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Handover Decision Based on User Preferences in Heterogeneous Wireless Networks

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***Abstract*—A handover decision is a significant problem, in next generation of wireless networks (4G). This is exacerbated when the Handoff decision is driven by user preferences (mainly transmission cost and wireless interface power consumption), wireless environment constraints (access network availability and properties and client communication capabilities). In this paper we present a handoff decision based on user preferences which consider not only the traditional handover decision factor (RSS) but also user preferences, user profiles and other requirements. We introduce APBSW (Access Point Best Satisfied Weights) for selecting access network; our proposed methods, UPHO (User Preference Handoff) use a fuzzy logic-based inference system to process all appropriate context information, which satisfy the best user preferences. The simulation result show that UPHO algorithm performs better than other handover decision algorithm in terms of user preferences satisfaction.**

***Index Terms*—Always-Best-Satisfying (ABS), APBSW (Access Point Best Satisfied Weights), Heterogeneous Wireless Network, Fuzzy Logic-based Inference system and Vertical Handoff**

I. INTRODUCTION

THE 4G or next generation networks consists of heterogeneous network managed by different operators like 2G, 3G mobile communication systems as well as Wireless LAN (WLAN), IEEE 802.16e (WiMax), satellite [1]. Mobility management is one important issue in 4G network, when a mobile user is switch from one network to another network or base station to BS there a mechanism is used “Handover”. There are two types of handover; Horizontal handoff (HHO) and Vertical handoff (VHO). As in Figure 1 .When the mobile users switching between the networks with the same technology (Wimax to WiMax) this process called HHO. In VHO the mobile users switched in different networks which have different technology (WiMax to WiFi). So in heterogeneous network vertical handoff decision (VHD) is mainly used for continuous service [2]. In this paper, we focus on handover decisions which occur when a mobile device needs to choose a different access network to which to connect. Traditionally, handover decisions have been based on evaluation of the Received Signal Strength (RSS) at the mobile device to support Always-Best-Connected (ABC) communication [3].

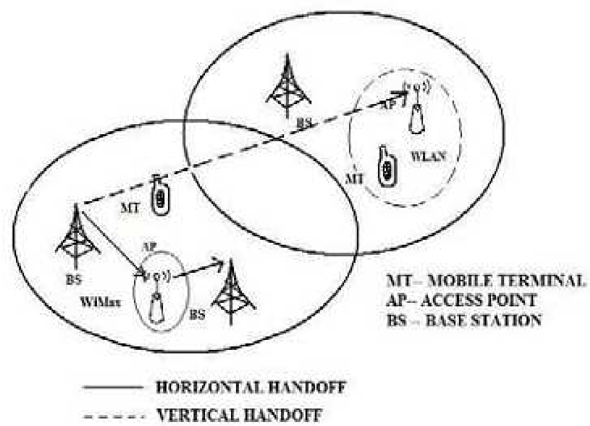

Fig. 1. Vertical and Horizontal Handoff

However, the prospects of 4G include Seamless roaming and personalization. The latter refers to the method used to provide tailored services that are built on the individual preferences of users in a given context, automatically reflecting user’s needs in a specific situation [4]. This user centric approach means that the applications and services in 4G will need to adapt to who the user is, the user’s interests and context [5]. If the handoff decision does not serve the interests and preferences of the user, then it is not user centric. The user centricity of the handoff decision means the user specifies the context changes that trigger handoff and the network properties of the target network they wish to handoff to. This is based on their current context, profile and preferences. This paper presents a handover decision based on user preferences in heterogeneous networks. As we mentioned earlier, previous hand-over management has focused on always-best-connected (ABC). In our case, a handover decision uses the collected information as input to evaluate the available access networks and to select the network best capable of satisfying the user’s request at a particular time. We name such a network an Always-Best-Satisfying (ABS). However, current and future applications that wish to offer smart handover decisions for personalized services should consider ABC and ABS. The ABS network provides always-on-connectivity as well as giving the user the best service according to his or her preference at any time or place [6].

Our proposed methods, UPHO use a fuzzy logic-based inference system to process all appropriate context information, which satisfy the best user preferences. We introduce APBSW for selecting access network.

The results of our evaluation show that our proposed method provides a higher degree of user preferences satisfaction than other handover decision algorithms.

