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A heterogeneous network choice algorithm based on dynamic

Hong Yu Gao, Yi Jiang and Yang Zou

Chongqing University of Posts and Telecommunications, School of computer science and technology, Chongqing, China

Abstract. To enhance the user experience and quality of service about wireless heterogeneous networks,I presented a dynamically selected heterogeneous network algorithm.The algorithm considereed the variability of the real-time network property and user demanded for real-time multi- business.The algorithm added weight between the right multi-business on the basis of AHP.And it introduced dynamic index matrix by calculating in GRA algorithm,thereby selecting the optimal access network.Simulation results show that the improved algorithm can effectively reduce the switching frequency and blocking rate, enhance the user experience QoS to some extent.

1 Introduction

With the popularity of intelligent terminals, users have demand more and more diverse. So synergy between heterogeneous networks, integration interoperability can give users better communication service. The best access to the network could maximize the quality of service and users satisfaction[1]. The choice of wireless network needs to comprehensive include users experience and network performance, and many other characteristics or requirements. Including bandwidth, delay, jitter, cost, business type, user policies, etc..Also it constitute a multi-attribute decision making problems[2].

In the heterogeneous network selection, the more common type of network is about MADM algorithm. For example, [1] proposed user level using AHP, the network using objective weighting method and deviation minimization method. Finally it use the TOPSIS determine the optimal network. [3] shows that by the integration to a variety of subjective and objective results with weighting method, it use of consistent criteria to determine the weight vector of consistency, and to determine the final network through TOPSIS method. The factors above algorithms are integrated user and network multifaceted. But in reality, the user's business is changing, network property is also changing in real time, both do not consider the multi-business and attribute dynamic situation. This affects the accuracy of the optimal network selection, as well as ping-pang effect and have other adverse circumstances. To solve these problems, this paper proposes a heterogeneous network dynamic selection algorithm based on the present view.The algorithm adds user multi-business priority weights on the basis of AHP in subjective level and reflects the user's dynamic nature. In the network, the use of GRA process each judgment indicators, while using a mathematical way to determine the dynamics of the judgment indicators over time and in conjunction with the GRA, in order to determine the optimal network. Examples and simulation results demonstrate the effectiveness of the algorithm.

2 Dynamic selection algorithm

The algorithm join multi-business priorities in subjective weight, then according to the dynamic of index judgment,it calculate the index of dynamic change weight matrix in a period of time, and combined with gray relational analysis to select the best network.

2.1 Analytic Hierarchy Process

Analytic Hierarchy Process (AHP) is proposed by TLSatty in operations research expert from the United States in the 1970s and has become one of the most popular multi-attribute decision problem and most important method to effectively solve multi-attribute decision problem.AHP can well reflect the impact of user needs,preferences and other subjective attributes[5-8].

2.1.1 Establish a hierarchy model

According to business type have requirements for QoS property, so the paper choose delay, jitter, bandwidth, packet loss rate as QoS setting parameters.

In order to better reflect the needs of users,in addition to the relevant parameters of QoS attributes, it choose cost,security,network load,historical preference and other

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attributes as judged parameters.According to the hierarchy of AHP,namely the target layer,criterion layer,project layer construct hierarchical model of the algorithm shown in Figure 1.

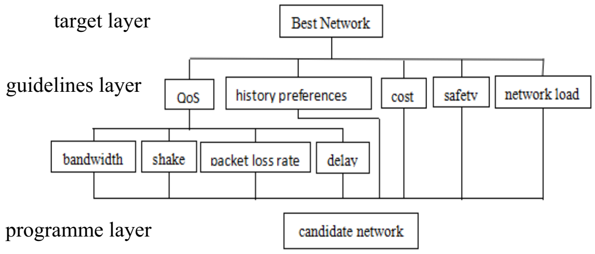

Figure.1. Hierarchical model

2.1.2 Determine the weights

In AHP,Satty and others recommend that referencing 1 to 9 scale method and the inverse indicate both the attributes of importance,so that construct judgment matrix[9-11].Its scale value and meaning as shown in Table 1.

Table1. 1~9 Scale method

The importance of scale	The importance of the ratio between elements
1	Equally important
3	The former is slightly more important than the latter
5	The former obviously more important than the latter
7	The former than the latter is very important
9	The former than the latter is extremely important
2、4、6、8	Intermediate values adjacent to judgment

According to property element use the above 1 to 9 scale method to construct a judgment matrix A :

$$A=(a_{ij})_{n\times n}, a_{ii}=1, a_{ji}=1/a_{ij}, a_{ij}>0, i,j=1,2,\cdots,n.$$

Wherein a_{ij} represents the same time the importance of the two types of business correspondence ratio between the properties, n as the number of elements.

