A Network Selection Algorithm Based On Reputation Model

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***Abstract*—In order to deal with the problem of access network selection in the next generation wireless networks, it is necessary to develop an adequate model for its selection. This paper presents the proposal of optimal network selection algorithm in wireless heterogeneous environment that is based on reputation model. It not only considers the users' preferences, but also the results of network admission. And the simulation results show that the algorithm proposed in this paper can effectively reduce the energy consumption, have lower packet loss rate and balance the load of candidate networks.**

Keywords—heterogeneous networks; network selection; reputation model; load balancing

I. INTRODUCTION

In recent years, wireless communication networks, such as Global System for Mobile Communications (GSM), Universal Mobile Telecommunications System (UMTS), Wireless Local Area Network (WLAN), Worldwide Interoperability for Microwave Access (WiMAX), and satellite network, can meet different users' requirements anywhere and anytime. These existing multi-access networks, in terms of coverage, access speed, capacity, mobility, etc. have their own characteristics and advantages. Therefore, the coexistence and integration of heterogeneous networks must be an important feature of the next generation wireless networks. A heterogeneous wireless environment integrated a variety of different access technologies, constituted a complex network environment, in order to satisfy the requirements of different users. So, how to design a network selection algorithm which can help users select a suitable network to meet their needs is a problem. Network selection algorithm must guarantee Quality of Service (QoS) of different services [1], and has become an important research aspect.

Paper [2] proposed a network selection algorithm which is only based on the Received Signal Strength (RSS) from different available networks. But it is not comprehensive because of ignoring the user's preferences and so on. Paper [3] designed a "WLAN priority" selection algorithm. Though it is easy to implement in function, its considerations is one-sided, and it is difficult to make the best choices in complex network environment. Network selection algorithm proposed in [4] is based on Grey Relational Analysis (GRA). This method mathematically solves the problem of network selection by applying Multi Attribute Making Decision (MADM). It considers network performances roundly, but does not consider the safety performance of network. A policy-based network selection algorithm proposed in [5], aims at considering the channel parameters, network environment, service types, terminal capabilities and many other factors, but actually, is difficult to achieve because the complexity of algorithm is too high. The network selection algorithms above are just from the perspective of users to select the "best" network, but do not consider whether the "best" networks accepts the user.

Based on the issues above, this paper will design a heterogeneous network selection algorithm based on reputation model [6] which can effectively reduce the energy consumption, have lower packet loss rate and balance the load of candidate networks. The rest of this paper is organized as follows. In section II, the beta reputation model and the forgetting factor are introduced. A network selection algorithm based on reputation model is proposed in section III. Section IV illustrates numerical comparison among the proposed algorithm and the existing ones. Conclusions are drawn in the last section.

II. THEORY OF REPUTATION MODEL

A. The Beta Reputation Model

Currently, Beta reputation model is mainly used in the peer (Peer-to-Peer, P2P) network [7]. The beta reputation model is based on using beta probability density function to combine feedback and derive reputation value. The advantage of the beta reputation model is flexibility and simplicity as well as its foundation on the theory of statistics.

The reputation model is applied to heterogeneous network selection in this paper. Users select the suitable network based on the reputation value which is figured out by the interactive results between different networks. Our reputation model is based on the beta probability density function which can be used to represent probability distributions of binary events. This provides a sound mathematical basis for combining feedback and for expressing reputation value. The mathematical analysis leading to the expression for posteriori probability estimates of binary events can be found in many text books on probability theory [8], and we will only present

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the results here. The Beta Reputation model used in this paper is based on two values, the interactive results include two kinds:"good" and "bad". Related definition is as follows [9]:

Definition 1: The interactive results is the description of the selection results after users select the target network, can be "good" or "bad", respectively using 1,0 to represent. Define o_{ij}^{n} as the result of user i select the network j at the nth time.

We use < $good_{ij}$, bad_{ij} > to refer to the numbers of positive and negative outcomes for n times network selection, respectively.

From Definition 1, we can get:

$$good_{ij} = \sum_{n<N} o_{ij}^{n} \tag{1}$$

$$bad_{ij} = \sum_{n<N} (1 - o_{ij}^{n}) \tag{2}$$

Definition 2: The reputation value of the candidate network j can be defined as P_j, which denotes the probability of admission, $P_j \in [0,1]$.

