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Vertical Handoff decision based on MADM for Network selection in 4G Heterogeneous Wireless Networks

Kapil Sharma

Delhi Technological University
E-mail: kapil@ieee.org

Abstract—*Seamless continuity is the main goal and challenge in fourth generation Wireless networks, to achieve seamless connectivity handoff technique is used, Handoff mechanism are mainly used when a mobile terminal(MT) is in overlapping area for service continuity. In Heterogeneous wireless networks main challenge is continual connection among the different networks like WiFi, WiMax, WLAN, WPAN etc. In this paper, Vertical handover decision schemes are compared, Simple Weighted Additive method and Weighted product model are used to choose the best network from the available Visitor networks (VTs) for the continuous connection by the mobile terminal. In our work we mainly concentrated to the handover decision phase and to reduce the processing delay in the period of handover. In this paper both methods are compared with the QoS parameters of the mobile terminal (MT) to connect with the best network.*

1. INTRODUCTION

On next generation wireless networks heterogeneous broadband technologies coexist in order to guarantee a seamless connectivity to mobile users. Different network characteristics are basically expected to different multimedia applications [1]. So, as mobile applications require service and quality-of-service (QoS) continuity, cooperation of mobile access networks in heterogeneous environments is an important feature to assure [2]. In this context, vertical handover (VHO) techniques can be applied when connectivity switching is needed to preserve host connectivity and optimize QoS as perceived by the end user. A VHO is a process preserving user's connection on the move and following changes of network, (i.e. from a base station (BS) UMTS to an access point (AP) WIFI) [3]. Many approaches are used to vertical hand over from a serving network (SN) to a candidate network (CN), with the goal of provide a maximization of throughput, and a limitation of unwanted and unnecessary vertical handovers [4]. This aspect is also called ping-pong effect [5] and leads to excessive network resource consumption and also affects mobile terminal's performance (i.e. battery life). As a consequence, the minimization of the number of VHOs is an important deal in handover management and many criterions.

The scope work is mainly in handover decision phase, as mentioned in the decision phase; decision makers must choose the best network from available networks. In this paper, the decision makers are Simple additive weighting (SAW) and Weighted product model (WPM) to take the decision and to select the best target visitor network (TVN) from several visitors networks [3].

In this paper, two vertical handover decision schemes (VHDS) , Distributed handover decision scheme (DVHD) and Trusted Distributed vertical handover decision schemes (T-DVHD)are used. DVHD is advanced than the centralized vertical handover decision scheme and T-DVHD is the extended work of DVHD. Here we compare the distributed and trusted vertical handover decision schemes as distributed decision tasks among networks to decrease the processing delay caused by exchanging information messages between mobile terminal and neighbour networks[5]. To distribute the decision task, vertical handover decision is formulated as MADM problem. In our work, the proposed decision making method use WPM in a distributed manner and compared with SAW method. The bandwidth, delay, jitter and cost are the parameters took by the MT as the decision parameters for handover[6].

At present many of the handoff decision algorithms are proposed in the literature. In [4] a comparison done among SAW, Technique for Order Preference by Similarity to Ideal Solution(TOPSIS), Grey Relational Analysis (GRA) and Multiplicative Exponent Weighting (MEW) for vertical handoff decision. In [3] author discuss that the vertical handoff decision algorithm for heterogeneous wireless network, here the problem is formulated as Markov decision process. In [5] the vertical handoff decision is formulated as fuzzy multiple attribute decision making (MADM). In [8] their goal is to reduce the overload and the processing delay in the mobile terminal so they proposed novel vertical handoff decision scheme to avoid the processing delay and power consumption. In [7] a vertical handoff decision scheme DVHD uses the MADM method to avoid the processing delay. In [10] the paper is mainly used to decrease the processing delay and to make a trust handoff decision in a heterogeneous wireless environment using T-DVHD. In [11] a novel distributed vertical handoff decision scheme using the SAW method with a distributed manner to avoid the drawbacks. In [14] the author provides the four steps integrated strategy for MADM based network selection to solve the problem. All these proposal works are mainly focused on the handoff decision and calculate the handoff decision criteria on the mobile terminal side and the discussed scheme are used to reduce the processing delay by the calculation process using MADM in a distributed manner.

