Modeling and Simulation of the System Dynamics of Cloud Computing Federation Knowledge Sharing

Liang Hong [1, 2]

[1] School of Management, Harbin University of Science and Technology, Harbin 150040, Heilongjiang, China
[2] School of Management, Heilongjiang University of Science and Technology, Harbin 150022, Heilongjiang, China

Changyuan Gao

School of Management, Harbin University of Science and Technology, Harbin 150040, Heilongjiang, China

Abstract
Knowledge sharing is the core areas created by cloud computing alliance. It is the key of obtaining competitive advantage and the inexhaustible source of value creation. Study on the causation and evolution of behave of cloud computing alliance knowledge sharing process is the key to improving the efficiency of knowledge sharing. According to the characteristics of cloud computing federation, we construct the corresponding system dynamics model by using the system dynamics theory. Using the Vensim PLE software, the simulation system and the main parameters of sensitivity analysis is implemented to prove the cloud computing alliance knowledge sharing model is better fitting with the reality process. It can reflect the alliance knowledge sharing in the evolutionary process, which has certain guiding role for lifting cloud computing federation knowledge sharing efficiency.
Key words: CLOUD COMPUTING FEDERATION, KNOWLEDGE SHARING, SYSTEM DYNAMICS, SIMULATION

1. Introduction

At present, cloud computing technology has been rapid development in the world, cloud computing has been developed to the stage of implementation. It provides a new growth point for relevant industries. And it also has brought the new opportunity and challenge for the development of all kinds of organizations. In order to better share the bonus of cloud computing development, gave birth to a new form of organization-cloud computing alliance. Cloud computing alliance is market demand-oriented, value chain based collaboration federation, specifically refers to the value chain involved enterprises, research institutes, industry associations and among users. To achieve maximize value overall value chain and improve continuously overall competitiveness and members of its own strength and level, a loose network is composed by contract, which is risk-sharing organization, complementarily and sharing benefits[1]. In cloud computing alliance, knowledge sharing reflects the strong role and advantages. It is the key of obtaining competitive advantage and the inexhaustible source of value creation. Therefore, the research on cloud computing alliance knowledge sharing in the process of evolution of causality and behavior Evolution characteristics, great theoretical and practical significance.

Recently, the main body of the researches on the knowledge sharing is usually the individual, work group and enterprise while less on federation for the study. The research findings are focused on building knowledge sharing model, the analysis of knowledge sharing factors within the cluster, and the discussion on the rational knowledge sharing and the appropriate protective measures of knowledge. Lacking of the research on cloud computing federation as the main body, which is emerging organization. Rarely research content is about the restricting factors of knowledge sharing among partners, causality, behavior evolution characteristics outcomes [2].

This paper combined with the inherent characteristics of cloud computing federation, using system dynamics methods to analyze the Knowledge Sharing of cloud computing federation causality and dynamic behavior characteristics. Building system dynamics model and simulating analysis that gives reference for the designing of improved cloud computing federation knowledge sharing behavior mechanism.

2. Analysis on the cloud computing federation knowledge sharing

System Dynamics is a discipline which studies the information feedback system. It establishes a causal relationship network between the various subsystems, based on the researches on the overall and the relationship between the overall. Quantitative research system development dynamic behavior, whose main means is computer simulation technology, provides the basis for strategic decision making [3]. When use the system dynamics analysis the problem, it must satisfy some basic features, including: dissipative characteristics of the internal structure, there are clear boundaries, there is a causal relationship between the factors and dynamics of regularity. Cloud computing federation knowledge sharing is main focus on the stream of knowledge flows among alliance members, with clear boundaries. It is a two-way communication that contains feedback, causality is clear, and the whole system has a growing knowledge dissipation characteristics. Therefore, system dynamics can be used to model and analyze cloud computing alliance knowledge sharing [4].

2.1 Analysis of main influencing factors of knowledge sharing

Cloud computing federation knowledge sharing contain a variety of factors, among these factors interrelated, interaction which formation of a very complex structure models. Reference to the existing results of federation knowledge transfer influencing factors and the inherent characteristics of the cloud federation, this paper build a cloud computing federation knowledge sharing model, based on the two dimensions of the overall impact factors of alliance' and 'members of the alliance individual factors'. For simplicity, as Fig1 shown, KS is knowledge sender, KR is knowledge receiver.