The structure of the paper is as follows: section II describes the related work on handover decision management. Section III presents the architecture that supports handoff decision based user preferences. Section IV describes our solution approach used to evaluate the handoff decision method. The simulation environment is presented in section V. Section VI concluded the paper.

II. Related Work

Much of the research in 4G networks has focused on either seamless roaming or personalization but not the integration of both. Different methods have been used in literature for handoff decision to provide seamless roaming. Analytical Hierarch Process (AHP) has been proposed in [7] other methods such as Technique for Order Preference by Similarity to Ideal Situation (TOPSIS) has been proposed in [8]. AHP and TOPSIS are limited in supporting user preferences these methods only consider decision making under certainty. In wireless networking, not all context information is available at decision time.

Angermann and Kammann [9] proposed another scheme to model the handover with HTTP traffic, but it has problems with other types of traffic, such as video and audio streaming, where the bandwidth demand is much higher than HTTP traffic. Chen et al. [10] proposed a smart decision model to perform vertical handover to the ‘‘best’’ network interface at the ‘‘best’’ moment; this was tested on the Universal Seamless Handover Architecture (USHA). The smart decision model is based on the properties of available network interfaces (e.g., link capacity, power consumption and link cost), system information (e.g., remaining battery) and user preferences. Although the model presented a detailed example on the USHA test-bed, it did not describe in enough detail how to calculate the properties and the meaning of cost value. Calvagna and Di Modica [11] aimed to understand how to define a metric in order to devise a solution that balances the overall cost of the vertical handover with the actual benefits they bring to the user’s networking needs.

This way, each mobile user could autonomously apply the handover decision policy, which is more appropriate to the user’s specific needs. However, this approach did not present a feedback control loop for adaptive decision and change policies autonomously by context changes. [12] Presents a personalized handoff decision method to offer personalization in seamless roaming for the next generation of wireless networks. This is done by assigning profiles to different users with different preferences and using these profiles to offer personalized handoff. However user’s profiles consider only QoS or Cost parameters not both together. Hence, these solutions provide less support for context propagation, personalization and hence less user preferences.

III. System Architecture

There are two major parts in this architecture, the network side and the terminal side. An optimal handover decision must consider their joint contributions. On the network side, the Operations and Support Systems (OSS) of each network performs network monitoring and reports to the context server. The various repositories distributed in the networks store the context information, such as location information and user profiles. The context server located in the network collects the relevant context information from the context repositories. On the terminal side, the Terminal Management System (TMS) interacts with the context server for the purpose of making the optimal selection of the appropriate radio segment to which the terminal will eventually be assigned. The terminal's estimation of RSS and QoS levels in the system are beneficially combined for making an informed selection of the appropriate radio technologies through which services can be obtained as efficiently as possible. Thus, both the network and the terminal contribute useful information that should be combined in order to make an optimal decision (Fig. 2).

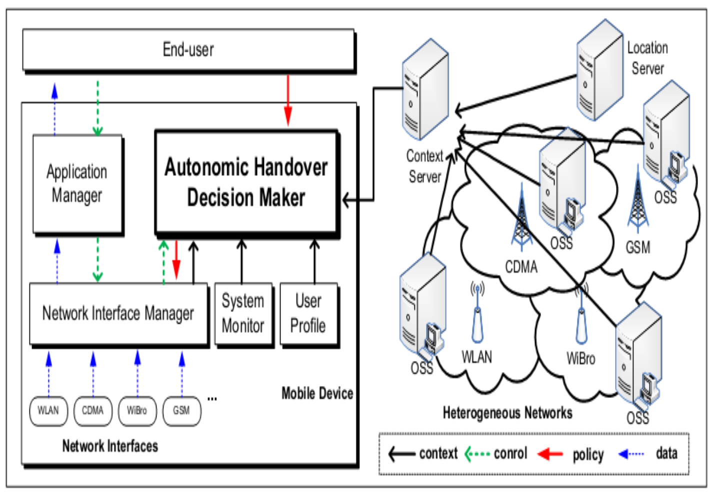

Fig. 2. Terminal management system in heterogeneous wireless network

IV. Solution Approach

We use four user preferences to make a handover decision: RSS, Cost, Quality, and Lifetime. We define four Access Point Weights (APWs), one for each of the following user preferences: RSS (APRW), cost (APCW), quality (APQW), and lifetime (APLW). An APRV is calculated using Received Signal Strength Indicator (RSSI) which is a measurement of the power present in a received radio signal [13].

