Free Compensation in The Market of Green Cloud Computing

Yujia Xiao, *Student of SEIEE,* Xiaohua Tian, *Advisor,*

Abstract—The objection of this project is to develop a practical and concrete methodology to give assessment of compensation needed for a green-energy friendly company to maintain the same utility and profit compared to the case when using traditional energy in the cloud computing. As cloud computing has take important proportion in the energy market, the encouragement in introducing green energy in it is of great perspective. The characteristics of cloud computing, market supply and demand, price of market is utilized to develop the amount of compensation. Not only the Bayesian Game but also Rothschild-Stiglitz model[1] is used as mathematical model to compare the utility of green energy driven and traditional energy driven schemes. The lower band of the compensation is calculated using the parameters given by optimum contract found by Rothschild-Stiglitz model. The upper band compensation and the compensation time duration is the interest of future work.

Index Terms—Compensation, green energy, cloud computing, Rothschild-Stiglitz model.

1 Introduction

THE formation of the idea of this paper is to provide a way of reducing the traditional energy consumption and green gas emission produced as the result of utilizing traditional, also named as brown energy, resources from the respect of cloud computing. The decrease of carbon dioxide in the using of cloud computing is of great value because the supporting facilities such as base station, data center and also the related things like cable or cooling system used to maintain a data center consumes many energy. These power load has contributed a lot to the emission of the green gas.

Many research has focused on the technical aspects of reducing power consumption. Professor Xiaorui Wang' team has proposed PowerNetS as a power optimization strategy to jointly consider server and data center network to reduce the workload, which contributes to the cut of energy by 44.3%.[2] They also introduced a method of using thermal energy to reduce the total energy consumption of data center.[3]Above two work is based more on the hardware consideration, and many other work has been focused more on the software consideration. Optimal algorithms for the geographical load balancing is introduced[4],which made the geographical load more balanced through exploiting the electricity price differences across regions.

However, it is not enough to achieve our goal if we only consider this problem from the section of how to increase the efficiency and improve the mechanism to reduce energy consumption. The advantage of using green energy to achieve the goal of carbon emission reduction is obvious, and detailed statistics are displayed in related tutorial papers.[5] Although research on how to cut the cost of using green energy by increase efficiency and solve load collision is of certain value, most important thing is to let the users favour the green energy based cloud computing.

The users may not choose the green energy based cloud computing is because the green energy has the characteristic of variable and transient which is know by mass of people and also be discussed by multimedia as a tradoff of the new sustainable energy. Finding a Method of how to increase the Quality of service should contribute more than increasing the efficiency as the main point is let more and more people to use green energy base cloud computing. Research about the spectrum sharing has been

a hot topic for many years, and some mature mechanism has also been proposed by main scholars. [6]

The unique and brilliant idea of this paper is that we put focus on the connection point of theory and real economic market. Even if we increased the capacity, efficiency and the Quality of service, it is still not attractive for users to choose green energy based cloud computing because users will automatically underestimate the value of green energy based cloud computing in that they will enlarge the failure possibility of sustainable energy according to their common sense. This mental activity can be revised to a more willing situation by giving users Free Compensation as to make up for the possible failure loss. The calculation of the compensation should be based on the characteristic of green cloud computing.

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2 THE MODEL DEVELOPMENT

In the model of Rothschild-Stiglitz[1], the concept of dividing the user to two classes is of great value for this is more close to the reality world than single user type assumption. We first develop three stage Bayesian Game to analyse the user behaviour in the monopoly market, as monopoly market is the first stage market of this problem. The monopoly market model is also of great research value, for the sustainable energy is precious resource and technology that they may first appear in the form of a utility in monopoly market.

2.1 Three Bayesian Game

2.1.1 the first step

we first assume that the whole story is happen in the monopoly market with two type of users: U_h and U_l.And there are totally N user in the market to take the game:

$$U = [U_1, U_2, U_3, ...U_N] \tag{1}$$

As they are in the monopoly market, we set there is only one provider P. We set the failure possibility λ_h for the high-risk type user, which means that this group of user has higher demand for the capacity of cloud computing and timeout should set shorter than ordinary users thus increasing the failure possibility. In the same way, we set failure possibility λ_l as the failure possibility for the low-risk users. Obviously, these two parameters should satisfy:

$$1 > \lambda_h > \lambda_l > 0 \tag{2}$$

2.1.2 the second step

after we set related resources in the first step, we set the total utility function for type k: $K \in (h, l)$

$$U_k = (1 - \lambda_k)r(Wn - B - \alpha) + \lambda_k r(Wa - B + \lambda_k) \tag{3}$$