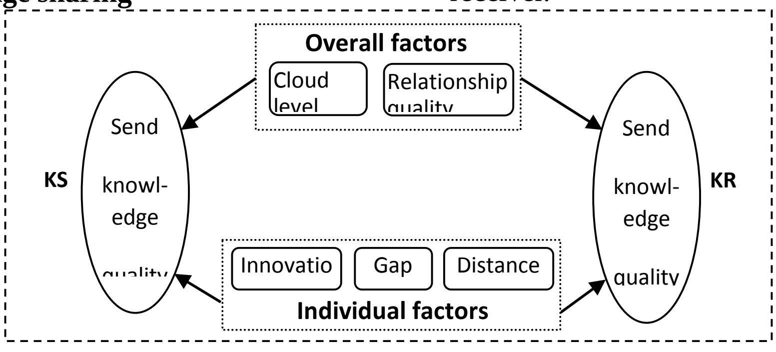

Figure 1. Knowledge sharing model of cloud computing federation

Overall factors of federation mainly consist: federation cloud computing level and alliance partner quality level. The constitution of cloud computing federation is cloud computing industry chain-related enterprises and related organizations. The cloud computing technology development and application is the core of it. Bases on this actual situation, federation cloud computing level is presented, including economic, technical level, quality level, agility and user-friendliness and other indicators, which can reflect cloud computing technology research development capabilities and application level league of overall alliance. It directly impact on the transfer efficiency of homogeneity knowledge and the absorption levels among coalition partners [5]. Alliance partner quality level is mainly refers to the trust level among the partners guaranteed by alliance mechanisms, distribution of benefits encourage effectiveness, and curb protectionism, and so on. It is directly impact on the total sent knowledge quantity and enthusiasm of sender [6]. The individual influence factors of alliance members mainly include three aspects: knowledge innovation ability, knowledge gap and organizational distance. Where, the knowledge innovation ability includes knowledge innovation ability of both sender and receiver, which is the main purpose of knowledge sharing. It is the main source of generated new value by alliance partners, but also the basis for the development of the alliance to stabilize. Knowledge gap is the power base of guarantee the knowledge transfer among alliance partner, the size of gap is directly affects the size of the knowledge sharing quantity [7]. Organizational distance contains organizational goals, organizational culture, product type and the other differences. It is directly impact on the knowledge quantity, which can truly be used by absorption party. Organizational distance is inversely proportional to the knowledge quantity absorbed [8].

2.2 Analysis of knowledge sharing main causal

According to the previous analysis about the impact factors of knowledge transfer, the knowledge transfer causal diagram and its loop are built in this part, as shown as Figure2.

The main loop:

KS knowledge stocks → sharing threshold → knowledge sharing quantity → KS innovation efficiency → KS innovation quantity → KS knowledge stocks

KR knowledge stocks →sharing threshold → KR innovation efficiency → KR innovation quantity → KR knowledge stocks

KR knowledge stocks →sharing threshold → knowledge sharing quantity → KR knowledge stocks

Knowledge gap → knowledge sharing quantity → KR knowledge stocks → knowledge gap

The first 3 loops of the above four loops are all positive feedback loops while the last one is a negative feedback loop. They reflect the causality of knowledge sharing from different angles. Sharing threshold reflects the protection to the core competitiveness of knowledge sender of cloud computing federation, which ensures the leading position in the industry itself. It is in line with the actual situation of market competition. Knowledge gap means the similarity of the knowledge stocks of sender and receiver. It is knowledge transfer between different body of knowledge, knowledge sharing and other acts of power. When the knowledge gap between the two is small, knowledge is no longer sent.