Posteriori probabilities of binary events can be represented as beta distributions. The beta-family of probability density functions is a continuous family of functions indexed by the two parameters α_{ij} and β_{ij} . The beta distribution $f(P_j \mid \alpha_{ij}, \beta_{ij})$ can be expressed using the gamma function $\Gamma(\cdot)$ as:

$$f(P_j \mid \alpha_{ij}, \beta_{ij}) = \frac{\Gamma(\alpha_{ij} + \beta_{ij})}{\Gamma(\alpha_{ij})\Gamma(\beta_{ij})} P_j^{\alpha_{ij}-1} (1 - P_j)^{\beta_{ij}-1} \tag{3}$$

Especially:

$$\Gamma(z) = \int_0^{+\infty} e^{-t}\, t^{z-1}\, dt \tag{4}$$

$$\alpha_{ij} = good_{ij} + 1 \tag{5}$$

$$\beta_{ij} = bad_{ij} + 1 \tag{6}$$

So the probability expectation value of the beta distribution is given by:

$$E(P_i) = \int_0^1 f(P_j \mid \alpha_{ij}, \beta_{ij})\, P_j dP_j = \frac{\alpha_{ij}}{\alpha_{ij} + \beta_{ij}} = \frac{good_{ij} + 1}{good_{ij} + bad_{ij} + 2} \tag{7}$$

When observing binary processes with two possible outcomes {positive, negative}, the beta function takes the integer number of past observations of positive outcome and negative outcome to estimate the probability of outcome, or in other words, to predict the expected relative frequency with which outcome will happen in the future.

B. Forgetting Factor

Old feedback may not always be relevant for the actual reputation value, because the target network may change its behavior over time. What is needed is a model in which old feedback is given less weight than more recent feedback. This translates into gradually forgetting old feedback. This can be achieved by introducing a forgetting factor which can be adjusted according to the expected rapidity of change in the observed entity. We will use a forgetting scheme first described by Jøsang [10].

In order to get the reputation value of the licensed channel accurately, we multiply the outcomes o_{ij}^{t} by a forgetting function $f(n)$. Supposing $f(n)$ as an exponential attenuation function:

$$f(n) = e^{-\lambda(N-n)} \tag{8}$$

λ is the forgetting factor. Introducing the forgetting function into (1) and (2),

$$good_{ij} = \sum_{n<N} o_{ij}^{n}\, e^{-\lambda(N-n)} \tag{9}$$

$$bad_{ij} = \sum_{n<N} (1 - o_{ij}^{n})\, e^{-\lambda(N-n)} \tag{10}$$

So we can get the reputation value of candidate networks considering the forgetting factor, with (7)，(9) and (10).

III. NETWORK SELECTION ALGORITHM BASED ON REPUTATION MODEL

After studying the existing network selection algorithms, we can find that traditional multi-attribute decision algorithms can't suit for the dynamically changing network conditions and can't meet user requirements. Though the improved multi-attribute decision algorithms are able to meet the changing needs of users dynamically, the complexity of the algorithm is too high, and will increase the energy consumption of terminals. Besides, these algorithms do not consider the feedback mechanism. So, reputation model can be introduced to the network selection algorithm. The core idea of this algorithm is: Each user acquires the reputation value of each candidate network, selects the network which has the largest reputation value as the target network. Besides, the algorithm need to record whether the target network admits the user and updates each network's reputation. The process of the proposed algorithm is shown in Fig 1.

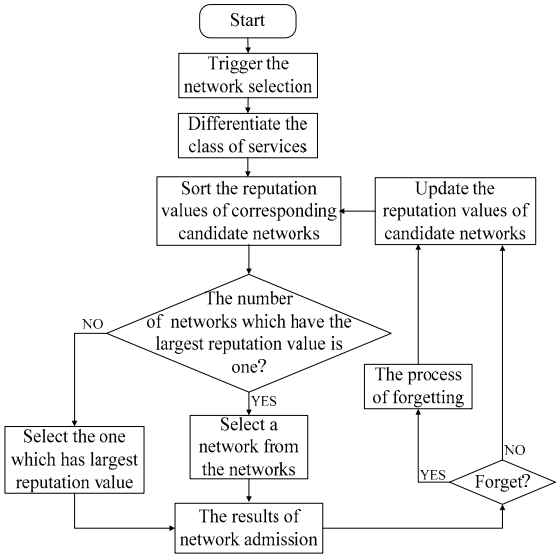

Fig. 1. The process of the proposed algorithm

The network selection algorithm can be triggered by the user and also can be triggered by the network side. When sorting reputation values of candidate networks, using (7). When the admission results of the networks need to be forgotten, using (8). And, realize updating the reputation values of the candidate networks by introducing (9) and (10) into (7).

