A Multi-objective Genetic Algorithm Based Handoff Decision Scheme with ABC Supported

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Abstract. A handoff decision scheme of heterogeneous wireless networks should be comprehensively considered with application quality of service (QoS) requirement, service fee, user preference, mobile terminal condition and access network condition, so as to make users and network providers achieve a win-win situation. With the knowledge of fuzzy mathematics and microeconomics introduced, the influence factors are characterized, and a multi-objective genetic algorithm based handoff decision scheme with always best connected (ABC) supported is proposed. Simulation results show that the proposed scheme is effective with excellent performance.

Keywords: handoff decision, heterogeneous wireless networks, genetic algorithm (GA), always best connected (ABC).

1 Introduction

The Fourth Generation (4G) heterogeneous wireless networks [1] are forthcoming with integrating various wireless access technologies. So wireless networks should enable users to be always best connected (ABC) [2], so as to achieve the global roaming of users in communication networks of different technologies [1].

ABC supports users to connect with the best access network at anytime anywhere according to the user demand. For this 'best' choice, handoff decisions should depend on plenty of factors, such as quality of service (QoS) [3], service fee, and user preference, etc. But QoS requirements are difficult to accurately quantify, and they have very strong fuzziness [4], so that an ability of processing fuzzy information is needed in handoff decision schemes. However, with the commercialization of network nowadays, ABC is not only an unilateral affair of users, but also needs to take user utility and network provider utility into account to realize the maximization of both utilities and avoid frequent handovers, which can lead to the ping-pong effect [5]. In this paper, there are N terminals in M access networks at the same time, and an optimal handoff solution of assigning N terminals to M access networks is found with a lot of factors to make user utility and network provider utility achieve or approach for Pareto optimum solution under Nash equilibrium. Since the number of terminals and access networks will be extraordinarily large in the future application, it is a

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multi-objective optimal decision problem with a great deal of computation to select the best one from the M^N handoff schemes, and requires heuristics or intelligent optimization algorithms.

Existing algorithms [6] considered service fee, received signal strength information (RSSI), and user preference, etc. Some algorithms made handoff decision based on total payoff [7], load balancing, and battery lifetime [8], etc. However, most of the works haven't fully considered ABC supporting handoff decision factors. In this paper, application type, application QoS requirement, access network and mobile terminal are characterized with the knowledge of fuzzy mathematics and microeconomics, and they are analyzed attentively. Although it is similar to some other studies [6] that this proposed scheme is regarded as a multiple attribute decision. We try to apply the game analysis to seek a Pareto optimum solution under Nash equilibrium of user utility and network provider utility, and use an elitist selection and individual migration of multi-objective genetic algorithm [9] to improve decision efficiency. So that handoff decision technologies could be widely used.

2 Model Description

2.1 Types of Applications and QoS Requirement

According to the differentiated services (DiffServ) model [10], assume that there are I different types of applications and $ATS = \{AT_1, AT_2, \cdots, AT_I\}$ expressing the set of application types. The QoS requirement of each application has four parameters, bandwidth, delay, delay jitter and error rate. And it is denoted by QS_i, where $QS_i =< [BW_i^l, BW_i^h], [DL_i^l, DL_i^h], [JT_i^l, JT_i^h], [ER_i^l, ER_i^h] >$ and $i = 1, 2, \cdots, I$.

2.2 Access Network Model

Assume that the order number of an access network is j, $1 \le j \le M$, where M denotes the number of access networks.

The access network provider is PI_j and the set of all access network providers is $PIS = \{PI_1, PI_2, \cdots, PI_{|PIS|}\}$. Similarly, the access network type and coding scheme are TI_j and CI_j, and the sets of all access network types and all coding schemes are $TIS = \{TI_1, TI_2, \cdots, TI_{|TIS|}\}$ and $CIS = \{CI_1, CI_2, \cdots, CI_{|CIS|}\}$. CA_j, MV_j, FR_j and TP_j are the coverage, supporting highest velocity, frequency range and lowest signal strength of access network, respectively. The set of application types supported by access network j is $NAS_j \subseteq ATS$. The total bandwidth and available bandwidth of access network are TB_j and AB_j respectively, and the minimum bandwidth threshold of AB_j is $AB_j^{\min}$. When $AB_j < AB_j^{\min}$, the performance of access network will decline sharply, so it should not accept any of terminal requests to avoid the ping-pong effect.