If the user wants to use an application with a high quality of service and does not care about the price of the network, the AP that has the maximum (APQW) is the best one. However, if the user wants to use an application that has a high quality of service but a low price, the AP that has the maximum APQW may not be the best one, since its (APCW) may be unacceptably low (i.e., the network is too expensive). This also applies to the AP that has the maximum APCW (i.e., the AP that has the least cost) because it may have an APQW that is unacceptably low. Therefore, we define APBSW for solving these problems. An APBSW represents how well a particular AP satisfies the needs of the end user based on his or her user profile (which is selected by the end user's preferences) for a specific context. In determining an AP that best satisfies the needs of the end user, APBSWs based on fuzzy goals and fuzzy constraints have unequal importance to decision making, and the proper fuzzy decision making operator should be considered. The weighted additive model (which is widely used in vector objective optimization problems) can handle this problem; the basic concept is to use a single utility function to express the overall preference of decision making to draw out the relative importance of each criterion [14].

In this case, a linear weighted utility function is obtained by multiplying each membership function of fuzzy goals by their corresponding weights and then adding the results together.

In this paper, we define a utility function to calculate the set of APBSWs of all candidate APs by applying a weighted UP. We use additive aggregate utility function which aggregates multiple criteria in a composite criterion, using the information given by a subjective ranking. We used user profiles as subjective ranking. The following Equation calculates an APBSW of each AP.

The notation of UP is a set of weights of user preferences, such as:

UP= (WR; WC; WQ; WL), where WR+WC+WQ+WL= 1.0 (1)

$$APBSW(AP_{i,j}) = (W_R\, W_C\, W_Q\, W_L) \bullet \begin{pmatrix} AP_R(AP_{i,j}) \\ AP_C(AP_{i,j}) \\ AP_Q(AP_{i,j}) \\ AP_L(AP_{i,j}) \end{pmatrix}$$

$$= W_R \bullet AP_R(AP_{i,j}) + W_C \bullet AP_C(AP_{i,j}) + W_Q \bullet AP_Q(AP_{i,j}) + W_L \bullet AP_L(AP_{i,j}) \quad (2)$$

TABLE I
PRE-DEFINED WEIGHTS OF USER PROFILES FOR ORDINARY USERS

User preference	RSS	Cost	Quality	Lifetime	RSS & Cost	Cost & Quality	Cost & Quality & Lifetime	RSS & Cost & Quality & Lifetime
WR	0.7	0.1	0.1	0.1	0.4	0.1	0.1	0.25
WC	0.1	0.7	0.1	0.1	0.4	0.4	0.3	0.25
WQ	0.1	0.1	0.7	0.1	0.1	0.4	0.3	0.25
WL	0.1	0.1	0.1	0.7	0.1	0.1	0.3	0.25

We implemented the fuzzy membership functions and inference rules using jFuzzy-Logic [15], which is an open source fuzzy logic written in the Java language.

V. SIMULATION ENVIRONMENT

In this experiment, we used CDMA, IEEE 802.16 Mobile WiMax, and IEEE 802.11 based WLAN access networks, as illustrated in figure 3. The area of the simulation network was 1,000 m by 1,000 m. Three CDMA BSs, one Mobile WiMax Radio Access Station (RAS), and three WLAN APs were covering the area. In this experiment, we considered BSs, RASs, and APs to each function as an AP. These access nodes were connected to the Router via 100 Mbps trunks with different traffic parameters.

The coverage of each access point was represented by an associated ellipse. We chose the MIPv6 protocol as the IP mobility management protocol for the mobile nodes. One mobile node, MN1, was managed in our simulation environment. This mobile node moved from a starting coordinate (147; 316) to an ending coordinate (864; 504), with a speed of 40km/h. The MN1 had three different types of network interfaces: CDMA, Mobile WiMax, and WLAN, which enabled it to communicate with each access network for the specific application. The context server gathered the context information from each access network.

We controlled all network parameters of each network device. The application server provided three different types of application traffic: VoIP, Streaming Multimedia, and FTP. We created traffic for each application using an NS-2 network simulator. In this study only voice call application is considered.

