International Journal of u- and e- Service, Science and Technology
Vol.8, No. 10 (2015), pp.193-202
http://dx.doi.org/10.14257/ijunesst.2015.8.10.19

Game Analysis on Logistics Cloud Service Discovery and Combination

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Abstract

In order to analyze the premise condition of logistics cloud service discovery and composition and provide the basis for subsequent research, the logistics cloud service cooperation system framework was constructed from the perspective of modern logistics Virtual Enterprise Alliance. Base on this, extracts the preconditions of the logistics cloud service discovery and combination were extracted, then the game models were built and analyzed. Finally, reasonable countermeasures were proposed, which have a certain practical significance for carrying out the cloud logistics and developing the modern logistics.

Keywords: *Logistics cloud service, Service discovery, Service combination, Game analysis*

1. Introduction

Enterprises, especially in logistics industry, recognize the value of competitor existing, with the acceleration of the economic step and the rapid development of technology power. When undertaking the logistics tasks, many logistics enterprises often spend much cost only depending on their own logistics resources, and even they could not complete the tasks. In this case, they must resort to the resources of competitors and use effectively the differences among themselves, thus, create common development competition pattern by cooperation. The main form of organization of this cooperative competition is the strategic cooperative alliance [1]. However, there may be conflicts on profit maximization between the alliance and individual members, by the way, many questions, such as technology spillovers, resources sharing, interest sharing, risk sharing, supervision and management and *etc*., may influence the stability of the Alliance. Whether there is an agreement to complete the tasks by cooperation at the stage of operating is be worth to study. The paper will build logistics cloud service cooperation system framework and research the key prerequisite for cloud logistics with game theory.

In recent years, there have been extensive and deep studies on cloud logistics and game analysis method in the academic circle. For the cloud logistics, Bernhard Holtkamp, Sebastian Steinbuss and other persons made exploratory research on the logistics cloud, they thought the logistics cloud as a “vertical cloud”, and then built the demand of the logistics cloud service based on the NIST cloud services model, finally, they made research on the cloud platform trading, logistics IT services and logistics processes by putting the model into a shopping center [2]. Reference 3 put forward the concept of the cloud logistics based on the concepts and characters of logistics information, public logistics information platform and intelligent logistics, preliminary studied the architecture of the cloud logistics, analyzed the public cloud logistics application mode by combining with a variety of logistics services demand, and conducted research on its key technologies [3]. Ming ZHAO designed a multi-layered system architecture, and described the detailed characteristics of each layer, in order to integrate enterprise information resources in the logistics service chain

ISSN: 2005-4246 IJUNESST

based on the cloud model [4]. However, a cloud logistics service platform-oriented dynamic virtual enterprise collaboration system model is the premise and key in order to achieve the above applications.

For the game analysis methods, Junyang Li, Xiaomin Zhu and Runtong Zhang deal with the competitive relationship among different warehouses & ports in the same company by used Game Theory in carrying out the optimization model and Genetic Algorithm to solve the model [5]. ZHAO Qiang and XIAO Ren-binestablished the information sharing game model in virtual enterprises, analyzed the reasons for low-level information sharing, put forward the specific resolving measures, and demonstrated the design methods for punishing mechanism in the corresponding measures [6]; Ye Fei and other persons indicated in their paper that he quality of MIS directly affects the efficiency of virtual enterprises, established the game model to supervise the partner's investment of MIS for the core business and rewarded the partner building appropriate MIS by incentive function [7]. To consider the information sharing between two oligopolies from the view of allowing initial information, References 7 concluded that information sharing can improve all corporate profits and consumer's social welfare, however, there are "prisoner's dilemma" phenomenon in the process of the information sharing, each of the enterprises try to increase their own profits by reducing the level of information sharing, which leads to the situation that each enterprise and consumer' social welfare are all reduced[8]. This paper will build a logistics cloud service cooperation system framework based on the previous studies, and research the key prerequisites for cloud logistics by combining with game theory.

2. Theories and Concepts

2.1. Cloud Logistics Model

In the large-scale needs of resource and its load, traditional logistics service are challenged with the development of the cloud computing technology and the continuous improvement speed of the data transmission and accumulation [9], which makes the service form and content of the logistics service become more complex and important, and changes the structure and methods of the traditional logistics service. New theories and methods are required, because the traditional logistics cannot satisfy those new requirements. In this case, a new logistics model, cloud logistics, is born, which is based on the cloud computing and facing the service. A centralized and efficient system is built-in cloud logistics with the use of cloud computing technology in the logistics field, which is a platform and carrier of modern logistics operation. Through the platform, logistics service suppliers and logistics enterprises can provide customers with safe and reliable service according to the demand of the market and customers, customers can also find their own satisfactory logistics services. Its operation mode is illustrated in Figure 1.