$r()$ refers to the utility function, which reveals the relationship of capital and the utility of the users in the market.Wnrefers to the income when there is no failure experienced by the users, and inversely we denote Wa as the income when accident occurs. We used the contract theory in Rothschild-Stiglitz[1], which allow us an observation of the market behaviour. The contract theory allows the utility function will maintain approximately the same as the utility that there is no accidents occur. So the utility calculated by this model can be set as the lower band of the free compensation that we seek. In the Rothschild-Stiglitz model, B represents for the cost and α_k and $\beta_k$is the parameter of contract in:

$$C_k = (\alpha_k, \beta_k), k \in (h, l) \tag{4}$$

In which α_k is the additional pay as security contract fee, and β_k is the additional net income when accidents occur. We also developed the utility function for the provider:

$$R_k(C_K, \lambda_k) = (1 - \lambda_k)r \tag{5}$$

In these function, the $r()$ is selected according to the need of various situation and for precision consideration. In this paper, I chose the $1/x$ utility function.

2.1.3 the third step

The third stage is the setting up of the optimum condition.we set the optimum condition as follows:

$$U_k(C^*, \lambda^*) \geq U_k(C^*, \lambda_k), \forall \lambda_k, k \in (h, l) \quad (6)$$

$$R_k(C^*, \lambda^*) \geq R_k(C^*, \lambda_k), \forall C_k, k \in (h, l) \quad (7)$$

$$R_k(C^*, \lambda^*) \geq 0, \forall \lambda_k, k \in (h, l) \quad (8)$$

3 SIMULATION

The simulation is divided into two parts. The first part is using the RS model to observe the behaviour of the three Bayesian Game we set before. Second part is getting the free compensation point from the observation that has been done in the first part.

3.1 Behaviour in monopoly market

The contract solution is solved by the thinking of candidate separating equilibrium. We set $Wn = 60, Wa = 10, B = 9$, and simulation is conducted by matlab.

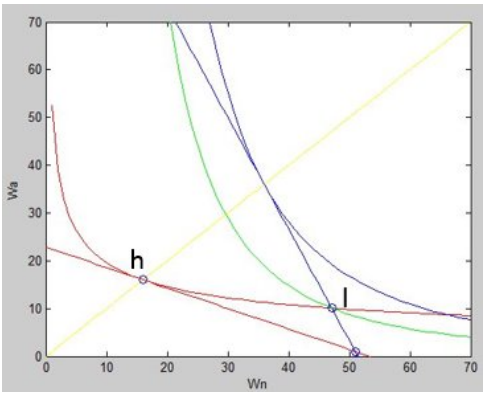

Fig. 1. RS model

The contract of the high-type users is calculated from the point h in the diagram. The red straight line is the fair-odds line of high-risk type users, which mean this line go through the point of $(Wn - B, Wa - B) = (51, 1)$and at the slop of $\lambda_h - 1/\lambda_h$.This line include all the possible points of the states the monopoly market have. The red curve is the utility function of high-type users, which is draw from the cross point of fair-odds line and 45 degree line. All point in this curve is of the same utility. we assume 45 degree is best situation because the income when there is or is not an accident is the same.

There are some differences in the case of low-risk contract calculation. We do not take the cross point of fair-odds line of low-risk type and 45 degree line, but take the cross point of utility function of high-risk type and the fair-odds line of low-risk type as the contrast point of low-risk type. The $\alpha_k$andβ_k can be calculated from:

$$h(x, y) = (Wn - B - \alpha_h, Wa - B + \beta_h) \quad (9)$$

$$l(x, y) = (Wn - B - \alpha_l, Wa - B + \beta_l) \quad (10)$$

3.2 Find the free compensation

The concept of free compensation is to let the costumer know the true value of the cloud computing, not underestimate them. Only when more and more people use the green energy based cloud computing, there the research about how to make it efficient and cheap can obtain practical value and change the energy using of the world. So the free compensation may not pure free concept, it can be fully-compensated or partly-compensated according to the calculation.

The lower band of that compensation is the point when the utility reaches or slightly above the point find by RS model for the high-risk and low-risk users. The utility is almost the same.The difference is that under the RS model it is not real for users will underestimate the value, where in free compensation case utility are calculated when users see the real value.We compare four different utility functions:

$$U_k = (1 - \lambda_k) r(Wn - B - \alpha) + \lambda_k r(Wa - B + \lambda_k) \quad (11)$$