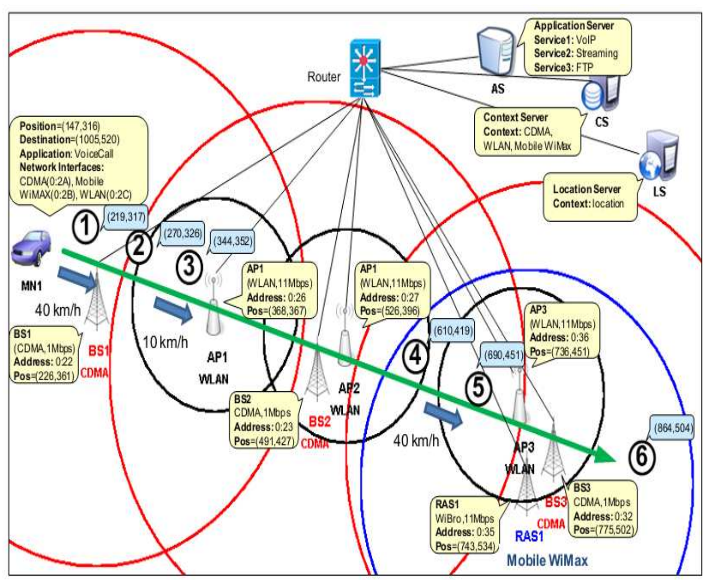

Fig. 3. Simulation environment for handover decisions in CDMA, WLAN, and Mobile WiMax access networks

A. Network Parameter

TABLE II
NETWORK SETTING AT EACH LOCATION

Access network (access point)	CDMA (BS1)	CDMA (BS2)	CDMA (BS3)	WLAN (AP1)	WLAN (AP2)	WLAN (AP3)	Mobile WiMax (RAS1)
Coverage (meter)	1000	1000	1000	400	400	400	800
Bandwidth (kbyte)	1000	1000	1000	11,000	11,000	11,00 0	2000
Delay (ms)	25	19	22	8	25	45	25
Jitter (ms)	7	6	7	4	8	10	8
Bit error ratio (dB)	0.001	0.001	0.001	0.00001	0.00001	0.000 01	0.0001
Throughput (Mbyte/s)	1.3	1.7	1.7	25	25	25	15
Burst error	0.6	0.5	0.5	0.2	0.2	0.2	0.1
Packet loss ratio	0.08	0.07	0.07	0.04	0.04	0.04	0.02
Cost rate ($/min)	0.9	0.9	0.9	0.2	0.2	0.2	0.5
Power Tx (W)	1.4	1.4	1.4	2.8	2.8	2.8	2.0
Power Rx (W)	0.925	0.925	0.925	0.495	0.495	0.495	0.7
Power idle (W)	0.045	0.045	0.045	0.082	0.082	0.082	0.06
Minimum speed (km/h)	0	0	0	0	0	0	0
Maximum speed (km/h)	300	300	300	12	12	12	80

In the experiment, we configured network parameters for our case studies as shown in table 2. Each of the six locations represents different control points to calculate handover decisions. The characteristics of each location, and the different semantics that they provide, are as follows:

Location 1: Starting point (only one access network, CDMA (BS1), is available. All decision algorithms will select it.

Location 2: The delay and jitter of BS1 are higher than those of BS2, and the speed of the MN1 is changed to 10 km/h.

Location 3: The power consumption rate of CDMA is lower than that of WLAN.

Location 4: The quality of WLAN is lower than that of CDMA. However, the price of WLAN is lower than that of CDMA.

Location 5: The speed of MN1 is changed to 40 km/h. WLAN is filtered by the speed filter. The quality of BS2 is higher than that of BS3.

Location 6: The price of Mobile WiMax is lower than that of CDMA. We will show that our proposed algorithm selects the best AP at all locations in terms of end user satisfaction, and hence performs better than the other algorithms.

We create a mobile device that supports multiple network interfaces and applications. We then assign a moving path for the mobile device; this is shown in figure 3 as the large horizontal arrow. We then apply voice call application traffic, which we generated from an NS-2 network simulator. Finally, we measure the APBSWs of each handover decision algorithm and compare them.