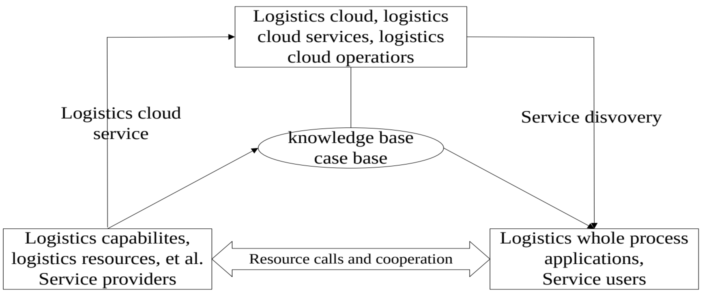

Figure 1. Cloud Logistics Operation Mode

As observed in the Figure 1, the user roles of the cloud logistics system mainly include logistics service provider, logistics cloud operator and logistics service user. The first role virtualizes the logistics capability and resources and puts into platform, which are stored as logistics cloud in the service form and managed by the second role. When a user issues the application of logistics service requests, the platform quickly and efficiently matches the cloud service and provides the third role [10].

2.2. Logistics Cloud Service

Logistics service is geared to the needs of logistics tasks and users. It is the process to provide the service to meet the requirements of users. It is the set of a series of logistics activities to meet customers' needs [11]. Logistics cloud service(cloud service) is the basic elements of logistics cloud, it is a kind of service logistics resources and capabilities, which can provide logistics whole process applications by network, It is a new logistics service mode, which can intelligent manage and deploy logistics resources according to customer' demand, can book and provide safe, efficient, high quality, low cost, flexible and personalized logistics services by integrating the customer resources and logistics resources(such as transport means, transportation routes, storage resources, information resources, software, knowledge, and so on) with the support of network technology. The formation of cloud service is a process of resource virtualization and service-oriented, which include three steps. Firstly, cognitive scattered resources in the Internet of things technology. Then, virtualization process resources and input them into logistics cloud platform in order to form virtual resources, which are gathered on an on-demand virtual resource pool. Finally, encapsulate, release and registered the virtual resources, thus become cloud services. Cloud services have many unique characters compared with the resource services of the traditional networked logistics mode, such as interoperability, self-organizing, self-adaptive, self-matching, self-combination and so on, which provide favorable conditions for building efficient, intelligent logistics cloud based on knowledge.

2.3. Logistics Cloud Service Cooperation System Framework

It is known that in a Virtual Organization scenario the difficult to select the most appropriate logistic providers is even higher [12]. "Virtual enterprise" was firstly present by Kenneth Preiss in the paper "21st Century Manufacturing Enterprises Strategy: An Industrial-Led View" [13]. It was referred to the innovation means to make the enterprise systematization. It is a typical application mode of agile manufacturing. According to the relationship between the members of the virtual enterprise, virtual enterprises were divided into two categories: static virtual enterprise and dynamic virtual enterprise. The relationship between static virtual enterprise members is relatively fixed over a period of time, while the relationship between dynamic virtual enterprise members is not stable. This uncertainty of the relationship determines the application of dynamic virtual enterprise is more complex and more practical. Some scholars hold the opinions that the dynamic virtual enterprise is a business alliance which is composed of some independent companies in order to adopt the changing market environment and grasp the market opportunity. The business alliance was built by information technology means based on the network and focusing on the product, service and knowledge. The business alliance can realize the resources and capabilities sharing and the cost and risk sharing. It was in a position to win the market through establishing a particular product or service in a very short period of time. In order to reflect the relationship among the logistics service provides, as well as the relationship between logistics service users and the demander for services, the paper proposed the logistics cloud service cooperation system framework, which is shown in figure 2.

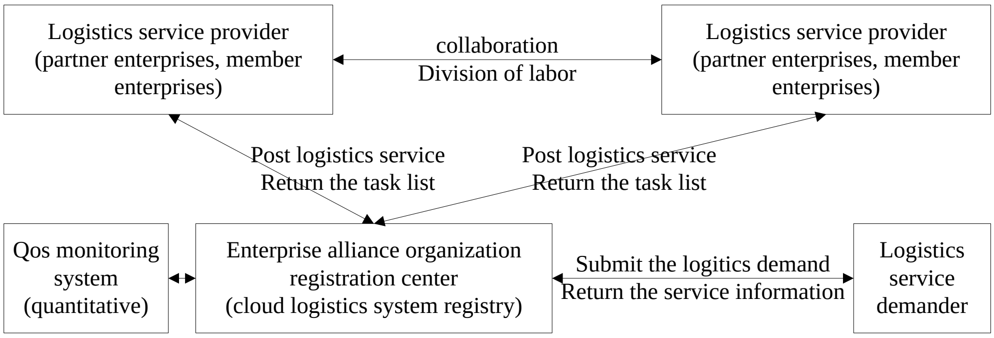

Figure 2. Logistics Cloud Service Cooperation System Framework

Its process includes the following 4 steps:

1. Logistics service demander submit logistics service request with Qos constraints to the enterprise alliance institutions (cloud logistics system);

2. Registry releases message and informs Qos monitoring system of quantifying demander’s Qos constraints and get back a set of Qos classification information;

3. System registry put the classification information as part of the query conditions for looking up cloud service:

Definition 1: When the logistics service request is simple and simplex, registry match the highest customer satisfaction cloud service in a wide range of logistics cloud services according to the classification information, which is single. This process is known as logistics cloud service discovery.

Definition 2: When the logistics request is complex, the registry will decompose the complex task into a series of subtasks and match the appropriate services for each subtask, then calculate the highest matching degree combination service by artificial intelligence algorithm. This process is called logistics cloud service combination.

4. Registry feedback the matching results to the demander in the form of service information and notice the matching results to the service provider in the form of task list.

The feasibility study is very necessary before a kind of new things running, and the feasibility study is mainly reflected in the determination of the premise. Through the analysis of the above, it is easy to find that logistics cloud service discovery only involves a single logistics service providers and logistics cloud service combination involves more. So, in order to meet the efficient service lookup mechanism, at least two prerequisites are necessary:

1. Many logistics service providers (partner enterprises, member enterprises) release logistics services in the registry to satisfy the requirements of logistics cloud service discovery;

2. Logistics service providers are willing to complete the complex logistics tasks by collaborating with others to satisfy the requirements of logistics service combination.

3. Game Analysis on Logistics Cloud Service Discovery

Logistics service providers may be deemed as the bounded rationality party in complex environment, they can learn game in the process of game and find a better strategy by trial, which means that the equilibrium is obtained by constantly adjusting and improving, rather than a one-time choice, and even the equilibrium obtained may be deviated again.

In the limited rational game, the real stability and strong forecasting ability equilibrium must be obtained by the adjustment process of imitation and learning of the game party, which can withstand the interference of error deviation and "recover" equilibrium after a small disturbance, so, the core of the game analysis is not a game's optimal strategy choice, but also the strategy adjustment process, trend and stability of the party members. The effective analysis framework of limited rational game is consisted of repeated game among a certain size specific members of the group. It is shown from above analysis that the development of cloud logistics is a complicated system engineering, the user of cloud logistics system are influenced by various environmental, the formation of cloud logistics scale is progressive, and the process of logistics service providers join "cloud plan" is a major strategic adjustment process.

Now suppose a certain area wants to develop "cloud logistics plan", which is a cloud logistics virtual enterprise alliance. Service providers register their own services in the cloud services platform and become the service cloud. There are 5 logistics companies in the region and game with each other. If join "cloud plan" and register and provide the corresponding services in cloud logistics platform, the enterprise will get profit $profit(Y,Y)$; if one party join but others not, some complex logistics task need at least two provider to complete, which make the profit decrease, so he will get profit $profit(Y,N)$,and $profit(Y,N) < profit(Y,Y)$; If all enterprises don't join it, they will get profit $profit(N,N)$,and $profit(Y,N) > profit(N,N)$.The game model's benefit matrix is shown in Figure 3.

	Participate(Y)	Not Participate(N)
Participate(Y)	$profit(Y,Y)$ $profit(Y,Y)$	$profit(Y,N)$ $profit(N,N)$
Not Participate(N)	$profit(N,N)$ $profit(Y,N)$	$profit(N,N)$ $profit(N,N)$

Figure 3. "Coordination Game" Model of Virtual Enterprises Participating "Cloud Plan"

It can be seen that the static game has a Nash equilibrium (Y,Y).Now the paper uses the optimal reaction dynamics simulation analysis, suppose that there is only one party joining the "cloud plan" in the first game and its decisions remain unchanged as Figure 4.

