IOSR Journal of Engineering (IOSRJEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Vol. 08, Issue 6 (June. 2018), ||V (IV) || PP 15-17

A Hybrid Multi Attribute Decision Making Method in Heterogeneous Wireless Networks

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Abstract: A variety of Multi Attribute Decision Making (MADM) methods have been applied to the problem of network selection in heterogeneous wireless environment. As each kind of MADM approach has its own strong and weak points, it is quite difficult to ensure which MADM algorithm is more appropriate for network selection. From end user perspective, an algorithm that can improve selection accuracy ismore preferred, with minimal or no consideration towards prevalence and the methodology involved. So, in such a context, the effect of hybrid outranking MADM method on optimal network selection is studied in this article. The performance of the algorithm is tested in terms of Decision Making Accuracy.

Date of Submission: 05-06-2018 Date of acceptance: 20-06-2018

I. INTRODUCTION

The vision of next generation wireless networks is heterogeneous where wired and wireless networks coexist to provide wide coverage and diversified services to the user. In such an environment, a user always has multiple networks available to him, for providing the necessary services such as voice call, web browsing, email, online gaming, video or audio streaming etc. When multiple networks are simultaneously available the problem of network selection arises.

Network selection is the process of identifying the best network when multiple networks are simultaneously available to the user. However, the selection process is not simple but extremely complex, because it depends on multiple factors such as user preferences, mobile terminal capabilities, service cost and Quality of Service (QoS) parameters of the available networks. Since large number of parameters is to be considered, network selection can be viewed as a Multi Attribute Decision Making (MADM) problem[1].

In literature, number of MADM methods have been developed and applied to the problem of network selection. The scoring methods i.e Simple Additive Weighting and Weighted Product Method[2] are the simplest types of MADM methods. The compensatory method i.e.Technique for Order Preference by Similarity to Ideal Solution[3]suffers from ranking abnormality problems. The outranking methods ELimination Et Choix Traduisant la REalité[4] (ELECTRE)and Preference Ranking Organization Method for Enrichment Evaluation[5] (PROMETHEE) are quite simple in conception and application when compared to other MADM methods.The basic concept of ELECTRE and PROMETHEE is identical i.e ranking is based on pair-wise comparison amongst the networks, however the approach is different. PROMETHEE constructs outranking relations based on the concordance analysis using various preference functions and does not take discordance into account. However, the concept of discordance also plays an important role in the outranking analysis, because it indicates the degree of dissatisfaction of a network under consideration with respect to the alternative network it is being compared with. The concept of discordance is introduced in PROMETHEE by integrating it with ELECTRE resulting in a hybrid algorithm.

In this article the effect of hybrid scheme on network selection in heterogeneous environment is studied. The rest of the paper is organized as follows. The hybrid methodology is discussed in the Section II. In Section III, simulations are performed to evaluate the performance of the hybrid algorithm followed by conclusion in Section IV.

II. HYBRID OUTRANKING ALGORITHM

The hybrid algorithm is an amalgam of ELECTRE and PROMETHEE. It involves step 1, 2, 3 and 4 of ELECTRE, to generate concordance and discordance matrices. It is then followed by step 6 and 7 of PROMETHEE to generate outranking flows. The stepwise procedure of hybrid algorithm is presented below.

Step 1: Normalize the decision criterion g_{ij} acquired from the n candidate networks.

$$z_{ij} = \frac{g_{ij}}{\sum_{i=1}^{n} g_{ij}} \qquad (1)$$

Step 2: Generate the weighted normalized matrix by multiplying the normalized decision criterion z_{ij} with its assigned weight w_{ij}.

$$r_{ij} = z_{ij} w_{ij} \quad (2)$$

Step 3: Compute concordance and discordance sets

$$C_{kl} = \{j, z_{kj} \geq z_{lj}\} \quad (3)$$

$$D_{kl} = \{j, z_{kl} \leq z_{lj}\} \quad (4)$$

Step 5: Compute global preference index[6]

$$\pi(a_i, a_j) = \begin{cases} C_{k,l} & D_{k,l} \leq C_{k,l} \\ D_{k,l} \prod_{J \in j(k,l)} \frac{1-D_j(k,l)}{1-C(k,l)} & J(k,l) \end{cases} \quad (5)$$