To evaluate our proposed UPHO algorithm, we compared its performance with the following five handover decision methods: 1) Random decision (RD), 2) RSS-based decision (RSSD), 3) Cost-based decision (CD), 4) Quality-based decision (QD), and 5) Lifetime-based decision (LD). First, we compare available access networks, and then reduce the candidate access networks by speed filtering, and then compute all BSAPs for all candidate APs, and present the AP selected by all handover decision algorithms at all locations (Fig. 3). Finally, we compare the APBSWs of the AP selected by all handover decision algorithms to prove our hypothesis.

B. Simulation Analysis

We use a voice call application with three different ordinary (i.e., pre-defined) user profiles: Cost & Quality (CQ), Quality & Lifetime (QL), and Cost & Quality & Lifetime (CQL). A voice call application uses VoIP traffic, figure 3. The duration of our simulation is 651 seconds which the mobile node will take from the starting point to the ending point. Table 3 shows the experimental results of a voice call with the user profile, CQ.

At location 1, all decision algorithms select BS1 as the best AP.

At location 2, RD, RSSD, CD, and LD select the CDMA (BS1) as the best AP, whereas QD and AUHO select the CDMA (BS2) as the best AP. Although the RSS of BS1 is stronger than the RSS of BS2, the quality of voice call traffic of BS2 is better than that of BS1 (because the delay and jitter of BS1 are higher than that of BS2). That is, the APBSW of BS2 is higher than the APQW and APBSW of BS1. In this experiment, BS2 is the best AP because the UP is CQ. Our UPHO provides a better solution than RD, RSSD, CD, and LD at location 2.

At location 3, RD, RSSD, CD, QD, and UPHO select WLAN (AP1) as the best AP, whereas LD selects the CDMA (BS1) because the power consumption rate of CDMA is lower than that of WLAN. In this location, AP1 is the best AP because the UP is CQ. Our UPHO method provides a better solution than LD at location 3.

At location 4, RD, CD, and UPHO select WLAN (AP2) as the best AP, whereas RSSD, QD, and LD select CDMA (BS2) as the best AP. The quality of a voice call application of BS2 is higher than that of AP2, but the cost of BS2 is higher than that of AP2. In terms of Quality, BS2 is the best AP. However, AP2 is the best AP in terms of Cost. The strength of our proposed UPHO method is shown here particularly well. In a complex situation such as this, we measure the satisfaction weight, APBSW, of each AP, based on the user profile. With the consideration of end user satisfaction, the APBSW of BS2 is 0.503, whereas that of AP2 is 0.584, which is higher than that of BS2. See table III. At location 4, our UPHO method provides a better solution than QD.

At location 5, the speed of MN1 is changed to 40 km/h. The WLAN (AP2) is removed from the candidate access network list by the speed filter because the supporting maximum speed of WLAN is 12 km/h. RD, RSSD, and LD select CDMA (BS3), CD selects Mobile WiMax (RAS1), and QD and UPHO select CDMA (BS2). CD selects RAS1 because the cost rate of Mobile WiMax is lower than that of CDMA. In terms of Cost, RAS1 is the best. However, the quality of RAS1 is lower than that of CDMA. In this case, APBSWs of BS2 and RAS1 are equal. When they are equal, our proposed algorithm selects the AP that has the stronger RSS (since the UP is CQ).

Finally, at location 6, RD, RSSD, QD, and LD select CDMA (BS3), whereas CD and UPHO select Mobile WiMax (RAS1). The quality of BS3 is higher than that of RAS1, whereas the cost of CDMA is higher than that of Mobile WiMax. The APBSW of BS3 is 0.401, whereas that of RAS1 is 0.459. As can be seen in table III, our proposed UPHO selects RAS1 as the best AP. We compared the APBSW of the selected AP.

We summarized the mean and standard deviation of the APBSWs of the AP selected by all handover decision algorithms with different user profiles. In figure 4, we show that our proposed UPHO algorithm provided a better ABS mobility than other decision algorithms.