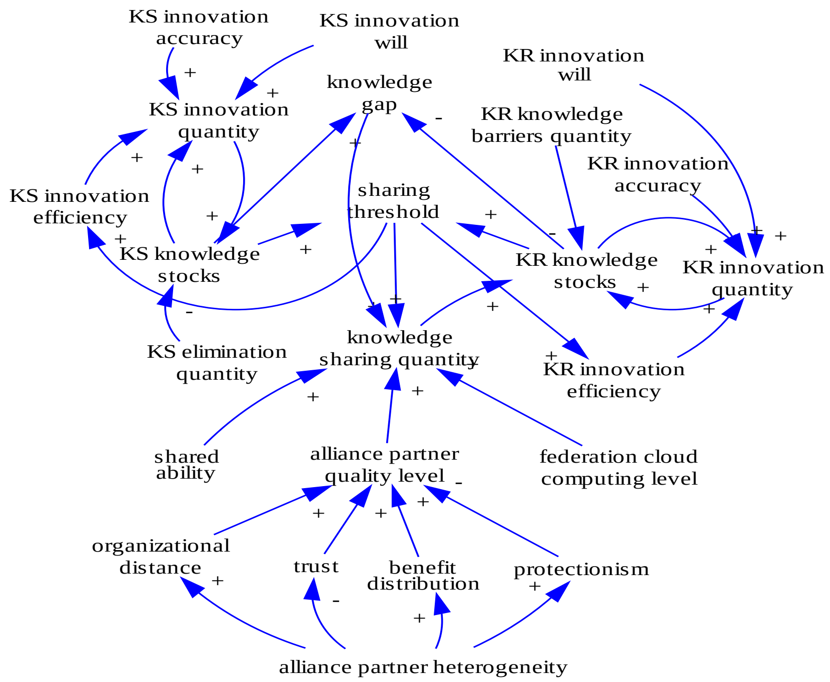

Figure 2. The causal loop diagrams of knowledge sharing in the cloud computing federation

3. Model of system dynamics for cloud computing federation knowledge sharing

3.1 Model boundary and assumption

The boundaries this model determined is a feature collection for cloud computing federation knowledge sharing behavior and the behavior impacting knowledge sharing. The basic assumptions of the model: 1) there is no knowledge spillover or inflows between cloud computing alliance and the outside. And the increased internal knowledge only comes from within federation knowledge sharing and individual innovation; 2) there exist knowledge gap within cloud computation federation, and the knowledge potential of knowledge sender is higher than the knowledge receiver's; 3) knowledge innovation efficiency of sender is higher than the receiver's; 4) in order to ensure the leading position, the sender's innovation will is greater than the receiver; 5) As knowledge receiver absorbed the leading knowledge, which is authenticated by the knowledge sender, and used it to digest and innovation, so the knowledge innovation accuracy is higher than the sender.

3.2 System Flow Diagram

Based on the consideration that the data can be calculated and reality, the causal diagram has been simplified and summarized. The system stream flow diagram of knowledge flow in the knowledge sharing is shown in Figure 3. In this system, including 2 state variables (L), 5 flow rate variables (R), 10 auxiliary variables (A), 6 constants (C), a total of 23 variables.

3.3 Design and description of the main equations

(1) INITIAL TIME = 0

(2) FINAL TIME =48

(3) L1: KS knowledge stocks = INTEG（KS innovation quantity - KS elimination quantity ， 90）

(4) L2: KR knowledge stocks = INTEG(knowledge sharing quantity + KR innovation quantity - KR knowledge barriers quantity, 20)

(5) R1: KS innovation quantity = KS knowledge stocks * KS innovation efficiency * KS innovation accuracy * KS innovation will

(6) R2: KS elimination quantity =STEP(KS innovation quantity *0.2+0.1,3)

With the continuous generation of new knowledge, it would have required to eliminate a certain amount of worthlessness knowledge. Because of needing time to discriminate the new knowledge and the worthlessness knowledge, so the process is simulated by the step function. Assume that there is 20 percent of worthlessness or failure knowledge exists in innovative knowledge; the initial value knowledge elimination is 0.1; knowledge sharing starts from the 3rd month.

(7) R3: KR innovation quantity = KR knowledge stocks * KR innovation efficiency * KR innovation will * KR innovation accuracy

(8) R4: KR knowledge barriers quantity = STEP(KR innovation quantity *0.3+ knowledge sharing quantity *0.15, 3)

As knowledge potential of knowledge absorption is below the knowledge sender's, the innovation failure rate is higher than the sender, so it is supposed as 30%; While, due to the organizational differences, trust, technology level and other issues, will result part of the knowledge sharing absorption and application failure, so such losses of 15%; The loss of knowledge, comes from the knowledge obstacles, begins from the 3rd months.

