Optimized Heterogeneous Wireless Network with Scoring Methods

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ABSTRACT

In this network era, the need for an user to always best connected with optimize services called as Always Optimized Connected (AOC). To execute a vertical handoff decision for perfect and effective services continuity and quality of services (QoS), different type of multi-displinary algorithms had been proposed for addressing this problem. The comparative analysis of these methods including SAW,MEW,TOPSIS,ELECTRE,VIKOR,GRA,WMC,AHP have been studied showing their performance for different application (i.e. voice, data)with decision factors such as received signal strength(RSS),available bandwidth, service type, monetary cost ,network condition and user choice.

General Terms

Heterogeneous Wireless Network , Sscoring methods.

Keywords

Vertical handoff decision ,Multi-displinary, Always Oplimaized Connected (AOC),4G wirelessnetwork.

1. INTRODUCTION

In the Fourth Generation (4G) wireless Communication will inexorably integrate triple-play services, which mean that all traffic classes of voice, video and data will be managed to meet the particular quality of services (QoS) requirement, such as strict packet delay, jitter and loss guarantees. It will be known that 4g will inevitably include Internet as the major backbone network i.e. fourth generation network may integrate wireless local area network (WLAN/Wi-Fi),3G Universal Mobile Telecommunication system (UMTS),wireless metropolitan area network(WMAN/WIMAX).The expected 4G network is shown in the Fig. 1,Here User demand the optimized connectivity to application anytime at anywhere ,which is the most crucial issues in such communication also known as the always Optimized connected (AOC)concept.

A handoff is the process of changing the mobile connection between access point supporting different wireless technologies. Meanwhile, in the horizontal connection just move from one base station to another within the same access network .The vertical handoff consist of mainly in three phases: network discovery, handoff decision and handoff execution. In the first step, the mobile terminal (MT) discovers its available neighboring networks. In the decision phase, the MT determines whether it has to redirect its connection based on comparing the decision factors offered by the available networks and required by the mobile user ,that is information gathered in the first phase .The last phase , is responsible for the establishment and release of the connection according to the vertical handoff decision.

Various Multi-Disciplinary method have been proposed in the previous work for vertical handoff ,methods[JUE] such as SAW(simple additive weighting)[WZ],TOPSIS(techniques for order preference by similarity to ideal solution)[WZ].MEW (multiplicative exponent weighting)[SNW].GRA(Grey relational analysis)[WB]. WMC (weighted Markov Chain)[WB].considerable amount of research on different multidisciplinary algorithms for vertical handoff have been conducted and it is necessary to evaluate their performance under different scenario in order to provide the best solution for a particular application .In this paper ,we present a comparative study of different multidisciplinary algorithm for an approach of selection of optimized heterogeneous wireless network such as WLAN,UMTS, and WiMAX network ,when the user perform different application like video, data etc.

The rest of the paper is organized a fallows ,In Section II the studied Multidisciplinary algorithm for vertical handoff decision are explore .In section III ,Always optimal connected results are presented and some observation are marked .Finally ,In section IV conclusion.

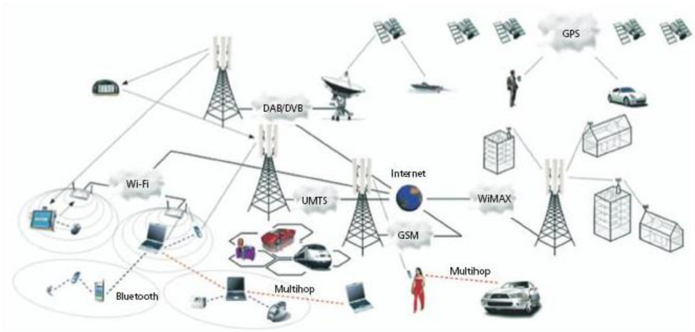

Figure 1 Scenario of Vertical Handoff Heterogeneous Wireless Network . [CSI]