According to the method of characteristic root and root calculate weights, then weight vectors can be obtained by normalization process.

Assume $Aw=\lambda_{\max} w$ available

$$w_i=\prod_{j=1}^{n} a_{ij},\quad i=1,2,\cdots,n \qquad (1)$$

A where $\lambda_{\max}$ is the greatest characteristic root, w is the corresponding feature vectors, n is the number of evaluation parameters, A is element values in a_{ij} matrix .

Compute w_i n -th root $\overline{w_i}$,

$$\overline{w_i}=\sqrt[n]{\prod_{j=1}^{n} a_{ij}},\quad i=1,2,\cdots,n \qquad (2)$$

$\overline{w_i}$ is normalization process,which is

$$u_i=\overline{w_i}=\sum_{i=1}^{n}\overline{w_i},\quad i=1,2,\cdots,n \qquad (3)$$

Consistency check. Because the judgment matrix is obtained by the user subjectively,it is necessary for consistency check. $C.I.=\frac{\lambda_{\max}-n}{n-1}, C.R.=\frac{C.I.}{R.I.}$, Wherein $C.I.$ is the consistency index, n is the judgment matrix order, $C.R.$ is the consistency ratio, $R.I.$ is the Mean Random Consistency Index ,it can look-up table available. When $C.R.<0.1$, it considered to have a satisfactory consistency, otherwise A judgment matrix need to correction, until a satisfactory consistency.

Can be obtained from the above that the right decision attribute parameters of each weight vector is $\vec{U}=\{u_1,u_2,\cdots,u_n\}$.

2.2 Priority right multi-business weight

3G business is divided into four types by 3GPP, including streaming type, background type, conversation type,interactive type. Users business conducted in constant change, and users of the different service types have certain preferences.But also there is a certain conflict and competition between a variety of business .This requires that the user wants to prioritize the various business when it generates the conflict between the business according to their preferences or actual situation and give priority to certain types of business[10,12].

According to the above AHP, the priority for all types of business construct the judgment matrix $B=(b_{ij})_{n\times n}, i,j=1,2,\cdots n$, n is the number of businesses.In accordance with the calculation method described above AHP right weight vector can be drawn judgment matrix B weight vector $\vec{V}=\{v_1,v_2,\cdots,v_n\}$.

Both the calculated weight vector $\vec{U}$ by the front of the decision property parameters and business type priority weight vector $\vec{V}$ are to combine as subjective weight vector. According to equation (4) can be obtained $\vec{W}=\{w^1,w^2,\cdots,w^n\}$ with the reunification of the right weight vector as the subjective weight vector finalized, n is the number of operations.

$$w^i=u_i v_i\Big/\sum_{i=1}^{n} u_i v_i \qquad (4)$$

2.3 Dynamic decision Indexes

Because of the instability of network, the decision indicators are real-time dynamic changes.To reflect the dynamic of the decision indicators for the impact of network selection, it choose the parameter value over a period of time more than one time decision indicators.By the corresponding calculation,it reflect the degree of dispersion and volatility of each candidate network parameter values in this period of time.And thus it calculate the dynamic matrix judgment indicators, as the optimal network selection factors.

2.3.1 Decision matrix

Assume that dynamic multiple index decision set for candidates network is $s = \{s_1, s_2, \cdots s_m\}$, m is the number of candidates network,decision index set is $p = \{p_1, p_2, \cdots, p_n\}$, n is the number of indicators,time sample point is $T_t(t = 1,2,\cdots,k)$, k is the number of sample points,time weight vector is $\lambda = \{\lambda_1, \lambda_2, \cdots, \lambda_k\}^T, 0 \le \lambda_t \le 1, \sum_{t=1}^{k} \lambda_t = 1$. Candidate network s_i respect to the property index p_j value is b_{ij}^t in the period of T_t .In the period of T_t ,candidate network for the index set of decision matrix is $B^t = (b_{ij}^t)_{m \times n}, t = 1,2,\cdots k$.

