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A review of vertical handoff algorithms based on Multi Attribute Decision Method

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Abstract - Next Generation Wireless Networks (NGWN) consists of heterogeneous networks with the support for vertical handoff. Hence vertical handoff algorithms (VHA) are the key components of NGWN. The vertical handoff decision may depend on the bandwidth available for each wireless access network, cost for accessing network, the power usage requirements, user preference, Quality of Service (QoS), and security. Hence vertical handoff decision may be solved using multi attribute decision making (MADM). Multi attribute decision making (MADM) problems involve ranking or evaluating a finite number of alternatives with multiple, attributes. There are several vertical handoffs decision algorithm proposed in the literature based on MADM techniques. In this paper we provide a overview on existing MADM algorithms for vertical handoff.

Keywords: Multi attribute decision making, Simple additive weighting, Multiplicative Exponential Weighting, Grey relational analysis, etc,.

1. INTRODUCTION

Next Generation Wireless Network (NGWN) aims to integrate heterogeneous wireless systems with seamless continuity as major goal. In such heterogeneous network supporting vertical handoff becomes major challenging issue. Vertical handoff is responsible for service continuity when a connection needs to migrate across heterogeneous wireless access networks [1]. The vertical handoff decision problem deal with making selection between available candidate networks which provide varies technologies and services with respect to different criteria. This is a type of Multiple Attribute Decision Making (MADM) problem [2][3]. In general, MADM deals with the problem of choosing an alternative from a set of alternatives which are considered in terms of their attributes. For decision making multiple attribute, multiple criteria and multiple objectives are the terms are often used. Similarly vertical handoff decision algorithm should consider many parameters such as available bandwidth, QoS, security, power consumption, user preference, with proper weightage for each parameter.

In general, the vertical handoff process consist of three main steps [14][15], namely system discovery, handoff decision, and handoff execution. The system discovery phase is responsible for detecting and collecting information of all the available networks. The mobile terminals which are equipped with multiple interfaces have to determine which networks can be used and the services available in each network. The networks may also advertise the supported data rates and other characteristics for different services. During the handoff decision phase, the mobile device determines which network it should connect to. The decision may depend on various parameters such as available bandwidth, delay, jitter, access 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. This phase also includes the authentication and authorization, and the transfer of user's context information.

MADM problems are diverse in disciplines, but all share the following common characteristics: alternatives to select, multiple attributes describing the alternatives in different units of measurement, and a set of weights representing the relative importance among attributes [4]. MADM decision problem can be expressed in an M x N decision matrix, where the jth attribute of the ith network is represented as xij. The MADM methods use scoring techniques to rank alternatives. An index or score is calculated by taking into account the contributions from each parameter. Before the calculation of the index, normalization of the parameters is required to deal with different units. Several vertical handoff algorithms based on MADM methods have been proposed in the literature. The MADM includes many methods such as Simple Additive Weighting (SAW), Multiplicative Exponential Weighting (MEW), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), Analytic Hierarchy Process (AHP), Grey Relational Analysis (GRA). In the next section we will provide a brief introduction on these algorithms.

A. *Simple Additive Weighting*

Simple additive weighting (SAW) is one of the best known and most widely used scoring methods because of its simplicity [3]. In SAW, the criteria value for each alternative are normalized and is multiplied with the weights assigned to the criteria [5]. If there are M networks and N number of parameters for each network, then total score of each candidate network i is obtained by adding the contributions from each attribute rij multiplied by the importance weight wj [4].

$A_{SAW} = \arg \max_{i \in M} \sum_{j \in} j\ r_{ij}$ with the condition that $\sum_{j=}^{N} j = 1$.

In [17], the authors proposed a SINR (Signal to Interference plus Noise Ratio) and AHP (Analytic Hierarchy Process) based SAW (Simple Additive Weighting)(SASAW) vertical handoff algorithm. The algorithms uses the combined effects of SINR, user required bandwidth, user traffic cost and available bandwidth of the participating access networks to make handoff decisions for multi-attribute QoS consideration according to the features of the traffic. In [16] the authors proposed a vertical handoff method based SAW which uses user preference parameter like cost for selecting the target network.

B. Multiplicative exponential weighting

In this technique a handoff decision matrix is formed where a particular row and column corresponds to the ith candidate network and jth attribute of that network, respectively. The weighted product of the attributes is used to determine the score Si of the candidate network as follows:

$S_i = \prod_{j} {}_{ij}^{wj}$ where x_{ij} denotes attribute j of candidate network i, w_j denotes the weight of attributed j, and $\sum_{j=}^{N} j = 1$.