2. MULTIDISCIPLINARY ALGORITHM FOR VERTICAL HANDOFF DECISION

A. SAW (Simple Additive weighting)

The decision problem can be expressed in a M x N decision matrix, where the j^{th} attribute of the i^{th} network is represented as x_{ij}. SAW is the best known and most widely used scoring method, the score of each candidate network *i* is obtained by adding the contribution from each attribute r_{ij} multiplied by the weight factors w_j. .Then the selected network A^*_{saw} is:

$$A^*_{saw} = \arg\max_{i \in M} \sum_{j \in N} w_j r_{ij} \quad (1)$$

Where $r_{ij} = x_{ij}/x_j^+$ for benefit parameter, and $r_{ij} = x_j^-/x_{ij}$ for cost parameters , moreover, $\overset{+}{x}_j = \max_{i\in M} x_{ij}$ and $\overset{-}{x}_j = \min_{i\in M} x_{ij}$. weight vector must satisfy $\sum_{j=1}^{N} w_j = 1$.

B. MEW (Multiplicative Exponent Weighting) :

MEW is another scoring method, for which the scores of the networks are determined by the weighted product of the attributes. The selected network A^*_{MEW} is:

$$A^*_{MEW} = \arg\max_{i\in M} \prod_{j\in N} r_{ij}^{wj} \tag{2}$$

C. TOPSIS (techniques for order preference by similarity to ideal solution)

In this technique for Order Preference by Similarity to Ideal Solution Algorithm (TOPSIS) With M alternatives that are evaluated by N decision criteria is viewed as geometric system with M point in the N dimensional space. Here , the chosen candidate network is the one which have the shortest to ideal solution and longest distance to the worst case solution .To compute the network ranking-list, TOPSIS requires the following steps.

Step 1 : Construct the normalized decision matrix, which allows comparison across the attributes, this matrix is given by:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \tag{3}$$

Step 2: Construct the weighted normalized decision matrix as $v_{ij} = w_j * r_{ij}$. This Matrix v_{ij} is calculated by multiplying each column of the matrix R with its associated weight w_i.

$$V = \begin{bmatrix} v_{11} & . & . & v_{1m} \\ . & . & v_{ij} & . \\ . & . & . & . \\ v_{1n} & . & . & v_{mn} \end{bmatrix}$$

$$V = \begin{bmatrix} r_{11} * w_1 & . & . & r_{1m} * w_m \\ . & . & r_{ij} * w_j & . \\ . & . & . & . \\ r_{1n} * w_1 & . & . & r_{1m} * w_m \end{bmatrix} \tag{4}$$

Step 3: Determine ideal and negative-ideal solutions

$$A^+ = \left\{ (\max_{i\in M} v_{ij} \mid j \in J \ ), (\ \min_{i\in M} v_{ij} \mid j \in J') \ \right\} \tag{5}$$

$$A^- = \left\{ (\min_{i\in M} v_{ij} \mid j \in J \ ), (\ \max_{i\in M} v_{ij} \mid j \in J') \ \right\} \tag{6}$$

Where J is the set of benefit parameters, and J' is the set cost parameter,

Step 4 : Calculate separation measure between the networks and the positive and negative ideal networks by using following equations :

$$s_i^+ = \sqrt{\sum_{j\in N} (v_{ij} - v_j^+)^2} \tag{7}$$

$$s_i^- = \sqrt{\sum_{j\in N} (v_{ij} - v_j^-)^2} \tag{8}$$

Step 5: Calculate the relative closeness to the ideal solution .

$$c_i^* = \frac{s_i^-}{(s_i^+ + s_i^-)} \tag{9}$$

A set of alternatives can now be preference ranked according to the descending order of c_i^*.Then the selected network A^*_{Top} is :

$$A^*_{TOP} = \arg\max_{i\in M} c_i^* \tag{10}$$

D.GRA (Gray Relational Analysis)

In the Grey Relational Analysis (GRA) algorithm , Grey Relational Coefficient(GRC) is used as the coefficient to describe the similarity between each candidate network and the best reference network . An ideal network formed by choosing the best values of each attribute .GRA is usually implemented following three steps :

a) Normalization data
b) Defining the ideal sequence,
c) Computing GRC.