The set of service levels supported by access network j is SL_j, which can offer many QoS services to various types of applications. And various access networks provide all or part of service levels according to their capacities, so that $SL_j \subseteq SL$.

Assume that it is a k level service that the access network provides to AT_i type of applications, where $k \in SL_j$. The QoS of k level services is $QS_{ji}^k =<[bw_{ji}^{kl}, bw_{ji}^{kh}]$, $[dl_{ji}^{kl}, dl_{ji}^{kh}]$, $[jt_{ji}^{kl}, jt_{ji}^{kh}]$, $[er_{ji}^{kl}, er_{ji}^{kh}]>$. The service cost and service fee are ct_{ji}^k and pr_{ji}^k per unit bandwidth and unit time, respectively. For load balancing, pr_{ji}^k is determined by control coefficient and basic fee, which are set by access network providers based on the marketing strategy. Since there are N terminals transferring M access networks, terminals or access networks may cooperate in order to seek greater benefits. If there is any cooperation among terminals or access networks, pr_{ji}^k should be cut or risen.

2.3 Terminal Model

Assume that the order number of a terminal is t, $1 \le t \le N$, where N denotes the number of terminals.

The set of application types and the set of coding schemes supported by terminal t are TAS_t and MCS_t, where $TAS_t \subseteq ATS$ and $MCS_t \subseteq CIS$. WF_t and RS_t are the frequency range of terminal and the lowest signal strength received by terminal t respectively. CV_t is the velocity of terminal at current, and CV_h represents the threshold of high velocity. When $CV_t \ge CV_h$, the terminal is at high velocity condition. Similarly, RC_t and RC_{th} are remainder battery capacity and threshold of low battery capacity. The sequences of user preference in access networks and providers are $PC_t = \{PC_{t1}, PC_{t2}, \cdots, PC_{tq}\} \subseteq CIS$ and $PP_t = \{PP_{t1}, PP_{t2}, \cdots, PP_{tm}\} \subseteq PIS$, where PC_t and PP_t are sorted by preference degree from high to low. HP_{ti} is the service fee that the user is willing to pay for.

In summary, the handoff request of terminal t is $HR_t =< AT_i, PC_t, PP_t, HP_{ti} >$.

2.4 QoS Satisfaction

There are four coefficients, ϖ_i^B, ϖ_i^D, ϖ_i^J and ϖ_i^E, which represent the importance of bandwidth, delay, delay jitter and error rate respectively, and $\varpi_i^B + \varpi_i^D + \varpi_i^J + \varpi_i^E = 1$. The tolerance matrix method is utilized to determine the four coefficients. A judgment matrix $A = [a_{mn}]_{4\times4}$ is constructed by relative importance between ones of QoS parameters. The rows and columns of A correspond to bandwidth, delay, delay jitter and error rate respectively. The a_{mn} is the approximate value of the parameter weight of m divided by that of n, and $a_{mn} \in (0,9]$, $a_{mn} = 1/a_{nm}$, where $m,n = 1,2,3,4$. A tolerance matrix $B = [b_{mn}]_{4\times4}$ is calculated according to A, where $b_{mn} = \sqrt[4]{\prod_{k=1}^{4} a_{mk} \cdot a_{kn}}$. The QoS parameter weight ϖ_i^m is calculated as $\varpi_i^m = c_m / \sum_{k=1}^{4} c_k$ and $c_m = \sqrt[4]{\prod_{g=1}^{4} b_{mg}}$. The ϖ_i^m for AT_i type applications is calculated and assigned to ϖ_i^B, ϖ_i^D, ϖ_i^J and ϖ_i^E, which are held for online. The coefficients are calculated offline only if the importance of QoS parameters has changed. Assume that access network j provides a k level service to terminal t with the AT_i type application running, where k is determined for HR_t by the access network condition and evaluated based on the grey relational analysis method. BS_{ji}^k and DS_{ji}^k are the weighted fuzzy satisfactions for bandwidth and delay, as Equations (1) and (2). Similarly, the weighted fuzzy satisfactions for delay jitter and error rate, JS_{ji}^k and ES_{ji}^k, are calculated only by replacing the relevant parameters of Equation (2) with the corresponding ones.

