IJIREEICE
ISSN (Online) 2321 – 2004
ISSN (Print) 2321 – 5526
INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH IN ELECTRICAL, ELECTRONICS, INSTRUMENTATION AND CONTROL ENGINEERING
Vol. 4, Issue 5, May 2016

Optimal Network Selection using PROMETHEE Method

K.S.S. Anupama[1], Dr. S. Sri Gowri[2], Dr. B. Prabhakara Rao[3]

Associate Professor, Dept. of EIE, V.R. Siddhartha Engineering College, Vijayawada, Andhra Pradesh, India[1]

Professor and Head, Dept. of ECE, SRK Institute of Technology, Vijayawada, Andhra Pradesh, India[2]

Rector, JNTUK, Kakinada, Andhra Pradesh, India[3]

Abstract: The upcoming wireless environment is a fusion of numerous networks with diverse technologies. Efficient Network selection in such an environment plays a crucial role in performance. depends on several parameters such as application quality of service requirements, user preferences and cost of service. In this paper, an effective access network selection algorithm for heterogeneous wireless networks is proposed that combines two Multi Attribute Decision Making (MADM) methods, the Analytic Hierarchy Process (AHP) method and the Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE). More specifically, hybrid AHP and Entropy method is used to determine weights of the criteria and the PROMETHEE method is used to obtain the final access network ranking.

Keywords: PROMETHEE, AHP, Entropy, Network Selection.

I. INTRODUCTION

A heterogeneous wireless environment integrates several different wireless access technologies, each with different characteristics, in order to satisfy the needs and the requirements of the mobile users. In such a diverse environment, the requirement for with the Always Best Connected (ABC) service, i.e., the selection of the access technology that best suits the needs of the users is a tedious problem.

In order to achieve ABC a number of parameters such as application QoS requirements, user preferences and cost of service must be included in the decision making process. Since all these criteria must be taken into consideration, the network selection problem is usually studied from the aspect of multi-criteria analysis, and more specifically by applying different Multi Attribute Decision Making (MADM) algorithms[1][2][3].

I.Joe et .al [4] proposed a network selection algorithm based on AHP and GRA to select the best network between CDMA, WiBro, and WLAN networks. A wide range of parameters: bandwidth, delay, jitter, BER, monetary cost, transmission power, receiver power, idle power and user preferences are considered ,which makes decision making process complex.

In [5] Liu et al. use a SAW function of available bandwidth, monetary cost, and power consumption to select between WiFi, WiMAX, and 3G, whereas in [6] I. Smaoui et.al. made use of TOPSIS to solve the multi criteria network selection problem.

In this paper, we propose an optimal network selection algorithm for heterogeneous wireless networks that combines the Analytic Hierarchy Process (AHP) [7] and entropy method to determine weights of the criteria and Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE) methodology [8] to obtain the final ranking of the networks.

The main reasons for utilizing the above methods are as follows:

- The AHP method can reflect the hierarchy of the criteria.
- Entropy method is an unbiased evaluation procedure.
- PROMETHEE is simple in conception and application compared to other MADM methods for multi criteria analysis.

II. APPLICATION OF PROMETHEE ALGORITHM IN NETWORK SELECTION

PROMETHEE belongs to a family of outranking methods developed by Brans et al. in 1986. It is designed to deal with multi criteria problems with finite set of solutions. It is simple in conception and application compared to other methods for multi criteria analysis. The basic principle of PROMETHEE algorithm is “pair-wise comparison of the alternatives” in order to rank them with respect to a number of conflicting criteria.

To evaluate the performance of PROMETHEE algorithm in network selection, an application scenario of four heterogeneous networks UMTS1, UMTS2, WiFi, and WiMAX is considered. In such a scenario a MS is assumed to be connected to UMTS1 network and is traversing through an area overlapped by three more networks UMTS2, WiFi, and WiMAX. So, four networks are available simultaneously to the MS. The MS has to select the best network from the available networks for handoff.

Decision is based by assessing various criterions from each network: Cost (CB), Bandwidth (BW), Packet Delay (D), Packet Jitter (J), Network Utilization (U) and Packet Loss (L). A snap shot of the decision criteria values at the time of network selection are shown in Table 1.

TABLE I NETWORK SELECTION EVALUATION CRITERIA

Network	CB (usd)	AB (mbps)	D (ms)	J (ms)	U (%)	L(per10^6)
UMTS1	100	0.2	35	5	10	60
UMTS2	90	1	42	10	40	80
Wifi	10	2	140	12	30	20
Wimax	40	5	90	7	20	30

A. Assignment of Weights

Most of the existing network selection algorithms have employed AHP methodology for assigning weights to the criterion. AHP is a subjective weighting method, in which weights are assigned according to the knowledge of the decision maker. In order to utilize the subjectivity of the decision maker and objectiveness of the performance values, this paper employs a combination of AHP and Entropy methods for assigning weights to each criterion.