The normalization of the sequences data is performed according to the three situations (larger–the- better, smaller- the-better and nominal-the-best) as follows

$$r_{ij} = \frac{x_{ij} - l_j}{u_j - l_j}, \quad r_{ij} = \frac{u_j - x_{ij}}{u_j - l_j},$$

$$r_{ij} = 1 - \frac{|x_{ij} - m_j|}{\max(u_j - m_j, m_j - l_j)}$$

Where $u_j = \max_{i\in m} x_{ij}, l_j = \min_{i\in M} x_{ij}$ and m_j is the largest value in the situation of nominal-the-best, for j=1,2,3,.......N. The ideal sequence x_0 is defined to contain the upper bound ,lower bound ,or moderate bound respectively in the larger-the-better or nominal-the-better situations. The GRC can be then calculated as following:

$$GRC_i = \frac{1}{m} \sum_{j=1}^{m} \frac{\Delta_{\min} + \Delta_{\max}}{\Delta_i + \Delta_{\max}}$$,WHERE

$$\Delta_i = |x_{0j} - r_{ij}|,$$

$$\Delta_{\max} = \max_{i\in M, j\in N} \Delta_i, \quad \Delta_{\min} = \min_{i\in M, j\in N} \Delta_i$$

The larger the GRC , the more preferable the network will be. The Selected A^*_{GRA} is :

$$A^*_{GRA} = \arg\max_{i\in M} GRC_i, \tag{11}$$

E.WMC(Weighted Markov Chain)

The weighted Markov Chain (WMC) algorithm includes the following steps:

Step 1: Construction of Weighted Markov Chain transition matrix MC .Initialize a M x M matrix MC = $\{mc_{ij}\}$ represent transition probability from alternative p_j.

Step 2: For each decision factor q, a ranking list is obtained as

$$\tau_q = [p_1 \geq p_2 \geq p_3 \geq .... p_M]$$

Where " $\geq$" represent some ordering relation , and $\tau_q(p)$ determine the ranking alternative p with regard to factor q.

Step 3: For each mc_{ij} in MC , Update

$$mc_{ij} = mc_{ij} + \frac{w_q}{\tau(p_i)}, \quad \text{if} \quad \tau_q(p_i) \geq \tau_q(p_j).$$

Step 4: Computation of Stationary probabilities :

$$\pi_j = \sum_{i=0}^{M} \pi_i mC_{ij}, \sum_{i=0}^{M} \pi_j = 1$$

The Selected network A^*_{WMC} is :

$$A^*_{WMC} = \arg\max_{j \in M}(\pi_j) \quad (12)$$

TABLE I. Network Parameter with range value

Parameter	Net1	Net#2	Net#3	Net#4	Net#5	Net#6
Available Bandwidth(Mbps)	0.1-2	0.1-2	1-11	1-54	1-60	1-60
Total bandwidth	2	2	11	54	60	60
Packet Delay(ms)	25-50	25-50	100-150	100-150	60-100	60-100
Packet Jitter(ms)	5-10	5-10	10-20	10-20	3-10	3-10
Packet loss(per 10^6)	20-80	20-80	20-80	20-80	20-80	20-80
Cost Per Byte(price)	0.6	0.8	0.1	0.05	0.5	0.4

3. ALWAYS OPTIMAL CONNECTED RESULTS

In order to evaluate the performance of each Multidisciplinary algorithm under the our new concept of Always optimized connected(AOC) , we consider a network selection situation in a 4G environment integrated by three network types as WLAN,UMTS and WiMAX, and there are two networks of each type. In this work, six decision criteria have to be evaluated and compared in order to detect and to trigger a vertical handoff. Including available bandwidth (Mbps), total bandwidth (Mbps), packet delay (ms), packet jitter (ms), packet loss (per each 106 packets) and cost per byte (price). The range of values of the parameters or decision criteria are shown in Table I. The values of assigned weights for different services considered in this study are:

Case 1: all parameters have the same weight, this is the baseline case; ***Case 2***: delay and packet jitter have 70% of importance and the rest is equally distributed among the other parameters, this case is suitable for voice connections; Case ***3***: available and total bandwidth have 70% of importance, this case is suitable for data connections.