IV. SIMULATION RESULTS

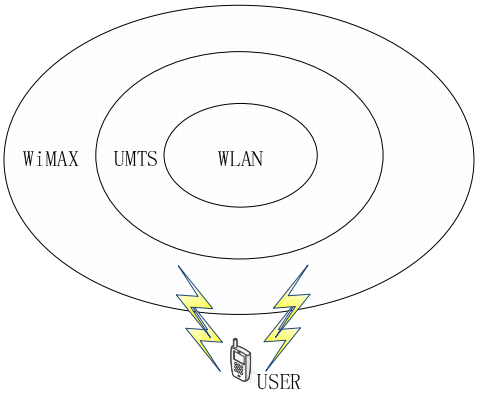

Fig. 2. The network selection simulation scenario

In this simulation, we consider a heterogeneous environment that entails three candidate networks, and each network with four parameters. The scenario consists of WiMAX, UMTS and WLAN in Fig 2. The four attributes associated in this heterogeneous environment are: packet loss rate (PLR), Packet Delay (D), Packet Jitter (J), Available Bandwidth (AB). During the simulation, the measures of every criterion for candidate networks randomly vary according to the ranges shown in table I. The users' services are divided into four categories: conversational service, streaming service, interactive service and background service. And the forgetting factor λ is set to 0.077.

TABLE I. PERFORMANCE OF CANDIDATE NETWORKS

Parameters / Candidate Network	PLR （%）	D （ms）	J （ms）	B （Mb）
WiMAX	0.09～0.11	30～36	20～23	10
UMTS	0.08～0.11	35～38	20～24	50
WLAN	0.07～0.08	100～105	50～54	90

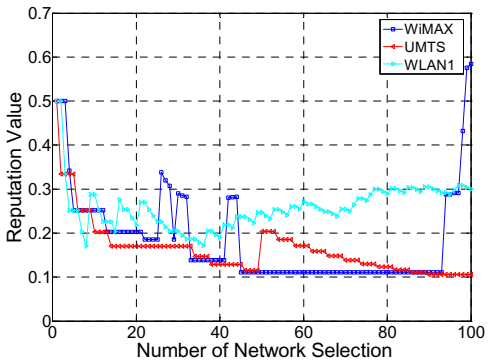

Fig. 3. Curve of reputation values

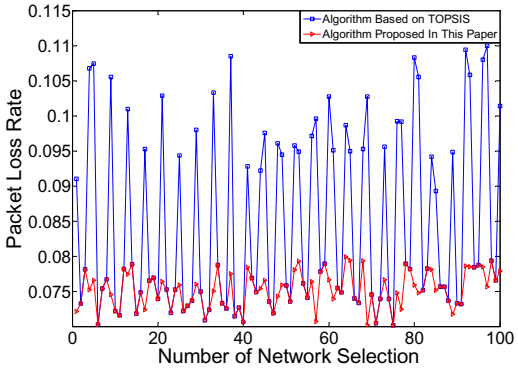

Fig. 4. Comparison of packet loss rate using different algorithms

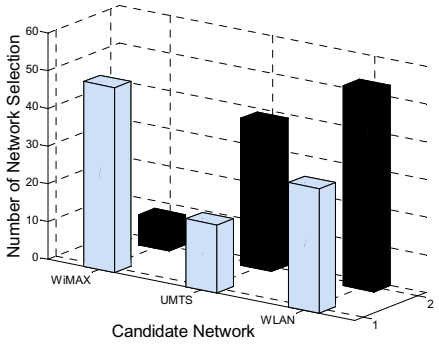

Fig. 5. The number of selecting different networks

Fig.3 shows the change of reputation values when the

users select the different networks. From the figure, when the reputation value of the selected network will be updated, the reputation values of other candidate networks remain unchanged. In addition, the results of the former 20 times network selection were not satisfactory. As the increasing times of network selection, the historical results which calculate the reputation values of candidate networks are more plenary, so that the most users are admitted by the selected networks during the latter 80 times network selection.

Fig 4 shows that the comparison of network packet loss rate which adopts two different algorithms (algorithm based on TOPSIS and algorithm based on reputation model). Network selection algorithm suggested in this paper can have lower network packet loss rate than the network selection algorithm based on TOPSIS. This algorithm takes the results of network admission into account, which leads the users to select the "best" (largest reputation value) network in their mind, thus the possibility of having the best network performance is also the largest.

Fig.5 records the number of selecting different networks. It is obvious that the network selection algorithm proposed in this paper can not only meet the needs of the users, but also balance the load of candidate networks effectively.

V. CONCLUSIONS

In this paper, we proposed a network selection algorithm based reputation for heterogeneous network. We consider service requirements, network conditions and the result of call admission control. The first two factors decide users' preferred networks and the last factor guarantees not only the preferred networks provide users satisfactory QoS but also the network permitting users' accesses. The simulation results revealed that the proposed algorithm outperformed the existing user-centric schemes in terms of packet loss rate and load balancing.

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