Step 6: Calculate positive and negative outranking flows for each alternative

$$\Phi^-(a_i) = \frac{1}{n-1} \sum_{a_j \in A} \pi(a_j, a_i) \quad (6)$$

$$\Phi^-(a_i) = \frac{1}{n-1} \sum_{a_j \in A} \pi(a_j, a_i) \quad (7)$$

Step 7: Calculate net outranking flow of each alternative

$$\phi(a_i) = \phi^+(a_i) - \phi^-(a_j) \quad (8)$$

Rank the alternatives from best to worst depending on their net outranking flows. The alternative with highest outranking flow is selected as the best alternative.

III. SIMULATIONS AND RESULTS

In this section the simulation results of hybrid algorithm in a case study involving four networks-WIFI-1, WIFI-2 LTE and HSPA for different traffic options viz, conversation, streaming, interactive and background is presented. The Analytic Hierarchy Process[7] (AHP) is used to assign weights to the decision criterion. The decision attribute values at the time of network selection are shown in Table no1

Table no 1: Network selection environment

Alternative Network	Cost Rs/Mbps	Bandwidth Mbps	Latency ms	Jitter ms	Network Utilization	Packet Loss Per 10^6
WiFi1	0	6	45	10	80	30
WiFi2	1	44	95	17	70	18
LTE	1.5	7	43	6	70	5
HSPA	2	2	185	9	60	35

The performance of hybrid algorithm is tested in terms of Decision Making Accuracy (DMA) for various traffic classes. DMA is the ability of the algorithm to make a right decision by selecting a network that is most appropriate for a application. It is defined as the ratio of number of right decisions to total number of decisions. If an algorithm selects a low delay network for background traffic, the decision is a right decision and the DMA of the algorithm is good. An algorithm that selects a network with high packet loss for Interactive traffic suffers from poor DMA. The ranking order generated by the hybrid algorithms for various traffic classes and the best selected network in each case is given in Table no2.

For conversational traffic low latencies are preferred. In this context LTE is the best network. Hybrid algorithm selected WIFI-1 as best network, an acceptable decision, since its delay and jitter values are low and very close to the first best network LTE. Also, LTE selected for web browsing and email applications is a good decision, but selection of LTE for streaming application is a bad decision because it is having low bandwidth (7Mbps) when compared to WiFi2 (44Mbps) at the time of decision making. 75% DMA has been achieved by the hybrid algorithm

Table no 2: Network selection environment.

Traffic class	WiFi1 (Rank)	WiFi2 (Rank)	LTE (Rank)	HSPA (Rank)	Decision
Conversation	1.5023 (1)	-0.3103 (3)	0.7981 (2)	-1.9901 (4)	Right
Streaming	0.9967 (2)	-0.4693 (3)	1.3705 (1)	-1.8979 (4)	Wrong
Web browsing	0.4625 (2)	-0.3184 (3)	2.2878 (1)	-2.4245 (4)	Right
Email	0.6183 (2)	-0.2871 (3)	2.1674 (1)	-2.4986 (4)	Right

IV. CONCLUSION

This paper studies the effect of hybrid outranking algorithm on network selection in terms of decision making accuracy. Simulation results show that the algorithm exhibited good accuracy in decision making for conversational, web browsing and Email traffic classes. Only 75% DMA has been achieved by the hybrid algorithm. Moreover, the procedure is lengthy and complex. So, the established outranking methods are more suitable than hybrid method in identifying the best network in heterogeneous wireless environment

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IOSR Journal of Engineering (IOSRJEN) is UGC approved Journal with Sl. No. 3240, Journal no. 48995.

C.S.S. Anupama "A Hybrid Multi Attribute Decision Making Method in Heterogeneous Wireless Networks." IOSR Journal of Engineering (IOSRJEN), vol. 08, no. 6, 2018, pp. 15-17.