$$BS_{ji}^k = \varpi_i^B \cdot \frac{\frac{1}{2}(bw_{ji}^{kl} + bw_{ji}^{kh}) - \min\limits_j \frac{1}{2}(bw_{ji}^{kl} + bw_{ji}^{kh})}{\max\limits_j \frac{1}{2}(bw_{ji}^{kl} + bw_{ji}^{kh}) - \min\limits_j \frac{1}{2}(bw_{ji}^{kl} + bw_{ji}^{kh})} \tag{1}$$

$$DS_{ji}^k = \varpi_i^D \cdot \frac{\max\limits_j \frac{1}{2}(dl_{ji}^{kl} + dl_{ji}^{kh}) - \frac{1}{2}(dl_{ji}^{kl} + dl_{ji}^{kh})}{\max\limits_j \frac{1}{2}(dl_{ji}^{kl} + dl_{ji}^{kh}) - \min\limits_j \frac{1}{2}(dl_{ji}^{kl} + dl_{ji}^{kh})} \tag{2}$$

Assume that the ideal service level of AT_i type applications is k^*, where the bandwidth satisfaction is $BS_i^{k^*} = \max\limits_j BS_{ji}^k$. Similarly, $DS_i^{k^*}$, $JS_i^{k^*}$ and $ES_i^{k^*}$ are obtained. In this paper, the grey relational degree from k level service to k^* level ideal service is regarded as the evaluation QP_{ji}^k of k level service, where $QP_{ji}^k = (GR_{ji}^{kB} + GR_{ji}^{kD} + GR_{ji}^{kJ} + GR_{ji}^{kE})/4$ and GR_{ji}^{kB} is calculated as Equation (3). Similarly, GR_{ji}^{kD}, GR_{ji}^{kJ} and GR_{ji}^{kE} are calculated only by replacing the relevant parameters.

$$GR_{ji}^{kB} = \frac{\min\limits_i \min\limits_j \left|BS_{ji}^k - BS_i^{k^*}\right| + \frac{1}{2}\min\limits_i \max\limits_j \left|BS_{ji}^k - BS_i^{k^*}\right|}{\left|BS_{ji}^k - BS_i^{k^*}\right| + \frac{1}{2}\min\limits_i \max\limits_j \left|BS_{ji}^k - BS_i^{k^*}\right|} \tag{3}$$

CB_{ji}^k and CD_{ji}^k are the suitability of bandwidth and delay to bandwidth request and delay request of AT_i type applications, as Equations (4) and (5), where β is a constant. Similarly, suitability CJ_{ji}^k and CE_{ji}^k of delay jitter and error rate are calculated only by replacing the relevant parameters of Equation (5). The suitability of QoS for k level service is denoted by CQ_{ji}^k, where $CQ_{ji}^k = \varpi_i^B \cdot CB_{ji}^k + \varpi_i^D \cdot CD_{ji}^k + \varpi_i^J \cdot CJ_{ji}^k + \varpi_i^E \cdot CE_{ji}^k$.

$$CB_{ji}^{k}=\left(\frac{\frac{bw_{ji}^{kl}+bw_{ji}^{kh}}{2}-BW_{i}^{l}}{BW_{i}^{h}-BW_{i}^{l}}\right)^{\beta} \tag{4}$$

$$CD_{ji}^{k}=\frac{1}{2}-\frac{1}{2}\sin\frac{\pi}{DL_{i}^{h}-DL_{i}^{l}}\left(\frac{dl_{ji}^{kh}+dl_{ji}^{kl}}{2}-\frac{DL_{i}^{h}+DL_{i}^{l}}{2}\right) \tag{5}$$

In summary, the QoS satisfaction is calculated as $SQ_{ji}^{k}=QP_{ji}^{k}\cdot CQ_{ji}^{k}$.

