Energy Efficient Network Selection in Heterogeneous Network using TOPSIS

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Abstract— Due to integration of heterogeneous wireless technology demand of seamless communication is increases. Various approaches have been proposed for network selection in vertical handoff. Here we propose a new energy efficient network selection algorithm by considering three networks (CDMA, WIMAX &WLAN) for network selection .In this work, based on the power consumption, traffic class and current battery level of each network interface card , the mobile terminal lifetime is to be calculated. As the lifetime of mobile terminal decreases, we reduce the number of attributes and networks by eliminating the particular network form network list. AHP (Analytic hierarchical process) and TOPSIS (Technique for order of Preference by similarity to the Ideal Solution) are used for network selection.

Keywords- *power consumption; lifetime; Heterogeneous wireless network; Network selection ;MADM.*

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I. INTRODUCTION

In the next generation heterogeneous environment user can move within or among different types of networks. For supporting seamless mobility across heterogeneous networks vertical handoff has been required. Vertical handover process consists of three main phases as information gathering, decision making and handoff execution [1]. In the first step, the mobile terminal (MT) discovers its available neighboring networks. During the handoff decision phase, mobile device decides whether the connection to be continued with current network or to be switched over to another one. The decision may depend on various parameters including the available bandwidth, delay, jitter, bit error rate, cost, transmit power, current battery status of the mobile device, and the user's preferences. During the handoff execution phase, connections need to be re-routed from the existing network to the new network in a seamless manner. Due to integration of various wireless technologies, terminal power consumption and handoff latency increases which results in reduction of battery life time of mobile terminal. In energy efficient vertical handoff it is essential to choose a network having highest lifetime value and low handoff latency. The decision making method used for network selection is expected to play an important role to minimize the energy consumption, and to extend the terminal lifetime [2], so here we focus on decision making phase of vertical handoff. Multiple attributes decision making (MADM) algorithms are able to deal with multi criteria nature based vertical handoff decision. Thus in this work AHP & TOPSIS multiple attributes decision making algorithms have been used for efficient network selection. AHP is used to assign priority weights to various attributes and TOPSIS is used for optimum network selection among the available networks. Network selection in handoff decision phase depends on user's preference because each traffic class (conversational, streaming interactive, background) consume a different amount battery power .While the handoff latency can be reduced by eliminating unnecessary attributes in particular traffic class. For example to deliver streaming traffic the identification of criteria based QOS must not only satisfy streaming traffic in term of reduce end to end delay but must also takes into consideration low bit error rate which is not necessary to deliver background traffic. In this work, conversational traffic class has been considered for network selection. As the lifetime offered by a particular network decreases we eliminate that network from list of available network and at the same time we reduce unnecessary attributes in order to decrease handoff latency.

Rest of the paper is organized as follows: Section 2 present the related work proposed by different researchers. In section 3, we present the proposed work in which we calculate power consumption, expected lifetime of available networks and describe energy efficient network selection algorithm. Section 4 provides the result of proposed approach. Finally Section 5 concludes this paper.

II. RELATED WORK

The various researchers propose different approaches for energy efficient network selection in heterogeneous wireless network. In [3] *WISE* (Wise Interface Selection) algorithm was proposed which selects the energy efficient network interface, by taking into consideration not only the energy consumption of each NIC(WLAN&3G), but also the network throughput. *WISE* utilizes *VDC*, which balances the network traffic load and takes the decision to perform vertical handoff. In the proposal [4] MADM method is used for network selection in hybrid wireless networks for vertical handover. This algorithm is composed of the power consumption prediction algorithm for estimating the expected lifetime of mobile station and the MADM method (AHP&GRA) for final network selection. If the expected lifetime of the mobile station in a certain network is not long enough compared with the handover delay, this particular network will be removed from the candidate network list (CNL).MADM method was also used for reducing handoff matrix in [5], from this method it can be deduce that due to correlation between the three criteria (packet delay, packet jitter and packet loss) the optimized network selection algorithm eliminates packet jitter and packet loss. A novel method of utility-based fuzzy TOPSIS method is presented in[6] for energy efficient network selection that takes into account user preferences, network conditions, QOS and energy consumption requirements in order to select the optimal network which achieves the best balance between performance and energy consumption. In [7], User preference (based on user application) service type, QOS, Cost of Service, Power consumption, Network Condition and Previous history records of the mobile node are used as input parameters for calculation which leads to handover to an appropriate network. In [8] fuzzy rule based (FRB) and TOPSIS technique was presented that integrates the mechanisms of energy efficiency by considering power consumption at mobile station, and various QOS parameters. MADM methods are also used for network selection by considering low handoff latency in [9]. For this purpose an effective and novel vertical handoff decision scheme is introduced by considering bandwidth, dropping probability and cost parameters as metrics of the network selection function. It places the calculation of the network quality at the target network (TVNs) side instead of the mobile terminal side. Simulation results showed that it has lower level of processing delay and a higher level of throughput. MADM methods will also used for network selection by considering low handoff latency. In [10] Five MADM algorithms (SAW, MEW, TOPSIS, AHP and GRA) were considered for network selection by comprising six candidate networks as UMTS, WLAN and WIMAX (two of each kind). Simulation results show that MEW algorithm possesses least handover latency among all the MADM algorithms but network selection is not accurate as desired by user. On the other hand TOPSIS exhibits large handover latency along with desired network selection.