(9) R5: knowledge sharing quantity = DELAY1I(IF THEN ELSE(sharing threshold <0.8, knowledge gap * federation cloud computing level * alliance partner quality level * shared ability,0),3,0)

The total quantity of knowledge sharing is simulated by the first-order delay function. When the transfer threshold is reached 0.8, knowledge sender is no longer shared the knowledge with knowledge receiver. At this time, the amount of transfer knowledge is zero. Whether the transfer threshold is reached 0.8, knowledge sender need time to judge, let delayed three units.

(10) A1: knowledge gap = KS knowledge stocks -KR knowledge stocks

(11) A2: sharing threshold = KR knowledge stocks / KS knowledge stocks

(12) A3: KR innovation efficiency =0.2* sharing threshold

(13) A4: KS innovation efficiency =0.4* sharing threshold

(14) A5: federation cloud computing level =WITH LOOKUP (Time, ([(0,0)-(48,1)], (0,0.4), (48,0.8)))

The state of cloud computing development and application levels gradually increase of alliance is simulated by table functions. Increasingly cloud level can increase knowledge sharing efficiency, improve the ability of the alliance to absorb new knowledge. Assumptions time step is 48 in the simulation, the initial value and the final value of 0.4 and 0.8 respectively.

(15) A6: alliance partner quality level = organizational distance * trust * benefit distribution * protectionism

Alliance partner quality level reflects the scientific rationality of alliance selecting members of the partnership, but also includes trust mechanism, incentives and intellectual property protection mechanism. In the simulate time, let them be positive related to the knowledge sharing will of sender, and respectively in [0, 1] value.

(16) A7: organizational distance =0.3* alliance partner heterogeneity

(17) A8: trust =1- alliance partner heterogeneity

(18) A9: benefit distribution =0.4* alliance partner heterogeneity

(19) A10: protectionism =0.5* alliance partner heterogeneity

(20) C1: KS innovation accuracy =0.4

(21) C2: KS innovation will =0.25

(22) C3: KR innovation will =0.7

(23) C4: KR innovation accuracy =0.6

(24) C5: shared ability =0.4

(25) C6: alliance partner heterogeneity =0.5

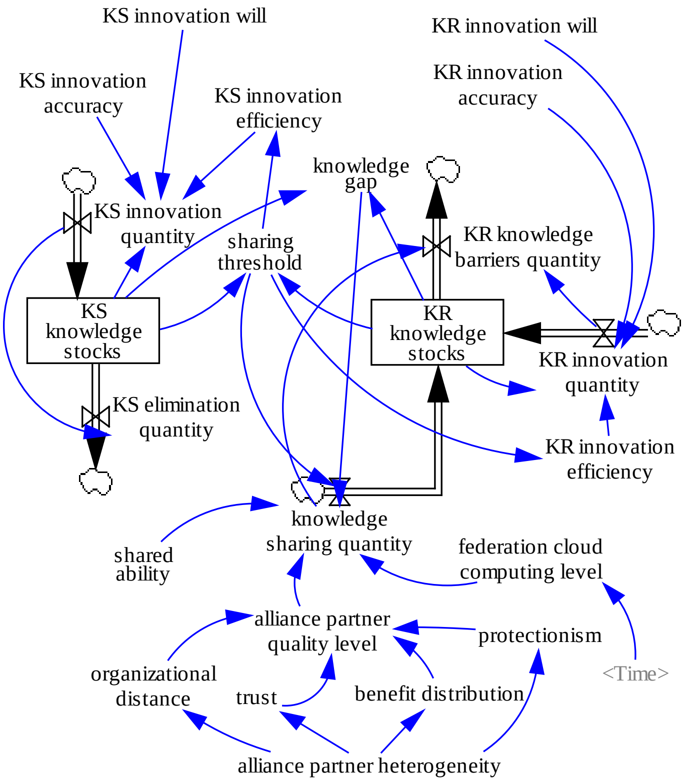

Figure 3. The SD diagram of knowledge sharing in the cloud computing federation

4. Model Simulation

The model is built and simulated under Vensim PLE software environment. The simulation time is 48 months. The initial value of the total knowledge, come from sender, is set to 90. The total knowledge of knowledge receiver is set 20 as initial value.

4.1 Validity Test

According to the setting of the initial value parameters, the simulation of knowledge transfer can be carried out. The results are shown in Figure 4. Simulation results from Figure 4 can be drawn: The total knowledge quantity of knowledge sender and receiver become a growing trend. The knowledge stocks of knowledge sender are higher before knowledge sharing. Meanwhile, the sender has strong knowledge innovation ability, willingness and efficiency, so that total knowledge spirals up. While, increased the total knowledge of the receiver is due to the absorption of the mount of knowledge sharing and itself knowledge innovation behavior.