2.5 Other Satisfactions or Suitability

This paper describes the other satisfactions or suitability as follows:

$SP_{t_i j}$ is the satisfaction of user for price pr_{ji}^{k}.And if $pr_{ji}^{k}\le HP_{ti}$, $SP_{t_i j}=1$; otherwise, $SP_{t_i j}=0$. SC_{tj} is the satisfaction of user for coding scheme CI_{tj}. If $CI_{tj}\in PC_{t}$, $SC_{tj}=1/x^{2}$; otherwise, $SC_{tj}=0$. Where x is the order number of CI_{tj} in PC_{t}. SR_{tj} is the satisfaction of user for access network provider PI_{tj}. If $PI_{tj}\in PP_{t}$, $SR_{tj}=1/y^{2}$; otherwise, $SR_{tj}=0$. Where y is the order number of PI_{tj} in PP_{t}. SV_{tj} is the velocity suitability. If the velocity of a terminal is high at current, an access network with larger coverage should be considered to transfer for decreasing the number of handovers. It can help to avoid the ping-pong effect. So that if $CV_{t}<CV_{h}$, $SV_{tj}=1$; if $CV_{h}\le CV_{t}\le MV_{j}$, $SV_{tj}=1/z^{2}$; otherwise, $SV_{tj}=0$. Where z is the order number of access network type TI_{j} in TIS sorted by the coverage from high to low. SY_{tj} is the battery capacity suitability. If the battery capacity of a terminal is low at current, an access network with smaller coverage should be considered to transfer for decreasing the power of receiving and sending, and it can help to extend terminal working time. So that if $RC_{t}\le RC_{th}$, $SY_{tj}=1/(|TIS|-z)^{2}$; otherwise, $SY_{tj}=1$.

2.6 Game Analysis and Utility Calculations

In this paper, the players are a terminal and an access network. Hence the payoff matrices of terminal and access network are denoted by TG and NG, as Equations (6) and (7). Where the rows or columns of matrix express that terminal t or access network j is willingness and unwillingness to accept in turn. The minus sign shows the lost payoff, and the penalty factor is $v>1$. If a pair of policies $\{a_{i^*},b_{j^*}\}$ satisfies $TG_{i^*j^*}\ge TG_{i^*j}\wedge NG_{i^*j^*}\ge NG_{ij^*}$, the terminal payoff and access network payoff achieve Nash equilibrium, where $i^*,j^*,i,j=1,2$.

$$TG = \begin{bmatrix} HP_{ti} - pr_{ji}^k & HP_{ti} - pr_{ji}^k \\ -\nu \cdot (HP_{ti} - pr_{ji}^k) & -(HP_{ti} - pr_{ji}^k) \end{bmatrix} \tag{6}$$

$$NG = \begin{bmatrix} pr_{ji}^k - ct_{ji}^k & -\nu \cdot (pr_{ji}^k - ct_{ji}^k) \\ pr_{ji}^k - ct_{ji}^k & -(pr_{ji}^k - ct_{ji}^k) \end{bmatrix} \tag{7}$$

A coefficient matrix $\Lambda = [\lambda_1 \ \lambda_2 \cdots \lambda_6]$ is introduced in this paper, $\sum_{i=1}^{6} \lambda_i = 1$. The elements of Λ express the relative importance of factors, such as application QoS requirement, service fee, access network coding scheme, access network provider, terminal velocity and terminal battery capacity. The value of λ_i is also determined by the tolerance matrix method, similarly with Section 2.4.

An evaluation matrix $G_{t_i j} = [SQ_{ji}^k \ SP_{t_i j} \ SC_{t_i j} \ SR_{t_i j} \ SV_{t_i j} \ SY_{t_i j}]^T$ and a control coefficient Ω are introduced. If both sides achieve Nash equilibrium, $\Omega = 1$; otherwise, $\Omega = 0$. The user utility and network provider utility are $uu_{t_i j}$ and $nu_{t_i j}$. If terminal t transfers access network j , $uu_{t_i j} = \Omega \cdot \Lambda \cdot G_{t_i j} \cdot ((HP_{ti} - pr_{ji}^k) / HP_{ti})$ and $nu_{t_i j} = \Omega \cdot \Lambda \cdot G_{t_i j} \cdot ((pr_{ji}^k - ct_{ji}^k) / pr_{ji}^k)$; otherwise, $uu_{t_i j} = 0$ and $nu_{t_i j} = 0$.