Under normal circumstances indicators divided efficiency, costs and interval.Efficiency of the indicators is more larger and more better;costs of the indicators is more smaller and more better; interval index whose value falls within a certain range for the best.In order to eliminate unfairness by a different dimension,it need to do standardization process to decision matrix,so that standardized analysis and processing of data.Equation (5) and (6) are the normalized process about costs and efficiency indicators.

$$c_{ij}^t = \frac{(b_{ij}^t)_{\max} - b_{ij}^t}{(b_{ij}^t)_{\max} - (b_{ij}^t)_{\min}} \quad (5)$$

$$c_{ij}^t = \frac{b_{ij}^t - (b_{ij}^t)_{\min}}{(b_{ij}^t)_{\max} - (b_{ij}^t)_{\min}} \quad (6)$$

After the normalization process of decision matrix is $C^t = (c_{ij}^t)_{m \times n}$ 。

2.3.2 Dynamic matrix

To reflect the changing trends of the indicators, it introduce a dynamic matrix.Equation(5) reflects the average of the decision index in period of corresponding time.Equation (6) reflects the degree of dispersion about corresponding index in the period of time, the larger value, the larger volatility index, the more unstable.Structure dynamic matrix $D^t = (d_{ij}^t)_{m \times n}, t = 1,2,\cdots,k,$ among them $d_{ij}^t = D(c_{ij}^t - c_{ij}^{t-1})$ 。 $c_{ij}^t - c_{ij}^{t-1}$ is growth degree about indicators for sample point T_t .

$$E(x) = \sum_{i=1}^{n} x_i p_i \quad (7)$$

Where,x is the value of the corresponding judgment index,p is the probability of emergence about x, n is the number of sample values for judgment index the.

$$D(x) = \sum_{i=1}^{n} p_i \cdot (x_i - \mu)^2, \mu = E(x) \quad (8)$$

2.3.3 Comprehensive evaluation decision matrix

After normalization the decision matrix C^t and dynamic matrix D^t is binding, we can get a comprehensive evaluation decision matrix:

$$V^t = (v_{ij}^t)_{m \times n}, v_{ij}^t = E(c_{ij}^t)c_{ij}^t + d_{ij}^t, t = 2,3,\cdots,k \quad (9)$$

$E(c_{ij}^t)$ reflects network parameters the current state.

2.4 Grey Relational Analysis

Grey Relational Analysis(GRA) refers to the trend of development and change in things which a quantitative description and method of comparison.The basic idea is to determine the geometry of the similarity about reference data columns and the several of comparative data columns to judge which contact is tight.Curve is more closer,between the correlation degree of the corresponding sequence is more larger,the contrary is more smaller,it reflects the degree of association between the curves[13-15].

This article will be applied GRA to dynamic multiple index decision, gray correlation were calculated for each available network with over networks and non-ideal network.Finally, according to the comprehensive evaluation value of the network is to sort,and determine the best access network.

According to matrix V^t define period T^t's the ideal and not ideal network: $H^t = \{\max v_{i1}^t, \max v_{i2}^t, \cdots, \max v_{in}^t\}$, $L^t = \{\min v_{i1}^t, \min v_{i2}^t, \cdots, \min v_{in}^t\}$. According to Gray Correlation Theory,in the period T^t candidate network s_i and over the network H^t and not over network L^t grey correlation coefficients about indicators p_j were:

$$\xi_{ij} = \frac{\min_i \min_j |v_{ij}^t - h_j^t| + \rho \max_i \max_j |v_{ij}^t - h_j^t|}{|v_{ij}^t - h_j^t| + \rho \max_i \max_j |v_{ij}^t - h_j^t|} \quad (10)$$

$$\xi_{ij} = \frac{\min_i \min_j |v_{ij}^t - l_j^t| + \rho \max_i \max_j |v_{ij}^t - l_j^t|}{|v_{ij}^t - l_j^t| + \rho \max_i \max_j |v_{ij}^t - l_j^t|} \quad (11)$$

Wherein, ρ is discrimination coefficient, $\rho \in [0,1]$, there $\rho = 0.5$.

Obtained weights vector $\overrightarrow{W} = \{w^1, w^2, \cdots, w^n\}$ by the AHP, according to equation (10) and (11) can obtain gray correlation about candidate network with positive and negative ideal network.

$$\xi_i = \sum_{i=1}^{k} \lambda_t \sum_{j=1}^{n} w_j \xi_{ij}^t, i = 1,2,\cdots,m \quad (12)$$

$$\eta_i = \sum_{i=1}^{k} \lambda_t \sum_{j=1}^{n} w_j \eta_{ij}^t, i = 1,2,\cdots,m \quad (13)$$

Among them, $0 \le \xi_i \le 1, 0 \le \eta \le 1$.