TABLE III
EXPERIMENT RESULT AT EACH LOCATION (APPLICATION = VOICE CALL; UP = COST & QUALITY

Location	1	2	3	4	5	6
Simulation time (sec)	25	44	157	553	585	651
Available access networks (AP)	CDMA (BS1)	CDMA (BS1,BS2)	CDMA (BS1,BS2), WLAN (AP1)	CDMA (BS2,BS3), WLAN (AP2), Mobile WiMax (RAS1)	CDMA (BS2,BS3), WLAN (AP3), Mobile WiMax (RAS1)	CDMA (BS3), Mobile WiMax (RAS1)
Speed filtering (AP)	CDMA (BS1)	CDMA (BS1,BS2)	CDMA (BS1,BS2), WLAN (AP1)	CDMA (BS2,BS3), WLAN (AP2), Mobile WiMax (RAS1) (RAS1)	CDMA (BS2,BS3), Mobile WiMax (RAS1)	CDMA (BS3), Mobile WiMax (RAS1) (RAS1)
AP (APRW)	BS1(0.816)	BS1(0.779), BS2(0.019)	BS1(0.530), BS2(0.335), AP1(0.703)	BS3(0.256), BS2(0.527), RAS1(0.114), AP2(0.141)	BS3(0.598), BS2(0.203), RAS1(0.501)	BS3(0.652), RAS1(0.385)
AP (APCW)	BS1(0.100)	BS1(0.100), BS2(0.100)	BS1(0.100), BS2(0.100), AP1(0.800)	BS3(0.100), BS2(0.100), RAS1(0.500), AP2(0.800)	BS3(0.100), BS2(0.100), RAS1(0.500)	BS3(0.100), RAS1(0.500)
AP (APQW)	BS1(0.500)	BS1(0.500), BS2(0.900)	BS1(0.500), BS2(0.900), AP1(0.900)	BS3(0.614), BS2(0.900), RAS1(0.500) AP2(0.500)	BS3(0.614), BS2(0.900), RAS1(0.500)	BS3(0.614), RAS1(0.500)
AP (APLW)	BS1(0.500)	BS1(0.500), BS2(0.500)	BS1(0.500), BS2(0.500), AP1(0.500)	BS3(0.500), BS2(0.500), RAS1(0.203), AP2(0.500)	BS3(0.500), BS2(0.500), RAS1(0.203)	BS3(0.500), RAS1(0.203)
AP (APBSW)	BS1(0.372)	BS1(0.368), BS2(0.452)	BS1(0.343), BS2(0.483), AP1(0.800)	BS3(0.361), BS2(0.503), RAS1(0.432), AP2(0.584)	BS3(0.395), BS2(0.470), RAS1(0.470)	BS3(0.401), RAS1(0.459)
Random (best AP)	CDMA (BS1)	CDMA (BS2)	WLAN (AP1)	WLAN (AP2)	CDMA (BS3)	CDMA (BS3)
RSS (best AP)	CDMA (BS1)	CDMA (BS1)	WLAN (AP1)	CDMA (BS2)	CDMA (BS3)	CDMA (BS3)
Cost (best AP)	CDMA (BS1)	CDMA (BS1)	WLAN (AP1)	WLAN (AP2)	Mobile WiMax (RAS1)	Mobile WiMax (RAS1)
Quality (best AP)	CDMA (BS1)	CDMA (BS2)	WLAN (AP1)	CDMA (BS2)	CDMA (BS2)	CDMA (BS3)
Lifetime (best AP)	CDMA (BS1)	CDMA (BS1)	CDMA (BS1)	CDMA (BS2)	CDMA (BS3)	CDMA (BS3)
AUHO (best AP)	CDMA (BS1)	CDMA (BS2)	WLAN (AP1)	WLAN (AP2)	CDMA (BS2)	Mobile WiMax (RAS1)