2.7 Mathematical Model

The mathematical description of optimal handoff solution is shown as follows.

$$\text{maximize}\{\sum_{t=1}^{N}\sum_{j=1}^{M} uu_{t_i j}\} \tag{8}$$

$$\text{maximize}\{\sum_{t=1}^{N}\sum_{j=1}^{M} nu_{t_i j}\} \tag{9}$$

$$\text{maximize}\{\sum_{t=1}^{N}\sum_{j=1}^{M} (uu_{t_i j} + nu_{t_i j})\} \tag{10}$$

3 Algorithm Design

In this paper, the elitist selection and individual migration of multi-objective genetic algorithm is applied, because it converges more rapidly with keeping diversity.

3.1 Definitions and Operation Rules

S is the size of each population, and each individual $in_q =< ch_{q_1}, ch_{q_2}, \cdots, ch_{q_N} >$ is a solution of handoff decision problem. Chromosome $ch_{q_t} =< AN_{q_t}, k_{q_t} >$ expresses access network AN_{q_t} provides a k_{q_t} level service to terminal t in the q^{th} solution, where $1 \le q \le S$, $1 \le t \le N$, $1 \le AN_{q_t} \le M$, $k_{q_t} \in SL$.

The population initialization is a process of assigning an initial value to each individual of populations, where AN_{q_t} and k_{q_t} from each chromosome ch_{q_t} of each individual in_q are randomly assigned with the values of interval $[1, M]$ and interval $[1, |SL_{AN_{q_t}}|]$ respectively. If $\forall t\ ((TAS_t \subseteq NAS_{AN_{q_t}}) \wedge (MCS_t \cap CI_{AN_{q_t}} \neq \varnothing) \wedge (WF_t \subseteq FR_{AN_{q_t}}) \wedge (RS_t \leq TP_{AN_{q_t}}) \wedge (CV_t \leq MV_{AN_{q_t}}) \wedge (HP_{ti} \geq pr^k_{AN_{q_t}i}) \wedge ((AB_{AN_{q_t}} - bw^{kh}_{AN_{q_t}i}) \geq AB^{\min}_{AN_{q_t}}))$, handoff solution in_q is feasible. $FT_U(in_q)$, $FT_N(in_q)$ and $FT_{UN}(in_q)$ are fitness functions for Equations (8)-(10). If in_q is feasible, $FT_U(in_q) = \sum_{t=1}^{N}(1/uu_{t_i AN_{q_t}})$, $FT_N(in_q) = \sum_{t=1}^{N}(1/nu_{t_i AN_{q_t}})$, and $FT_{UN}(in_q) = \sum_{t=1}^{N}(1/uu_{t_i AN_{q_t}} + 1/nu_{t_i AN_{q_t}})$; otherwise, $FT_U(in_q) = FT_N(in_q) = FT_{UN}(in_q) = +\infty$.

In this paper, a linear crossover is utilized and a crossover probability is CP, where $0 < CP < 1$. Assume that two parent individuals are in_{q1} and in_{q2} taking part in the crossover, and ρ is a random pure decimal. If $\rho > CP$, copy the parent individuals as child individuals. Otherwise, execute the linear crossover operation and generate two child individuals in'_{q1} and in'_{q2}. The linear crossover operation of chromosome is that $AN'_{q1_t} = (\alpha_1 AN_{q1_t} + (1-\alpha_1) AN_{q2_t})$, $k'_{q1_t} = (\alpha_1 k_{q1_t} + (1-\alpha_1) k_{q2_t})$, $AN'_{q2_t} = (\alpha_2 AN_{q1_t} + (1-\alpha_2) AN_{q2_t})$, and $k'_{q2_t} = (\alpha_2 k_{q1_t} + (1-\alpha_2) k_{q2_t})$, where $0 \leq \alpha_1, \alpha_2 \leq 1$.