In each vertical handoff decision point, the attribute values may be the same, increase or decrease within the range In order to varying the values of the decision criteria, a Markov chain is used for each attribute, where the transition probabilities for an increment or decrement are 0.4, while the probability of being in the same value is 0.2. For each application, we consider 50 vertical handoff decisions points for a total of 150 points in the simulation study.

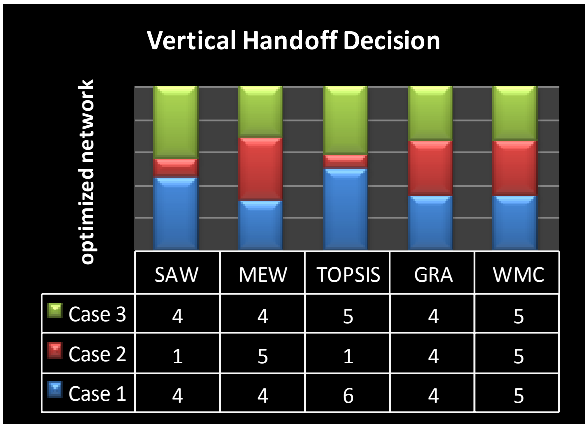

Figure 2: Optimal selected network for multidisciplinary method

B. *Always Optimal Connectied Nework*

Figure 2 shows the selected alternatives for each multidisciplinary algorithm, in this figure are included the applications as follows: points 1-50 for case 1, 51-100 for case 2, and 101-150 for case 3. In Figure 2, according to Table I, network1 corresponds to UMTS1, network 2 to UMTS 2, network 3 to WLAN1, network 4 to WLAN2, network 5 to WiMAX1,and network 6 to WiMAX2.

For the baseline case, in almost all vertical handoff decisions five of the algorithms select networks WiMAX1 and WiMAX2 and only GRA and MEW select WLAN2. In fact, this behavior of GRA is the same in the other cases. For case 2 (voice connections), SAW, TOPSIS execute vertical handoffs between WiMAX1 and UMTS1 since the 3G network is able to offer lower values of packet delay and jitter. For case 3 (data connections), SAW, MEW, TOPSIS execute vertical handoffs between WiMAX2 and WLAN2 since the WiFi network is able to offer higher values of available and total bandwidth. Note that in cases 2 and 3, WMC remains in the same network all the time.

B. Compare Result Case 1(baseline) vs Case 2(voice)

For the voice connections case, note in Figure 2 that there are more vertical handoffs in order to achieve the best connectivity by reducing the packet delay, except for WMC and GRA methods. With MEW, a vertical handoff from WLAN2 to WiMAX1 is required. For this application, packet delay and packet jitter are the most important parameters. Figure 3 shows the packet delay to achieved by the different vertical handoff algorithms, decision points 1 to 50 corresponds to case 1 and decision points 51 to 100 to case 2. We can see that in case 2 SAW and TOPSIS is able to obtain the lowest values of packet delay followed by other existing methods. Note that MEW is able to reduce its packet delay compared to case 1, while GRA and WMC remain with the same values as in case 1 since they decide not perform vertical handoffs.