In [18] the authors proposed an improved MEW algorithm for vertical handoff in heterogeneous wireless networks. It introduced the signal to interference plus noise ratio (SINR) effects, least square (LS) and information entropy method into the algorithm. An attribute matrix is constructed considering the parameters - SINR in the source network and the equivalent SINR in the target network, the required bandwidth, the traffic cost and the available bandwidth of participating access networks. Handoff decision is made according to the traffic features the meeting multi attribute quality of service (QoS) requirement. The subjective weight relation of decision elements is determined with LS method. The information entropy method is employed to derive the objective weights of the evaluation criteria, and lead to the comprehensive weight. Finally decision is made using MEW algorithm based on the attribute matrix and weight vector.

C. Technique for Order Preference by Similarity to Ideal Solution

TOPSIS is based on the concept that the chosen alternative should have the shortest geometric distance from the positive ideal solution and the longest geometric distance from the negative ideal solution. The ideal solution is a "hypothetical solution" with the best values in each parameter while the negative ideal solution is the opposite. The ideal solution is obtained by using the best values for each metric. Let ci denote the relative closeness (or similarity) of the candidate network i to the ideal solution. The selected network ATOPSIS is:

$A_{TOPSIS} = \arg \max_{i \in i}$

Steps in TOPSIS method are as follows:

- Construct the normalized decision matrix,
- Construct the weighted normalized decision matrix
- Determine ideal and negative-ideal solutions
- Calculate the separation measure between the networks and the positive and negative ideal networks.
- Calculate the relative closeness to the ideal solution.

In [11] authors proposed a vertical handoff based on TOPSIS with the introduction of the utility function in Fuzzy Utility TOPSIS which greatly influenced the ratings of the alternatives. The proposed method was the first to utilize the Fuzzy TOPSIS method for the aggregation of conflicting criteria resolving the issue of possible inconsistency that would arise if the standard TOPSIS method was used.

D. Grey Relational Analysis

Grey relational analysis (GRA) is suitable for solving problems with complicated inter relationships between multiple factors and variables. The Grey theory can provide a solution of a system in which the model is unsure or the information is incomplete. Besides, it provides an efficient solution to the uncertainty, multi-input and discrete data problem [7]. GRA solves MADM problems by combining the entire range of performance attribute values being considered for every alternative into one, single value. This reduces the original problem to a single attribute decision making problem.

The ranking of GRA is performed by building grey relationships with a positive ideal network. A normalization process to deal with benefit and cost metrics is required and the Grey Relational Coefficient (GRC) of each network is calculated. The GRC is the score used to describe the similarity between each candidate network and the ideal network. The selected network is the one which has highest similarity to the ideal network. The selected network is given by

$A_{GRA} = \arg \max_{i \in M} l$, where $\Gamma_{0,i}$ is the GRC of network i.

In [12] authors proposed algorithmic approach that can realize dynamic interface selection with multiple alternatives and using GRA. The alternative solutions are introduced to reduce and eliminate the probability of rank inconsistency, caused by the addition or deletion of an interface.

E. Analytic Hierarchy Process

This process decomposes a complex decision problem into a hierarchical structure. The vertical handoff decision using AHP decomposes the network selection problem into several smaller problems and assigns a weight value to each of them. As given in [10] to make a decision in an organized way to generate priorities of the target network the decision is decomposed into the following steps [10].

1. Define the problem and determine the kind of knowledge sought.

2. Structure the decision hierarchy from the top with the goal of the decision, then the objectives from a broad perspective, through the intermediate levels to the lowest level.

3. Construct a set of pairwise comparison matrices. Each element in an upper level is used to compare the elements in the level immediately below with respect to it.

4. Use the priorities obtained from the comparisons to weigh the priorities in the level immediately below. This is done for every element. Then for each element in the level below add its weighed values and obtain its overall or global priority.

This process f weighing and adding is continued until the final priorities of the alternatives in the bottom most level are obtained.

In [13] proposed a network selection scheme for the integration of UMTS and WLAN. Analytic hierarchy process (AHP) is applied to decide the relative weights of evaluative criteria set according to user preferences and service applications.

II. Conclusion

Vertical handoff algorithms with the requirement of seamless connectivity are the key requirement of next generation wireless networks. A key issue that aids in providing seamless vertical handoff is handoff decision, that is, the ability to correctly decide at any given time whether or not to carry out vertical handoff and determine the best handoff candidate access network. Several classes of vertical handoff methods are available in literature. Vertical handoff decision problem can be formaulated as a MADM problem. Several vertical handoff algorithms based on MADM method are proposed in the literature. In this paper a detailed overview on vertical handoff strategies based on MADM methods are discussed.

