signal strength and channel availability in addition to three basic parameter (Link Cost, Charge Consumption, and Data Rate) and also dynamic weight factor is used according to 4,5,6,7,8,9 equations.

In case of channel availability we use random function for current users where available channel is deference between maximum user and current user. Because of using the random function every time it gets different value for current user i.e. If at T th time if the value of current user pick the maximum value, at (T+1) th times it may get the minimum value. If the ratio of available channel and maximum channel is larger in a network then this network will get greater weight for channel availability.

So if the available channel is higher, the network will achieve more weight for channel availability which in turn generates highest score increasing the probability for being selected. In that case the network with highest link cost or highest charge consumption may be selected. For signal strength we observe, the effect is similar to channel availability.

We compare our combined model with Basic model on the basis of -

1) Usage cost
2) Charge consumption and
3) Number of handoff occurred

The average saved Usage cost of our combined model is 15.49%, saved charge consumption is 8.69% and number of handoff is 963.75. If we compare the save of link cost and charge consumption with the basic model this is not very significant change. We think this is for adding more two parameters and using the random function. In our model that weight factor of channel availability depends on ratio of available channel and maximum channel. But if a network has one channel available and its other factor like usages cost, charge consumption etc is better than this network should be selected. In basis of this idea we just use the channel availability as a multiplier in the next model.

F. Proposed Model 3

In this model we concern only is there any channel available or not? If there is any channel available then we give the channel availability function value 1 otherwise 0. Instead of addition we use multiplication of channel availability function with other four parameters.

Here goes the final score function:

$$S_i = f_{aC,i}(W_{dF,i}f_{dF,i} + W_{lC,i}f_{lC,i} + W_{cG,i}f_{cG,i} + W_{sG,i}f_{sG,I}).$$

Where the value of faC,i is either 1 or 0. Here we also use random function for counting current users but difference is here we use only binary value 1/0, no fraction value is used. For using binary value we get some benefit. In the combined model 2 we use weight factor in the basis of available cannel.

If a network has more available channel then it gain more weight factor for channel availability thus sometimes it may select more link cost or more charge consumption. So always may not select best network in the basis of link cost and charge consumption. But in this model number of available channel is no matter, all network will get equal priority if there is any available channel. So decision model select the best network in the basis of link cost and charge consumption.

We compare our combined model 3 with Basic model on the basis of -

1) Usage cost
2) Charge consumption and
3) Number of handoff occurred

The average saved Usage cost of our combined model is 22.26%, saved charge consumption is 21.67% and number of handoff is 513.6667. If we compare the save of link cost and charge consumption with the basic model or combined model2 this is very significant change. We think this is for counting the channel availability as multiplier.

IV. RESULTS AND FINDINGS

This chapter provides our simulation results. A set of experiments and simulations has been performed to evaluate our proposed modifications. We perform the experiment in our proposed model with different perspective as well as previously proposed model- basic smart decision model, dynamic weight model, Enhanced model and rank them in a numerical order. We compare the performance of various experimented model in terms of charge consumption, usage cost and number of handoff.

A. Analysis of the Usage Cost

We perform the experiment in our proposed model with usages cost basic smart decision model, dynamic weight model, Enhanced model and rank them in a numerical order. Table 4 shows the savings of usages cost with respect to basic Smart Decision Model. We rank the lowest number as the highest performance in the case of usage cost.

Table 4 Comparison of usage cost (in percentage)

Scenarios	Scenes	Usage cost Save on Dynamic Weight	Usage Cost Save on Enhanced model	Usage Cost Save on combined model 1	Usage Cost Save on combined model 2	Usage Cost Save on combined model 3
Networks are overlapping side by side	1	12.01	5.95	13.52	10.59	18.60
	2	12.51	6.39	14.12	11.11	19.50
	3	7.72	3.70	8.72	6.89	15.69
	4	7.69	3.70	8.70	6.97	15.34
Networks have a common overlap	5	13.00	5.75	14.21	11.59	19.24
	6	15.79	6.85	17.27	14.04	21.79
	7	13.29	5.62	14.45	11.83	19.54
	8	11.25	4.45	12.32	9.85	18.05
Networks are eccentric	9	22.42	7.40	26.31	25.12	28.97
	10	24.13	8.32	28.62	27.33	31.26
	11	22.52	7.57	26.48	25.29	29.73
	12	22.52	7.35	26.47	25.24	29.44
Average Save		15.40	6.09	17.60	15.49	22.26

The usage cost saved in the various models has been depicted in the table and the graph. From the graph and table we arrive at the decision that in the proposed combined model 3 whose channel availability is considered as the multiplier in the function, the savings percentage of the usage cost is **22.26%** which is highest among the other models and ranked as number 1 on the other hand in case of enhanced model it was 6.09% which is ranked as number 5.