The AHP procedure is given below:

Construct pair-wise comparison matrix (PWCM). For each pair, within each criterion award a score, on a scale between 1 and 5. The pair wise comparison matrix (PWCM) for conversational traffic is shown in Table 2.

TABLE II PWCM FOR CONVERSATIONAL TRAFFIC

Network	CB (usd)	BW (mbps)	D (ms)	J (ms)	U (%)	L(per 10^6)
CB	1	4	1/4	1/5	2	2
BW	1/4	1	1/5	1/5	1/2	1/4
D	4	5	1	1	4	2
J	5	5	1	1	4	2
U	1/2	2	1/4	1/4	1	1/3
L	1/2	4	1/2	1/2	3	1

Determine the geometric mean of each row for each matrix and normalize the results obtain the weights for each criterion

$$W_i = GM_i \Big/ \sum_{i=1}^{M} GM_i \quad (1)$$

Where GM_i is the geometric mean of the i^{th} row.

Check the consistency of a pair wise comparison by using consistency ratio (CR)

$$CR = CI / RI \quad (2)$$

Where CI is the Consistency Index and RI is the Random Index. If the CR is less than or equal to 0.1, the pair wise comparison is considered acceptable or else the subjective judgment is revised. Entropy Method is an objective weighting method that assigns weights according to the value of each criterion and does not depend on decision maker's subjective judgment. This establishes the entropy method as an unbiased evaluation procedure, and the same holds true for the weights obtained for the criteria. The entropy procedure is as follows

Normalize the decision parameters in Table 1.

$$b_{ij} = a_{ij} / \sum_{i=1}^{m} a_{ij} \quad (3)$$

Compute an entropy value E_{ij}

$$E_{ij} = -\sum_{i=1}^{m} b_{ij} \ln b_{ij} \ln n \quad (4)$$

Calculate the degree of divergence d_j

$$d_j = 1 - E_{ij} \quad (5)$$

Where j = 1, 2... m Compute the weights for all criteria by additive normalization

$$w_{ej} = d_j \Big/ \sum_{j=1}^{n} d_{ij} \quad (6)$$

Combine AHP weight w_{aj} and entropy weights w_{ej} to obtain the comprehensive weights w_j of the criterion.

$$w_j = w_{aj} w_{ej} \Big/ \sum_{j=1}^{n} w_{aj} w_{ej} \quad (7)$$

The AHP, Entropy and Comprehensive weights for conversational traffic is shown in Table 3.

TABLE III WEIGHT ASSIGNED TO CRITERION FOR CONVERSATIONAL TRAFFIC

	CB	BW	D	J	U	L
AHP weights	0.126	0.043	0.305	0.317	0.069	0.140
Entropy weights	0.212	0.374	0.141	0.049	0.101	0.123
Comprehensive weights	0.213	0.128	0.344	0.124	0.056	0.138

B. PROMETHEE

The PROMETHEE Algorithm for network selection decision making is given below.

Perform pair wise comparisons between all the networks with respect to all the criterions listed in Table 1,

$$d_k(a_i, a_j) = f_k(a_i) - f_k(a_j) \quad (8)$$

Where $d_k(a_i,a_j)$, is the difference between two networks a_i and a_j with reference to criterion 'k'.The usual preference function is applied to translate the difference d_k into a preference P_k of a network a_i over another network a_j on a given criterion f_k. The preference indices of streaming traffic for delay criterion are shown in Table 4.

TABLE IV PREFERENCE INDICES WITH RESPECT TO COST CRITERION

	UMTS1	UMTS2	WiFi	WiMax
UMTS1	-	0	0	0
UMTS2	1	-	0	0
WiFi	0	0	-	0
WiMAX	1	1	0	-

Compute the global preference index

$$\pi(a_i, a_j) = \sum_{k=1}^{q} P_k(a_i, a_j) w_k \quad (9)$$

where wk is the weight of criteria k.

Determine the preference flows.

The leaving flow Φ+ (ai) is a measure of the strength of a network ai with respect to the other networks.

$$\phi^+(a_i) = 1/n-1 \sum_{a_j \in A} \pi(a_i, a_j) \quad (10)$$

The entering flow Φ-(ai) is a measure of the weakness of a network ai with respect to

$$\phi^{-}(a_i) = 1/n-1 \sum_{a_{j \in A}} \pi(a_j, a_i) \quad (11)$$

The net outranking flow Φ (ai) expresses the balance between the strength and weakness of each network.

$$\phi(a_i) = \phi^{+}(a_i) - \phi^{-}(a_i) \quad (12)$$

Rank the networks in descending order of net flow values. A network with highest net flow value is identified as the best network. Table 5 presents the flow values of PROMETHEE, and ranking of the networks for the Conversational traffic class.