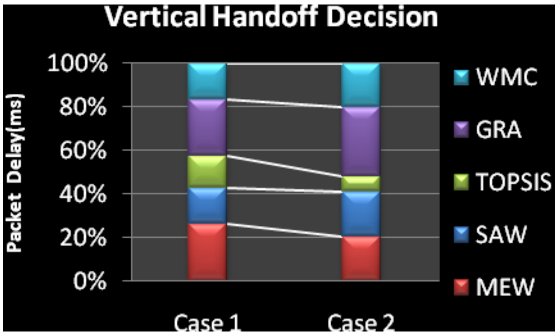

Figure 3 Values of Packet delay (ms) selected by decision method

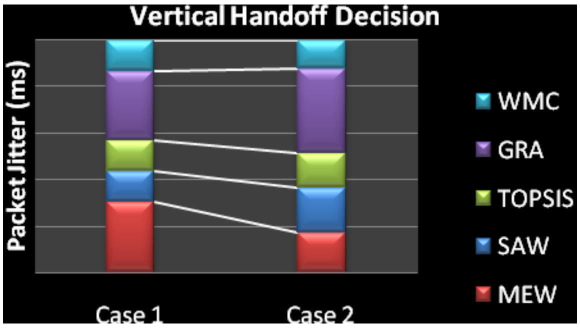

Figure 4 Value of packet jitter selected by the decision methods

Figure 4 shows the packet jitter achieved by the vertical handoff algorithms, decision points 1 to 50 corresponds to case 1 and decision points 51 to 100 to case 2. We can see that in case 2 SAW, TOPSIS and WMC are able to achieve slightly lower values of jitter compared to case 1. MEW is able to reduce its packet jitter to less than 50% compared to case 1, while GRA remains with the same values as in case 1

C. Compare Result case 1 (baseline) vs case 3 (data) :

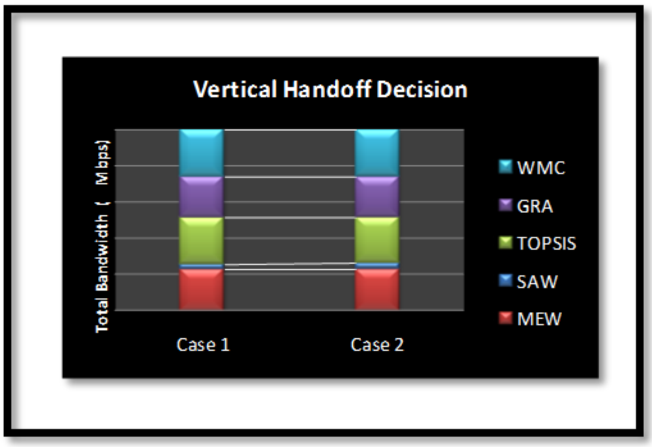

Figure 5.Total Bandwidth selected different multidisciplinary

Figure 5 shows the total bandwidth achieved by the vertical handoff algorithms, decision points 1 to 50 corresponds to case 1 and decision points 51 to 100 to case 3. We can see that TOPSIS and WMC obtain the highest values followed by SAW and MEW and GRA. For data connections case, note in Figure 5, one of the most important criteria is the total bandwidth and corresponds to WiMAX1, methods as WMC. On the other hand, the available bandwidth is necessary for data transmission, but in the simulation, WLAN2 provides a higher available bandwidth than the rest. This causes that methods as SAW, MEW and TOPSIS, GRA perform a vertical handoff to WLAN2 to achieve the best connectivity.

4. CONCLUSION

In this paper, we have studied of several vertical handoff decision algorithms, with the aim of understand its performance for different user applications. This study allows us to highlight and identify the limitation of each multidisciplinary algorithm influencing the decision making for interface selection.

The simulation results presented above show that each algorithm has its own limitations. TOPSIS suffered from "ranking abnormalities"and SAW provide less precision in identifying the alternative ranks compared to TOPSIS.

We consider two different application : voice and data connection , so by analysis a network SAW and TOPSIS are suitable for voice connection , these algorithm provide a comprises for achieve the lower values of jitter and delay packet available in a 4G wireless network.

In a data connection case, GRA and MEW algorithm provide the solution with highest available bandwidth necessary for this application.

As future work, we plan to consider other types of connections and study the impact of the importance weights assignment in the performance of the multidisciplinary algorithms.

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