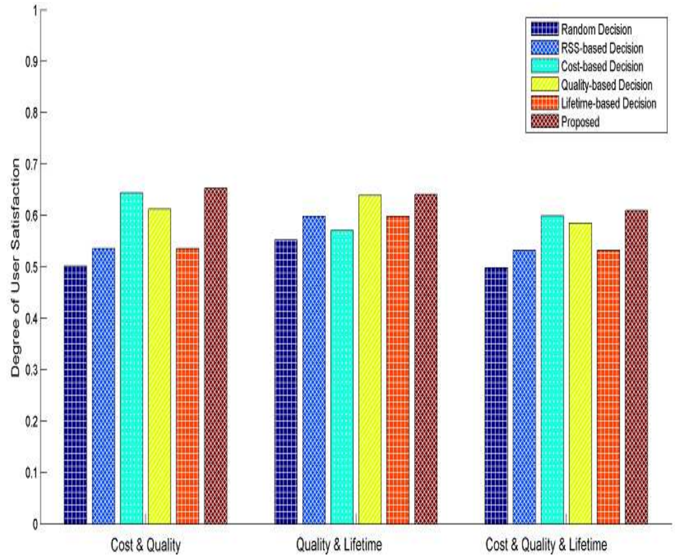

Fig.4. Comparison of the mean of all APSV in the first experiment

VI. CONCLUSION

This paper has presented a handoff decision based on user preferences designed for seamless roaming for next generation of wireless networks. The proposed handoff decision can integrate a variety of wireless technologies (CDMA, WLAN, and Mobile WiMax access networks) into a seamless communication environment. It uses a range of context information about networks, users and applications to perform personalized handoff decision for each profile. It implements a profile based approach that categorizes different users and their needs into different profiles thus offering deep personalization. This method provides a personalized handover decision method for finding the AP that can best satisfy the requirements of the end user for a particular context. For instance, when all the networks meet the application's QoS requirement, the user can still specify their preferred network in such a scenario based on their own preference. In our approach, APBSW represents end user satisfaction. By selecting the AP that has the maximum APBSW. We showed that our UPHO algorithm supports better ABS than other decision algorithms.

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REFERENCES

[1] IEEE S02 standards, http://www.ieeeS02.

[2] N.Nasser, A.Hasswa and H.Hassanein, “Handoff in Fourth Generation Heterogeneous Networks”, IEEE communication Magazine, Vol.44, pp. 96-103, Oct 2006

[3] De Leon, M.P.; Adhikari, A. “A user centric always best connected service business model for MVNOS” 14th international conference, intelligence in next generation network (ICIN), 2010, pp. 1-8

[4] P. Bellavista, A. Corradi, and L. Foschini. “Context-aware handoff middleware for transparent service continuity in wireless networks.” Believer Pervasive and Mobile Computing 3, pages 439–466, 2007.

[5] Ramjee Prasad “personal network and 4G” 49th International Symposium ELMAR-2007, Croatia, pp.1-6

[6] X. Yan, Y.A. Sekercioglu, S. Narayanan, “A survey of vertical handover decision algorithms in fourth generation heterogeneous wireless networks”, Computer Networks vol. 54, no. 11, pp. 1848–1863, 2010.

[7] M. Kassar, B. Kervella, and G. Pujolle. “An overview of vertical handover decision strategies in heterogeneous wireless networks.” Computer Communications, vol. 31, no.10 pp. 2607–2620, 2008

[8] Farooq Bari and V. C. Leung, “Automated network selection in a heterogeneous wireless network environment” IEEE Network, vol. 21, no. 1, pp. 34-40, 2007.

[9] M. Angermann, J. Kammann, “Cost metrics for decision problem in wireless ad hoc networking”, in: Proc. of IEEE CAS Workshop on Wireless Communications and Networking, September 2002.

[10] Ling-Jyh Chen, Tony Sun, Benny Chen, Venkatesh Rajendran, and Mario Gerla., "A Smart Decision Model for Vertical Handoff," The 4th ANWIRE International Workshop on Wireless Internet and Reconfigurability (ANWIRE 2004, in conjunction with IFIP Networking'04), Athens, Greece, 2004.

[11] A. Calvagna, G. Di Modica, “A user-centric analysis of vertical handovers”, in: ACM Wireless Mobile Applications and Services on WLAN Hotspots, Philadelphia, PA, USA, pp. 137–146, 2004

[12] Mokhesi, L.; Bagula, A.; “Personalized handoff decision for seamless roaming in next generation of wireless networks”, International Conference on Network and Service Management (CNSM), pp. 362-365. 2010

[13] http://en.wikipedia.org/wiki/Received_signal_strength_indication. [Online; accessed 9-November-2011].

[14] Y. Lai and C. Hwang, “Fuzzy multiple objective decision making: (methods and applications). Springer, 1994

[15] http://jfuzzylogic.sourceforge.net/. [Online; accessed 7-September-2011].

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