Because of the total knowledge of knowledge sender is larger, knowledge quantity eliminated by sender is larger than that of receiver's. While, the eliminate time of the cloud computing technology is short, so that the mount of eliminate knowledge is larger than receiver's. Moreover, in the whole knowledge sharing process, most of the knowledge increased of receiver is the new knowledge, which absorbed in sharing or innovated itself. So, the oblivion and failure are lower than the level of knowledge of the sender. The knowledge gap is increase gradually. On the one hand is due to the knowledge sender has a strong innovative ability and efficient absorption of part of the shared knowledge during knowledge sharing, which can further promote the upgrading of its knowledge stocks. On the other hand, because of the weak ability of knowledge receiver, there need a digestion process after knowledge sharing be received. With the knowledge sharing quantity reached a critical point of sharing threshold, knowledge sender will stop to transfer the knowledge to the receiver. It affects the rapid increase of knowledge quantity. All the above reasons lead to the gap between two sides gradually increased.

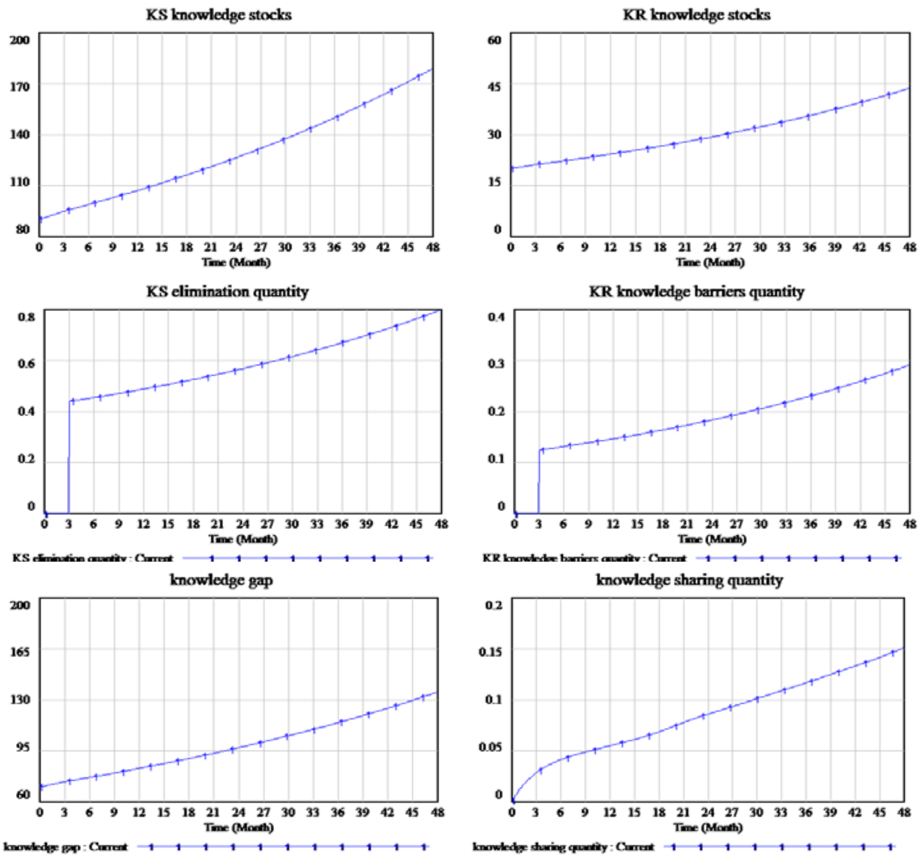

Figure 4. The results of model simulation

With the time accumulation, knowledge sharing quantity gradually increased. The front 3 grow faster, it because knowledge sender and receiver set 3 month delay. The knowledge sharing quantity is larger between both sides. Then, with federation cloud computing level and knowledge innovation quantity are increasing gradually, the knowledge sharing quantity within the alliance is increasing gradually.

4.2 Sensitivity analysis

Sensitivity analysis provides a theoretical basis and decision support for the actual work. The operation results of the model are compared with the original model, which draws the impact of the model by changing the relevant parameters or model structure. Sensitivity analysis includes the structure sensitivity analysis and parametric sensitivity analysis. This paper selects the main parameters of the model for sensitivity analysis [9-11].