III. PROPOSED WORK

In this paper we propose energy efficient network selection algorithm by considering hybrid wireless networks comprising of CDMA (code division multiple access), WIMAX (Worldwide Interoperability for Microwave Access), and two WLANs (wireless local area network) for network selection depending upon power consumption, expected lifetime, traffic class and current battery level of mobile station. Handover between the available networks is based on different QOS parameters (bandwidth, jitter, delay, bit error rate etc), cost and lifetime parameters. By using the proposed approach power consumption and lifetime is calculated. And then based on the lifetime of mobile terminal particular network will be eliminated from network list. In the same time, we eliminate the unnecessary attributes in conversational traffic class for reducing handoff latency. Hence the algorithm allows the mobile terminal to always get connected to most energy efficient network. The proposed algorithm is evaluated on the bases of various handoff matrix such as energy, cost, lifetime etc.In order to provide an optimal network selection algorithm we have used MADM (multi attribute decision making) methods for network selection. Analytic network process (AHP) to find the weights of the available networks and Technique for order of Preference by similarity to the Ideal Solution (TOPSIS) method is used to determine the ranking of available networks. The proposed algorithm minimizes the handoff latency and selects the most energy efficient network according to the user preference.

A. Energy efficient network selection algorithm

In our proposed work first of all we determine the available networks and user preference. After that we calculate its power consumption and expected lifetime of available networks .The network offering less life time to the mobile terminal is eliminated from network list. In second phase the network is selected according to current battery level. If battery level of mobile terminal is maximum, all the attributes are applied to TOPSIS for selected network selection.

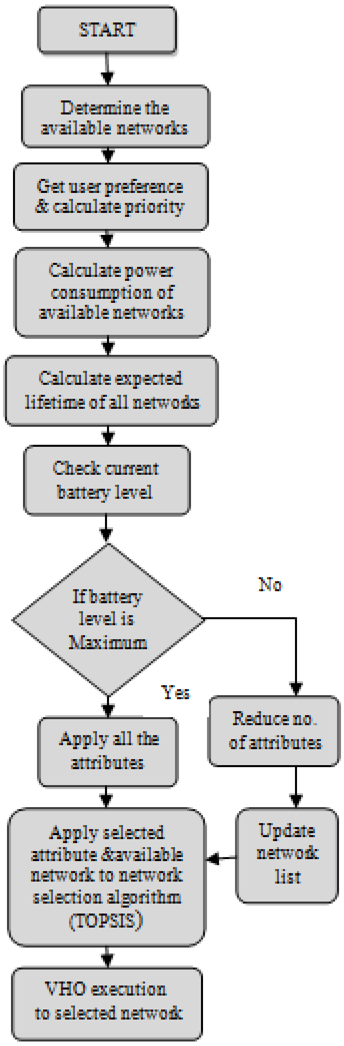

Figure1: Flow chart for Energy efficient network selection algorithm

If mobile terminal has low battery level then we reduce the number of attributes also update the network list. Decision matrix is used for network selection among the available networks which includes bandwidth, jitter, bit error rate, delay, cost, and power consumption of network in transmit, receive & idle mode. In last step, execution is to be done on selected network. Fig.1 shows the energy efficient vertical handoff algorithm.

B. Power Consumption and Lifetime prediction

The mobile terminal consume different amount of power in each network and traffic class. Power consumption is calculated by using the parameters given in table 1. Depending upon the current battery level, traffic class (conversational) and power consumption of each network, the expected lifetime of mobile station has been calculated. As the power consumption increases, expected lifetime of mobile terminal decreases. Hence the network which has least lifetime value is to be eliminated from network list.