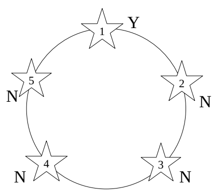

Figure 4. The First Game

For enterprise 2, if the enterprise choose "Y", the profit is $profit(Y,Y) + profit(Y,N)$ for enterprise 1 is "Y" and enterprise 3 is "N", if the enterprise choose "N", the profit is $profit(N,N) + profit(N,N)$, it is very obvious that $profit(Y,Y) + profit(Y,N) > 2\,profit(N,N)$, so the enterprise will change the choice to "Y ". Each of these participants repeat the game, when every enterprise game with others, the game process is shown in figure 5(the arrows represent the coordination game stage.).

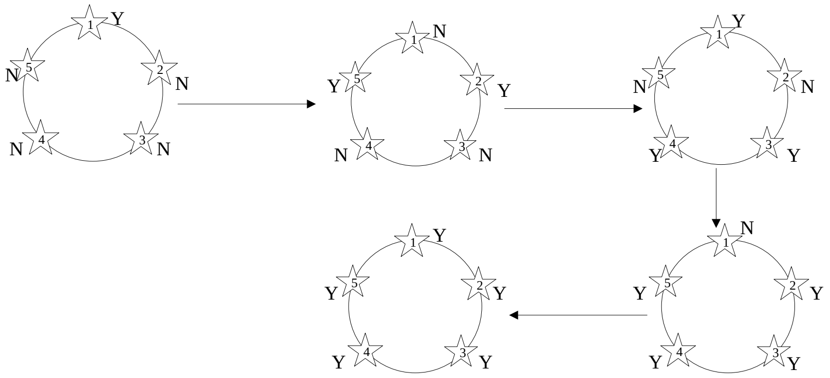

Figure 5. "Coordination Game" Process

It can be seen from the game process, a party chooses the strategy "Y" in the first time, and then two parties choose the strategy "Y", eventually all parties choose the strategy "Y", which indicates that all game parties' choosing of the strategy "Y" is steady state of implementation of the above coordinated game of the limited rational game parties.

Competition relationship enterprises can work together because both or all parties have common interests in some ways, so, the cooperative industry alliance can success if the balance among enterprise's benefits and competition is founded[14], while the maintaining of the balance need powerful propellent for promoting and contribution. The conclusion can be obtained that only at least one logistics enterprise's choosing "Y"will bring all parties' choosing the strategy "Y", which is just one of the prerequisites for development of cloud logistics. So, the most powerful propellents, as building logistics industry alliance, government's top priority is to support the leading enterprise of logistics industry and make it join "cloud plan"[15], then other logistics service providers will join the "cloud plan" little by little through the game, thus the demand of the logistics cloud service discovery is satisfied in cloud logistics system. In a word, government lead big enterprises, and big enterprises support small and medium enterprises, which can complete a full range of cloud logistics plan by the cooperations.

4. Game Analysis on Logistics Cloud Service Combination

Various logistics service providers are required to complete the task together when the task is very complex, which is a process of service composition, and is also a process of collaboration among the virtual enterprises. On the one hand, the cloud logistics service platform provide a new cross-platform and organization environment for virtual enterprise cooperation, enterprises do not only spend too much information infrastructure construction cost, but also support many-to-many on-demand service lease access pattern by this mode, enterprises can easily access service platform through the "cloud" at any time and any place, timely obtain the information of resources and ability of cooperative members, which can realize highly information sharing and transparent accessing. On the other hand, cloud logistics service platform has strong credibility because it has supervision mechanism for virtual enterprise cooperation members, putting punishment mechanism into the cloud logistics service platform can promote enterprise good faith cooperation and in the end achieve a "win-win" situation among cooperation members. The game model of logistics cloud service combination with a penalty factor is shown in Figure 6.

		Party j: Cooperate(C)	Party j: Not cooperate(N)
Party i	Cooperate(C)	$Profit(C,C)/n-Cost\_co$ $Profit(C,C)/n-Cost\_co$	$Profit(C,N)/n-Cost\_co\_IT$ $Profit(C,N)/n-a_jF\_punish$
	Not cooperate(N)	$Profit(N,C)/n-a_iF\_punish$ $Profit(N,C)/n-Cost\_co\_IT$	$Profit(N,N)/n-[(a_i+a_j)/2]F\_punish$ $Profit(N,N)/n-[(a_i+a_j)/2]F\_punish$