$$U_k = (1 - \lambda_k) r(Wn - B) + \lambda_k r(Wa - B) \quad (12)$$

$$U_k = (1 - \lambda_k) r(Wn) + \lambda_k r(Wa) \quad (13)$$

$$U_k = (1 - \lambda_k) r(Wn) + \lambda_k r(Wa - B) \quad (14)$$

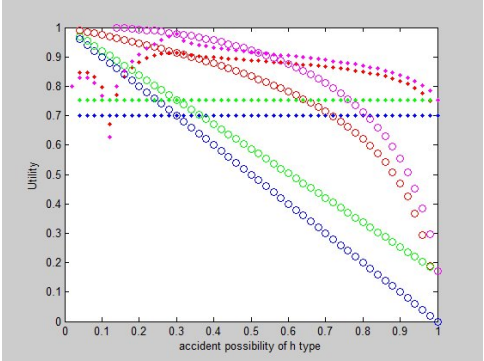

Fig. 2. Utility,h-type possibility

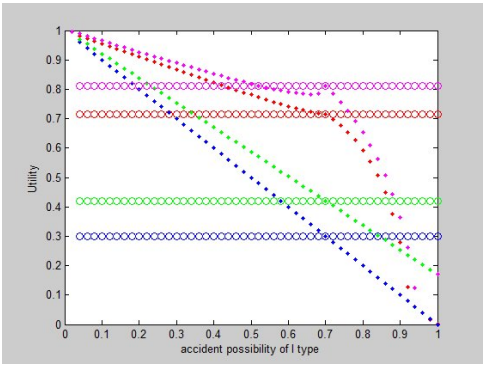

Fig. 3. Utility,l-type possibility

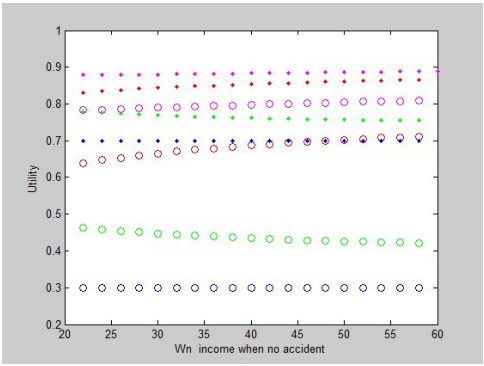

Fig. 4. Utility, Wn

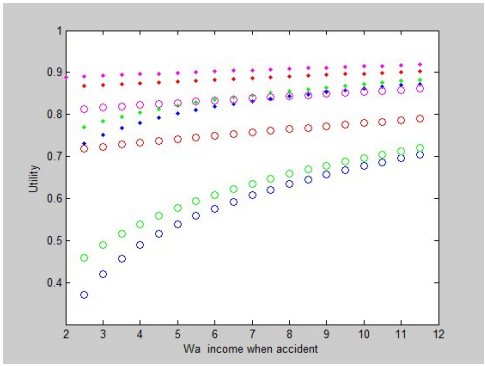

Fig. 5. Utility, Wa

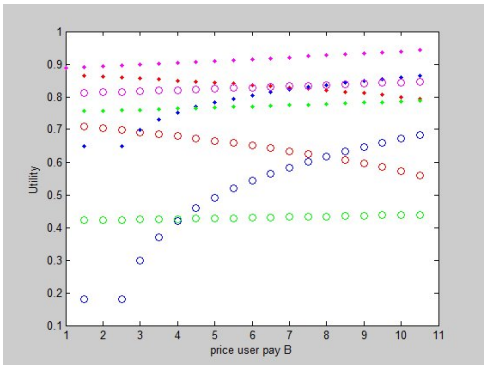

Fig. 6. Utility,B

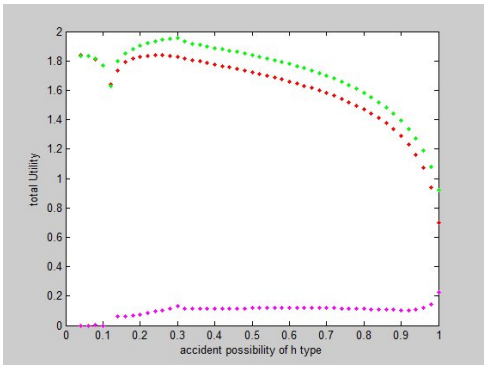

Fig. 7. Total Utility,h-type possibility

The red is for the utility 1 function, blue for 2, green for 3 and purple for 4. The real dot is for low-type users and circle one is for the high-type ones.

We can see the most similar function to the function 1, which is calculated by RS model is function 4. Then we decided to see more clearly about the relation of these two funtions and done the following simulation:

For the Figure7 11, the red is the relation of RS model total utility, which is the sum of high-type and low-type users, and parameters labelled below the figure. The green line is that of the function 4 and purple one is the difference of the two. We can see the green line is slightly above the red line and it can serve as the lower band of the free compensation.

To see this problem from more widened situation, we set both failure possibility of high-type and low-type as free parameter to be decided, and drawed the three dimensional figure, as showed in Figure 12 and Figure 13.