2. VERTICAL HANDOVER DECISION SCHEMES

Centralized vertical handover decision (C-VHD), Distributed vertical handover decision (D-VHD), Trusted Distributed vertical handover decision (T-DVHD) are the schemes used to reduce the processing delay between the mobile node and neighbour network while exchanging the information during the handover. In this paper, D-VHD and T-DVHD schemes are compared. MADM have several methods in literature [16]. TOPSIS is used in distributed manner for network selection.

Centralized Vertical Handover Decision Schemes

In C-VHD, a Mobile Node (MN) exchanging the information message to the Neighbour networks mean processing delay was increased by distributing in centralized manner. When processing delay had increased overall handover delay increases. This is one of main disadvantage in C-DHD, so Distributed Vertical handover decision (D-VHD) schemes was proposed in [7][8].

Distributed Vertical Handover Decision Schemes

D-VHD is used to decrease the processing delay than the C-VHD schemes. This scheme is mainly used for handover calculation to the Target visitor networks (TVNs). TVN is the network to which the mobile node may connect after the handover process was finished. In our work D-VHD takes into account: jitter, cost, bandwidth, and delay as evaluation metrics to select a suitable VN which applied in MADM method.

$$NQV_I = \sum_{i,j}^{N,n_p} W_i \times P_{ij}$$

Where, NQV_i represents the quality of ith TVN. W_j is the weight of the P_{ij}, P_{ij} represents the jth parameter of the i^{th} TVN. N is the number of TVNs. While n_p is the number of parameters.

$$NQV_I = R_i = \frac{\prod_{j=1}^{n} x_{ij}^{w_j}}{\prod_{j=1}^{n} (x^*)_j^{w_j}}$$

Where, NQV_i represents the quality of i^{th} TVN. w_j is the weigth of the attribute values , x_{ij} is the positive attributes and x^*_{ij} is the negative attribute . R is the value ratio between network I and positive idea.

Based on the user service profile, handover decision parameters have assigns different "Weights" to determine the level of importance of each parameter. In equation, the sum of these weights must be equal to one.

$$\sum_{i,j}^{N,n_p} W_{ij} = 1$$

Trusted handover decision and to avoid the unnecessary handover events are the important factors while exchanging the trusted information between networks and mobile node. The extension work of the DVHD scheme is T-DVHD scheme. The scheme is mainly introduced [10] for decreasing the processing delay than DVHD scheme.

The T-DVHD schemes followed by the DVHD Network selection function and Distribute Decision schemes, before sending request to connect a new base station trusted process is started after handover is executed by the mobile terminal with the proper TVN. Trusted Test Function is started, once the mobile terminal connects to the TVN trusted test function is calculated by the following steps to finish the T-DVHD schemes.

3. SIMPLE ADDITIVE WEIGHTING (SAW) METHOD

Simple Additive Weighting (SAW) which is also referred as weighted linear combination or scoring methods or weighted sum method is a simple and most often used multi attribute decision technique. The method is based on the weighted average. An evaluation score is calculated for each alternative by multiplying the scaled value has given to the alternative of that attribute with the weights of relative importance directly assigned by decision maker followed by summing of the products for all criteria.

The application of SAW scoring requires identification of objectives and alternatives, evaluation of alternatives, determination of sub-objective weights, additive aggregation of weighted partial preference values, sensitive analysis. It uses direct rating on the standardized scales only in purely qualitative attributes. For numerical attributes score are calculated by normalized values to match the standardized scale. The SAW is a comparable scale for all elements in the decision matrix, the comparable scale obtained by r_{ij} for benefit criteria and worst criteria.

$$V_{ij} = \frac{x_{ij}}{x_j^{max}} \quad , \quad V_{ij} = \frac{x^{min}{}_j}{x_j}$$

The SAW method, underlying additive values function and compute as alternatives score $V_i = V(A_i)$ by adding weighting normalized values W_j V_{ij} and j = {1,…m} before eventually ranking alternatives

$$V_i = \sum^{m} W_j \times V_{ij}$$

4. WEIGHTED PRODUCT MODEL (WPM) METHOD

The weighted product model (WPM) similar to the weighted sum model (WSM) and it is also called as Multiplicative exponent Weighting (MEW). It is another MADM scoring method. The main difference is that instead of addition usually mathematical operation now there is multiplication. As with all MADM methods, WPM is a finite set of decision alternatives described in terms of several decision criteria. The vertical handover decision problem can be expressed as a matrix form and each row i corresponds to the candidate network i and each column j corresponds to the attributes.