The expected lifetime of the mobile station is calculated as:

$$\text{ptx}(i,c) = \frac{p(c)}{\text{Rup }(i)} * \text{ptx}(i) + \left(1 - \frac{p(c)}{\text{Rup }(i)}\right) * \text{pidle}(i) \quad (1)$$

$$\text{prx}(i,c) = \frac{p(c)}{\text{Rdown }(i)} * \text{prx}(i) + (1 - \frac{p(c)}{\text{Rdown }(i)} * \text{pidle}(i) \quad (2)$$

$$\text{pc expect}(i,c) = \text{ptx}(i,c) * \gamma\text{tx}(c) + \text{prx}(i,c) * \gamma\text{rx}(c) \quad (3)$$

$$\text{T expect}(i,c) = \frac{\text{CBL}}{\text{pc }(i,c)} \quad (4)$$

Table1: Parameters for power consumption & expected Lifetime of the mobile terminal

Parameters	Description
P(c)	Traffic load of conversational traffic Class
Ptx(i)	TX power consumption of i network interface card
Prx(i)	RX power consumption of i network interface card
Pidle	idle power consumption of i network interface card
PTX(i,c)	TX power consumption of i network, conversational traffic Class
PRX(i, c)	RX power consumption of i network, conversational traffic Class
Pexpect (i, c)	expected power consumption of i network, conversational traffic class
Rup(i)	uplink maximum transmission rate of i network
Rdown(i)	Down link maximum transmission rate of i network
γtx(c), γrx(c)	TX/RX rate of conversational traffic Class
CBL	current battery level of mobile terminal
T expect(i,c))	expected lifetime of i network, conversational traffic Class

C. Network selection

In heterogeneous environment, network selection plays an important for efficient VHO. Here we use MADM (Multiple Attributes Decision Making Methods) methods AHP and TOPSIS for network selection during vertical handoff. AHP (Analytic Hierarchy Process) method allows the decision makers to evaluate the relative weights of multiple criteria (or multiple options) against given criteria and TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method is used to rank the alternatives. The basic principle of TOPSIS is that the chosen alternative should have shortest distance from the positive ideal solution and farthest distance from the negative ideal solution based .A set of alternatives can be ranked according to the decreasing order of Cj.

$$C_j^* = \frac{S_j^-}{S_j^+ + S_j^-}, j = 1, \ldots, n.$$

TOPSIS has several advantages over other multiple criteria algorithms. Like its concept is simple, efficient computing characteristic and requires only one subjective input to calculate the decision. For network selection process in TOPSIS Decision matrix is required given in table 2.

Table2: Decision matrix of available networks

Parameters	CDMA	WIMAX	WLAN1	WLAN2
BW	1000	60000	11000	54000
Jitter	6	5	10	20
BER	0.001	0.0001	0.00001	0.00001
Delay	19	60	100	150
Cost	0.9	0.4	0.1	0.2
TX	2.8	2.409	1.3	1.3
RX	0.495	1.485	0.9	0.9
Idle	0.082	0.6	0.74	0.74

As shown in architecture of network selection in Fig.2, the bandwidth, delay, jitter, bit error rate are QOS parameters and PTx, PRx, and Pidle are lifetime parameters.

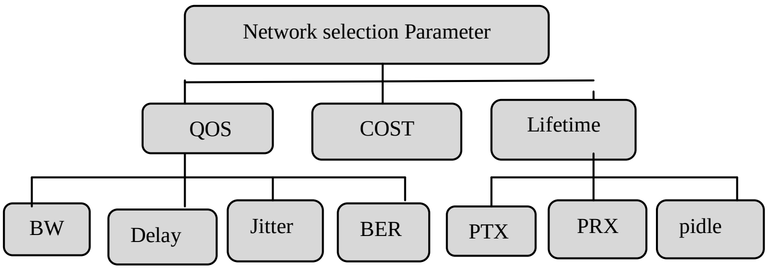

Figure 2: Network selection parameters

These network selection parameters are weighted by AHP (analytic hierarchy process) method. The process is subdivided into two levels 1 and 2 as given in Table 3 and 4.

Table3: Level 1 AHP matrix

	QOS	Cost	Lifetime
QOS	1	5	7
Cost	1/5	1	4
Lifetime	1/7	1/4	1

Table4: Level 2 AHP matrix

Parameters	Weights
Bandwidth	0.03546
Jitter	0.31920
BER	0.03546
Delay	0.31920
Cost	0.21409
PTX	0.03598
PRX	0.03598
PIDLE	0.00382

Table 3and 4 provide the weights for network selection parameters of conversational traffic class. In first phase we consider eight attributes for four networks (CDMA, WIMAX, WLAN1 and WLAN2) for network selection. In second phase as the battery lifetime decreases we reduce the number of attributes to 6 attributes in VHO process. So for six attribute we consider 3 networks (CDMA, WIMAX, WLAN2) and six attributes (delay, jitter, BER, cost, TX, RX). In third phase number of attributes and network are further reduce and we consider 5 attribute (delay, jitter, cost, TX, RX) and 2 network (CDMA, WIMAX) for network selection in vertical handoff given in Table 5. Here for conversational traffic class two wireless local area networks are eliminated due to less lifetime value.