In the case of maintaining the alliance partner quality level and alliance partner quality ability, let the threshold of federation cloud computing level reduced from an initial value of 0.8 to 0.65, the curve is shown as 'change 1' in Figure 5. Then, the threshold raised to 0.9, the curve is 'change 2' in Figure 5. As can be seen from Figure 5, change the federation cloud computing level result in the change of knowledge stocks and the knowledge sender innovation quantity. They are positive changes to cloud computing level, which shows that the model has a high sensitivity to the cloud computing level. Cloud computing federation should focus on the cloud computing applications ability promotion, in the system design and partner selection. It must pay attention to the economy, technology, quality level, agility, and user-friendly and other indicators that can ultimately promote the overall competitiveness of the alliance.

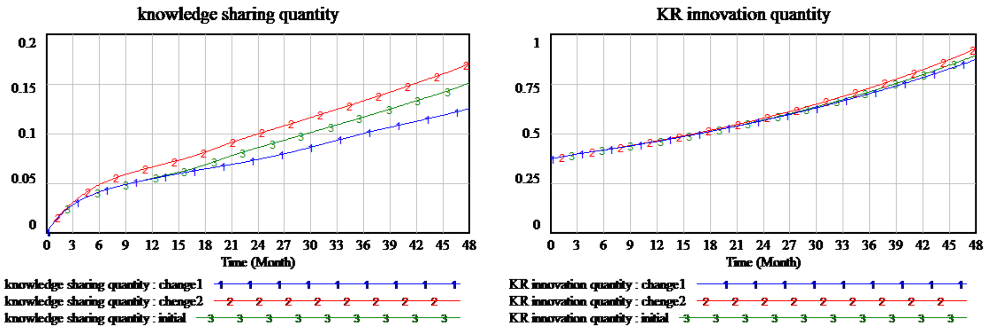

Figure 5. Sensitivity analysis of federation cloud computing level

Let the shared ability initial value of 0.4 be increased to 0.6, we can obtain the 'change 1' curve as shown in Figure 6. When this value is up to 0.8, the curve is 'change 2' in Figure 6. As can be seen from Figure 6, change the shared ability result in the change of sharing threshold and knowledge sharing quantity, they are both increase along with shared ability. It suggested that the model has a high sensitivity to the shared ability. Alliance should continue to enhance internal knowledge sharing capabilities, and institution-building in terms of the quality of personnel, incentives, platform construction etc.

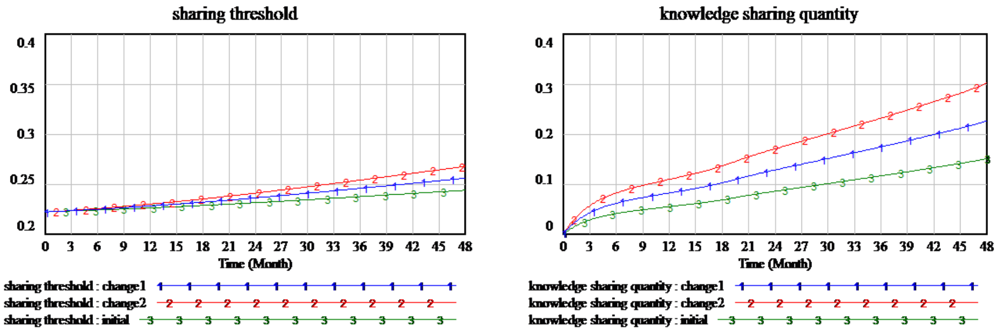

Figure 6. Sensitivity analysis of shared ability

5. Conclusion

This paper describes the knowledge sharing process among internal members of alliance, by using system dynamics theory. Construct the corresponding system dynamics model, by means of analysis the factors of factors of cloud computing alliance knowledge sharing. Using the Vensim PLE software, we realize the system simulation and the sensitivity analysis of the main parameters. From the simulation results, the cloud computing alliance knowledge sharing model is better fitting with the reality process. It can objectively reflect the characteristics of knowledge sharing within the alliance and emphasis on the characteristics of cloud computing. That can improve knowledge sharing efficiency and provide a theoretical reference for use of knowledge resources.

Acknowledgements

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