Figure 6. Game Model of Logistics Cloud Service Combination with Penalty Factor

$$Cost\_co = Cost\_busi + Fee\_service \tag{1}$$

Here: $Cost\_co$ is the cooperation cost when the enterprise adopts cooperative strategy; $Cost\_busi$ is the service cost to complete the task; $Fee\_service$ is the service fee paid by the cooperation members to the third party cloud logistics service platform; a_i and a_j respectively refer to member i and j 's penalty factor when they adopt non-cooperation strategy in a cooperation process; F_punish is punishment base that cloud logistics service platform determined before cooperation of the virtual enterprises and is a punishment stipulation for non-cooperation strategy at time of building cloud logistics virtual alliance. If all parties cooperate, they enjoy the profit share minus the cost, represented by formula $Profit(C,C)/n-Cost\_co$; if one party does not cooperate, he will be punished accordingly, his benefit is equal to $Profit(N,C)/n-a_iF\_punish$, at the same time, one of the partners will have to bear the cost of building the "cloud", his benefit is equal to $Profit(C,N)/n-Cost\_co\_IT$; if they do not cooperate, the punishment mechanism for all members, sharing the penalty cost, their benefit are equal to $Profit(N,N)/n-[(a_i+a_j)/2]F\_punish$.

$$a_i = \frac{n_i - m_i + \lambda}{m_i + \lambda} + \theta \tag{2}$$

Here: n_i is the total number of enterprises participating in combination in cloud logistics service platform database; m_i is the total number of enterprise credit for completing the combination task; θ is the punishment factor adjustment coefficient and its initial value is zero, the value of the parameter can be adjusted to restore enterprise credibility when the member compensates in time after it adopts non-cooperation strategy, so:

$$\theta \in \left\{ -\frac{n_i - m_i + \lambda}{m_i + \lambda}, 0 \right\} \tag{3}$$

At the same time, considering dishonest behavior may appear in the first cooperation, a fine-tuning coefficient is set and its value is approximate to zero.

Analysis process:

Situation 1: $Cost\_co \in \left(0, (profit(C,N) - profit(N,N))/n\right)$

Now (C,C) is the only Nash equilibrium solution, and the "win-win" situation is appeared among virtual enterprise cooperation. The cooperation members only pay very low fee $Fee\_service$ to the cloud logistics service platform for the registration fee and don't invest information construction cost in the environment of cloud logistics service platform, thus, the value of $Cost\_co$ is effectively reduced, which makes the cooperation enterprises take (C,C) as inevitable choice.

Situation 2:

$(profit(C,C)/n - Cost\_co) > (profit(C,N)/n - a_j F\_punish)$,

$(profit(C,C)/n - Cost\_co) > (profit(N,C)/n - a_i F\_punish)$ and

$(profit(C,N)/n - Cost\_co) > (profit(N,N)/n - (a_i + a_j)F\_punish/2)$

Now (C,C) is the only Nash equilibrium solution, and the Pareto optimality is appeared under the function of punishment mechanism. The integrity of the supervision mechanism, which is provided by the cloud logistics service platform, can stimulate enterprise good faith cooperation, punish the dishonest behavior, and finally realize the high trust among virtual enterprise partner, thus form a “win-win” situation.

Cloud logistics service platform provides the public service platform for high-level information sharing among the enterprises, the cooperative members can obtain the cooperation information about all members of the virtual alliance by the “cloud” at any time, which can effectively prevent the situation appeared that is “prisoner’s dilemma” of virtual enterprises information sharing. Therefore, cloud logistics service platform realizes the information sharing among enterprises from a higher level, improves the ability of information exchange and collaboration among enterprises, reduces the cost of the enterprises information construction and management, inspires the integrity of cooperation among enterprises, greatly expands the profit space and provides a new network service pattern for the cooperation of virtual enterprises and the operation of the virtual alliance. From above game analysis, effective information integration and high sharing among cooperative members is the key factor whether the virtual league run success. Only in this way, can be efficiently complete logistics task and satisfy customer’s demand through the way of cloud service’s combination on the face of the complex logistics tasks.

5. Conclusions

The paper defined Logistics Cloud Services through the cloud logistics operation mode, and on this basis, set up the frame of Logistics cloud service cooperation system framework, then analyzed the premise condition of logistics cloud services discovery and combination, finally, established the logistics cloud services discovery and combination game model with the game theory method. By game analysis, it is apparent that the government’s guidance and support and cooperative members’ effective information integration and sharing height by using internet and cloud computing technology are the key factors, which are related to success or failure of logistics cloud service discovery and combination, even cloud logistics operation. The next step will research on intelligent optimization algorithms of integration and sharing technology, logistics cloud services discovery and combination on this basis. These studies have certain practical significance by providing a strong theoretical foundation in order to carry out the cloud logistics.

Acknowledgements

The authors gratefully acknowledge the support of Key Research Institute of Humanities and Social Science in University of Anhui Province (grant No.SK2013ZD08), Soft Science Research Project of Anhui Province (grant No.12020503075) and NSFC (grant No.70171035, 71201044).

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