Table 5: Weights for six and five attributes

Parameters	No. of attributes	
	6	5
BW	----	----
Jitter	0.33102	0.34802
BER	0.04728	----
Delay	0.33102	0.34802
Cost	0.21409	0.21409
PTX	0.03726	0.03828
PRX	0.03726	0.03826
PIDLE	-----	-----

IV. Results

In this section we evaluate the performance of proposed algorithm, by using the system parameter and weights given in table1&4 power consumption and lifetime of available network has been observed and result are given in Table 6.

Table6: Power consumption & lifetime of available networks (1000 mah)

Available networks	Power consumption(watts)	Expected lifetime (sec.)
CDMA	0.6915	1446.1
WIMAX	0.6045	1654.3
WLAN1	0.7421	1347.5
WLAN2	0.7404	1350.6

From Table 6 it is clear that WIMAX consume less power in conversational traffic class hence it has highest lifetime with compare to another network. On the other hand wlan1having less lifetime which is slightly lower than wlan2. Hence wlan1 has been eliminated form network list and the number of attributes is also reduced. Thus for 6 attribute network selection, we consider CDMA, WIMAX and WLAN 2 while for 5 attribute network selection CDMA & WIMAX are considered for reducing handoff latency. Fig.3-6 represents the lifetime for all available networks.

 ISSN: 2321-8169
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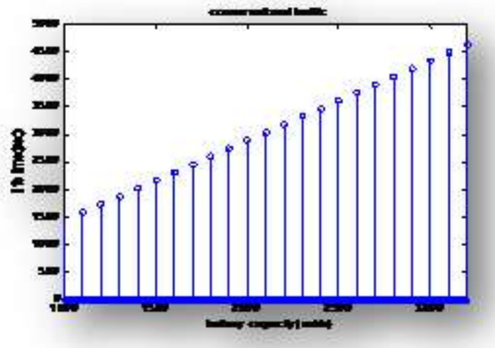

Figure.3 Lifetime of CDMA network

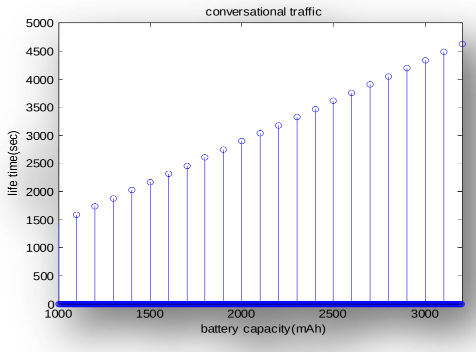

Figure.4 Lifetime of WIMAX network

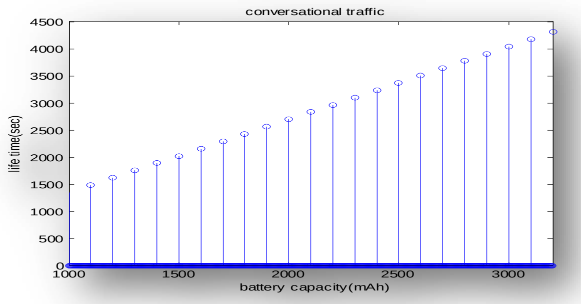

Figure.4: lifetime of WLAN1 network

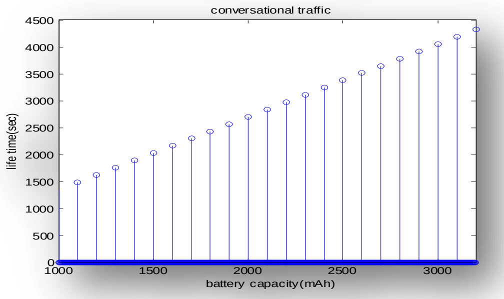

Figure6:.lifetime of WLAN2 network

Comparative analysis of handoff latency and network selection

Simulation result indicates that as the number of attribute decreases handoff latency will be also decreases. Table 7 represents the network selection by using different attributes in conversational traffic class.

Table7: Network selection & latency for different no of attribute

NO. of attributes	Handoff latency (second)	Ranking of available networks			
		CDMA	WiMax	WLAN 1	WLAN2
8	0.050130	0.6219	**0.7428**	0.6062	0.3416
6	0.043851	**0.5304**	0.4810	---	0.5270
5	0.008221	**0.6557**	0.3443	----	---

From table 7 it can be concluded that in 8 attribute network selection for conversational traffic class handoff latency is higher and handoff is done to WIMAX network .While by using 6 & 5 attribute CDMA network is selected and handoff latency will be further reduced.

V. Conclusion

In this paper a new energy efficient network selection algorithm is proposed by considering four networks for network selection in VHO. By using the system parameters based on the power consumption, traffic class and current battery level of each network interface card the mobile terminal lifetime is to be calculated. As the lifetime of mobile station decreasing we reduce the number of attributes and network by eliminating the particular network form network list. Simulation result indicates that by reducing number of attributes handoff latency can also be reduced and select optimal network from network list. Hence our proposed approach can fulfill the requirement of energy efficient network selection in VHO.

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