TABLE V PROMETHEE FLOWS AND RANKS

Network	Conversational Traffic			
	Leaving flow Φ+	Entering flow Φ-	Outranking Flow Φ	Network Rank
UMTS1	2.3266	0.5472	1.7794	1
UMTS2	1.1333	1.7405	-0.6072	3
WiFi	0.9536	2.0464	-1.0928	4
WiMAX	1.4603	1.5397	-0.0794	2

III. SIMULATION AND RESULTS

The performance of PROMETHEE algorithm is tested in terms of Optimal Network Selection Accuracy (ONSA) for various traffic classes. ONSA is the ability of the PROMETHEE in selecting an optimal network in the presence of multiple conflicting criteria. The optimal network selected by PROMETHEE algorithm for various traffic classes is given in Table 6.

TABLE VI PROMETHEE NETWORK SELECTION

	UMTS 1	UMTS 2	WiFi	WiMAX	Optimal Network
Conversational	1.7794	-0.6072	-1.0928	-0.07 94	UMTS1
Streaming	0.8382	-1.3997	-0.3078	0.8693	WiMAX
Interactive	0.8499	-1.2843	0.7371	-0.30 26	UMTS1
Background	0.4	-1.6606	1.5362	-0.27 56	WiFi

Each traffic class has specific QoS requirements. Conversational class is extremely sensitive to delay and jitter. Applications of conversational class include telephony speech, voice over IP and video conferencing. The delay and jitter requirements for this class are extremely stringent and should be low to provide the required quality of service. PROMETHEE algorithm selected UMTS1 network for serving conversational traffic class users. As this network has lowest delay (30ms) and jitter (5ms) when compared to other candidate networks, PROMETHEE selection is rightly justified.

Streaming class is characterized by that the time relations between information packets and requires large bandwidth to provide good quality stream. It does not have any requirements on delay. Applications of streaming class include listening to audio or watching real time video. PROMETHEE algorithm selected WiMAX network for serving streaming class users. As WiMAX network has highest available bandwidth (5Mbps) when compared to other candidate networks, its selection as optimal network for servicing streaming class mobile users is justified.

For Interactive class mobile users delay is the most important attribute. In addition packet loss also should be very low. Applications of interactive class include web browsing, database retrieval, Telnet etc. PROMETHEE algorithm selected UMTS1 network with lowest delay but slightly higher packet loss for serving interactive class mobile users. In Background traffic class, applications run in the background. Background traffic is characterized by that the destination is not expecting the data within a certain time. Thus this class is less delay sensitive but the contents should be delivered with low packet loss. Accordingly PROMETHEE selected WiFi network with lost packet loss. Applications of background traffic class include Email, FTP, SMS etc.

IV. CONCLUSION

Always best connected concept requires the selection of the optimal access network in a heterogeneous wireless environment. In this paper an optimal network selection algorithm for heterogeneous wireless networks is proposed that combines the AHP and Entropy method to determine the importance of the network parameters and PROMETHEE method to rank the candidate networks. The performance of PROMETHEE algorithm is tested in terms of Optimal Network Selection Accuracy (ONSA) for various traffic classes Simulation results have shown that PROMETHEE methodology can be very effective for the selection of the optimal network according to application requirements. Future work includes testing the efficiency of the algorithm on handoff dropping rates.

REFERENCES

[1] L.Mohamed, C.Leghris and A.Adib "A Hybrid Approach for Network Selection in Heterogeneous Multi-Access Environments", New Technologies, Mobility and Security (NTMS), 2011 4th IFIP International Conference on, pp.1-5, 7-10 Feb. 2011
[2] F.Bari, and V.C.M Leung "Use of non-monotonic utility in multiattribute network selection", in Wireless Telecommunications Symposium, 2007. WTS 2007, pp.1-8, 26-28 April 2007
[3] P.N.Tran and N. Boukhatem "Comparison of MADM decision algorithms for interface selection in heterogeneous wireless networks", in Software, Telecommunications and Computer Networks, 2008. (SoftCOM 2008). 16th International Conference on, pp.119-124, 25-27 September. 2008.
[4] I. Joe, W.-T. Kim, and S. Hong, "A Network selection Algorithm considering power consumption in Hybrid Wireless Networks," in Proc. 16th ICCn, 2007, pp. 1240–1243.
[5] H. Liu, C. Maciocco, V. Kesavan, and A. L. Low, "Energy efficient network selection and seamless handovers in mixed networks," in Proc. IEEE Int. Symp. WoWMoM, 2009, pp. 1–9.
[6] I. Smaoui, F. Zarai, R. Bouallegue, and L. Kamoun, "Multi-criteria dynamic access selection in heterogeneous wireless networks," in Proc. 6th ISWCS, 2009, pp. 338–342.
[7] K. Yoon and C. Hwang, Multiple Attribute Decision Making: An Introduction. Sage Publications, 1995.
[8] J. P. Brans, P. Vincke, and B. Mareschal, "How to select and how to rank projects: the Promethee method," European Journal of Operational Research, vol. 24, no. 2,1986, pp. 228–238.