The same mutation probability occurs in every chromosome of individuals, and it is denoted by MP, where $0 < MP < 1$. Randomly select a chromosome ch_{q_t} from an individual in_q, and then randomly generate a pure decimal δ. If $\delta > MP$, not execute the mutation operation. Otherwise, assign random values which are in the domains to AN_{q_t} and k_{q_t} of chromosome ch_{q_t} respectively.

3.2 Algorithm Description

Step 1: Set the crossover probability is CP, the mutation probability is MP, the size of the tournament race is RS, the size of subpopulations is S, the upper limit of the individual copy number is RT, and the time of continuous iterations is IT.

Step 2: According to Section 3.1, generate the subpopulation P_U, P_N and P_{UN} for the three optimal objectives of Equations (8)-(10). The elitist populations of them are $ES_U = ES_N = ES_{UN} = \varnothing$, the minimum fitness of subpopulations are $FT^*_U = FT^*_N = FT^*_{UN} = +\infty$, and the global minimum fitness is $FT^* = \min\{FT^*_U, FT^*_N, FT^*_{UN}\} = +\infty$.

Step 3: Let $it = 1$.

Step 4: According to Section 2.6, make the terminal and access network from each chromosome of the individuals of P_U, P_N and P_{UN} play the game. And then determine the utilities of both sides according to whether to accept cooperation.

Step 5: Calculate the fitness of each individual of P_U, P_N and P_{UN}, and denote the minimum fitness of each population by $P_{U_{\min}}$, $P_{N_{\min}}$ and $P_{UN_{\min}}$. If $\min\{P_{U_{\min}}, P_{N_{\min}}, P_{UN_{\min}}\} < FT^*$, $FT^* = \min\{P_{U_{\min}}, P_{N_{\min}}, P_{UN_{\min}}\}$ and $it = 1$. If $P_{U_{\min}} < FT_U^*$, use all the corresponding individuals of $P_{U_{\min}}$ to displace ES_U and $FT_U^* = P_{U_{\min}}$; if $P_{U_{\min}} = FT_U^*$, unite ES_U with all the corresponding individuals of $P_{U_{\min}}$; execute the same operation to ES_N and ES_{UN}, and then $ES = ES_U \cup ES_N \cup ES_{UN}$.

Step 6: If $it > IT$, go to Step 10.

Step 7: Initialize the copy number of each individual with 0 in P_U, P_N, P_{UN} and ES. Randomly select RS individuals from P_U and ES with ensuring that all the copy numbers of the individuals selected are less than RT, select the individual with minimum fitness as a parent individual of P_U and the copy number of it is increased by 1. Execute the same operation to P_N and P_{UN}. Execute repeatedly the operation until parent population P_U, P_N and P_{UN} are generated.

Step 8: Execute the crossover and mutation to P_U, P_N and P_{UN} respectively, so as to generate the new generation subpopulation P_U, P_N and P_{UN}.

Step 9: Let $it = it + 1$, go to Step 4.

Step 10: If $FT^* \neq +\infty$, regard the individual of ES corresponding to FT^* as the handoff decision solution, successfully finish; otherwise, there is no solution, failed.