B. Analysis of the Charge consumption

We also perform the experiment in our proposed model with charge consumption in basic smart decision model, dynamic weight model, Enhanced model and rank them in a numerical order. The charge consumption saved in the various models is depicted in the table 5 and the graph 4.2. The same rule has been followed here also i.e. rank the lowest number as the highest performance .From the graph and table we arrive at the decision that also in the case of charge consumption the combined model 3 whose channel availability is considered as the multiplier in the function like combined model, the savings percentage of the charge consumption is 21.67% which is highest among the other models and ranked as number 1 where as in Enhanced Model it is 3.44% and ranked as number 5.

Table 5 Comparison of charge consumption (in percentage)

Scenarios	Scenes	Save on Dynamic Weight	Save on Enhanced model	Save on combined model 1	Save on combined model 2	Save on combined model 3
Networks are overlapping side by side	1	6.12	3.15	7.36	5.57	12.92
	2	6.96	3.69	8.40	6.38	14.01
	3	4.52	2.24	5.47	4.17	12.46
	4	4.48	2.24	5.42	4.20	90.09
Networks have a common overlap	5	6.62	3.12	7.67	6.07	13.21
	6	7.82	3.61	9.07	7.15	14.20
	7	6.69	3.00	7.68	6.12	13.33
	8	5.93	2.51	6.90	5.34	12.94
Networks are eccentric	9	11.21	4.27	15.39	14.41	18.58
	10	12.07	4.83	16.95	15.86	20.14
	11	11.26	4.39	15.50	14.50	19.26
	12	11.26	4.23	15.49	14.48	18.91
Average Save		7.91	3.44	10.11	8.69	21.67

C. Analysis of the Handoff

Our observation point is focused on the number of hand off in different models .Theses observations are showing a dramatically nature in the case of hand off. The number of Hand off is highest in Enhanced model which is 1710.667 and ranked as 6 where as the number of hand off in combined model- 3, is 513.667 and ranked as number 4 among the models. It should be kept in mind that the lowest ranking number is showing the better performance in case of hand off.

From the table 5 we notice that the hand off in Basic model is the lowest one which is 21.58333.But this model cannot be considered as the best one because of its low performance in Usage cost and charge consumption.

If we observe the table 5 we see that the handoff in the proposed combined model - 3 is (513.667) better than that of the enhanced model (1710.67). It is because in combined model -3 we use the dynamic weight factor of the four parameters (data rate, link cost, charge consumption, signal strength) along with the channel availability as the multiplier whereas in the enhanced model static weight factor of those parameters has been used and if a network has no channel available but score function is better that network may be selected. But In proposed combined model 3, if no channel is available that network is not considered as a candidate network and that score is 0.

Table 5 Comparison of handoffs

Scenarios	Scenes	Basic model	Dynamic weight	Enhanced model	Combined Model 2	Combined Model 1	Combined Model 3
Networks are overlapping side by side	1	10	17	767	606	20	179
	2	34	34	834	630	44	193
	3	35	39	857	609	49	194
	4	35	39	855	627	49	212
Networks have a common overlap	5	55	57	1091	786	67	341
	6	32	38	1098	790	44	264
	7	32	31	1045	737	35	299
	8	26	31	991	769	39	277
Networks are eccentric	9	0	58	2879	1292	120	970
	10	0	81	4222	1971	184	1368
	11	0	86	2940	1372	176	954
	12	0	86	2949	1376	176	913
Average		7.91	21.6	49.8	1710	963	83.6

We further notice that in combined model 1 the handoff (83.58) is less than that of the combined model -3.It is because that in model 1 we do not use the channel availability parameter which in result reduce the number of hand off .