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IV. References

[1] Chi Sun; Stevens-Navarro, E.; Wong, V.W.S., "A Constrained MDP-Based Vertical Handoff Decision Algorithm for 4G Wireless Networks," Communications, 2008. ICC '08. IEEE International Conference on, pp.2169-2174, 19-23 May 2008.

[2] W. Zhang, "Handover Decision Using Fuzzy MADM in Heterogeneous Networks," in Proc. of IEEE WCNC'04, Atlanta, GA, March 2004.

[3] Yoon, K. & Hwang, C., Multiple Attribute Decision Making: An introduction, Ed. Sage Publications, 1995.

[4] Stevens-Navarro, E.; Martinez-Morales, J.D.; Pineda-Rico, U., Evaluation of Vertical Handoff Decision Algorithms Based on MADM Methods for Heterogeneous Wireless Networks, Journal of Applied Research and Technology, vol. 10, No. 4, pp. 534-548, 2012.

[5] H.A Vine, comparison between MADM algorithms for Vertical handoff decision, Technical Journal, University of Engineering and Technology Taxila, 2010.

[6] Stevens-Navarro, E. & Wong, V., Comparison between Vertical Handoff Decision Algorithms for Heterogeneous Wireless Networks, IEEE Vehicular Technology Conference – Spring, 2006, pp. 947-951, Melbourne, Australia, May 2006.

[7] Chan WK and Tong TKL, (2007), Multi-criteria material selections and end-of-life product strategy: Grey relational analysis approach, Materials & Design, Volume 28, Issue 5, Pages 1539-1546

[8] Deng , J.L., "A course on Grey System Theory", HUST Press(in Chinese), Wuhan, 1990.

[9] Yiyo Kuo, Taho Yang, Guan-Wei Huang, The use of grey relational analysis in solving multiple attribute decision-making problems, Computers & Industrial Engineering, Volume 55, Issue 1, August 2008, Pages 80-93.

[10] Thomas L. Saaty, Decision making with the analytic hierarchy process, International Journal Services Sciences, Vol. 1, No. 1, pp. 83-98, 2008.

[11] I. Chamodrakas, I. Leftheriotis, D. Martakos, A utility-based fuzzy TOPSIS method for energy efficient network selection in heterogeneous wireless networks, Applied Soft Computing vol. 11 pp. 3734–3743, 2011.

[12] Huszák, A.; Imre, S., "Eliminating Rank Reversal Phenomenon in GRA-Based Network Selection Method" IEEE International Conference on Communications (ICC), pp. 1-6, 2010.

[13] Wei-wei Jiang, Hong-yan, Cui Qiang-jun, Van Xiao-juan, Wang Jian-Ya Chen, "A Novel Application-Oriented Dynamic Network Selection in an Integrated UMTS and WiMAX Environment" ,IEEE,2008.

[14] J. McNair and F. Zhu, "Vertical Handoffs in Fourth-generation Multinet-work Environments,"IEEE Wireless Comm., vol. 11, no. 3, June 2004.

[15] W. Chen, J. Liu, and H. Huang, "An Adaptive Scheme for Vertical Handoff in Wireless Overlay Networks," inProc. of ICPADS'04,New-port Beach, CA, July 2004.

[16] Jorge Lima de Oliveira Filho, Edmundo Madeira, "A Mechanism for Vertical Handover Based on SAW Using IEEE 802.21", In proceeding of Mobile Networks and Management - Second International ICST Conference, MONAMI 2010, Santander, Spain, September 22-24, 2010.

[17] Liu Sheng-mei; Pan Su; Mi Zheng-kun; Meng Qing-min; Xu Ming-hai, "A Simple Additive Weighting Vertical Handoff Algorithm Based on SINR and AHP for Heterogeneous Wireless Networks," Intelligent Computation Technology and Automation (ICICTA), 2010 International Conference on , vol.1, no., pp.347-350, 11-12 May 2010.

[18] Liu Shengmei Pan Su Mi Zhengkun Meng Qingmin Xu Minghaim, "An improved multiplicative exponent weighting vertical handoff algorithm for WLAN/WCDMA heterogeneous wireless networks", [J] Engineering Sciences, Vol. 10, Issue 1, pp. 86-90, 2012.