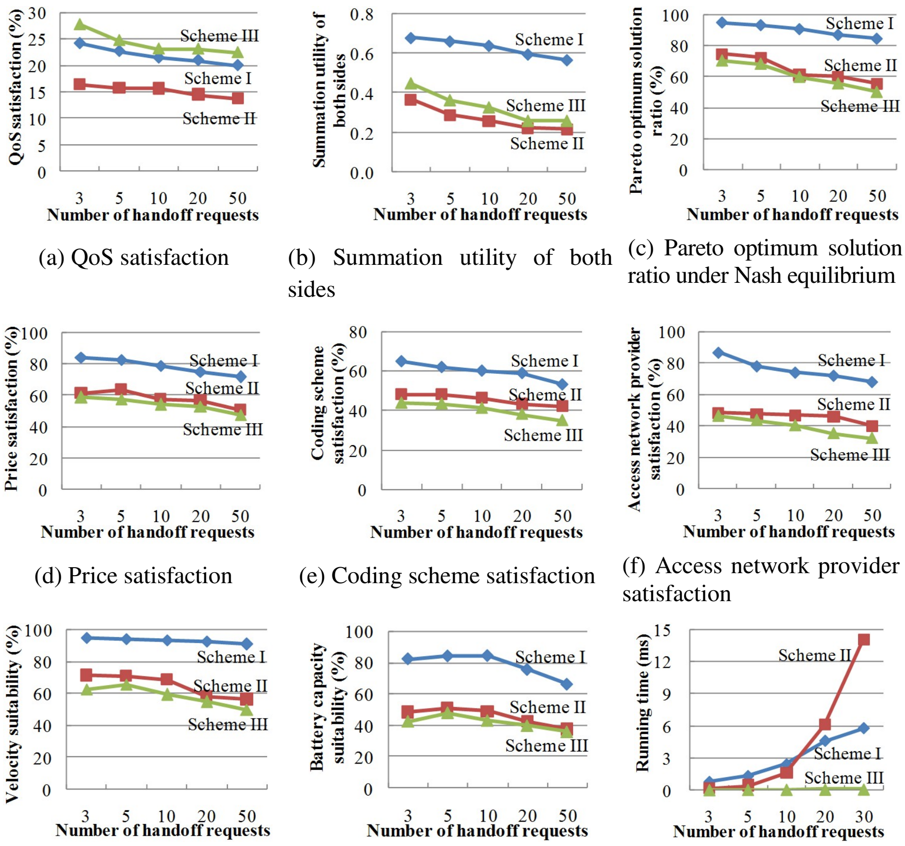
4 Simulation Results and Discussions

In the network simulator 2 (NS2), we simulate the scheme of this paper (Scheme Ⅰ), the greedy algorithm based handoff decision scheme [11] (Scheme Ⅱ) and the QoS based handoff decision scheme [12] (Scheme Ⅲ) in three hexagonal honeycomb topologies, which are covered by many different types of access networks. We use 3, 5, 10, 20 and 50 terminals to execute 500 times handoff decisions respectively, and set two user cases in each different number of terminals, according to Table 1.

Table 1. User cases

User cases	Coding scheme (%)			Network provider (%)			Velocity (%)			Battery capacity (%)		
	PC_1	PC_2	PC_3	PP_1	PP_2	PP_3	high	medium	low	high	medium	low
1	33	33	33	33	33	33	33	33	33	33	33	33
2	60	20	20	60	20	20	60	20	20	20	20	60

We make comparisons and regard the means as simulation results in Fig. 1. As shown in Fig. 1a, Scheme Ⅲ has the best performance in QoS satisfaction, but Scheme Ⅰ is still better than Scheme Ⅱ. Because Scheme Ⅰ gives consideration to plenty of factors and QoS is just one of them. Scheme Ⅲ only seeks the QoS satisfaction of user. Fig. 1b-1h shows Scheme Ⅰ has better performances than the others in these factors, such as user utility and network provider utility, Pareto optimum solution ratio, price satisfaction, coding scheme satisfaction, access network provider satisfaction, velocity suitability, and battery capacity suitability. As shown in Fig. 1i, Scheme Ⅰ takes a bit of time acceptable. And the larger the number of handoff requests is, the more rapid this genetic algorithm is than the greedy algorithm.



(a) QoS satisfaction (b) Summation utility of both sides (c) Pareto optimum solution ratio under Nash equilibrium

(d) Price satisfaction (e) Coding scheme satisfaction (f) Access network provider satisfaction

(g) Velocity suitability (h) Battery capacity suitability (i) Running time

Fig. 1. Performance analyses among Scheme Ⅰ, Ⅱ and Ⅲ

5 Conclusions

In this paper, the handoff decisive factors are synthetically considered, and a multi-objective genetic algorithm based handoff decision scheme with ABC supported is proposed. And the simulation results show that the proposed scheme has better performance compared with existing schemes in most of the quotas.

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