$$V(A_i) = \prod_{j=1}^{n} x_{ij}^{w_j}$$

Where x_{ij} denotes attribute j of candidate network i, wi denotes the weight of attributed j . Note that in above eq., w_j is a positive power for benefit metrics $x_{ij}^{w_j}$, and a negative power for cost metrics $x_{ij}^{-w_j}$. Since the score of a network obtained by MEW does not have an upper bound , it is convenient for comparing each network with the score of the positive ideal network .This network is defined as the network with the best values in each metric. For a benefit metric, the best value is the largest. For a cost metric, the best value is the lowest.

$$R_i = \frac{V(A_i)}{V(A^*_i)} = \frac{\prod_{j=1}^{n} x_{ij}^{w_j}}{\prod_{j=1}^{n} x_{ij}^{*w_j}}$$

5. NUMERICAL EXAMPLE

The above section outlines the vertical handover decision schemes and MADM methods, SAW and TOPSIS which is used for the network selection in this paper. For instance, suppose a mobile terminal is currently connected to a WiFi cell and has to make decision among six candidate networks A1, A2, A3, A4, A5, A6, where A3, A4 are WiFi cells and others are WiMax cells. Vertical handover criteria considered here are delay, bandwidth, cost, jitter which denoted as X1, X2, X3, X4 respectively. Decision matrix D is shown in table 1.

Table 1 Decision Matrix

Network	X1	X2	X4	X5
A1	0.984	0.533	0.667	0.438
A2	1.0	0.1	0.75	0.812
A3	0.984	1.0	0.5	0.061
A4	1.0	0.467	1.0	1.0
A5	0.984	0.733	0.6	0.119
A6	0.968	0.667	0.667	0.263

The users running application was voice. The preference on handover criteria is modeled as weights assigned by the user on the criteria, for voice W_v which shown below in table 2.

Table 2: Criteria Weights

W_v	0.3	0.2	0.2	0.3

MADM methods handle in this paper for decision problems with above data. The following section discussed the SAW and WPM are applied and the results are compared

SAW requires a comparable scale for all elements in the decision matrix, the comparable scale is obtained. In these x_{ij} is the performance score of alternatives A_i with respect to criteria x_j.

A_v	0.664	0.714	0.563	0.793	0.595	0.635

After scaling, the normalized decision matrix is evaluated as depicted in table 3. Applying the weight factor, weighted average values for A1, A2, A3, A4, A5 and A6 are calculated for the respected to the voice application A_v.

Table 3: Normalized Decision Matrix

Network	X1	X2	X4	X5
A1	0.00062	8	9	0.411
A2	0.00063	1.5	8	0.762
A3	0.00062	15	12	0.057
A4	0.00063	7	6	0.939
A5	0.00062	11	10	0.103
A6	0.00061	1	9	0.247

The best network is A4 which is the network selected to connect the mobile terminal for service continuity with the minimum processing delay. The ranking order using SWE is given in table 4.

Table 4: Ranking using SAW

Network	Rank
A4	1
A2	2
A1	3
A6	4
A5	5
A3	6

6. WPM

The WPM is called dimensionless analysis because its mathematical structure eliminates any units of measure. Transformation is not necessary

When multiplication among attribute values are used then weights become exponents associated with each attribute values. The ranking order using WPM is given in table 5.

A_v	0.054	0.065	0.024	0.065	0.035	0.042

$A_v = 0.074$

$R_i = [0.73, 0.89, 0.32, 0.88, 0.47, 0.57]$

Table 5: Ranking using WPM

Network	Rank
A2	1
A4	2
A1	3
A6	4
A5	5
A3	6

7. COMPARISON

The ranking order using different methods of MADM are summarized in Table 6. SAW and WPM ranks A4 and So the A4 and A2 BS have connected the mobile terminal with less processing delay to get seamless handover in between the MT and BS A4,A2 in each method.

Table 6: Comparison of WPM and SWA

WPM	SWA	Rank
A2	A4	1
A4	A2	2
A1	A1	3
A6	A6	4
A5	A5	5
A3	A3	6

8. CONCLUSION

In this paper, we have compared the schemes of vertical handover decision in the heterogeneous wireless networks. The observation of schemes to reduce the processing delay and a trusted handover decision is done in heterogeneous wireless networks. We proposed decision makers SAW and WPM to select the best network from the visitor network for the Vertical decision schemes. The best decision maker is analyzed by the relative standard deviation and the best one is WPM. Our main goal is in the decision phase of the handover phases to take decision to which VN the mobile terminal to connect to decrease the processing delay by different decision algorithms.

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