Comprehensive evaluation value is $\gamma_i = \dfrac{\xi_i}{\xi_i + \eta_i}$ 。 (14)

Finally, depending on the size of γ_i to sort candidate network, it choose the largest network of its value as the best network.

3 Simulation and Analysis

This paper is simulation in Matlab environment, in order to verify the feasibility and effectiveness of the algorithm.

3.1. Simulation

It assumes that there are four types of wireless network environment, including the UMTS, GSM, WLAN, multi-mode terminal is located in the four kinds of wireless network environment at the same time. When user uniform motion within the range, the terminal select the appropriate network .Analog simulation scene as described below, users need to undertake a variety of business services in a heterogeneous network coverage area, such as type session (IP telephone), interactive type (web), streaming media (such as FTP download). Among them, the various of business according to the parameters forλ poisson distribution reache overlapping coverage of the network, the duration of the various types of business is to obey exponential distribution with meanμ . Draw four time points t1, t2, t3, t4, including t1 < t2 < t3 < t4. The corresponding time weight vector is set toλ = {1/3, 1/3, 1/3}.

In the above-mentioned AHP ,it set attribute parameters and these three categories network about UMTS, GSM, WLAN s'the actual situation of corresponding attribute.Under the above emulation scenario assumes that multimode terminal monitored network parameters such as table2,4 times sample points attribute parameters as shown in Table 3.

Table2. Network attribute parameter settings

Network parameters	UMTS	GSM	WLAN
Bandwidth	4	6	8
Cost	0.8	0.4	0.2
Security Level	8	6	7
Network Load	0.4	0.7	0.6
History Preferences	1	1	1

Table3. Network dynamic attribute parameter settings

Candidate network		Delay	Shake	Packet loss rate
UMTS	t1	20	6	0.08
	t2	18	6	0.07
	t3	18	7	0.06
	t4	17	8	0.06
GSM	t1	30	7	0.05
	t2	28	8	0.06
	t3	27	8	0.05
	t4	25	9	0.04
WLAN	t1	45	12	0.06
	t2	44	11	0.05
	t3	46	11	0.04
	t4	43	13	0.03

3.2 Results and analysis

Based on the above assumptions simulation scenarios and parameter values,this paper makes experimental comparison with the dynamic selection algorithm and original static AHP, GRA algorithm. The simulation results shown in Figure 2- 3.

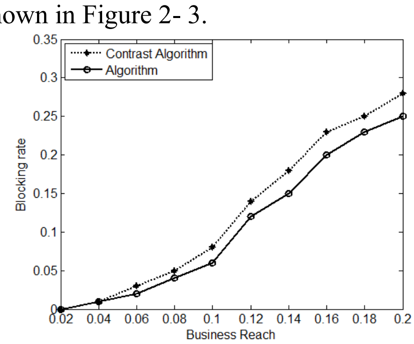

Figure.2. Blocking rate comparison

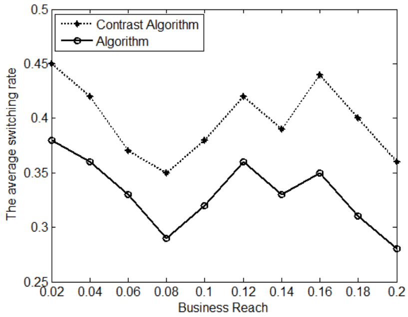

Figure.3. The average switching rate comparison

From figure 2 shows, when the business arrival rate increases, blocking rate are constantly increasing, but the dynamic selection algorithm blocking rate is lower than static selection algorithm. The figure 3 shows that ,with the increasing arrival rate of business, two algorithms for comparing the average switching rate has different amplitude fluctuations, but the dynamic selection algorithm on the average switching rate overall value has a certain reduce than static selection algorithm.

From the above experimental results and analysis can be concluded that when users is using business services in a heterogeneous network environment ,dynamically selects algorithm selecting the best network than static network algorithms have obtained better performance with the best results. In terms of switching rates, blocking rates, etc. have been some optimization , enhance the QoS experience in a certain extent .

4 Conclusion

In this paper,for heterogeneous networks indicators with dynamic, it presents a heterogeneous network access algorithm based on dynamic selection.The core idea is to use AHP to calculate the subjective weight of user level, and combined with real-time multi-business priority weight.When selecting the optimal network,it bind with properties' dynamic matrix based on the GRA , on this account reflect the decision indicators dynamic for influence of network selection.Through compares with the static multi-attribute network selection algorithm,the proposed algorithm reduces the number of network switching, reduces the ping-pong effect, improve the accuracy of network selection and effectively improve the QoS.

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