In some cases we observe that hand off is greater in combined model than basic model. It is because; in basic model we use the fixed weight factor. But in combined model we use the dynamic weight factor to find out the score function. Moreover in combined model we use the random number function to calculate the current user whereas we don't use such random function in basic model. That is why hand off is less in basic model. But the performance of the usage cost and charge consumption of the basic model is very poor which can be maximized in combined model.

Moreover we see that the handoffs are not same in basic model and dynamic weight factor model. In scenery 3 from table 6 we also notice that the hand off are not same (The blue front) between the basic model and the dynamic weight factor model .Network configuration is the main reason for this difference. In Scenario 3 the network configuration is eccentric and the area coverage of the network 3 i.e. N3 is large. Since the weight factor is fixed in basic model, the score function is also fixed in N3.The score function of N3 of basic model is highest and fixed, so there is no hand off.

But In scenario 1 and 2 the hand off are near to same in basic model and dynamic weight factor model. In basic model since the weight are fixed, the score function is also fixed. In the dynamic model, the weight factor is dynamic and there is a great probability to vary the score function. If we notice we can see that the network configuration are overlapping side by side and have a common space in scenario 1 and 2 respectively. The coverage area of Network 1 and network 2 are not as large as the networks 3.so there is more probability of hand off in basic model which we see in scenario 1 and. 2

In this chapter we provide our simulation's results. Here we compare the performance of three parameters i.e. link cost, charge consumption and number of handoff among the smart decision model, dynamic weight factor model, enhanced smart decision model and our proposed models from different perspectives.

In the proposed combined model 3 whose channel availability is considered as the multiplier in the function, the savings percentage of the usage cost is 22.26%.The savings percentage of the Usage cost on Dynamic Weight model, Enhanced model, combined model 1 and combined model 2 are 15.40%, 6.09%, 17.60% and 15.49% respectively. The saving percentage of the charge consumption of the proposed model 3, Dynamic Weight model, Enhanced model, combined model 1 and combined model 2 are 21.67%, 21.67%, 3.44%, 10.11%, 8.69% respectively and the number of handoff is 513.66667, 49.75, 1710.6667, 83.583333 and 963.75 respectively. Using channel availability as the multiplier (as binary either 0 or 1) has a great impact here .From the above scenario the decision can be made that proposed mode 3 is the best one among the others in term usage cost and charge consumption. In the case of handoff it is better than enhanced model and combined model 2.

V. CONCLUSION

The crucial task during vertical handoff is to provide seamless service to mobile user. In this paper we presented the proposed combined smart decision model on the basis of three previous works, which select the best network at a given time. The parameter that we considered in the model: included link cost, charge consumption, data rate, channel availability and signal strength. In this paper we also presented the results for the performance comparison between proposed five vertical handoff decision model: basic smart decision model, dynamic weight model, enhanced model, proposed combined model 1, proposed combined model 2, proposed combined model 3 .According to the result proposed model 3 presents better performance to all three performance comparison parameter: link cost, charge consumption and handoff.

The main objective of our thesis is to develop and simulate the *Dynamic Decision Model,* for performing the vertical handoffs to the “Best” interface at the “best” time moment, successfully and efficiently. From the previous chapter we say that our proposed combined model 3 successfully save large percentage of link cost and charge consumption comparison to other proposed model. Also this model takes only those networks into account to make handoff decision which has available channel. Network with low link cost, low charge consumption and high data rate might be user’s desired network but this factor cannot be taken into consideration during making handoff decision if that network has no channel available.

The proposed model implemented in our thesis is proven for save the link cost and charge consumption. There is much more work that can be done to improve on this thesis. Our first plan is to overcome the all possible current limitations of our implemented technique of our thesis. In future we introduce the concept of threshold to reduce the number of handoff. We will also introduce the time limit concept that can be useful to select the best network during handoff. The network with highest score will be considered as best network if the score remain same during this time limit. This paper tries to focus on various parameters that will impact taking decision to perform handoff .This paper also present performance comparison of various proposed model to prove the effectiveness our proposed model.

REFERENCS

[1] Wang, H. J., Katz, R. H., & Giese, J., “Policy-Enabled Handoffs across Heterogeneous Wireless Networks,” *Proceeding of ACM WMCSA*, 1999.