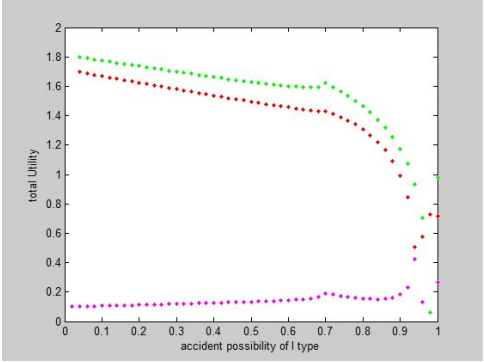

Fig. 8. Total Utility,I-type possibility

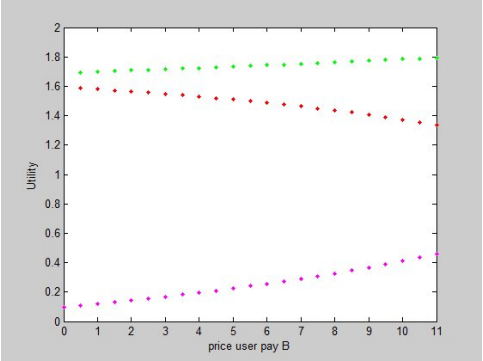

Fig. 11. Total Utility,B

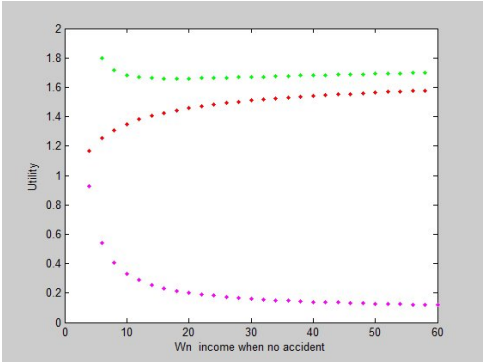

Fig. 9. Total Utility, Wn

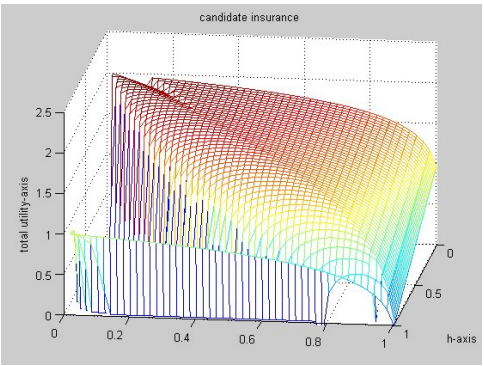

Fig. 12. Total Utility,B

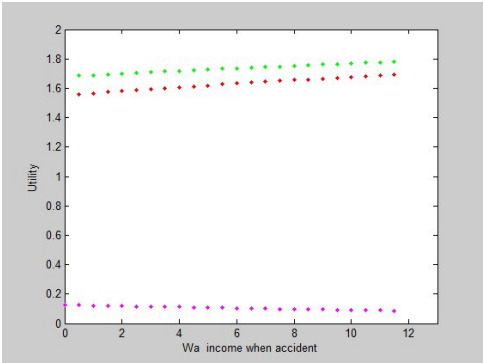

Fig. 10. Total Utility, Wa

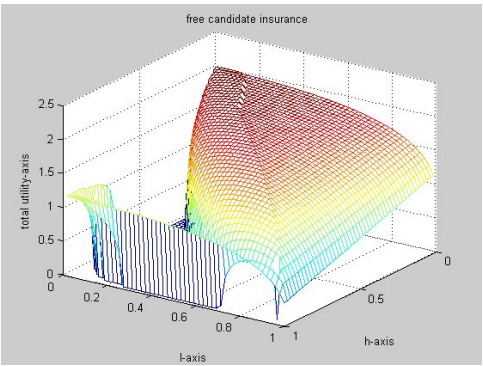

Fig. 13. Total Utility,B

now we can come to an conclusion that the free compensation $A = B + \beta_k$is the lower band of free compensation.

4 Conclusion and Future Work

The main contribution of this paper is from the observation of Rothschild-Stiglitz model to find the free compensation point of each high-risk and low-risk users. This free compensation will attract more people to use the green energy based cloud computing by making the value of it known to the public and not be underestimated by the public. The objection of this paper is to connect the research of increasing efficiency and improving price advantage into practical use in that these researches' value will be seen only when users want to and actually use the green energy based cloud computing.

The way of eliminating the bias and worries of green energy, sometimes called as sustainable energy, is introduced by means of econ-

omy in that economy considers deeply about the customer behaviour and psychology and its function on economic atmosphere. Thus, by introducing free compensation, the effect of reducing the green gas emission is achieved by firstly focusing on the green energy based cloud computing, a very energy-consuming area in the human society.

This work is not completed yet, because this paper put too much attention on the RS model, which is not so flexible to change the parameter and analyse the detailed situation in green cloud computing. I would like to find a new way uniquely suitable for free compensation and also find the upper or optimum band of free compensation, in addition to deepen and redefine the lower band of it.

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