[2] Chen, L., Sun, T., Chen, B., Rajendran, V., & Gerla, M., “ A Smart Decision Model for Vertical Handoff ” - *The 4th ANWIRE International Workshop on Wireless Internet and Reconfigurability (ANWIRE 2004)*, Athens, Greece, 2004.

[3] Chen, L.-J., Sun, T., Cheung, B., Nguyen, D., & Gerla, M., “Universal Seamless Handoff Architecture in Wireless Overlay Networks”, *Technical Report TR040012, UCLA CSD*, 2004.

[4] Mahmud, K., Gope K., & Haq, K. N., “Introduction of Dynamic Weight Factor for Explicit Vertical Handoff”, *International Conference on Computer and Electrical Engineering, 2008 (ICCEE 2008)*, pp. 281-285, published in IEEE Xplore Database.

[5] *Joarder, M. A., Mahmud, K.,“Enhanced Smart Decision Model for Vertical Handoff”, Journal of the Bangladesh Electronic Society, (ISSN: 1816-1510) Volume 8, Number 1-2, pp 37-45, June-December, 2008.*

[6] Saleem, B., "Channel_capacity". *Lecture notes for M.Sc. Data Communication Networks and Distributed Systems D51 -- Basic Communications and Networks*. Retrieved from http://www.cs.ucl.ac.uk/staff/S.Bhatti/D51-notes/node31.html retrieved on 7/10/2011.

Md. Mahbubul Alam Joarder is Professor and Director of the Institute of Information Technology (IIT), University of Dhaka. He also currently serves as Provost, Sir Salimullah Muslim Hall, University of Dhaka. He received a B.Sc. in Applied Physics & Electronics from Dhaka University in 1990, and an M.Sc. from the same University in 1991. He received his Ph.D. in Computer Science & Engineering (Information Systems) from the University of Ibaraki, Japan in 2002. From 1996 to 1998 he worked at Lecturer in Institute of Scientific Instrumentation (ISI), University Grants Commission of Bangladesh (UGC). From 2005 to 2007, he was the PiL(Partners in Learning) advisor of Microsoft Bangladesh ltd.

Last few years, he successfully implemented some projects for the betterment of the Dhaka University. One is Remodeling of the two modern computer lab with the assistantship of KOICA in his Institute, Institute of Information Technology (IIT), University of Dhaka and another was Campus Network for Dhaka University under the guidance of University Grants Commission of Bangladesh funded by World Bank. As an independent consultant he completed a project, Public Investment Management (PIM) of Planning Commission's (PC) Programming Division and making a report which is intended to provide objective assessment of the current IT Systems and Architecture, and to make concrete, practical recommendations for improvement funded by World Bank. Now, He is also serving as Director of Bangladesh sub marine cables company limited.

His research interests center on improving the understanding, design, and performance of non-linear systems, recognition problems, computer simulation of complex systems and risk factors in software engineering. He has already published more than 33 research papers and 02 books in his field. He serves as a reviewer in many peer to peer national and international conferences and journals. He has given numerous invited talks and tutorials, and consultant to companies involved in Internet technologies.

Khaled Mahmud is lecturer at the Institute of Business Administration (IBA), University of Dhaka. He is a Fulbright business fellow and received his MBA in finance from Bentley University, Massachusetts, USA. Prior to that, he completed his Masters of Business Administration in marketing form Institute of Business Administration (IBA), University of Dhaka. He completed his under-graduation in Computer Science and Engineering (CSE) from Bangladesh University of Engineering and Technology (BUET).

He worked as consultant for Bangladesh Police in association with UNDP to formulate the strategic plan 2012-14 for Bangladesh Police. Prior to joining IBA as a fulltime faculty, he worked in Standard Chartered Bank as Assistant Manager. Besides being full time faculty in IBA, he also had been adjunct faculty in the Department of Business at Northern University Bangladesh and University of Liberal Arts Bangladesh. He also worked as full time faculty in the Department of Computer Science at University of Information Technology and Sciences for three years prior to his MBA at IBA.

He has a very diversified research portfolio. He published articles related to IT, marketing, finance, human resources, business strategy and social sciences. In the field of IT, he published several articles on vertical hand off. Other areas of his IT research include optical character recognition, mobile learning, e-learning, e-governance, and mobile governance.